THE PROCESS MONITORING COMPUTER SYSTEM AN INTEGRATED OPERATIONS AND SAFEGUARDS SURVEILLANCE SYSTEM

Neil A. Liester
Idaho National Engineering Laboratory
Lockheed Idaho Technologies Company
Nuclear Operations
PO Box 1625
Idaho Falls, ID 83415-5224 USA
(208) 526-2046

ABSTRACT

The use of the Process Monitoring Computer System (PMCS) at the Idaho Chemical Processing Plant (ICPP) relating to Operations and Safeguards concerns is discussed. Measures taken to assure the reliability of the system data are outlined along with the measures taken to assure the continuous availability of that data for use within the ICPP. The integration of process and safeguards information for use by the differing organizations is discussed. The PMCS successfully demonstrates the idea of remote Safeguards surveillance and the need for sharing of common information between different support organizations in an operating plant.

SYSTEM DESCRIPTION

The Process Monitoring Computer System (PMCS) at the Idaho Chemical Processing Plant (ICPP) consists of various data acquisition devices that transmit process information to a minicomputer where the data is processed, stored, and displayed. This process information is either analog (continuous) or digital (discrete) data from the plant instruments and special sensors installed throughout the plant. The PMCS began as an experiment in remote Safeguards surveillance of an operating nuclear fuel extraction plant and evolved into what it is today. The system today is used by Operations, Safeguards, and Support staff to assure the controlled operation of the facility through timely on-line analysis of process data. Figure 1 illustrates the current extent of this system in the nuclear fuel extraction portion of the ICPP. The heart of the system is composed of two minicomputers, a Micro-VAX 3800 and a VAXStation 3100. The MicroVAX 3800 is the main computer and handles all of the PMCS work the majority of the time. The VAXStation is configured as

a hot backup computer and will take over the duties of the PMCS in the event the main computer should fail.
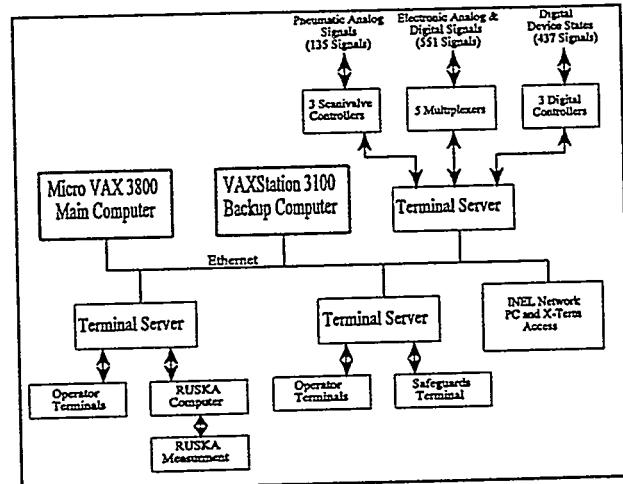

Figure 1. PMCS Block Diagram

The PMCS currently monitors and stores the following kinds of signal information:

1. Three Scanivalve Controllers - These controllers gather data from the pneumatic plant instruments such as level and density transmitters and converts the data to an electronic signal for processing by the computers.
2. Four Analog Multiplexers - These devices gather voltage data signals from thermocouple and other electronic transmitters and feed the information into the system. Electronic instrumentation has replaced some of the older pneumatic instrumentation within the fuel extraction process areas. The Multiplexers together with the Scanivalve units discussed above gather about

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540 analog signals from the plant.

3. Four Digital Controllers - These devices gather about 580 digital state (on/off) signals from various devices throughout the facility such as, pumps, jets, airlifts and samplers. This is done to determine whether the devices are actuated or not.

There are about 440 calculated variables such as, volumes, specific gravities, and jet statuses. These variables are computed from combinations of acquired data and are also stored by the computer. All of this data is either scanned or calculated once per minute and stored in on-line mass storage for one year. Data older than one year is archived onto optical disks for permanent storage. The optical data is in the same format as the on-line data and can be quickly made available for analysis.

Access to the PMCS computer system is controlled by VAX-VMS username/password combinations and through the use of dedicated display terminals. Six color graphic dual session terminals with dedicated laser printers are connected to this system and are located within the fuel processing areas of the ICPP. These terminals are used by Operations personnel and aid in the operation of the plant. A single dedicated color graphic terminal with attached laser printer is located within the offices of the Safeguards staff and is used in analyzing the process data. Other personnel, such as, Operations Support Engineers and Environmental Engineers access the PMCS using X-terms and PC's connected to the INEL wide ethernet network. Network access to the PMCS data is achieved through dedicated, captive VMS accounts that only allow read access to the process information.

