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APPLYING NEW SAFEGUARDS TECHNOLOGY TO EXISTING NUCLEAR FACILIITIES

by

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ABSTRACT

The application and operation of safeguards instrumentation in a facility containing special nuclear material is most successful when the installation is designed for the operation of the specific facility. Experience at the Idaho National Engineering Laboratory demonstrates that installation designs must consider both Safeguards and Production requirements of specific facilities. Equipment selection and installation design influenced by the training and experience of production operations and safeguards personnel at a specific facility help assure successful installation, reliable operation, and minimal operator training. This minimizes impacts on existing plant production activities while maximizing utility of the safeguards information obtained.

INTRODUCTION

The Safeguards Development Program at the Idaho Chemical Processing Plant (ICPP) has as one of its major goals the design and installation of an integrated safeguards system in an operating nuclear facility.

The objectives of a modern Safeguards System can be conveniently classified as physical protection, accountability, and material control. Physical protection subsystems are concerned with controlling access to Special Nuclear Material (SNM) by means of physical barriers, penetration alarms, and guards. Accountability subsystems use precise measurements and bookkeeping methods to provide a physical inventory of SNM. Material control subsystems utilize data from a variety of sources to provide constant automated surveillance of SNM. It should be noted that these classifications are not mutually exclusive, and a single device may provide inputs to more than one subsystem. The portions of the system being installed at the ICPP are primarily concerned with material control. The completed system will make use of data from physical protection and accountability computer networks when these inputs become available.

The improved material control concept under development at the ICPP is based on rapid monitoring of plant operations by a computer. Monitored items include: valve positions, tank levels, liquid densities, flowrates, temperatures, pressures, presence of liquid in lines, and sequences of operations. The computer will evaluate the validity of plant operations by comparing process sensor data with "acceptable" ranges or sequences of operations. Deviations from these conditions would be identified by the computer as possible diversion attempts which require further investigation by the safeguards staff. The ICPP was designed to recover uranium from a wide variety of highly-enriched uranium fuels. The plant has been in operation since 1952.

Several aspects of the plant construction have significant influence on the design of the safeguards development system. The plant was built as a series of shielded cells to facilitate direct maintenance, so all areas of the plant are accessible (access is limited by varying radiation fields).

The ICPP was also designed for flexibility of operation, so that there are many possible flow paths for SNM. In keeping with the time in which it was built, most plant operations are controlled manually.

In some areas of the plant, most importantly in the loadout and product storage areas, this reliance on direct manual control prevented effective remote surveillance. To solve this problem, manual valves are replaced with remote valves, and a new control panel is installed in the loadout area to further remove personnel from the product storage area. Some other equipment such as pumps and pressure gages are upgraded to improve reliability for remote operation. These changes not only allow remote process monitoring, but decrease routine access to SNM. The plant benefits by receiving a more modern and efficient system, and by decreased radiation exposure of the operating personnel.

FUNDAMENTAL DESIGN CRITERIA

The system being installed at the ICPP was designed to demonstrate that a material control system could be retrofitted into an existing reprocessing plant without adversely affecting production. Three fundamental design criteria were established in order to achieve this goal. First, the safeguards data collection equipment must not place additional burdens on plant operating personnel. Ideally, the plant operators would not even know that the system was present, negating the need for additional training. Second, all components must be highly reliable, both to maintain system integrity and to avoid making frequent demands on the maintenance department. Third, failures of any part of the safeguards system must not require a stoppage of plant operations. This criteria can be met by selecting devices whose failure has no impact on operation of the plant processes, or by providing means of rapidly isolating the failed component.

CONCEPTUAL DESIGN

A fundamental concept of this system is that sufficient data can be collected and correlated to define and evaluate the state of the plant. The sensor array can be scanned by a computer at intervals from seconds to minutes, depending on the type of signal. This allows for rapid detection of changes in plant status, and timely identification of abnormal or unusual conditions which may indicate process problems or an attempt to divert material.

If a system of this nature is to be effective, intimate knowledge of plant operating procedures and physical configuration is required for the system design and operation. In an existing plant, information on physical configuration must be obtained by a thorough study of blueprints and flow-sheets, followed by physical verification that the descriptions are accurate. Basic understanding of plant procedures can be obtained from formal documents such as Standard Operating Procedures, but much valuable information can only be obtained from discussions with operating and maintenance personnel. The knowledge so obtained can then be used to determine the sensor locations necessary to define the plant status during normal operations, during unusual procedures such as cleanout or recycle, and during possible intentional misuse of operating equipment.

SENSOR SELECTION CRITERIA

Detailed knowledge of how the plant functions is also required to ensure that sensor selection will meet the fundamental design criteria. Once a sensor location has been identified, five questions must be answered in order to choose among candidate devices:

- What are the normal operating conditions and the range of abnormal conditions to which a device will be subjected?
- What effect would failure of the device have on the process, and how can adverse effects be eliminated or minimized?
- Will the existence of the device cause physical or procedural changes for the plant operators?
- Does the device require special maintenance or calibration?
- Will the device create a diversion route instead of blocking one?

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The first question is very important, since the selection of sensor devices is often determined by the conditions under which it must function. Few standard industrial components can withstand the highly corrosive environment in a reprocessing plant such as the ICPP. In many areas of the plant, resistance to radiation damage is also important. In many instances it has been necessary to trade-off accuracy for physical ruggedness.

If any of the failure modes of a device could adversely affect the process, it is desirable to select a device which is so overdesigned that failure by that mode is extremely unlikely. If no candidate device is sufficiently well built, it is necessary to provide a means, such as a valve for isolating the device from the process or a redundant backup device if failure occurs.

