CONF-790701--22

Material Control Test and Evaluation System

at the ICPP

C. E. Johnson, Safeguards Development Program Manager

INEL/ACC - ICP, Idaho Falls, Idaho

Abstract

The U. S. DOE is evaluating process monitoring as part of a total nuclear material safeguards system. A monitoring system is being installed at the Idaho Chemical Processing Plant to test and evaluate material control and surveillance concepts in an operating nuclear fuel reprocessing plant. Process monitoring for nuclear material control complements conventional safeguards accountability and physical protection to assure adherence to approved safeguards procedures and verify containment of nuclear materials within the processing plant.

1. Introduction

The primary goal of the Safeguards Development Program at the Idaho Chemical Processing Plant (ICPP) is to design and install an integrated safeguards system in an operating nuclear facility. This system will test and evaluate safeguards concepts with potential benefits for national and international safeguards. The ICPP recovers uranium from a wide variety of highly-enriched uranium fuels and has been operating since 1952. The safeguards techniques evaluated at the ICPP are applicable to either uranium or plutonium reprocessing plants and have application to any nuclear facility with special nuclear material distributed in solutions.

The United States Department of Energy recognizes three essential elements for national safeguards: accountability, physical protection, and material control. Accountability precisely measures and records physical inventory of special nuclear material (SNM) in a facility. These material balance measurements require significant nonproduction intervals for the plant and are usually required after short processing campaigns or between processing intervals of several months. Physical protection limits access to special nuclear material by physical barriers, alarms, or guards. Material control techniques review data from several sources to maintain a constant and automated surveillance of SNM. Material control verifies the other two safeguards techniques and estimates material balance changes between precise accountability measurements.

International safeguards uses two techniques; accountability, and containment/surveillance. The current assay instrument technology cannot provide real-time accountability. Both National and International safeguards require accountability as a precise measurement of special nuclear material and also require techniques to assure nuclear material containment and estimate material balance between accountability intervals. The INEL Safeguards Development Program is also testing and evaluating material monitoring techniques for international safeguards containment and surveillance.

This development is Task I of the Tokai Advanced Safeguards Technology Exercise (TASTEX) at the Power Reactor and Nuclear Fuel Development Corporation (PNC) plant at Tokai-Mura, Japan.

The test and evaluation of material monitoring techniques at ICPP and PNC requires installation of process monitoring systems for gathering safeguards information. These systems monitor plant data to assure compliance with approved safeguards procedures and determine special nuclear material distribution in the process. This is achieved by observing plant instruments and process control devices and applying chemical analysis results to volumetric or weight measurement of the solutions for nuclear material estimates.

Safeguards development at INEL complements other DOE programs. INEL material monitoring techniques for precise volumetric and weight measurement of reprocessing plant solutions complements DOE nondestructive assay development. The combination of the two may eventually provide safeguards real-time accountability. These techniques also complement other nuclear material surveillance for verification of nuclear material containment.

2. Safeguards Monitoring Concepts

Safeguards techniques for test and evaluation at INEL focus on process solutions containing uranium or plutonium nuclear material and tracking their flow through a processing plant. Both national and international safeguards require operational test and evaluation of techniques and devices before implementation. These techniques maximize use of existing plant instruments to minimize equipment and installation costs.

A. Precision instrumentation measures tank solutions volumes and weights. The addition of analytical chemistry results or nondestructive assay instrumentation provides estimates of nuclear material content for updating the material balance estimate.

B. Process valve sensors provides plant operational data for procedural verification and indicators of material containment. For example, a sequence of open valves defines a pipe route between two parts of the process. Similarly, other valves indicate that possible transfer routes are blocked. The monitoring of the status of these valves provide the indications of containment. The sequence of manipulation of the valves, corresponds to an operational procedure and can be verified for adherence to approved procedures.

C. Transfer monitoring observes and measures nuclear material solution movement in a process. Examples include detection of turn-on or turn-off of a transfer pump or jet and verification of transfers by observing tank level or weight changes or temperature changes or flows in plant pipes.

