1 of 1

Conf-940307--15

LA-UR- 94-0256

Title: CONTINUOUS REMOTE UNATTENDED MONITORING FOR SAFEGUARDS DATA COLLECTION SYSTEMS

Author(s): S. F. Klosterbuer, J. K. Halbig, W. C. Harker, H. O. Menlove, J. A. Painter, and J. E. Stewart

Submitted to: IAEA Symposium on International Safeguards
Vienna, Austria
March 14-18, 1994

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

MASTER

Los Alamos
NATIONAL LABORATORY

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the U.S. Department of Energy under contract W-7405-ENG-36. By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. The Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Form No. 836 R5
ST 2629 10/91

IAEA-SM-333/111

CONTINUOUS REMOTE UNATTENDED MONITORING FOR SAFEGUARDS DATA COLLECTION SYSTEMS

S. F. Klosterbuer, J. K. Halbig, W. C. Harker,
H. O. Menlove, J. A. Painter, and J. E. Stewart
Los Alamos National Laboratory
Safeguards Assay Group. NIS-5, MS E540
Los Alamos, NM 87545 USA

CONTINUOUS REMOTE UNATTENDED MONITORING FOR SAFEGUARDS DATA COLLECTION SYSTEMS*

ABSTRACT

To meet increased inspection requirements, unattended and remote monitoring systems have been developed and installed in several large facilities to perform safeguards functions. These unattended monitoring systems are based on instruments originally developed for traditional safeguards and the domestic nuclear industry to nondestructively assay nuclear materials. Through specialized measurement procedures, these instruments have been adapted to be unattended monitors. This paper defines the parts of these unattended monitoring systems, describes the systems that have been installed in the field and their status, and discusses future trends for unattended systems.

1. INTRODUCTION

The Los Alamos Safeguards Assay Group has been involved in the development and installation of several unattended monitoring systems in Europe, North America, and Asia.[1] The need for these systems was prompted by the increased demands on the various inspectorates to inspect more facilities and to maintain around-the-clock inspections on operations in some of the newer facilities but to perform these increased duties with the same or fewer inspectors as before these new facilities and requirements arose.

2. GENERIC SYSTEM DESCRIPTION

In the full implementation, these systems are composed of several parts shown in Fig. 1: acquisition, collection, review, analysis, accountability, record keeping, and report generation.

*Work supported by US Department of Energy, Office of Arms Control and Nonproliferation and Program of Technical Support to IAEA Safeguards.

The various parts can be thought of as levels with needed data being passed to the next highest level. A description follows of a complete, generic, unattended system for monitoring radiation. Actual systems may contain all or only part of the generic system.

2.1. Hardware Components

From the hardware viewpoint, the first part of the system is the detector or detectors that sense the radiation. The detectors transform the radiation signal into signals that can be measured by data acquisition electronics (DAE): (GRANDs* or JSR-11s** in our applications or VMEbus Extensions for Instrumentation (VXI) based systems in the future. The DAEs supply the power for and process the signals from the detectors. The DAEs are connected to Collect computers using a serial line. Normally the higher-level functions (review, analysis, and accountability) are performed on another computer (s) located away from the Collect computer; data are transferred between the two computers via disk, but electronic transfer would be possible. Since remote and unattended monitoring systems must operate continuously and unattended, battery backup or uninterruptable power, special racks, seals, visible cable runs, and other hardware components may be necessary to provide authentication.

2.2. Acquisition

Acquisition is performed by the program Monitor, which resides in firmware in the DAE. It continuously collects the data at the specified intervals, eliminates statistically insignificant data, temporarily stores the data, checks for tamper situations, and dumps data upon request. A DAE with its data storage capabilities and a Monitor program is the only continuously operating system component required. Not all DAEs have the capability for a Monitor program and in these systems the Monitor functions are performed by the next software level, Collect.

*D. S. Davidson Co., 19 Bernhard Road, North Haven, CT 04673.
**Canberra, Inc., Jomar Division, 110 Eastgate Drive, Los Alamos, NM 87545.

2.3. Collect

Collect off-loads the data from the DAEs, organizes and stores the data, shows the inspector the current status of the systems, and is used by the inspector to copy the relevant data from hard disk to floppy or Bernoulli disks.

2.4. Review

The next software component, Review, organizes the data from several data collection systems into one database, allows the large amount of data to be quickly examined graphically and summarized, and selects subsets of data for transfer.

