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Title: **Institutional Glovebox Safety Committee (IGSC) Annual Report FY 2011**

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Institutional Glovebox Safety Committee (IGSC) Annual Report FY 2011

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ABSTRACT

The Institutional Glovebox Safety Committee (IGSC) is chartered to minimize and prevent glovebox operational events. The focus of this working committee is to address glovebox operational and safety issues and to share *Lessons Learned*, best practices, training improvements, and glovebox glove breach and failure data. Highlights of the IGSC's fourth year are discussed. The results presented in this annual report are pivotal to the ultimate focus of the Los Alamos National Laboratory's glovebox safety program, which is to minimize glovebox work-related injuries. This effort contributes to the LANL Continuous Improvement Program by providing information that can be used to improve glovebox operational safety.

Executive Summary

During the Institutional Glovebox Safety Committee's (IGSC) fourth year, 31 glovebox operational and safety issues have been discussed. Twenty *Lessons Learned*, 17 best practices, 3 training improvements, and 18 glovebox glove breach and failure events have been shared. Using Lean Manufacturing and Six Sigma business practices (LSS), outcomes that are significant to the Los Alamos National Laboratory (LANL) management, glovebox ergonomic injuries and glovebox glove breaches and failures, have been tracked and analyzed as output metrics. The frequency of glovebox operations recordable and first aid ergonomic injuries and glovebox glove failures has decreased to the point that they are now tracked as days between events instead of events per month. The long-term trend for glovebox glove breaches is slightly favorable. Communication of these topics, through periodicmeetings and the distribution of minutes, improves the safety configuration of the glovebox system and contributes to the Lab scientific and technological excellence by increasing its operational safety. In summary, the IGSC continues to be an effective tool that the Lab uses to promote institutional learning and reduce the probability of injuries due to glovebox operations. This increases technical knowledge and augments operational safety.

Introduction

Chemical and metallurgical operations involving nuclear materials and other toxic chemicals account for most activities performed at the Lab. Engineered barriers provide the most effective protection from toxic materials and have been incorporated through architectural and structural design. Engineering controls at LANL include differential pressure zones, High-Efficiency Particulate Air filtration, gloveboxes, radiation shielding, and guides for work. Engineered barriers such as gloveboxes (the glovebox, coupled with an adequate negative pressure gradient) provide the most effective protection from radioactive and toxic materials. The Institutional Glovebox Safety Program (IGSP) augments this passive safety feature with requirements for maintenance and inspection, glovebox and glove integrity, ergonomics, glovebox sharps management and housekeeping, radiological monitoring, communication, and training.[1] Extensive safety analysis reports document these controls and evaluate "design basis accidents" to ensure stipulated release limits, under accident conditions, are not exceeded.[2] All glovebox operations conducted at the Lab's must be performed within this established "safety envelope." In order to achieve and sustain lower accident/incident rates, the IGSC was chartered.

The IGSC meets periodically to address glovebox safety issues. The focus of the team is to proactively investigate processes and procedures to minimize glovebox operational events. The membership of the team consists of glovebox workers, engineers, chemists, training professionals, Health Physicists, and Industrial Hygienists. The team reviews recent glovebox operational incidents, identifies barriers to minimizing glovebox glove failures and breaches, considers measures that lower the overall risk of glovebox

operations, and identifies mechanisms (processes) that systematically reduce glovebox operational incidents. Communication of these topics, through periodic meetings and the distribution of minutes, improves the safety configuration of the glovebox system and contributes to the Lab's scientific and technological excellence by increasing its operational safety.

In partnership with the LANL Continuous Improvement Program, Lean Manufacturing and Six Sigma business practices (LSS) have been used to track outcomes that are significant to the Lab's management, i.e., glovebox ergonomic injuries and glovebox glove breaches and failures.[3] Performance metrics, which are part of the LANL Dashboard, monitor the implementation of the IGSP. Three major output metrics have been identified: glovebox ergonomic injuries and glovebox glove breaches and failures. The likelihood of a glovebox-related ergonomic injury increases with the amount of programmatic work performed. Tasks become more difficult to perform when the thickness of a glove is increased or shielding is added to the formulation.[4] A breach is caused by mechanical damage during operations (e.g., penetration with a sharp object, rotating equipment, pinch points, thermal sources, etc.). Breaches are managed through the proper selection of glovebox gloves and over-gloves and operating discipline viewed as engineering controls and administrative controls, respectively.[5] A failure is caused by degradation of the glovebox glove's mechanical properties over time, e.g., exposure to mechanical stresses, chemicals, and nuclear and thermal radiation. The primary means of controlling failures is through a robust glove inspection program and control of the service life intervals for the glovebox gloves. The addition of over-gloves to protect glovebox gloves is also beneficial in preventing failures due to mechanical wear.[4]

Output Metrics

The development of output metrics had been discussed in the previous IGSC annual report.[6] To iterate, in the following bar charts, the light blue bars represent recordable outcomes that are significant to the Lab's management or an external regulator. The light yellow bars represent non-recordable outcomes. In addition, each output metric includes a 12 Month Rolling Average and a Linear Trend Line. Recordable outcomes are significant to LANL management, while non-recordable outcomes are not. The 12 Month Rolling Average 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 month period. For each month 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 month period. The linear trend line (depicted in the metric as Linear) is a best-fit straight line. The linear trend line shows whether something is increasing or decreasing since the time that data had been first collected. Thus, the 12-Month Rolling Average and linear trend line represent short- and long-term trends respectively. If no recordable outcomes have occurred in the last twelve month then the 12 Month Rolling Average and linear trend line of non-recordable outcomes is presented. Only the data from the last year 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 non-

recordable data steadily decreasing both in the short- and long-term. The number of non-recordable events should be an order of magnitude higher than reportable ones.[7]

A *c*-chart format is chosen to validate the variation of glovebox operational ergonomic case and glove failure metrics because the days between these events are tracked. Also, a *c*-chart format is used to validate the variation of the glovebox glove breach metric because the number of breaches is tracked monthly. Performance from control charts are rated using the flow chart in Figure 1.

