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Chemical Security Principles of Material Control and Accountability (MC&A) using a Chemical Inventory Management System

Christine M. Straut* and Andrew Nelson

Sandia National Laboratories, 1515 Eubank Blvd, Albuquerque, NM

ABSTRACT

Chemical Risk Management is a system or process to control safety and security risks associated with hazardous or toxic chemicals. Chemical Risk Management includes the management of both chemical safety and chemical security. There are five pillars that make up chemical security management (Figure 1). Each of the five pillars are key components to the implementation of a chemical security risk management system. In this paper, we will review the "Material Control and Accountability" pillar and how an academic institution can implement this principle using a chemical inventory management system.

Figure 1. Chemical Risk Management includes the management of both chemical safety and chemical security. Five pillars make up chemical security management.

KEYWORDS

Laboratory Management

Material Control and Accountability (MC&A) is a term that has been historically used in Nuclear[1] and Biological[2] security. It includes physical security control and accounting of materials at all times through a system of recording, reporting, and audits. This principle is applicable to chemical security across the entire chemical life cycle from raw material mining, manufacturing, mid-stream, down-

stream, end-user consumption, and final disposal or destruction. The objective of MC&A at each stage is to reduce the likelihood of theft or diversion of chemicals under the ownership of the facility or institution. As with many of the five pillars, MC&A implementation is risk-based and needs to be layered to provide optimum risk reduction.

Given the complexity and multiple stages of a chemical lifecycle, MC&A in each of the chemical sectors has different requirements for proper implementation. MC&A of laboratory chemical risk management is the process of monitoring and ensuring that materials (i.e., chemicals, information, or equipment) at a facility or institution are controlled and accounted for at all times. At a chemical laboratory, this begins with procurement through removal, disposal, or destruction of these materials. Proper implementation of MC&A would require well-documented assets and risk assessment to adequately identify and prioritize the risks. This first step is imperative to achieve a balanced, layered, and graded risk-based approach to chemical security.

The procurement, storage, inventory, transportation, and disposal of a chemical are important to consider for a MC&A program in a chemical laboratory. In practice, MC&A for a chemical laboratory can be achieved through a robust chemical inventory management system (CIMS).

THE KEY ELEMENT OF MC&A—CHEMICAL INVENTORY MANAGEMENT SYSTEM

A Chemical Inventory Management System (CIMS) is a system or program that tracks chemicals or chemical samples throughout its lifecycle at a given facility or institution. A proper management system will ultimately lead to better quality control and chemical security risk reduction, waste reduction, surplus sharing, recycling, and decrease unknown and orphan chemicals (a chemical with no owner) in the lab. These benefits not only reduce time and resource costs but also vulnerabilities that could lead to a safety or security incident.

There are five important components to a chemical inventory management system: 1) Documentation, 2) Database, 3) Employee training, 4) System Management, and 5) Access Control.

Each component is essential and must work together with the other components for the system to be effective and sustainable.

