

Massachusetts Office of Technical Assistance Advisory Preventive Hazard Evaluation for Process Safety

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OVERVIEW

The 2012 Massachusetts Fire Code hazardous material processing regulation (527 CMR 33) requires a hazard evaluation or limited process safety program for many companies that have never faced this requirement before, (though many companies have been essentially performing these tasks as good practice).¹ Many companies covered by this regulation must now document that a hazard evaluation has been done, and safety measures are being integrated into operations.

Preparing for emergencies involving hazardous chemicals processing requires an understanding of what can go wrong and how to control it if it does. Preventing such emergencies requires an understanding of alternative ways of accomplishing work without creating the hazards that pose a risk of harm.

OSHA's Process Safety Management (PSM) and EPA's Risk Management Program (RMP) rules set standards for large facilities posing risks of significant property damage or toxic releases to the community. The new Fire Code regulation provides facilities with lesser risks (Categories 3 and 4) the flexibility to formulate an approach that is appropriate for the facility. This advisory concerns the essentials of preventive hazard evaluation, and the formalization of the process in a way that fits the scale of operations and which captures the potential value of the effort. *All facilities that have processes that pose risks should implement preventive hazard evaluation to reduce the chance of an accident involving injury or other losses.*

Integrating Process Safety with Related Efforts

PSM and RMP are procedures for understanding what can go wrong, and the maintenance of proper and optimal functioning. These are also goals of the Toxics Use Reduction Act (TURA),² quality and productivity efforts, and safety and environmental programs. Identifying opportunities to reduce the use of toxics, energy and water, and to improve process and product quality all involve the same exercise of analyzing existing processes, comparing them to intended purposes, and identifying alternative and perhaps better ways of achieving the intended purposes that lessen the chances of negative outcomes. There are many commonalities between the search for ways to make

¹ MA Executive Office of Public Safety and Security, 527 CMR 33.00: New Hazardous Material Process or Processing: <http://www.mass.gov/eopss/agencies/dfs/dfs2/osfm/fire-prev/527-cmr-33.html>.

² Applicable to industrial facilities with ten or more full-time equivalents using above-threshold amounts of chemicals listed at 310 CMR 41. See: <http://www.mass.gov/eea/docs/dep/toxics/approvals/chemlist.pdf>. Thresholds are 25,000 lbs per year if the chemical is manufactured or processed, 10,000 lbs/year if otherwise used, 1,000 lbs/year for "higher hazard chemicals", and smaller thresholds are designated for Persistent, Bioaccumulative and Toxic chemicals (PBTs).

a process inherently safe and the search for ways to make a process inherently clean or more productive. *It is more efficient to conduct these evaluations in an integrated manner than to perform them without attempting to construct a comprehensive perspective, and it is more likely that the value of the exercise will be increased if these related purposes are combined in some way.*

Capturing Potential Value

When viewing a system for the purposes of hazard reduction, the focus is what might go wrong and what the consequences would be. When viewing that same system for the purposes of toxics use reduction planning, the focus is whether there are cleaner alternatives or whether reduced use is sufficient. A hazard analysis will focus on how to prevent release of a dangerous chemical, while a Toxic Use Reduction (TUR) analysis³ will consider using less of that chemical or a safer method of doing what the chemical does. The two perspectives are complementary. But a hazard analysis as conventionally performed may fail to illuminate source reduction options as effectively as a TUR plan, and a TUR analysis as conventionally performed may fail to consider accident scenarios with the rigor of a hazard analysis. A hazard analysis should focus on conformity to design, while a TUR analysis should focus on potential changes to design assumptions that could increase optimality. An integrated approach will increase the chances that operations will occur as intended, under optimal conditions and with safer inputs, and will best accomplish the facilities production goals. An integrated approach will reduce the chance of both routine and accidental losses, and both waste and inefficiency. Doing either alone without integration will reduce the potential to capture opportunities for improvement.

