AECL's Plant Information Technologies

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ABSTRACT

The competitiveness of the world-wide energy market is a continual driving force for improvements to CANDU performance and lower operating, maintenance, and administration costs. As in other industries, advanced Information Technologies (IT) are changing the way we work and conduct business. The nuclear industry is no different and there exists strong incentives to improve work processes and provide faster and more flexible access to the information needed to effectively manage and maintain nuclear plant assets. AECL has responded to these forces through the development of a vision of integrated IT systems addressing all phases of nuclear plant development and operations. This includes the initial engineering, design, and construction processes as well as support to the long-term operations and maintenance. Integral to the AECL vision is the need for cost-effective engineering and operational configuration management systems, proactive maintenance processes and systems, and advanced plant surveillance and diagnostics. This paper presents the vision and describes the integrated information systems needed to manage both the design basis and operating plant data systems to ensure the cost-effective, long-term viability of CANDU plants.

1. INTRODUCTION

There is no doubt that the advent of increasingly powerful Information Technologies (IT) are changing the way we live and work. In every industrial and market sector, the use of new IT tools permits the evolution of work processes and practices that continuously strive for higher levels of efficiency, cost-effectiveness, reliability and safety. As the CANDU nuclear industry matures, it has been recognized that greater emphasis must be placed on the plant operations and maintenance processes, as well as the IT systems and infrastructure supporting their implementation. This is especially true in the areas of life-of-plant maintenance, and the management of both the engineering design basis and plant's operational configuration.

This is a challenge that is being addressed within AECL through the development of an IT vision, a suite of IT systems, and a plant infrastructure supporting a wide range of operational and maintenance processes. The individual components of this vision have evolved from the investigation of new plant processes coupled with the analysis of the information needs of operations, maintenance, and technical support staff [1, 2, 3, 4, 5, 6]. The principal components of this vision include:

- Engineering tools and information systems capturing the engineering design basis, facilitating changes to the physical plant, and enabling long-term engineering configuration management,

- Control centre information systems supporting the fundamental control room operations and providing data to a plant-wide information systems,
- A suite of plant-wide information systems specifically designed to enhance the long-term retention of plant operational data and facilitating the management of the plant's operational configuration, life-of-plant maintenance, and ongoing technical support processes, and
- Plant business information systems supporting all of the remaining aspects of asset management.

The integration of new information technologies as described herein will provide the tools necessary to support the cost-effective, life-of-plant management of the CANDU reactor product. Strategically oriented information technologies will also increase plant reliability and availability while lowering plant operating, maintenance, and administration (OM&A) costs. This has a net effect of both increasing revenue and lowering total unit energy costs which are both positive to the plant's economic success.

2. WORK PROCESS RELATIONSHIPS TO INFORMATION SYSTEMS

The development of information systems is a step-wise process that is based on the needs of the plant work processes to be supported. The hierarchy of processes, information systems, and the underlying IT infrastructure is shown in Figure 1.

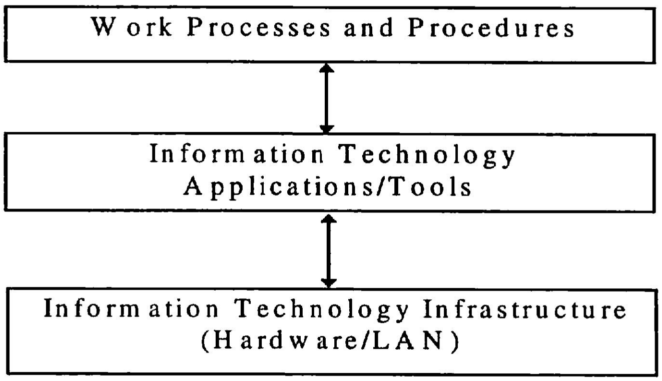

Figure 1: Hierarchy of Plant Information Systems

The starting point for plant information technologies is the development and optimization of the work processes and procedures. These processes and procedures are the real-value business activities that are necessary to design, construct, operate, and maintain the plant in a optimal and cost-effective manner. The IT applications and tools facilitate the implementation of the work processes and procedures. New database and communication technologies can influence the detailed development of the processes and procedures because they provide capabilities not previously available. However, the intent is not to push new technologies simply to appear state-of-the-art. The work processes are designed to optimize the efficiency of the operational and maintenance strategies. The IT systems and infrastructure supports the plant processes and procedures rather than define them. Integrated information systems embed the work flows and procedures and bring data to plant staff as required to support the information exchange, data analysis, decisions, and work activities. Similarly, the underlying plant IT infrastructure is designed and implemented to best meet the needs of the IT applications and end-users.

3. OPERATIONAL CONTEXT OF PLANT INFORMATION SYSTEMS

The nuclear plant staff are responsible for execution of plant work processes and procedures supporting all work activities. Each work activity has unique information needs. However, virtually all plant data can be viewed as being part of the engineering/design basis or as part of the plant's operational history. The context of this information flow and the relationships to the principal plant staff organization is shown in Figure 2.