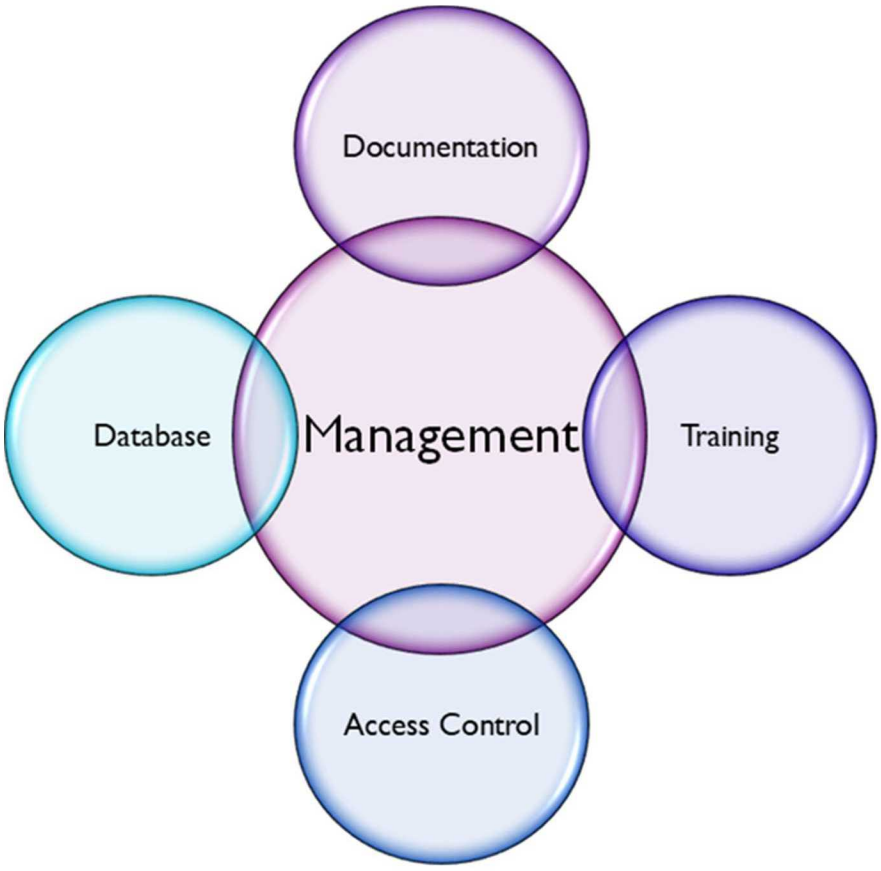

Figure 2. Components of a Chemical Inventory Management System. There are five important components to a chemical inventory management system: 1) Documentation, 2) Database, 3) Employee training, 4) Management, and Access Control.

Documentation

Documentation is the first and sometimes largest component of a CIMS. Documentation includes all the policies, procedures, and SOPs about the institution's CIMS. It can be the most time intensive and difficult to implement. Documentation must be continually reviewed and updated to ensure accuracy and efficiency of the system. Documents that address policies or procedures for procurement, chemical transportation/transfer, access control, waste/chemical removal, and inspections/audits are all necessary. These documents (SOPs, policies, and procedures) form the backbone of proper CIMS implementation, maintenance, and sustainability. They must include all the details of what is required for the CIMS to track chemicals (or samples) from procurement through destruction or disposal. Key aspects that also need to be included in those documents include roles,

responsibilities, and expectations of management and staff at your institution, access control guidance for the chemicals and the inventory information, physical inspections or auditing requirements, and any reporting requirements.

Database

A CIMS includes information collected for each chemical and must have some type of data collection system to store, find, and retrieve that information. The information collected and the data collection system make up the "Database" component of a CIMS. There are many different approaches to implement a database and the selection for your institution will be based on multiple factors such as staff/employee knowledge & skills, financial restraints, and institutional needs. In general, there are four basic types of databases to use for an inventory: 1) paper-based, 2) computer-based, 3) advanced computer-based systems, and 3) web-based or networked system (Table 1). Simple systems may be paper-based with more complex systems being computer-, web-, or network-based. Each format has advantages and disadvantages that should be considered prior to full implementation at a facility. Although some technologies may provide desirable functions (barcode scanning, streamlined workflow, etc.), these advantages should be weighed against cost and accessibility. The following table summarizes the advantages, disadvantages, and appropriate setting for the different management tools.

Table 1. CIMS Database Type Comparison

Format	Appropriate Facility	Advantages	Disadvantages
Paper-based system or Log-book	• Small Laboratory or Department • Few chemicals (<100 items), low turnover • Few or no regulatory/reporting requirements	• Very low initial and maintenance costs • No technical Support needed	• Easily bypassed • May be difficult to maintain for accuracy • Can only track a limited amount of information • Limited productivity and efficiency benefits • Limited operational cost savings
Simple computer-based system or Spreadsheet	• Medium size laboratory or department • Moderate number of chemicals, moderate turnover • Some regulatory/reporting requirements	• Low initial and maintenance costs • Can track and organize more information than paper-based system • Some productivity and efficiency benefits	• May be difficult to maintain for accuracy • May be bypassed • May be difficult to control access to information