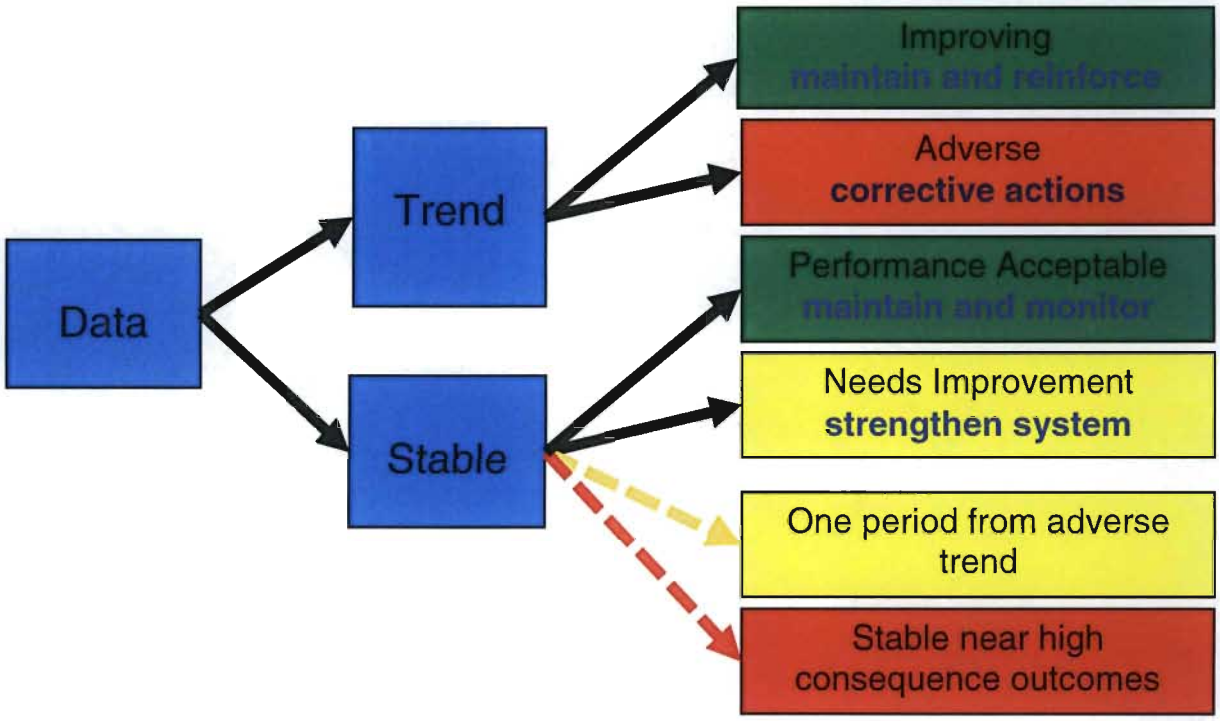

Figure 1. Rating Performance from Control Charts

Results

LANL Glovebox Operational Ergonomic Injuries

LANL glovebox operational ergonomic case status, both recordable and non-recordable (First Aid), are shown in Figure 2-3.

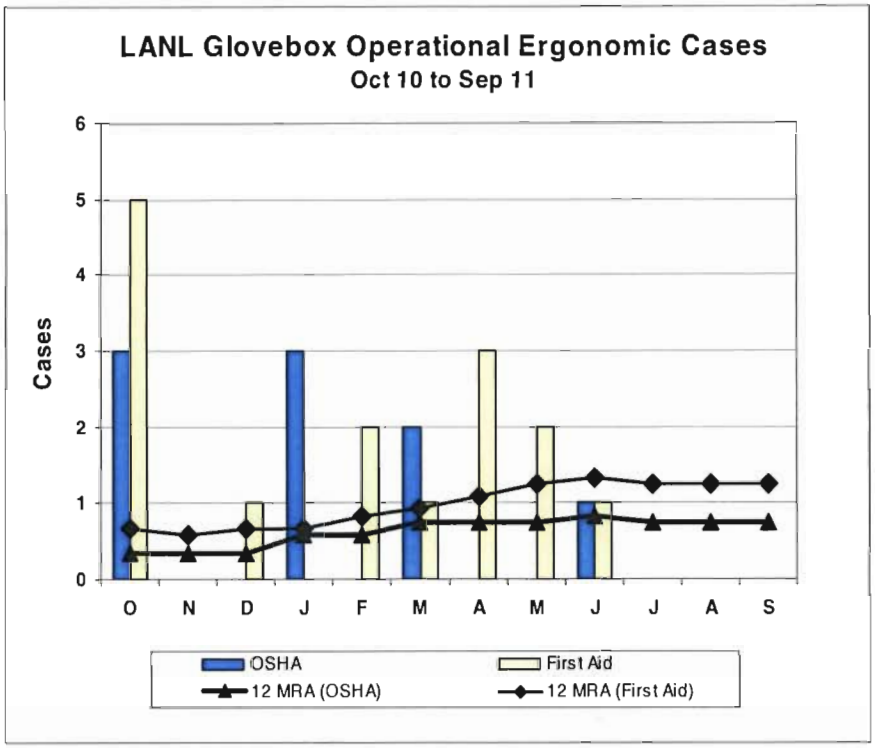

Figure 2. LANL Glovebox Operational Short-Term Ergonomic Case Metric

The number of LANL glovebox operational ergonomic cases for the last 12 months is 9 recordable and 15 first aid cases. The ratio of first aid to recordable cases is 1.7. The short-term trends for reportable and first aid cases are flat.

