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## Double-Shell Tank Monitor and Control Subsystem Definition Report

**R. R. Bafus**

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Richland, WA 99352

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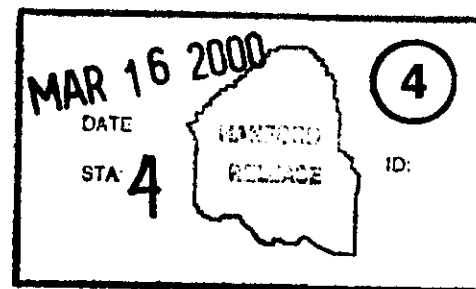
**Key Words:** Double-Shell Tank Monitor and Control Subsystem, Scope, Boundaries, Interfaces, Functional Requirements

**Abstract:** The system description of the Double-Shell Tank (DST) Monitor and Control Subsystem establishes the system boundaries and describes the interface of the DST Monitor and Control Subsystem with new and existing systems that are required to accomplish the Waste Feed Delivery (WFD) mission.

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# **Double-Shell Tank Monitor and Control Subsystem Definition Report**

Prepared for the U.S. Department of Energy  
Assistant Secretary for Environmental Management

**CH2MHILL**  
*Hanford Group, Inc.*

Richland, Washington

Contractor for the U.S. Department of Energy  
Office of River Protection under Contract DE-AC06-99RL14047

Approved for public release; further dissemination unlimited

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Date Published  
March 2000

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## TERMS

CASS	Computer Automated Surveillance System
DST	double-shell tank
HLW	high-level waste
HSEMS	Hanford Site Environmental Management System
I/O	input/output
LAW	low-activity waste
MPSS	Master Pump Shutdown System
PLC	programmable logic controller
RPM	revolutions per minute
SACS	Surveillance Analysis Computer System
SST	single-shell tank
TMACS	Tank Monitoring and Control System
V ac	volt alternating current
VTa	ventilation tank annulus
VTP	ventilation tank primary
WFD	Waste Feed Delivery
WST	waste storage tank
WSTA	waste storage tank annulus



## **1.0 INTRODUCTION**

### **1.1 DOCUMENT PURPOSE**

The purpose of this document is to describe the Double-Shell Tank (DST) Monitor and Control Subsystem. This document will establish the bounds of the system to facilitate the functional analysis of the DST Monitor and Control Subsystem.

### **1.2 EXECUTIVE SUMMARY**

The system description of the DST Monitor and Control Subsystem presented in this document was developed to establish the system boundaries and describe the interface of the DST Monitor and Control Subsystem with new and existing systems that are required to accomplish the Waste Feed Delivery (WFD) mission. This was done to provide a complete and accurate description of this subsystem, which is a constituent of the DST System.

The DST Monitor and Control Subsystem consists of the new and existing equipment used to provide tank farm operators with integrated local monitoring and control of the DST System for the WFD mission. The operator will be able to monitor and control waste tank storage conditions and waste preparation, retrieval, and transfer activities, and monitor the status of tank farm ancillary systems.

### **1.3 DOCUMENT ORGANIZATION**

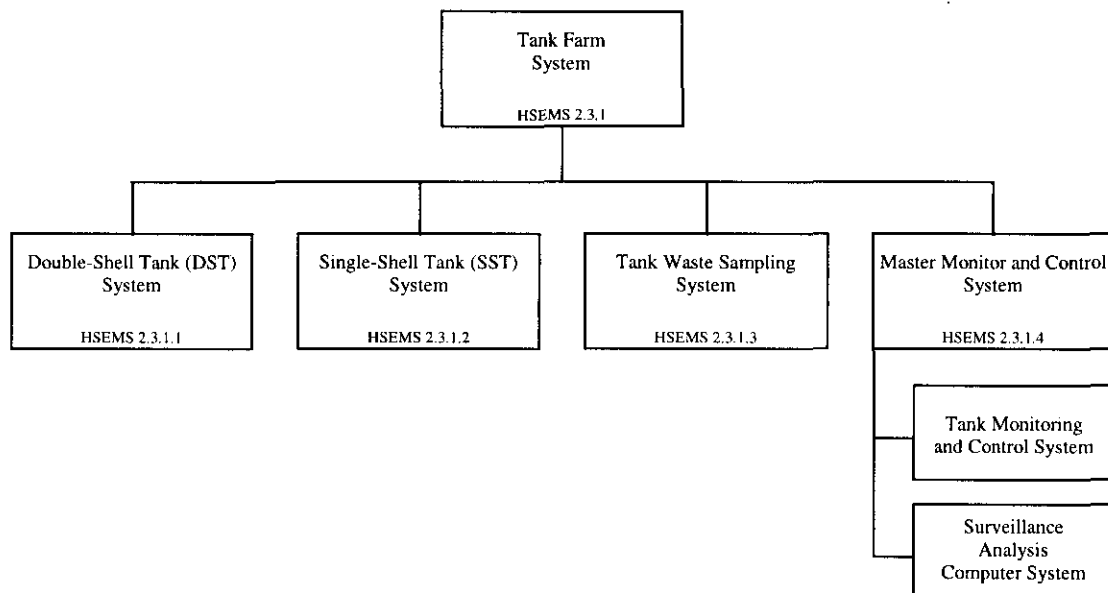
The remainder of this document is organized into sections, briefly described as follows.

