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The Keys to Developing a Successful Constituents Management System

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A. The Case for Constituents Management

Chemicals are essential to all that we do in life and business. It is a reality that we cannot escape or deny. However, so too is the need for facilities to have control over their chemicals. Manufacturing, industrial, and institutional facilities must know not only what constituents they have within their sphere of control, but also where each constituent is, what's happening with/to it, and where it's going.

When early environmental regulations were developed in the 1970s and early 1980s, the EPA focused on simple hazards that managers could cheaply analyze or readily determine from experience. As environmental regulation matures, the EPA (driven by the laws that empower them) has increasingly taken the stance that a person must know the constituents in their processes and wastes, as well as the hazards exhibited by it. Here are some examples:

Clean Air Act: Until the Clean Air Act Amendments of 1990, the EPA regulated only a half dozen conventional air pollutants and seven hazardous air pollutants. Today, the EPA regulates almost 200 hazardous air pollutants (HAPs).

Plus, the early HAP rules' applicability was based primarily on descriptions of regulated operations. Today, simply determining applicability of some HAP rules requires detailed knowledge of dozens of specific chemical constituents in your operations.

Clean Water Act: In the early days of the Clean Water Act, the EPA regulated only about a dozen "conventional" pollutants, such as suspended solids, oil and grease, and nitrates. A complete wastewater analysis cost only a couple hundred dollars. In the late 1970s, NPDES permits were amended to require control of over 100 toxic priority pollutants if these were "expected to be present" in the discharge. Today, these and many other pollutants must be known and reported. A single NPDES analysis can now cost thousands of dollars!

Hazardous Waste: In 1980, most hazardous wastes were identified by narrative description of the process from which it was generated. For example, if a person uses acetone as a solvent, and the used or "spent" solvent becomes a waste, it is "spent solvent acetone," and is identified as Hazardous Waste Number F003. For such waste, the EPA has done substantial research into typical hazards posed and all the generator needs to do is compare his or her waste to these descriptions.

Characteristics or properties posed by the waste were simple and only considered 14 chemical constituents (eight metals and six pesticides). In 1990, the EPA expanded this list by adding 25 toxic organics (volatiles and semi-volatiles) for a total of 39 chemicals presence of which can cause a waste to be regulated as hazardous waste. Testing for just these 39 constituents can cost $1,000 to $2,000 *per test.* To obtain any level of certainty, three or more tests must be run.

Since 1990, the EPA has been considering various options for a new "hazardous waste identification rules" (HWIR), all of which involve the addition of 200 to 300 more toxic constituents to the toxicity characteristic [see for example 57 FR 21449, May 20, 1992; 60 FR 66343, December 21, 1995].

Right-to-Know: When the toxic chemical release inventory reporting requirements (TRI, or Form R, 40 CFR 372) were first published, The program to applied to a small set of facilities that manufactured, imported, processed, or otherwise used one or more of 300 substances. In the mid-1990s that list grew to over 600 substances as did the list of reporting facilities.

In the late 1990s, the EPA had made a policy commitment to require chemical manufacturers and other industrial companies to report detailed information regarding the types of chemicals, and the quantities brought in, produced, released, discarded, destroyed, shipped off in product, and so forth. In other words, this was *full* constituents mass balance reporting. The program that would have incorporated this comprehensive accounting and reporting would have been the TRI program.

REACH: In 2008, the European Union's comprehensive chemical management program came into effect, called REACH (which stands for Registration, Evaluation, Authorization, and Restriction of Chemical Substances). The rules require any person manufacturing or importing *any* chemical substance in the EU above minimal thresholds to submit a comprehensive report of the environmental and health risks associated with that substance. The registration must take into account the hazards associated with all of the various down-stream uses.

The REACH program is assembling a list of substances that will not be allowed to into the EU without rigorous approval (authorizations). Even before the list is finalized, manufacturers and importers of articles containing "candidate list" substances must warn their customers and downstream users of its presence in their product.

Knowledge of constituents at manufacturing/industrial/institutional facilities is not only critical for traditional compliance programs, such as environmental control and release programs (e.g., Clean Air Act operating permits, Clean Water Act discharge permits, and Resource Conservation and Recovery Act waste management) or workplace safety and health (e.g., OSHA hazard communication and employee exposure), it has become increasingly important in the growing chemical management programs (e.g., TSCA, FIFRA, FDA, REACH, and state initiatives). The 11th Congress and the EPA are currently committed to reinventing the TSCA chemical management program in the U.S., and REACH has been the model most discussed.

Initiatives such as waste minimization/pollution prevention, and even green chemistry and sustainability product development, require knowledge of the constituents under our control; their locations, quantities and effects. In many cases, the pressures to eliminate or change substances in products have come from sources outside of government. An ABC News report in February 2010, while discussing Congress' TSCA reauthorization efforts, reported that increasing pressure is coming from the scientific community, the media, non-governmental organizations (NGOs), and the public at large to eliminate hazardous chemicals from the marketplace. Consumers are increasingly putting pressure on companies to remove "hazardous" or "toxic" substances from the products they buy or use, whether the hazard is real or perceived. The recent news of Bisphenol A (BPA) in plastics is a ringing example of consumer pressure. Companies' PR campaigns that substances or products are "safe" are rarely successful. This pressure, whether tied to specific fact, has increasingly put pressure on manufactures to makes changes or face lost business. SH&E professionals play a critical role in chemical management efforts and reporting obligations at their facility.

