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Use of Chemical Inventory Accuracy Measurements as Leading Indicators

David Quigley, David Freshwater, Mikhail Alnajjar, Dina Siegel, and Murty Kuntamukkula

David Quigley is affiliated with the Y -12 National Security Complex, Oak Ridge, TN, United States; David Freshwater is affiliated with the US Department of Energy/ NNSA, Washington DC, United States; Mikhail Alnajjar is associated with Pacific Northwest National Laboratories, Richland, WA, United States; Dina Siegel is associated with Los Alamos National Laboratory, Los Alamos, NM, United States; and Murty Kuntamukkula is affiliated with Savannah River Nuclear Solutions LLC, Aiken, SC, United States.

Introduction

Chemical safety and lifecycle management (CSLM) is a process that involves managing chemicals and chemical information from the moment someone begins to order a chemical and lasts through final disposition(1). Central to CSLM is tracking data associated with chemicals which, for the purposes of this paper, is termed the chemical inventory. Examples of data that could be tracked include chemical identity, location, quantity, date procured, container type, and physical state. The reason why so much data is tracked is that the chemical inventory supports many functions. These functions include emergency management, which depends upon the data to more effectively plan for, and respond to, chemical accidents; environmental management that uses inventory information to aid in the generation of various federally-mandated and other regulatory reports; and chemical management that uses the information to increase the efficiency and safety with which chemicals are stored and utilized. All of the benefits of having an inventory are predicated upon having an inventory that is reasonably accurate. Because of the importance of ensuring one's chemical inventory is accurate, many have become concerned about measuring inventory accuracy. But beyond providing a measure of confidence in information gleaned from the inventory, does the inventory accuracy measurement provide any additional function? The answer is "Yes". It provides valuable information that can be used as a leading indicator to gauge the health of a chemical management system. In this paper, we will discuss:

- what properties make leading indicators effective,
- how chemical inventories can be used as a leading indicator,
- how chemical inventory accuracy can be measured, what levels of accuracies should realistically be expected in a healthy system, and
- what a subpar inventory accuracy measurement portends.

Leading indicators

Leading indicators must share a number of properties in order for them to be effective (2,3). First, leading indicators are not to be confused with lagging indicators, which are events that have already occurred and, while valuable for activities such as trending, are of little predictive value. Second, leading indicators must be able to predict future events before they occur. Because of this, leading indicators must have a relationship back to an expected outcome. For example, measuring car gas mileage may be a leading indicator on engine health because the worse the gas mileage, the more engine repair that may be needed if repairs are delayed. Third, leading indicators must be linked back to core issues. A leading indicator that provides information on unimportant issues has little or no significance. Fourth, too many leading indicators should not be chosen in any given area. When multiple indicators are chosen, there is a chance that there will be overlap between the indicators. Having leading indicators that overlap can result in confusion when one is unsure of what story the indicators are telling. One measure that fits all of the above criteria and can be used as a leading indicator in the world of CSLM is inventory accuracy.

Inventory accuracy as a leading indicator

Chemical inventory accuracy is an important parameter to measure since the chemical inventory is an essential component of CSLM. A chemical inventory is typically a computer database system that contains a significant amount of data. The reason why so much information is tracked in a typical inventory is that there are many regulations that affect CSLM. While many of these regulations do not specifically require an actual inventory, an inventory is the easiest and most convenient method for collecting the required information. Regulations affecting CSLM come from emergency response, environmental management, fire protection, facility safety, process safety and other disciplines (Table 1).

Inventory accuracy can be an important leading indicator because so many organizations utilize chemical inventory information. Information accuracy may be related to and be able to predict numerous unwanted outcomes. For example, inventory accuracy may be one of the leading indicators that predict the potential ability of an emergency response organization to effectively respond to an incident, since having incorrect information about types and quantities of hazardous materials could negatively impact the event outcome. Another example of using inventory accuracy to predict a potentially unsatisfactory outcome would be in the use of resources. Poor inventory accuracy would indicate an inability to track chemicals. This could result in unnecessary procurements, which would potentially lead to increases in the number and amounts of unneeded chemicals in the facility. Excess chemical inventories will result in higher waste disposal costs and a decreased safety envelope. Because chemical inventory measurement is both a statistical event (i.e., based on multiple data points) and a fundamental parameter of CSLM, it provides an accurate indication of the system's basic health. But because each business or organization has different methods of tracking their chemical inventories, the question that often comes up is "How does one measure inventory accuracy?"