- Section 2.0 establishes the DST Monitor and Control Subsystem as a subsystem of the DST System.
- Section 3.0 discusses the rationale for the DST Monitor and Control Subsystem description provided herein.
- Section 4.0 describes the interface between the DST System and the DST Monitor and Control Subsystem
- Section 5.0 is a summary description of the DST Monitor and Control Subsystem.
- Section 6.0 lists the references to this document.

## 2.0 BACKGROUND

A hierarchical breakdown of the Tank Waste Remediation System (now the River Protection Project) is provided in HNF-4208, *Tank Waste Remediation System Architecture Tree*. The architecture describes and communicates the system's selected and existing architecture to provide a common structure to improve the integration of work and resulting products and to provide a framework for River Protection Project specification-tree development. Figure 2-1 shows the Hanford Site architectural decomposition for the Tank Farm System with the associated Hanford Site Environmental Management System (HSEMS) numerical prefix as assigned by the *Hanford Site Technical Baseline Database* (HSTD [n.d.]).

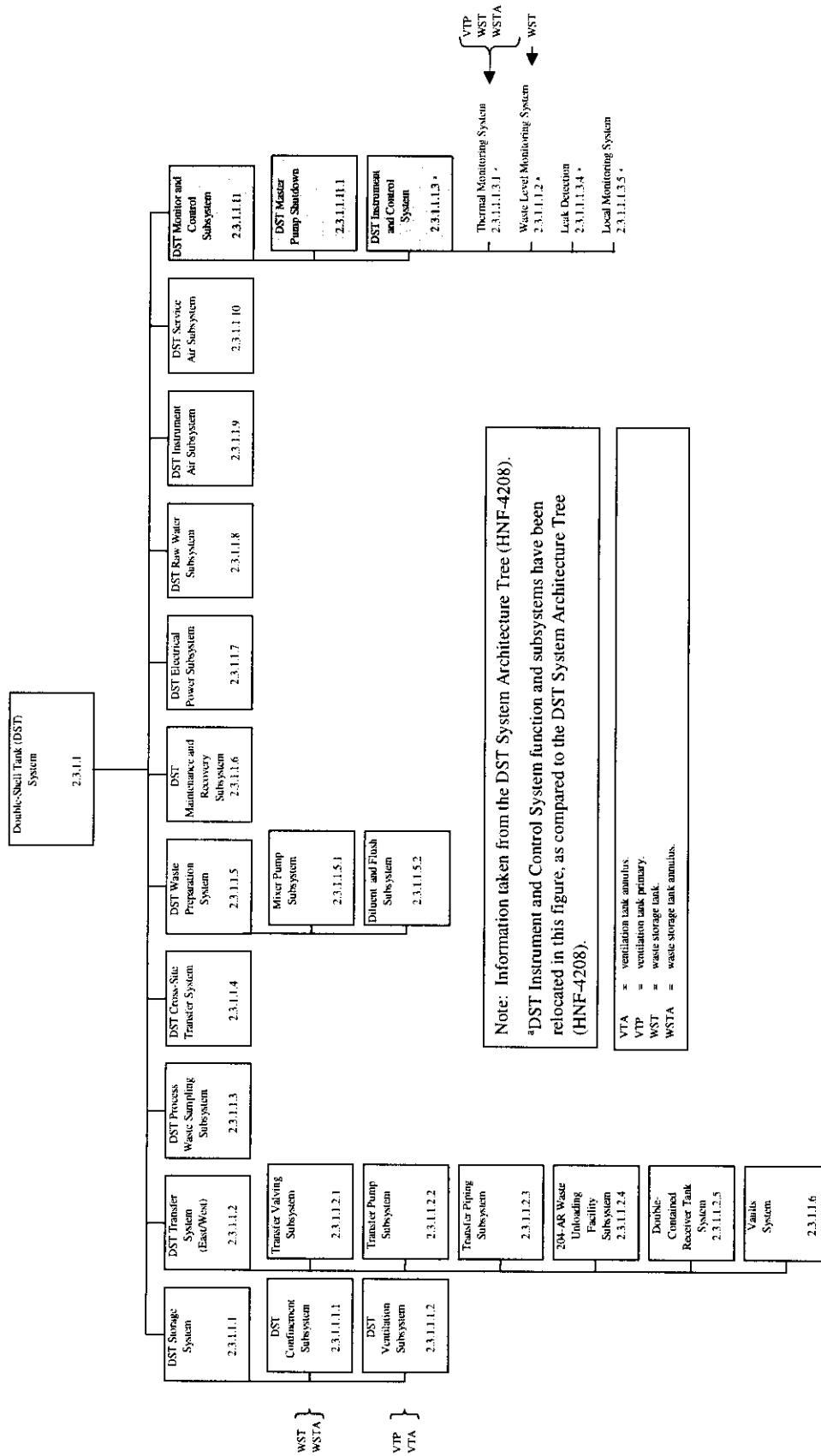
Figure 2-1. Tank Farm System Architectural Decomposition.