The Answer: Knowledge-based Management of Constituents

It is becoming less and less feasible to test for all potentially regulated constituents. Managers with foresight in every type of industry are already implementing systems to identify and track every significant chemical constituent that is either produced at their facility(ies), or brought within their sphere of management control.

Many managers are already finding *savings* in both cost and work required through such knowledge-based constituents management.

"Mass balance" is defined at Section 11023(l)(4) of Title 42 of the United States Code as:

> an accumulation of the annual quantities of chemicals transported to a facility, produced at a facility, consumed at a facility, used at a facility, accumulated at a facility, released from a facility, and transported from a facility as a waste or as a commercial product or byproduct or component of a commercial product or byproduct.

Mass balance accounting is not [yet] explicitly required by law, but is offered as a compliance *option* under many regulations.

The more you know about chemical flow through your operations, the less you will be required to analyze waste products and environmental releases to document compliance. Usually, obtaining and maintaining knowledge through mass balance accounting is far less expensive and more certain than attempting to analyze "unknowns" after the fact.

Retroactive MBA

Most environmental managers are already doing a considerable amount of informal and retrospective mass balance accounting. Imagine the situation where the receiving department supervisor walks into your office and the following conversation ensues:

Supervisor: "I have a dumpster full of fiberboard boxes I need to throw out. The recycler won't take them. Are they hazardous waste?"

Manager: "Well, did they contain any listed commercial chemical products?"

Supervisor: "Any what?"

Manager: (Handing the receiving supervisor a copy of 40 CFR 261.33) "Anything on these lists."

Supervisor: (Looking through the list) "Uh, I don't think so..."

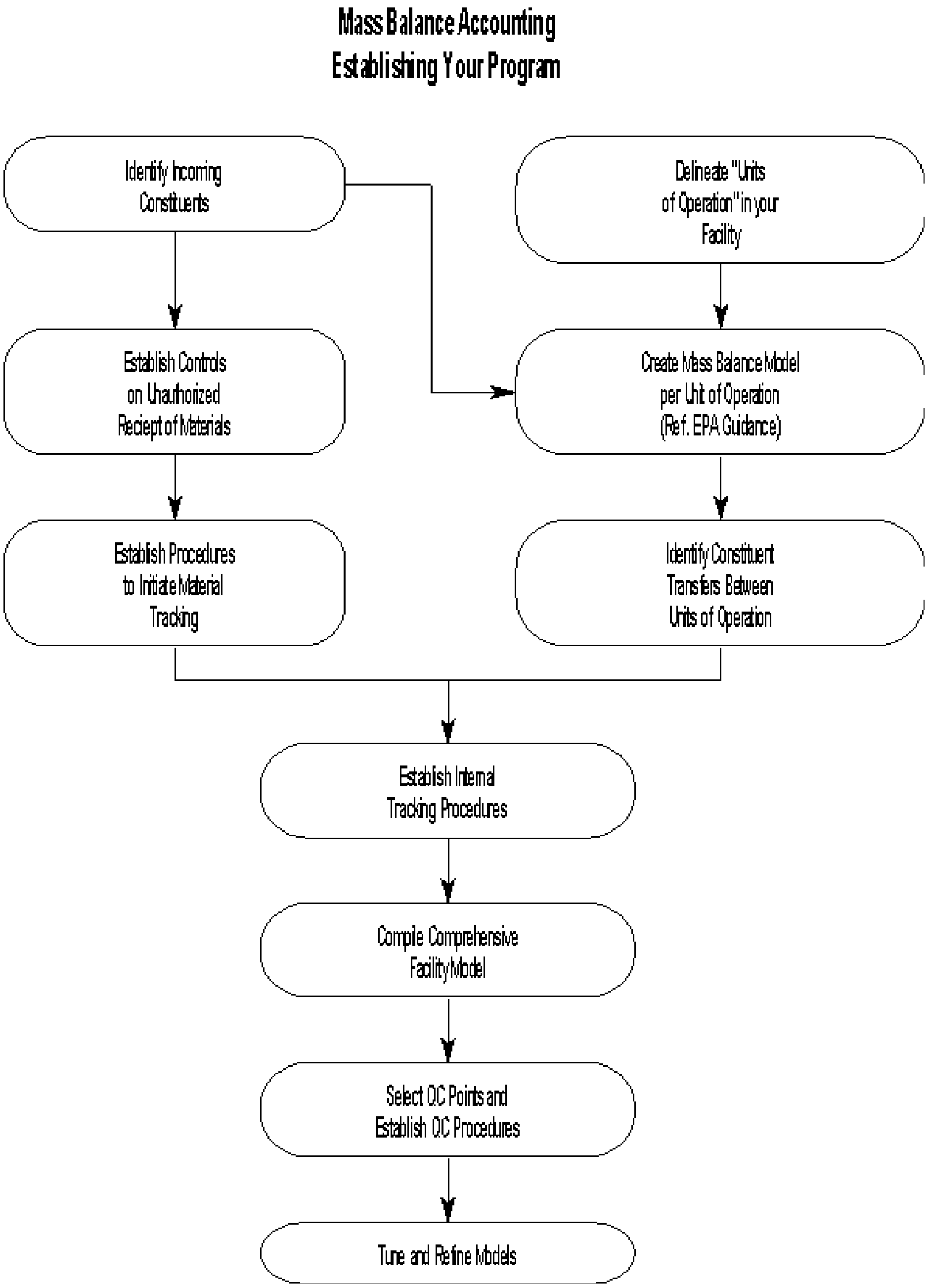
Manager: "OK. Then take half a dozen samples, according to random sampling protocol, and have them analyzed for all hazardous waste characteristics. Here's the lab's telephone number. By the way, it'll cost about $1,500.00 per sample."

