FEATURE

Investigation of injury/illness data at a nuclear facility: Part II

At Los Alamos National Laboratory (LANL), there are several nuclear facilities, accelerator facilities, radiological facilities, explosives sites, moderate- and high-hazard non-nuclear facilities, biosciences laboratory, etc. The Plutonium Science and Manufacturing Directorate (ADPSM) provides special nuclear material research, process development, technology demonstration, and manufacturing capabilities. ADPSM manages the LANL Plutonium Facility. Within the Radiological Control Area at TA-55 (PF-4), chemical and metallurgical operations with plutonium and other hazardous materials are performed. LANL Health and Safety Programs investigate injury and illness data. In this study, statistically significant trends have been identified and compared for LANL, ADPSM, and PF-4 injury/illness cases. A previously described output metric is used to measures LANL management progress towards meeting its operational safety objectives and goals. Timelines are used to determine trends in Injury/Illness types. Pareto Charts are used to prioritize causal factors. Data generated from analysis of Injury/Illness data have helped identify and reduce the number of corresponding causal factors.

By Michael E. Cournoyer, Vincent E. Garcia, Arnold N. Sandoval, Gerald L. George, David C. Gubernatis, Stephen B. Schreiber

Michael E. Cournoyer *is affiliated with the Los Alamos National Laboratory, Los Alamos, NM 87545, United States (Tel.: 505 665 7616; e-mail: mec@lanl.gov).*

Vincent E. Garcia *is affiliated with the Los Alamos National Laboratory, Los Alamos, NM 87545, United States.*

Arnold N. Sandoval *is affiliated with the Los Alamos National Laboratory, Los Alamos, NM 87545, United States.*

Gerald L. George *is affiliated with the Los Alamos National Laboratory, Los Alamos, NM 87545, United States.*

David C. Gubernatis *is affiliated with the Los Alamos National Laboratory, Los Alamos, NM 87545, United States.*

Stephen B. Schreiber *is affiliated with the Los Alamos National Laboratory, Los Alamos, NM 87545, United States.*

INTRODUCTION

At Los Alamos National Laboratory (LANL), there are several nuclear facilities, accelerator facilities, radiological facilities, explosives sites, moderate- and high-hazard non-nuclear facilities, biosciences laboratory, and other facilities.[1] The Plutonium Science and Manufacturing Directorate (ADPSM) provides special nuclear material research, process development, technology demonstration, and manufacturing capabilities. ADPSM manages the LANL Plutonium Facility (PF-4) at Technical Area 55 (TA-55). PF-4 is a Radiological Control Area, where chemical and metallurgical operations with plutonium and other hazardous materials are performed.

The most effective protection from radioactive materials is engineered barriers and has been incorporated through architectural and structural design. Engineering controls at TA-55 include differential ventilation pressure zones, High-Efficiency Particulate Air (HEPA) filtration, gloveboxes, and radiation shielding. Gloveboxes used for radioactive materials are maintained at a lower pressure than the surrounding room atmosphere, so that relatively small leaks result in air inflow rather than radioactive release.[2] In addition, they are constructed of stainless steel to provide structural stability.

The LANL Health and Safety Programs augment these passive safety features by identifying job hazards, minimizing exposure to hazards and investigating injury, illness and exposure data to identify appropriate prevention and mitigation measures. LANL management expects all injuries and illnesses cases to approach zero.

As previously reported in this journal, statistically significant variations (trends) were identified in TA-55 injury/illness reports, using recognized statistical tools (Output Metric, Control Chart, Failure Modes and Effects Analysis, and Pareto Chart).[3] Investigation of TA-55 injury/illness data demonstrated that ADPSM management expectation that workers seek medical attention before an injury or illness becomes serious has been effectively implemented.

PF-4's defense-in-depth is the facility's built-in capacity to detect or prevent errors without suffering undesirable consequences, i.e., PF-4's "safety envelope."[4,5] Redundant defenses improve safety margins, but also increase complexity. Flawed defenses and safety hazards become more difficult to detect. Redundant defenses make Health and Safety program improvements more difficult to identify as well.

Quality trending prevents defenses from degrading or being eliminated

1871-5532
http://dx.doi.org/10.1016/j.jchas.2014.09.014

over time. Positive trends that reflect LANL management commitment to operational safety may be overlooked. In this regard, quality trending continues through the use of Lean Manufacturing and Six Sigma business practices (LSS).[6]

In this study, trends have been identified and compared in LANL, ADPSM, and PF-4 injury/illness cases. A previously described output metric is used to measures LANL management progress towards meeting its operational safety objectives and goals.[3] Timelines are used to determine trends in Injury/Illness types. Using Pareto Charts, the causal factors have been prioritized.

