Success in Behavior-Based Safety at Los Alamos National Laboratory's Plutonium Facility

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Abstract

Los Alamos National Laboratory's (LANL's) Plutonium Facility is responsible for a wide variety of actinide processing operations in support of the United States Department of Energy's (DOE's) stockpile stewardship of the nation's nuclear arsenal. Both engineered and administrative controls are used to mitigate hazards inherent in these activities. Nuclear facilities have engineered safety systems that are extensively evaluated and documented, and are monitored regularly for operability and performance. Personnel undergo comprehensive training, including annual recertification of their operations. They must thoroughly understand the hazards involved in their work and the controls that are in place to mitigate those hazards. A series of hazard-control plans and work instructions are used to define and authorize the work that is done.

Primary hazards associated with chemicals and radioactive materials are well controlled with minimal risk to the workforce and public. The majority of injuries are physical or ergonomic in nature. In an effort to increase safety awareness and to decrease accidents and incidents, a program focusing on the identification and elimination of unsafe behaviors was initiated. Workers are trained on how to conduct safety observations and given guidance on specific behaviors to note. Observations are structured to have minimal impact upon workload and are shared by the entire work force. This program has effectively decreased a low accident rate and will make long-term sustainability possible.

1. Los Alamos National Laboratory

Los Alamos is one of the United States' national laboratories owned by the DOE and operated by the University of California. The Laboratory is one of the original nuclear weapons complex laboratories dating back to Project Y of the Manhattan Engineering District during World War II [1]. Consequently, research with radioactive materials has been conducted at Los Alamos for over half a century and remains one of the primary responsibilities of this institution. The capabilities of the Plutonium Facility are essential in accomplishing one of the Laboratory's core missions of Stockpile Stewardship of the Nation's nuclear arsenal.

The Laboratory occupies about 111 square kilometers in north central New Mexico about 40 kilometers northwest of Santa Fe, the state capital. It is located at an elevation of approximately 2,200 meters above sea level on the Pajarito plateau on the east flank of the Jemez Mountains.

2. Nuclear Materials Technology Division

The Nuclear Materials Technology Division (NMT) is one of the Laboratory's organizational units and is responsible for the operation of the Plutonium Facility. The Plutonium Facility is a concrete-reinforced structure designed in accordance with DOE general design criteria for plutonium processing and handling facilities and was completed in 1978. It has a floor area of 14.000 square meters consisting of a service floor and an operations floor that is divided into two independent halves and organized into four operating areas numbered 100 to 400. The 100 and 200 areas contain plutonium research and development laboratories, reactor-fuels laboratories, plutonium-238 heat-source fabrication operations, analytical chemistry, and personnel decontamination areas. The 300 and 400 areas contain actinide processes (both wet chemistry and pyrochemistry), metallurgical operations, parts machining, waste operations, and nondestructive assay laboratories. Diverse activities and a rapidly changing project base present a challenge to waste operations.

3. Nuclear Facility Safety Philosophy

Engineered barriers provide the most effective protection from radioactive and hazardous materials. The barriers in the Plutonium Facility have been incorporated through architectural and structural design and employ differential pressure zones, High-Efficiency Particulate Air (HEPA) filtration, gloveboxes and radiation shielding in the design of the facility. Administrative procedures augment these passive safety features with the identification of radiological control areas, routine monitoring programs, use of personnel protective clothing and detailed work instructions. Extensive safety analysis reports document these controls and evaluate “design basis accidents” to ensure that stipulated release limits, under accident conditions, are not exceeded. Safety-significant structures, systems and components critical to the proper operation of engineered safety systems are identified. Surveillance and test criteria are established to verify their operability. All operations conducted within the facility must be performed within the established “safety envelope.”