Optimizing Continuous Improvement

Continuous improvement is a commonly-stated aim of industrial facilities. However, the institution of change can be difficult. A more accurate picture of the value of proposed changes is key to the success of continuous improvement efforts. An integrated effort has a higher likelihood of producing a comprehensive picture of costs and benefits, improving business decision-making. For a process that uses a hazardous chemical, a productivity analysis may note the time necessary for following protective measures. A pollution prevention program may note excessive waste management or compliance costs. A safety program may note increasing workers' compensation or insurance costs. *Conducted by themselves, without integration, each analysis details costs that by themselves may not be enough to convince management that a change holds sufficient potential benefits to consider.* An integrated approach produces a wider consideration of cost exposures and a more accurate picture of the benefits that may accrue from a change in practice that reduces hazards, wastes, and liabilities. There is a better chance that the value of actions that reduce risks will be clear, which will provide motivation to overcome the inertia that often impedes continuous improvement.

³ For those not familiar with TUR, it is a form of "pollution prevention": the effort to reduce the use of toxic chemicals by using safer methods of accomplishing the task that the toxic chemical performs, or by using no more than is needed to accomplish that task. It is also referred to as "Source Reduction" because it addresses pollution and waste at the source: the decision to use the chemical that results in pollution or waste. The same source reduction approach can be used to reduce accident risks that are presented by the use of a hazardous chemical.

MANAGING THE PROCESS

This advisory is intended to assist in the development of an effective program. It is not a complete presentation of all the actions or questions that might be appropriate for every scale or kind of operation. Its central point is that an integrated approach that enhances continuous improvement and captures potential value is likely the best way to use limited resources. How can management create a process that attempts to be both comprehensive and efficient at the same time? Formation of a team can help. A team that brings together various perspectives, invested with management support, is most likely to form a comprehensive picture, characterize risks appropriately, and identify and accurately evaluate opportunities. To increase the chances that the effort will have lasting value, companies should view the effort as ongoing, and institute:

- Periodic reviews and documentation
- Accountability for critical actions
- Communication of safety policies
- Reliable methods of managing change

Management should take actions to combat any tendency to see the safety effort as an “extra” initiative, or one that takes time away from core business activities.

It is suggested that facilities become informed about the various approaches that have been developed for risk reduction, such as EPA’s Risk Management Program guidance,⁴ OSHA’s 2000 informational booklet *Process Safety Management*,⁵ EPA’s Chemical Emergency Prevention and Planning Office newsletter,⁶ and industry and professional sources, such as AIChE’s Center for Chemical Process Safety.⁷ Information about recent accidents and analyses of what went wrong and recommended preventive measures is also available from the U.S. Chemical Safety Board.⁸

These and other resources will help the team to understand process safety. But it is most efficient to also conduct a Toxics Use Reduction, pollution prevention, or waste minimization effort that comprises ongoing reviews of the viability of alternatives to hazardous chemicals. This can reduce process risks at the source. A team that reviews operations and incident history, understands what might go wrong and the underlying causes of actual or potential accidents, and generates ideas for improving process safety can also seek to discover opportunities for reducing chemical use to reduce costs, and for enhancing productivity.

⁴ <http://www.epa.gov/oem/guidance.htm#rmp>. Inspection checklists can also be found on regional sites, e.g.: [http://yosemite.epa.gov/R10/airpage.nsf/3ac6cd2257698ab088256b66007eb08d/1a76355d09786fd9882575f6006004cf/\\$FILE/RMP%20Program%20Level%201%20Process%20Checklist.pdf](http://yosemite.epa.gov/R10/airpage.nsf/3ac6cd2257698ab088256b66007eb08d/1a76355d09786fd9882575f6006004cf/$FILE/RMP%20Program%20Level%201%20Process%20Checklist.pdf).

⁵ <http://www.osha.gov/Publications/osha3132.pdf>. See also the home webpage at <http://www.osha.gov/SLTC/processsafetymanagement/index.html>, and the summary at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9763.

⁶ <http://www.epa.gov/region10/pdf/rmp/CEPPnewsMarchApril2013.pdf>: “Process Hazard Analysis”.

⁷ Courses such as *Process Safety Boot Camp* are described at <http://www.aiche.org/ccps/resources/education>.