The DST Monitor and Control Subsystem is a subsystem of the DST System shown in Figure 2-2. This figure is a more detailed hierarchical layer taken from HNF-4208, which further defines the DST System block shown in Figure 2-1.

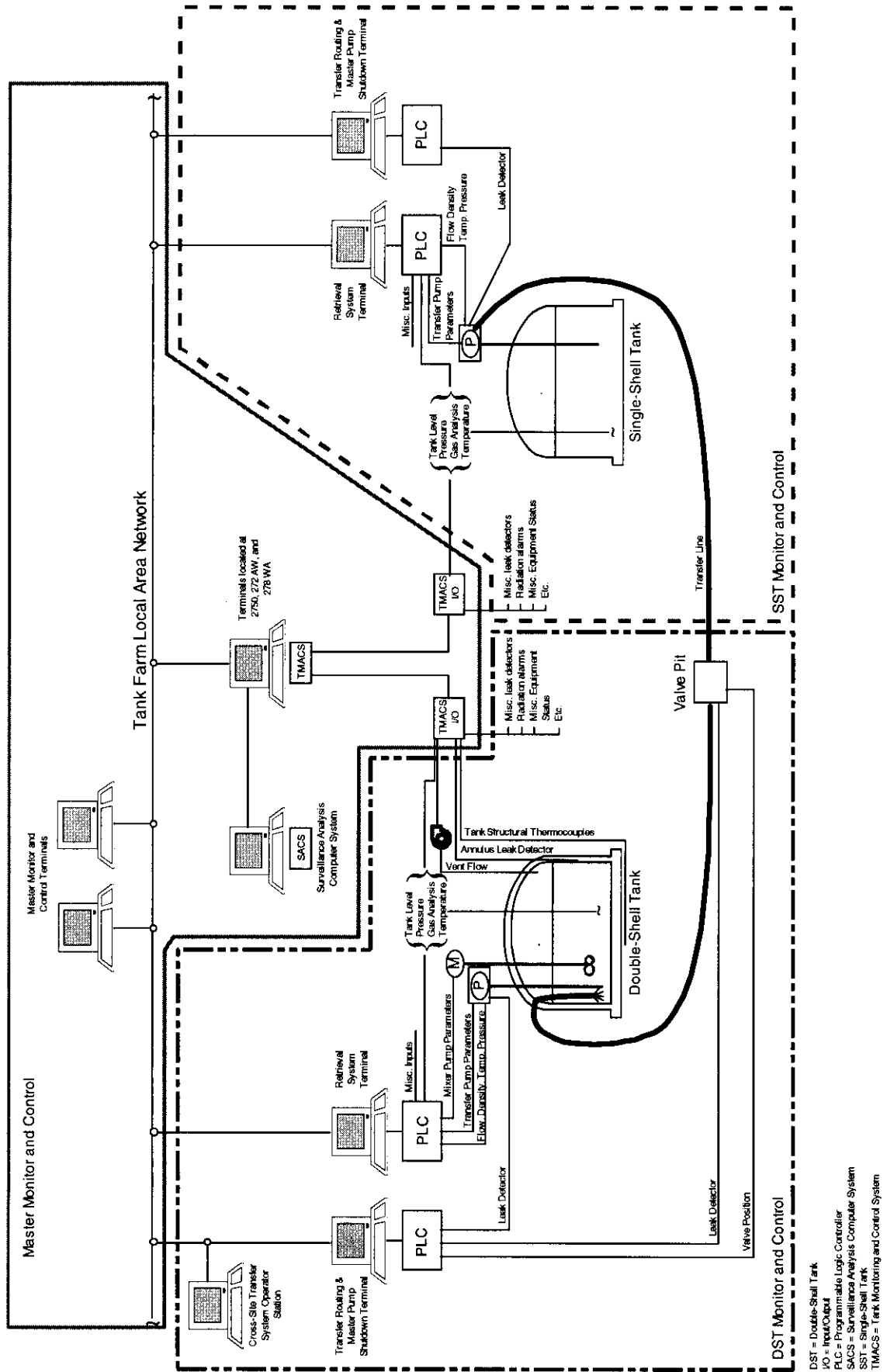
Figure 2-1 also shows a Master Monitor and Control Subsystem. This system is yet to be developed and consequently does not exist in its final envisioned configuration. Although a functional analysis has not yet been performed for this system, it will be the tank farm overall supervisory control system. The existing Tank Farm Monitor and Control System (TMACS) now performs this function, but the WFD mission will change the function of TMACS as a result of new requirements in data acquisition and data communication between tank farms. Specifically, the Master Monitor and Control System operator interface stations will access and display all information available at the DST Monitor and Control operator interface stations and thus will serve as an emergency or back-up monitor and control location. The Master Monitor and Control station will be manned by personnel who have the responsibility to administratively authorize, approve, and electronically, via password, enable tank farm activities such as