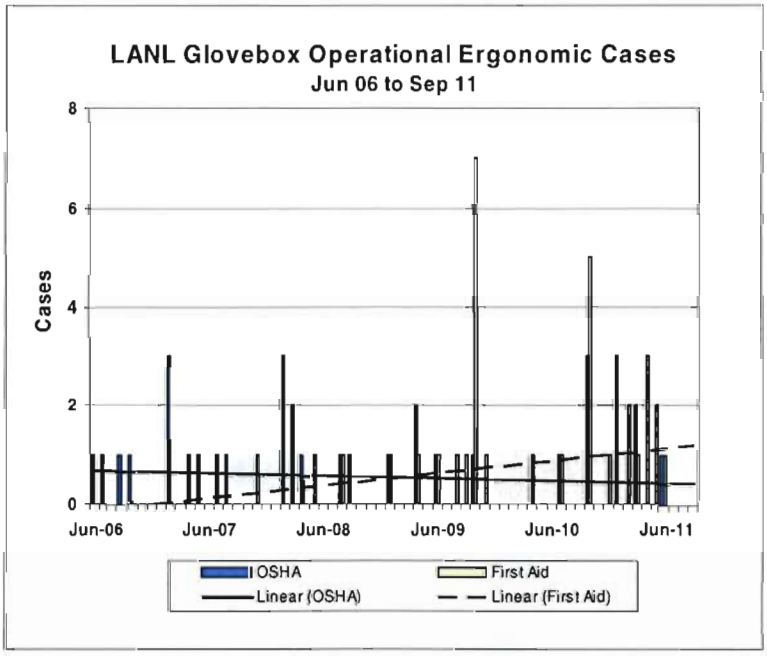

Figure 3. LANL Glovebox Operational Long-Term Ergonomic Case Metric

Since June 2006, the number of LANL glovebox operational ergonomic cases is 34 recordable and 33 first aid cases. The greatest number of reportable cases (3) occurred in February 2007 and 2008, October 2010, and January 2011. The maximum number of first aid cases (7) occurred in October 2009. The ratio of first aid to reportable cases peaked at 7 during the same month. The long-term trends for reportable and first aid cases are decreasing and increasing, respectively.

The *c*-chart for the average number of days between LANL glovebox operational recordable ergonomic cases during the last 12 months is shown in Figure 4.

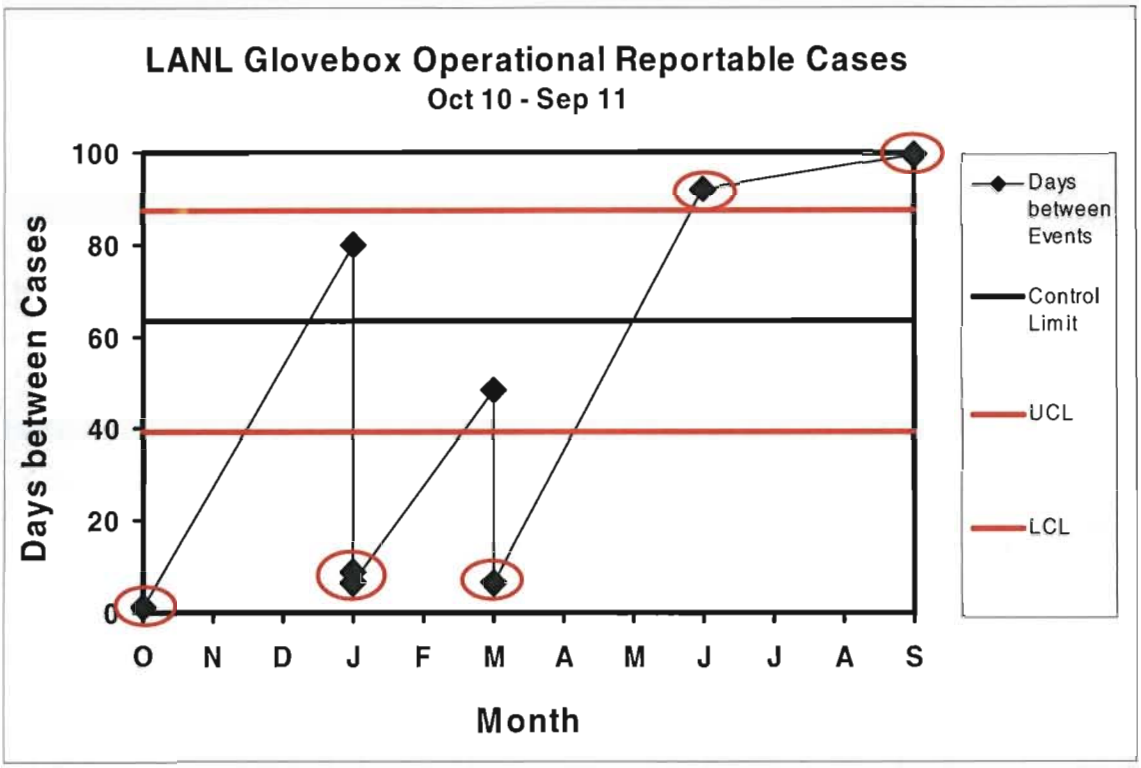

Figure 4. LANL Glovebox Operational Recordable Ergonomic Case *c*-Chart

The average number of days between LANL glovebox operational recordable ergonomic cases is 63 with upper and lower control limits of 87 and 40 days, respectively. Five **Definitive** trends occur in October 2010 and January and March 2011; one point outside the lower control limit. These special cause variations, due to repetitive motion/ cumulative trauma and voluntary motions, are considered adverse and require LANL management action to reverse the trend. Two **Definitive** trends occur in June and September 2011; one point outside the upper control limit. These special cause variations, due to increased ergonomic evaluations, are not considered adverse and require no LANL management action to reverse the trend.

The average number of days between LANL glovebox operational first aid ergonomic cases is 52 with an upper and lower control limit of 74 and 30 days, respectively. The *c*-chart for the average number of days between LANL glovebox operational first aid ergonomic cases during the last 12 months is shown in Figure 5.