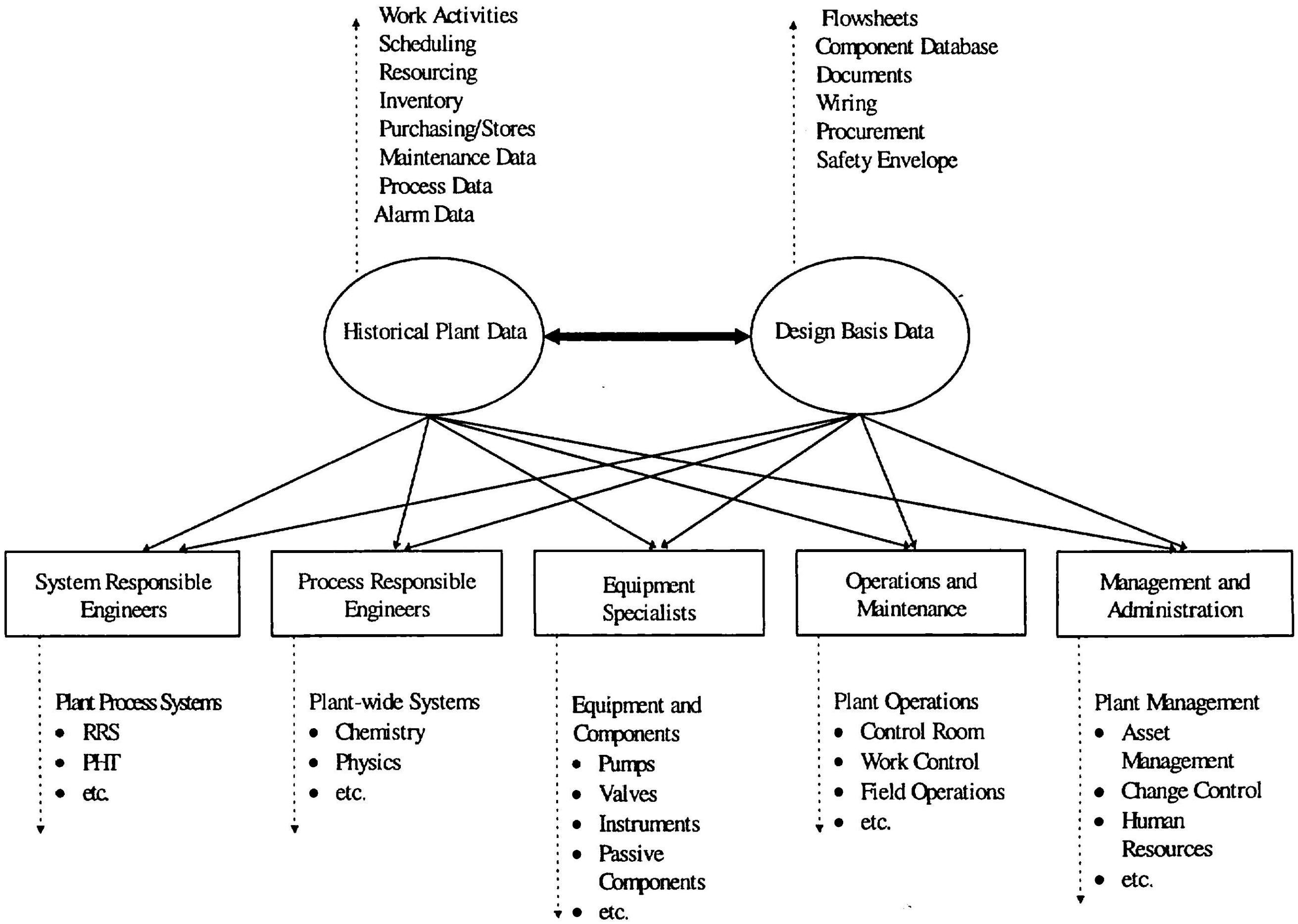

Figure 2: Operational Context of Plant Information Systems

Design basis data includes all engineering and design data that defines the plant. This data includes design data (requirements, descriptions, specifications, manuals, etc.), models, drawings, analysis, wiring lists, component/material lists, procurement data, and other technical data. It also includes all of the design and safety analysis data that defines the safety envelope of the plant. Managing this information as the plant is constructed, commissioned, operated, and maintained is critical to ensure continued safety and performance. Ensuring that the design basis data is consistent between the designed plant, the analyzed plant, and the physical plant is the central premise of plant 'configuration management'

Historical plant data consists of all information that is gathered through the operating history of the plant. This embodies both near real-time data and long term historical information. Not only does this include physical plant data (temperatures, flows, flux, component states, etc.) as a function of time, but also data associated with work management and the activities necessary to support ongoing operations and maintenance. This results in an array of traditional Business Information Systems coupled with specialized nuclear applications that are necessary to monitor the state of the plant and analyze possible future component failures that could have safety or economic impacts.

The design basis and historical plant data are used by a number of principal work groups. The system and process responsible engineers (SRE's and PRE's) are technical support staff having responsibilities for specific CANDU systems or physical processes that transcend the individual system boundaries. Their goal is to maintain or enhance the performance of the physical systems without compromise to safety. Equipment specialists are key holders of specific domain knowledge on components such as pumps and valves, rotating machinery, piping, sensors and instrumentation, and power distribution. Their knowledge is shared across systems and are key station resources. Operations and maintenance staff perform the bulk of the daily activities associated with the physical plant. This includes both control room and field operations as well as in-situ and off-line maintenance. Lastly, there is management and administration personnel requiring both historical and design basis data as required to manage the plant physical assets, processes and procedures, and staff.

4. OVERVIEW OF AECL'S INFORMATION SYSTEMS

Historically, AECL has supplied design basis information in the form of paper-based drawings and engineering/design documents. Computer-based systems were limited to the primary plant control and safety shutdown systems. However, the need to provide extended plant life management, configuration management, and lower OM&A costs, all while ensuring higher plant reliability and revenues, has become the driving force behind AECL's new information technologies. The systems resulting from analysis of viable configuration management processes, maintenance strategies, work processes, and advances in engineering design are shown in Figure 3.

The Design Basis Data systems within Figure 3 are shown as ellipses filled in 'black'. These systems are the core engineering tools used to design, analyze and construct the physical plant. Once the plant evolves beyond construction and into commissioning the engineering tools form the nucleus of a Plant CADD system which is used throughout the life of the plant to maintain the design basis. As such, the plant CADD system is unique in that it bridges both the design and operation phases of the plant and has a role in each of the design basis and historical plant data domains. Therefore, the plant CADD system is shown as a 'grey' ellipse.

The Historical Plant Data systems within Figure 3 are shown as 'white' ellipses with the exception of the plant CADD system discussed above. The traditional plant control, display, and safety (reactor protection) systems transmit process information in the form of process data (temperatures, pressures, flows, etc.) and alarm data to a plant process/alarm Historical Data System (HDS). The plant display systems also include Critical Safety Parameter Monitoring (CSPM), the CANDU Annunciation Message List System (CAMLS) for advanced alarm processing and analysis, and the capability for advanced signal processing (e.g. transmitter anomaly monitoring). The process/alarm HDS becomes the long term repository for process-related data and acts as a provider of process data to other information systems. The term 'historic' is considered a relative term since the process/alarm HDS maintains information only seconds old, and as such can be considered a combination of near real-time and truly historical data. Computerized procedures are also used to collect data from field devices and instruments where no automated data collection is available. This may account for the bulk of process data collected and stored in the HDS necessary to support surveillance, diagnostics, and maintenance activities. The computerized procedures also support the execution of other forms of plant operations and maintenance procedures such as scheduled call-ups, orders-to-operate, and field maintenance procedures. Reliability Centre Maintenance (RCM) systems support the Failure Mode Effects and Criticality Analysis (FMECA) used for RCM maintenance planning and the Condition Based Monitoring (CBM) system supports on-line component monitoring. CBM is the central component providing on-line monitoring of component condition indicators which forewarn against pending component failures. The CBM system maintains a database and hierarchy of components, condition indicators, failure limits, and links to the RCM-FMECA analysis. Surveillance and diagnostic tools include a variety of generic tool-kit components and System Health Monitors for Physics (flux mapping, maximum channel and bundle power monitoring), Chemistry (chemistry control, corrosion control, steam generator performance monitoring, etc.), and others. The SRE and PRE tool-kit enables custom monitoring to suit the needs of the individual user through a collection of integrated tools for monitoring, display, trending, reporting, and mathematical analysis. The plant historical information also includes the Equipment Status Monitoring (ESM) system. The ESM system provides an integrated application that links animated operational flowsheets with equipment status, jumper status, and work protection and is used to maintain the plant's operational configuration. This ensures that the status of all operable devices in a CANDU plant (over 40,000 in a single unit station) is known and that changes to operational configuration are appropriately managed. The plant historical information system is completed with the addition of more traditional Business Information Systems (BIS), which are also often referred to a Management Information Systems (MIS). The BIS provides finance, human resources, work management, planning, project management, and other services as required.