D. Diversion path monitoring provides direct indication of unauthorized material transfers. Candidate devices include: detectors for liquid in normally empty lines, and low threshold flow detectors to detect movement of solution in lines that should be normally stationary. Other technologies that would be applicable include special nuclear material detectors to verify nuclear material concentrations within process flowsheet limits.

E. Verification and tamper indication capabilities of the monitoring system provide assurance that the monitoring is not being compromised. Specific capabilities that have been incorporated in the test and evaluation systems include:

1. Physical constraints include location of equipment in controlled access areas and switches to indicate equipment cabinet access. Monitoring system software is also controlled by computer access techniques or direct reloading of software by authorized personnel.

2. Process parameter analysis helps assure that process variables are not being modified for the purpose of diverting nuclear material. For example, process variable time signatures have unique parameters and interdependencies with other process variables. "Plant noise" normally accompanying plant process variable signatures, is often correlated to other process variables. The knowledge of these correlations can be used to verify that the signal originated from the original process.

3. The measurement or derivation of the same process variable with different instruments provides additional assurance that the process data has not been altered either intentionally or due to individual instrument calibration or maintenance requirements.

4. Process values can be verified by comparison with programmable sources or signals injected into the monitoring system. This includes independent calibration techniques. This allows verification of instrument performance and provides very sensitive instrumentation capable of measuring small process changes or holdup.

3. System Implementation

The safeguards concepts are tested by computer monitoring of process sensors and instruments. Data is collected during fuel reprocessing campaigns and analyzed for safeguards information content. The Safeguards Development Program at INEL has been developing safeguards material monitoring techniques for several years. These techniques included computer monitoring and analysis of interdependent process variables. The current program is a significant expansion of past work for a more detailed coverage of a nuclear fuel reprocessing facility. This past work established design criteria for the current system expansion.

A. Process analysis has identified the significant process parameters containing safeguards information. Approximately 800 process points have been selected for the expanded material control monitoring at ICPP. This large number of points provides multiple instrument applications for analysis of device reliability and comparative performance. It also provides testing of the monitoring techniques in several different process areas.

B. Equipment surveys and ICPP test experience identified devices for providing safeguards data to the computer.

1. Equipment selection criteria defined the sensor and instrument requirements for safeguards data collection in an operational nuclear fuel reprocessing plant. Commercially available devices

are used whenever possible. Environmental requirements vary depending on the plant area for installation.

a. Materials resistance to corrosive decontamination solutions and high radiation fields.

b. Pressure transducer protection for recovery from overpressurization when high pressure air is used for clearing process lines.

c. Device resistance to heat and moisture when steam is used for cleaning or clearing plugged process lines.

d. Constraints on physical size of instrumentation because of plant mounting locations.

e. Provisions for isolation of sensors and instruments during system failures.

f. Equipment requiring minimum operator training or orientation to assure minimum impact on plant operational personnel.

g. System self-checking and self-calibration to minimize maintenance demands on plant support personnel.

2. Twelve classes of process device initially provide data for safeguards concept testing:

a. Pressure switches for valve and jet monitoring.

b. Air flow monitors for detecting sparging and air lift operation.

c. Liquid-in-Line detector.

e. Jet temperature detector

f. Electrical current detector.

g. Precision differential pressure transducer.

h. Manual valve position indicator.

i. Pressure transducer.

j. Tank temperature detector.

k. Electrical instrument (4-20 milliamp).

l. Process liquid flow monitor.

C. Computer Requirements

1. Real-time data collection is necessary to access process information on a minute by minute basis to measure changing process parameters. Special interrogation of process variables require hundreds of data points per second to provide detailed time signatures.

2. Large volumes of data must be processed and recorded for data analysis.

   a. hundreds of monitoring points.

   b. at least 24-bit precision must be available for precision instrumentation.

   c. process variables must be scaled in engineering units and referenced to identifiable process points.

3. The system must be simple to operate. Development personnel familiar with the chemical process will analyze the data base to determine the available safeguards information. Software data analysis routines will be written by these program personnel in higher level languages.

