Determining the Adequacy of Process Knowledge for Facilities to Be Transitioned to Deactivation and Decommissioning (D&D) - 9002

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ABSTRACT

The objective of this paper is to identify the key elements of the body of process knowledge (PK) about a facility that are highly desirable, if not essential, to have in hand when planning for D&D of that facility. If such a body of PK is available, the D&D project cost and schedule will be greatly improved over the situation in which the required PK is not available to the integrated project team (IPT). In addition, a full body of PK will likely result in reduced health and safety risk to D&D workers. The scale of the Department of Energy (DOE) D&D program and the complexity of situations that must be addressed add weight to the importance of understanding the benefits of assembling an acceptable level of PK early in project planning. Thorough understanding of the radiological and chemical process history of systems, structures, and components informs the facility characterization effort, greatly improving characterization efficiency, with resultant reduction in cost and schedule. A full body of PK may nearly eliminate the need for a costly and time-consuming sample and/or survey program.

INTRODUCTION

The Department of Energy (DOE) Office of Environmental Management (EM) is responsible for a vast number of facilities at numerous sites around the country which have been declared excess to current mission needs. In addition, there are hundreds of additional facilities from other DOE program offices such as the National Nuclear Security Agency, the Office of Science and the Office of Nuclear Energy which have reached or soon will reach the end of their useful life. These facilities are also being considered for transfer into the EM program for ultimate disposition. They are typically old, some dating back to the Manhattan project of World War II. They often have had multiple missions involving different production processes over their lifecycle. DOE-EM is interested in identifying the minimum body of process knowledge (PK) about such facilities which must be assembled to allow their safe and efficient D&D.

Additionally, since the end of the cold war and the termination of weapons production, many of these facilities have been in a state of surveillance and maintenance (S&M) with minimal budget. They have typically been used for storage of legacy materials and equipment that originated in other facilities at their sites. This occurred because it was more economical to simply transfer legacy materials and equipment from one facility to another rather than characterize and properly dispose of them.

When such excess facilities are scheduled for D&D, the responsible project team is faced with the task of evaluating them to plan for the removal, characterization and disposition of all legacy materials and process equipment. The characterization process is considerably easier if equipment design information is available that addresses potential material holdup (e.g. internals that may have surface contamination or contain bulk materials), weights, and potential presence of hazardous materials (beryllium, lead, cadmium, etc.). Knowledge of the types of process materials that flowed through the equipment during its operational history is highly desirable, as well. Furthermore, the equipment removal activity is easier if the way it was designed and installed is known.

Methodology Used to Assess Process Knowledge Acquisition in the Complex

Organizations across a wide spectrum of industries are concerned with managing the knowledge that they need to successfully achieve organizational objectives. This need has fostered the creation of the rapidly evolving discipline of knowledge management (KM). The general tools and techniques developed by the leaders in the KM field are applicable to the specific needs of organizations interested in PK management. Therefore, the initial activity in this work was a survey of the general field of KM, with the goal identifying KM strategies that could be implemented by D&D IPTs to manage the process of PK acquisition.

Next, Lines of Inquiry (LOI) were developed to assess how various organizations in the DOE complex acquire and use PK for D&D projects. These LOI were sent via email to several DOE sites. Responses were received from Hanford, the Savannah River Site (SRS) and the Paducah gaseous diffusion plant. Telephone discussions were initiated with personnel at Sandia National Lab (SNL), Lawrence Livermore National Lab (LLNL), and the East Tennessee Technology Park. LLNL and SNL provided electronic copies of the documents that control their historical information gathering process. SNL was also visited to discuss its exceptional PK management program in greater detail.

Finally, the PK management practices of the Department of Defense and the commercial nuclear industry that are potentially relevant to D&D of DOE facilities were surveyed. A literature search of US Army Corps of Engineers (USACE) publications was performed to identify USACE experience in this area. The Electric Power Research Institute (EPRI), which conducts research and development for the global electricity sector, recognizes that PK management is a significant issue in all phases of the nuclear power plant lifecycle, including decommissioning. Several EPRI documents which address the issue of PK management were reviewed.

It is anticipated that the following groups will find this guidance helpful:

- D&D contractors who may have limited experience in the process design, construction and operation of the kinds of facilities typically found at DOE sites. These contractors may also have limited knowledge of the kinds of administrative and document repository systems, which are typically in place at DOE sites. Such administrative systems require that certain types of documents (design drawings, equipment information provided by vendors, incident reports, etc.) be prepared, maintained current, and stored for retrieval as needed.
- Personnel familiar with operations at DOE facilities, but who have limited experience in conducting D&D projects. Information is provided to these users to help them understand what data is useful for the D&D IPT. These users may be tasked with assembling a PK package for a facility to be deactivated and placed in initial S&M for an extended period of time until the facility is eventually funded for final D&D. Such packages may be archived during the extended period of S&M during which the experienced personnel who operated the facility may disappear.