The third question is important at an existing facility. Space in instrument and control rooms is at a premium, and crowded process piping makes it a challenge to find locations for devices. It is necessary to ensure that new devices do not cause unnecessary inconveniences or hazards for the operating and maintenance personnel who must work around them. If certain procedures, such as steam cleaning or overpressurization, may harm a device, it is necessary to include a means of protection in the system design. Reliance on operating or maintenance personnel to take special precautions not only places an undesirable burden on them, but may eventually lead to the destruction of the device.

In general, the greater the precision demanded of a device, the more frequent will be the demands for calibration and maintenance. Devices must be selected to minimize these requirements. The location of devices requiring calibration must be chosen for ease of access and for minimizing radiation exposure to the personnel involved. Automated calibration, self-checking, and comparative verification can help alleviate the maintenance burden

The fifth question may seem frivolous, but is actually a serious consideration. Devices which require new penetrations into process lines or through process cell walls may cause new diversion hazards unless precautions are taken. In the ICPP system it was necessary to install the high precision pressure transducers for the liquid product storage banks inside the process cell to prevent this problem, even at the cost of more difficult access for calibration.

DESIGN REVIEWS

In order to design a successful system, it was necessary to work closely with the many groups which are involved in operating the ICPP. Operations, Maintenance, Engineering, Safety, Safeguards and Security, and Technical Support organizations were all required to review the system design. This review assured that all installations met or exceeded applicable plant standards and that all operational and procedural changes were coordinated and incorporated. It also assured adequate documentation for updating plant drawings and for maintenance troubleshooting. Inputs from these groups allowed selection, where feasible, of devices compatible with existing facilities and familiar to plant personnel. In those areas of the plant which had to be extensively modified to allow remote monitoring, this close cooperation was essential.

Many opportunities were available to install instruments which significantly expanded the capability of the existing plant instrumentation. Taking care to maximize the benefits of the new safeguards instruments, while minimizing the impact on plant operations helped overcome the natural tendency of any institution to resist change.

SPECIFIC SENSORS

Much Safeguards information can be obtained from normal plant instruments. This information includes tank levels and densities, fluid flow rates, and temperatures. In the existing plant this information was not recorded in a central location, or in a form which could be accessed by a computer. In many instances, the desired data could be obtained by installing a sensor in parallel with an existing instrument. Many pneumatic signals could be monitored by installing a tee in the instrument line, and connecting it to a suitable pressure transducer. The most suitable device for this application is a Scanivalve*, which can monitor up to 64 signals with a single pressure transducer and rotary switches. The Scanivalve is designed for computerized control and data transmission.

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*Tradename model of an instrument manufactured by Scanco, Incorporated.

In high radiation areas, fluid transfers are accomplished with steam jets or by means air lifts. Valving is done with pneumatic remote control valves. Monitoring of the pneumatic valves and many steam jets was accomplished by installation of pressure switches in the supply lines. Static-O-Ring "Omni" pressure switches** have provided the necessary physical durability and corrosion resistance for this application. The valving arrangement on certain transfer jets makes pressure switch signals ambiguous. These jets are monitored by mounting a stainless steel clad thermocouple on the jet discharge pipe in the process cell. The thermocouple output provides a means of identifying the start and end points of a transfer, and has the potential for providing a useful tool to aid plant operators who currently must rely on indirect methods to follow the transfer.

High precision level and density measurements on selected tanks are important components of the system. These measurements provide an independent check on input accountability volume measurements. They also will allow material balance estimation in the areas of the plant where no accountability information is available. Small changes in storage tank levels will also be rapidly detected by the high precision transducers. Precision pressure transducers are expensive, so the system uses pneumatic multiplexing to measure a total of 38 signals with 12 transducers. Two pneumatic multiplexing schemes are being tested--one based on solenoid valves, and the other based on a Scanivalve instrument. The hazard which must be overcome by both systems is the introduction of transients or leaks which affect plant instruments.

The system is capable of checking the validity of sampling procedures. Operation of the sample jet is detected by a pressure switch. Operation of the mixing sparge and sampler air lifts may be detected using magnetically coupled flow switches or thermal detectors. The computer can analyze the sequence of operations to ensure that adequate mixing time was allowed and that the required pauses for precision level measurement were taken.

**Tradename of device manufactured by SOR, Incorporated.

An important class of devices for detecting illicit removal of material from the process is the Liquid-in-line detector. Several types of sensors have been investigated for this application. The simplest is a vacuum switch. Sensors under development include ultrasonic and thermal devices. In cases where introduction of a siphon tube is possible, a simple device for preventing tube entry has been developed. The device forces the line to make four sharp 90° bends while maintaining full flow cross section and adequate drainage.

SUMMARY

A Department of Energy sponsored safeguards instrument development program at the ICPP (Idaho Chemical Processing Plant) of the INEL (Idaho National Engineering Laboratory) designed safeguards instrument installations for an operating nuclear fuel reprocessing plant. This design for the ICPP illustrates that safeguards techniques can be applied to an existing facility without adversely affecting plant production.

Improving safeguards at an existing nuclear facility often requires adding to or replacing existing instruments. The disruptive effects of these changes on plant operations can be reduced by considering the capabilities and experience of Safeguards, plant support, and operator personnel at specific plants. The installation and operation of these safeguards devices are designed and specified to satisfy safeguards information requirements and minimize the impact on plant operations.

This program developed and applied criteria to assure successful installations. These criteria were thoroughly reviewed with plant personnel, including nuclear materials management personnel. The criteria provide guidelines to assure benefits for safeguards and existing production activities.