4. Test and Evaluation

The Safeguards Development Program at INEL is a progressive test and evaluation program. The first major implementations test and evaluate safeguards monitoring concepts in operating nuclear facilities at INEL and PNC. PNC data is scheduled for early FY 1980 collection and analysis. The next ICPP processing campaign in late FY 1980 and FY 1981 will be evaluated in 1981. Concurrent with this test and evaluation, other safeguards information at the ICPP will be evaluated for inclusion in the test and evaluation system. This includes other physical protection and accountability systems and other classes of process monitoring devices. It is expected that this integrated safeguards testing at the ICPP will include prototype devices from other DOE programs.

Once the system has the availability of the integrated safeguards inputs, the Safeguards Development Program will assemble these inputs and develop further routines for efficient manipulation and display of this information for safeguards advisory support. This demonstration capability in 1982 will provide an example of how an integrated system can directly support safeguards personnel.

By 1983, the system will also have the capability for extrapolating the results from the ICPP studies to other nuclear facilities. Simulation capabilities can be added to the system so that data can be modified to be representative of other reprocessing plants or other types of nuclear facilities such as fuel fabrication plants.

5. Summary

The safeguards development program at the Idaho Chemical Processing Plant is actively developing safeguards concepts for test and evaluation. These concepts have evolved from U. S. DOE, NRC, State Department, and IAEA needs. It is the goal of the program at INEL to provide continuing technical support to these national and international safeguards functions. This program will test and evaluate capabilities in an operating nuclear fuel reprocessing facility. The experience gained in an operating nuclear facility is invaluable for the satisfaction of safeguards improvement requirements. We enthusiastically request continuing coordination and technology exchange with other national and international safeguards development activities.

REFERENCES

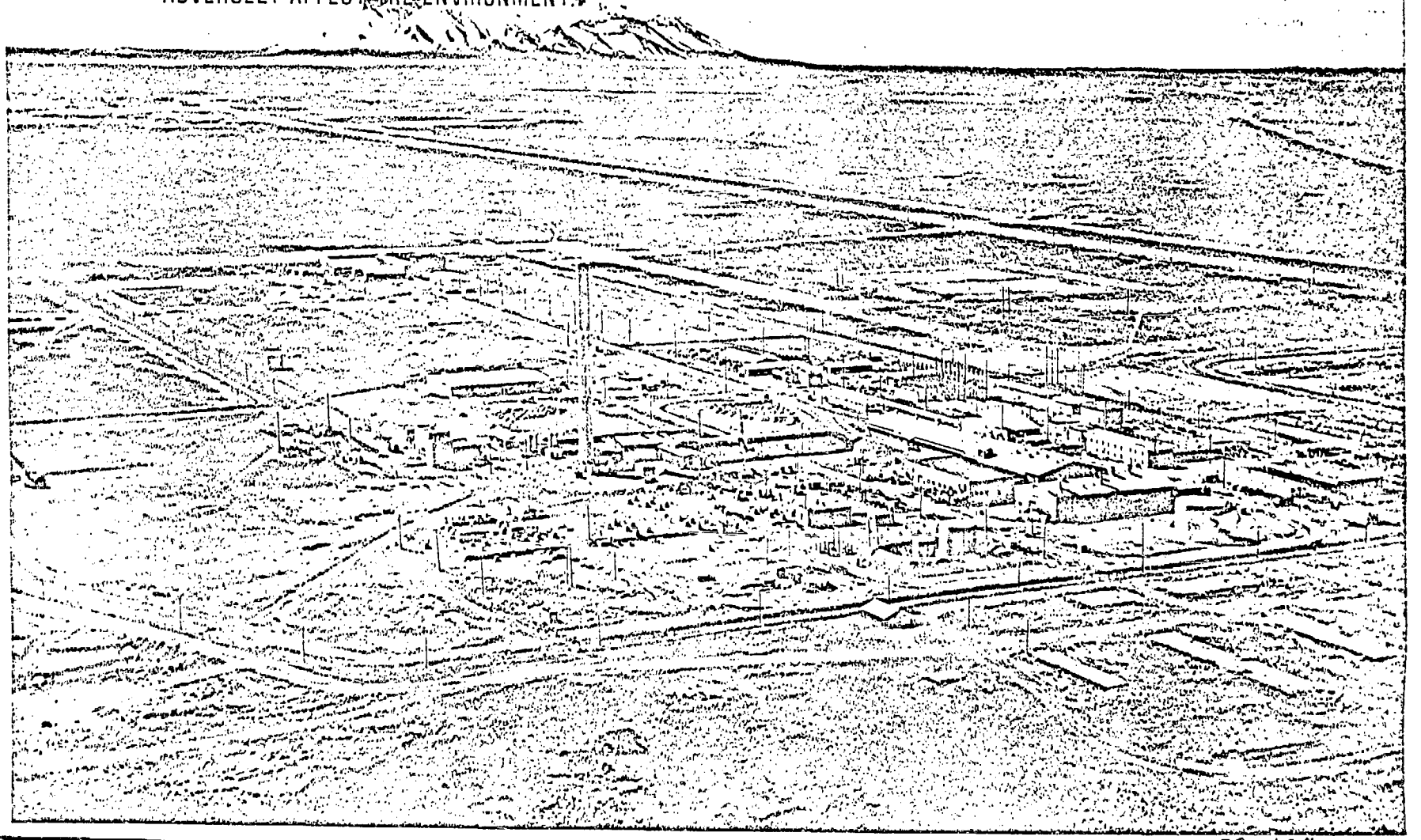
1. "Instrument Installation Design Criteria, Safeguards Test and Evaluation System", E. P. Wagner et al, ACI-381, dated June 1979.