Of course, this would be ridiculous. The receiving manager should already have a policy in place to assure that any containers are "empty" *before* they are placed in a dumpster. The policy should include assurances that any containers that held "acutely hazardous" products are triple rinsed. At a minimum, before deciding to perform expensive sampling and analysis on a bunch of fiberboard boxes, you would likely review all materials that the company could have received in these boxes and look at available information to see which hazardous waste characteristics, if any, the empty boxes *might* exhibit.

“Reasons to Believe”

For industrial process wastes, the link between records of materials actually received and the waste being identified for disposal (or discharge through a permitted vector) is less explicit than identifying the product that formerly resided in the used packaging materials. However, through simple management practices and with some planning, most facilities can get reasonable estimates of or expectations of whether a particular waste does or does not pose a particular characteristic. Once those estimates are developed and “reasons to believe” are assessed, sampling and analysis becomes more of a quality control measure than a waste ID measure.

The theory behind mass balance accounting has existed for quite some time. It is merely a combination of accounting and auditing practice, which has been developed and refined in financial accounting for centuries, with mass balance/unit operation theory, that has been part of engineering practice for almost as long. The following flow chart summarizes the primary steps to instituting good mass balance accounting practice.



B. Elements of Mass Balance Accounting

Mass balance accounting is predicated on the principle of the conservation of matter (mass). That is, matter can neither be created nor destroyed. So, if we examine a particular process or activity, the amount of matter entering must be in balance with the amount in the process and the amount leaving the process or activity. Simply stated:

$$\text{Input} = \text{Accumulation} + \text{Output}$$

For example, consider a basic chemical reaction in which ammonia (NH_3) is reacted with oxygen (O2) to yield nitric oxide (NO) and water (H_2O).

$$\_\_\_\ \mathrm{NH_3} + \_\_\_\ \mathrm{O_2} \text{-}\rightarrow \_\_\_\ \mathrm{NO} + \_\_\_\ \mathrm{H_2O}$$

The equation must balance, so that the number of nitrogen, oxygen, and hydrogen atoms is the same on either side of the equation. The balanced equation would look like:

$$\underline{4}\ \mathrm{NH_3} + \underline{5}\ \mathrm{O_2} \text{-}\rightarrow \underline{4}\ \mathrm{NO} + \underline{6}\ \mathrm{H_2O}$$

A close examination would show that there are 4 atoms of nitrogen on either side of the equation (reaction) as well as 12 hydrogen and 10 oxygen atoms.

Mass balance accounting is much like financial accounting. While financial accounting tracks, records, and reports what is happening with the organization's money, mass balance accounting is doing the same with respect to the facility's various chemicals (constituents). In fact, in an ideal setting there are ways to incorporate both; however, environmental cost accounting is as rigorous as mass balance accounting and would demand its own paper.

As will be discussed in more detail, in order to complete mass balance accounting, the activity will need to go through several steps:

1. **Identify the Process Stream**. This is the overall process. For example this, may be the factory that produces a "widget" (Figure 1):

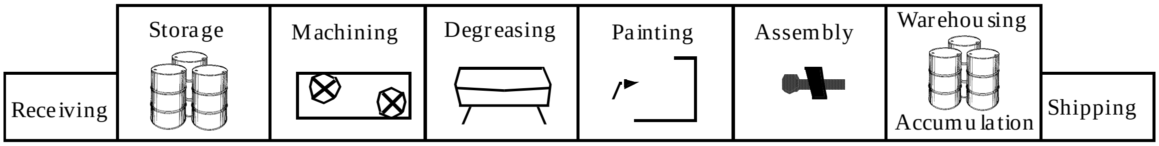


Figure 1. Steps in Producing a "Widget"

2. **Identify each "Unit of Operation."** In this step, we break down the process stream (i.e., the manufacturing process) into the various steps. In the example above, we might break it down into the following units of operation:
   - *Receiving*: All incoming materials must be checked through the receiving department.
   - *Storage:* Materials not being used immediately are held in storage.
   - *Machining:* Metal parts are cut, ground, drilled, and milled.
   - *Degreasing:* Shaped parts are degreased in a solvent.
   - *Painting:* Clean parts are painted.
   - *Assembly*: All parts are assembled into final products and packaged.
   - *Warehousing/Accumulation*: Finished materials are warehoused. Wastes are accumulated for disposal.
   - *Shipping:* All materials leaving the facility leave through the shipping department.

