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THE NINO CASK-LOADING SAFEGUARDS SYSTEM*

Sidney Fiarman

Brookhaven National Laboratory

Upton, New York 11973

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ABSTRACT

It is, in general, difficult to determine by means of camera-surveillance techniques what is loaded into spent-fuel casks being prepared for shipment from light-water reactors to other reactors, reprocessing facilities, or long-term storage. Furthermore, the expected high frequency of cask loadings in the coming years would place too great a burden on the IAEA and Euratom inspectorates if each had to be observed by an inspector. For the case of shipment to other reactors and reprocessing facilities, the casks are soon opened and, in principle, their contents could be ascertained by direct inspection. In the case of long-term-storage facilities, the casks would stay sealed for years, thereby requiring the IAEA to know positively how many spent-fuel assemblies were loaded at the reactor and to have a continuity of knowledge of the cask's contents. It has been proposed instead that the facility operator place the cask seal on the cask within the field of view of a surveillance system linked to the cask seal. This solution, however, may not provide enough credibility for acceptance by the safeguards community. This paper presents an alternative to both inspector presence at cask loading and operator assistance in applying seals; this alternative is called the No Inspector, No Operator system (NINO).

I. INTRODUCTION

The spent-fuel arisings at light-water reactors under International Atomic Energy Agency (IAEA) and Euratom inspection are even now taxing the storage capabilities of some spent-fuel-storage pools (SFSP) [1]. Since present and near-future reprocessing capabilities are not adequate to eliminate this backlog of spent fuel [2], long-term spent-fuel storage facilities have been or are being constructed, e.g., dry storage at Gorleben and Ahaus in The Federal Republic of Germany and wet storage at CLAB in Sweden. The rate of transfer of spent-fuel storage casks from reactors to dry-storage facilities has been estimated to reach 17 casks per year for each reactor being serviced. At this rate, direct viewing of the final loading of the casks and the direct application of seals by the inspector would place too great a burden on the IAEA and Euratom inspectorates.

An alternative solution has been proposed [3], i.e., that the facility operator apply the VACOSS [4] safeguards seal while being observed by a surveillance camera linked to the seal by a special interface that overlays the seal information onto the camera-picture frames [5]. Whereas until now, the main function of the surveillance cameras has been to capture (on one or more frames) the presence of a very large cask entering or leaving the spent-fuel-pool area, an event that should be easily seen during review of the frames by the inspector, this new application of surveillance cameras requires the inspector to verify that the operator correctly applies the correct seal to the correct cask. These operations are on a much smaller scale than looking for large casks, complicating the inspector's task significantly. Thus, this proposal may not achieve the credibility needed for the international safeguards community. Is there not another alternative to inspector presence?

II. THE NINO CONCEPT

The two main functions of an inspector at a cask loading are counting the number of assemblies loaded into the cask and applying to the cask lid a tamper-indicating seal that detects any attempts to lift the lid and remove assemblies. Fortunately, two safeguards components currently exist that together can do both these functions; the Laser Surveillance System (LASSY), which is designed to track and count assemblies which are moved from the storage bay and loaded into the cask, and the VACOSS seal, which is designed to be serially coupled to detectors [6]; one of these can be a special "lid detector" to confirm that the lid remains in place. This proposed safeguards approach, NINO, requires no inspector and no operator.

It is to be emphasized that coupling two technically complex safeguards system to mimic what an inspector easily does has the unavoidable drawbacks of increased intrusiveness on the facility operation and greater chance of system

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failure. By all means, if the resources are available, use an inspector. If not, then perhaps a simpler solution along the same lines of NINO can be found. It is the purpose of this paper to encourage the IAEA, Euratom and other safeguards support groups to search for a better solution.

A. The LASSY System

LASSY has been described several times before [7,8] and so only a brief review will be given, emphasizing the more recent advances. It is assumed that, if adopted, LASSY would initially complement camera surveillance at spent-fuel pools, and if very reliable, eventually replace cameras altogether; the use of two redundant safeguard systems may be too expensive for the IAEA. Hence, after LASSY is described and some field-test results are presented, a brief comparison between LASSY and camera surveillance is given.

