INTEGRATED INSTRUMENT PLATFORM FOR IN SITU CHARACTERIZATION OF TANK WASTES

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ABSTRACT

An integrated instrument platform will support robotic characterization of radioactive chemical waste materials in the underground storage tanks at the Department of Energy's Hanford Site in Richland, Washington. The support platform supplies the basic support infrastructure needed to perform remotely controlled robotic deployment of sensors. A trailer serves as a field operations center, providing power and utilities, data acquisition and control equipment, common instrumentation, and test equipment. As part of the platform development effort, information on operational requirements and interface specifications is being compiled and distributed to potential suppliers of instrumentation. An overall characterization strategy has been developed, incorporating the currently identified characterization missions. This strategy will evolve over time and should provide a baseline to assist in planning for future deployment of characterization technology.

INTRODUCTION

An integrated instrument platform for in situ characterization of tank wastes is being developed to support characterization and eventual retrieval of the underground waste storage tanks at the Hanford Site in the state of Washington. This integrated platform will comprise a deployment device to position sensors and probes inside the tank, a number of sensors and sampling devices, and an extensive support platform to allow remote operations and control of the devices. The goal is to provide components of a modular system that will allow the use of several deployment devices as well as a large number of sensors and probes. A significant systems integration effort is required to incorporate the deployment device, sensors, and support system into an integrated system and to test all operations before deployment in the waste tanks.

The Hanford Site includes 177 underground waste storage tanks, each one containing from 200,000 to 4,000,000 L (50,000 up to 1,000,000 gal) of mixed chemical radioactive wastes. Most of the tanks are approximately 24 m (75 ft) in diameter and 11 to 15 m (37 to 51 ft) high, buried under at least 2 m (6 ft) of soil, with limited access through a small number of ports or "risers," many only 10 to 30 cm (4 to 12 in.) in diameter.

The current plan for tank material characterization stemming from the *Hanford Federal Facility Agreement and Consent Order* (1), commonly called the Tri-Party Agreement, requires that two full depth core samples be taken from each tank so that laboratory analyses may be performed on the samples. The laboratory analysis process is costly and time consuming, provides increased risk for exposure to personnel to the caustic, radioactive materials, and generates additional waste that cannot be placed back into the tanks. In addition, core sampling methods are limited to the areas directly beneath existing risers. There is no way of ensuring that core sample analysis provides information that is truly representative of the entire tank. Some of the limitations of core sample analysis may be overcome by the implementation of in situ waste tank material characterization methods.

IN SITU CHARACTERIZATION

In situ characterization sensors and improved sample screening methods for hot cell analysis may provide complementary analyses to those obtained from core sampling. Implementation of these improvements requires development of both sensor and deployment technologies and engineering of those technologies to meet field operational requirements. Many of these activities are coordinated through a characterization system integration task operating under the Underground Storage Tank Integrated Demonstration.

The development and implementation of methods for in situ characterization of the waste tank contents will facilitate the interim stabilization and final retrieval of the tank materials. In situ characterization methods allow determination of many waste properties without the removal of materials, personnel exposure, and generation of new waste. Many physical properties, such as hardness or viscosity, are best measured with the material in place, as physical removal could alter these properties.

In situ characterization of underground waste storage tanks requires both deployable sensors and deployment mechanisms capable of positioning the sensors in the tanks. Probes designed for in-tank use may be combined with robotic deployment systems to allow the detailed mapping, sensing, and sampling of large areas of the tank interior, rather than just the area under risers.

A large number of promising technologies are being developed for remote and in situ characterization. Technology sources include the national laboratories and other government sponsored research facilities, universities, and commercial companies. Instruments and sensors are needed to address the characterization of waste material chemical, physical, and radiological properties. Technologies for these applications vary in maturity, from benchtop novelties to field instruments that have been used and tested for years.

The earliest in-tank deployment of characterization technology will use mature technologies that require engineering to be deployed and operated in the harsh environment. As an example, mature technologies for nondestructive chemical speciation include Raman and infrared spectroscopy, both of which have potential to be deployed in situ using optical fiber probes. In situ measurement of physical properties, including hardness, viscosity, abrasiveness, and density, are not as readily addressed with commercially available instruments. More development is expected before a suite of sensors is ready to measure the required physical properties.