Knowledge Management Concepts

Although there is no universally accepted definition of KM, it is generally agreed that KM is the creation, capture, storage, availability and utilization of information, knowledge, and experience [1]. EPRI reviewed then-current KM practices with the objective of developing methods for capturing high-value undocumented knowledge in the nuclear power industry. EPRI concluded that methods and technology are available to help nuclear power operators retrieve, present and store valuable undocumented knowledge for future use [1]. These methods are also available to D&D IPTs for use in gathering the knowledge needed for safe and effective D&D of DOE facilities.

All knowledge is either explicit or tacit. Explicit knowledge is the type of knowledge which can be recorded in familiar documents such as drawings, specifications, reports and manuals. Explicit knowledge may or not have yet been recorded. Explicit knowledge is distinguished from tacit knowledge by the fact that it is defined to the extent that it could be documented, although it may not yet have been. Undocumented explicit knowledge is in the minds of people. Once extracted, it is easily documented [1].

Tacit knowledge only exists in the minds of people. By definition it is undocumented. In some situations people possessing tacit knowledge may not even be aware of its importance or value. Tacit knowledge is valuable if its application to a relevant activity results in the activity being executed in safer or more efficient and effective manner than if the knowledge were not applied. Tacit knowledge may not be valuable if its application has limited or no positive impact on the activity to which it is applied. There is much tacit knowledge that is not valuable and not therefore worth capturing [1].

Among other names, tacit knowledge is also known as tribal or hidden knowledge. EPRI identified a type of tacit knowledge that relates to what it calls corporate history [1]. People who have been in an organization for many years have been exposed to key events, informal notes, documents and records and other people. They often have valuable knowledge in their heads or know where it might be found, whether it be in physical repositories or in the minds of others. These knowledgeable people are aware of the rationale behind specifications, procedures, designs and processes because they were there when these things were created or introduced [1]. Such knowledge may be relevant to D&D efforts and is therefore worth extracting or eliciting.

Valuable undocumented knowledge consists mainly of tacit knowledge but it may also involve explicit knowledge. Following elicitation, tacit knowledge becomes explicit. The process of extracting tacit knowledge from people is known as eliciting or harvesting the knowledge [2]. Tacit knowledge is made explicit by elicitation. EPRI suggests several methods for capturing and transforming elicited knowledge into a usable form [1]. Interview methods are perhaps the most familiar.

The following sequence of knowledge elicitation has been proposed [2]:

Focus: Determine what knowledge is being sought. Choose the appropriate strategies and techniques for eliciting the knowledge. Identify the target audience for the knowledge to be elicited and its specific needs.

Find: Find the experts whose knowledge is being sought and prepare to interview them by studying existing documentation that is relevant to the information being sought.

Elicit: Interview the experts. This is the key event in the elicitation process. Preferably it should be performed by someone with at least some training in knowledge harvesting. The elicitation goal is to fill gaps in the existing knowledge about the subject being investigated. A comprehensive interview requires significant effort by the elicitor before and after the actual interview. After the interview, the interviewer must then compare the information elicited with the needs of the users to verify that knowledge gaps have been closed as much as practical. Multiple iterations through the whole process may be necessary for maximum benefit.

Organize: Appropriately categorize the resulting information.

Package: Publish the knowledge in an electronic repository available to those who need it.

EPRI concluded that the most valuable tacit knowledge is often difficult to elicit [1]. Trained elicitors may be required. EPRI also noted that elicited knowledge from an expert should be considered invalid and should not be used by others until it is validated by appropriate personnel and approved as accurate and, therefore usable. Selection of knowledge elicitation methods is based on several factors, including the nature of expert and the background of the elicitor.

Advance preparation increases the effectiveness of knowledge elicitation and capture sessions. Procedures, maps, photos and drawings should be available at the interview to aid the interviewee to recall valuable information. The elicitor should be as knowledgeable as possible of the subject of the interview [3].

The critical decision method is an incident-based technique. A challenging incident is elicited from the expert. The elicitor leads the expert through the development of a time line. A basic record of what happened at what point in time, at what location within the system is created. This method may yield useful information about problems and incidents that occurred at each location and steps taken to correct the problem [3]. In the context of D&D, it may reveal undocumented incidents, (e.g. a major spill) and the action taken in response, (e.g. installing a steel liner or several inches of poured concrete over the contamination). Without this knowledge, the D&D IPT would encounter surprises during the D&D, resulting in schedule delays, increased costs and potential safety concerns.