⁸ <http://www.csb.gov/>

The Preventive Hazard Evaluation Team

The team should include personnel charged with safety, environmental, and process control, someone in or connected to top management, people who can visualize what can go wrong, and people who can generate solutions. There should be some link to those in the organization who determine chemical use, process or product design. Employees should be informed of the team effort and encouraged to interact with the team to provide observations and suggestions. The team should:

- *Inspect all areas where hazardous chemicals are located, using or constructing charts of their movement through the facility, from delivery to final conversion or shipping.* TUR process flow diagrams and chemical pathway analyses will be useful here.⁹
- Consult relevant guidance (such as PSM) for a list of information that should be collected (for example: chemical characteristics, indicators of intended and unintended reactions, maximum potential inventory, safe upper and lower limits for such items as temperatures, pressures, flows or compositions).
- Review any incident history, injuries, near-misses, worker complaints about odor, indoor air, releases or exposures, attempting to identify root causes.
- Gather information about the materials of equipment and construction, the piping system, the electrical classification, pressure relief and ventilation systems and the requirements they are designed to meet, any design codes and standards employed, expected materials and energy balances and any needed safety systems (e.g., interlocks, detection, or suppression systems). Add to or correlate with process flow diagrams. OSHA OSM guidance will be helpful in identifying specific areas and methods.
- Understand the full costs of current chemical use, including regulatory compliance, waste management, insurance, impacts related to worker safety, safety precautions currently undertaken, and understand actual and potential impacts on community or environmental health. Identify relevant requirements and evaluate compliance. Estimate the costs of addressing likely and worst-case accident scenarios.¹⁰ EPA RMP tools will be helpful in projecting accident consequences.

The team should consider process areas and storage, delivery, dispensing, (which are covered by the 527 CMR 33 hazard evaluation provisions if adjacent or relevant, and are part of a full-facility preventive safety approach even if not covered by the processing rule). The team should review normal operating conditions and how they are to be maintained, and consider what will happen if they are not maintained. The team should include ancillary chemical use (for example, equipment cleaning chemicals, as well as process chemicals, for which many safer alternatives may be

⁹ See p. 25 of MassDEP's TUR Planning Guidance: <http://www.mass.gov/eea/docs/dep/toxics/laws/planguid.pdf>.

¹⁰ If the process of auditing discovers violations, be aware of the benefits of self-reporting and small business compliance policies. EPA: <http://www.epa.gov/compliance/incentives/auditing/auditpolicy.html>, <http://www.epa.gov/compliance/incentives/smallbusiness/index.html>. Mass DEP: <http://www.mass.gov/eea/agencies/massdep/service/enforcement/enforcement-regulations-policies-and-guidance.html>.

available¹¹). While generating recommendations to decrease the chances of deviation, the team should consider if operations can be improved by reexamining parameters such as temperature, flow, and composition, or through changes in materials use.

Some Questions To Ask In Examining Equipment Containing Chemicals:

- What is it made of? Is there rust? Stains? Dents? Are the supports strong?
- What is the expected life of every component? Is piping condition known, would anyone know what flows through it and the direction of flow? Are there areas you can't inspect, such as under insulation? If so, what methods will you use to determine the integrity of these areas? Does what we see match the blue prints? Are these the best materials to use? Is this the best equipment for the purpose?
- Are the pressure relief valves the proper rating and are they inspected, maintained, and replaced, particularly during freezing conditions? What control and monitoring equipment is used (or should be) and how do we ensure they are functional?
- What protocols for filling or use of the vessel are necessary and how we do ensure they are followed? Is there signage to ensure we know what's going where and what's in what? Are bonding and grounding followed? Is grounding to plumbing appropriate?
- What traffic passes by the vessel, piping, etc.? How do we prevent an accident? Are the roof and floor in good shape?
- Are there necessary process conditions to remain safe? If something needs to be kept cold or hot or under a certain pressure or below a certain volume how is that ensured? Are process steps and parameters that should be measured fitted with adequate gauges and monitors? Are alarm set points in place where they ought to be and set at appropriate levels?
- Can the process take place in a smaller vessel? Can less be used to accomplish the task? How do we know how much is necessary?

Some Questions To Ask To Improve Process Safety:

- What temperature change, pressure change, accidental intrusion, negligence, weather event, negligence, vandalism could cause a rupture or spill?
- What if there's a loss of power?
- What will happen if there's a fire? What would melt? What gases would be released from burning materials? What would prevent spread?
- What will happen if there's water intrusion? Where might that come from?
- What if there's an earthquake, hurricane, or tornado?