Measuring Inventory Accuracy

To ensure inventory data are accurate, one must first determine what parameters are going to be measured. Since so much data is available in the inventory database, one must avoid the temptation of attempting to measure too many parameters. There are several reasons why this should be avoided. One reason is that the process of measuring parameters can consume valuable resources. If one is going to measure multiple parameters, then one must ensure that information gained from these measurements sufficiently offsets measurement costs.

Another reason is parameter dependency. When related parameters are measured, there is a probability that the depth and breadth of any perceived problem is overstated. If multiple parameters are chosen to be measured, then each parameter should be completely unrelated to each other or confusion may be encountered. For example, one parameter selected for use could measure how many chemical products are present in the workplace but are not listed in the inventory database. Another parameter selected for use could measure how many chemical products in the workplace do not have a material safety data sheet (MSDS) present. These two parameters are related. If a product is not present in the inventory database, then there is a strong likelihood that the product was obtained using nonconventional methods. If a product was obtained using nonconventional routes, then there is a strong likelihood that other systems were bypassed as well and that no MSDS was entered into the system. Measuring these two parameters may lead one to think that there are two problems – people are obtaining chemical products using nonconventional routes and MSDSs are not being entered into the system. If one understands the interrelationship between these parameters, then one can see that only one problem, obtaining chemical products using unconventional routes, may exist and that the other problem, MSDSs not being entered into the system, stems from the first. This is why poor selection of parameters can result in an overstated problem.

Several criteria exist for proper parameter selection. Parameters should be simple to measure. More time and other resources are typically required to measure complex parameters and these must be weighed against the expected benefits to be obtained. In general, parameters measured should result in a simple "Yes" or "No" answer. No parameter should be measured that could result in a "Partially met" response since these responses may lead to incorrect interpretations, causing confusion. Parameters measured should be critical to inventory accuracy. Measurement of peripheral parameters may result in confusion since they may be dependent upon issues unrelated to inventory accuracy.

Determining Acceptable Inventory Accuracies

There are many myths associated with chemical inventories and their accuracies. One myth is that anything short of 100% accuracy is unacceptable. It should be clear that 100% accuracy can only be obtained when 1) there is no work being performed, 2) the inventory is very small and simple to manage within the facility, or 3) the inventory is static for some other reason. Generally, for organizations of any size or complexity, a 100% accurate inventory is impractical, cost-prohibitive, and of little or marginal benefit. The reason for this is that once a chemical container is removed from the shelf and moved to another location for use or is consumed, the inventory is inaccurate. (While some may argue that computerized inventories that utilize radio frequency identification (RFID) tagging with sensors that track container movement will lead to a 100% accurate inventory, the reality is that the accuracy is simply increased to be closer to 100% than could otherwise be obtained.)

Organizations that recognize the fallacy of the 100% accuracy myth typically invoke the second myth: that the organization should strive to obtain an inventory accuracy of an arbitrary, lesser percentage. The different methods and procedures used for maintaining inventory (e.g., bar coding of individual containers vs. RFID tagging of individual containers vs. tracking by bulk) and the different levels of "granularity" used (e.g., location measured as plant, building, room, or shelf) dictate the levels of accuracy that each organization can achieve. Attempting to enforce a myth can lead to numerous detrimental effects that include implementing procedures and policies that focus so much on inventory management that other work, such as research, suffers.

Another myth is related to this concept: that the accuracy of the chemical inventory should be the same as the accuracy of an inventory at another workplace. Variations in workforce size, management processes, and computer applications utilized, make this concept impossible to achieve. For example, an organization that tracks individual containers to a given shelf in a given room in a given building using paper and pencil technology is not going to be able to achieve the level of accuracy that an organization that uses barcodes or RFID tagging and computers to track their chemicals to a specific building. Differences in how organizations track their chemicals makes it impossible to cite one number as the accuracy level one should seek to obtain.

The final myth is that workers want to be given a definitive percentage as a goal to achieve. This can lead to either an unattainably high accuracy goal or an accuracy goal well below that which is achievable. Having an unattainably high accuracy goal will lead to expensive and ineffective program changes. It will result in an eroding the morale of the CSLM workers. Having an accuracy goal well below that which is achievable will lead to sloppiness and other undesirable effects.

The correct method of using inventory accuracy is not as a goal, but as a measurement of CSLM program health. There are several steps to setting up inventory accuracy as a leading indicator. First, measurement parameters of the chemical inventory are determined. Chosen parameters must be central to accuracy and easily measured. Next, the general health of the inventory system is determined and inventory accuracy parameters measured. Parameter measurements are then periodically made. If inventory processes are stable, then these measurements will show a trend. This trend is a moving average. It should be noted that trending should be based upon the frequency of measurements and the time between these measurements. Since inventory accuracy measurements will become a statistically based measure, the more measurements made over the longer period of time will improve one's understanding of what one should expect of their inventory processes.