Interview methods may be used alone or in combination with other methods and techniques to elicit valuable knowledge from experts. Many elicitors naturally use interview methods as an obvious way to obtain information. A dialogue is created with an expert. Questions are asked and answers recorded. Interviews may be structured or unstructured. Unstructured interviews usually involve a dialogue between the knowledge elicitor and the expert. The elicitor may ask open-ended questions about the expert's knowledge. As the interview progresses, the elicitor can add more structure. The results obtained from an unstructured interview can lead to a follow-up structured interview. Interviews require that the expert's responses to questions be recorded. This can be done by note taking or audio/video recording. The problems identified with unstructured interviews include loss of focus by the expert and inadequate technical knowledge by the elicitor.

Interviews with current or previous employees are performed to collect first-hand information about the site or facility and to verify or clarify information gathered from existing records. Interviews to collect first-hand information concerning the site or facility are generally conducted early in the data-gathering process. Interviews cover general topics, such as radioactive waste handling procedures. Results of early interviews are used to guide subsequent data collection activities [4].

Interviews scheduled late in the data gathering process may be especially useful. This activity allows questions to be directed to specific areas of the investigation that need additional information or clarification. Photographs and sketches can be used to assist the interviewer and allow the interviewees to recall information of interest. Conducting interviews onsite where the employees performed their tasks often stimulates memories and facilitates information gathering. In addition to interviewing managers, engineers, and facility workers, interviews may be conducted with other support personnel such as vendors to obtain information from their perspective. The investigator should be cautious in the use of interview information. Whenever possible, anecdotal evidence should be assessed for accuracy and results of interviews should be backed up with supporting data. Steps that ensure specific information is properly recorded may include hiring trained investigators and taking affidavits.

Definition of Process Knowledge for D&D

The following operational definition of PK for D&D is offered:

Process knowledge is that body of technical information about each process in a facility that will allow that process to be safely deactivated, its equipment decontaminated of residual process material (if required) and dispositioned in a manner to meet the final decommissioning end points.

Note that this definition goes beyond the information needed for waste characterization and includes the engineering information to deactivate the facility and prepare it for final decommissioning (either by demolition or in situ disposal). Process history (PH) is sometimes mistakenly used as a synonym for PK. It is clear from the above definition that PK encompasses a significantly greater body of knowledge than PH. PH is limited to the record of past production operations in a facility, including types of materials processed in various campaigns, material control and accountability (MC&A) records, spill and release records, incident reports, raw material use records, and waste characterization/disposal records. This information is necessary for D&D, but not sufficient. The engineering information that defines the facility design, construction and current configuration is needed to form the complete body of knowledge sufficient for D&D of the facility.

ELEMENTS OF PROCESS KNOWLEDGE DESIRABLE FOR D&D

The above definition indicates that PK is a body of technical information about a given process. The primary elements that make up a robust body of PK are discussed below.

Process Design

Several types of documents are commonly used to define the design of process of facilities in the process industries (e.g. chemical, paper, food and beverage chemicals, pharmaceuticals, petroleum, ceramics, base metals, plastics, rubber, textiles, tobacco, wood and wood products) in general and the nuclear industry in particular.

Engineering drawings and documents are used to sufficiently define the design of a process so that it may be constructed. In well managed facilities, these documents are maintained to match the current installed or as-built configuration. In fact, DOE O 420.1B, *Facility Safety*, defines a System Engineer Program for operating DOE nuclear facilities (hazard category 1, 2, and 3). Among other things, the program requires that the design basis of facility systems be kept current using formal change control and work control processes. Key process system design documents must be identified and consolidated to support facility operation. This body of design basis documentation forms the technical baseline for the facility during the operations and maintenance (O&M) lifecycle phase. Since many D&D tasks are similar to those performed during the O&M lifecycle phase, the O&M technical baseline is a key, if not an essential element of the PK required for safe and efficient facility D&D. To deactivate, dismantle and remove process systems safely and efficiently, it is necessary to know their design. Therefore accurate as-built process design information is an essential element of the PK needed for D&D.

This design information should be available for all hazard category 1, 2, and 3 facilities that operated after about 1990. For DOE process facilities whose hazard category is other than nuclear (i.e. radiological, chemical, or other industrial), the information may also be available because the same technical baseline requirements may have been applied for these facilities at some sites for consistency, even though not required by DOE order. If the facility ceased operations prior to 1990, the available technical baseline information is not likely to be as rigorous or accurate as for post-1990 facilities.

The categories of documents that define the design of a process typically include the following.

Process and instrumentation diagrams (P&IDs, sometimes also called piping and instrumentation diagrams) schematically identify equipment items such as vessels, heat exchangers, pumps, valves and the piping that interconnects them. The PK presented on these drawings is extremely useful for preparing tap and drain plans and estimating waste volume. Documented knowledge typically depicted on P&IDs of the equipment materials of construction and the nature of the process materials that may still be present as contaminants in the equipment is often sufficient to characterize the equipment and associated process materials for disposal. The P&ID for a process is one of the most useful elements of PK needed for D&D. An example of a simplified P&ID is shown in Fig. 1.

