Preventing Chemical Accidents

Mechanical Integrity – Preventing Maintenance Breakdowns

Process Safety Management Training
from the
NJ Work Environment Council

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About WEC

The New Jersey Work Environment Council (WEC) is a non-profit collaboration of organizations working for safe, secure jobs, and a healthy, sustainable environment.

Visit WEC’s website at www.njwec.org

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Preventing Chemical Accidents

Unexpected releases of highly hazardous toxic, reactive, or flammable chemicals create the possibility of a disaster for workers, employers, and communities.

OSHA’s Process Safety Management Standard helps prevent accidental releases of highly hazardous chemicals, thus protecting employees, as well as plant neighbors.

Effective worker training about PSM helps achieve safer, healthier, and more productive workplaces.

In New Jersey, PSM regulates approximately 100 facilities, including certain chemical plants, oil refineries, food processors, electric utilities, warehouses, and public and private sector water and sewage treatment operations. PSM may also cover other types of facilities. PSM has special provisions for contractors working in covered facilities.

WEC’s training curriculum covers key aspects of the PSM standard. Training introduces the concept of systems of safety and accident prevention and why facilities should establish an organizational structure to oversee PSM implementation. We address OSHA’s performance-based requirements for a plant “mechanical integrity” program. Training also covers accident, incident, and near-miss investigations, focusing on root causes. We also can provide training on closely related subjects, such as the New Jersey Toxic Catastrophe Prevention Act (TCPA), employer and worker/union rights to participate during OSHA and TCPA inspections, and development of effective labor-management safety and health committees.
The Small Group Activity Method

Basic Structure
The Small Group Activity Method* is based on a series of problem-solving activities. An activity can take from 45 minutes to an hour. Each activity has a common basic structure:

• Small Group Tasks
• Report-Back
• Summary

1. Small Group Tasks: The training always begins with groups working together at their tables. Each activity has a task, or set of tasks, for the groups to work on. The task asks that the groups use their experience and the factsheets to solve problems and make judgements on key issues.

2. Report-Back: For each task, the group selects a scribe that takes notes on the small group discussion and reports back to the class as a whole. During the report-back, the scribe informs the entire class as to how his or her group solved the particular problem. The trainer records each scribe’s report-back on large pads of paper in front of the class so that everyone can refer to them.

3. Summary: Before the discussion drifts too far, the trainer needs to bring it all together during the summary. Here, the trainer highlights the key points of the activity and brings up any problems or points that may have been overlooked during the report-back.

*The Small Group Activity Method (SGAM) is based on a training procedure developed by England’s Trades Union Congress (TUC) in the 1970s. The Labor Institute and Oil, Chemical, and Atomic Workers Union (now part of the United Steelworkers Union) used a similar method around economic and health and safety issues for workers and further developed the procedure into SGAM. The New Jersey Work Environment Council has used SGAM since 1986.
Three Basic Learning Exchanges

The Small Group Activity Method (SGAM) is based on the idea that every training is a place where learning is shared. With SGAM, learning is not a one-way street that runs from trainer to worker. Rather, SGAM is a structured procedure that allows us to share information. It is based on three learning exchanges:

- Worker-to-Worker
- Worker-to-Trainer
- Trainer-to-Worker

Worker-to-Worker: Most of us learn best from each other. SGAM is set up in such a way as to make the worker-to-worker exchange a key element of the training. The worker-to-worker exchange allows participants to learn from each other by solving problems in their small groups.

Worker-to-Trainer: Lecture-style training assumes that the trainer knows all the answers. With SGAM it is understood that the trainers also have a lot to learn and this is the purpose of the worker-to-trainer exchange. It occurs during the report-back and it is designed to give the trainer an opportunity to learn from the participants.

Trainer-to-Worker: This is the trainer’s opportunity to clear up any confusion and make points they think are key. By waiting until the summary section, trainers know better what people need to know.
The Factsheet Reading Method

The process described below focuses everyone on the important information in the factsheets.