¹¹ The Toxics Use Reduction Institute operates a Surface Cleaning Laboratory to help companies evaluate safer cleaning chemicals: http://www.turi.org/Our_Work/Green_Cleaning_Lab.

- What if there's extreme weather – flood, lightning, very high winds, very heavy snow, deep cold, extreme heat?
- Do contractors operate at the site, and can their operations impact process conditions?
- What if a forklift bangs into the vessel or piping?
- Could a spill occur at any point? Where would the material flow? Could it ignite? Could it mix with an incompatible? Could it be contained? What is necessary to respond to the spill? Consider both acute and chronic - small spills that build up over time, such as drips from a dispensing operation.
- Is there a flammable gas that could escape? What must happen to ensure it does not escape?
- Is the area where it is used up to code? Is there classified electrical equipment (for example, spark-proof) where the gas could accumulate (will it sink or rise? What is the ventilation system, how does it operate, could it fail?) What about portable electrical equipment being brought into the area?
- Are there dusts that are created by normal operations? Do they build up anywhere? Are they combustible? Are there procedures for cleaning? Can their release be prevented? What causes their creation?
- What will happen if the equipment corrodes faster than expected? What could cause that? How do we tell if that happens and address it in time?
- Don't just consider product, input – but also intermediates, byproducts.
- Are there odors or other evidence of emissions to indoor air? Examine worker complaints of headaches or odors that could be indicators.

The TEAM's Report

The team should prepare a report that answers the following question: What can we do to prevent these events and mitigate the consequences of these events if we can't prevent them?

Prevention First: Try first to find ways to remove or reduce the underlying hazard.

- Consider whether the amounts, pressures, temperatures or flows can be changed to reduce use of the hazardous material and whether there might be productivity or quality benefits (determining the exact operating conditions for optimal results is a primary focus of productivity efforts).
- Consider the function of the material and whether alternative means can be used to accomplish that function.
- Understand the full cost of current use of toxics, including compliance with all relevant requirements, and the benefits of alternatives that might reduce regulatory and management burden, in order to have an accurate understanding of potential savings from implementing alternatives.
- Map the location of critical controls to prevent deviations from intended operating conditions and establish protocols for diagnostic maintenance.

- Look for opportunities to reduce costs or improve production, including regulatory burden (for example, if the operation can be performed in a smaller vessel or with a safer chemical).

Mitigation: Do consequence analysis in case all efforts fail and there is an accident.

- Identify vulnerable receptors.
- Identify shut-down and restart issues.
- Consider the severity and the likelihood of the accident occurring so that remote possibilities that could have terrible consequences are properly recognized, and small risks that occur frequently are assessed for their cumulative and long-term costs.
- Evaluate conditions for rapid availability and proper functioning of needed emergency response actions and equipment, alert and communication systems, evacuation planning and training, coordination with local responders.

Continuous Improvement and Value:

- Note training or retraining needs, such as evacuation, or the new Global Harmonization System, and needed equipment.
- Describe changes that should be instituted or evaluated, and changes that should not occur without review.
- Present a comprehensive picture of the actual and potential value of recommended changes, such as reduced insurance costs, improved community relations or reduced wastes, in addition to reduced likelihood of accidents and reduced expenses of response.

Process Change: Research potentially beneficial changes on an ongoing basis. Solicit ideas from experts and employees outside of the team concerning product, input and process optimization. Establish procedures to manage change. Refer to original blue prints and manufacturer specifications and check if current operations have changed: if they have, determine the reason and evaluate whether it is acceptable. Evaluate whether any uncontrolled changes indicate a need for process design improvement. Put in place checks on changes in equipment or processing to ensure evaluation. Put in place written standard operating procedures to reduce the chances of deviation from design.