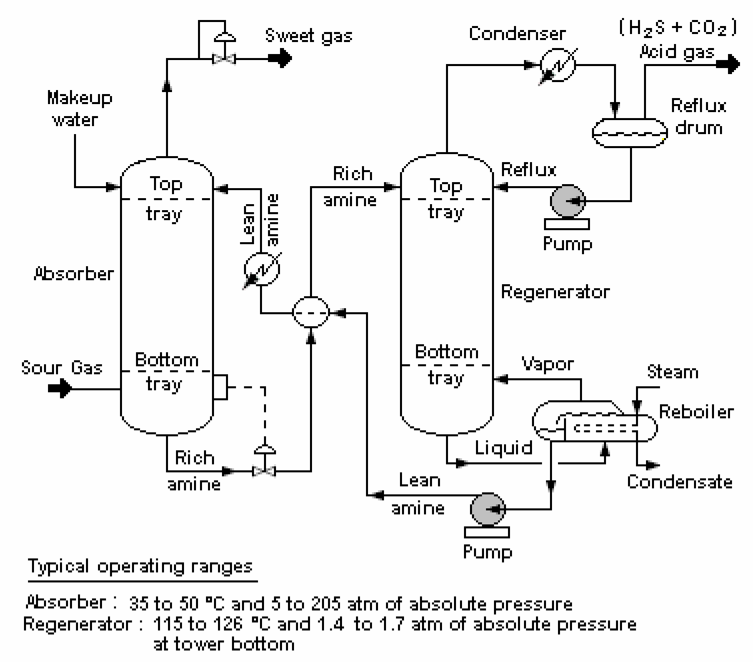
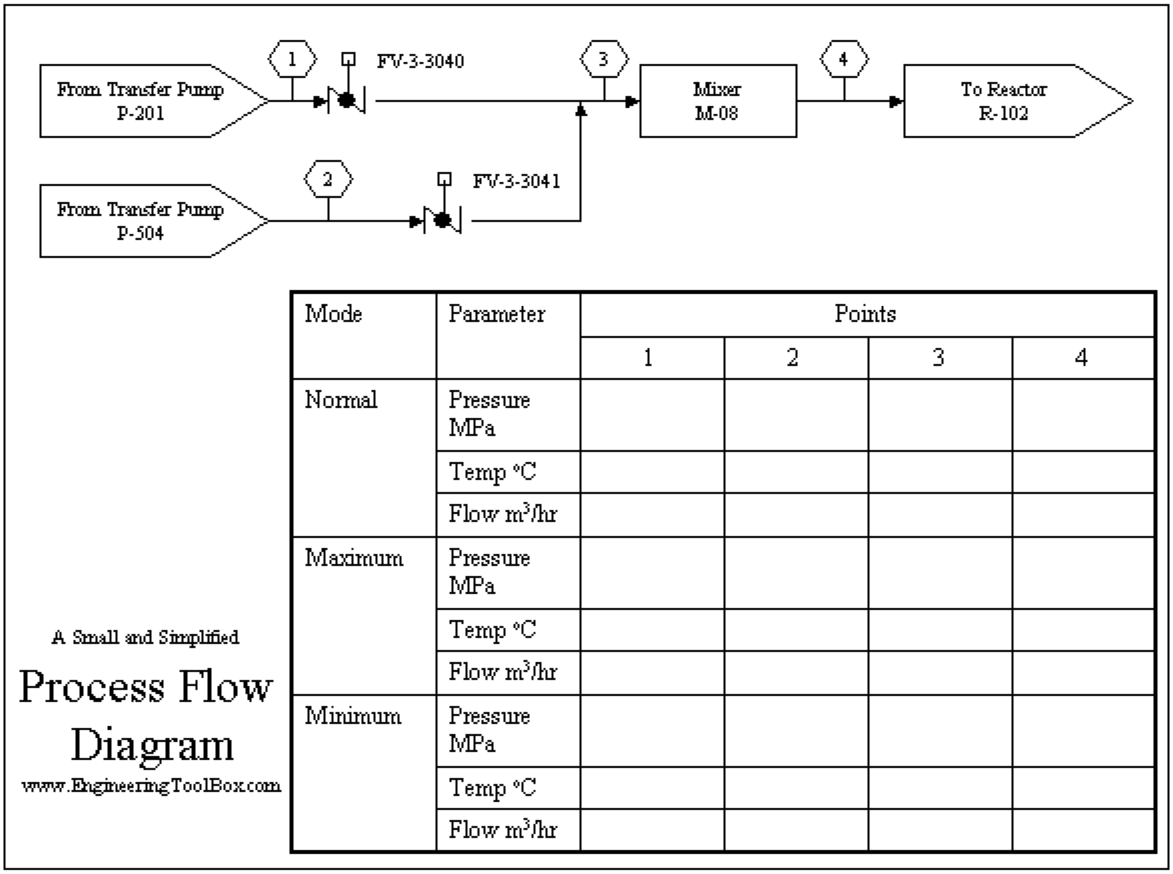


Fig. 1. Example of a Process and Instrument Diagram [5].