The process is as follows:

First, select a scribe for this Task.

Each of you will be assigned a small number of factsheets to read. You will then share the factsheet information with your table.

Your trainer will assign your individual factsheets this way:

Starting with the scribe and moving to the left, count out loud from 1 to 8. Keep going around the table until all numbers (factsheets) are distributed. For example, if there are four people at your table, the scribe will have self-assigned Factsheets 1 and 5; the person to their left will have Factsheets 2 and 6, etc. The assigned numbers correspond to Factsheets 1 through 8 on the following pages.

Once everyone has read their assigned factsheets individually, your scribe will go around the table and ask each of you to explain to the group what you have learned. You do not need to take notes. Factsheets should be explained in the order assigned (1 through 8), since the factsheets build on the previous one. In this way, we all start at the same place and with the same information.
Mechanical Integrity - Preventing Maintenance Breakdowns

Purposes

To become familiar with the OSHA performance-based requirements for a plant “mechanical integrity” program.

To examine the causes and solutions of “breakdown” maintenance.

This Activity has two tasks.
Task 1

In your groups, choose a scribe. Then, using factsheets 1 - 6 on pages 3 - 11, answer the following questions:

1. What are some causes of maintenance breakdowns?

2. Could maintenance breakdowns happen at your plant? List some examples.
Factsheet #1

Maintenance Myths Most Often Heard

Here are some commonly-used excuses for not following safe mechanical integrity practices and examples of the consequences of not doing so:

It’s only temporary:
A leak developed on one of the six in-line reactors. All six were connected with 28-inch-diameter pipes and expansion bellows. The leaking reactor was bypassed with a 20-inch pipe with two elbows and the expansion bellows were left intact.

The pipe was not supported properly; it was resting on scaffolding. Because of the bellows, it was free to rotate or “squirm” and in the process it failed, killing 28 people and destroying the plant.

It’s factory set; no need to test it:
In an automatic fire-fighting system, a small explosive charge cut a rupture disc and released the fire-fighting agent, Halon. The manufacturer said it was not necessary to test. To test would require the loss of the Halon which was very expensive.

The buyer insisted on the test even with the added expense. The smoke detectors worked but when the explosive charge was activated, the rupture disc was not activated. The manufacturer was in error.
Factsheet#1(continued)

Go ahead and use this one; it'll work:
A carbon steel valve was painted with aluminum paint instead of using a stainless steel valve. It corroded rapidly.

I don’t need an operator; I’m just going to look:
A maintenance foreman was asked to look at a faulty cooling water pump. He decided that, to prevent damage to the machine, it was essential to reduce its speed immediately. He did so, but did not tell any of the operators. The cooling water rate fell; the process was upset; and a leak developed on a cooler.

Factsheet #2

Work Order Backlog: #1 Warning Sign

Most companies have very good written preventive maintenance (PM) plans on equipment. But in reality, as the work orders pile up, they are unable to keep their PMs caught up.

To make matters worse, preventive maintenance work orders are often treated as having a lower priority than most other work orders.

The problem is compounded by the fact that most companies do not employ enough maintenance workers to stay on top of the regular work orders, much less the PMs.

A huge backlog of work orders is a sign that the Mechanical Integrity (MI) program is not doing what it is intended to, and it may be considered a violation of the performance-based Process Safety Management (PSM) Standard.
Factsheet #3

If It Ain’t Broke . . .

Many companies consciously decide to Run to Failure (RTF). RTF is rarely less costly than preventing failure. A company that manages using RTF twists the old cliché, “If it ain’t broke, don’t fix it.” Unfortunately, this approach can lead to catastrophe.

“An ounce of prevention is worth a pound of cure” is a better maxim:

• A $10 seal may wind up costing thousands of dollars, not to mention death and injury.

• The normal rule of thumb is that corrective (breakdown) costs are four to five times more expensive than preventive costs.

