Waste Minimization/Pollution Prevention at R&D Facilities: A Cradle-to-Grave Tracking and Information System that will be Implemented at Sandia National Laboratories*

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INTRODUCTION

A comprehensive ES&H program allocates an extensive portion of its resources to information collection, management, and manipulation. Much of these resources are difficult to obtain and even more costly to ensure that they are sufficiently accurate; however, a system which collects information at the point which a process begins or a material enters a facility and maintains that information throughout its entire life-cycle is a more efficient approach to providing the data necessary to meet ES&H requirements. These data requirements for all the various groups within an ES&H program are associated with the properties and interactions among materials, personnel, facilities, hazards, waste and processes. Although each group is charged with addressing a particular aspect of these properties and interactions, the information they require can be aggregated into a coherent set of common data fields. It is these common data fields that the Cradle-to-Grave Tracking and Information System (CGTIS) is designed to satisfy.

Research and development laboratories such as Sandia National Laboratories (SNL) are diverse in nature and, therefore, present a complex challenge to ES&H professionals, yet this complexity can be dealt with by the proactive approach to information management adhered to by CGTIS. The CGTIS at SNL is designed to track materials, wastes, and hazards; support process assessments; and provide access to other related ES&H information. The remainder of this paper will describe the CGTIS as envisioned and implemented at SNL, define the requirements of a complete CGTIS, and review the current status of each system module at SNL.

SYSTEM DESCRIPTION

The CGTIS has three primary functions: 1) to track materials from procurement to disposal by correlating information on personnel, locations, processes and materials, 2) to store

other useful information for ES&H purposes, and 3) to achieve "cradle-to-grave" mentality in waste generators. The tracking function will be accomplished utilizing bar-coded containers and performing process assessments that account for the outflow of wastes from a process to any discharge pathway (i.e., air emissions, wastewater effluent, hazardous waste, or radioactive waste). Both hazardous and radioactive materials will be tracked from procurement until process initiation (process initiation is defined as the point at which the substance is removed from the encoded container) by the Chemical Information System (CIS) developed by AT&T Bell laboratories (AT&T-BL). After a process has been generated, the waste containers will be place in a bar-coded container and tracked to the point of final disposition by the Hazardous Waste Data Management System (HWDMS). The linkage between material use and waste generation will be made by the Process Waste Assessment (PWA), which provides process knowledge on the characteristics, discharge path, and quantities of waste exiting a process. The information collected by PWAs will be predictive in nature, meaning generators will describe their processes for the coming year and estimate their waste generation to all environmental media. The accuracy of these estimates will be vastly improved, however, by the detailed data provided by both CIS and HWDMS. The process owner will then know what his or her past material inputs and hazardous and radioactive waste outputs have been, and he or she can place meaningful bounds upon PWA estimates.

Other information not associated with material tracking, but related to industrial hygiene, emergency preparedness, and risk management functions will be stored within CIS such as Material Safety Data Sheets (MSDS). CIS also has the capability to track anything on which a bar-code label can be attached; therefore, information on other items such as hazardous equipment will be collected and maintained.

The most valuable aspect of the overall system is that waste generators will be further instilled with the "cradle-to-grave" mentality necessary to create a corporate culture which promotes waste minimization and pollution prevention. This culture shift is accomplished with several approaches, the first being the establishment of material, waste, and process "ownership" that compels generators to take responsibility for the effects their projects have upon the environment, and human safety and health. The detailed "ownership" accounting achieved by the system will also eliminate the "orphaning" of materials and waste which result in significant analysis and disposal costs. Another method employs an economic incentive to minimize waste by charging generators for the waste they produce; this is done through a charge-back tax according to both the quantity of the waste generated and its toxicity. Charges are administered through the Waste Minimization Implementation Center (WMIC) based on data provided by CGTIS. The most effective way to achieve pollution prevention is to incorporate it into a project's design phase and during material procurement, which both result from a cradle-to-grave mentality.