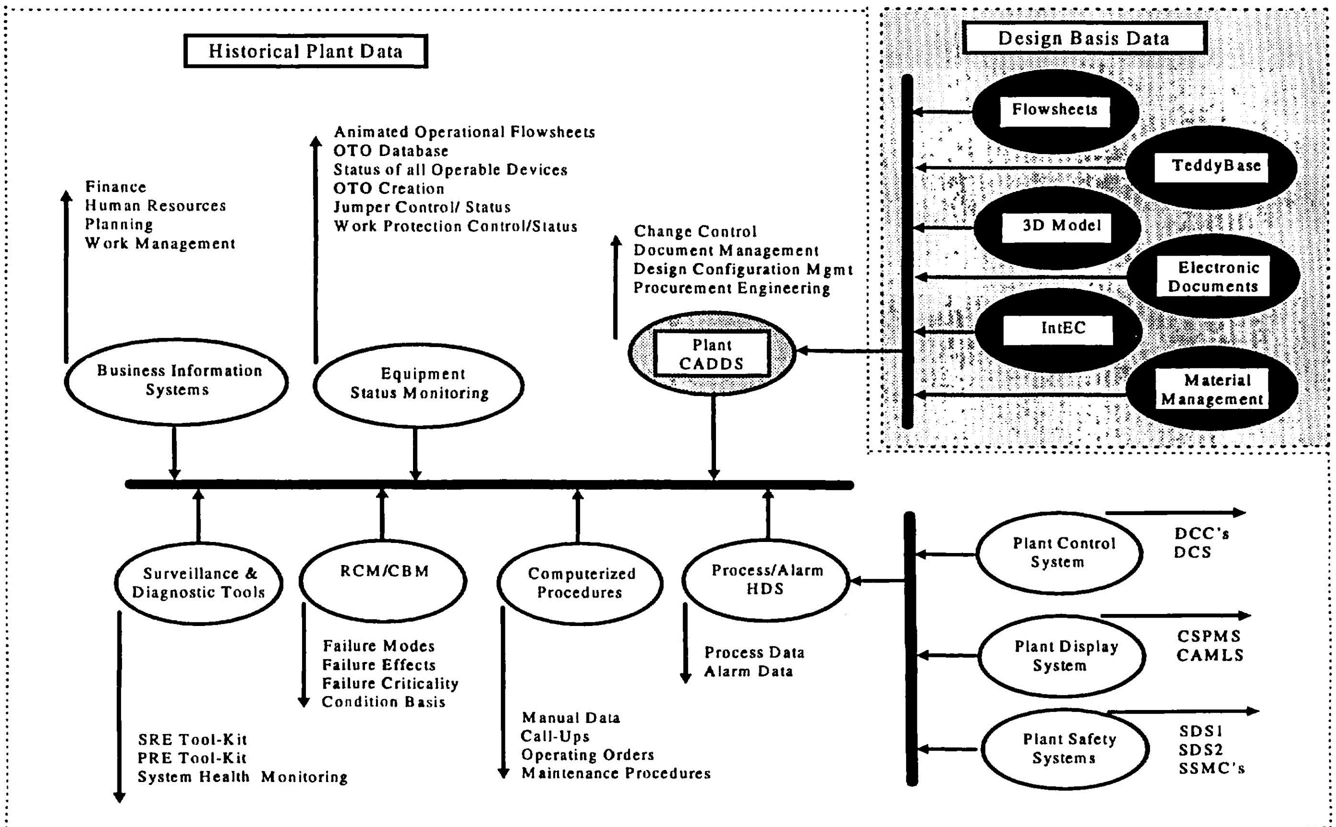

Figure 3: Plant Information System Flow Diagram

The individual systems comprising both the design basis data and the historical plant data are discussed in more detail in the following sections.

5. DESIGN BASIS INFORMATION SYSTEMS

The design basis information systems support two key phases of nuclear plant life. The initial phase of engineering design and construction is subsequently followed by a long-term operational plant phase. During each phase, configuration management of the design basis is needed to ensure consistency between the designed plant, analyzed plant, and as-built physical plant.

At the heart of the design basis data lies the computer-aided design and development (CADD) system [5]. The AECL system is based on the use of Intergraph Inc. CADD systems. Although the CADD system is capable of design and drawing in a 2-D environment, the latest advances in AECL engineering processes result in a complete 3-D model of the plant using Intergraph's Plant Design Software. Coupled to the detailed 3-D plant model are 'intelligent' object-oriented design flowsheets built using the P&ID software. The design flowsheets and 3-D design of the plant are supported through the implementation of an equipment and component database which is dynamically linked to both the flowsheets and model. This database, which has been customized to meet the needs of the nuclear engineering and design environment, is TeddyBase (Tagged Equipment Dynamic Database). The integrated plant design, P&ID, and Teddybase software environment ensures design data integrity that results in a final design with no conflicts and interferences.

Examples of custom AECL developed components of the integrated design basis engineering environment are systems supporting advanced wiring design, and pipe hanger design and analysis. Integrated Electrical and Control (IntEC) software has been developed by AECL to support all aspects of wiring design, connection, cable and conduit routing. Another example is the Piping Support Design System (PSDS) developed to support integrated piping and pipe hanger design and analysis. The IntEC and PSDS software is integrated with the other CADDs components to improve design efficiency and design integrity.

Other engineering design basis tools include electronic document and drawing management, control, and delivery using Intergraph's AIM software product and material management using the CANDU Material Management System (CMMS). AIM is used to maintain all design documents and drawings such as design plans, quality documentation, design requirements, design manuals, specifications, and all other design document types. CMMS is used to manage the procurement process. The flow of information and integration between flowsheets, 3-D model, TeddyBase, IntEC, PSDS, AIM, and the CMMS system ensures that all components and parts are traceable throughout the design, specification, and procurement processes.