Personnel integrity and competence are key to the success of any endeavor, and safety is no exception. Individual training plans are established based upon job assignments. Personnel must be knowledgeable of the hazards and risks that they face, and training is designed to reinforce their understanding. Technicians participate in the evaluation of their operations to identify and quantify hazards inherent in work activities. Mitigating factors (both engineered and administrative) are considered that reduce risk to acceptable levels. These hazards analyses are documented and provide the basis for the development of work instructions that are used to perform the work. Personnel are trained and qualified on these hazards analysis and work instructions. In addition to classroom training, new personnel are mentored by experienced operators before being allowed to work independently. Risky operations always require at least two people to perform.

This safety methodology has resulted in low accident/incident rates. Serious accidents involving chemicals and radioactive materials are rare. Physical injuries (cuts, scrapes, strains, sprains, etc.) and repetitive motion injuries dominate job-incurred injuries. In order to achieve and sustain lower accident/incident rates, it became apparent that a new approach to safety must be employed that would change the traditional perception of safety and would result in a fundamental shift in behavior and attitudes toward safety.

4. Tracking of Accident and Incidents

Two independent systems are used to track accidents and incidents at LANL. One addresses radiological incidents such as unplanned exposures to penetrating radiation, contamination with radioactive materials and internal uptake of radioisotopes. The other records chemical exposures and physical injuries incurred on the job. A database is used to record information pertaining to the injury and document factual information on the incident, root-cause analysis, and track corrective actions. No-blame inquiries are held as soon as possible after the incident in order to capture the accurate information needed to perform a thorough investigation and to take action to prevent accident recurrence. This information is also advertised Laboratory-wide and sometimes DOE-wide as lessons-learned for facilities that conduct similar operations. If the incident is serious enough, it triggers a higher level of notification and response as outlined in DOE order 232.1, *Occurrence Reporting and Processing of Operations Information* [2]. We will concentrate on accident response within the Laboratory and NMT Division in this paper.

The collection and reporting of industrial accident data is conducted in accordance with the *Occupational Safety and Health Act* (OSHA) [3]. Accident rate definitions are calculated on the basis of a one-year running average and are expressed by a normalized factor of lost workday cases per 200,000 working hours (100 person-years). Accidents are defined as job incurred or aggravated injuries requiring more than first aid to treat. These accident rates have been declining in an irregular manner and appear to be approaching an asymptotic limit. It is this artificial limit that behavior-based safety is intended to address.

5. Behavior-Based Safety Philosophy

The application of principals relative to one's daily experience is beneficial in order to realize a more complete understanding of the concept behind behavior-based safety. The idea of consequences controlling behavior, generally regarded as the foundation concept, is the key. In day-to-day activities, the majority of behaviors rely on applying previous experience of consequences (both negative and positive) as the reinforcing factor. A simple example: a burn received from touching a hot stove uses a negative consequence as a predictor of future behavior. Conversely, the use of protective measures preventing the negative consequence of a burn reinforces the behavior from a positive aspect. The imitation or modeling of behavior provides additional consequences acquired from something other than trial and error experience. The approval demonstrated by parents as their infant smiles communicates a positive consequence and repeatedly reinforces repetition of the behavior.

It is the work of B.F. Skinner [4], generally regarded as the founder of behavior-based science merged with W. Edwards Deming's Total Quality Management (TQM) [5] that provides the basis for successful implementation of behavior-based safety. Scientific sampling of statistical data provides a measurement of the quality of safety and when coupled with positive, reinforcing consequences encourages the desired safe behaviors.

The behavior-based safety process is designed to engage the workforce in the implementation and utilization of their own safety initiative. The process, being employee-driven, is based on the simple act of having workers observe other workers and provide feedback to safe and at-risk behaviors. Observations typically take 10 to 15 minutes. Observations are strictly conducted under the conditions that **no names are used and no blame is placed**. A prospective observer takes 2 days of training on how to perform observations.

- The observer uses a Critical Behavior Inventory® and a data sheet looking for safe and at-risk behaviors.
- Following an observation, the observer gives feedback to the worker and allows the worker to comment on the feedback.
- Observation data are entered into a database for analysis and problem solving.