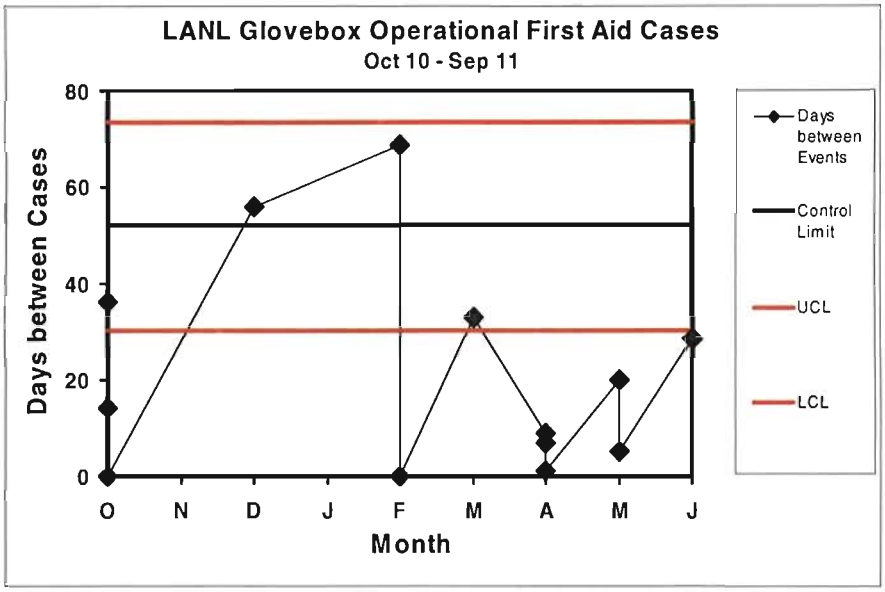

Figure 5. LANL Glovebox Operational First Aid Ergonomic Case *c*-Chart

A couple of **Definitive** and one **Pattern** trends have been observed. Since these data points are part of the baseline, no analysis or correction is made. A total of twenty-five data points have now been documented. The Pareto chart highlights the most important body parts, as displayed in Figure 6.

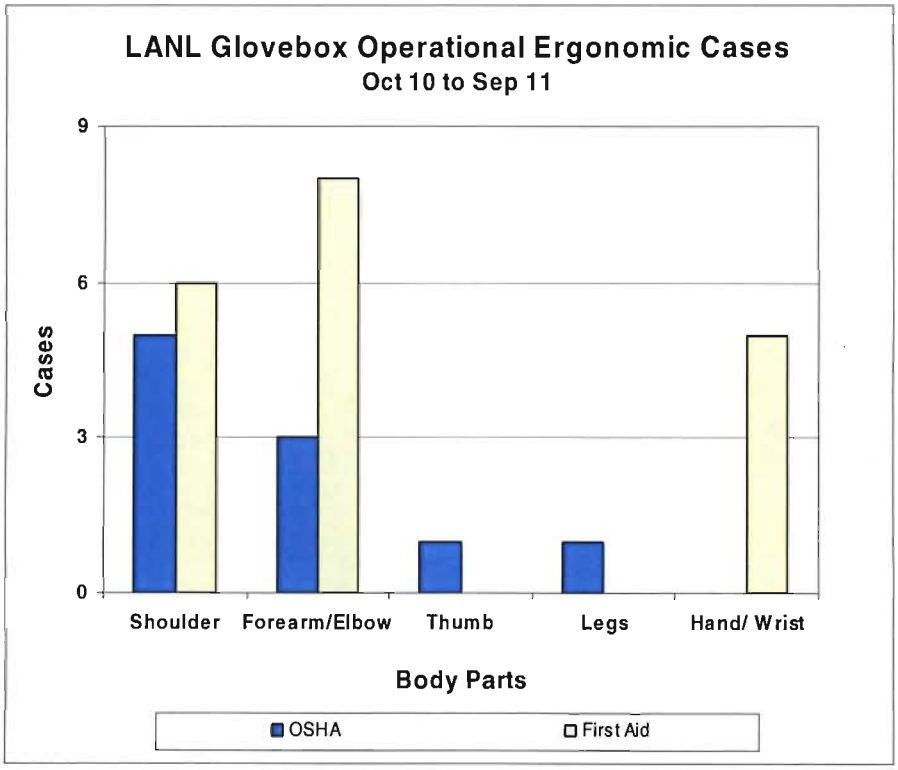

Figure 6. LANL Glovebox Operational Ergonomic Case Pareto Chart

Ten and 19 body parts were affected in reportable and first aid cases, respectively.

LANL glovebox glove failure status is shown in Figures 7-8.

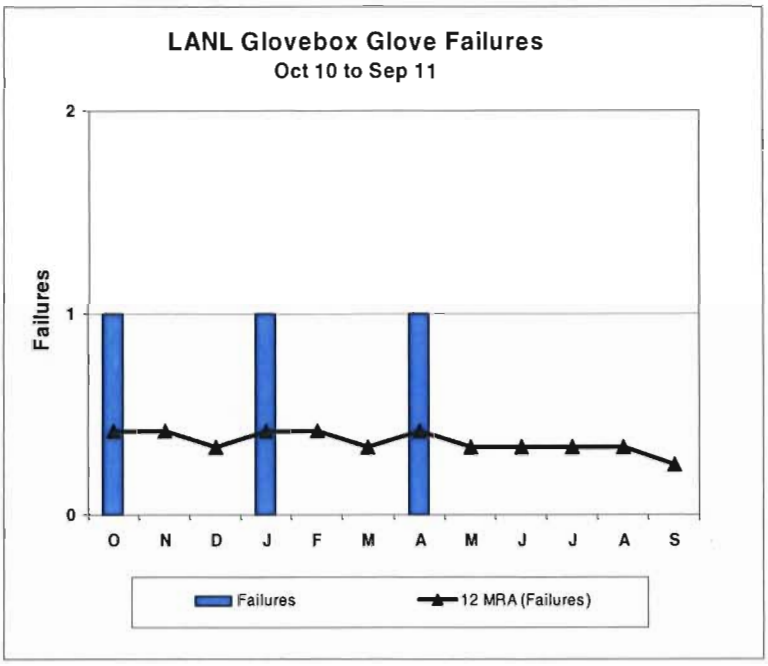

Figure 7. LANL Short-Term Glovebox Glove Failure Metric

The number of LANL glovebox glove failures for the last 12 months is 3. The short-term trend for glovebox glove failures is decreasing.