OPERATIONAL USE OF THE SYSTEM

The PMCS monitors the ICPP fuel extraction operations which consist of various head end dissolutions, one cycle of TBP solvent extraction, two cycles of hexone extraction, and a denitration step. The goal of the system is to gather the highest quality process information available and make that information equally available to the Production, Safeguards, and Supporting staffs. The PMCS provides a convenient means by which the process can be monitored to look for unusual happenings and to flag those happenings for further investigation by appropriate plant personnel.

The largest use of the system is the interactive analysis of process operation using the stored data. All of the stored process information is readily retrievable through a set of interactive programs designed for that purpose. Each organization interested in analyzing the ICPP

operation has differing uses for the process information, however, the different uses all involve analysis of the same information. The PMCS information is retrievable as tables, graphs, calculations, and pre-printed forms designed to aid in the operation of the facility.

All plant process data is available for trending or plotting. Digital signals may be plotted along with Analog signals as well as computed process variables. The time span of these graphs may be anywhere from one hour to 30 days and the Y axis, or value axis, can be either auto scaled or set to any desired scale. Figure 2 illustrates an Analog signal plot. Shown in the figure is the option called "FIND" which places a pointer on the plot and displays the exact value and time of the variable in the lower corner of the plot. A second plot can be added to this graph and both variable values may be read in the lower corner.
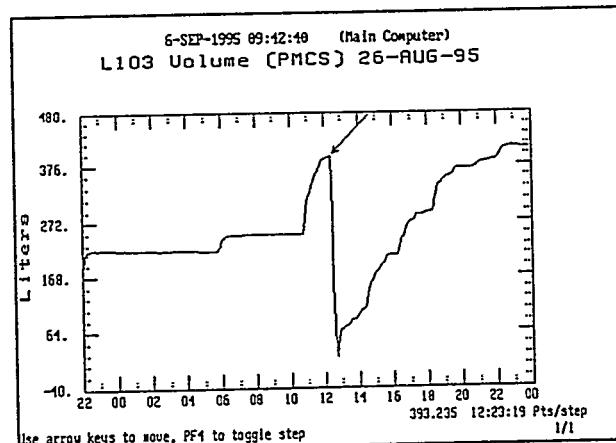

Figure 2. An Example Plot

A useful feature of the plot is the ability to scroll through the time axis using single keystroke commands, allowing the time frame of the plot to be moved forwards and backwards through time. Also, both scales of the plot may be easily changed. This flexibility greatly increases the power of the system to track down problems within the process. This contrasts sharply with the traditional methods of looking at tracings on plant instrument charts and analyzing the information contained on individual charts.

The plotting or graphing feature on the PMCS also gives the analyst the ability to calculate statistics about any portion of the data which is plotted. The statistics calculated include, high, low, mean, and standard deviation values as well as providing a option for doing a curve fit and displaying a control chart. The curve fit slope value is very useful in determining flow rates or rates of change for analog values over either long or short periods of time.

A significant operating concern addressed by the PMCS is the reduction or, ideally, elimination of inadvertent transfers. An inadvertent transfer is the accidental sending of solution to an unintended location. The reduction in the number of inadvertent transfers is accomplished through several programs on the system. The first of these programs calculates available headroom or space within a receiving vessel and also calculates the target instrument readings for both the sending and receiving vessels at the completion of the transfer. These desired readings provide guidance to let the operators know when the end of a transfer is approaching. The system uses current process data for this calculation, limiting the amount that may be transferred to the amount which the receiving vessel can hold.

Inadvertent transfers are also reduced by the generation of operating sheets, or Batch Transfer Forms, that specify the status of equipment to be used during a given transfer. These sheets are retrievable from the computer by specifying the sending and receiving vessel names. When the PMCS is notified that a transfer is to start, the system checks the piping route of that particular transfer against the piping routes of other currently active transfers. This is done to assure that there are no conflicts in required equipment states between the current transfers and the new requested transfer. If there is such a conflict a printout, illustrated in Figure 3, is generated which lists the equipment with the conflict and the active transfer that is generating the conflict. The system then asks for verification that the Operator wishes to continue with the new transfer. The conflicting states are flagged under the following conditions:

1. A device, such as a valve, needs to be open for both transfers.
2. A device needs to be open for one transfer and closed for another transfer.
3. One of the vessels used in the transfer is being used in another transfer.