This process is founded on the premise that for every accident there are hundreds or sometimes thousands of at-risk behaviors. When at-risk behaviors are reduced, the likelihood of injuries is reduced also. A successful approach must not, in any manner, imply that the workers are the problem. In fact, the two-way feedback promotes the idea that the workers are indeed the solution. Workers typically perform at-risk behaviors because barriers to safe work often force workers in conflicting directions. The following barriers are categorized into groups and offer some examples:

- Hazard Recognition and Response
  The worker has inadequate skills or knowledge and does not know or is unaware that the situation represents risk. The worker may be adequately trained and experienced but has become used to the risk.
- Business Systems
  The at-risk situation is the result of an organizational system that was unreliable. When a system is inefficient, employees will avoid using it or they may find ways around the system.
- Rewards/Recognition
  The at-risk behavior is encouraged (or conversely the safe behavior discouraged) as a result of misguided reward and recognition practices or by the absence of accountability for following safe practices. Misguided rewards and recognition may be formal but based on production and not on safety, or informal through peer pressure leading to the omission of certain safety-critical steps.
- Facilities and Equipment
  The task is performed at risk in that it is difficult or impossible to do it safely because of equipment or workstation design, lack of adequate maintenance, or unavailable tools or equipment needed to do the work safely.
- Disagreement on Safe Practices
  The at-risk behavior stems from an absence of agreement on the safe way to perform a job.
- Personal Factors
  The at-risk behavior results from personal characteristics of the worker that result in him/her deliberately taking risks or refusing to work safely as a result of factors such as fatigue, medication, stress, or illness.
- Culture
  The at-risk behavior is a long-established practice; "we've always done it that way."
- Personal Choice
  The worker has adequate skill, knowledge, and resources but chooses to work at risk to save time, effort, or something similar.

In order to remove these barriers we must understand which ones are causing at-risk behaviors. The way this is accomplished is through observing and talking with employees. The feedback loop provides individual employees a method of hazard recognition and reporting that remains anonymous, with a built-in matrix to elevate safety issues for resolution as necessary. As the data and feedback are received in large numbers from the employees, the barriers to safe work are defined and addressed.

6. Program Structure

The NMT behavior-based safety initiative began by forming an identity separate from existing Laboratory institutional safety programs. Employees were asked to participate in a contest to find a name. Ultimately the name chosen was ATOMICS. This acronym stands for Allowing Timely Observations Measures Increased Commitment to Safety.

The roles and responsibilities were established and clearly defined. These included definitions of roles for the management sponsor (the champion of the process initiative), the facilitator, the steering team, the observers, and the employees. Brief examples are listed below.

- Management sponsor
  - Assists committee members and obtains necessary resources.
  - Has regular contact with facilitator and steering committee.
  - Serves as liaison between management and the committee that includes representing management's point of view to the committee and bringing committee concerns and views to other managers.
  - Supports the confidential nature of the observation process.

- Facilitator
  - Serves as liaison with management, which includes meeting with management sponsor and/or NMT Facility management team at least monthly for progress and status reviews.
  - Serves as liaison with outside groups, which includes providing information about the NMT behavior-based safety process to other Laboratory organizations and outside institutions.
  - Acts as facilitator/chair of committee meetings.

- Steering Committee
  - Attends training as necessary to implement this process in NMT division.
  - Completes individual or subcommittee assignments to fulfill committee objectives.
  - Recruits and trains observers.
  - Maintains observation skills. Mentor observers to ensure quality observations.
  - Uses observation data for problem solving.

- Observers
  - Explain and emphasize "no names, no blame," and keep observations confidential.
  - Know and understand the observation data sheet and definitions.
  - Give immediate and positive feedback to the person or persons being observed.
  - Attempt to understand why at-risk behavior occurred.
  - Support the NMT behavior-based safety process and the Behavior-based Accident Prevention Process (BAPP®) by words and actions.
  - Follow all postings applicable to the area while performing observations
  - Stop work when necessary, using LANL guidelines. (See LIR 401-10-010, *Stop Work and Restart* [6].)
    If work is stopped: **Immediately** stop the observation so that anonymity is not confused or compromised.