The development of an integrated instrument platform for waste characterization will bring instruments from the laboratory or prototype stages and facilitate their integration into a field deployable system. A series of deployment stages are planned, beginning with hot cell demonstration of surface scanning instruments. Demonstrations will progress through several increasingly complex and capable robotic deployment mechanisms for in-tank deployment. The first deployment device is expected to be a simple extendable mast that will be capable of lowering a sensor package to the waste surface or penetrating soft wastes. It will be deployed in 1994 to provide initial characterization data including video and still imagery, radiation doses, and chemical speciation from Raman spectroscopy.

A true robotic system, the Light Duty Utility Arm, is planned for in-tank deployment in the 1995 time frame. This system will include a six degree-of-freedom robotic arm with a reach of 2.4 to 3.0 m (8 to 10 ft). This flexible robot arm will support the characterization of many different points on the waste surface and perhaps depth profiling as well. The sensor complement will expand to include additional chemical sensors and physical property sensors.

The initial characterization systems will provide the groundwork to allow more complex robotic retrieval systems to be placed in the tanks in the future. Robotic retrieval of waste will require a high degree of automation and will be supported by many of the sensors and instruments initially tested with the Early Deployment System and Light-Duty Utility Arm.

CHARACTERIZATION FIELD SUPPORT SYSTEM

The variety of deployment devices and sensors under consideration share a number of common needs, in addition to the need for an overall control system, data handling system, and operations center. The Characterization Field Support System (Fig. 1) is designed to meet these common needs. The Characterization Field Support System provides the basic infrastructure required for any type of deployment system in the tank, including shelter and environmental control for instruments, a common data acquisition and handling unit, support for deployment mechanism and instrument control, test equipment, and safety monitoring equipment.

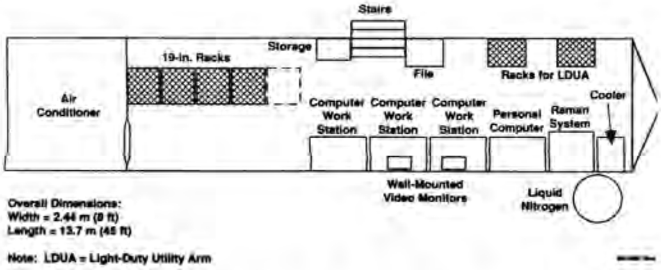

Fig. 1. A diagram showing the physical layout of the Characterization Field Support System. A field trailer provides power and utilities, acts as an operations center for personnel, and houses data acquisition and control equipment, instrumentation and test equipment.

As part of the development associated with the Characterization Field Support System, the developers will communicate characterization needs to technology providers and match technologies to needs. The requirements on sensors and deployment mechanisms from the hostile tank environment (e.g., radiation levels of 200 to 700 r/hour, high pH) will be communicated to providers of technology to ensure operability. The integration effort defines the requirements levied on the instruments and deployment mechanisms by the operational users and provides a strategy to assist instrument developers in meeting requirements to bring instruments to deployment readiness. Common interfaces between elements of a complete characterization system (mechanical, electrical, and data format interfaces) are being defined so that future technology may be integrated into a system readily.

CHARACTERIZATION STRATEGY

A characterization strategy has been developed as part of this effort, an outline of which is shown in Fig. 2. The strategy addresses characterization technology development and deployment from the perspective of the robotic *characterization* and retrieval programs. The strategy has been developed in close coordination with the waste tank operations organizations and the Tank Waste Remediation System. It is intended that this strategy will evolve over time as work on tank characterization and retrieval progresses.

The initial strategy takes into account the needs of the waste tank operations personnel to address ongoing safety concerns for the tanks, as well as the needs of the tank retrieval personnel who require characterization information both before and during retrieval processes. The strategy diagram (Fig. 2) shows how these needs are combined with known constraints to begin the process of assessing available characterization technology. As dates are determined for various characterization and retrieval activities (e.g., deployment of the Early Deployment System), they are incorporated into the strategy. The strategy may thus be used to develop plans and schedules to show how specific technology efforts fit into the overall process of characterizing and retrieving the tank waste.