The conflict report does not take into consideration whether the device is actually physically actuated. The report is designed to flag conflicting requirements between two transfers that it has been told will be going on simultaneously. There is no decision capability placed within the PMCS. Operational decisions are still the responsibility of assigned personnel. The PMCS is only used to provide information required for those decisions.

If the decision to proceed with the transfer is made, or if there are no conflicts with other transfers, the system compares the list of devices in that transfer with a database maintained for validating the digital signals on the system. If the PMCS sensors on the devices used in a particular

transfer have not been verified as being correctly operable within the previous six months, the system asks the Operator to verify the current state of the first five devices in the list. If all device sensors in a given list have been verified, this part of the program is bypassed. At this point, a Pre-Transfer Form is printed out for the Operator to use while doing the transfer. This form lists the vessels used in the transfer, administrative preconditions to the transfer, and the equipment state required to do the transfer. The form also lists the current status, as sensed by the PMCS, of the devices involved in the transfer. A listing of possible inadvertent transfer destinations is also provided to allow easier tracking of where the solution may be going during a mistaken transfer.

**** Listing of common equipment in other currently active transfers ****

Possible causes for this discrepancy report:
A currently active transfer indicates a certain valve must be Closed and the requested transfer says to Open the same valve.
Both transfers indicate the same valve must be Open.
Two transfers into or out of same tank, or attempt to fill an emptying tank, or empty a filling tank.

This report does not take into account the actual status of the device as monitored by the PMCS.

Requested Transfer: U129 to Tankfarm   Start time: 9-SEP-1995 12:00
Transfer Number : 12786

Device	Conflicting Transfer	Reason
U129	U129 to Tankfarm	Second Transfer From Tank
Tankfarm	U129 to Tankfarm	Second Transfer Into Tank
RCV-U-10	U129 to Tankfarm	Both Open

Figure 3. A Transfer Conflict Printout

The PMCS maintains a table of active or on going transfers. This table is easily retrievable any time and is also printed out at the beginning of each shift to provide the oncoming crew a better picture of the condition of the plant operation.

A form is also generated for the closeout of a transfer. This form is requested in the same manner as a Pre-Transfer Form. The steps followed in the process are the same as with the Pre-Transfer Forms with the exception that the system does not look for conflicts with existing transfers. The system calculates a volume balance between the sending and receiving vessels to provide an added assurance that all of the solution transferred did indeed arrive at the intended destination.

Another feature implemented on the PMCS to upgrade the quality and efficiency of the ICPP operation is placement of the plant vessel calibration curve equations

on the computer. The equations, generated from a combination of instrument data and known volume equations, are contained in the system and used by the computer. By making the computer the sole source of the controlled calibration equations, it is assured that any changes to the equations automatically cause the system to begin using the new equations. Only one data base currently exists for the vessel calibrations where before these equations could be found in three different locations. The consolidation of the equations assures the continuity and quality of the information. Vessel volumes can be displayed on the system in many ways. One interesting way provides a listing of current instrument readings and the resulting volume from those readings for a typical plant instrument. Included in this display is the calibration equation, overflow volume and operating volume limit. A calibration curve, illustrated in Figure 4, plots volume against level in the vessel, includes lines to show the overflow and operating volumes, and places a mark at the current volume of the vessel. These same equations are also used in the Pre-Transfer calculations discussed previously.
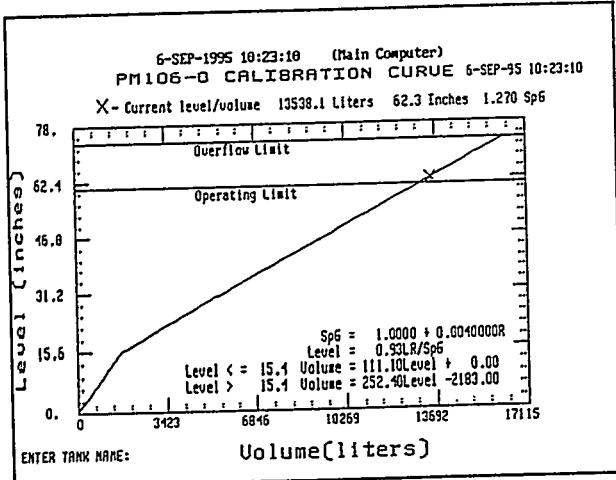

