Session 618

Auditing Mechanical Integrity Programs in PSM-Covered Facilities

Steven P. Pereira, CSP
President
Professional Safety Associates, L.L.C.
Denham Springs, LA

Facilities governed by the OSHA Process Safety Management Standard, 29 CFR 1910.119, are required to implement a Mechanical Integrity Program. Equipment used to process, store or handle highly hazardous chemicals covered under the standard must be designed, constructed, installed and maintained to minimize the releases of such chemicals. The Mechanical Integrity Program must include the following types of PSM-covered equipment:

- Pressure vessels and storage tanks
- Piping systems and components such as valves
- Relief and vents systems and devices
- Emergency Shutdown systems
- Controls (monitoring devices, sensors, alarms and interlocks)
- Pumps

Elements of a Mechanical Integrity Program include:

- Identifying and categorizing PSM-critical equipment and instrumentation
- Equipment manufacturers' recommendations and mean time to failure rates
- Inspection and test methods and rationale for inspection frequencies
- Criteria for acceptable inspection and test results
- Maintenance procedures
- Training of maintenance personnel
- Recordkeeping

In this session we will focus on techniques for improving the quality of Mechanical Integrity audits. Good audits "peel the onion" several layers deep to identify strengths and weaknesses of the program. The goal is to drive continuous improvement.

Procedure Review

Before starting the physical audit, review the facility's Mechanical Integrity Procedure(s). The procedure(s) should identify:

- What equipment is covered
- Clearly defined duties and responsibilities
- Inspection and repair codes and standards adopted by the company
- A schedule for tests and inspections
- What constitutes an overdue inspection
- What approvals are required if an inspection schedule is not met
- What to do if inspection or test results are outside acceptable limits
- How temporary or emergency repairs will be authorized, made and documented
- How to address anomalous readings or test results
- Quality control procedures for new or replacement equipment
- Positive material identification methods where exotic metals are used
- Training and auditing requirements

Start the physical audit process by reviewing the past three (3) years' accident and incident reports from the facility. Look for any signs of releases or spills that may have been the result of equipment failures. This will help identify potential problem areas. Also look at the results of previous audits to see if any identified mechanical integrity issues have been addressed. It is not uncommon to find recurring problems. Ask to see a list of overdue inspections or tests. Facilities with a strong program publish an inspection schedule and overdue list on a regular basis.

If equipment is past due for inspection, determine:

- Why is it overdue?
- What precautions have been taken to assure the equipment is safe to operate?
- Who authorized the extension?
- When will it be done?

Walk Through

After reviewing the incident reports and results of previous audits walk through the covered process areas to observe physical conditions. Signs of a weak program often include but are not limited to:

- Missing bolts in flanges or short bolting
- Long runs of unsupported pipe or incorrectly supported pipe
- Damaged hoses
- Expansion joints used to join misaligned pipe
- Damaged or missing insulation
- Damaged fireproofing on structural supports
- Relief valve discharge piping without drain holes
- Isolation valves on the inlet or outlet of relief valves without car seals or locks to secure valves in the open position
- Heavily corroded pipe or pipe repaired with leak repair kits (engineered and bolt-on)
- Small diameter pipe particularly on the bottom of tanks and vessels
- Drain or vent valves without caps or plugs
- Heavily vibrating equipment

- Damaged conduit or missing covers on junction boxes

When performing the walk-through, focus on process safety systems such as scrubber and flare systems and vent stacks, as these types of equipment are often overlooked in the inspection program but are the most critical in an emergency. Flares, vent systems, scrubbers and knockout pots or drums often see the most corrosive or hazardous products under emergency situations.

During the walk-through make a list of equipment design standards and inspection and test records to review. Record equipment names, numbers and nameplate data such as pressure and temperature ratings. Where possible check and record pressure ratings on pressure relief devices and compare them with that of the protected equipment. Where allowed take digital photos of areas of concern.

Document Review

Once the initial walk-through is completed review the facility's PSM-critical equipment list(s). Check to see if equipment observed in the field is on the critical equipment list and included in the Mechanical Integrity Program. Also review the results of the most recent Process Hazard Analyses (PHA's) and the Piping and Instrumentation Diagrams (P&ID's) for the corresponding equipment. Compare equipment pressure and temperature ratings obtained in the field with those shown on the drawings. Look for materials of construction. Pay close attention to instruments, interlocks and other forms of safety-related equipment and devices. As a general rule, anything listed as a safeguard on the Process Hazard Analysis worksheets should also be shown on the critical equipment list for inspection or testing. Very often a significant gap will be discovered. The critical equipment list is usually much shorter than the list of safeguards identified during the PHA.