3. **Perform a mass balance on each "Unit of Operation."** As we perform a mass balance on each unit of operation, we will need to further classify the process based on:
   - *Temporal variation*: That is, we will need to consider how the process may vary over time. A process is either categorized as:
     - Steady-state: That is the process does not change over time
     - Transient state: The process may vary each time we examine it. In a manufacturing process, you may have what appears to be a transient state process with an assemble

line that produces Widget A sometimes and Widget B at other times. This may easily be remedied, by considering each as separate steady-state processes.

- *Process design:* We will need to consider whether the process is:
    - Continuous: the feed streams are moving into the process and product streams are moving out of the process at all times (e.g., refining process).
    - Batch process: the feed streams are fed into the process to get it started
    - Semi-batch/semi-continuous: obviously this process has characteristics of both

4. **Compile a mass balance on the sequence of "Units of Operation."**

C. Identifying Incoming Constituents

The first step to developing a mass balance accounting system is to identify the materials received by the facility (by chemical constituent and weight percent in mixtures). Efforts should be focused first on the most environmentally "significant" constituents (i.e., those most likely to be regulated or to cause environmental harm). There are five steps to identifying constituents in product mixtures are:

1. **Ask the vendor**. This would be the obvious starting place. The vendor would likely have the intimate knowledge of the material, either as the manufacturer or one close to the manufacturer, so as to provide a breakdown of the constituents in the product. In fact, you may already have access to constituent information from the vendor through material safety data sheets (MSDSs) or other technical documents. However, carefully review the information to determine the completeness of the information. Federal rules do not require the manufacturer to provide a comprehensive listing of every constituent in their product on the MSDS. Rather, they only need to include those that meet OSHA's criteria for being hazardous chemicals and only if they are present in a specific quantity or greater [29 CFR 1910.1200(g)].

   Approaching the vendor for a full breakdown (i.e., formulation) of their product may understandably be met with some resistance. After all, the formulation may be what makes their product special in the marketplace and their livelihood as a company is tied into limiting the disclosure of their business secrets.

2. **Offer confidentiality.** When resistance is met, the next step would be to receive full disclosure through some binding, legal, confidentiality agreement. The arrangement of the agreement may vary by vendor, but the essence is you are obtaining a full breakdown of the material's constituents to be used solely for your mass balance and regulatory determinations. Sharing this information beyond what the regulations require would subject your organization to whatever the punitive measure is spelled out in the agreement.

   As this is likely to be a legal document, you will need to involve your corporate counsel. These matters take time, so it will be important to build a margin into your planning process, especially if you are looking to start up a new process or line.

3. **Use a different vendor/product.** In some cases, the resistance from the vendor is strong. You will need to be willing to increase your leverage. One strategy is to evaluate whether you have options for other materials (from other vendors). Obtaining materials form vendors who are willing to work with you places you in a more comfortable position of knowledge. In some instances, threats to lose you business outweigh the protection from disclosure, and your vendor may be more willing to cooperate.

   However, use of alternatives may impact your process. You will need to determine if these substitutes will meet your process demands (e.g., quality control, standard operating procedures, customer mandates/expectations, and government standards). It is important to keep the big picture in mind. You don't want to make a move that ends up hurting the bottom line.

4. **Threaten to analyze and publish results**. It's a matter of leverage. However, keep in mind that there are tens or thousands of possibilities for the unknown constituents. The cost of analysis when you aren't certain what you are looking for can be astronomical. You will need to determine how far you are willing to go.
5. **Take all risk**. Whenever you do not have complete information, you proceed at risk. So, if you are not able to achieve 100% accountability of the incoming constituents, you have to realize that there may be constituents in your process that are subject to one or more regulatory requirements. As the regulations are typically structured, it is your obligation to know of their presence and take the necessary actions specified in the rules. Lack of knowledge would not be a legitimate defense. You and your organization will need to assess what level of risk exists with your missing information and what level of risk are you willing to bear. In some situations, the response may be to start all over again in obtaining the constituent makeup of the incoming substance(s).

