Application Case Study on Gamma Ray Imaging Technology for Nuclear Power Plant Decommissioning

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1. Introduction

The gamma ray imaging system(GRIS) can be used for collecting images and gamma rays and displaying the intensity of the radioactive source in a color overlay over the normal image. The GRIS is usually designed to provide two-dimensional information on the position and relative strengths of the gamma ray radiation fields located from a few feet to several hundred feet from the camera. The system consists of a portable sensor head that contains both gamma ray and visual imaging systems and a portable control computer. And also, the system has been successfully used as an ALARA(as low as reasonably achievable) tool for identifying source terms and additional shielding requirements. Because the control system can be positioned away from the camera, the radiation exposure to personnel can be reduced without extensive shielding requirements. This paper is intended to review the applicability of GRIS as decommissioning tool. In order to review the actual applicability, we investigated various application cases for US power plants.

2. Description of Process

The GRIS which has been used in US nuclear power plants provides a two-dimensional color image of a gamma radiation field superimposed on a black-and-white visual image. The gamma image has a spectrum of colors to provide a qualitative measurement of gamma intensity as shown in Fig. 1.

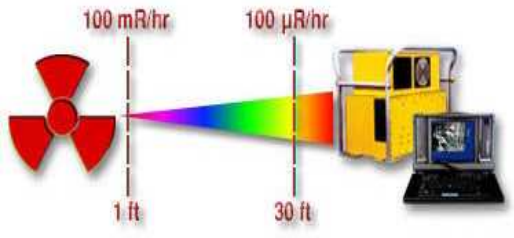

Fig. 1. GRIS spectrum measurement

The specification for the GRIS which has been used in many sites is provided in Table 1. The data acquisition time can be varied from 10 milliseconds to a number of hours. The field-of-view of the gamma-ray imaging system is either 25 (1.3 angular resolution) or 50 (2.6 angular resolution). Both the collection time and the field-of-view are controlled by computer input. The radiation and visual images are stored on a disk in a PC format for future use.

Table 1 : General Specification of GRIS

PARAMETER	SPECIFICATION
SPECTRAL RANGE	< 80 keV to > 1.3 MeV
DETECTOR	High density terbium-acitvated scintillating glass
SENSITIVITY	1 µR integrated dose for Cs-137 point source and 7:1 signal to noise ratio
EXPOSURE TIME	User selectable, 10 milliseconds—10 minutes
FIELD OF VIEW	25 degrees narrow mode, 50 degrees wide mode
SPATIAL RESOLUTION	1.3 narrow mode, 2.6 wide mode
DYNAMIC RANGE	Instrument: > 10E7, Single Image: >10:1
B&W VIDEO FIELD OF VIEW	73 Horizontal, 55 Vertical
TEMPERATURE	Operation: 5 C to 40 C Storage: –20 C to 50 C
HUMIDTY	0 to 99% non-condensing
DETECTION HEAD	Weight: 55 pounds Size: 19 in. length, 10.in. width, 15 in. height Tripod mountable
PROCESSOR	Rugged portable computer (IBM compatible) Intel Pentium CPU Active Matrix LCD Color Display Internal Hard Drive PC Card Slot (Type II/ Type III)
STANDARD SOFTWARE	GammaSoft
SYSTEM POWER	215 Watts, 110 –240 VAC, 50/60 Hz

3. Case Study on Field Experience

Field experience for commercial decontamination and decommissioning has included Maine Yankee, Trojan, San Onofre-1, Big Rock Point, and Millstone-1. In each instance the GRIS was used to provide supplemental radiation source term information. Extensive manual surveys had been performed at each of the five sites. The GRIS was used to search for new source terms or to obtain additional information on previously identified source terms. The greatest success occurred at Maine Yankee where twelve new source terms were identified and approximately 200 person-rem were saved. Summaries of the decommissioning field experience at each if the sites are provided below.

3.1 Maine Yankee

In January 1999 Maine Yankee personnel performed a comprehensive survey of the reactor and auxiliary buildings using the GRIS. The unit had been shut down for approximately eighteen months and had been manually surveyed. The GRIS survey revealed twelve new radiation sources and helped characterize approximately 300 previously identified sources. The new sources were primarily in overhead areas, which were difficult to reach and survey by conventional methods. Fig. 2 shows a source from the Reactor Coolant pump.

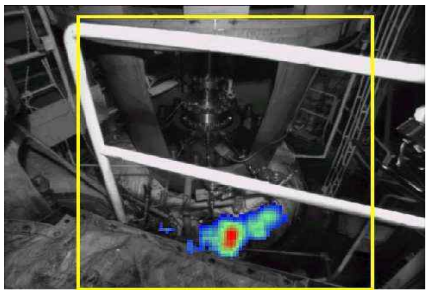

Fig. 2. Marine Yankee Reactor Coolant Pump

3.2 Trojan

The plant had been extensively surveyed and the radiation levels had significantly decreased since the plant shutdown. A unique feature of the Trojan decommissioning was the shipment of the reactor vessel, with all its internals, to a low level waste disposal site in Washington State. Trojan personnel used the GRIS to take pictures of the reactor vessel for shielding planning purposes and then performed a post shielding evaluation prior to shipment for burial. The GRIS image of the reactor vessel prior to shielding is shown in Fig. 3.

