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AUTOMATED SYSTEM FOR ACCOUNTABILITY PROCESS TANKS (U)

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Abstract

An automated tank monitoring system has been installed in a plutonium processing plant at the Savannah River Site (SRS). This system reads tank instrumentation and displays the calculated volume, mass, and density of connected tanks while meeting the measurement control requirements of Department of Energy (DOE) Order 5633.3. The system has a self–checking feature that provides a high level of assurance that the instruments are functioning at a satisfactory level. Additionally, costs and radiation exposure to personnel are significantly reduced by eliminating calibration checks and allowing instrument calibrations to be performed on an as needed basis. As part of the measurement control features, the system periodically displays self–generated control charts and checks the variability of the tank instruments to decide if the readings are accountability grade.

Introduction

A volume measuring system was designed and installed to calculate the volume, mass, and density of solutions in tanks. Design considerations were to satisfy the intent of DOE Order 5633.3, concerning measurement control, and to improve tank measurements. The name given to this system is the Automated Tank Monitoring System (ATMS).

The ATMS provides high quality measurements. It assures that measurements are reliable through measurement control features that incorporate inter–comparisons of redundant instrumentation. These comparisons provide continuous calibration checks on tank–volume instrumentation. The ATMS identifies out–of–control instruments, eliminates these instruments from making measurements, and relies only on instruments that are determined to be in calibration. Because of those reasons and many other benefits, the ATMS is a very desirable system to install.

How the System Works

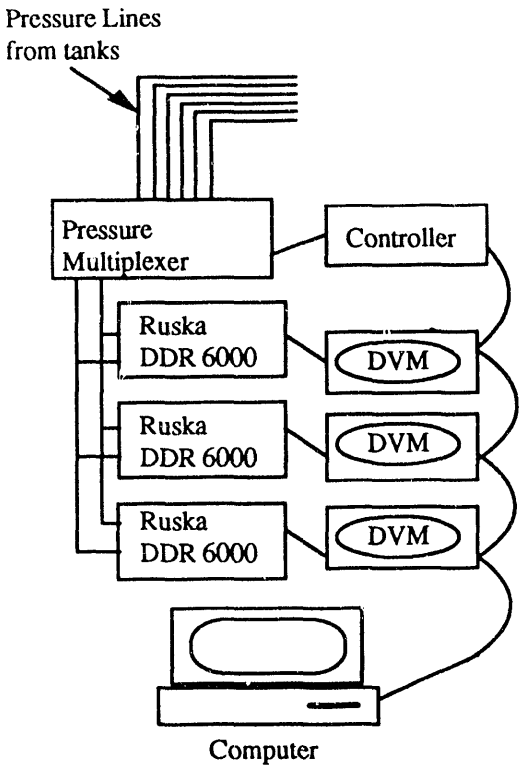
Accountability tanks at SRS that require a high degree of accuracy use bubbler tube manometry systems for inferring the volume and mass of the fluid contained in these tanks. There are two dip tubes in each tank for measuring both liquid level and density. Differential pressure (DP) sensors read the dip tube pressures; Ruska® DDR 6000's, which are extremely accurate, are used at SRS. These sensors are relatively expensive and very difficult to calibrate.

The Scanivalve® Corporation makes a multiplexer for DPs. This multiplexer can relay the DP from several tanks to a single DP sensor. The ATMS uses this multiplexer to read the DP from several tanks.

If two, well–calibrated pressure sensors are connected in parallel, their output measurements should agree within statistical limits. If they do not agree, at least one sensor requires calibration, but the problem arises in identifying which one. This problem can be solved by connecting a third sensor in parallel with the others. All three should agree unless one or more is out of calibration. If one of the three sensors requires calibration, then it can be easily identified.

The system at SRS uses a Macintosh® computer with software that enables it to control a differential pressure multiplexer, read digital voltmeters (that read the output of the Ruska® DP sensors), and average those readings over 10–second intervals. This eliminates the process variability induced from the bubbling and allows for stable dip–tube pressure measurements. In the ATMS, three Ruskas are connected in parallel to the output of the differential pressure multiplexer. In this configuration, all three sensors

simultaneously read the dip–tube pressure supplied by the multiplexer.



With all sensors reading the same pressure, comparisons can be made with each reading. Since the system averages the readings over time and calculates the standard deviations, the standard deviation is used to measure stability. Therefore, an individual instrument's measurement must meet two criteria:

- the average must agree with the other instruments within limits
- the standard deviation must be small enough for the reading to be considered stable

If an instrument meets both these criteria, it is used to calculate the volume, mass, and density of the fluid in the tank.

The computer system rotates the DP multiplexer to a set of ports that are open to the same pressure. This obtains the Ruska "zero" that is subtracted from the dip–tube pressure readings. This helps to eliminate instrument drift and significantly improves the accuracy of the measurement. This also allows the differential pressure sensors to be more realistically compared.