Process flow diagrams present a higher level view of the process design than P&IDs. Individual equipment items are not shown. Process unit operations and materials are typically shown schematically using blocks with arrows used to show the interconnecting material flow paths. A sample flow diagram is shown in Fig. 2.



Mode	Parameter	Points			
		1	2	3	4
Normal	Pressure MPa				
	Temp °C				
	Flow m^3/hr				
Maximum	Pressure MPa				
	Temp °C				
	Flow m^3/hr				
Minimum	Pressure MPa				
	Temp °C				
	Flow m^3/hr				

Fig. 2. Example Process Flow Diagram [6]

Process flow diagrams help D&D engineers know what materials flowed through the various process unit operations and individual equipment items such as tanks, pumps, and piping. Although not shown in the Fig. 2 example, they may even allow compositions or concentrations of specific process chemicals and radionuclides to be determined at various points in the process. Consequently, they are a significant element of the body of PK needed for facility D&D.

Often the characteristics of process feed materials and products are controlled by documented material specifications. For example, the isotopic distribution or chemical composition of a feed or product stream may be administratively controlled by written specification. This PK may be sufficient to characterize materials and items contaminated with those materials for disposal as waste. Likewise, procurement specifications for equipment items often provide good information that can aid in dismantling and disposing of equipment.

Newer facilities usually have a master equipment list (MEL). In fact maintaining an up-to-date MEL is required by the DOE system engineer program. If available, the MEL is an excellent starting point for D&D planning. If not available, the scope of equipment removal required for D&D will have to be developed from facility walkdowns.

The instrument list is useful in identifying components that will require removal and management as RCRA hazardous waste. For example, the list may make it possible to easily identify mercury

thermostats and switches, components with circuit boards, and brass constituents that must be segregated and managed as hazardous waste.
During process design, a list or table of process lines is typically developed. This list usually identifies each line by line number. Such information is useful for the same reasons discussed above for PI&Ds.

System design descriptions (SDDs) are sometimes available for newer facilities. Well done SDDs provide a wealth of information on facility systems which is extremely useful for D&D planning.

Valve lists are useful to aid in identifying the number of brass and bronze valves that may need to be managed as hazardous waste due to lead content.

Vendor print files and technical manuals are very useful in identifying critical information about individual equipment items such as composition of equipment internals (lead, brass, beryllium, etc.), surface areas that may have been exposed to contamination, and void spaces where bulk process materials may have accumulated. This information is also helpful in characterizing the equipment for disposal and in planning for removal and size reduction of the equipment for packaging and disposal.

Operations training manuals have proven to be very useful for D&D planning. They provide knowledge of how the process operated, which is not always obvious from drawings alone. In fact, a well prepared training manual may possibly be the best single source of information about a process because it often includes up to date flow diagrams and simplified P&IDs.

Safety basis documents discuss the processes that are authorized by DOE to operate in the facility and types of materials that can be processed. They often give insight into location of hazardous materials in the facility. The following documents comprising the facility's authorization basis for operations, deactivation, and/or S&M, should be examined if available [7]:

- Safety Analysis Report (or Safety Assessment)
- Other Safety Analyses
- Hazard Classification Documents (or Preliminary Hazards Analysis)
- Technical Safety Requirements (or Technical Specification, or Limiting Conditions Document)
- DOE-issued safety evaluation reports
- Facility-specific commitments regarding compliance with DOE Orders and Policies

Process History

Knowledge of the history of process operations is a major component of the process knowledge needed for D&D. In many older facilities in the DOE complex, entire processes were installed, operated for a few years, dismantled and removed to allow newer processes to be installed in the same valuable space. For example, at the Y-12 National Security Complex at Oak Ridge, an electromagnetic uranium isotope separation process, employing what were called calutrons was originally installed in a facility there. The contaminants of concern (COCs) left behind in the building components and support systems (e.g. ventilation system) as result of calutron operations would be expected to include various isotopes of uranium.