2.5. Analysis

Data analysis uses the packet produced by the data acquisition, collection and review system to perform the unique analysis needed for the particular system. Programs such as the International Atomic Energy Agency's (IAEA's) high-level neutron coincidence counter (HLNC) or Los Alamos's neutron coincidence counter (NCC) are used as analysis programs when it is necessary to calculate the amount of material present. Other analysis programs might be neural network programs used to do pattern recognition and event occurrence.

2.6. Accountability

The data accountability system uses the results from analysis to update its total safeguards information database, draw conclusions, and generate reports. This level is defined and implemented by the IAEA.

3. SYSTEMS TODAY

Systems installed in the field can be categorized as nondestructive assay monitoring systems (NDAMS) or radiation monitoring systems (RMS). NDAMS are installed at facilities in which a quantitative special nuclear material (SNM) value must be obtained by the inspector. RMS are used when the inspector needs to know when a valid event occurred; a quantitative measure of the amount of SNM is not required.

3.1. Thorp—RMS

A GRAND electronics package connected to a pair of ionization chambers detects the presence and determines the direction of movement of spent fuel in containers at the Thorp facility in England.[2] Detectors are placed underwater in the channel through which containers move to carry irradiated spent-fuel into or out of a storage area. The GRAND interfaces to a camera system that records the IDs and information supplied by the GRAND.

3.2. PFPF—NDAMS

At the Power Reactor and Nuclear Fuel Corporation's (PNC's) Plutonium Fuel Production Facility (PFPF) in Japan[3,4], JSR-11 shift-register-based systems are installed at the input and output paths of a fuel fabrication plant to continuously monitor material moving into and out of the plant; assays are performed to determine the amount of material present. Other systems, installed at various locations along the process, operate either continuously or unattended for shorter times; some interface to camera systems that record sample IDs. The JSR-11, Collect computers, and cameras are located in sealed cabinets near the detectors. Inspectors collect data from the systems every 30 days; the data are reviewed and analyzed to determine the amount of material present.

3.3. CDM—RMS

The core discharge monitoring system (CDM) at the Darlington facility in Canada monitors the radiation levels in the reactor containment shielding of a CANDU reactor[5] to detect when irradiated fuel bundles are removed from the reactor. Each reactor is outfitted with four detector enclosures placed inside the containment: two on each end of the reactor face on opposite sides of the containment room. Cables run through the penetrations to GRANDs located nearby. The two primary Collect computers are in a remote room several hundred feet away from the GRANDs and each services eight GRANDs. A "watchdog" processor controls which GRANDs are routed to which Collect computer and annunciates messages to the regional office so problems can be relayed in near real time. Inspectors retrieve data every 90 days and use Review to determine when fuel moved.

3.4. Fast Reactor—RMS

Other RMS applications are the fuel-flow monitors at PNC's Joyo and Monju reactors in Japan. Both reactors have a monitor at the input to the fresh-fuel storage and another monitor at the input to the spent-fuel storage. At Joyo two other monitors detect when assemblies move into and out of the reactor core and when fuel moves along a fuel transport corridor. At Monju two other monitors detect radiation in the transport carts that move along the fuel flow path. Inspectors visit every 30 days and use the data to determine when fuei moved.

3.5. Spent Fuel—RMS

In another RMS application, GRAND-based systems installed in the field monitor the movement of spent fuel assemblies into a storage pond to determine when fuel moved.

3.6. Siemens—NDAMS

Significant work has been done on a second major NDAMS for the Siemens MOX facility[6], but the systems have not yet been installed. Detectors will be placed at the entry and exit of the two fuel-pin storage areas to monitor the movement of trays into and out of the storage areas. JSR-12/Collect computer systems assay the material; the electronic-mechanical sensor (EMS) computer interfaced to a Siemens S5 controller reads the position of several sensors indicating tray position and tray ID. A serial interface between the Collect and EMS computers provides time synchronization. Software handles the time synchronization of the two computer systems and merges the NDA and EMS data. The data are reviewed and analyzed to determine the amount of material present in the trays.

4. CURRENT STATUS

Forty unattended monitoring systems that collect data continuously are operating in the field or are ready for installation. An additional seven systems collect data unattended for shorter periods of time. Of the 40 systems, 12 are NDAMS and 28 are RMS. All NDAMS systems are JSR-based while the RMS systems are a mixture of JSR and GRAND electronics-based systems. The total operating years, as of March 1994, of the NDAMS systems are 45 years and of the RMS systems are 77 years. During this time the NDAMS systems have acquired and processed over 300 MB of data and the RMS systems have handled approximately 9 GB of data. The JSR-based systems are all connected to ^{3}He-based coincidence-type detectors. The GRAND-based systems connect to a variety of detectors: FC, IC, NaI, ^{3}He, ^{10}B, and Si. The count times on the various systems range from 60 s to 1 s.