Figure 2-2. Double-Shell Tank Facility Architecture Tree.



waste transfers and mixer pump operation. The Master Monitor and Control System and TMACS will share data to optimize the resources of both systems. Figure 2-3 shows the proposed relationship among the Master Monitor and Control System, TMACS, the DST Monitor and Control Subsystem, and the Single-Shell Tank (SST) Monitor and Control Subsystem. This figure is general in nature because not all of the inputs and outputs to the DST Monitor and Control Subsystem can be shown and because the SST Monitor and Control Subsystem has not yet been defined architecturally. However, the SST Monitor and Control Subsystem is expected to incorporate features of the DST Monitor and Control Subsystem to provide operations personnel with continuity of user interface equipment and software. Figure 2-3, then, is a composite representation of the overall monitoring and control system for the 200 East and 200 West Area tank farms.

Figure 2-3. Diagram of Relationship Among Master Monitor and Control, Double-Shell Tank Monitor and Control, and Single-Shell Tank Monitor and Control.



### **3.0 DOUBLE-SHELL TANK MONITOR AND CONTROL SUBSYSTEM DEFINITION METHOD**

The first-tier DST System functions that support the Phase 1 WFD mission are generally organized in HNF-5136, *Functional Analysis for Double-Shell Tank Subsystems*, as follows:

- Store Waste
- Transfer and Receive Waste
- Prepare Waste
- Distribute DST Utilities.

Further decomposition of these functions is described in HNF-5136 and discussed in Section 4.0 of this document as the functions relate to the DST Monitor and Control Subsystem.

The subsystems shown in Figure 2-2 comprise the tank farm architecture that performs the tasks required to accomplish the four functions listed above. This architecture includes the structures, systems, components, subsystems, hardware, and software that make up the DST System. This document explains how the DST Monitor and Control Subsystem is interdependent with the other systems in the architectural tree, further analyzes and conceptualizes the system, and then defines the DST Monitor and Control Subsystem.