When this process became obsolete due to the superior performance of isotope separation by gaseous diffusion, the calutron equipment was removed. The facility was then used for lithium enrichment using the Column Exchange (COLEX) process. It is known that the COLEX process used large quantities of mercury. The COCs left behind as a result of COLEX operations would, of course, be different from those left by the earlier uranium process. The COLEX process also eventually became obsolete and all its equipment was removed. The facility was then used for processing uranium and beryllium. As a result of these operations beryllium must be added to the list of COCs that D&D planners must be concerned with. If the D&D IPT had no historical information on previously removed processes, but did all their planning based on the installed processes it found when the facility was transitioned to D&D, the team may by totally unprepared for the consequences of encountering large amounts if mercury during the D&D process. A surprise of this magnitude would likely have major impact on the project schedule and baseline estimate when it became apparent. Thus, it is critical for effective planning to understand what campaigns were run with various process materials. The D&D engineer must also be aware that the same equipment was often used for different materials over time (various isotopic mixtures of Pu, Np, etc.).

DOE has provided guidance elsewhere recommending that the following facility operating and S&M records documents and information be reviewed by D&D planners [7]:

- Records of nuclear and chemical materials used
- Records of nuclear and chemical materials stored
- Records of spills and leaks
- Records of on-site disposals, if any
- Facility drawings
- Deactivation final report
- S&M plan
- S&M records and annual reports
- Lessons learned reports
- Information in the Facility Information Management System (FIMS)
- DOE Occurrence Reporting and Processing System (ORPS) database events for the facility. The Office of Environment, Health, Safety and Security is responsible for maintaining this unclassified central database (see http://www.hss.energy.gov/CSA/analysis/orps/orps.html). The Occurrence Reporting Program, including the ORPS, is described in DOE O 231.1A, Environment, Safety and Health Reporting, and its associated Manual, DOE M 231.1-2, Occurrence Reporting and Processing of Operations Information. Other related documents are DOE G 231.1-1, Occurrence Reporting and Performance Analysis Guide, and DOE G 231.1-2, Occurrence Reporting Causal Analysis Guide.

There are several methods of gathering process history at DOE facilities. Review of production and technical reports from the operations phase of facility lifecycle often yields valuable PH information. Especially in the early days of the weapons complex when production processes were constantly being modified to accommodate new technical information from laboratory research and rapidly changing needs for materials and components, facilities typically documented performance by issuing periodic (e.g. monthly) production and technical reports. These often described the production campaigns that occurred in the facility and documented material throughput, operating conditions and typical problems that were encountered. This kind of information is useful in understanding why certain facility modifications were made (e.g. plugged lines abandoned in place instead of being removed, spaces sealed with contamination inside, contaminated surfaces grouted or painted over, etc.).

Historical Site Assessments

The *Multi-Agency Radiation Site and Survey Investigation Manual (MARSIMM)* was developed jointly by the Nuclear Regulatory Commission (NRC), USEPA, DOE, and the Department of Defense to provide a consistent approach for planning site investigations. MARSIMM describes a graded site investigation process that starts with the Historical Site Assessment (HSA). The first phase of the HSA process, known as the Preliminary HSA, focuses on gathering existing data about the facility and its level of contamination [6]. Many of the sources of information recommended by MARSSIM are also recommended by others, as discussed earlier. However, MARRSIM recommends that the following additional information sources be consulted:

- Estimates of the total activity disposed of or released at the site and the physical and chemical form of the radioactive material
- Environmental monitoring records
- Site inspection reports
- License applications
- Operational permits
- Waste disposal material balance and inventory sheets
- Site photographs
- Aerial surveys, and maps (which help verify the accuracy of drawings or indicate changes after the time when the drawings were prepared)

Corporate contract files may also provide useful information during subsequent stages of the radiation survey and site investigation process. Older facilities may not have complete operational records, especially for obsolete or discontinued processes. Financial records may also provide information on purchasing and shipping that in turn help to reconstruct a site's operational history. Useful information may also be obtained from special studies that were performed, such as dose reconstruction studies that identify the radionuclides processed in different portions of the facility at various times in its history.

In many cases there may be no easily retrievable information on the history of operations in a particular facility. The only source of information about past operation may be the memories of personnel who worked in the facility at the time. In fact, even if written documentation concerning facility's processes and its operating history exists, a comprehensive PK acquisition program should include interviews with as many knowledgeable people as practical. However, it must be recognized that human memory is not completely accurate. Therefore, it is likely that some faulty information will be obtained and some important information will inevitably be lost to incomplete memory. For this reason, the vagaries of human memory should not form the complete foundation of a PK (or even a PH) gathering program. The collection of verbal information based on memory should supplement a PK program based on a foundation of maximum use of available engineering documentation and other written reports.

CURRENT PK MANAGEMENT PRACTICES IN THE NUCLEAR INDUSTRY

All segments of the nuclear industry are confronted with the common need to decommission contaminated excess facilities. D&D PK management practices within DOE, the commercial nuclear industry and the Department of Defense are summarized below.