		• Some operational cost savings	
Advanced computer system	• Large laboratory or department • Many chemicals, high turnover • Many regulatory/reporting requirements	• Excellent productivity and efficiency benefits • Operational cost savings • Can track large quantities of information • Excellent access control to sensitive information	• High initial cost (purchase of software and barcode scanners) • Potentially recurring costs for software licenses • Requires training and commitment to maintain accuracy
Web-based, Networked Systems	• Large facilities, institutions, or corporations • Many chemicals, high turnover • Many regulatory/reporting requirements	• Can accommodate many users simultaneously • Access to sensitive information can be protected • Extensive databases with system-generated alerts and automated features	• High initial cost (purchase of software, barcode scanners, computer network) • High recurring costs for software licenses and network maintenance • May require training to ensure proper use

Advanced inventory systems driven by a computer network can offer the most robust features for chemical inventory management; there are many commercially available systems that continuously guide inventory management to be more efficient and secure. Regardless of the system, the underlying database can vary in size and scope, and depending on regulatory needs, a variety of reporting options may be possible. Systems that can handle more chemical and regulatory data will be able to generate more substantial reports.

Regardless of the format chosen, the data that is collected for chemicals or samples is the key component of the inventory system. The recommended minimum data collected includes name, CAS number, quantity (container size), owner, location, physical state, safety data, and date (purchase or expiration). More advanced inventory systems can collect and track more information such as barcode number, manufacturer's lot or batch numbers, use or transfer history, regulatory requirements, storage compatibility, etc. An expanded list of information to consider including in an inventory database are listed in Box 1 below.

Box 1. An Example of Information for a Chemical Inventory Management Software.

- Name (IUPAC, common, trade)
- CAS number
- Formula
- Ingredient
- Lot number
- Location (facility, building, room, cabinet, shelf)
- Owner (organization, individual)
- Requestor
- Purchaser
- Barcode
- Supplier or producer
- Physical state (solid, liquid, compressed gas)
- Hazards (compatibility/storage info, health hazards, biosafety/biosecurity level)
- Safety Data Sheet (SDS)
- Certificate of Analysis (quality assurance/quality control)
- Quantity (volume, mass, number of vessels)
- Date purchased, received, and opened
- Expiration date
- Status (open or closed)
- Use and transfer history
- Reporting requirements

The data can then be used for physical management, such as inspections and audits, and allow for a better understanding of the safety and security needs of the whole chemical inventory. The database both guides the physical management process and can be used as a repository for additional data collected during this process, such as those associated with visual assessments. Audits are also an opportunity to check for database accuracy and are to be performed periodically, minimally once a year. This data is also useful for reporting to a variety of international, national, or institution requirements such as: a summary of chemical hazards that can be generated for emergency responders, detailed information pertaining to compliance with the Organisation for the Prohibition of Chemical Weapons (OPCW CWC), European Unions' Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), or other international, national, and institutional regulations.

It is important to understand that data collected for a chemical inventory at a facility or institution is sensitive and must be kept private (or controlled) from non-authorized users. The control of the

information collected is the key element of the overall MC&A principle which may include physical security and information security principles.

Employee Training

Employee training is an essential component of the CIMS. The specifics and frequency of the training will depend on the institution, but it is recommended that all staff and employees have annual training on their specific roles and responsibilities in the overall CIMS. Regular training will ensure that all staff and employees are familiar with their roles and responsibilities and follow the institution's standard documentation and policies. These trainings also provide an opportunity to gather feedback on those documents (i.e., SOPs, policies, and procedure) which may require periodic updating for accuracy and improved efficiency. Key principles that should be included for all staff and employees' training include: access control principles, recognizing authorized personnel, and challenge unfamiliar individuals or non-authorized personnel in restricted areas.

Management

Management including facility or institution upper management support is critical for the longevity of any chemical inventory management system both procedural and financial. The management component of a CIMS is the final and essential component to maintain an accurate and sustainable system at your institution. The management component is the management of each of the CIMS components that is the maintenance, review, and periodic inspections of the documentation (SOPs, policies, etc.), database, and personnel access and training.

Documentation management includes continual review and updating of all CIMS policies, procedures, and SOPs for accuracy and improved efficiency. Documentation review should include surveys, feedback, and/or employee monitoring. The most efficient and accurate SOPs include the involvement of staff and/or employees who are performing the tasks during the creation and review process. The recommended minimum documentation review is once per year or earlier if changes to the system occur. Any changes should be followed promptly by employee training.