A key aspect of the integrated design tools is the fact that data rather than documents becomes the central focus. The 3-D model, drawings, and other documents are rendered from the design data. The tools work with data structures so that physical changes (e.g. wiring changes) are controlled at an elementary level. The safety rules and design codes are built into the tools to ensure compliance with CANDU design philosophies and regulatory requirements. In addition, due to the integration between tools, the design and subsequent design changes are guaranteed to be consistent with the design requirements, safety analysis, design and equipment specifications. Change control and the propagation of the design changes through the design cycle becomes automated and manageable.

The suite of design basis systems improves the design processes and reduces the design, procurement, and construction schedules. As a result, there is a significant reduction in the costs associated with the design and construction over the manual paper-based design processes of the past.

6. PLANT HISTORICAL DATA INFORMATION SYSTEMS

6.1 Plant CADD System

Once the plant is constructed and commissioning is completed, the life of the design basis systems is not ending but beginning. The same design basis tools are applicable throughout the operating phase of the plant and are just as important to ensure continued configuration management as the plant ages and evolves. The entire suite of design basis data systems becomes the new Plant CADD system. This includes the intelligent flowsheets and 3-D model, IntEC for wiring, PSDS for pipe hangers, AIM for document management, and CMMS for material management. These systems become the basis of the plant CADDs environment and the cornerstone to plant configuration management throughout the life-of-plant.

6.2 Plant Control, Display, and Safety Systems

The plant control centre systems are an evolution of the original AECL digital control computers (DCCs) and reactor protection systems. Added to the original DCCs and safety system computers is a new Plant Display System (PDS). The PDS is based on the Advanced Control Centre Information System (ACCIS) software that was developed in support of AECL's CANDU 9 program and which is currently being implemented as part of the Qinshan project.

ACCIS is a generic plant display system that is configured to meet the functional and reliability needs of CANDU implementations. It is based on commercial off-the-shelf software and hardware that embrace the most recent advances in computer and software engineering technology. ACCIS provides four key services; 1) information, 2) display, 3) system, and 4) gateway. The system and gateway services provide access to operating system-level functions, and plant process equipment and external systems respectively. The information service includes an object-orientated database that is used to support system-wide communication of configuration, real-time process and alarm data, an advanced alarm processing sub-system based on CAMLS technology, a short-term historical data storage capability, and a suite of configuration tools. The display service supports a graphical user interface and functions that allow operators to manage all aspects of plant operation. A key feature of this service is the tight integration of display with control and CAMLS advanced annunciation. This makes a new style of operator interface that meets or exceeds the latest human factors standards possible.

The CANDU 9 PDS design not only includes real-time displays and advanced alarm processing, but also is the main operator interface to the plant control computers. At the heart of the PDS is an implementation of ACCIS that makes effective use of redundancy to meet the reliability and fault-tolerance requirements. The implementation also includes:

- fault and status displays driven by the CAMLS alarm processing capability included in ACCIS,

- an Alarm Interrogation Workstation (AIW), which is an advanced feature of CAMLS that supports root cause fault and failure analysis by allowing forward/backward browsing and playback of alarm information, as well as sorting and querying of alarm data associated with specific plant systems, and
- gateway computer systems which link to the plant control computers and other potential data sources.

An example PDS display is shown in Figure 4.

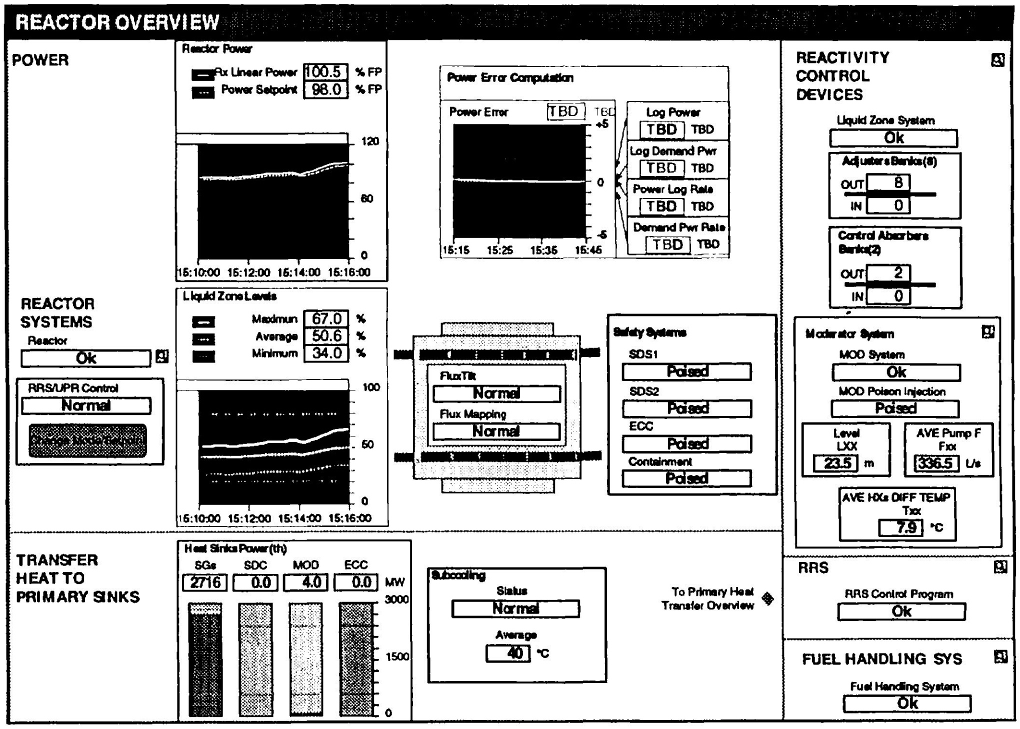

Figure 4: Example PDS display: Reactor Overview Display

6.3 Process and Alarm Historical Data Systems

The cornerstone of the historical plant process data storage and retrieval is a life-of-plant historian for process and alarm data [6, 7]. This is called the Process/Alarm Historical Data System (HDS). This data is gathered through a combination of automated process control and data acquisition systems and through manually executed station procedures. The interface between the Process/Alarm HDS and the plant control and PDS is called the Plant Support System Interface. Traditional gateway interfaces would be used when retrofitting the HDS to the traditional DCCs. These interfaces also function as a firewall between the HDS and the plant process control systems. Data from local field instrumentation can be gathered through the use of computerized procedures and efficiently uploading directly into the HDS.