When the inventory is working correctly, the trend will reflect a relatively high accuracy. This accuracy does not become a goal to attain; rather it is a measure of inventory health. If, over time, changes are made to the chemical safety and lifecycle tracking system and the moving average for inventory accuracy increases, then this would indicate that changes made were beneficial to the management of the inventory.

Implications of an Inaccurate Inventory

There are many potential causes of decreased inventory accuracy; properly chosen parameters will help pinpoint where issues in the inventory exist. If one measures multiple parameters and only one parameter begins to show a decline in accuracy, then the issue needing work is likely localized. When measuring parameters are carefully chosen, issues affecting a single parameter are usually easy to find and corrective measures quickly identified. If accuracies start to decline in multiple parameters, then it is likely that a more systemic issue is present, affecting the inventory on a more fundamental level. If inventory accuracy begins to slowly decrease over time, then this would indicate that smaller changes are at work to negatively affect the inventory. Examples of these changes would include employees taking shortcuts, employees becoming less motivated to take important steps, or an overly complex management system that is error provocative. Lastly, if a spike in parameter inaccuracy occurs, then it is likely that a single event of a short duration occurred. When this is observed, it is important to identify the event and implement controls so that the event does not occur again lest it become a chronic issue. For example, if a significant new process that affects CSLM has been instituted, this new process may not be working as well as one would hope. When used this way, measured parameters become leading indicators that make a statement about inventory health and provide warnings when the health of the inventory starts to decline.

Conclusions

A chemical inventory can be used as a tool for making businesses more efficient and safe, complying with regulations, and aiding emergency response. Because of the importance of ensuring an accurate chemical inventory, many have become concerned about measuring inventory accuracy. Once the parameters of the chemical inventory are selected, they can be measured. But beyond providing a measure of confidence, inventory accuracy measures the health of the chemical safety and lifecycle management system by identifying positive and negative trends or leading indicators. The leading indicators identified from a properly managed chemical inventory will help one identify root causes and develop corrective actions for maintaining a safe, reliable, and accurate system.

Table 1. Examples of Regulations and National/Local Codes that May Require a Chemical Inventory

Source	Requirement
6 CFR 27, Chemical Facility Anti-Terrorism Standards (4)	Requires reporting of quantities of hazardous chemicals present at or greater than listed screening threshold quantities.
21 CFR 1308, Controlled Substances; 21 CFR 1310, List I and II Regulated Chemicals (4)	Requires the maintaining of inventories and records of all transactions involving controlled substances.
29 CFR 1910.38, Emergency Action Plans; 29 CFR 1910.39, Fire Prevention Plans (4)	Requires a listing of major workplace hazards such as hazardous chemicals
29 CFR 1910.119, Process Safety Management (PSM) of Highly Hazardous Chemicals (4)	Requires a PSM program if hazardous chemicals are present in an amounts at or greater than established threshold quantities.
29 CFR 1910.1020, Access to Employee Exposure and Medical Records (4)	Requires records of chemicals present and where they were used to help evaluate potential employee exposure issues.
29 CFR1910.1200, Hazard Communication (4)	Ensures that information concerning chemical hazards is transmitted to employers and employees.
40 CFR 61; 40 CFR 63, National Emission Standards for Hazardous Air Pollutants (4)	Identifies locations and quantities of hazardous chemicals that may be released as air pollutants.
40 CFR 68, Chemical Accident Prevention Provisions (4)	Requires a risk management plan if specified chemicals are present at or greater than listed threshold quantities.
40 CFR 82, Protection of Stratospheric Ozone (4)	Requires the tracking of ozone depleting substances.
40 CFR 302, Designation, Reportable Quantities, and Notification (4)	Requires the notification of hazardous substance releases in amounts at or greater than established reportable quantities.
40 CFR 355, Emergency Planning and Notification (4)	Requires management actions when hazardous chemicals are present in amounts at or greater than established threshold planning quantities.
40 CFR 370.40 to 370.45, Hazardous Chemical Reporting: Community Right-to-Know (4)	Requires inventory reports on hazardous chemicals present when amounts exceed *de minimus* quantities.
40 CFR 372, Toxic Chemical Release Reporting: Community Right-to-Know(4)	Requires reports on releases to the environment or offsite transfers of toxic chemicals from a facility if it had manufactured, processed or otherwise used that chemical in excess of an applicable threshold quantity.

NFPA 45, Fire Protection for Laboratories Using Chemicals (5)	Provides basic safety requirements for laboratories using chemicals.
Locally enforced building and fire codes	Require chemicals to be safely managed and specified chemical hazards maintained below limits.

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