2. "Program Plan, Advanced Safeguards Systems Development for Chemical Processing Plants", ACI-346, revised January, 1979.

3. "Tokai Advanced Safeguards Technology Exercise, Program Plan", International Safeguards Project Office, Brookhaven National Laboratory, revised January 15, 1979.

IDAHO CHEMICAL PROCESSING PLANT
IDAHO NATIONAL ENGINEERING LABORATORY

- THE PRIMARY MISSION OF THE IDAHO CHEMICAL PROCESSING PLANT IS TO RECOVER URANIUM FROM SPENT RESEARCH REACTOR AND SHIP PROPULSION FUELS FOR RE-USE IN REACTORS.
- ANOTHER KEY ACTIVITY IS TO MANAGE AND DISPOSE OF NUCLEAR WASTES IN A MANNER THAT WILL NOT ADVERSELY AFFECT THE ENVIRONMENT.



SAFEGUARDS

NATIONAL	INTERNATIONAL
Accountability	Accountability
Material Control	Containment/Survcillance
Physical Protection	

SAFEGUARDS MONITORING CONCEPTS

Precision Volume and Weight Measurement

Process Valve Monitoring

Transfer Monitoring

Diversion Path Surveillance

Verification and Tamper-Indicating

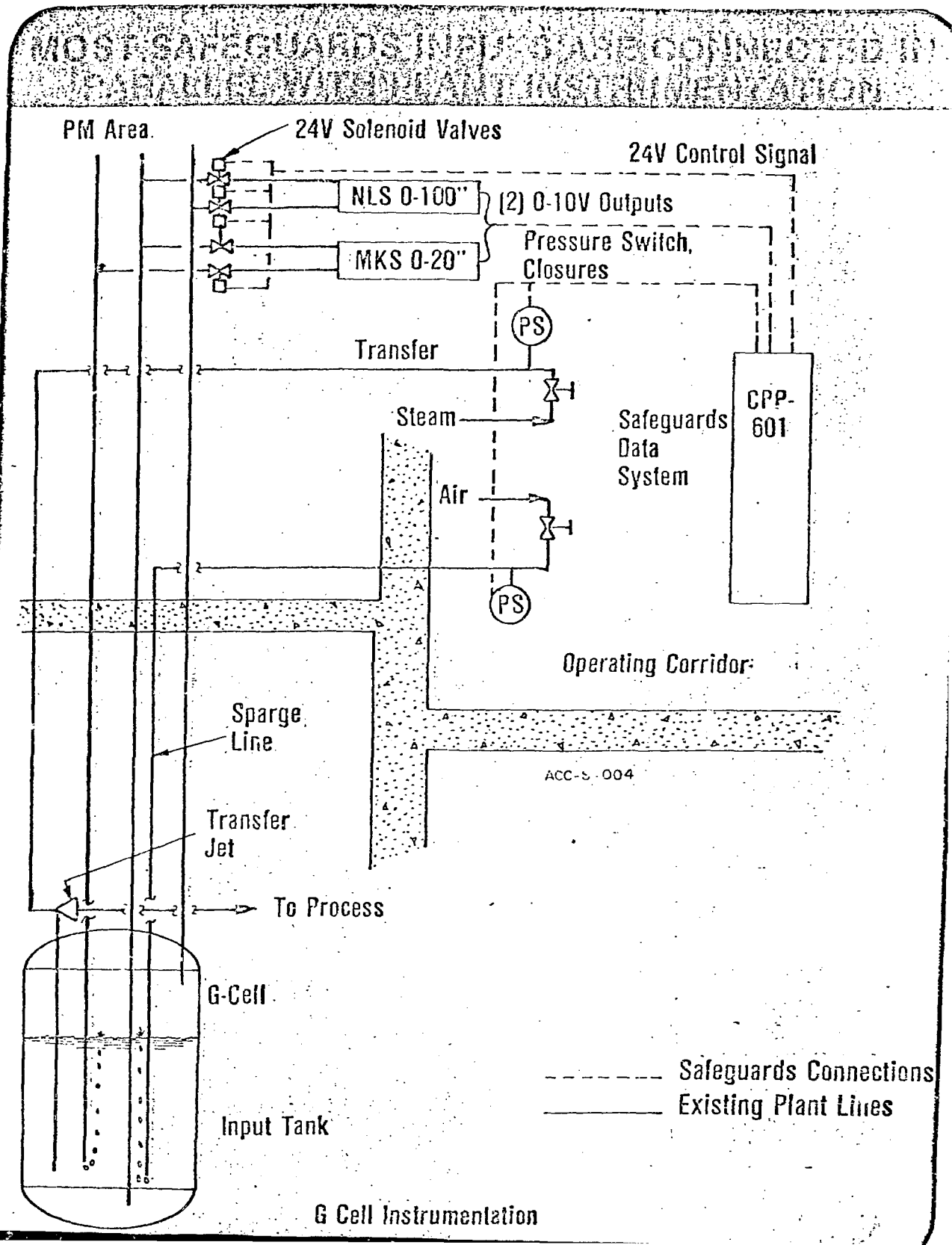
VERIFICATION AND TAMPER-INDICATING CONCEPTS

Physical Constraints

Process Parameter Analysis

Multiple Measurements

Programmable Sources and Self-Calibration


MOST SAFEGUARDS INPUTS ARE DOMINATED BY
PM Area
24V Solenoid Valves
24V Control Signal
NLS 0-100"
(2) 0-10V Outputs
MKS 0-20"
Pressure Switch,
Closures
PS
Transfer
Steam
Air
PS
CPP-
601
Safeguards
Data
System
Operating Corridor
Sparge
Line
ACC-S-004
Transfer
Jet
To Process
G-Cell
Input Tank
Safeguards Connections
Existing Plant Lines
G Cell Instrumentation

SYSTEM IMPLEMENTATION

Process Analysis

Monitoring Points: ICPP - 800
PNC - 200

Equipment Selection

Environmental

Resist Corrosion and Radiation
High Pressure Air and Steam
Limited Space
Reliability and Failure Isolation
Minimum Training
Self - Calibrating