The requirements for life-of-plant process and alarm HDS, the evaluation of suitable off-the-shelf technologies, and the qualification of an off-the-shelf process HDS to OASES (Ontario Hydro - AECL Software Engineering Standards) software standards has been the focus of an ongoing AECL program. The process HDS system is based around the use of the OSI Software Inc. PI-3 data historian. The process HDS for each CANDU plant unit is designed to maintain up to 40,000 parameters and all plant alarms for the entire life-of-plant. This data is used to support a wide range of programs including RCM, CBM, ESM, and other surveillance and diagnostic activities. Integrated user interface tools allow for easy on-line data retrieval, analysis, and reporting in a client-server and web-enabled environment. HDS data can also be directly accessed through standard Microsoft Office tools such as Microsoft Excel. The alarm HDS has been developed by AECL as part of a CANDU Owner's Group (COG) program. The alarm HDS is an Oracle database application that uses the DCC raw alarm pages as input. The alarm HDS parses the alarm pages into individual alarms and their attributes, computes statistics (daily, weekly, yearly, and life-of-plant occurrences) for each alarm, and stores this information in the database. An alarm HDS add-in to Microsoft Excel allows the SRE and other technical staff to use predefined queries to retrieve and sort alarm information, including the statistics. Full integration of the alarm and process HDS allows both alarm and process data to be viewed simultaneously and correlated by the end user. Example Excel-based interfaces for both process and alarm data are shown in Figure 5.

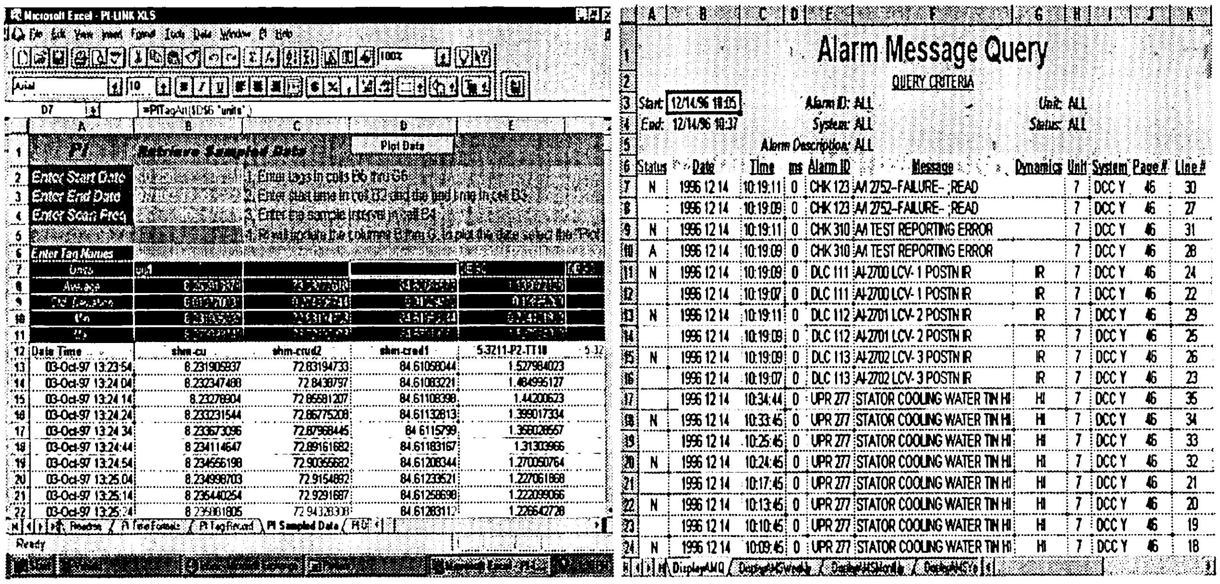

Figure 5: HDS Data Interface using Standard Microsoft Excel

6.4 RCM and CBM Information Systems

The processes used in CANDU maintenance are continuously evolving to predictive-based maintenance programs and reducing the percentage of reactive maintenance. The basis of this evolution is the use of Reliability Centre Maintenance (RCM) philosophies. RCM is a process where the failure-modes and their effects are used to plan and execute the appropriate maintenance activities [8]. RCM strategies were first developed and implemented in the aircraft industry in the 1960's. RCM analysis is an engineered approach to determine the criticality of components within complex systems. The resulting strategy involves planning and prioritizing system and component maintenance activities based on their failure impact to the plant performance and safety. On-line Condition Based Monitoring (CBM) is an RCM maintenance activity that is used to determine the ongoing status of critical components where failures have a high impact to safety, performance, and economics. More traditional maintenance activities (standard preventative and even run-to-failure reactive maintenance) can be applied to noncritical components. Off-the-shelf RCM and CBM products (e.g. RCM Analyst and Mainstay (CBM) from GasTops Inc.) can be integrated with plant process HDS and BIS components. AECL has also developed interfaces between the computerized procedure system, HDS, and CBM products to ensure that all of the automated and manually collected plant process data is available in support of on-line condition based maintenance strategies.

6.5 Surveillance and Diagnostic Tools

Surveillance and diagnostic tools have also been the focus of both COG and AECL research and product development projects [6, 7]. A SRE and PRE tool-kit for the retrieval and analysis of HDS data includes the use of the process and alarm HDS user tools, third-party off-the-shelf software, and Microsoft Office products. The SRE/PRE tool-kit is the equivalent of a technically-based office suite in support of the SRE/PRE activities. Using the elements of the SRE/PRE tool-kit, specialized applications can be developed in support of long term plant life management and performance monitoring. Integration of the user tools allows the same 'cutting' and 'pasting' of information and direct object embedding between applications that end-users are familiar with in their current office tools. The core surveillance and diagnostic user tool-kit depends on the choice of process HDS technology. The current AECL suite is based on the use of the PI-3 HDS (OSI Software Inc.) and includes PI-Processbook (graphics), PI-Datalink (Microsoft Excel add-in), DaDISP and MatLab (scientific analysis tools), and standard Microsoft Office components. Other tools can be added, as appropriate, to meet client needs. An example of the retrieval of HDS data for the evaluation of instrument loop calibration is seen in Figure 6. Information from redundant sensors is retrieved and used to compute and compare variances to the acceptable limits to assess the potential of an individual instrument loop being off-calibration.