- Employees
  - Give the behavior-based safety process a chance to work.
  - Maintain familiarity with the process.
  - Cooperate with observers.
  - Provide the steering committee feedback on process effectiveness.
  - Review feedback charts.
  - Discuss safety concerns with the steering committee members or other observers.

7. Program Planning and Implementation

NMT Division contracted Behavioral Science Technology, Inc. (BST®) [7] to guide our efforts to improve our safety record and decrease the accidents and incidents that consistently kept the Division on an unacceptable plateau. The BST® consultants initially made an extensive assessment of site safety perceptions by making numerous visits to the Laboratory, performing informational training and surveying the existing culture. The results of the evaluation are measured on a series of scales defining the degree to which personnel judge the adequacy of site safety. The consultant then uses an implementation design team to communicate and educate the Division and develop a strategy based on previous data and experience. Participants in the implementation of the process were selected from the workforce based upon specific guidance criteria. The consultant trained the steering team in the details of the technology, and behaviors critical to safety were mapped out. The inventory that was derived from past accidents and incidents defines the Critical Behaviors Inventory[â] (CBI®) and forms the basic pool of observational data to be collected. Input and comments from employees were solicited through a series of ownership presentations given to all groups in the Division. The steering committee developed and subsequently trained the workforce in behavior-based observation techniques to collect the data for tracking and identifying the barriers to safety improvement. The steering committee also underwent training in interpretation and action planning using the collected data.

8. Program Evaluation

Indicators of the success of the ATOMICS process are showing steady improvement. The level of demonstrated management support for employee participation in observation training, observation data collection, and anonymity has been clearly defined and communicated by memorandum to the Division. The group leaders, in turn, lend support for the implementation by setting a positive example and by providing financial resources. Allowing time for the participants to support behavior-based safety is actively encouraged, and regular progress reports are expected and used by managers. This level of commitment is crucial to the long-term success of the behavior-based safety process in the Division.

Employee efforts during a pilot implementation at another NMT facility (before the ATOMICS process) yielded invaluable experience and lessons learned that were incorporated into the ATOMICS implementation. A major obstacle identified in the pilot was the lack of defined and demonstrated management commitment; the importance of midlevel manager support was severely underestimated. To overcome this barrier it was critical that participation in observations (both observed and observer roles) be viewed as part of the employee's daily tasks. The ideas of doing observations that were "not part of the job" and were separate from "real work" were addressed. It was imperative that programmatic work assignments include the time necessary to participate in this process and that personnel be evaluated for their contribution.

By October of 2000, the ATOMICS Steering Team had conducted three observer-training classes, and field observations were in full swing. By March of 2001, fourteen observer training classes had been conducted, and the number of trained observers reached 200. This is indicative of the level of worker and management commitment, considering that the observer training is a full two-day class. The resistance to observations has been sporadic as the process enters its second year in existence. The fears voiced during initial ownership meetings that this would be a "flavor-of-the-month safety initiative" are becoming remote as participation increases. The direct support of management continues to demonstrate a high level of interest and promotes the success of the process. Over 65 have participated in additional manager/team leader classes that cover data interpretation and use. The data collected since October have continually improved in quality and indicate repeatedly increased employee recognition of at-risk behaviors. Because the comments are requested from the employee being observed, not only has the awareness increased, the employees are agreeing to the risk assessment and are frequently self-correcting.

Another major success of the ATOMICS program at this stage is the fact that 200 employee observers have made behavior-based observations of over 1,250 individuals who were given positive feedback on the safe behaviors demonstrated. At this writing, roughly 2,600 individuals have clearly made the choice to participate in an informal one-on-one discussion of safety as it relates to their work.