Equipment Files

After reviewing the PHA's and P&ID's check the equipment files for identified pieces of equipment. Look for the design codes and standards to which the equipment was built. This should be consistent with what was found in the field. For pressure vessels one should find a U-1 Report or similar document. The U-1 Report is the "birth certificate" of the equipment. It includes all of the design parameters, the name of the equipment manufacturer, the date it was fabricated and the code certification. If it was built to code it should be repaired to code by personnel who have been trained and certified to do so. When code repairs are made they should be documented on an R-1 report or equivalent document. The R-1 report should identify what repairs were made, who made them and who inspected and approved the repairs.

When reviewing documents related to code repairs, ask to see the "traveler file." This is a series of documents outlining what repairs were to be made, what procedures and standards were to be followed and what documentation was required. It will usually contain the names and certifications of the contractors, fabrication shops and welders who made the repairs and the names of the inspectors. Always review the certification records of contractors, repair and fabrication shops and welders who made the code repairs.

In some older facilities it is not uncommon to find equipment in service that was built to standards that are no longer in existence. Always ask if there is any such equipment on site. If so, there must be documentation from a qualified person that the equipment is "fit for service." This must be verified.

Reference Documents

Each facility should have certain data to support their Mechanical Integrity Program. Such data should include but is not limited to:

- Manufacturers' design standards, recommended maintenance, inspection and test procedures as well as inspection and test frequencies. **Note:** These are often based on mean time to failure rates.

- Codes and recommended practices for inspection and repair of equipment published by groups such as the American Petroleum Industry (API) or the American Chemistry Council (ACC) and adopted by the facility. Copies of adopted codes and recommended practices should be readily available on site and kept up to date.

Pressure Relief Devices

With respect to pressure relief devices, check the design basis. Is the protected vessel likely to be exposed to a fire? If so, the design basis should reflect that the calculations are based on fire conditions. Tests and repairs of pressure relief devices must be done by an American Society of Mechanical Engineers (ASME) code authorized shop. Verify that this is being done. When reviewing relief valve inspection and test reports check to see if recommendations were made to correct any noted problems. The really well managed programs closely track relief valve failure rates to determine and correct problems. Failures include situations where the valve did not open or did not open at the specified pressure and temperature. If relief valves discharge into headers, verify that the headers are also inspected for obstructions.

Recordkeeping

Equipment inspection and test records must include:

- The date of the test or inspection
- The identity of the person who did the work
- The equipment name or identification number (serial number)
- A description of the test or inspection
- Results of the inspection or tests

Thickness test readings must be correctly documented and compared to original design standards and corrosion allowances. Thickness Measurement Locations (TML's) must be clearly identified on drawings and in the field so comparative readings may be taken over time. Failure to document TML's is a common problem. Close attention should be given to insulated piping. Coupons or cut outs are necessary to perform thickness test readings. Ask the point contact for

the criteria used to identify the number and location of the TML's. This information is required but often lacking.

Test Equipment Calibration

All test equipment requires some form of calibration. Calibration checks should be documented. Verify that all test equipment is calibrated in accordance with the equipment manufacturers' recommendations.

Training

Equipment inspectors must be properly trained and qualified to perform specific assignments. This must be verified. Inspectors should have a detailed working knowledge of the standards being used and the applicable requirements. Certification is highly desirable and required in certain situations. Verify equipment inspector qualifications and certifications. Make sure their credentials have not expired.

Personnel who perform maintenance and repairs also need to be trained. They should not only have the requisite craft skills, they should also be trained on:

- Equipment-specific maintenance procedures
- Management of Change (MOC) procedures
- Safe work practices including work permit procedures
- The facility work order system
- Maintenance recordkeeping requirements

As part of the audit, interview a representative number of maintenance personnel from each trade or craft and engineering department. Verify they understand how and where to obtain equipment-specific maintenance procedures and the MOC process. Ask if they are aware of any problematic equipment or equipment that no longer meets minimal acceptable criteria. If the answer is affirmative follow-up by the auditor is critical.

Lined Equipment

Tanks, pressure vessels and process equipment with metal or composite liners require special inspection, test and repair procedures. Verify that equipment-specific test and inspection procedures are being used for lined vessels. The same should be done for heat exchangers that are not disassembled for inspection.