Significant Constituents

Recognizing that resources and time may be limited, your facility's efforts should be prioritized. You will want to first look for certain constituents. While this list is certainly long, it will at least serve to prioritize your efforts. Here is a list of some common substance lists:

- Hazardous Waste Toxicity Characteristics (39 specific substances at 40 CFR 261.24)
- Underlying Hazardous Constituents (40 CFR 268.48)
- Hazardous Constituents (40 CFR 261, Appendix VIII)
- Groundwater Monitoring Constituents (40 CFR 264)
- CERCLA Hazardous Substances (40 CFR 302)
- SARA Extremely Hazardous Substances
- EPCRA Toxic Chemicals (40 CFR 372)
- Clean Water Act Toxic Pollutants (40 CFR 122)
- Clean Water Ac Hazardous Substances (40 CFR 117)
- Clean Air Act Hazardous Air Pollutants (CAA §112)
- FIFRA Restricted Use Pesticides (40 CFR 152)
- DOT, Marine Pollutants (49 CFR 172.102, Appendix B)
- DHS Chemical Facility Anti-Terrorism Security Planning (6 CFR 27, Appendix A)
- REACH Candidate List substance
- REACH Authorization substances

The next stage in assuring the accuracy of a mass balance accounting system is to assure that "unknown" chemicals do not enter your facility. Remember, a small amount of a hazardous constituent can cause considerable compliance headaches! Consider all potential chemical routes of entry into the facility, including:

- Purchase orders,
- Standing and blanket orders (products may change over time?),
- On-site contractors,
- Maintenance contracts,
- Sales samples,
- Petty cash purchases,
- Water supply, and

- Within equipment (mercury switches, lead acid batteries, hearing aid batteries, electronic circuit boards).

As your mass balance accounting system develops, you will also want to begin tracking actual chemical flows through your facility. Again, controlling the point of entry for chemicals coming into your facility is essential to assuring the effectiveness and accuracy of your efforts. Your point of entry procedures will need to include provisions for logging chemicals into the chemicals tracking system, tagging the containment devices, and training personnel so that constituents may begin to be tracked through the facility.

D. Delineating "Units of Operation"

The raw knowledge collected up to this point will be valuable in itself for evaluating environmental issues as they arise. However, to be most useful and proactive, you will want to incorporate this information into a facility-wide mass balance model. This model will track chemical constituents through facility processes and will identify chemical changes and vectors from each operation.

Initially, developing a model that represents every chemical change, transfer, or release at your facility may appear inordinately complex and difficult. It can, however, be simplified by breaking your overall operation into discrete units, each of which can be examined independently. Typical "units of operation" might consist of:

- Individual machines (e.g., the wave solder machine that uses its own specific materials or the freon degreaser in the pre-assembly room);
- Groups of machines performing the same or similar functions (e.g., all carbon-steel grinders or all ammonia-based blue-line printers);
- Departments performing a relatively uniform and specific function (e.g., the printing department);
- A sub-facility or building (e.g., the wastewater treatment plant or the chemical storage warehouse)

There are two key criteria to delineating your units of operation:

1. Is the operation discrete? Is there minimal interaction with other units of operation/interactions can be described by simple material flows?
2. Is it relatively simple/straight-forward to model the operation?
   - Specify chemical constituents in materials entering the process,
   - Determine chemical changes taking place in the process, and
   - Determine chemical constituents in products and releases from the process.

Generally speaking, the larger the process, the more "discrete" it will be. For example, the entire facility is probably the most discrete process you could define. A series of production-line, metal-working machines that share oil sumps have considerable interaction. Conversely, the smaller the process, the easier it will be to model. A single-solvent cleaning device can be easily modeled. A model developed from scratch for the entire plant would be either hopelessly complex or uselessly generalized.

These two criteria need to be balanced against one another to achieve the most reasonable, workable unit of operation on which to base your models. If, as you are developing the models for individual operations, you find that the process is either too complex to model or too tightly integrated with other processes, you should reevaluate your selection of units of operation.

The simplest and most useful method for modeling each unit of operation is the steady-state model. This model considers the operation essentially to be a black box; then examines the units of input and output for each cycle of operation. The cycle of operation can be chosen at random (one work shift, one month, one batch, and so on), provided that each input and output can be quantified for that cycle. For each constituent involved in the operation over the chosen cycle, the following equation should be true:

[Amount Input + Amount Created] – Amount Destroyed = Amount Output

Or, for those who prefer algebraic equations:

$$I + C - D = O$$

Where:

I = The total quantity of that chemical constituent input to the process in all material inputs
C = The quantity of that chemical constituent created in the process
D = The quantity of that chemical constituent destroyed in the process, and
O = The total quantity of that chemical constituent output from that process (including product, waste, and environmental releases).

Inputs are already known through your efforts in identifying chemical constituents. You will want to begin your steady state modeling with the first processes in a process chain, since outputs from these processes may become inputs to downstream processes.

Constituents created and/or destroyed are minimal in many commercial processes and can be ignored. In processes such as chemical manufacturing, electroplating, or wastewater treatment, the reaction chemistry is fairly well known and can be estimated from either process knowledge or publicly available literature. These data and criteria may be adjusted later, based on operations data.

Outputs are of three generic types: product, waste, and environmental releases. Products are generally well known. Environmental releases are often monitored as part of permit conditions and may often be calculated on the basis of generic “emission factors” or similar criteria available from the EPA (see “for further information”). Knowing all other outputs, chemical constituents in waste can be calculated through simple mass balance.