Database management is essential to a well-maintained inventory. Periodic inspections and audits are the basis of database management. First, any anomalies in chemical receiving or disposal can raise awareness to potential malevolent acts. Second, by attributing responsibility of a chemical to a person or persons, there is increased accountability for securing chemicals on site. Third, maintaining records of chemicals can prevent the accumulation of orphan chemicals.

An inventory management best practice is to physically inspect the inventory through audits and/or reconciliation. Given that chemical stocks and employee rosters change, and compliance to internal policies is not 100%, inventories will invariably contain outdated or inaccurate information. Physical inspection of chemicals in an inventory system is an effective means to assure the accuracy of inventory data. In addition to verifying the accuracy of stored information, physical inspections provide an opportunity to visually assess the condition of chemical stocks. This should occur at least once or twice per year, and more often for chemicals of interest.

Personnel management includes tracking, managing, and updating staff and employees that have access to the CIMS. Personnel management includes tracking training and access privileges. Personnel management is the precursors for defining authorized and non-authorized personnel for access control. Roles and responsibilities for individuals with access to a chemical inventory system are also important and should be reviewed and updated regularly. Access to physical and information assets must be controlled by designating tiers of permissions and security measures, such as physical locks and individual accounts for computer-based systems. In addition, designated owners need to be assigned and accountable for the security of specific materials and ensure there are no orphan chemicals.

Depending on the turn-over of staff and employees at the institutions, the review of personnel access should be updated every 6 months to 1 year. More frequent updates should be done for any high value and high-risk chemical security measure. This component of personnel security may be

overlapping with the institution's personnel reliability or screening programs. More information on access control will be discussed below.

Access Control

Control of a material (chemical, information, or equipment) is a principle component of MC&A (including the CIMS). For a CIMS, control is defined as access control to the chemicals (or samples) and of the information to the documents and databases. Access control is a graded approached to chemical security for limiting access to high-risk chemicals depending on need. All chemicals and CIMS information should be subject to balanced, layered, and graded security. The degree of security is ultimately based on a risk-based approach to appropriately determine the layers.

Chemical inventories are important for any chemical security system. This detailed information provides the initial target or asset and location information critical for an accurate risk assessment; however, they also pose a risk as they contain detailed information on facility assets. Different levels of access to the inventory system and database should be granted to insiders (authorized users). For example, in an academic center, different levels of access should be given to students, faculty, department heads, administrators, custodial staff, procurement officers, and chemical safety and security officers. To mitigate insider threats, best personnel management practices should be employed and information should be protected using information security best practices. Outsider threats should also be considered that include security measures such as physical protection for chemicals of interest and information protection of the inventory database.

CONCLUSION

Material Control and Accountability (MC&A) is one of the chemical security principles that is part of laboratory chemical risk management. MC&A includes the control and accountability of materials at an institution including chemicals, information, and equipment. A chemical inventory should be a comprehensive system for defining what chemicals (and samples) are in a facility, where they are located, how they are secured, and who is accountable for the management (safety and security) of specific chemicals. The creation of a comprehensive chemical inventory management system (CIMS) is

necessary to fully track the chemicals in a facility, laboratory, or institution and to manage processes for safe and secure handling of these chemicals.

An inventory system will also support and help to sustain a chemical security program. A fully implemented and efficient CIMS will enforce good chemical management practices and reduce the potential for chemical theft or diversion. Not all chemicals require the same level of detail in the inventory system; rather, a risk-based approach should be used to define the level of information required in the inventory for the various chemicals on hand. Considerations for an inventory may include defining where different chemicals can be used and stored, how they are identified, and how the inventory is maintained. The person defined as accountable for the management of the chemicals should be the person best able to answer questions about the chemicals or samples and to ensure chemicals are not orphaned.

AUTHOR INFORMATION

Corresponding Author

*E-mail: cmstrau@sandia.gov

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DISCLAIMER

This paper describes objective technical results and analysis. Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. Department of Energy or the United States Government.

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