1. System Description

LASSY covers the spent-fuel assemblies in the pool with an underwater scanning sheet of light such that movement of an assembly into or out of a position in the storage racks will be detected, and a record of position, date, and time will be stored in LASSY's computer memory for later access by an inspector. As shown in Figure 1, two scanning beams of light are used to triangulate the position of the assembly. The underwater transducer (or "eye") is a concentric transmitter/receiver for the 488-nm Argon-ion laser beam (Figure 2). The laser beam is switched electronically from one eye to the other and the switching frequency is used to modulate the electrical signal, thereby reducing the detection of background lighting. The photodetector in the eye has a band-pass filter at 488 nm to reduce further the unwanted background signal.

For most pools, the pool-wall area in a plane just above the assemblies will be free of tools and most other irregularly shaped objects, and so the response of the photodetector to light reflected from this area will be similar to that observed during experiments in a pool near the IAEA [Figure 3]; scans both with and without a mock-up assembly intercepting the beam are shown. The differences in the response from scan-to-scan are calculated and when no mock-up assembly is present, the response for each of the 1150 points in the range from 0° to 90° will be reproducible within a few percent. When a mock-up assembly is in place and is intercepting the beam in a few (or many) beam positions, the photodetector response will most likely produce a %Diff of tens of percent. If two or more adjacent scan positions record events in both scanning eyes and for two successive scans, then the computer interprets that as an assembly in motion. This redundancy should virtually eliminate false alarms.

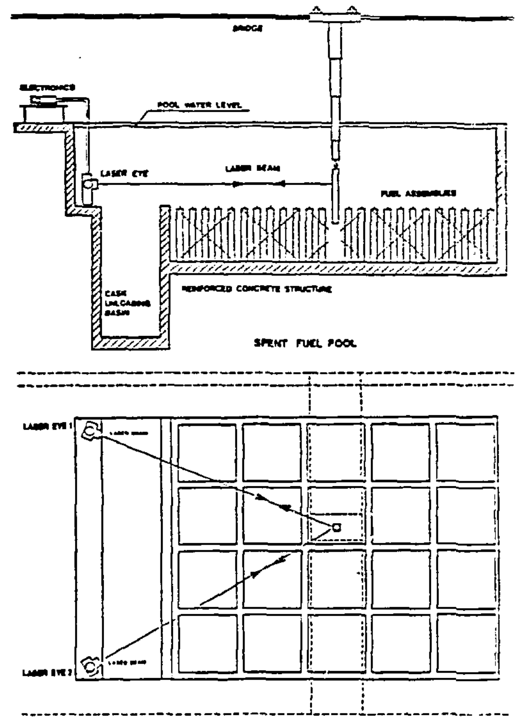


Fig. 1 LASSY - Laser Surveillance System

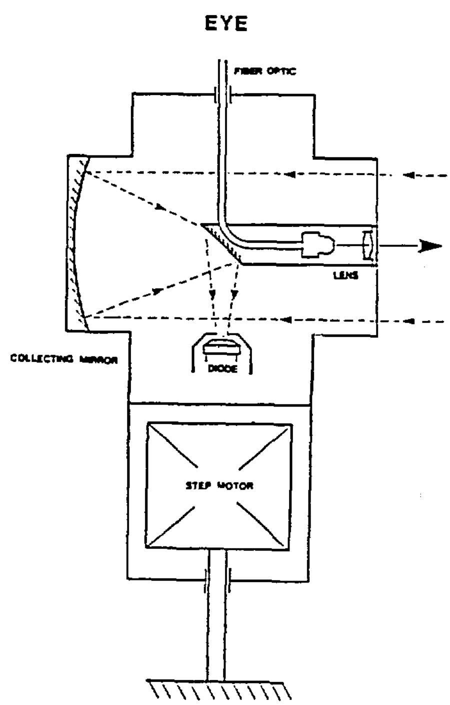


Fig. 2 LASSY "EYE"