#### 4.0 DOUBLE-SHELL TANK MONITOR AND CONTROL DESCRIPTION

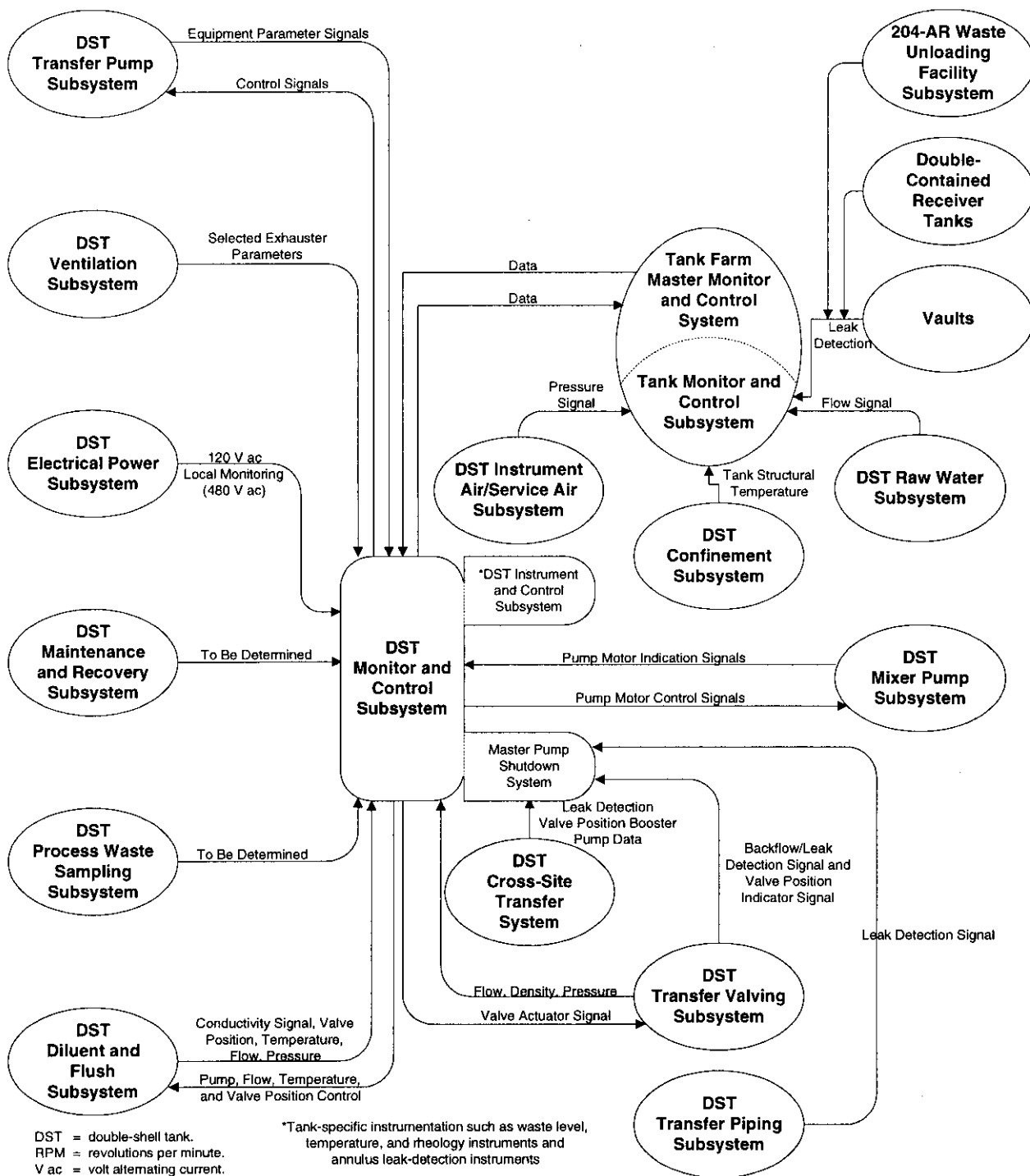
Automated monitoring and control of waste tanks and tank farm parameters has existed since the waste tanks were first used. The existing systems currently monitor and control tanks and equipment that support waste storage, waste transfers, and utility systems. Initially, the existing systems consisted of sensors, transmitters, panel board meters, annunciator panels, and relays that aided operators in controlling the various processes (e.g., leak detection, tank ventilation, transfer pump operation). Computer-controlled automated monitoring was added to a large portion of the tank farm instrumentation in 1978. This system was called the Computer Automated Surveillance System (CASS). It provided a centralized monitoring station that was staffed continuously by operators; consequently, the number of staff required to monitor the many tank farm parameters was reduced.

TMACS is the computerized system that now provides integrated monitoring of DST farms and SST farms. This monitoring system was provided in 1991 in response to Public Law 101-510, Section 3137, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation" (U.S. Congress 1990). This law addressed safety concerns for 50 Hanford Site waste tanks that involved ferrocyanide, high-heat, hydrogen, and tank leakage issues. TMACS monitors vital waste storage parameters and provides the information necessary to assess and ensure the safety of these tanks. It has been expanded and improved over the years, replacing CASS, and will continue to support tank farm monitoring and control and to fulfill the requirements of Public Law 101-510.

TMACS thus presently serves the function of a DST monitoring system and a Tank Farm master monitoring system; it is the only Sitewide tank farm data acquisition system in existence at the Hanford Site. However, the WFD mission requires monitoring and controlling dynamic functions, such as preparing waste for transfer by utilizing mixer pumps and transferring waste to staging tanks and/or to the Privatization Contractor. Because TMACS is primarily a data acquisition system for monitoring (not controlling) the storage conditions of waste, the DST Monitor and Control Subsystem was included in the DST architectural tree to provide a system that will monitor and control dynamic processes. Therefore, certain sensors monitored by TMACS also will be monitored by the DST Monitor and Control Subsystem, principally those sensor signals required for process control and safety interlocks for retrieval activities such as waste level and temperature and tank head-space pressure. Other TMACS-monitored parameters will be linked to the Tank Farm Master Monitor and Control System so that TMACS data can be available throughout the tank farm complex instead of just at the three locations where the data presently are available. This is shown in Figure 2-3 and more empirically in Figure 4-1, which is a diagram of the DST Monitor and Control Subsystem interfaces.