Hoses and Expansion Joints

Hoses and expansion joints can be a problem. Hoses can be visually inspected and pressure tested. Expansion joints are usually inspected visually or replaced on a scheduled basis. Verify that inspection procedures for hoses and expansion joints have been developed and implemented. This is very often a weak link in the Mechanical Integrity Program.

Critical Instruments and Controls

Critical instruments, monitoring devices and controls require a high level of attention. In some cases, there is a reluctance to functionally test such equipment for fear of an inadvertent shutdown of the process. Keep in mind there are circuit tests and functional tests. Circuit tests simply confirm that a signal travels from one point to another; it does not verify that the equipment it controls functions as intended. Functional tests are needed to verify that the equipment received the signal and functioned as intended. Procedures should clearly spell out how each type of equipment is to be checked and at what frequency. Verify that tests are done in accordance with facility procedures.

Quality Control

Quality control for new and replacement parts is often a weak link in a Mechanical Integrity Program. When new projects are initiated, job-specific quality control procedures must be implemented and documented. This might include such things as leak checking, torquing of flanges, hydrostatic testing and x-raying welds. Verify that this is being done.

Procedures should be in place for warehouse personnel to confirm that spare parts ordered match what is received and meet the correct specifications. Likewise, procedures should be in place to verify that maintenance personnel obtain and install the correct spare parts and equipment.

When a process utilizes different metals, a Positive Materials Identification procedure is necessary. Machines can be purchased to determine metallurgy characteristics.

Check project files to identify any newly installed or retrofitted equipment. Verify that project quality control requirements were specified in the project specifications and performed. Ask to see documentation the required tests were performed and met the acceptable criteria.

Temporary or Emergency Repairs

Check to see if any temporary or emergency repairs have been made. Verify that the MOC process was rigidly followed and that temporary repairs have not exceeded their authorized time limit. Verify that all precautions mandated by the MOC were followed and not compromised in any way.

Documenting the Audit

The audit should be as objective as possible. The results should be observable and measurable. Findings should be clearly communicated noting positive indicators as well as deficiencies. Safety-related issues should be distinguished from clerical or paperwork issues. The report should identify:

- Policies and procedures reviewed including issue and revision dates
- Equipment names and / or numbers audited

- Job titles of personnel interviewed
- Positive program indicators
- Deficiencies including some reference to the magnitude of the problem. (i.e., a review of six [6] PHA's and the corresponding critical equipment lists revealed on average that an additional 15 instruments should have been included on each unit's critical instrument list. Fifteen (15) out of 50 pressure relief valves were overdue for testing by 90 days or more. There were 15 out of 40 overdue action items from the last audit.)
- Recommendations to address noted deficiencies
- Date of the audit and the name(s) of the auditor(s)

Lessons Learned from 50+ Mechanical Integrity Audits

1. The facility did not have a list of the following types of critical equipment:

    - Pressure vessels and storage tanks
    - Piping systems
    - Pressure relief devices
    - Instruments
    - Pumps

2. There was no documentation that maintenance or contractor employees who perform maintenance and service work had been trained in an overview of the process and its hazards.

3. There were no (or insufficient) written procedures for maintenance and inspection of process equipment.

4. Inspections and tests were not being performed on process equipment in accordance with the facility's schedule, which should be based on generally accepted good engineering practices.

5. There were no procedures to assure that maintenance materials and spare parts were suitable for the process application for which they are used.

6. There was no Positive Materials Identification (PMI) of metallic parts or equipment components.

7. Checks of critical instrumentation and safety devices include a loop check (that a signal was sent and received) but often fail to include an actual operational check to assure that the controller functioned as intended (i.e., valve opened or closed as intended or the equipment shut down).

8. Facilities have indicated that they have adopted certain API standards for the inspection and testing of tanks, pressure vessels and piping but have not fully implemented the requirements of the adopted standards nor have inspection personnel been trained and certified to perform such inspections.

9. Instruments, alarms and interlocks listed on PHA worksheets as safeguards were not included on the PSM critical equipment lists and included in the Mechanical Integrity Program.

10. Piping, instruments and vessels associated with flare systems and scrubbers were not included in the Mechanical Integrity Program.

11. Small diameter process piping on site glasses and instrumentation were not included in the thickness testing process.

Summary

A strong Mechanical Integrity Program improves process safety, reliability and helps drive continuous improvement. Remember, management gets not what it expects, but what it inspects and measures. A good Mechanical Integrity Program includes key performance indicators that can be measured and audited. Does your current audit process give management a clear picture of the Mechanical Integrity Program? If not, can you use any of the information contained herein to improve your audit process?