DISCLAIMER

2. LASSY Results

LASSY has been successfully tested in a 9 X 15-meter shallow pool near the IAEA (1984) and demonstrated to over 70 IAEA inspectors and section leaders. There has been one extensive field test in the Hungarian reactor at Paks in July 1986, where 114 assemblies were moved about in the pool during a refuelling. LASSY detected all movements but some computer interpretations were incorrect [8]. More field-test experience will be needed to test the effectiveness of proposed LASSY upgrades to deal with the problems encountered at Paks.

3. Advantages Over Camera Surveillance

There are several major advantages of LASSY over IAEA camera surveillance that should justify an increased development effort.

a. LASSY is independent of pool lighting. Camera frames are occasionally overexposed or underexposed, thus making frame review difficult or impossible.

b. Even with proper exposure, camera-frame review can be inconclusive. In contrast, LASSY needs no frame review since it has the "intelligence" to sort out the various types of assembly movements (i.e., simple relocation, cask loading, reconstitution, refuelling, etc.) and provide a listing of each type to the inspector upon interrogation. More intelligence can be added.

c. The inspector can use the list to 1) count assemblies leaving the racks to be loaded into casks, and 2) identify pool locations where anomalous movement has been recorded and hence identify locations for application of NDA devices (such as the Cherenkov viewer or Ion-1/Fork). Since cameras do not see assembly movements at all, neither cask-loading nor positional information is possible.

d. LASSY is almost all solid-state electronics and should lead to a long mean time between failure(MTBF). Television-camera recorders are mechanically complicated and have more failure modes.

4. Future Direction

The tracking of assemblies from the rack position to the cask-loading area can be added to LASSY by use of a third eye and associated tracking software [9]. If the cask-loading area is separated from the storage pool by a wall, a second LASSY installed in that area could be linked with the main LASSY to provide continuity of movement of assemblies loaded into casks.

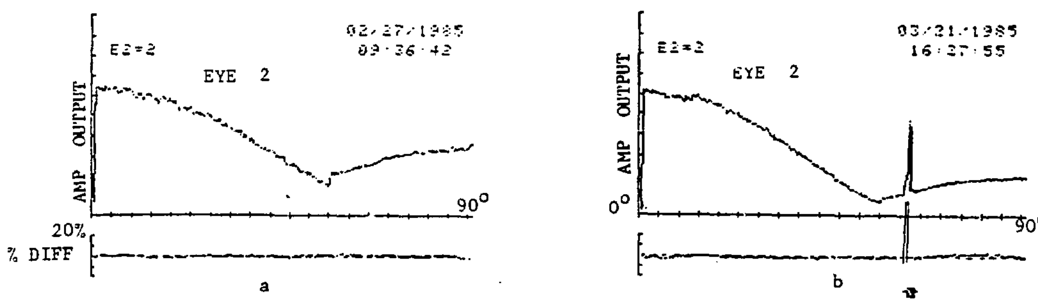
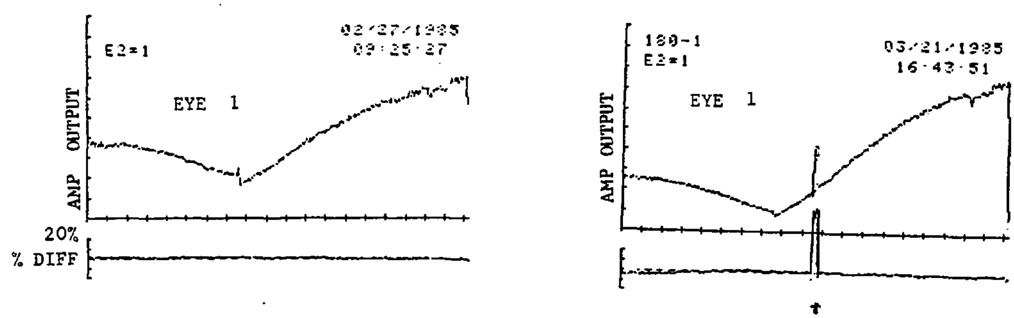