DOE Sites

Information was obtained from several following DOE sites. Sandia National Lab (SNL) has an exemplary PH data gathering approach to support its active D&D program. The SNL approach is described below as a best practice in the area of PH data gathering. Since the site has enduring missions, the focus of the SNL D&D program is on space recovery as opposed to area or site closure. SNL uses a tailored approach when conducting facility assessment investigations. Facilities planned for D&D are categorized as follows:

1. Administrative/office
2. Computer laboratory
3. Light laboratory
4. Radiological/chemical work area

5. Chemical/radiological storage
6. Non-chemical, non-radiological storage

The above areas are also categorized by radioactive materials management area (RMMA) status. The contamination assessment phase consists of an initial assessment to determine the level of detail needed to document the current and historical uses of the building. A site information audit may be performed to determine the potential for contamination at a facility and to inform the remainder of the contamination assessment. The site information audit consists of an effort to gather the following information:

- Building plans
- Structural and equipment specifications
- Operations logs
- Records indicating materials used or processed in the facility
- Records of types of activities performed in the building and chronology of these activities

Interviews with knowledgeable personnel are conducted to gather additional information. Questionnaires are used to insure thoroughness and consistency. Questions seek to reveal information on the types, locations and uses of hazardous and radioactive materials in the building. Completed questionnaires and other relevant information are compiled into site history documentation and used to direct the site inspection.

A site inspection is conducted at the facility to verify the information audit and to provide additional contamination information if needed. Due to the variety of potential contaminants present at SNL sites, inspections may requires the use of multidiscipline inspection team. The team may consist of subject matter experts in the areas of industrial hygiene, health physics, environmental regulations and D&D activities. Facility inspection checklists are used to ensure that areas of concern are thoroughly investigated and properly documented. Each area of confirmed or suspected contamination is documented on the inspection checklist and associated building layout drawing along with a brief description of the suspected contamination.

At the conclusion of the assessment phase, a Site Audit Report is prepared, which summarizes the information gathered. The report contains the following information:

- Description of the facility, including layout, type of construction, RMMA status, building classification (i.e. one the six described above) and activities conducted at the facility
- A summary of the site information audit and inspections, including methodology, extent and results of the audit
- Layout of the facility showing areas of actual and potential contamination
- A summary of information gathered form interviews, database searches, and historic record searches
- A summary of sampling and analysis activities, if any, carried out at the facility and their results with a list of items and areas of each structure identified as contaminated or requiring additional investigation or special handling
- A recommendation for one of the following
  - If the existing information is complete and of adequate quality and chemical and radioactive contamination is ruled out, the evaluation process is complete. Demolition may proceed.
  - If contamination is indicated and the information is adequate and of sufficient quality to determine the type, level and location of contamination, the evaluation process is complete and decontamination may proceed.
  - If more information is required sampling and analysis must be performed. The site audit report will make recommendations regarding the extent of sampling and analysis needed to characterize the facility.

Appropriate subject matter experts evaluate the information obtained during the information audit to determine its completeness and reliability. The information is considered complete if

- Information is available for all the years during which the facility was operational
- The building construction is standard and disposal pathways for the building materials are available
- Any releases of hazardous or radioactive materials are fully characterized and documented
- The methods used to obtain chemical and/or radiological data were standard, verified, methods, accepted by regulatory authorities
- The information has been provided by persons who held positions of responsibility at the facility and whose knowledge of the activities at the facility should be reliable
- The information is consistent

Commercial Nuclear Facilities

As discussed above, a key element of D&D planning focuses on the capture of historical information from facility operations. EPRI described approaches used and experience gained in the development of early characterization activities by several commercial nuclear power plants undergoing decommissioning [4]. Lessons learned in conducting an HSA were reported. As described below, the organizations performing these HSAs identified some best practices in the area of capturing historical process data.

EPRI indicates that the NRC endorses the use of MARRSIM for decommissioning of commercial nuclear facilities. As mentioned earlier, the HSA is a key component of the site investigation process described by MARRSIM [4]. The NRC in 10 CFR 50.75(g) provides key information for the development of an HSA. The following narrative is extracted from 10 CFR 50.75(g) as indicative of the record keeping that should be available for planning D&D of a NRC licensed reactor:

“Each licensee shall keep records of information important to the safe and effective decommissioning of the facility in an identified location until the license is terminated by the Commission. If records of relevant information are kept for other purposes, reference to these records and their locations may be used. Information the Commission considers important to decommissioning consists of

1. Records of spills or other unusual occurrences involving the spread of contamination in and around the facility, equipment or site. These records may be limited to instances when significant contamination remains after any cleanup procedures or when there is reasonable likelihood that contaminants may have spread to inaccessible areas as in the case of possible seepage into porous materials such as concrete. These records must include any known information on identification of involved nuclides, quantities, forms and concentrations.
2. As-built drawings and modifications of structures and equipment in restricted areas where radioactive materials are used and/or stored and of locations of possible inaccessible contamination such as buried pipes which may be subject to contamination. If required drawings are referenced, each relevant drawing needs to be indexed individually. If drawings are not available, the licensee shall substitute appropriate records of available information concerning these areas and locations.
3. Records of the cost estimate performed for the decommissioning funding plan or of the amount certified for decommissioning, and records of the funding method used for assuring funds if either a funding plan or certification is used.”