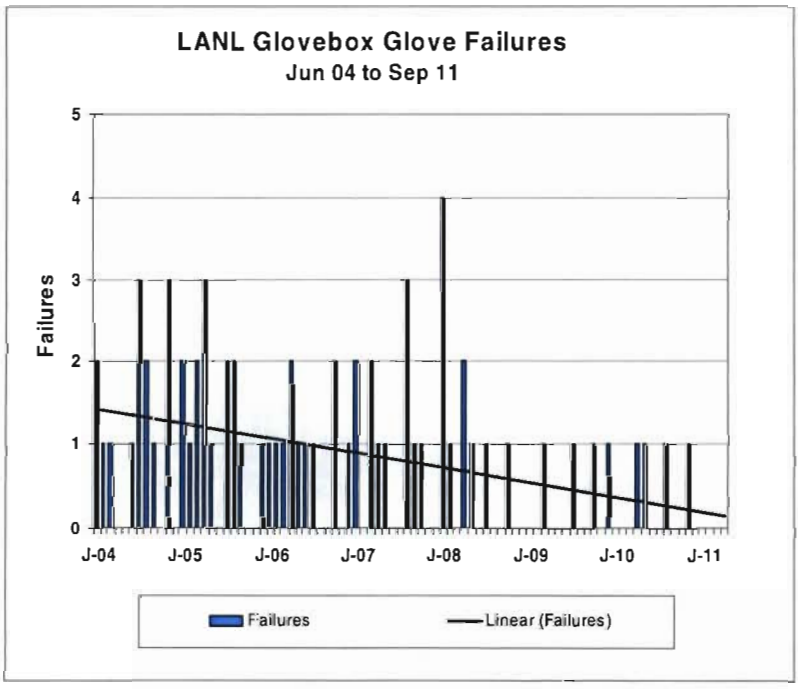

Figure 8. LANL Long-Term Glovebox Glove Failure Metric

Since June 2004, the number of LANL glovebox glove failures is 69. The greatest number of failures (4) occurred in January 2008.The long-term trend, for LANL glovebox glove failures, is decreasing.

The average number of days between LANL glovebox glove failures is 23 with an upper and lower control limit of 38 and 9 days, respectively, as shown in Figure 9.

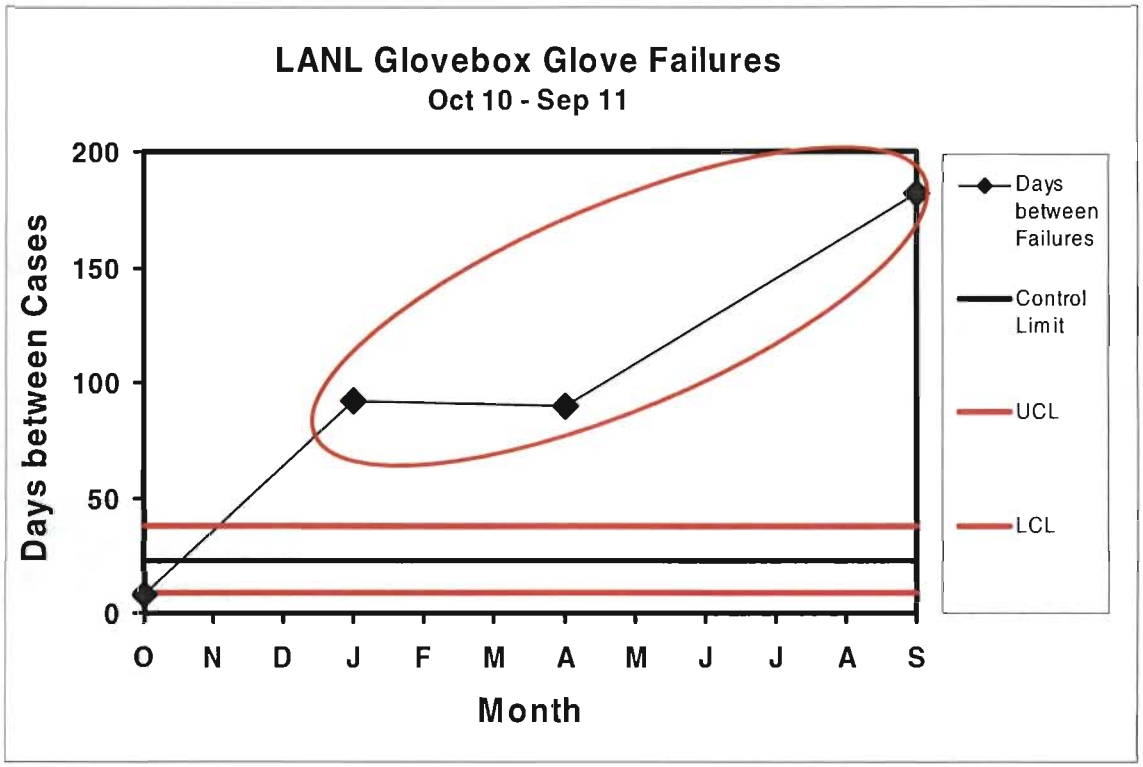

Figure 9. LANL Glovebox Glove Failure Control Chart

Three **Definitive** trends occur in January, April and September 2011; one point outside the upper control limit. These special cause variations, due to diligent use of over-gloves, are not considered adverse and require no LANL management action to reverse the trend.

LANL glovebox glove breaches are shown in Figures 10-11.