Since you know the sum of all “outputs” (product + releases + wastes) from the above equation and you can estimate constituents in products and releases, then chemical constituents in your waste may be calculated as:

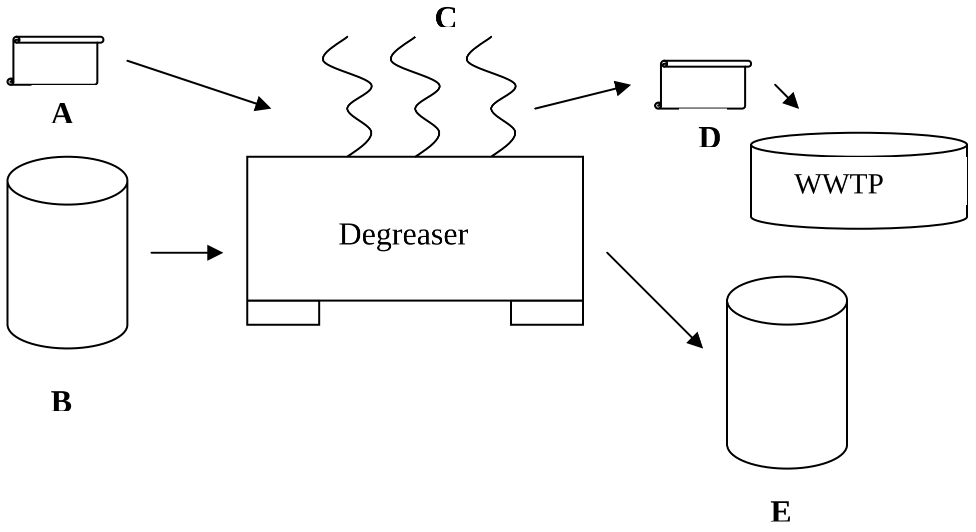
Amt. in Waste = [Amt. Input + Amt. Created] – Amt. Destroyed – Amt. in Products & Releases

Or:

$$w = I + C - D - (p + r)$$

Where:

w = Constituent in waste,
p = Constituent incorporated in products, and
r = Constituents released in all environmental vectors.



INPUT
A – Dirty widget (metal fines, oil, dirt from machining)
B – 100 lbs. Solvent X (raw material introduced into degreasing unit)

OUTPUT
C – 45 lbs. Evaporation (calculated based on surface area, vapor pressure, temperature, time uncovered)
D – 30 lbs. dragout sent to wastewater treatment (calculated from surface area of widget and dragout factor from literature)
E – 25 lbs. dirty solvent waste (calculated by mass balance → (100 lbs.) – (45 lbs. + 30 lbs.) = 25 lbs.)

Figure 2. An Example of a Typical Steady-State Model for a Solvent X Degreaser

E. Chemical Transfers & Tracking Through the Facility

Once individual unit operation models are complete, these may be linked into a comprehensive picture of facility operations. This is accomplished simply by linking the outputs of one unit of operation to the inputs of another. For example, among other outputs, a machining operation generates oily metal parts with a few metal fines adhering to them. These parts are transferred to a degreaser. In your unit of operation model for the machining operation, these are represented as a collection of constituents, including metal, oil, oil additives, and perhaps some dirt. One input for your degreasing unit of operation (oily parts to be cleaned) should be identical in chemical constituents and percent concentrations to the oily parts output from machining.

Linking all unit operations together will yield a material flowchart through which different constituents take different paths. For instance, for a simple industrial plant manufacturing painted metal products, the generalized material flow model might appear as in Figure 3:

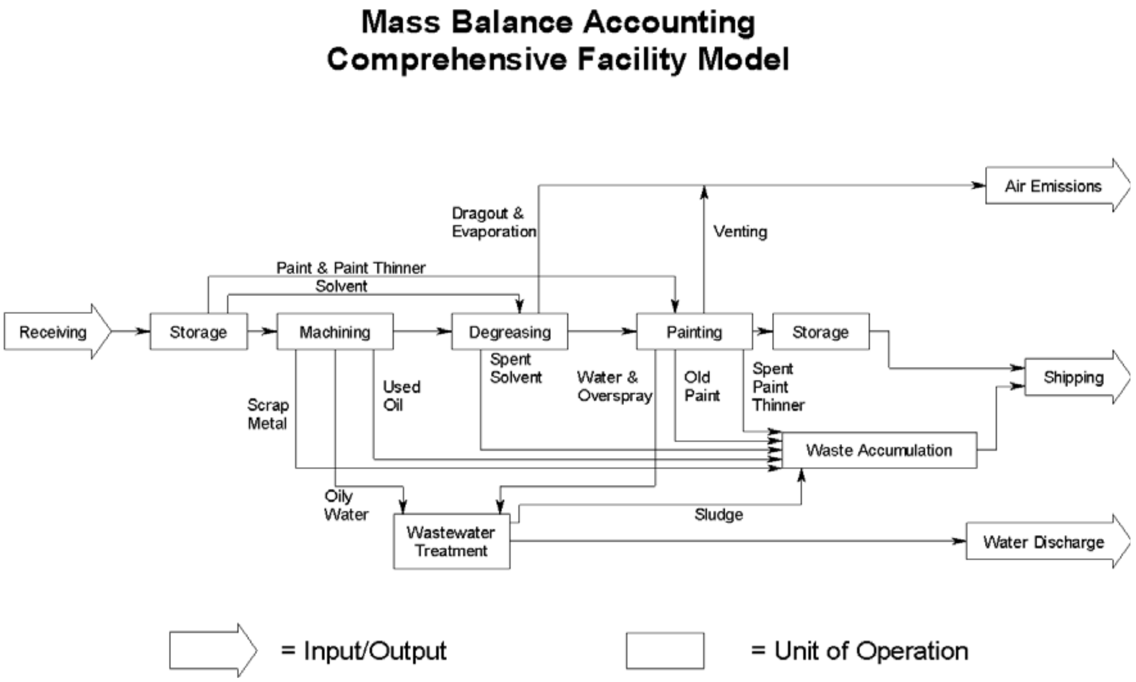


Figure 3. Mass Balance Accounting Comprehensive Facility Model

When a particular chemical constituent (e.g., toluene) is considered, only certain material flow vectors are significant. Toluene is brought into the facility only in paint and paint thinner. The painting operation uses a water curtain spray booth, where overspray is captured in water and eventually discharged to the plant wastewater treatment system. The paint spray system is drained and cleaned between colors of paint, generating both unused waste paint and spent paint thinner. Insignificant amounts of toluene are carried out on painted parts. Using a cycle of operation of one week, the specific constituent flow model is shown in Figure 3:

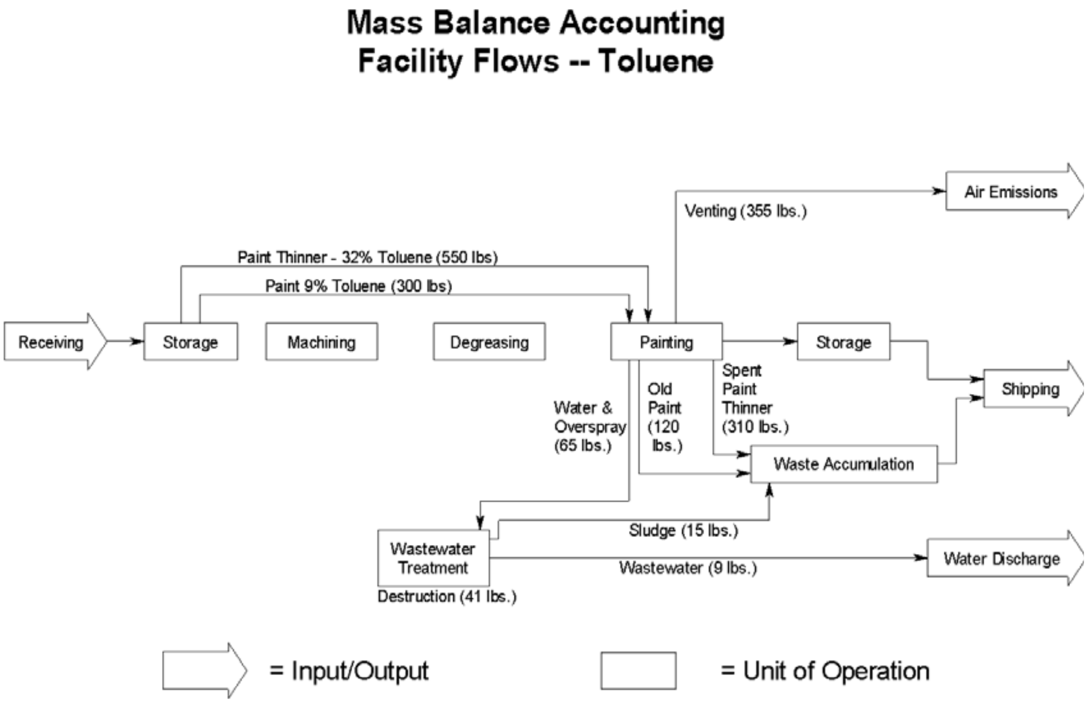


Figure 3. Mass Balance Accounting Facility Flows—Toluene

In the example above:

- Quantities of toluene in paint, paint thinner and unused discarded paint per week are calculated by use records, disposal records, and constituent knowledge.
- Air emissions are estimated, using EPA air quality emission factors for volatile organic air emissions from painting operations.
- Toluene in the water and overspray is calculated based on the amount of paint used, the known ratio of overspray to paint actually landing on the piece being painted (from process specs), and the concentration of toluene in the paint minus the air emissions from this portion of the painting operation.
- Destruction and partitioning of the toluene in wastewater treatment is calculated based on EPA water quality criteria documents.
- Toluene in the spent thinner is calculated as a mass balance from the above.