Figure 4-1 shows the interface of the DST Monitor and Control Subsystem with the other elements of the DST architectural tree. The signals shown between the DST subsystems and the DST Monitor and Control Subsystem are general and are not a complete listing. The DST Monitor and Control Subsystem specification will provide a more detailed analysis of the interface signals. Monitoring and control includes the receiving of the signal, signal processing, interlock logic, operator-interface station display, and recording and transmitting data to a

Figure 4-1. Double-Shell Tank Monitor and Control Interface Diagram.





Sitewide data communication network, which is the Master Monitor and Control System. The process sensors and transmitters are provided by the various DST subsystems. DST monitor and control data also may be received from TMACS via the Master Monitor and Control System data link between the two systems, as explained in the previous paragraph. Therefore, in the following text, where the statement is made that the DST Monitor and Control System monitors a certain parameter, the source of the data may be TMACS via the data link or the DST Monitor and Control input/output devices.

The DST Instrument and Control Subsystem, shown as a subsystem of the DST Monitor and Control Subsystem in Figures 2-2 and 4-1, includes tank dome intrusive equipment such as the tank closed-circuit television camera and the tank vapor space pressure sensor. This subsystem also includes waste-intrusive equipment such as temperature probes, waste-level instruments, and any waste rheology instrumentation. Finally, the subsystem includes tank bottom annulus leak detectors and annulus pit leak detectors. The DST Instrument and Control Subsystem thus comprises equipment that are components associated with the tank waste Confinement Subsystem but that are not architecturally (Figure 2-2) linked to that subsystem. This is because it has been determined that there will not be a formal specification for the Confinement Subsystem, because the waste tanks are the major component and are existing structures that will not require modification. The DST Instrument and Control Subsystem will be addressed in greater detail in the DST Monitor and Control Subsystem specification.

The DST Master Pump Shutdown System (MPSS), shown as a subsystem of the DST Monitor and Control Subsystem in Figures 2-2 and 4-1, includes portions of the existing MPSS and proposed new MPSS equipment. The MPSS system receives waste leak signals and/or incorrect transfer piping valve alignment signals, which the system uses to prevent or terminate operation of the transfer pump associated with the transfer. Existing and new MPSS sensors will be monitored by the DST Monitor and Control Subsystem. The MPSS will be addressed in greater detail in the DST Monitor and Control Subsystem specification.

The DST monitor and control interface for each element in the DST facility architecture tree is discussed below.

#### **4.1 DOUBLE-SHELL TANK STORAGE FUNCTION**

The DST Storage System includes all of the 200 East and 200 West Area DSTs. There are three DSTs in the 200 West Area at SY Tank Farm and 25 DSTs in the 200 East Area at tank farms AY (two tanks), AZ (two tanks), AN (seven tanks), AW (six tanks), and AP (eight tanks). The DST Storage System plays a role in accomplishing the five third-tier Store DST Waste functions as described in HNF-5136 and listed below:

- Control DST Chemical Composition
- Control DST Tank and Waste Temperature
- Control DST Hydrostatic Loads
- Control DST Primary Confinement Leaks
- Control DST Gaseous Discharge.

The following narrative explains the role of the DST Monitor and Control Subsystem that is required to support the DST storage functions listed above. Some DST Monitor and Control Subsystem operations are required by existing authorization basis documents, and other operations facilitate the WFD activities. The current basis for DST Monitor and Control Subsystem operations, which perform the following functions, are explained in HNF-5136 and are not repeated in this document. As the authorization basis amendments and additional regulations, standards, and formal agreements for WFD are developed, these additional requirements will be addressed in revisions to HNF-5136 and in the forthcoming DST Monitor and Control Subsystem specification.

Therefore, the terms “monitor” and “control” used in the remainder of Section 4.0 of this document refer to the DST Monitor and Control Subsystem receiving a signal from a device in the tank farm or receiving data from a digital data link to the Master Monitor and Control System and then performing an operation based on that signal. The operation may be a display of the data, an alarm, an interlock, a closed-loop control function, or a combination of these actions. This provides a general basis for the DST Monitor and Control interface to the other subsystems that empirically identifies the scope and boundaries of the system. The DST Monitor and Control Subsystem specification then will provide a more detailed development of the subsystem requirements. The DST Monitor and Control Subsystem supports DST functions as follows.

- The DST Monitor and Control Subsystem does not require an interface with the Control DST Chemical Composition function. The chemical composition is determined by sampling.
- The DST Monitor and Control Subsystem performs a portion of the DST Tank and Waste Temperature function by monitoring tank structural, dome, and bottom thermocouples and monitoring tank waste intrusive temperature probes containing thermocouples or resistance temperature detectors.
- The DST Monitor and Control Subsystem performs a portion of the Control DST Hydrostatic Loads function by monitoring waste tank level, head space pressure, and annulus pressure.
- The DST Monitor and Control Subsystem performs a portion of the Control DST Primary Confinement Leaks function by performing the monitoring of annulus pit leak detectors and tank bottom annulus leak detectors.