The CGTIS will collect and maintain comprehensive ES&H information with a minimum amount of duplication, while improving accuracy and reducing the burden of ES&H data requests upon line personnel. To achieve this, the overall system is based upon a distributed database design, drawing data from sources such as personnel, purchasing, facilities, and waste management.

TRACKING MODULE FUNCTIONS

The system will keep a current inventory of chemical, radioactive, and mixed materials by specific location, and track material usage by recording container transactions as they are used and subsequently transferred from CIS to HWDMS. By allowing all personnel assess to the inventory database, materials can be borrowed and exchanged more easily. Procurement control will be improved through the use of a central receiving point for material purchases where all bar-coding and data entry will be performed. The items will then be delivered directly to the user to validate data, and by interceding in the procurement process, goals such as chlorofluorocarbon (CFC) elimination can be more efficiently met. Lastly, in order for the inventory to be useful for emergency response teams, it will be maintained on a near real-time basis, accessible with a portable computer, and searchable by hazard (e.g., flammability or toxicity) category.

Much of the Waste Minimization/Pollution Prevention (WM/P2) Program centers around the PWA, because the PWA contains the information necessary to make decisions concerning the potential effects that modifications or material substitutions will have on a given process. PWAs also are designed to capture information that will be useful for other ES&H functions. The multimedia waste generation data from the PWA will establish a baseline to measure waste reduction performance and provide invaluable data for meeting regulatory reporting requirements. PWAs are performed in a series of stages, increasing in detail with each successive stage. The Process Definition (PD) phase describes the basic operation including process flow diagram and documents the previous year's waste minimization achievements. The Process Characterization (PC) phase estimates the average material usage and multi media waste generation during the normal operation of a process for the subsequent year. Waste Minimization Opportunity Assessments (WMOA) are performed only on those processes which warrant a more detailed examination in order to identify and evaluate various alternatives for waste minimization. The final output from a PWA is recommended WM/P2 options. Those options that are selected for funding will be tracked by CGTIS.

The hazardous and radioactive/mixed waste tracking modules operate in a similar fashion as the material tracking module, relying upon bar-coded containers. This accounting mechanism will allow for the actual waste package and corresponding disposal costs to be traced back to the generator at any point in the waste management process. Both shipping manifest, based upon waste compatibility criteria, and the Resource Conservation and Recovery Act's (RCRA's) Biennial Hazardous Waste Report are supported by the module.

Much of the data the system collect is used to assist ES&H regulatory reporting by industrial hygiene and air/water quality groups. This information is used to comply with the Emergency Planning and Community Right-to-Know Act Sec. 312 and 313, Clean Air Act, National Emission Standards for Hazardous Air Pollutants Act (NESHAPS), and state and local air quality control board regulations. Additionally, process level information on wastewater discharges will be used to identify sources of contaminant fluctuations.

For health and safety protection purposes other hazards and safety equipment will be tracked such as lasers, radiation and electromagnetic sources, fire extinguishers, structural asbestos, etc.; essentially any physical object on which it is possible to attach a bar-code can be tracked or inventoried as a static item. Additionally, PWAs help describe hazards that are an

inherent part of a process's operation.

Finally, in order to compile the data described above, all items should be entered into the system by a "wall-to-wall" inventory. In many cases such a thorough inventory will require an extensive degree of effort; therefore, significant commitment will be required to ensure that data integrity is maintained. To expedite this process, the inventory may be partially phased-in at the procurement end, as old items are replaced by new bar-coded items.

INFORMATIONAL FUNCTIONS

An ES&H program also requires information not provided by simply tracking materials and wastes that can be associated with tracking functions. Locations themselves will be bar-coded for identification purposes and descriptions stored to record the function of labs or other areas where materials are stored and/or used. Likewise, the location of wastewater drains and fume hoods will be linked to the PD phase when waste stream output information is captured. Personnel information is related to the location and material tracking data to create the "ownership" described previously. This relationship allows for employee exposure queries to be performed on hazards such as carcinogenic or teratogenic substances, which will help ensure that the proper training, handling, and storage measures have been taken.