Functions

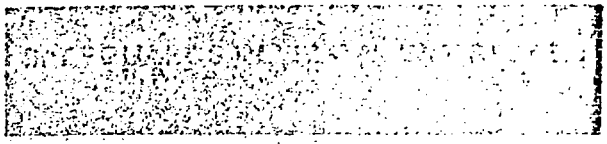
Pressure Switches and Transducers
Flow
Instrument and Plant Signal
Liquid-in-line
Temperature
Valve Position

Computer Requirements

Real-time

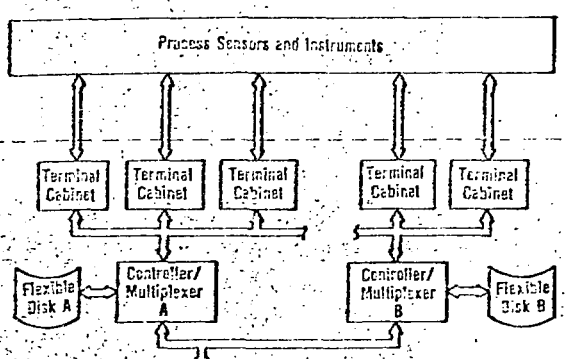
Large Data Base

Simple to Operate



Plant Safeguards Sensors

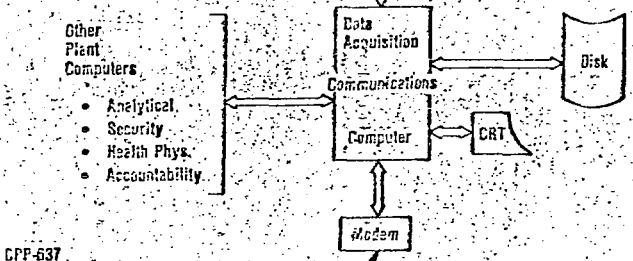
Plant Process Areas



Collection of Sensor Data, Interface to Computer

CPP-601
PM Area

High Speed Link



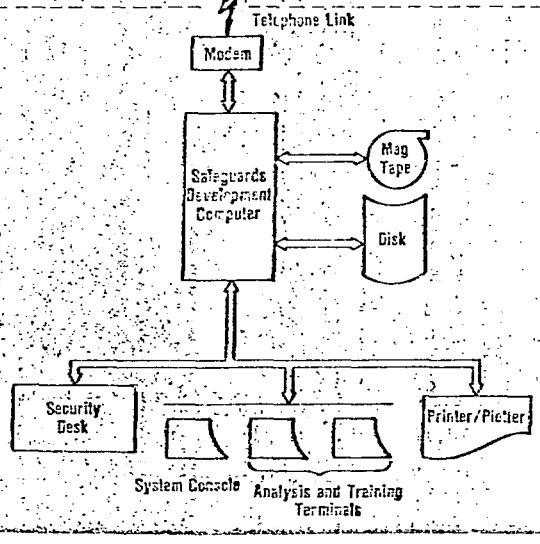
Conversion to Engineering Units
Preliminary Processing
Temporary Storage of Data
Communication Handling with other Plant Systems