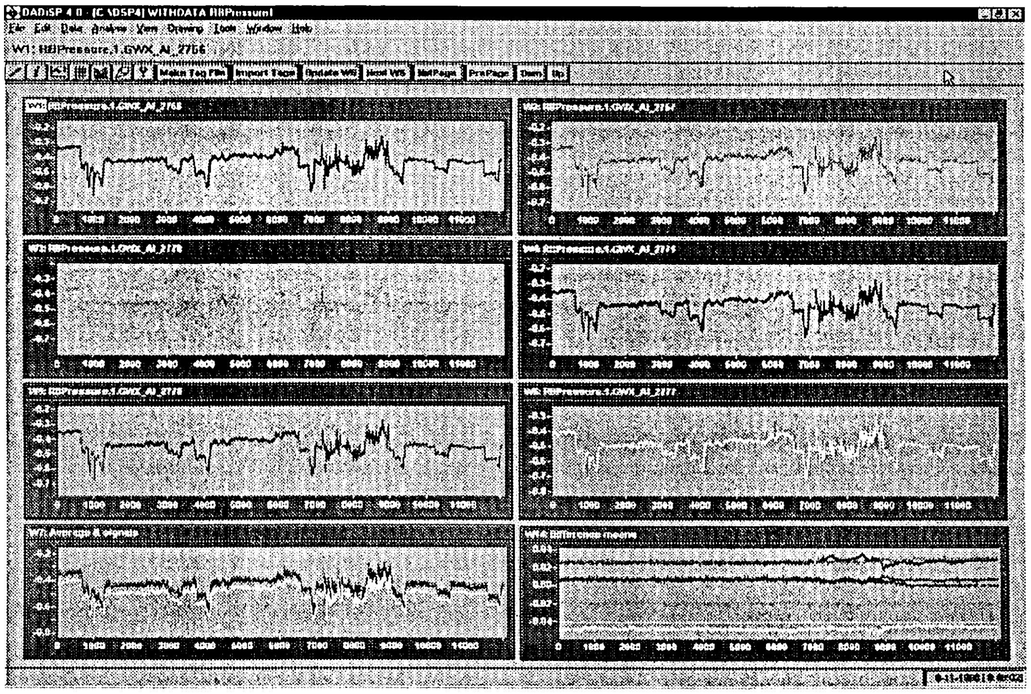

Figure 6: Transmitter Anomaly Monitoring using DaDiSP and HDS Process Data

The basic tool-kit can be enhanced through the addition of continuous on-line monitoring of the HDS process data through the use of third-party off-the-shelf products like FIX-32 (Intellution Inc.). This is the basis of AECL's System Health Monitor (SHM). The SHM application currently uses the FIX-32 real-time monitoring and control capabilities to provide an underlying environment that supports continuous monitoring, alarming specific to surveillance needs, and the embedding of advanced predictive and diagnostic software. The user interface to the SHM is the PI-3 ProcessBook interface, which is the same standard interface used by SREs/PREs to access the PI-3 HDS process data. In the future, this interface will continue to evolve to maximize the use of Internet web-enabled technologies. A key benefit of the SHM is the ability to embed specialized predictive tools built over time by the nuclear industry to assess the performance and behaviour of critical plant systems and components. Once linked to the SHM environment, the predictive codes and tools can be run on-line using HDS process data. In addition, other third party software is available that is already integrated and tested with the SHM components (PI-3, PI-3 ProcessBook, and FIX-32). This includes advanced artificial neural network tools and expert systems for both prediction and diagnostics. COMPAS is a SHM application that enables the on-line assessment of plant chemistry, corrosion, and steam generators. The SHM/COMPAS user interface includes standard monitoring displays, control of the predictive thermal-hydraulic and chemistry codes and the associated displays of analysis results, and the implementation of what-if scenarios. Future versions of COMPAS will include the use of Artificial Neural Networks for component fault prediction and virtual sensors. A new physics SHM product is also under development. The SHM-Physics environment will link CANDU physics codes to on-line HDS data to calculate and monitor maximum channel powers, maximum bundle powers, and 3-D flux maps. A COMPAS display of Steam Generator data generated from the Sludge prediction code is shown in Figure 7.