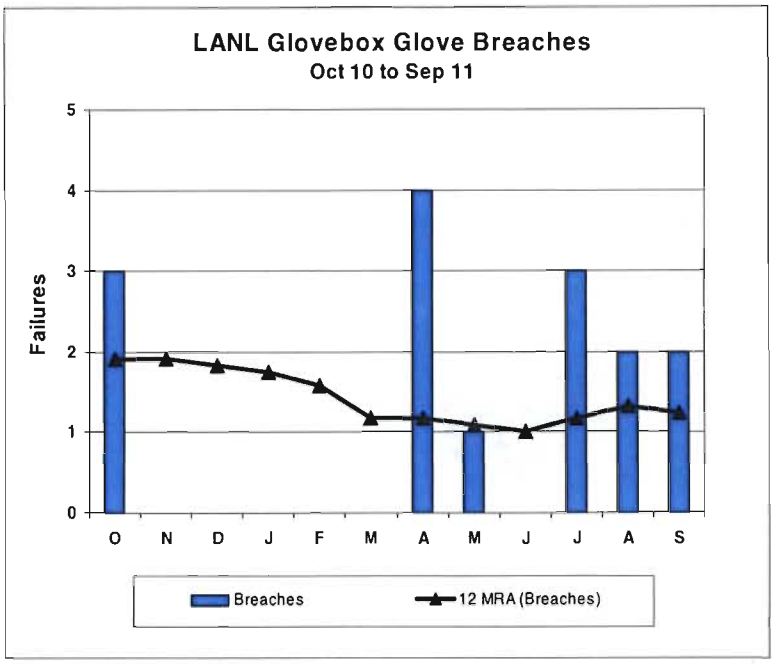

Figure 10. LANL Short-Term Glovebox Glove Breach Metric

The number of LANL glovebox glove failures for the last 12 months is 15. The short-term trend for glovebox glove failures is decreasing.

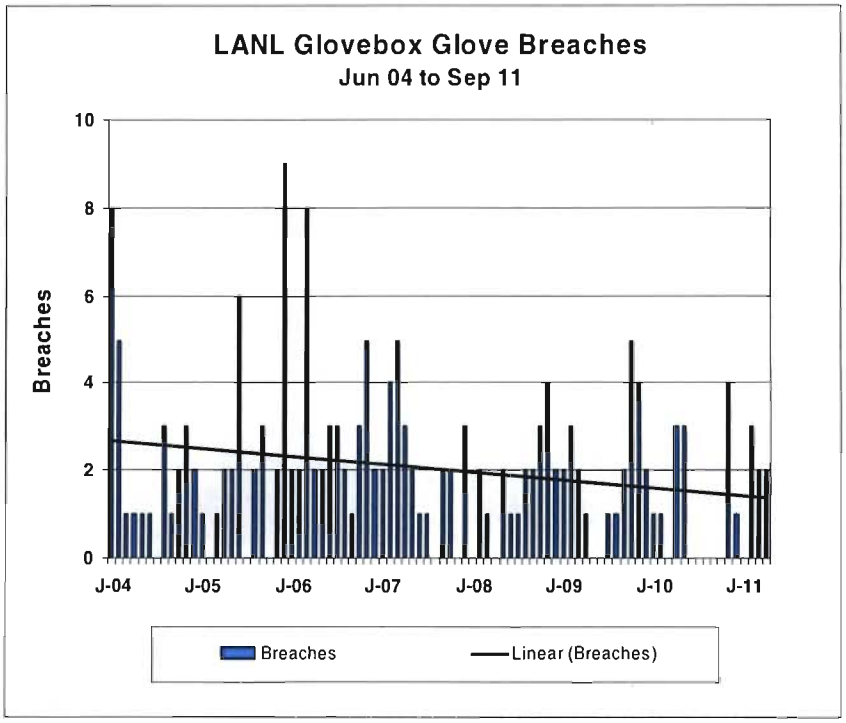

Figure 11. LANL Long-Term Glovebox Glove Failure Metric

Since June 2004, the number of LANL glovebox glove breaches is 179. The greatest number of breaches (9) occurred in January 2008.The long-term trend, for LANL glovebox glove breaches, is decreasing.

From June 2004 to June 2009, the average rate of glovebox glove breaches is 2.3 per month with an upper control limit of 6.9 as shown in Figure 12.

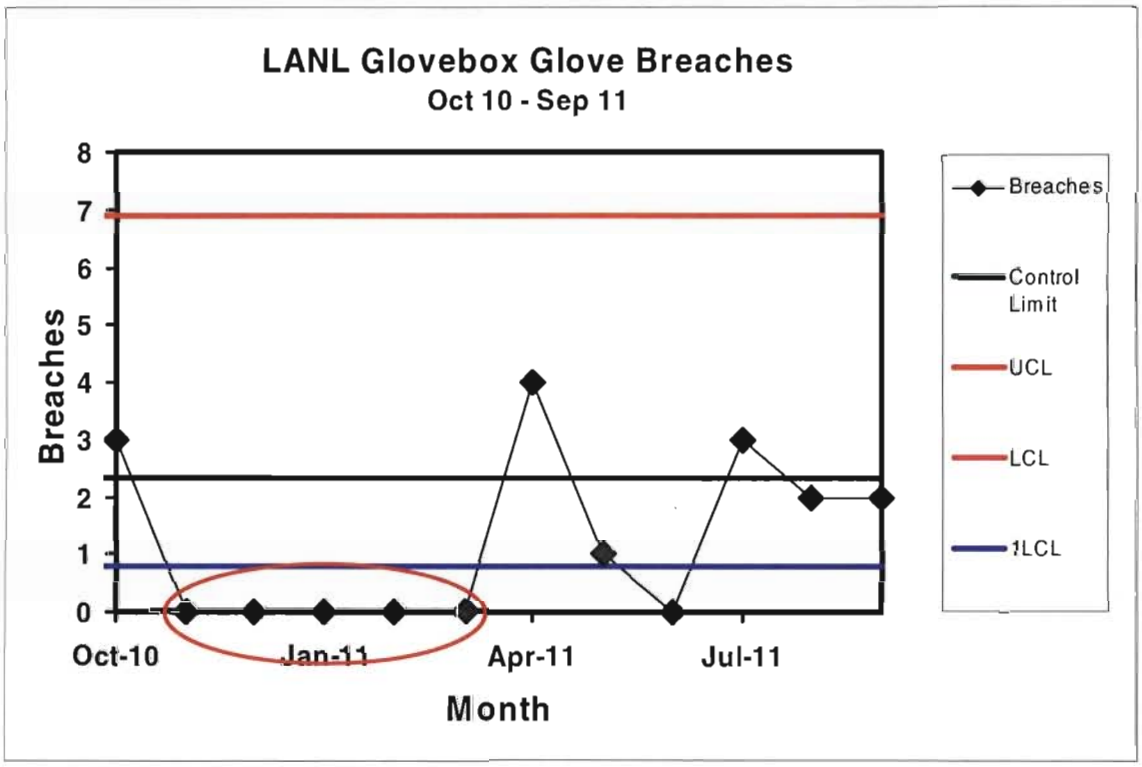

Figure 12. LANL Glovebox Glove Breach Control Chart

An extended **Sigma Zone** occurs between November 2010 and March 2011: Four out of five points; one standard deviation below average. This special cause variation, due to diligent use of over-gloves, is not considered adverse and requires no LANL management action to reverse the trend.