SUMMARY OF KEY CONSIDERATIONS

To be efficient and to capture the potential value of process review, view hazard evaluation as part of an overall productivity effort. Combine with LEAN¹², efficiency, compliance assurance, waste reduction, health and safety, pollution prevention, and/or toxics use reduction initiatives. Begin with evaluating whether use of the chemical that causes the risk can be reduced or eliminated. Identify all toxic, reactive, corrosive, flammable, compressed gas and incompatibility issues. Identify all relevant requirements such as hazard communication, hazardous waste, water, release

¹² LEAN is a methodology for quality, efficiency, waste elimination. See: <http://www.epa.gov/lean/index.htm>, <http://www.lean.org/whatslean/>.

notifications, air regulations, and building, fire or electrical codes. Assign accountability for ensuring they are followed. Test emergency equipment such as showers, eye washes, and personal protective equipment and train in their use as necessary. Review and train in evacuation procedures, the safe handling of hazardous materials and spill response. Solicit ideas from employees for improvements to reduce waste or processing time. Revise and integrate all existing emergency response plans into one plan that is preventive in nature.¹³ Identify the cost avoidance and liability prevention benefits of your recommendations.

The team's report to management should ensure that an accurate picture of what could go wrong and potential human and property damage are fully described. To emphasize that these things actually do happen, cite instances in similar operations. Note potential liabilities in case of release: fines for failing to make required notifications, denial of insurance coverage dependent on compliance with code, failing to uphold a standard of care necessary to defend against civil suit, reimbursement of public costs of response, delays in restarting operations, loss of business, cleanup costs. Provide your recommendations for reducing the chances of these ever happening noting their value in relation to eliminating these potential liabilities, and other costs such as reduced waste or other costs. If, for example, the report recommends chemical substitution, show how it will not just reduce the chance of an accident involving an evacuation but will also reduce compliance, waste management, insurance, ventilation, and other costs caused by its use. View the process as a spur to innovation. Look for opportunities to improve process and product.

Because the approach of this state regulation is flexible and the effort is to be conducted in a manner that works for the facility, this advisory contains two sample summaries of how to do a compliant and effective preventive hazard evaluation. The summary above focuses on how to integrate the effort into related initiatives the company may be conducting, and how to gain the most value out of the process. The summary below is more focused on safety. Neither summary is a comprehensive and exhaustive list of what a company should do, but are provided to assist a company in getting started.

Essential Actions for the Team

1. Define and document normal processes and set up indicating sensors for monitoring with selective alarms for critical process parameters and procedures to react to deviations before they become substantial enough to cause a problem.
 - Define the actions and changes that trigger checking.
 - Re-calibrate what needs to be calibrated. Recommission what needs to be recommissioned.
 - Consider automation and use fail-safe control elements, reduce reliance on operators doing too many things at once.
 - If relying on people, use a standard protocol, documentation that it was followed, and checking by others.
2. Check the hazards of each chemical, including compatibility. For each chemical identify what it must not come in contact with. If order of addition is important, ensure it is followed (for example,

¹³ See the Integrated Contingency Plan guidance <http://www.epa.gov/osweroe1/docs/chem/one-plan.pdf>.

add acid to water, not water to acid). Consider rust, container materials, floors. Consider if alternative chemicals may be used.

3. Evaluate facility suitability by checking for applicable codes and regulations. Review the electrical classification of the area around the vessel and whether appropriately rated electrical equipment is installed. Review the inventory of hazardous materials within the building area that contains the vessel and compare to building code quantity limits. Consider available industry consensus practice guides or codes related to the hazardous materials in use or to the type of industry or process.

4. Research what has gone wrong or almost gone wrong in your facility. (Incident history, including near-misses). What has gone wrong at similar facilities, or other facilities using the same chemicals? Review the literature, available guidance. Make sure it is safe to report problems and discuss them. Look for patterns. Identify what is lacking for a safe and optimal process.

5. Do preventive and diagnostic maintenance, know the expected life of components under expected conditions and check whether those conditions are maintained. Check pressure relief valves and ratings. Have a Replacement in Kind policy for minor equipment changes for process systems that have been through process hazard analysis. Establish safe maintenance procedures and checklists for safe startup.

6. Clarify authority. Make sure an emergency coordinator has authority to get information from staff and authority to make decisions when there is an emergency, particularly concerning what to tell emergency responders. Ensure safe shutdown procedures are known and available when needed. Ensure contractor and visitor activities are monitored and compliant with facility expectations.