This wide spectrum of systems is covered by two families of Collect/Review software. JSR-based-systems software consists of shift-register Collect (SC) and Review (SR); the JSR electronics units have no internal monitor capability. Parameters in programs handle the specifics for the different facilities; the basic programs are the same for all facilities. SC and SR are used with 19 systems that are installed at 3 different facilities. Additional Siemens requirements resulted in custom-tailored extensions of the basic shift-register software; Siemens Collect (SSC) and Review/Merge(SSR) fulfill the unique Siemens needs. The GRAND-based-systems software is made up of GRAND Monitor, Collect, and Review. One version of the Monitor program (GM) handles all 24 systems at 4 different facilities. One Collect program handles all single-unit systems (GCS); the CDM systems are covered by the multi-unit Collect (GCM) provided by the Canadian Safeguards Support Program (CSSP). One GRAND Review (GR) covers all 24 GRAND systems.

Table 1 summarizes these unattended monitoring systems.

Table 1. Unattended Monitoring Systems					
Facility/System	Detector(s)	DAE	Time	Software	Installation
PFPF PCAS-1A	^{3}He	JSR-11	60 s	SC, SR	09-88
PFPF PCAS-1B	^{3}He	JSR-11	60 s	SC, SR	09-88
PFPF FAAS-A	^{3}He	JSR-11	60 s	SC, SR	11-88
PFPF FAAS-B	^{3}He	JSR-11	60 s	SC, SR	11-88
PFPF FPAS-A*	^{3}He	JSR-11	60 s	SC, SR	11-88
PFPF FPAS-B*	^{3}He	JSR-11	60 s	SC, SR	11-88
PFPF MAGB-1*	^{3}He	JSR-11	60 s	SC, SR	09-89
PFPF MAGB-2*	^{3}He	JSR-11	60 s	SC, SR	09-89
PFPF MAGB-3*	^{3}He	JSR-11	60 s	SC, SR	09-89
PFPF PCAS-0A	^{3}He	JSR-11	60 s	SC, SR	11-88
PFPF PCAS-0B	^{3}He	JSR-11	60 s	SC, SR	11-88
PFPF PCAS-2A	^{3}He	JSR-11	60 s	SC, SR	11-88
PFPF PCAS-2B	^{3}He	JSR-11	60 s	SC, SR	11-88
PFPF PCAS-3A	^{3}He	JSR-12	20 s	SC, SR	01-93
PFPF PCAS-3B	^{3}He	JSR-12	20 s	SC, SR	01-93
CDM Unit 1 SE	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	07-90
CDM Unit 1 SW	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	07-90
CDM Unit 1 NE	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	07-90
CDM Unit 1 NW	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	07-90
CDM Unit 2 SE	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	11-88
CDM Unit 2 SW	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	11-88
CDM Unit 2 NE	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	11-88
CDM Unit 2 NW	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	11-88
CDM Unit 3 SE	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	03-92
CDM Unit 3 SW	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	03-92
CDM Unit 3 NE	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	03-92
CDM Unit 3 NW	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	03-92
CDM Unit 4 SE	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	09-92
CDM Unit 4 SW	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	09-92
CDM Unit 4 NE	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	09-92
CDM Unit 4 NW	2 FC, 2 IC	GRAND	11 s	GM, GCM, GR	09-92
Joyo ENGM-A	^{3}He	JSR-11	20 s	SC, SR	3-91
Joyo ENGM-B	^{3}He	JSR-11	20 s	SC, SR	3-91
Joyo CCRM	^{3}He, NaI	GRAND	60 s	GM, GCS, GR	3-91
Joyo EVRM	^{3}He, NaI	GRAND	60 s	GM, GCS, GR	3-91
Joyo EXGM	^{10}B, 2 IC	GRAND	5 s	GM, GCS, GR	3-91
Monju ENGM-A	^{3}He	JSR-11	20 s	SC, SR	2-92
Monju ENGM-B	^{3}He	JSR-11	20 s	SC, SR	2-92
Monju EVRM-A	^{3}He, IC	GRAND	60 s	GM, GCS, GR	2-92