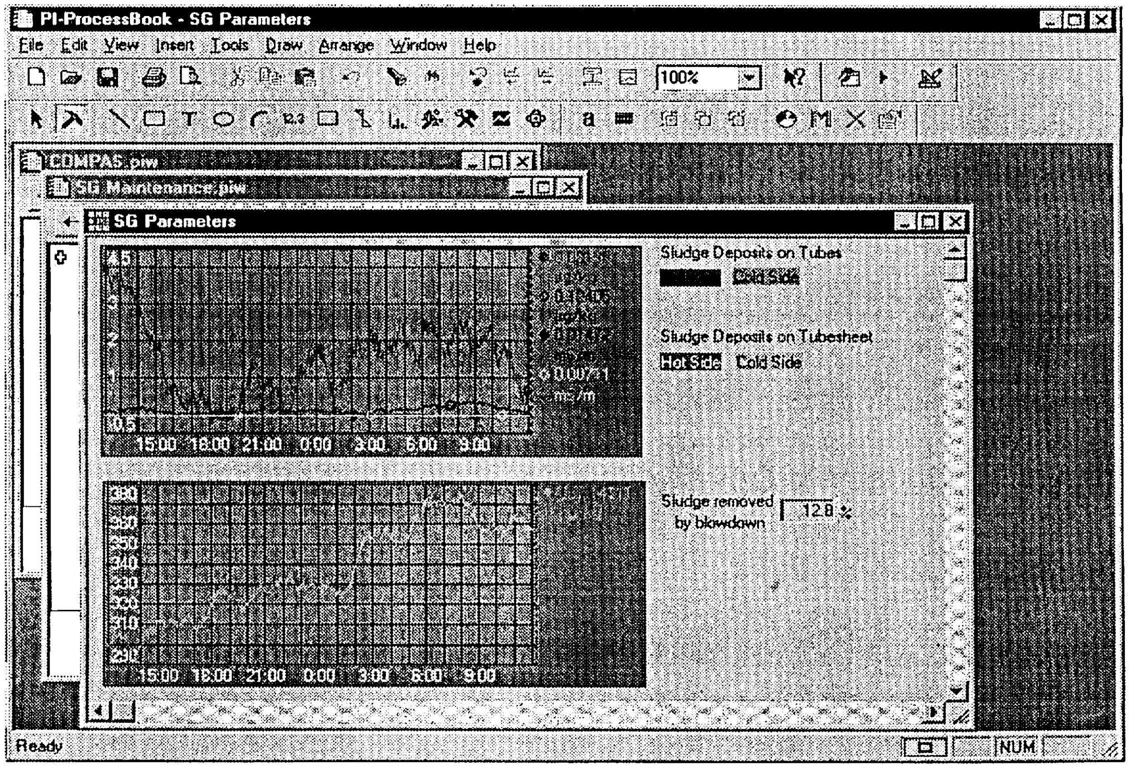

Figure 7: SHM-COMPAS Display of Steam Generator Sludge Predictions

6.6 Equipment Status Monitor

The Equipment Status Monitor (ESM) is an operational configuration management system [9]. The ESM uses an equipment status database linked to electronic operational flowsheets in order to view all plant device states. The ESM also includes a complete environment for creating, executing, and tracking operating orders or orders-to-operate (OTOs) using computerized procedures. Forty or more OTOs (field instructions) may be planned, created, and executed during a typical CANDU day. Changing the state of any device includes the creation of a work request and an OTO. Traditionally, the state of each device is kept on paper-based operational flowsheets in the work control area. Coloured dots and labels are used to identify changes to the as-designed state of each device and to identify work protection and jumper status (temporary changes to the plant). The collection of these flowsheets is often referred to as the 'pin-board'. OTOs are created using the pin-board as a reference. The execution of the OTO represents changes to the physical plant and the pin-board must be updated. The ESM computerizes this process.

The ESM electronic flowsheets and database are derivatives of the plant CADD information (CADD design flowsheets and device information in TeddyBase). The ESM adds information associated with each device such as the operating state (on/off, opened/closed, etc.), maintenance state (available, removed for service, etc.), work protection data, and jumper status. This information is shown on the electronic operational flowsheets as on the old pin-boards. With dynamic links between the flowsheets and database the flowsheets are animated. The database information is maintained via interfaces to the process HDS, electronic computerized procedures, and plant CADD system. The ESM is also used to create new OTOs using the electronic operational flowsheets and previously created OTOs as the starting point. Once a new OTO is created it is transferred to the computerized procedure system for execution in the field. Once the field work is completed the revised plant state is uploaded into the ESM database and the electronic operational flowsheets immediately reflect the change.

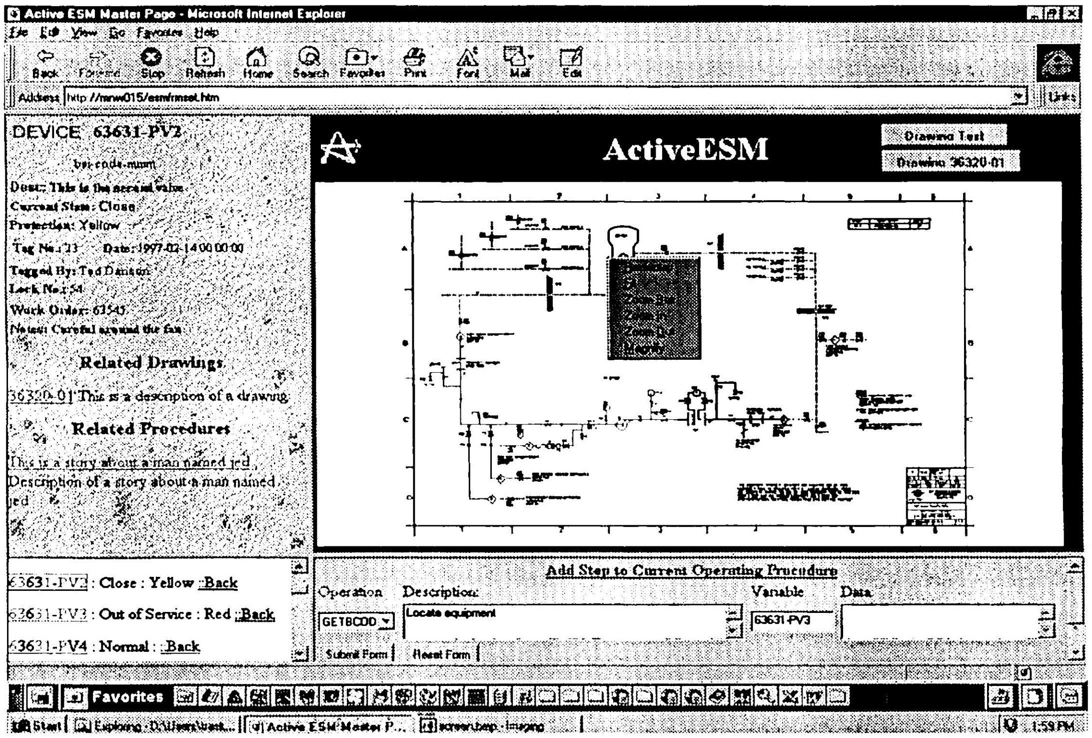

Figure 8: Example ESM Interface

The ESM is a web-enabled application. Therefore, the user interface uses standard Internet browser technology. An example of the ESM interface is shown in Figure 8. This interface window allows the user to view the state of any device on the animated operational flowsheets, view associated information on each device (documents, specifications, maintenance data, etc.), and to create an OTO for future execution as a computerized procedure.

6.7 Computerized Procedure System

The computerized procedure system concept and feasibility was originally established as a COG project and has subsequently been developed into an AECL product [10, 11]. Computerized procedures have been investigated in other non-nuclear industries, but procedure specific software limited their successful implementation. Transfer from a labour intensive paper-based process to a labour intensive software development process was not acceptable.

The AECL computerized procedure system is built around the same technology used to display and browse electronic documents on Internet Web sites. Standard Microsoft Word documents (or equivalent) are 'tagged' into an electronic version that is interpreted by the Computerized Procedure Engine (CPE) software, which is the centre of the computerized procedure system. The CPE software adds considerable value over just using electronic Microsoft Word forms or files. The CPE software ensures a consistent format; ties the procedure to a work process and flow including reviews and approvals; enforces procedural compliance; has the capability to embed calculations, drawings, and deficiency reports; uses bar-code scanning technology to assist in the identification of field equipment; and has the capability to upload information directly into other information systems like the process HDS and ESM. To the end user, the CPE software resides on an off-the-shelf hand-held tablet computer that can be purchased from a number of vendors. Procedures to be executed include safety system test procedures, OTOs, maintenance procedures, call-ups, field rounds, and performance monitoring. A sample procedure as it would appear using the CPE software on a hand-held table computer is shown in Figure 9.

The computerized procedures can be imported onto the hand-held computer across the stations Local Area Network using the CPE work flow software. The operator follows the procedure as if they were carrying a clipboard and pen. The tablet computer stylus is used to step though the procedure, fill in the blanks, and perform the tasks as specified. After completion of the procedure, the electronic file can be immediately archived for future reference and the data can be instantly transmitted to the end-user of the information. Data can be transmitted in wireless format, without the threat of electromagnetic interference, to the process HDS and into a pre-defined report format in a matter of seconds. Experience in executing CBM walk-arounds at Pickering NGS show that the CPE software and use of hand-held tablet computers greatly facilitate the task of gathering field data in support of condition based monitoring.