F. Refining Your Model

The final and on-going step in mass balance accounting is to test and continually refine your assumptions, your data, and your model itself. Existing information that will help in refining and fine-tuning your model may include:

- Permit monitoring data from environmental releases (mass flow = concentration × quantity)
- Simple inconsistencies: There are supposed to be 110 lbs. of toluene in this waste, but there are only 90 lbs. of waste. Where did the 20 lbs. of toluene go?
- Actual waste analysis data
- Product quality control information, including QC on intermediates

- Spill incidents or other product losses
- Records of materials used (including changes in quantity, chemical constituents, and so on)

In addition, you may wish to develop and maintain your own QA/QC systems for the purpose of assuring the chemical composition of wastes and releases. There are three specific types of systems you might consider:

1. **Operations Auditing.** Periodic audits of operations can help to assure that processes and materials used have not changed. They may also help to identify chemicals, releases, or other issues not included in your models. This is particularly true where outside (consulting or corporate) assistance is used in the audit. An operations audit may be as informal as making periodic “rounds” of the facility or may be as structured as a formal week-long study. To minimize redundancy, audits of your mass balance accounting system and constituent information should be integrated with related environmental compliance audits.
2. **QC Sampling and Analysis.** Although sampling and analysis alone is an expensive and often unreliable means of assuring environmental compliance, it can be used effectively as a means to test and control the quality of your “knowledge.” This sampling and analysis is different from that used to identify wastes and releases in two ways. First, it is less frequent, since it need not offer statistical confidence. Second, analyses are often done by less complex and less expensive “screening” methods (total organic halogen test kits, simple meters, indicator papers, GC screens, and so on) since you are looking primarily for anomalies, not data.
3. **Chemical Tracking.** Simple systems of inventory recordkeeping and bar coding can be used to track exactly where in a facility any particular chemical constituent is at any given time. To achieve this tracking, specific receiving controls must be in place.

First, such a system assumes all significant chemical constituents of each material you use are known. When received at your facility, the receiving clerk enters the material ID (your own internal name or code number), the number of containers, and the quantity per container. The computer automatically prints out one bar-coded label for each container. At the same time, the computer registers the material as present in the receiving department. In the computer, each bar code is now associated with a collection of chemical constituents and the quantity of each.

When a material is moved from one operations area to another, the movement is registered in the computer. This is done either by scanning the material with a dedicated bar code reader/terminal at the receiving location or by scanning the material’s bar code, followed by another bar code indicating the area to which the material is going. (You need not tell the computer where the material is coming from. It already knows.)

G. Case Studies

Motivations for implementing a constituents management system vary for organization to organization. In many instances, facilities have implemented mass-balance accounting to assist with reporting under the EPA toxic chemical release inventory reporting rules (TRI or Form R, 40 CFR 372).

In 1998, Carnegie Mellon University’s Green Design Initiative took them to a semi-conductor fabrication facility. The facility had implemented a chemical accounting system in response to the TRI program. It was their intent that the program would not only assist them in reporting, but also assist them in actually reducing the chemical usage per product output. Carnegie Mellon found a relative decrease in the toxicity or releases under the TRI reporting, even if in some instances the quantities did not change (or even increased).

Benefits beyond TRI reporting can bee seen through implementation of a constituents management system. Raymond Bloch reported in his article in *Rubber World* that, “A facilities [sp] daily operational efficiency is greatly increased through the chemical inventory management system (CIMS) by increasing accurate real time inventory information, through bar coding, on individual containers of chemicals within each facility. This continuous flow of accurate information allows for just in time ordering and total inventory minimization.” In the Carnegie Mellon University report, the benefits of a full cost accounting system (which includes chemical accounting) were reported, “…additional savings from handling time and reduce risk in the facility.” and, “by having a better understanding of the overall manufacturing process, the can identify problematic areas, time sinks, and excess waste to improve efficiency of the facility as a whole.”

Stanford University implemented a computer-based chemical management system to address their complex and dynamic system of chemical usage throughout nearly 200 buildings and 2,000 laboratories across a sprawling campus. Their system evolved from a paper-based system in the early 1980s into a desktop system by the end of the decade. As the campus grew, so did the jurisdictions on their chemicals and the complexity of those programs. The university sought to further improve their chemical management system in the 1990s. A benchmark of 50 universities showed great diversity and general dissatisfaction in the systems currently employed. An effort was made to improve a system with specific goals of:

- Generating compliance as a “byproduct of the core business”
- Allowing flexible implementation ad maintenance of data
- Providing value to the core user
- Being adaptable to new regulatory requirements
- Being sustainable and scalable
- Integrating with purchasing and property management systems

As a result, the university developed a web-based tracking system, taking 10 months to develop. In their system, all chemicals are linked to specific owners and can be tracked throughout the campus. The system allows users to track their inventories in real time and generate various regulatory reports based on inputs into the system.

Conclusion

The demand for instant knowledge of the types and amounts of chemicals is going to continue to increase. Regulatory reporting burdens apply to thousands of different chemicals. In addition, the number of regulatory jurisdictions increases as businesses find their markets in numerous countries worldwide.

On top of regulatory reporting, pressure will continue to increase from legislatures and consumers alike to replace existing constituents with those that are “safe” for the user and the environment.

Companies need to get a handle on their constituents. The implementation of a chemical material balance system, while time consuming and perhaps costly at first, is an essential cost of business in the 21st Century.

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