Per the Institutional Glovebox Safety Committee Charter, members or their alternates are required to attend IGSC meetings.[8] The directorates that have gloveboxes are shown in Table 2.

Table 2. Associate Directorates with Gloveboxes.

RAD
ADBS
ADCLES
ADEP
ADEPS
ADESH&Q
ADNNHO
ADPSM
PADGS
ADW

Meetings were held 11 of the twelve months with a quorum achieved in nine of the meeting, as shown in Figure 13.

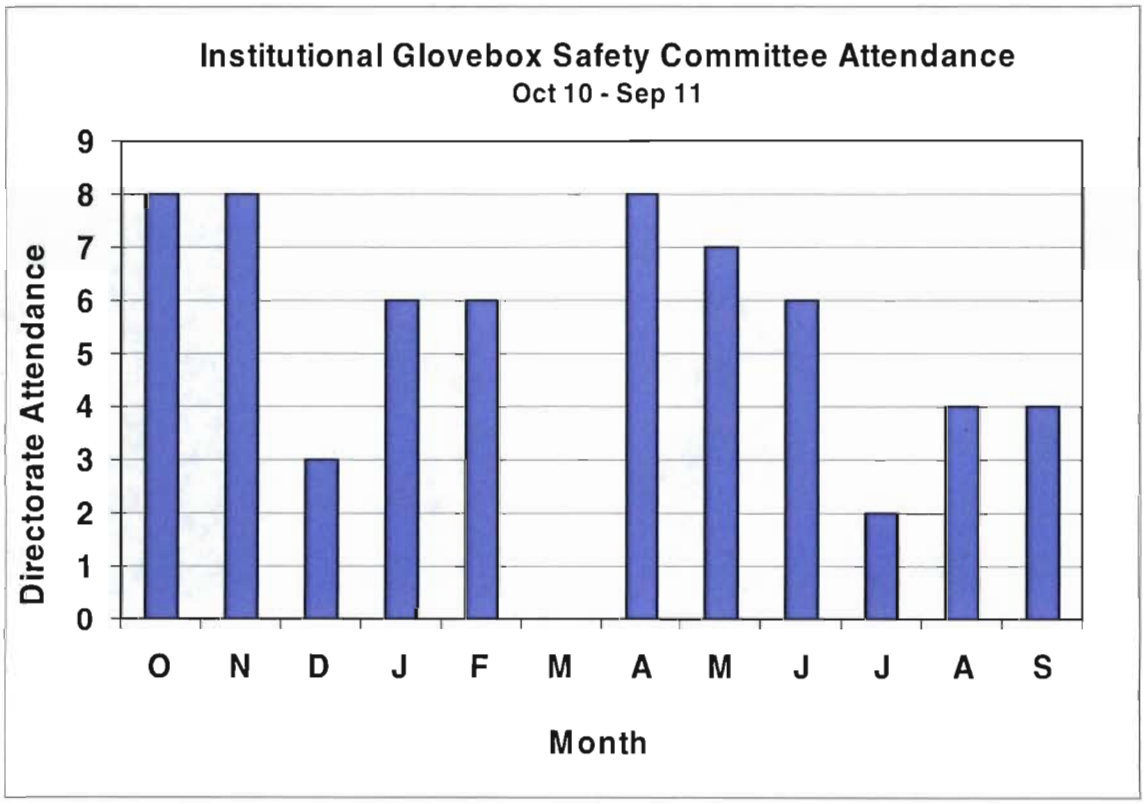

Figure 13. Institutional Glovebox Safety Committee Attendance

Before and during the periodic IGSC meeting, members bring up issues, *Lessons Learned*, Best Practices, training improvements, glovebox glove breach and failure events. Between October 2010 and September 2011, 31 glovebox operational and safety issues have been discussed. Twenty *Lessons Learned*, 17 best practices, 3 training improvements, and 18 glovebox glove breach and failure events have been shared. Details may be obtained from the periodic IGSC meeting minutes.

Discussion

Ergonomic evaluations and improved ergonomics training for all new glovebox workers has resulted in a significant reduction in ergonomic injuries, especially those related to glovebox operations. Short-term trends for glovebox operational recordable and first aid ergonomic cases are neutral, as shown in Figure 2. The ratio of first aid to recordable cases could be improved. Long-term trends for institutional glovebox operational recordable and first aid ergonomic cases are favorable and unfavorable, respectively, as shown in Figure 3. While first aid cases are contrary to the ideal output metric, the trend is consistent with LANL management expectation that workers seek medical attention before an injury or illness becomes serious.[9]

Analysis of glovebox operational recordable and first aid ergonomic cases between June 2006 and September 2010 has been reported in the previous annual report.[6] The five negative **Definitive** trends in Figure 4 are the direct results of mandatory glovebox ergonomic evaluation requirement in P 101-28, Glovebox Safety Program.[1] These trends could be reversed if LANL management invested in projects that reduce ergonomic stressors. The IGSC recommends the following:

- Replace all Bag-out Operations with Drum-Out Systems.
- Incorporate Zero-G Systems in Gloveboxes that use Power Tools

The Lab is currently experiencing 100 days without a glovebox operational recordable case. The two positive **Definitive** trends are due in part to the introduction of Polyurethane/ Chloro-sulphonated polyethylene (CSM)* glovebox gloves (13-mil, 20-mil, 22-mil) as well as Polyurethane-Nonhaz Shielding-CSM, 4X attenuation glovebox gloves. Replacement of glovebox gloves with polyurethane formulations improves the safety configuration of the glovebox system by reducing the glovebox workers risks of ergonomic injuries and internally deposited radionuclides and eliminating mixed waste generation.[10] The average number of days between LANL glovebox operational first aid ergonomic cases should be much lower than 52, as shown in Figure 5. Glovebox operational ergonomic injury prevention efforts should be concentrated on the shoulder and elbow areas, as shown in Figure 6. As reported in the previous year's report, ergonomic injuries to the shoulder, due to repetitive motion/cumulative trauma can be prevented with upper body strengthening.[6]

Both short- and long-term trends for LANL glovebox glove failures are favorable, as shown in Figures 7-8. Analysis of glovebox glove failures between June 2004 and September 2010 has been reported in the previous annual report.[6] The positive **Definitive** trends in Figure 9 should be maintained. LANL management should invest in aging studies with new glovebox glove formulations like polyurethane formulations discussed above.