Source: Total Productive Maintenance, Marshall Institute, Inc. (2900 Yonkers Road, Raleigh, NC).
Factsheet #4
Understaffing Leads to Problems: A Case Study

During testimony on the PSM Standard, one USW member described some of the effects that the reduction of maintenance workers had at his plant.

Maintenance staff cut in half:

“The staffing of the Mobil Beaumont refinery has steadily decreased in the past ten years. The Beaumont refinery had over 2,000 hourly employees, of which 1,200 were permanent maintenance employees when I went to work there 20 years ago. We now have less than 600 maintenance workers.”

The effects don’t hit you overnight:

“Maintenance workforce reductions are not something that hit you overnight. The effects are gradual; but as time marches on, the reductions become more and more obvious.”

“Running maintenance today in both quality and quantity is much worse than 10–15 years ago. Pumps and compressors are not maintained. They cannot be properly maintained when the people are not there to do the work.”
Factsheet#4 (continued)

The potential for disaster is present:

“Leaks of all sorts: oil, chemicals, which include toluene, ketone, etc., are not addressed in a timely manner. The limited amount of maintenance people are kept busy doing work necessary to maintain production; and the less important problems, in the company’s judgment, are left unattended.”

Understaffing leads to excess overtime and fatigue:

Years after this 1991 testimony, the problem of understaffing and related extended working hours was highlighted by the U.S. Chemical Safety and Hazard Investigation Board (CSB) in their 2007 Investigation Report of the March 2005, BP refinery explosion and fire in Texas City. The incident occurred during the startup of an isomerization (ISOM) unit when a raffinate splitter tower was overfilled. Among the underlying factors the CSB identified that resulted in overfilling the tower was “ISOM operators were likely fatigued from working 12-hour shifts for 29 or more consecutive days.”

Factsheet #5
Maintenance Downsizing

The number of production and maintenance workers in the petrochemical industry has been dropping since 1989.

But, along with these workforce reductions came an increase in production.

Factsheet #5 (continued)

A 30-year study of accidents in the petrochemical industry revealed that incidents which resulted in "large property damage losses" were most often caused by mechanical failure in the process equipment (41 percent of the time). The most recent update of this study shows piping failures and leaks, cryogenic plant equipment failure, and weather conditions as major causes.

![Diagram of Causes of Mechanical Failure]

Factsheet #6

Longer Time between Turnarounds Leads to Danger

Prior to the 1970s, the average length of time between turnarounds was one year. Now this period is much greater, with the duration between turnarounds sometimes as long as five years. This longer length of time means that some equipment, which can only be repaired when the unit is shutdown, has to wait.

A typical result of long turnaround times is that process units are run under dangerous conditions that would not have been acceptable years ago. A true life example is told in the “calculated risks” story below:

The Calculated Risks:

“A[n] . . . example of calculated risks occurred prior to a scheduled turnaround on the FCC. This fluid catalytic cracking unit had turnarounds put off time and again, because corporate needed it to meet gasoline demands. The expansion joint . . . was found to have a hole in it. The company dealt with this by installing a camera on the expansion joint so the operator could monitor the hole. The unit should have been shut down. It would have been shut down ten years ago; however, a decision was made to continue running the unit despite the potential of very radical consequences.”

Task2

Scenario:

During the night shift on unit “A” at ChemPetro, the process operator, Debbie, noticed a severe vibration on E-101 “G” fan. She radioed the control room and asked the Board Operator, Jim, to write a work order to get the bearings replaced.

Jim filled out the work order and gave it to his Foreman, Bob.

Bob made a notation in the unit log book that the bearings were bad and forwarded the work order to the unit supervisor for approval. Bob and his crew were finishing up their night rotation and were starting their days off.

When Ernest, the Unit Supervisor, arrived on the day shift, he assigned it a priority “2” (complete within a week) because it was cool outside and he knew they could run without it. Besides, the maintenance crew was already busy repairing the centrifuge which was a priority “1” (overtime authorized).