Fig. 3 LASSY scans a) no assembly, b) with assembly



B. The VACOSS Seal With A Lid Detector

In the original safeguards schemes [3], a VACOSS seal would tie together the cask lid to the cask body after the lid was in place. Instead, in the proposed NINO system, the VACOSS-seal fiber-optic cable would be tied around the girth of the cask by the inspector sometime before the cask was lowered into the pool [see Figure 4]. Attached to the VACOSS-seal cable could be a "lid detector" which operates by detecting gamma radiation from the cask [10]. As each assembly enters the cask, the gamma-radiation emissions from the cask should increase. When the lid is put in place, the radiation level should increase due to reflection from the massive lid [see Figure 5]. When the water is replaced with an inert gas, the radiation level should increase further. When the cask is removed from the pool, the radiation level should increase. All of these changes in radiation level could be recorded in the VACOSS seal memory, much as the openings and closings are now. If the lid is removed, the radiation level would decrease and would constitute an anomaly. Two or three lid detectors would provide the required redundancy, thereby reducing false alarms. There has as yet been no development work on such a "lid detector".

C. The NINO System

The two components noted above could be linked together simply by synchronizing the detected movements of assemblies into the casks. When LASSY detects an assembly being lowered into the cask, the VACOSS seal should also detect the increase in radiation. It would also be possible to link electronically the two systems via a photodetector in the VACOSS loop, with coded information being passed between the systems.

III. SUMMARY

Despite the apparent complexity of NINO, there really are only two safeguards components present, a LASSY and a VACOSS seal with detectors integrally part of the optical loop. Both LASSY and the VACOSS seal have been under development for several years and are both in the field-testing stage. The correct interaction of the two systems would guarantee that the cask receiving the assemblies is also the one sealed by the VACOSS seal. No inspector need be present during the cask loading and closing, and the operators performing their tasks would not interact in any way with the safeguards system.

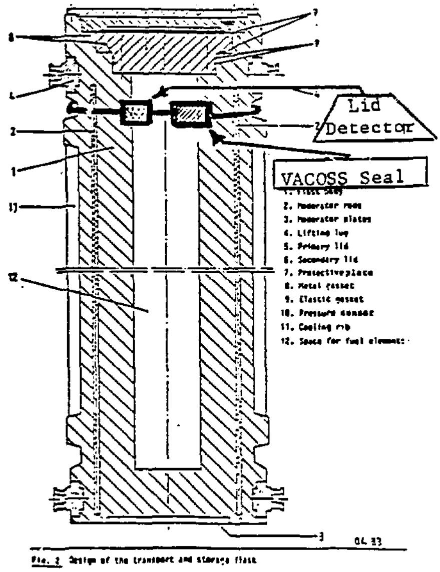


Fig. 4 Transport and Storage Cask with VACOSS Seal and Detector

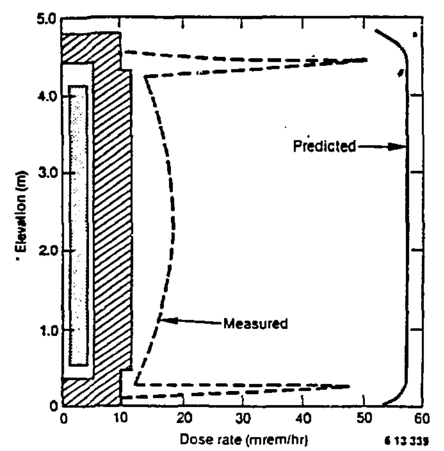


Fig. 5 Typical total dose rate profile comparing predicted to measured data.

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