FEATURE

Investigation of injury data at a detonator facility

Los Alamos National Laboratory (LANL) has been the design agency for nuclear weapon detonators for over 70 years. Detonator development, in support of the U.S. Department of Energy's (DOE) nuclear weapons program, account for most activities performed by the Detonator Production Agency (DET). Management of work-related injuries includes in-field monitoring of injury/illness reports. Employing Lean Manufacturing and Six Sigma business practices (LSS), statistically significant variations (trends) have been identified in DET injury reports. An output metric has been developed that measures DET management progress toward meeting its operational safety objectives and goals. An *I*-chart format has been chosen to validate the variation of DET Occupational Safety and Health Administration (OSHA) recordable and sub-recordable injury cases because this information is tracked as changes in the number of days between DET recordable and sub-recordable injury cases. Using a timeline, the primary injury types have been tracked. Using a Pareto Chart, the primary injury factors have been prioritized. This paper focuses on the collection of injury data; incorporation of this information into a visual format that DET management uses to make decisions to improving operations. Results from this study include of the following: chemical exposure cases have declined because the Hazard Assessment of each DET operation has been formally reviewed; Slip/Trip/Fall factors have decreased due to Slip Simulator training; and work station evaluations have led to fewer injuries with Lift/Push/Pull factors. Rotation of employees, ergonomically friendly balances, automatic powder dispensers, and other equipment procurements will lower ergonomic injuries.

By Michael E. Cournoyer, Cindy M. Lawton, Marylou Apodaca, Robert A. Bustamante, Mark A. Armijo

INTRODUCTION

Los Alamos National Laboratory (LANL) has been the design agency for nuclear weapon detonators for over 70 years.[1] A detonator is a device used to initiate the high explosive (HE) charge surrounding an implosion-type nuclear weapon. Detonators for the stockpile were built at LANL before the Picatinny Arsenal and Mound production agencies took over the manufacturing mission. With the closure of the Mound facility in 1993, detonator production for the nuclear weapons stockpile returned to LANL.

Detonator development, in support of the U.S. Department of Energy's (DOE) nuclear weapons program, account for most activities performed by the Detonator Production Agency (DET). Management of work-related injuries includes in-field monitoring of injury/illness reports. As previously reported in this journal, statistically significant variations (trends) have been identified in a National Security Laboratory injury reports through the use of recognized statistical tools (Output Metrics, Control Charts, Timelines, and Pareto Charts).[2] Investigation of National Security Laboratory injury data demonstrated that the management expectation that workers seek medical attention before an injury or illness becomes serious has been effectively implemented.[3]

DET's defense-in-depth is the site's built-in capacity to detect or prevent errors without suffering undesirable consequences, i.e., DET'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 improvements more difficult to identify as well.

Quality trending prevents defenses from degrading or being eliminated over time. Positive trends that reflect DET 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 in DET injury cases. An output metric is developed to measures DET management progress toward meeting its operational safety objectives and goals. Timelines are used to determine trends in injury types. Using Pareto Charts, the injury causal factors have been prioritized.

***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).*

***Cindy M. Lawton** is affiliated with the Los Alamos National Laboratory, Los Alamos, NM 87545, United States.*

***Marylou Apodaca** is affiliated with the Los Alamos National Laboratory, Los Alamos, NM 87545, United States.*

***Robert A. Bustamante** is affiliated with the Los Alamos National Laboratory, Los Alamos, NM 87545, United States.*

***Mark A. Armijo** is affiliated with the Los Alamos National Laboratory, Los Alamos, NM 87545, United States.*

© Division of Chemical Health and Safety of the American Chemical Society
Elsevier Inc. All rights reserved.
1871-5532
http://dx.doi.org/10.1016/j.jchas.2015.08.001

METHODOLOGY

- *Injury 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 those that require medical treatments such as wound closing that requires adding stitches.[2,3] Sub-recordable (First Aid) injuries 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 is the primary repository for injury and illness information, including all demographic information about the incident, employee statement, medical record, investigation report, primary injury factors, body parts, and all OSHA classification information. This study consists of all injuries that have occurred to programmatic employees at DET between June of 2006 and May 2015. An output metric for DET injury/illness data has been developed using four sets of data:
  - Recordable outcomes (OSHA) are represented by light blue bars
  - Sub-recordable outcomes (First Aid) are represented by light yellow bars
  - 12 Quarter Rolling Average (QRA)
  - Linear Trend Line