The NMT Division Total Recordable Injury Rate (TRI) began at 4.25 for 1,457,238 man-hours worked in March of 2000 and has dropped to a TRI of 2.60 in February of 2001 for 1,309,580 man-hours worked. In one year's time the TRI has shown a significant 1.65 reduction. This downward trend includes an approximate10 percent drop in man-hours worked. In the same period, the Lost Workday Cases (LWC) rate has dropped from 3.57 to 0.76. The introduction of the ATOMICS behavior-based safety process to the Division was implemented by conducting 16 separate ownership meetings to the individual working groups.

To date, approximately 900 field observations have been completed, and statistics confirm the importance of workplace ergonomics to the overall safety in NMT. The documented percentage of safe behaviors associated with the ergonomic factors and performance of tasks at these workstations indicate evidence of worker unfamiliarity with possible cause and effects of injuries that plague industry as well as NMT operations. The feedback loop includes informing the observed individual of whom to contact to provide an ergonomic evaluation. A meaningful reduction of at-risk behaviors affecting the overall safety record of the Division is anticipated as a result of consulting with safety professionals on ergonomic issues. Ergonomic issues make up the majority of the NMT Division lost workdays (see Figure 1) and are one of the current observation focus areas for observations. From January 2001 to April 2001, the percent of safe observed behaviors for ergonomics has shown a promising increase (see Figure 2). Observation data averages of approximately 100 observations per month indicate a percent safe increase from 83% in January to 93% in April. The awareness level of safe ergonomic behaviors and the encouragement of peer feedback to enlist the Health and Safety team for professional ergonomic evaluation of employee workstations demonstrate superior employee involvement and teamwork.

Radiation safety and housekeeping issues are additional areas that make up the current focus of observations. These categories are showing an upward trend in the percent of safe behaviors observed. Radiological Incident Report rates (RIRs) for both TA-55 and CMR from January 2000 to March 2001 are trending downward. These statistics, normalized to the OSHA rate of 200,000 hours have dropped from 30 to 14 at TA-55 and from 22 to 12 at CMR. Rates of contamination at exits for both facilities, again normalized to OSHA rates, are showing marked decreases, TA-55 from 8.2 to 4.2 and CMR from 6.0 to 2.5. Housekeeping issues are for the most part an enabled behavior (one that the employee has direct control over) and ATOMICS statistics are encouraging because they indicate an increase in safe observed behaviors.