The characterization strategy considers the steps that instruments and sensors will go through to become validated for operations in a hot cell or tank environment. It defines the series of useful deliverable products and information that will result from each stage. For example, hot cell testing and validation of instruments will perform two roles. First, it provides anenvironment where instruments may be tested using real waste materials but without the severe operational constraints of in-tank operation. Hot cell testing allows calibration, instrument adjustments, identification of problem areas, and development of methods in a controlled environment. Second, hot cell testing of new technology will contribute to the deployment of operational hot cell material scanning systems to support the analytic chemistry laboratories.

In addition, the strategy defines the questions to be addressed at each stage in the progression of deployment demonstrations and shows how the answers to those questions will be used to support the next stage in development. For example, in-tank deployment of chemical or physical property sensors at an early stage will provide critical information for

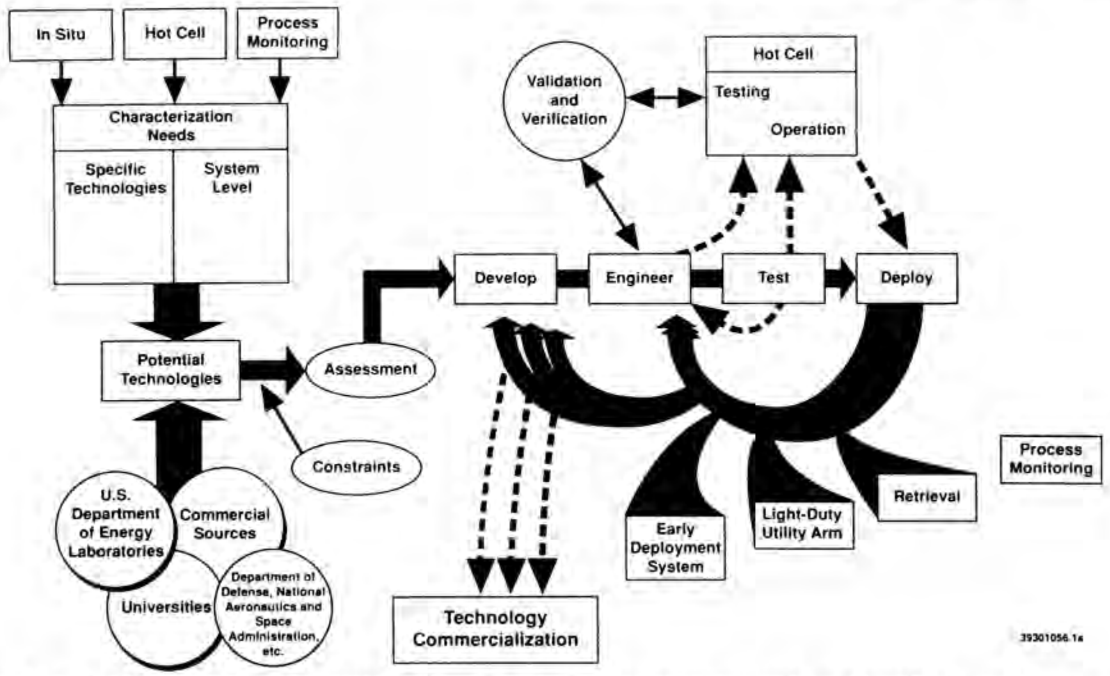

Fig. 2. An outline of the characterization strategy shows how technology progresses from identification of needs and potential technologies to implementation. The process is iterative, with the lessons learned at each cycle being applied in the next iteration.

the planning of retrieval protocols and waste pretreatment methods. A key part of this effort is to ensure that several separate demonstrations of in-tank characterization technology are indeed a series of stepping stones, each using the results of the previous demonstration, rather than a set of unconnected efforts.

CONCLUSION

This activity provides a focal point for the many laboratories and commercial companies that are producing instrumentation and deployment mechanisms that may be required for tank waste characterization and retrieval operations. By communicating information about needs and requirements to the development organizations in a timely fashion, it will reduce delays in bringing valuable technology to the field. The early definition of an overall characterization strategy also allows identification of areas requiring critical development before the process can proceed. This integrated approach ensures that all the pieces will be in place as needed to demonstrate the technologies that will lead to successful remediation of the waste tank problem.

REFERENCE

1. Ecology, EPA, and DOE, 1989 as amended, *Hanford Federal Facility Agreement and Consent Order*, Washington State Department of Ecology, U.S. Environmental Protection Agency, U.S. Department of Energy, May 1989, Olympia, Washington.