Figure 4. A Calibration Curve

In the past, prior to implementation of the PMCS, flow rate measurement at the ICPP has been difficult. The low, by industrial standards, flows used in the plant combined with the fact that high radiation fields demand remote operation has rendered most instruments unsuitable for flow measurement. Because of this, flow is calculated based on differences in vessel volumes over a time period. The vessel volume is determined from the process level and density instrumentation. This method of flow measurement is known as tank depletion. The flow calculation was done by manually taking level and density readings from a process strip chart and either doing a hand calculation of the volume or reading an estimated volume

from a calibration curve of the vessel. After several minutes a second volume calculation could be done and an approximate flowrate could be calculated.

The PMCS has been programmed to calculate tank depletion flow rates in real time for any given stream within the ICPP. The calculated rate is updated once a minute and is used to watch the effects of adjustments to the flow. Adjustments to the flow are visible within one minute on the screen display providing an indication of the correctness of the adjustment while the overall average for longer time intervals is also shown. This feature frees the process Operator to concentrate on the effects of the change to the process which effect flow rate, rather than the mechanics of hand calculating the flow rate.

Often, solution is added to feed vessels from makeup vessels to allow continuous processing in the facility. During this type of transfer a standard tank depletion calculation cannot be done since the apparent level in the tank will change based on inlet flow and outlet flow rather than just outlet flow. The tank flow rate program has an option which will correct such calculations by doing a material balance around the specified system by taking into account the volume change in the makeup vessel as well as in the feeding vessel.

SAFEGUARDS APPLICATIONS OF THE SYSTEM

Process information is needed by the Safeguards staff in tracking and accounting for Special Nuclear Material (SNM) with in the ICPP facility. Historically, much of this tracking has been done manually. However, manual tracking has become more difficult due to the complexity of the facility, the length of time of the process runs, and the shorter analysis times needed. The PMCS, therefore, has played a vital role in the Safeguards analysis of the facility. The system capabilities discussed thus far were all initially developed to enhance the reliability of the system for the Safeguards function. It must be recognized, however, that at the ICPP it is difficult to separate the information needs of Safeguards from the needs of Process Operation and Engineering Support. What is different is the way the information is analyzed. The requirements for the validity of the information is shared by all of the organizations.

The difficulties facing the Safeguards analysis might be better appreciated by understanding that the ICPP fuel extraction process is divided, for the sake of Safeguards, into five process Sub-Material Balance Areas (Sub-MBA). From a Safeguards point of view, material or solutions which are fully contained within one of these Sub-MBA's
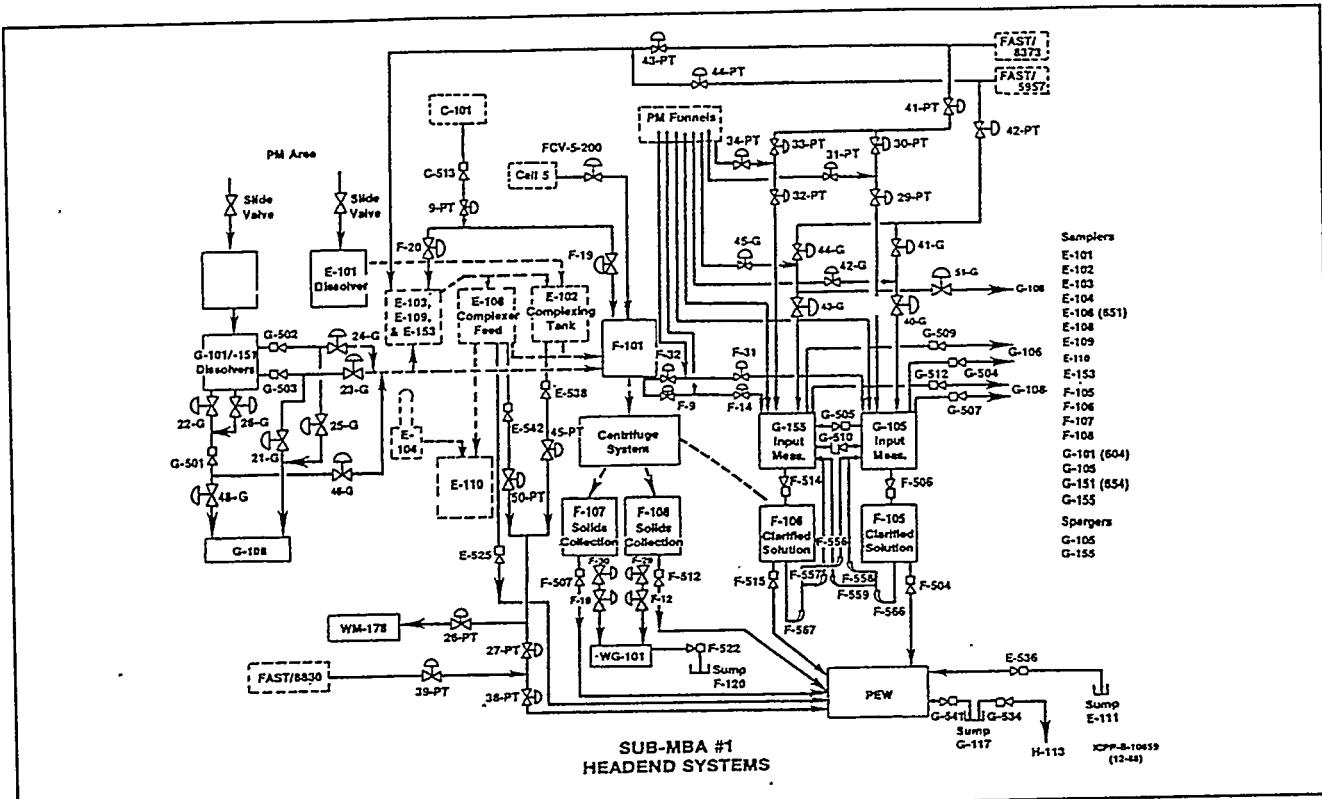
Figure 5. An Example MBA