Both short- and long-term trends for LANL glovebox glove breaches are favorable, as shown in Figures 10-11. Analysis of glovebox glove breaches between June 2004 and September 2010 has been reported in the previous annual report.[6] The positive **Sigma**

* Previously known as Hypalon.

Zone in Figure 12 should be maintained. LANL management should invest in new glovebox glove formulations and over-gloves that are breach resistant.

Twenty-five or more data points have been generated for each control chart. Thus, the observed trends are statistically significant. The GSP is considered to be under statistical control (stable) if all the variation is random; and out of statistical control (unstable) if the variation is systematic. Following the criteria in Figure 1:

- Days between LANL glovebox operational recordable ergonomic case *c*-Chart is trending upward. LANL management expectation is that this rate be maintained and enforced.
- Days between LANL glovebox operational first aid ergonomic case *c*-Chart is stable, but needs improvement. LANL management expectation is that reporting of first aid case be strengthen.
- Days between LANL glovebox glove failure *c*-Chart is trending upward. LANL management expectation is that this rate be maintained and enforced.
- LANL glovebox glove breach *c*-Chart is stable, but needs improvement. LANL management expectation is that minimization of glovebox glove breach be strengthen.

Except for PADGS, directorates with gloveboxes have representatives that attend the periodic IGSC meetings, as shown in Table 1. Attendance was acceptable, except for the months of December, March, and June, as shown in Figure 13. Beginning in 2012, minutes to the minutes will be sent to all associate directors with gloveboxes.

Recommendations:

The Executive Glovebox Safety Steering Team consists of the LANL Deputy Director, Associate Directors with glovebox operations, Associate Director for Environment, Safety, Health, and Quality, and Chair of the Institutional Glovebox Safety Committee. This committee provides executive oversight of the IGSC and determines the goals of the IGSC and the performance ranges for the Glovebox Safety Program on the LANL Dashboard. Based on the LSS methodology, the following recommendations to Executive Glovebox Safety Steering Team are suggested:

- Set eight recordable injury as a goal for FY 2012, with 3 to 4 times as many First Aid injuries as reportable injuries being documented.
- Set one glovebox glove failure, as a maximum, for 2012.
- Set a goal of a maximum of 4 breaches for 2012.
- Add Glovebox Operations Recordable and First Aid Ergonomic Injuries to the LANL Dashboard. Suggested Performance Ranges:
  - > 90 days between Recordable glovebox operations' ergonomic injuries = Green; 40 - 90 days between Recordable glovebox operations' ergonomic injuries = Yellow; < 40 days between Recordable glovebox operations' ergonomic injuries = Red.

- > 80 days between First Aid glovebox operations' ergonomic injuries = Green; 30 - 80 days between First Aid glovebox operations' ergonomic injuries = Yellow; < 30 days between First Aid glovebox operations' ergonomic injuries = Red.

- Change Glovebox Glove Failure Metric on the LANL Dashboard from events per month to time between event metric. Suggested Performance Ranges:
  - > 40 days between Glovebox Glove Failures = Green; 10 - 40 days between Glovebox Glove Failures = Yellow; < 10 days between Glovebox Glove Failures = Red.
- Change the Performance Ranges for the Glovebox Glove Breach Metric on the LANL Dashboard. Suggested Performance Ranges:
  - One Glovebox Glove Breaches per month = Green; 2 - 7 Glovebox Glove Breaches per month = Yellow; > 7 Glovebox Glove Breaches per month = Red.

Conclusions

Ergonomic evaluations, as required in P 101-28, Glovebox Safety Program, are being carried out. The graphical representation of glovebox operational ergonomic case data and glove failure and breach data variation, in terms of control charts, determines whether LANL glovebox operation program is under control. As these metrics deviates from the optimum, LANL operations can be improved to bring them back into control. This increases technical knowledge and augments operational safety.

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[1] Procedure P 101-28 Glovebox Safety Program.
[2] DOE Order 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*, U.S. Department of Energy, Washington DC, March 27, 1998.
[3] http://lanl.gov/orgs/adbs/lss/index.shtml: link verified January 5, 2012.
[4] Cournoyer, M.E., et al.; "Dexterity Test Data Contribute To Reduction in Leaded Glovebox Glove Use," Journal of the ASME., Proceedings from WM'09, Phoenix, Arizona, March 1-5, 2009.
[5] Cournoyer, M.E., et al., "Lean Six Sigma tools for a glovebox glove integrity program," J. Chem. Health Safety, 18 (1), 13-21, (2011).
[6] LAUR 11-00036, Institutional Glovebox Safety Committee (IGSC) Annual Report FY 2010
[7] Cournoyer, M.E., et al.,, "Safety Observation Contributions to a Glovebox Safety Program" *J. Chem. Health & Saf.* 2011, in press.
[8] Institutional Glovebox Safety Committee Charter, October 17, 2007.
[9] Cournoyer, M.E., et al., "Investigation of injury/illness data at a nuclear facility," J. Chem. Health Safety, 18 (5), 17-26, 2011.
[10] Castro, A. M.; et al1., Glovebox glove dexterity comparison, J. Chem. Health Safety (2011), doi:10.1016/j.jchas.2011.05.010