A major component of the system is the MSDS library of text and scanned images, readily accessible to all personnel for both emergency and routine queries. Likewise, other ES&H documentation can be stored for reference such as chemical hygiene plans, permits, or training records.

CURRENT STATUS

The approach taken at SNL, New Mexico (SNL/NM) in the creation of a CGTIS has been to develop and implement each system component independently as a part of an overall distributed database of compatible modules. All the elements of CGTIS are presently at various stages of development, implementation, and production, while the procedural and electronic linkages are actively being established for true "cradle-to-grave" tracking.

HWDMS has been operational at SNL/NM since August 12, 1991, using bar-codes and Oracle RDBMS to identify containers of hazardous chemical wastes. A comparable system for tracking radioactive and mixed waste is under investigation to replace the current system used by the radioactive waste management group.

SNL's site in Livermore, California (SNL/CA) completed the installation of CIS in April 1992 and has inventoried approximately three-fourths of the chemicals at the site. The system is a functional prototype of the chemical tracking component of CGTIS, and applying the lessons learned at SNL/CA, an identical system is being implemented at SNL/NM. Each site will retain backup data for the other. CIS uses Informix relational data base management system (RDBMS) and includes an MSDS library in which roughly thirty-five thousand MSDSs have been entered to date. It is proposed radioactive and mixed material tracking will be incorporated into the CIS as a seperate module.

At SNL/NM all bar-coding and initial data entry is being performed by Fisher Scientific company, who's SNL/NM's Just-In-Time chemical vendor. All chemicals procured first go through Fisher as a central receiving point and then delivered directly to the requestor. This allows material, location, and personnel data to be validated during delivery.

PWAs are currently being performed at SNL/NM using worksheets and guidance developed in 1992. The first iteration of PDs, PCs and WMOAs are to be completed by the end of fiscal year 1993, along with the PWA software under development and residing within CIS.

The procedural and software interfaces between CIS, PWAs, and HWDMS are being developed along with finalizing and incorporating the information requirements of all ES&H groups. In addition, a security plan has been written to resolve issues surrounding classified and proprietary information and network access alternatives.

FUTURE ENHANCEMENTS

Several projects are under way to investigate and/or develop enhancements to the CGTIS. Additionally, electronic transmission of waste disposal request forms for hazardous chemical, radioactive, and mixed waste is being researched and each waste itself identified by a PWA and PWA waste stream number.

Further in the future is a scheme to include Preliminary Hazard Assessments (PHA) into the system. PHAs are a risk assessment tool for identifying and screening hazards and by including them in CGTIS they will be able to be filed electronically and obtain data directly from the system. Likewise under development is a computerized project selection module to optionally select WM/P2 projects, based on cost/benefit analysis and other considerations. The new module will then track the progress of projects once they have been selected. A centralized chemical management system is also being explored for SNL/NM, which will likely involve distribution hubs throughout the laboratory. The ultimate goal is to incorporate the entire system into a Geographical Information System (GIS) platform.

CONCLUSION

The majority of the information required for all ES&H purposes can be aggregated into a set of common data elements, which then can be collected by a system that employs a "cradle-to-grave" approach to ES&H information management. This type of system continuously tracks materials and wastes, beginning at procurement and ending with a product or permanent disposal, while also providing access to other information useful to general laboratory personnel and ES&H professionals. Both the investment and maintenance required for the system to function properly is substantial; however, the result is better data accuracy and coverage without duplication and miscommunication. by making the investment in a CGTIS, SNL will be able to create a highly effective WM/P2 Program and ensure compliance with present and future ES&H regulations, while also improving the operating efficiency of all laboratory programs.

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