The ATMS also reads the tank temperature so that temperature corrections can be made on the calculated volume. A device interfaced to the computer reads a thermocouple in each of the tanks. This device is not limited to reading different types of thermocouples, but can also read 4 to 20 milliamp outputs and voltage outputs. This means that almost any type of liquid level measuring instrument can be read. All the tank measuring equipment in a material balance area (MBA) with these outputs can be interfaced to the same system. Additionally, a planned enhancement to the system is tracking tank–to–tank transfers by using the computer to compare volume changes in tanks.

By using a computer to control the system, several advantages can be realized.

- Calculations of tank contents is automated with the information continuously displayed.
- Only stable readings are accepted.
- Instrument performance is control charted with appropriate messages displayed for out–of–control instruments.
- A database of historical information is maintained for evaluation.

Fulfilling DOE Requirements

At least eight criteria of DOE Orders 5633.3 are addressed by this system. They include the following:

- ensuring the effectiveness of measurement systems
- ensuring the quality of measurement values for accountability purposes
- providing a means of calculating and monitoring control limits
- correcting out–of–control situations
- avoiding the use of instruments that do not demonstrate satisfactory performance
- guaranteeing that measurements are performed as specified
- allowing the instrumentation to perform at manufacturers specifications
- providing a system of measurements to reflect the flow of material within an MBA.

The ATMS meets these DOE order concerns through redundant instrument checks and computerization. The computer calculates sample means, standard deviations on the measurements, and, based on these values, accepts or rejects an individual instrument's measurement. This ensures the effectiveness of the system and the quality of the measurement values. Also, measurement data is stored to establish a database for calculating, monitoring, and updating the control limits used to compare instruments.

The comparison of the Ruska output average differences to control limits will immediately identify out–of–control

situations. The system acts by not using the suspect instrument in the volume/mass/density calculations. The system displays a message on the computer screen identifying the out–of–limits instrument and recommends calibration. By eliminating a suspect instrument's output from calculations, the system avoids using an instrument that does not demonstrate satisfactory performance.

Because the system is computerized and can obtain information from a multitude of sources, it allows consistent data manipulation and tank–to–tank comparisons. All instruments are controlled and calculations are executed in the same way every time, which guarantees the measurements are performed as specified. The ATMS eliminates the process variability introduced to the pressure transducers through consistent control and averaging. As a result the instruments can perform at the manufacturer's specifications; before this they could not when averaging was not available. Finally, the system can have access to all the process–tank instrumentation within a facility. Through that feature, the system can compare volume changes in tanks and track the general flow through the MBA.

Other Benefits

Besides providing measurement control and calculation of the volume, mass, and density of tank solutions consistently, there are several other benefits to this system that make it attractive to the operations personnel. They include the following:

- capital cost reduction
- calibration cost reduction
- reduced radiation exposure
- internal temperature corrections
- increased accuracy

Cost reduction and cost avoidance were primary objectives at SRS. It also reduces the cost of maintenance and a reduction in the radiation exposure to instrumentation and equipment mechanics.

With the pressure multiplexer, several tanks can be read by a single pressure sensor (or a bank of three instruments in parallel). The particular multiplexer used can read up to 11 tanks, while a larger model can read up to 23 tanks. Tanks at SRS are fit with two pressure sensors each: one for liquid level and one for density. The instrumentation for three key transfer tanks was replaced with the ATMS, retiring a net of three pressure sensors and a data logger. This was a cost savings to the facility.

A reduction in calibration effort of the pressure sensors resulted when the pressure sensors were eliminated. Also, the inter–comparisons feature of the ATMS eliminates the need to "blindly" check the Ruska calibration status. Before the ATMS, instrumentation mechanics checked the calibration of the Ruskas monthly. Now that the ATMS continuously checks the calibration, actual calibration work is necessary only once a year or as needed. For this particular system at SRS, the calibration work has been cut from over 800 work–hours per year to as low as 50 work–hours per year. Because these instruments are located within a radiation zone, the exposure to radiation is also reduced.

The ATMS controls the multiplexer; takes readings; and calculates the volume, mass, and density for each tank connected to the multiplexer. From temperature readings, temperature corrections on the volume and mass outputs are made. These corrections are very complicated. Since the calculations are automated, the MBA custodian or operator looks at the numbers displayed on the screen, which eliminates human error in the calculations.

Finally, the accuracy of the reported volume, mass, and density is greatly increased because the computer averages the measurements to eliminate the process variability and accounts for instrument drift. The system accounts for drift by taking the "zero" of the differential pressure instruments. Bias is reduced by subtracting this value from the tank pressure measurements. Also, averaging reduces each instrument's variability. If all three instruments agree within the assigned limits, an overall average will be calculated. All this helps to bring the final measurement value closer to the true measurement.

Summary

At SRS the ATMS was installed to reduce costs, to meet the DOE orders in several areas of measurement control, and to calculate accountability information for the MBA custodians. It was immediately recognized for providing a means of greatly improving accountability for special nuclear materials in solution, while reducing workloads for instrumentation mechanics. This system provides a cost–effective means of improvement to the SRS accounting system.

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