7. Do accident/release scenarios based upon probable consequences of system deviations that get out of control. Identify vulnerable receptors and pathways to them from your facility and evaluate feasibility of potential schemes for incident containment or loss mitigation. Estimate costs of business interruption, property damage and cleanup response actions. Use available resources from U.S. EPA to estimate consequences of releases, consider worst case scenarios, and have a checklist for ensuring quality process review.¹⁴

8. Prepare resources and train for probable incidents. Put in emergency equipment for: spill and leak detection, water curtains, containment. Evaluate ventilation, noting where vapors will go. Test and train. Attribute the costs of these actions to the decision to use the chemical that makes them necessary.

9. Inform employees and solicit suggestions for reducing risks. Consult experts and research options for alternative inputs that do not present the hazards identified, and process and equipment changes that reduce them.

¹⁴ For example, EPA's *CAMEO suite of tools*, *RMP* Comp*, *the Level One Risk Management Plan checklist*, [http://yosemite.epa.gov/R10/airpage.nsf/3ac6cd2257698ab088256b66007eb08d/1a76355d09786fd9882575f6006004cf/\\$FILE/RMP%20Program%20Level%201%20Process%20Checklist.pdf](http://yosemite.epa.gov/R10/airpage.nsf/3ac6cd2257698ab088256b66007eb08d/1a76355d09786fd9882575f6006004cf/$FILE/RMP%20Program%20Level%201%20Process%20Checklist.pdf), and *Level Two*: [http://yosemite.epa.gov/R10/airpage.nsf/3ac6cd2257698ab088256b66007eb08d/1a76355d09786fd9882575f6006004cf/\\$FILE/RMP%20Program%20Level%202%20Process%20Checklist.pdf](http://yosemite.epa.gov/R10/airpage.nsf/3ac6cd2257698ab088256b66007eb08d/1a76355d09786fd9882575f6006004cf/$FILE/RMP%20Program%20Level%202%20Process%20Checklist.pdf).

10. Establish clear policies and procedures that change must be managed in accordance with the standards established through this effort. Use documentation to create and maintain accountability. Monitor sufficiently and continuously communicate the importance of the effort.

RESOURCES:

Toxics Use Reduction Program: <http://www.mass.gov/eea/grants-and-tech-assistance/guidance-technical-assistance/agencies-and-divisions/ota/> (confidential assistance with process change options, alternative materials, and compliance). <http://www.turi.org/> (general information, training, library, and surface cleaning laboratory for trials of alternatives to hazardous cleaning chemicals).

EPA (RMP): http://www.epa.gov/emergencies/content/rmp/rmp_guidance.htm#General,
http://www.epa.gov/emergencies/content/rmp/rmp_comp.htm

OSHA (PSM): <http://www.osha.gov/SLTC/processsafetymanagement/index.html#recognition>

Center for Chemical Process Safety: www.aiche.org/ccps/. (Sign up for the monthly Beacon newsletter at: <http://www.aiche.org/ccps/resources/process-safety-beacon>)

Department of Labor Standards: <http://www.mass.gov/lwd/labor-standards/on-site-consultation-program/> (free consultation service designed to help employers recognize and control potential safety and health hazards at their worksites, improve their safety and health program, assist in training employees, and possibly qualify for a one-year exemption from routine OSHA inspections).

This advisory is not intended as a comprehensive guide to conducting compliant hazard analysis and reduction, but as an aide to compliance and achieving benefits that go beyond compliance. Please refer any comments to its principal author Rick Reibstein, rick.reibstein@state.ma.us, 617 626 1062. The Office of Technical Assistance is grateful for helpful suggestions in developing this document, from: Andy Irwin, IRWIN Engineers; Todd Dresser, Mabbett Associates; Tony Cartolano, SPEC Process Engineering & Construction; Martha M. Wik, Sunny Delight Beverages; Laura Bonk, The New England Consortium; Paul Scheiner, Simpson, Gumpertz and Heger; staff of the Massachusetts Department of Labor Standards, and staff of the Massachusetts Division of Fire Safety.

The Office of Technical Assistance and Technology (OTA) has developed several guidance documents. To see the other guidance documents please visit: <http://www.mass.gov/eea/ota>. OTA is a non-regulatory office within the Executive Office of Energy and Environmental Affairs (EEA) that provides a range of non-regulatory assistance services to help businesses cut costs, improve chemical use and energy efficiency, and reduce environmental impact in Massachusetts.

For further information about energy efficiency and renewable energy, or about OTA's technical assistance services, contact:

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