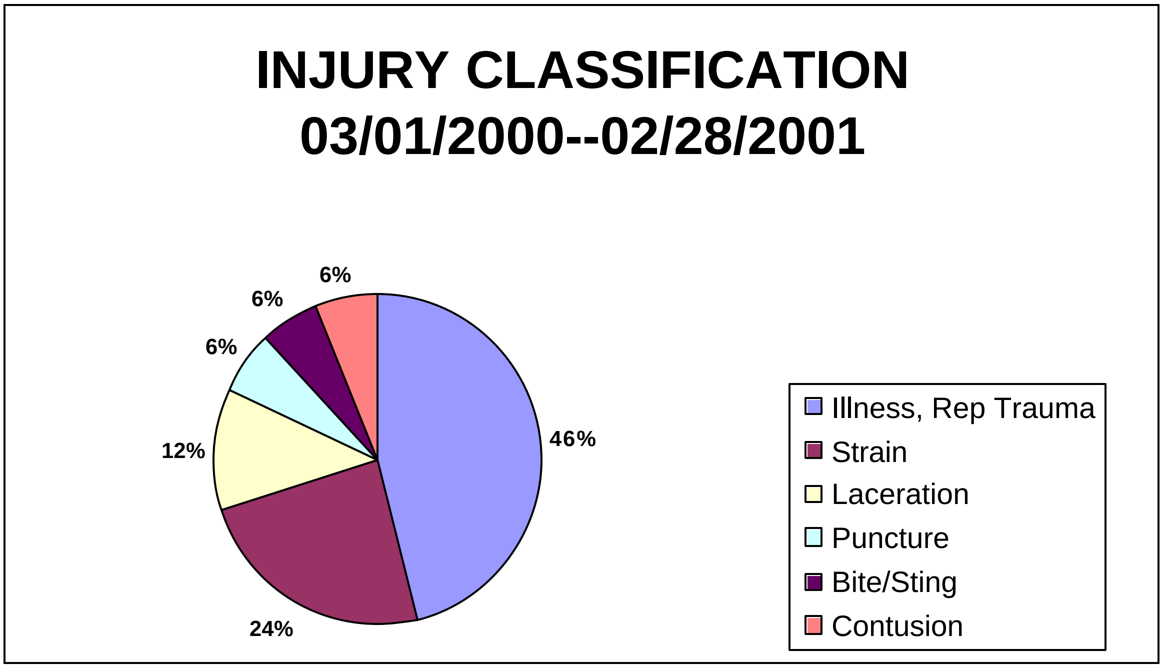

Figure 1. NMT injuries by category.

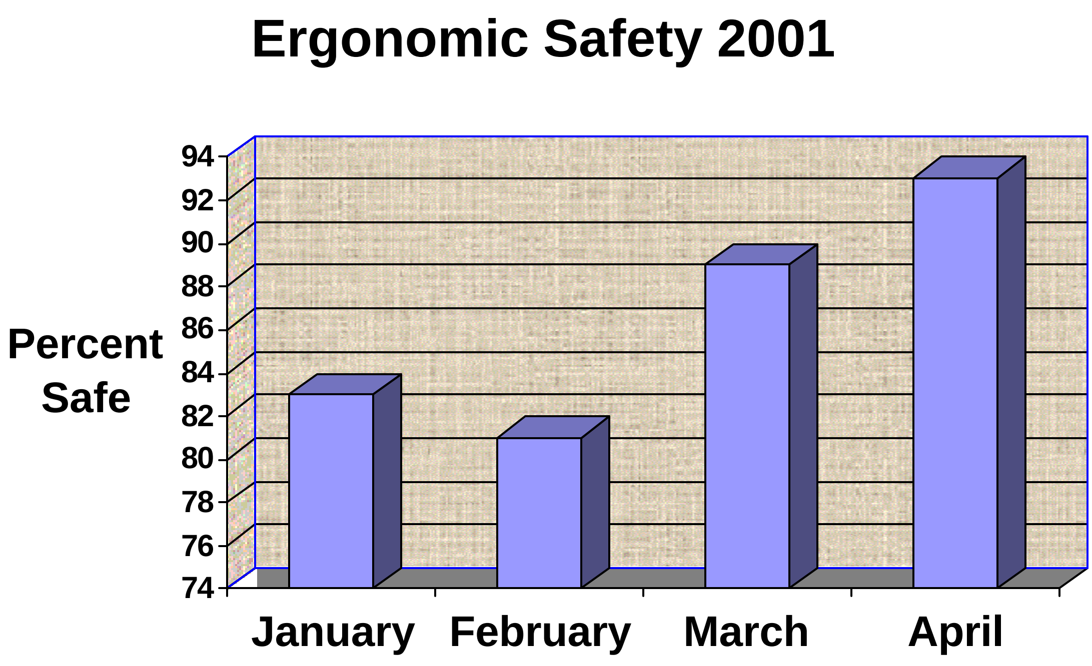

Figure 2. Trend in observations of safe behavior.

The NMT Division goal of 200 observations per month projects 2,400 total observations for the 2001 calendar year and should take minimal additional effort on the part of the workforce. Because an observation typically takes fifteen minutes from start to finish, this is more than a reachable goal should each observer perform a single observation in a calendar month.

For the calendar year 2001 all of the categories on the CBI® combined indicate an increase in the safe behaviors from 90% to 95% in four months (see Figure 3). As the observations increase in frequency, the percent of safe behaviors observed will increase as well. Comment reports from observational data are shared with the management team in order to remedy at-risk behaviors that are nonenabled (behaviors the employee has no control over). Starting in January, these reports have been distributed to each NMT group leader. Additional criteria for identifying group responsibility of nonenabled barriers to safe work are now added to the data sheets on a volunteer basis. This enables the individual work group opportunities to correct issues identified during observations.