Table 1. Unattended Monitoring Systems (cont.)					
Facility/System	Detector(s)	DAE	Time	Software	Installation
Monju EVRM-B	^3He, IC	GRAND	60 s	GM, GCS, GR	2-92
Monju EXGM	^{10}B, 2 IC	GRAND	5 s	GM, GCS, GR	2-92
SFRC UPPER	FC, Si, Sensors	GRAND	1 s	GM, GCS, GR	2-93
SFRC LOWER	FC, Si, IC	GRAND	1 s	GM, GCS, GR	2-93
Siemens IPNT-1	^3He	JSR-12	10 s	SSC, SSR	Not installed
Siemens IPNT-2	^3He	JSR-12	10 s	SSC, SSR	Not installed
Siemens IPNT-3	^3He	JSR-12	10 s	SSC, SSR	Not installed
Siemens IPNT-4	^3He	JSR-12	10 s	SSC, SSR	Not installed
*Operate unattended overnight only					

5. FUTURE TRENDS

We expect the demand for unattended measurement systems to increase and with these systems additional requirements and features will be needed. We see the following trends developing as these types of systems evolve:

- Current systems measure only coincidence/gross neutron data or gross gamma data or both. Future systems will need to handle additional data types and combinations and to automate scanning large samples in a continuous unattended manner.
- Minimum effort must be required to combine various detectors and different DAEs for use in a new facility. Commercial process-control packages are being evaluated to see if they could provide these features with the reliability demanded by the long unattended periods, the flexibility to handle typical safeguards data and the ability to quickly examine data collected for 30-90 days. If commercial software is not adequate, then the existing software must be extended and made more flexible so that it meets the "quick-configuration" need.
- Capabilities are needed to integrate radiation (neutron, gamma) and non-radiation (mechanical, video, and operator) data into one system. Several different hardware solutions can be used to integrate systems. A more difficult problem is to define the software protocol and data structures to handle all the types of data that might appear in these systems. Interfaces between

the data acquisition collection and review, data analysis, and data accountability system must be defined.

- The amount of data collected by these systems is very large and even with time-saving features such as data compression and graphical review, the time required to review the data for a 30-90 day period can be significant. New techniques such as neural networks can be used to automate part of the pattern recognition analysis now done by the inspector.
- Centralized data collection would make the systems easier to use by inspectors and provide the possibility of real-time data review and performance monitoring. This could be extended to remote review in Vienna. The hardware to integrate the system parts exists today. However, collecting data remotely from the acquisition systems introduces the problems that the data must be verified as actual data from the system and that all data from that system are transmitted. Presently authentication between different parts of the systems is handled by seals or carrying data disks. New advances using the Local Operating Network technology may provide authentication along with options for network media such as radio-frequency and power line transmission that may significantly reduce installation effort.

6. CREDITS

We were not the only participants in these activities. Other parties involved were the IAEA, the Japanese PNC, Sandia National Laboratory, the CSSP and Ontario Hydro, and the Siemens Corporation.

7. REFERENCES

[1] J. K. Halbig, S. F. Klosterbuer, R. H. Augustson, G. E. Bosler, H. O. Menlove, and M. C. Miller, "Applications for Unattended, Remote NDA Instrumentation," in *Conference Record of the 1991 IEEE Nuclear Science Symposium*, Catalog #91CH3100-5, Vol. II, (1991) pp. 1246-1253.

[2] G. E. Bosler, S. F. Klosterbuer, C. S. Johnson, W. R. Hale, R. D. Marsh, and R. J. Dickinson, "Unattended System for Monitoring Skip Movement at the Sellafield Facility in the United Kingdom," *Nucl. Mater. Manage.* **XVIII** (Proc. Issue), 1058-1063 (1989).

[3] S. F. Klosterbuer, E. A. Kern, J. A. Painter, and S. Takahashi, "Unattended Mode Operation of Specialized NDA Systems," *Nucl. Mater. Manage,* **XVIII** (Proc. Issue), 262-266 (1989).