At 3:00 a.m. on the following day, the bearing failed on E-101 “G” creating such a vibration that a pressure gauge leaked, causing a fire.

During the investigation that followed, it was found the vibration switch had failed to trip the fan off the line. It had been wired wrong, probably since the time of installation.
Task2(continued)

In your groups, choose a scribe. Then, using factsheets 1 - 6 on pages 14 - 21, answer the following questions:

1. List ways this fire could have been prevented.

2. In your groups, develop a “preventive maintenance” program for ChemPetro. List the key elements of the program below.
Factsheet #1
The PSM Standard Is “Performance-based”
A Review from the Introduction to PSM Activity

Performance-based Standards

The Process Safety Management (PSM) Standard is a performance-based standard. That means it is goal-oriented and what you should judge is a program’s effectiveness. The exact specifications are not spelled out, just the desired results.

The PSM Standard gives each facility the flexibility to design its own program to match its needs, as long as the outcome prevents or minimizes major releases, spills, fires, and explosions. (Specification-based OSHA standards prescribe precise rules, such as a guardrail’s height, exact limits of exposure, etc.)

Your work experience is your guide.

Another way to understand the accident prevention requirement of a performance standard is to think in terms of our five senses. We can look and listen for hazards; we can feel for vibrations and smell for leaks (although that is not always trustworthy); and, at times, we may even be alerted by our sense of taste. However, the most important sense we bring to the job is our work experience.
Factsheet#1 (continued)

You should ask yourself the following question when reviewing your facility’s PSM program:

Will this program, as it is written and applied, help to prevent accidents? If the answer is “no,” then the company is not complying with the spirit and intent of the law.

For example, if the company develops a preventive maintenance program (PM) but assigns PM work orders low priority, your work experience tells you that there really is no PM program!

Remember, this is a performance-based standard. It does not spell out the specifics, just the desired results. The goal or desired results of the Mechanical Integrity (MI) element of the PSM Standard is designed to prevent accidents through the proper maintenance of equipment. Common sense and experience are important tools to determine whether or not an MI system is fulfilling the intent of the PSM Standard.
Factsheet #2
What the PSM Standard Covers

The requirements for mechanical integrity under the PSM Standard apply to six specific types of process equipment where failure is likely to be catastrophic.

These types of equipment, used in the handling of highly hazardous chemicals are:

1. Pressure vessels and storage tanks;
2. Piping systems (including valves and other components);
3. Relief and vent systems and devices;
4. Emergency shutdown systems;
5. Controls (monitoring devices and sensors, alarms and interlocks); and
6. Pumps.

Factsheet #3
OSHA’s Elements for an MI Program

According to OSHA, the necessary elements of a good mechanical integrity (MI) program are:

- Establish and implement written procedures to maintain the integrity of process equipment.

- Train employees and contractors involved in maintaining the integrity of equipment.

- Perform periodic inspection and testing, following “recognized and generally accepted good engineering practices,” and document that inspections have been done.

- Correct equipment deficiencies before further use or in a safe and timely manner.

- Develop a quality assurance program to ensure that:

  - Equipment for new plants is suitable for use in the process, and is properly installed; and
  - All maintenance materials, spare parts and equipment are suitable for intended use.

Factsheet #4

Why Preventive Maintenance?

It’s the Law!

**OSHA:** The PSM standard requires preventive maintenance be performed before further use of the equipment or in a safe and timely manner when necessary means are taken to assure safe operation.

**EPA:** The Environmental Protection Agency has rules to cover preventive maintenance programs within its Risk Management Plan requirements.

**NJTCPA:** In addition to the OSHA PSM & EPA requirements, the NJ Department of Environmental Protection, under the NJ Toxic Catastrophe Prevention Act (TCPA), requires preventive maintenance be performed within 3 months or a written justification must be provided including an explanation of the necessary measures taken to ensure safe operation.