The DST Monitor and Control Subsystem performs the Control DST Gaseous Discharge function as follows:

- Monitors and/or controls toxic emissions by monitoring exhaust stack emissions analyzers where required
- Monitors and/or controls flammable gas concentrations in DSTs by monitoring the Standard Hydrogen Monitor System
- Monitors and/or controls radiological emissions by monitoring annulus and primary tank exhaust radiation detectors.

## **4.2 DOUBLE-SHELL TANK TRANSFER WASTE FUNCTION**

The Transfer Waste functions involve the transfer of waste between DST facilities or the transfer of waste between the DST System facilities external to the DST System. Waste received into the DST System includes waste from SSTs, the evaporator, and the private waste immobilization contractor, and waste from various 200 East and 200 West Area processing facilities and laboratories.

The third-tier functions for the Transfer Waste function are as follows:

- Establish Transfer Route for Waste Transfer
- Provide Diluent during Transfers
- Convey Waste
- Confine Waste along Transfer Route
- Confine Waste Leakage along Transfer Route
- Flush Transfer System
- Drain Transfer Piping
- Perform Material Balance for DST Transfers
- Reconfigure Transfer Route.

These functions are decomposed further in HNF-5136 and will be addressed in the DST Monitor and Control Subsystem specification. The following discussion details the interface of the above functions to the DST Monitor and Control Subsystem.

- The DST Monitor and Control Subsystem performs a portion of the Establish Transfer Route for Waste Transfer function by providing to the operator positive remote indication of valve position to establish and provide confirmation of the transfer route. In some instances, the operator will be able to establish portions of the transfer route by remotely actuating valves from the operator console. The subsystem also will monitor and control waste transfers to and from the privatization contractor. This function is performed by the Master Pump Shutdown System component of the DST Monitor and Control Subsystem.
- The DST Monitor and Control Subsystem performs a portion of the Provide Diluent During Transfers function by monitoring and controlling diluent parameters such as flow, temperature, and pressure.
- The DST Monitor and Control Subsystem performs a portion of the Convey Waste function by monitoring the position of the transfer pump suction intake; measuring total water/diluent additions; and monitoring flow rate of water/diluent additions and the transfer stream, transfer stream temperature corrected density, pressures in the transfer line, waste levels in the source and destination tanks where applicable, transfer pump rotation speed and power consumption, and transfer route configuration.

- The DST Monitor and Control Subsystem performs a portion of the Confine Waste Along Transfer Route function by monitoring for leaks within transfer-associated structures and monitoring for leaks from the transfer piping primary containment boundary. This is performed by the Master Pump Shutdown System, which is an element of the DST Monitor and Control Subsystem.
- No interface is identified between the DST Monitor and Control Subsystem and the Confine Waste Leakage Along Transfer Route function.
- The DST Monitor and Control Subsystem performs a portion of the Flush Transfer System function, which is the same as that performed for the Provide Diluent During Transfers function.
- No interface is identified between the DST Monitor and Control Subsystem and the Drain Transfer Piping function.
- No interface is identified between the DST Monitor and Control Subsystem and the Perform Material Balance for DST Transfers function. The DST Monitor and Control Subsystem monitors waste levels in source and receiving tanks, but the performance of a material balance currently is an administrative activity.
- The DST Monitor and Control Subsystem interface with the Reconfigure Transfer Route function is the same as with the Establish Transfer Route for Waste Transfer function.

#### **4.3 DOUBLE-SHELL TANK PREPARE WASTE FUNCTION**

The Prepare Waste function includes operations performed on the stored waste to support preparing waste for transfer to a staging tank or for transfer to the privatization contractor. The Prepare Waste function consists of the following:

- Prepare Waste in 200 East Area DSTs
- Prepare Waste in 200 West Area DSTs
- Prepare Low-Activity Waste (LAW) in LAW Staging Tanks
- Prepare High-Level Waste (HLW) Sludges in HLW Staging Tanks.

The DST Monitor and Control Subsystem performs the following for the DST Prepare Waste function.

- The DST Monitor and Control Subsystem performs a portion of the DST Prepare Waste in the 200 East Area DSTs function by monitoring and/or controlling mixer pump operational parameters such as rotational speed, motor power consumption, and nozzle orientation, and providing mixer pump shutdown interlocks. The LAW and HLW Process Control Strategies may require additional DST Monitor and Control Subsystem interfaces with this function, such as monitoring rheology instrumentation and/or pumped sampling and analysis instruments. A pumped sampling system consists of a riser-

mounted pump, flexible sampling tube, packaging chamber, and shielding that would replace the current grab sampling methodology.