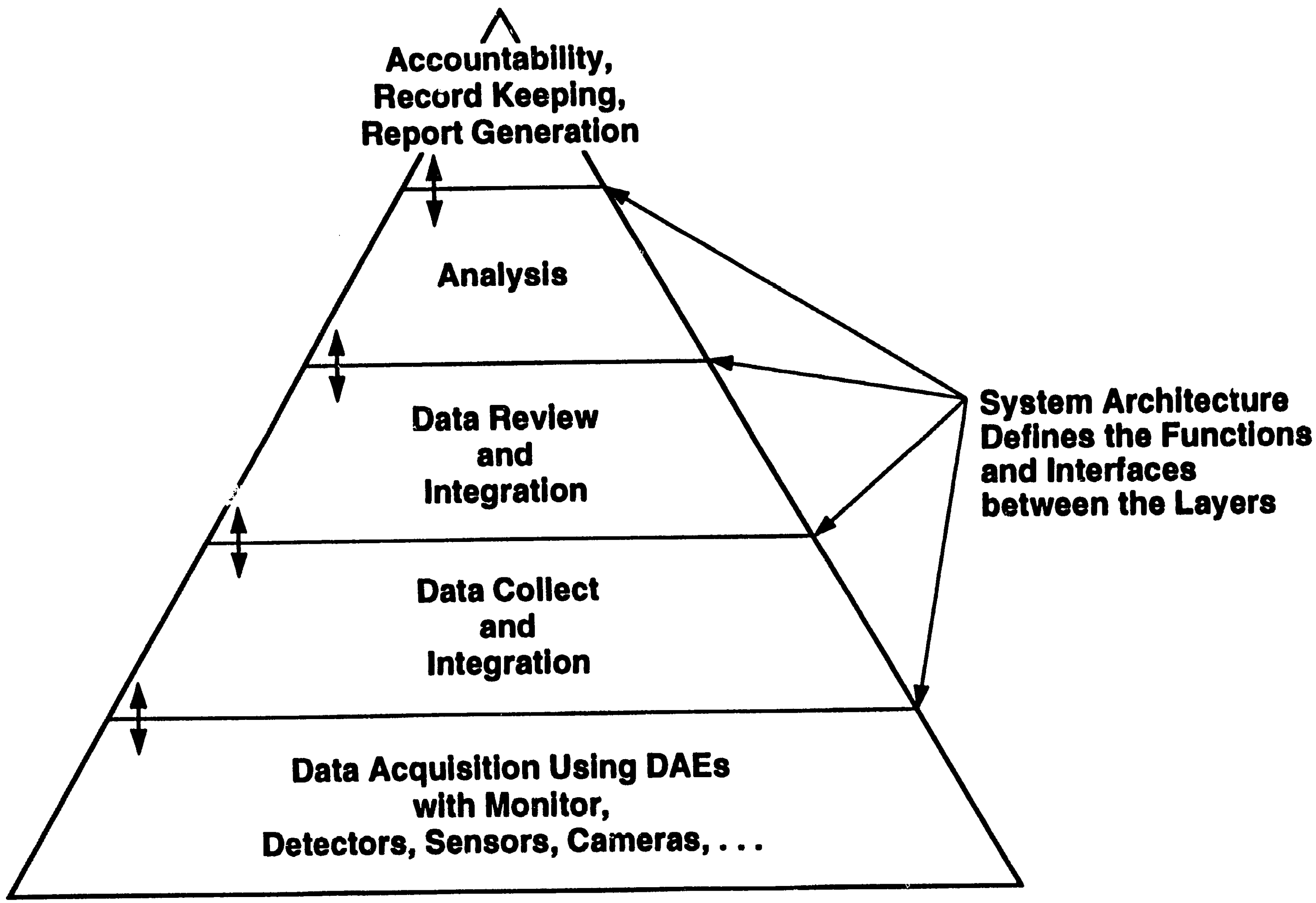
[4] H. O Menlove, R. H. Augustson, T. Ohtani, M. Seya, S. Takahasi, R. Abedin-Zadeh, B. Hassan, and S. Napoli, "Remote-Controlled NDA Systems for Feed and Storage at an Automated MOX Facility," *Nucl. Mater. Manage.* **XVIII** (Proc. Issue), 267-273 (1989).

[5] J. K Halbig, A. C. Monticone, L. Ksiezak, and V. Smiltnieks, "The Design and Installation of a Core Discharge Monitor for CANDU-Type Reactors," *Nucl. Mater. Manage.* **XIX** (Proc. Issue), 839-846 (1989).

[6] J. E. Stewart, R. R. Ferran, C. R. Hatcher, K. E. Kroncke, and L. L. Pollat, "Design of Neutron Coincidence Counting System for Light Water Reactor-MOX Fuel Pellet Trays," in Safeguards and Security Research and Development Progress Report, October 1992–September 1992," D. B. Smith and G. R. Jaramillo, Comps., Los Alamos National Laboratory report LA-12544-PR (August 1993) pp. 100-101.

FIGURE CAPTION

Fig. 1. Generic System.


Accountability,
Record Keeping,
Report Generation
Analysis
Data Review
and
Integration
Data Collect
and
Integration
Data Acquisition Using DAEs
with Monitor,
Detectors, Sensors, Cameras, . . .
System Architecture
Defines the Functions
and Interfaces
between the Layers

DATE FILMED

3/24/94

END