TCPA also requires companies to maintain accurate records of all inspections, breakdowns, repairs and replacements of process equipment. All mechanical integrity/preventive maintenance records must be kept for the lifetime of the process equipment.
Factsheet#4(continued)

If You Don’t, It Costs $$$.

The BP Texas City refinery explosion and fire in March 2005, is a painful example of the cost of failing to perform preventive maintenance. This disaster happened in part because several instruments were out of service and the operators had no way of knowing that a critical unit was being overfilled with highly flammable liquids. Timely and proper maintenance might have saved the lives of 15 workers and prevented another 180 from being injured. It also might have saved BP from financial losses that have thus far totaled over $1.5 billion.

It Pays.

According to some corporate managers, there can be positive benefits from Process Safety Management:

“Process safety management is intended to help you recognize, understand and control all your process hazards. If you do that, you’re going to understand and control your business; it runs better . . . it’s more efficient and your quality’s higher.”

Factsheet #5
Not All Employees Receive the Same Safety Training

After the Phillips 66 Houston Chemical Complex explosion in 1989, which killed 23 workers and injured 232 others, OSHA commissioned a team of experts to study the use of contractor labor in the petrochemical industry. One of the main concerns of the study (called the John Gray Report) was to determine the quality of health and safety training that contract workers received.

The survey showed that only 62 percent of contract workers reported that they received nine or more hours of company training in the last year, whereas 81 percent of the direct hires reported nine or more hours of training.

The report concluded:

“. . . the quality of the labor force in this industry is declining and the number of employees who are associated with higher accident rates (younger, less tenure, less education) is increasing. One implication of this is obvious: The need for increased education and training investments in this workforce is substantial.”

Different companies provide different types of training, but it’s not always enough.

Factsheet #6
Maintenance Failures Can Have Terrible Results

This list illustrates just a few examples of the human cost to both workers and the community caused by failure to properly maintain process equipment.

Piping:  (Internal Corrosion of Overhead Piping)
May 5, 1988 — An explosion and fire at a Shell Oil Refinery in Norco, Louisiana, killed seven OCAW Local 4-750 workers and injured 22 others. Some 2,500 residents had to be evacuated from nearby areas.

Vessel Failure:  (Reactor)
August 1992 — Three workers were injured and a group of motorists suffered respiratory injuries from ammonia inhalation when an explosion ripped through the Arcadian Chemical Corporation in Lake Charles, Louisiana.

Equipment Failure:  (Air Fin Exchanger)
October 1992 — An explosion at the Texaco Refinery in Wilmington, California, injured 16 workers and required the evacuation of residents within a one-mile area when an air fin exchanger failed due to unmonitored corrosion.

Wrong Piping:  (Feed line elbow)
August 2, 1993 — A fire at a Baton Rouge, Louisiana, refinery occurred when an elbow made of carbon steel instead of the required chrome alloy steel ruptured. Damage was estimated at $48 million.

Overfilled vessel:  (Blowdown drum)
March 2005 — A blast at the BP Texas City refinery which killed 15 and injured 180 people followed budget cuts of 25 percent from 1998 to 2000 at the plant. A blowdown drum overfilled and alarms and gauges that were supposed to warn of the problem did not work properly.
Summary: Mechanical Integrity

1. Preventive maintenance programs should be established, funded and staffed to sufficient levels to avoid the need for “breakdown” maintenance.

2. Turnarounds need to be held often enough to avoid “breakdown” maintenance. Units need to stay down until scheduled repairs are completed.

3. All maintenance work should be performed by trained and experienced crafts workers.

4. Requirements for, and documentation of, contractor training should be equivalent to that of regular employees.

5. All maintenance work must be done using proper equipment, installation procedures, safety devices and according to applicable codes and standards.

6. It is critical to actually implement the written mechanical integrity program. NJ TCPA requires preventive maintenance be performed within 3 months and detailed records of maintenance and inspections be kept for the life of the equipment.

7. If your workplace frequently experiences “breakdown maintenance”, your mechanical integrity program is not working.