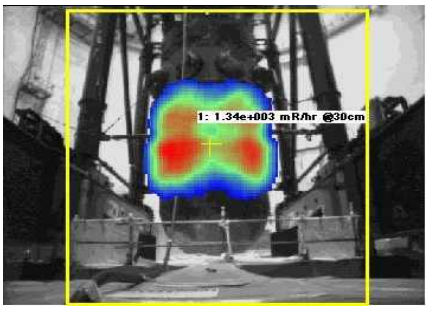

Fig. 3. Trojan reactor vessel prior to shielding

3.3 San Onofre-1

The San Onofre-1 site had been shut down six-years prior to the GRIS being on site. The areas had been extensively surveyed and the characterization was quite complete. Still, new information was obtained in several areas. Fig. 4 shows a “Beta Wall”. This wall had been contaminated during operation by pressurizer spray leakage.

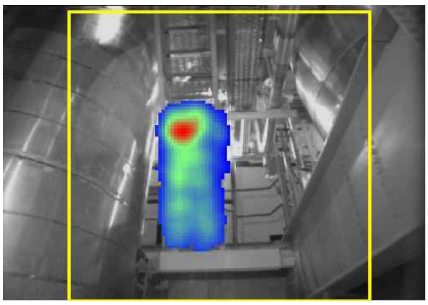

Fig. 4. San Onofe-1 betawall near pressurizer

The contaminated was well known to plant personnel but the GRIS images provided additional detail concerning the locations and extent of the contamination.

3.4 Big Rock Point

The GRIS was used at Big Rock Point in July 1999 to perform a general characterization survey. The unit had been shut down for approximately two years and had been manually surveyed. Although the equipment worked satisfactorily, Big Rock Point personnel indicated that additional training would have been beneficial. The personnel also indicated that the GRIS would have been very useful during the chemical decontamination process to help determine the extent and location of remaining hot source terms.

3.5 Millstone-1

The GRIS images were used to supplement manual surveys and generate area survey maps. Millstone-1 personnel were satisfied with the results and determined that selecting the proper field-of-view was extremely important. If the area selected is too large, an averaging the background radiation can mask some known radiation source locations. Fig. 5 show the location of the GRIS and the images acquired the 108 ft elevation of the Millstone-1 reactor building.

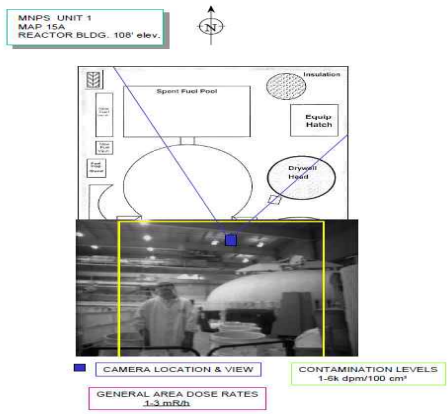

Fig. 5. Millstone-1 reactor building

4. Lessons Learned

4.1 Maine Yankee

The key to success at Maine Yankee was using the GRIS relatively earlier in the project and using a single crew to perform the entire survey. The crew obtained consistent results, which were used to identify and eliminate 12 previously unknown hot spots and save approximately 200 person-rem. The combination of gamma ray image data overlay on a photographic image

made identifying these hot spots quite easy. The personnel at Maine Yankee indicated that the equipment would have additional benefits if the sensitivity could be increased.

4.2 Trojan

The Trojan personnel were pleased with the results obtained on the reactor vessel. However, plant procedures still required that manual radiation surveys be performed before any radioactive material could be shipped off site. Calibration of the GRIS and developing plant procedures could alleviate this problem.

4.3 San Onofre-1

The San Onofre-1 site had been shut down for approximately seven years before the GRIS was brought on site. The areas had been extensively surveyed and the characterization was quite complete. Still, new information was obtained in several areas. The main problem was having three different crews operate the system. In retrospect, it was felt that more consistent and useful results could have been obtained, if a single crew had operated the system for the entire campaign.

5. Conclusion

The GRIS has demonstrated that it can be a beneficial tool in decommissioning activities. The GRIS can locate radiation sources and help determine the magnitude and extent of the radiation source. The GRIS images can locate multiple radiation sources in close proximity and help determine precisely where shielding would be most effective. Post-shielding images can assist in determining the adequacy of the shielding and pin point where additional shielding is needed, GRIS images are especially useful in ALARA briefings and job planning. The gamma ray images superimposed over the visual image helps in convey the exact location of the radiation sources. Finally, the gamma ray images can be easily stored and retrieved for record keeping or for any future use. The GRIS images are most beneficial when the equipment is used within a reasonably short time after shutdown.

REFERENCES

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