EPRI evaluated the historical data gathering processes used by eight commercial nuclear power plants that were in various stages of decommissioning. The process used by the Big Rock Point facility is a typical example of that used by the eight power plant sites reviewed in the EPRI study. The approach followed by Big Rock point is described below.

Big Rock Point is a single unit facility located on Lake Michigan. The reactor first achieved criticality in 1962. Fuel was permanently removed from the reactor in 1997. An HSA, conforming to MARSSIM guidelines, was completed in 2002. The HSA, which served as the basis for the overall site characterization activity, produced a complete account in chronological order of all events involving both radiological and non-radiological materials with potential to impact natural environmental media. Known or potential contamination of structures was not assessed. "Investigation and physical inspection and process knowledge" were used to evaluate the historical event data. Sources of information included:

- The health physics logbook, 37-year continuous record of radiological activities and site conditions.
- Employee and retiree questionnaires
- Corrective action records, including Deviation Reports, Event Reports and Condition Reports
- Interviews with past and present employees
- Physical walk down of site property
- Plant drawings
- Spill records
- Waste shipment records
- Hazardous material assessments

USACE Experience

USACE in its Engineering Manual EM 200-1-2 provides the planning guidance listed below to technical project teams for projects in general and specifically for those dealing with radioactive waste:

Identify existing site information and gather the most pertinent data. Compile and include the gathered information in team information packages [7]. This operation is the equivalent of the MARSSIM HSA. In addition to the normal avenues, site information may be obtained from a wide variety of other sources. Atomic Energy Commission or NRC licenses and amendments, Army radiation authorizations, Air Force radiation permits, local land use permits, as well as the site owner or operator's records may provide information on the past activities at the site. Additionally, USACE archivists are available who are experienced in gathering documents relating to sites. If possible, attempt to obtain facility operating procedures and inventories, and define the receipt, use, storage, and disposal areas for the hazardous and radioactive materials on the site. Capture a description of all the background literature into a single document, and ensure that the background information is available to all data users and implementers [8].

Consider conducting a preliminary site visit to identify all potential sources of site information. Obtain current and historical photographs of site conditions and operations. Preliminary site visits should be used to obtain site maps or drawings that depict critical site features (e.g., historical land use, buildings, tanks, topography, surface water locations, disposal/storage/staging areas, and treatment systems). It may also be beneficial to videotape the site and specific features [7].

Discussions with former and current responsible employees about previous operations and waste handling should be planned. Employees and personnel interviewed may include individuals involved with site operations, permitting, previous investigations, environmental and engineering personnel associated with the facility or site. This should include all users of the property, current and past, with the potential for contaminant releases. It is also crucial for the responsibility perspective to be involved to assure proper documentation is prepared and any related substantiation is considered [7]. Consider not only former and present site workers, but also past and present regulators and inspectors. Many sites using radioactive materials also had some form of area dose monitoring. These records may also prove valuable in estimating potential hazards at the site [8].

So that redundant data are not collected, determine and gather all existing site data and reports for reference and use by the team. Some of the most pertinent data includes [7]:

- Site maps
- Site and aerial photographs
- Historical ownership information
- Regulatory status of the site and facility
- Facility or site-related geology
- Hydrogeology, hydrology, climatology, ecology, and demographic information about areas adjacent to the site
- Results and reports of previous site studies or investigations
- Known influence of other nearby sites

SUMMARY

PK for D&D was defined as that body of knowledge about a process facility that allows the facility to be safely and effectively placed in its final end state. The main elements of PK for D&D are knowledge of the process design and knowledge of the history of operations that occurred in the facility during the operating phase of its lifecycle. The typical engineering documents (e.g. P&IDs, flow diagrams, equipment lists, system design descriptions, and equipment vendor files) that define the process design are suggested as information sources for D&D work planners. Various other documents (e.g. records of chemicals/radionuclides used/stored, incident reports, waste disposal records, operating permits, and environmental monitoring records) that contain the history of the facility are also suggested as information sources. The survey of KM practices discussed above indicates that knowledge elicitation methods, such as interviews, can capture undocumented knowledge about the facility and its operations that is extremely useful to D&D planners. Finally, the best practices by DOE facilities, the commercial nuclear industry, and the USACE presented above reveal proven approaches to capturing the PK needed for D&D.

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