The 12 QRA is a method of calculating central tendency over time, an attempt to even out short-term oscillations and thus identify trends. The average is calculated over a 12 quarter period. For each quarter after this, the earliest value is dropped from the calculation and the most recent one is added, again to make an average over a 12 quarter period. The linear trend line (depicted in the metric as Linear) is a best-fit straight line. The trendline was calculated using a linear least-squares method. The linear trend line shows whether something is increasing or decreasing since the time that data had been first collected. As stated above, data has been collected since June 2006. Thus, the 12 QRA and linear trend line represent short- and long-term trends respectively. Only the data from the last twelve quarters is displayed for the output metric. The trend line gives a good indication of past years performance in the output metric. An ideal output metric shows both recordable and sub-recordable data steadily decreasing both in the short- and long-term. The number of sub-recordable cases should be an order of magnitude higher than recordable ones.[4] The ratio of sub-recordable to recordable cases can only be used in time periods where recordable cases have occurred, or else the ratio goes to infinity.

- *Control Chart* An *I* (Individuals) chart format has been chosen to validate the variation of DET recordable and sub-recordable injury cases because this information is tracked as changes in the number of days between DET recordable and sub-recordable injury cases.

The individuals control chart is used for data that is collected and plotted one point at a time.[7]

1. First, the average of the individual values, i.e., the control limit (CL) is calculated:

$$\bar{x} = \frac{\sum_{i=1}^{m} x_i}{m}$$

where x_i = individual values, m = total number of events

2. The difference between an individual value, x_i, and its predecessor, x_{i-1}, is calculated as

$$MR_i = |x_i - x_{i-1}|$$

3. Next, the average moving range (the arithmetic mean of these values) is calculated as

$$M\bar{R} = \frac{\sum_{i=2}^{m} MR_i}{m-1}$$

4. The upper control limit (UCL) and lower control limit (LCL) for the individual values are calculated by adding or subtracting 2.66 times the average moving range to the process average:

$$UCL = \bar{x} + 2.66M\bar{R}$$
$$LCL = \bar{x} - 2.66M\bar{R}$$

The value of 2.66 is obtained by dividing 3 by the sample-size-specific d_2 anti-biasing constant for $n = 2$, 1.128.[8] d_2 is a function only of the sample size n.

5. The upper sigma limits (1UCL, 2UCL) and lower sigma limits (1LCL, 2LCL) for the individual values are calculated by adding or subtracting one-third or two-thirds of 2.66 times the average moving range to the process average:

$$1UCL = \bar{x} + \left(\frac{2.66M\bar{R}}{3}\right)$$

$$2UCL = \bar{x} + 2\left(\frac{2.66M\bar{R}}{3}\right)$$

$$1LCL = \bar{x} - \left(\frac{2.66M\bar{R}}{3}\right)$$

$$2LCL = \bar{x} - 2\left(\frac{2.66M\bar{R}}{3}\right)$$

In general, 25 or more data points create a statistical *Baseline*; the more data points, the sounder the statistical analysis. A trend is defined by the relationship of data points plotted on a control chart and are detected through preset rules. If a trend is detected, the special cause of the trend is determined. Trends in the existing data are determined by the following criteria[6]:

– One point outside the UCL or LCL (*Definitive*)
– Two out of three points; two standard deviations above/below average (*Sigma Zone*)
– Four out of five points; one standard deviation above/below average (*Sigma Zone*)
– Seven points in a row; all above/below the CL (*Pattern*)
– Seven points in a row; all increasing/decreasing (*Pattern*)
– Ten out of eleven points in a row; all above/below the CL (*Pattern*)

Trends serve as a notice a special cause variation likely exists and adjustments to DET operations may be necessary. When a trend is identified, one must determine if the trend is *Definitive*, *Sigma Zone*, or *Pattern*. A *Definitive* trend result occurs when one or more points fall outside the UCL or LCL. This is the case when outliers are

Download English Version:

https://daneshyari.com/en/article/573994

Download Persian Version:

https://daneshyari.com/article/573994

Daneshyari.com