Data Concentration for Transfer to CF-633

CPP-637

CF-633

Telephone Link



Storage of Safeguards Data

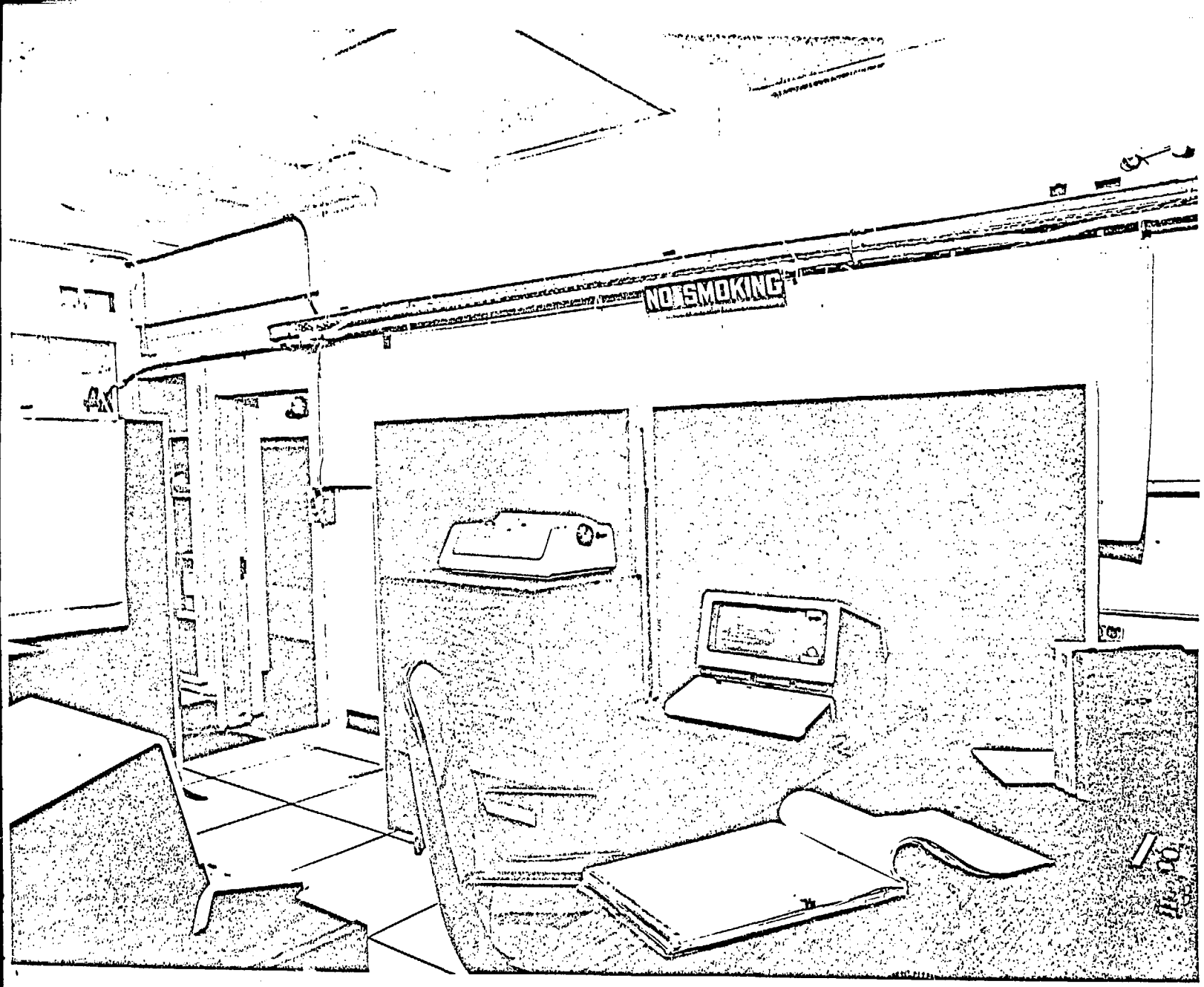
Development of Diversion Detection Systems

Operation of Experimental Security Desk

Material Flow Analysis and Modeling

Training and Procedures Development for Security Officer

Evaluation of Experimental Sensors, Sytem Components



79-632

EACH UPGRADE ADDS ADDITIONAL CAPABILITIES

Safeguards Coverage	1977 Demo	1978 Interim System	1979-1980 Plant T&E System	1981 ISI System	1981 Demonstration and Training	1982 Simulation
Tank precision measurement	X	X	X	X	X	
Instrument lines monitoring		X	X	X	X	
Sampler monitoring	X	X	X	X	X	
Transfer operations and volumetric validation	X	X	X	X	X	
Diversion path monitoring			X	X	X	
Analytical laboratory results				X	X	
Personnel occupancy				X	X	
Radiation alarms and monitors				X	X	
Safeguards inspector operation and training					X	
Extension of analyses to other nuclear facilities						X
Safeguards decision modeling						X