can be moved from vessel to vessel without having to be accounted for. However, whenever material leaves a Sub-MBA it must pass through an accountability vessel and proper measurements and analyses must be completed. Sub-MBA's, one of which is illustrated in Figure 5, are surrounded by sensing devices that allow the system to completely monitor transfers through the vessels that define the boundaries of these areas. This information is assembled within the computer system and stored in the proper format for on-line retrieval and analysis. Further, the data is analyzed and reports are generated each day for transfers that cross any of the Sub-MBA boundaries.

In addition to all of the previously discussed features, Safeguards Engineers use special reports generated daily by the system. These reports are:
1. The Sub-MBA Report
2. The System Status Report

The Sub-MBA report, which is illustrated in Figure 6, is the result of analysis of all defined transfer routes within the process that cross a Sub-MBA boundary. The report lists the transfer routes which had any activity and plots a 24-hour time line across the top of the page. The computer then places an asterisk in the line corresponding to the time that a combination of digital state devices actuated on the transfer route, showing that some event

could have occurred. This report is obtained daily by the Safeguards staff. Another report generated by the system on a daily basis is the system summary of the status of the data acquisition devices on the system.

If any of the devices lose contact with the computer system a series of question marks is printed for the appropriate device during the appropriate time span. These reports, the MBA and System Status report, together provide a daily analysis of events within the facility.

Another special program has also been developed for use by the Safeguards personnel. This program called, Tank Watch, allows special Safeguards surveillance limits to be set on any vessel which has liquid level sensing instrumentation. When a vessel is being watched by this program and the level in the vessel changes, either up or down, notification is sent to Safeguards. This is an excellent method to keep track of unused vessels or vessels which contain SNM accountable material. The program will detect very slow increases or decreases in a vessel liquid level and can be set to not report changes in level readings which are due strictly to instrument noise. The PMCS process information is a part of a larger Safeguards effort that maintains overall SNM control at the ICPP.

The plant is currently going through decommissioning activities that include flushing out and decontaminating all portions of the plant and making a final accounting of all SNM. The PMCS is still being used by both Operations and Safeguards to track and account for solutions as they move throughout the fuel extraction plant.

CONCLUSION

The PMCS has proven to be a valuable tool for the operation and analysis of the ICPP fuel extraction processes and provides the Safeguards staff with a source of information to independently verify procedural compliance. The PMCS has also shown that Safeguards and Production goals do not have to be mutually exclusive. Material benefits from the system are enjoyed by all parties.

ACKNOWLEDGMENTS

Figure 6. Sample MBA Report

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