METHODOLOGY

- **Injury/Illness Output Metric** Some injuries result in a recordable incident, as defined by the Occupational Safety and Health Act (OSHA), e.g., significant diagnosed injuries or illnesses or those that require medical treatments such as wound closing that requires adding stitches. Sub-recordable (first aid) injuries or illnesses are those that do not meet these criteria, such as the use of bandages to cover a wound or removing foreign bodies from the eye using only irrigation or a cotton swab. The LANL Injury/Illness database, supported by the Environmental Safety and Health Integration Office, is the primary repository for injury and illness information, including all demographic information about the incident, employee statement, medical record, investigation report, primary injury/illness factors, body parts, and all OSHA classification information.

  The study consists of all injuries and illnesses that have occurred to LANL employees between June of 2006 and June 2014. Using an output metric previously reported for TA-55 injury/illness data,[2] the following three sets of data are reported:
  - Recordable outcomes (OSHA-Recordable) are represented by light blue bars
  - Sub-recordable outcomes (First Aid) are represented by light yellow bars
  - Linear Trendlines (Linear)

  The linear trendline is a best-fit straight line. A linear trendline is created by using the following equation to calculate the least squares fit for a line:

  $$y = mx + b$$

  where m is the slope and b is the intercept. The linear trendline shows whether something is increasing or decreasing since the time that data had been first collected. The linear trendline represents long-term trends and gives a good indication of past years performance in the output metric. An ideal output metric shows both recordable and first aid data steadily decreasing both in the short- and long-term. The number of first aid cases should be an order of magnitude higher than recordable ones.[4] The ratio of first aid to recordable cases can only be used in time periods where recordable cases have occurred, or else the ratio goes to infinity.
- **Organizational Comparison** For this study, LANL records consist of all the records in the LANL Injury/Illness database. About 10,000 employees with a wide variety of educational backgrounds work at LANL full time. ADPSM records consist only of records for ADPSM employees. About 500 employees work for ADPSM. ADPSM Personnel must be knowledgeable of hazards and risks they face, and training is designed to reinforce their understanding. PF-4 records consist only of records for ADPSM employees that occurred at PF-4. In addition to training provided by ADPSM, new PF-4 personnel are mentored by experienced glovebox operators before being allowed to work independently.
- **Injury/Illness Types** Similar injuries and illnesses types were binned together. For example, punctures were included in lacerations. The most common types of injuries and illness documented in the LANL Injury/Illness database were the following: Injury (general), Ergonomic Injury, Strain/Sprain, Chemical Exposures, Laceration (cuts), Contusion (bruises), Abrasion (scrapes), Illness, and Other. Detailed descriptions of Ergonomic Injury, Strain/Sprain, Chemical Exposures, Laceration (cuts), Contusion (bruises), and Abrasion (scrapes) have been described previously in this journal.[3] Illness included allergic reactions, irritation, pain, rash, and dermatitis (not stemming from contact with chemicals), chronic hearing loss, heat stress, loss of consciousness, and stress. Other Injury/Illness types were primarily Possible Exposure-Not Diagnosed. A timeline was plotted of the Injury/Illness types over the June 2006 and June 2014 time period. The higher up the chart, the more often the LANL Injury/Illness type case occurred. No distinction between recordable and first aid cases was made.
- **Injury/Illness Factors** As with the Injury/Illness Types, similar Injury/Illness factors (causal factors) were binned together. For example, "Exposure to," "Hearing loss," and Bodily reaction" are grouped with "Contact with." Using a Pareto Chart, the primary causal factors were determined. The left vertical axis is the ranking of Injury/Illness factors for ADPSM and at PF-4. The right vertical axis is the ranking of Injury/Illness factors at LANL. Once again, no distinction between recordable and first aid cases was made.

RESULTS

From June 2006 to June 2014, there were 5,389 injuries and illnesses cases reported at LANL. Of those reported, 1,470 of them were recordable cases and 3,919 were first aid cases. See Figure 1.

The number of recordable cases peaked in 2007 with 227. The number of first aid cases peaked in 2010 with 623. The average numbers of cases per month during this time period were 20 and 54 recordable and first aid cases, respectively. The ratio of first aid to