- The DST Monitor and Control Subsystem interfaces with the DST Prepare Waste in the 200 West Area DSTs function are the same as for the same function in the 200 East Area DSTs.
- The DST Monitor and Control Subsystem performs a portion of the Prepare LAW in LAW Staging Tanks function by monitoring and/or controlling mixer pump operational parameters such as rotational speed, motor power consumption, and nozzle orientation, and providing mixer pump shutdown interlocks. Additional interfaces may be required by the LAW process control strategies, such as monitoring rheology instrumentation and/or pumped sampling and analysis instruments.
- The DST Monitor and Control interface with the Prepare HLW Sludges in HLW Staging Tanks function is the same as the interface with Prepare LAW in LAW Staging Tanks function, as well as any additional interfaces that may be required by the HLW Process Control Strategies.

#### **4.4 DOUBLE-SHELL TANK UTILITIES**

The DST Utilities Subsystem provides electrical power, raw and potable water, and service and instrument air to support the systems used to maintain safe storage within the DSTs; to process, stage, and transfer LAW and HLW feed to the privatization contractor; and to receive and manage routine waste receipts. The DST Utilities Subsystem as provided by the system breakdown structure consists of the following:

- DST Electrical Power Subsystem
- DST Raw Water Subsystem
- DST Potable Water Subsystem
- DST Service Air Subsystem
- DST Instrument Air Subsystem.

A general description of the DST Monitor and Control interface with the DST Utilities Subsystem is as follows.

- The DST Monitor and Control Subsystem interfaces with the DST Electrical Power Subsystem by receiving power from the DST Electrical Power Subsystem to energize instrumentation loops, signal conditioners, input/output devices, programmable logic controllers, operator interface stations, computers, servers, and data storage devices.
- The DST Monitor and Control Subsystem interfaces with the DST Raw Water Subsystem by monitoring, displaying, and recording raw water flow to aid in tank farm operations.
- The DST Monitor and Control Subsystem does not require an interface to the DST Potable Water Subsystem.

- The DST Monitor and Control Subsystem interfaces with the DST Service Air Subsystem by monitoring service air header pressure.
- The DST Monitor and Control Subsystem interfaces with the DST Instrument Air Subsystem by monitoring instrument air header pressure.

## 5.0 CONCLUSION

The above discussion about the DST System decomposition and the DST Monitor and Control Subsystem results in the following DST Monitor and Control Subsystem description.

*The DST Monitor and Control Subsystem consists of new and existing equipment used to provide tank farm operators integrated local monitoring and control of the DST System. New equipment will provide operators with visibility into the status of DST subsystems, status of subsystem operations (e.g., DST mixer pump operation and DST waste transfers), and the ability to permit/shut down a given operation, as necessary. The DST Monitor and Control Subsystem operator interface stations at individual tank farms will be connected together by the Master Monitor and Control System function to provide Sitewide data communication. The DST Monitor and Control Subsystem is not a specific DST System function; it supports the entire DST System. The DST Monitor and Control Subsystem provides the equipment and the interfaces to monitor and/or control the following functions to support the WFD mission.*

- (a) Receive Data from or Transmit Data to the Tank Farm Monitor and Control System*
- (b) Monitor and/or Control Master Pump Shutdown System*
- (c) Monitor and/or Control DST Instrument and Control Subsystem*
- (d) Monitor and/or Control Cross-Site Transfer System*
- (e) Monitor and/or Control DST Ventilation Subsystem*
- (f) Monitor and/or Control DST Confinement Subsystem*
- (g) Monitor and/or Control DST Diluent and Flush Subsystem*
- (h) Monitor and/or Control DST Mixer Pump Subsystem*
- (i) Monitor and/or Control DST Utilities Subsystem*
- (j) Monitor and/or Control DST Transfer Pump Subsystem*
- (k) Monitor and/or Control DST Transfer Valving Subsystem*
- (l) Monitor and/or Control DST Transfer Piping Subsystem.*

*The DST Monitor and Control Subsystem equipment and interfaces required to monitor and/or control the above consist of the following:*

- (a) Input/output modules*
- (b) Sensors and transmitters not provided by the other subsystems*
- (c) Programmable logic controllers*
- (d) Operator computer interface stations*
- (e) Operator computer work stations*
- (f) Software*
- (g) Battery-powered uninterruptable power supplies*
- (h) Data communication highways and associated equipment*
- (i) Network servers and data archiving, trending, and reporting equipment*
- (j) Existing DST farm panel boards, annunciators, indicators, recorders, etc. as required.*

## 6.0 REFERENCES

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