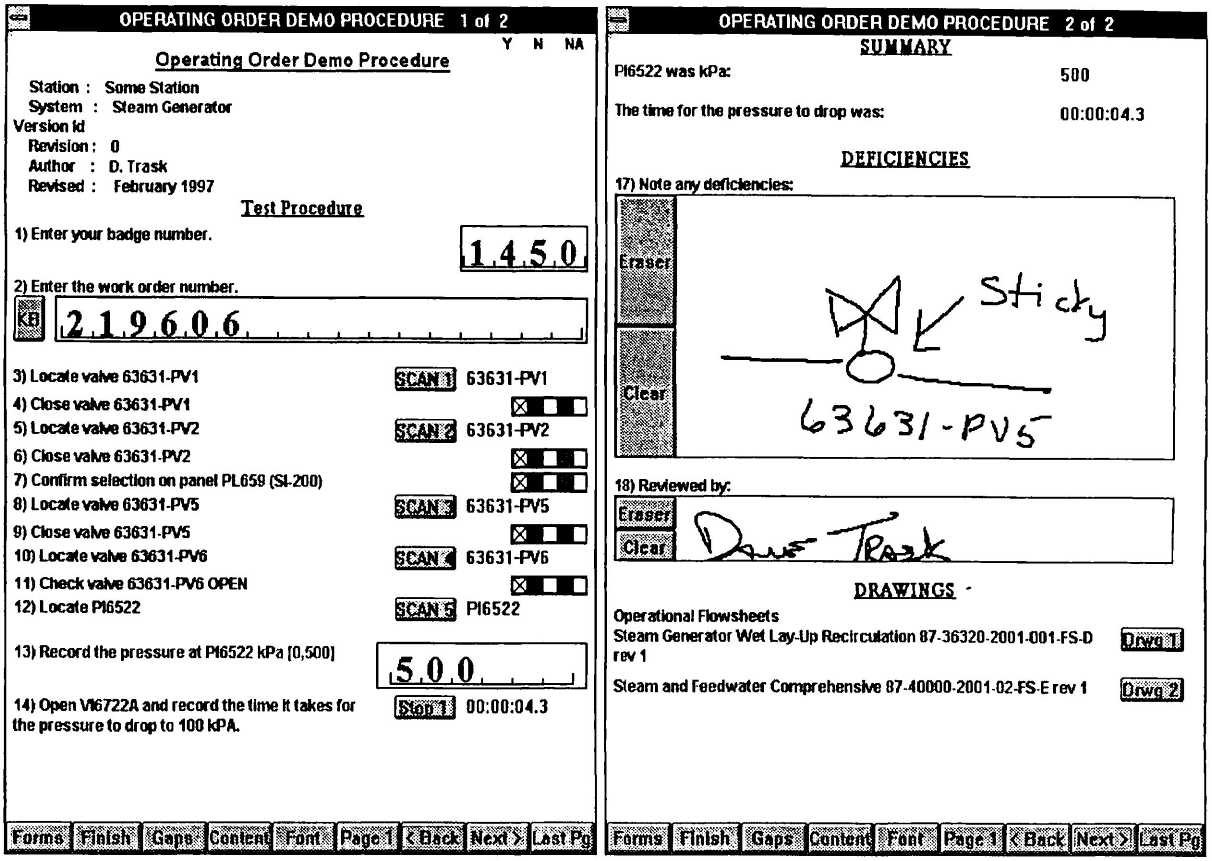

Figure 9: Computerized Procedure using the CPE Software

6.8 Business Information Systems

BIS technology is a critical component of the AECL vision. BIS components provide support to work management, planning, scheduling, resource management, procurement, finance, project management, inventory, stores, and other traditional business applications. These are often referred to as Enterprise systems since the intent is to integrate all aspects of the corporate (or plant) operations.

BIS technology has traditionally been the domain of the utility corporations, and as such, AECL is not developing BIS components but is investigating commercially-available systems that are used in other large-scale industrial environments, for example the Indus Enterprise MPAC and SAP. AECL may eventually adopt a BIS technology for delivery as part of CANDU sales depending on the actual model(s) associated with each specific build project. The other information technologies which have been discussed are developed using standard communication protocols and database interfaces to ensure compliance and integration with the commercially-available BIS technology options.

7. BENEFITS OF INTEGRATED INFORMATION SYSTEMS

The benefits of a fully integrated CANDU information system are numerous. The nuclear environment includes large, complex plants, highly skilled and trained staff, and an intensive procedurally-driven work methodology. Information gathering, which is the key element to the initiation and completion of any task or activity, can consume as much as 70% of the time it takes to complete an activity. The AECL Information Technologies are specifically designed to minimize the effort required to collect, archive, retrieve, and utilize information to support all elements of plant operations, maintenance, and administration.

Specific benefits include:

- Ability to effectively manage the plant's design and operational configuration,
- Cost-effective processes and procedures leading to reduced OM&A costs,
- Transfer of staff effort away from data gathering and into data analysis and decision making,
- Pro-active maintenance processes and improved information flow within the plant which lead to longer plant life and increased availability and reliability,
- Improved on-line monitoring and assessment of the state of critical structures, systems, and components leading to less reactive maintenance and a more proactive and cost-effective maintenance program, and
- An instantaneous awareness of the operational state of the plant leading to improved safety and a longer time frame for decision making.

8. SUMMARY

The increasingly competitive market requires that the plants are optimized for electrical energy production while achieving continually higher levels of availability, reliability, and extended plant life. AECL's suite of information systems have been designed to address all aspects of plant life from the initial design through long-term operation. At the core of this vision lies an information flow model based on design basis data and historical plant information. This is coupled with an understanding of the needs of the information users including the technical staff (SREs/PREs), equipment specialists, maintainers, management and administration.

The vision and systems described in this paper provide a level of integration that facilitates the effective management of the design basis data together with both near real-time and historical operational data. This enables plant management and staff to take control of the engineering design basis and the ongoing operational configuration of the plant. In addition, the suite of information systems enables the introduction of cost-effective pro-active maintenance processes that have been proven world-wide. High speed data gathering, access to information, and advanced analysis capabilities leads to more effective decision making. In turn, this results in a plant with higher production, availability, reliability, and safety while reducing the long-term OM&A costs.

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