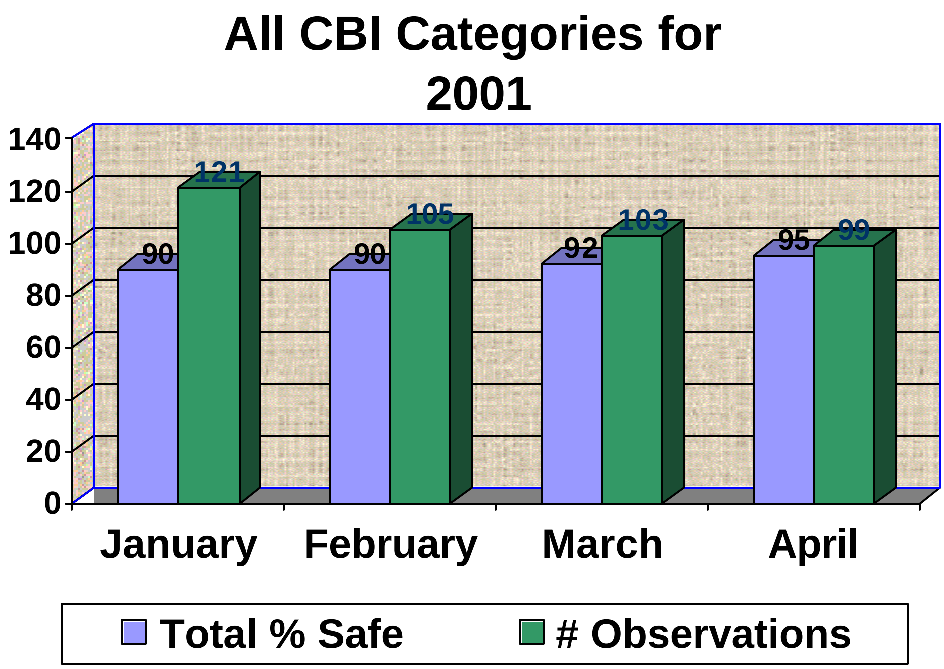

Figure 3. Trend of combined CBI® categories.

9. Future Direction

The next steps in the program are to continue coaching trained observers, to improve the skills needed to perform observations and feedback, and to begin applying behavioral principles to incident and accident investigation in the Division. It would be presumptuous to attribute the downward trends in TRI and LWC statistics solely to the ATOMICS efforts though. The bigger picture would credit the level of NMT Division employee involvement in a worker based safety effort that defines and supports a common, measurable goal. NMT employees are beginning to distinguish the difference between factors that are within their control from those they have little or no control over. The obvious benefit is a worker's increased perception of personal responsibility and control of behaviors essential to safety.

The ATOMICS program is successfully under way and already showing promising results at the Plutonium Facility, thanks to the enthusiasm of the workforce implementing the program. Management is aggressively addressing identified safety issues in order to ensure a safe working environment for everyone. Safety indicators are showing the potential of penetrating the current limit and attaining even lower accident/incident rates for the Division. It is NMT Division's intent to attain:

- The Vision of ATOMICS
  NMT Division is the Los Alamos National Laboratory and U.S. Department of Energy's model of excellence in the application of safety performance.

- The ATOMICS Mission
  NMT Division will continuously improve the health and safety of the workforce by reducing at-risk behaviors through ongoing behavior-based observations.

In order to realize this vision it must be communicated and shared throughout the Division and valued without compromise. It must be recognized by all levels within the organization and not subject to misinterpretation. As the observations increase; the accidents and injuries will decrease proportionately in both severity and frequency. It is anticipated that longer periods will pass without injuries. A powerful motivator is worker responsibility for the safety of coworkers as well as themselves. NMT Division will continue to embrace behavior-based safety as the standard and espouse the philosophy that there is no acceptable level of injury in operations at the Plutonium Facility.

References

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