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INSIDE

Photo by Sandra Valdez, IRM-CAS

Tom Lienert investigates how lasers, electron beams, and friction can be used to solve problems for national defense and global security programs. Early in his career, he gained an international reputation for his advancement of friction stir welding (left).

Tom Lienert

Stoking welding science to new heights

By Diana Del Mauro, ADEPS Communications

During the past 30 years, Tom Lienert has made a distinct mark on the science of welding and joining. He has developed new methods for joining metals and solved stubborn technical challenges on behalf of the nation's defense and global security programs.

> *"In the last several decades, welding has evolved into an interdisciplinary activity; it requires synthesizing knowledge from many disciplines and incorporating the most advanced tools of basic and applied sciences."*

"Tom is truly one of the most impressive welding researchers I have ever met," said Jerry Gould, who supervised Lienert early in his career at Ohio's Edison Welding Institute. Gould, among others, supported Lienert's nomination as a 2012 American Welding Society Fellow. "He has been a strong advocate of the welding sciences at every level, from foundational understanding to top-level research, to education, to technical outreach." Lienert was also recently named a 2013 ASM International Fellow.

Lienert is a research-and-development engineer with Materials Technology-Metallurgy (MST-6), which specializes in plutonium and uranium, as well as common engineering alloys. He tests his theories inside Sigma's massive welding shop, which offers an impressive array of welding machines, including laser welders, electron beam welders, and friction welding machines. While designing experiments for research technicians to run here, he draws from his doctorate in materials science and engineering, intertwining aspects of

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From David's desk . . .

Materials Capability Review:
As many of you know we held our annual Materials Capability Review in early May with a focus on Materials Dynamics and Integrated Nanomaterials. The science and technical aspects of these two areas was very well received with excellent or outstanding quality. Each year I am always impressed with the breadth, depth, and quality of science that we perform at this Laboratory but especially within this Division. These reviews do take a lot of our time, but they also illustrate the impact and importance of Materials at LANL. The committee did recognize the need for an institutional plan for maintaining our mid-scale experimental facilities like the EML and IBML but also developing an institutional capitalization investment plan. The Laboratory is taking action in this area with a team led by Ken Schlindwein in PADOPS, which includes myself along with other representatives from ADEPS and ADCLES. I am hopeful this effort will lead to a sustainable model for recapitalization and maintenance of our experimental facilities as opposed to the traditional year-by-year opportunistic approach.

Our outstanding scientific performance along with our continual high performance of delivering on high impact technical accomplishments makes me proud and honored to be leading this Division.

"MST Division and Los Alamos National Laboratory are well suited to help the nation and industries develop new advanced manufacturing technologies . . ."

Advanced Manufacturing Initiatives:
I believe we are entering a new manufacturing renaissance in the United States that will lead to the United States regaining competitiveness in the world marketplace. MST Division and Los Alamos National Laboratory are well suited to help the nation and industries develop new advanced manufacturing technologies by developing new materials and processes, accelerating product qualification using coupled experiments, modeling and simulation, and developing sensors and diagnostics for process and quality control. Dan and I have been leading the strategic efforts for the Laboratory in this area and we have been strengthening partnerships with some key LANL industry partners, namely Proctor & Gamble, Chevron, and Alcoa. We have also agreed to be a core partner with the University of Michigan on a proposal for one of the National Network for Manufacturing Innovation Institutes on lightweight and modern metals manufacturing. By working with the weapons and global security programs we are reinvigorating our additive manufacturing capability in MST through the new acquisition of a laser-based metal and ceramic additive manufacturing device. Many of you may have great ideas on how your capabilities could be used to enhance manufacturing processes, please come by and share them with me.

Cybersecurity:
Lastly, I would like for everyone to be vigilant with your computer security practices. Please ensure that your operating systems and virus checking software is current and up to date. Also ensure that your computer security protocols are correct before connecting to the internet. The average time in which a computer is attacked after being connected to the internet is 26 minutes. Be aware of phishing attempts which seem to be increasing. In a recent attack at Y-12, more than 500 people were targeted in a spear-phishing attempt. A spear-phishing attempt is an e-mail spoofing fraud attempt that targets a specific organization, seeking unauthorized access to confidential data. In this particular case, only 10% of the recipients actually opened the e-mail link and of those, 2 ended up getting infected which caused the entire network at Y-12 to be shut down. However it only takes one computer to get infected to potentially affect the entire Laboratory. In these spear-phishing attempts, the email may appear to come from a colleague but often the e-mail domain name is different. Consider it questionable if the domain name doesn't look right and either contact the sender or the CSIRT team to determine the whether the email is legitimate. It is better to ask questions than open the attachment or connect to a link in a suspicious email.

MST Division Leader David Teter

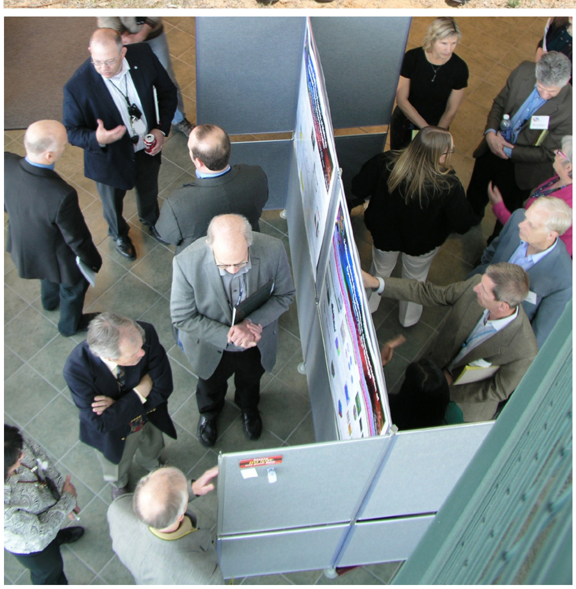
Views of the Review

The 2013 Materials Capability Review was held earlier this month and featured talks and posters by staff from across the Laboratory performing integrated nanomaterials and materials dynamics research.

The first full day of events kicked off with Principal Associate Director Alan Bishop thanking Susan Seestrom for her support of Materials for the Future at Los Alamos. Seestrom, who is the pillar's champion, is stepping down as Associate Director Experimental Physical Sciences later this year to return to research. The morning continued with MST Division Leader David Teter presenting an overview of the state of the Materials Capability at Los Alamos and MPA Division Leader Toni Taylor presenting a strategy implementation update on the Materials for the Future pillar.

MST's Rusty Gray and Ricardo Lebensohn gave talks: John Carpenter, Veronica Livescu, Saryu Fensin, Amy Clarke, Bill Blumenthal, Ellen Cerreta, and Carl Cady presented posters. Rob Dickerson hosted a tour of the Electron Microscopy Laboratory.

Photos by Sandra Valdez, IRM-CAS, and Karen Kippen, ADEPS



From top: Alan Bishop thanks Susan Seestrom for her support of the Laboratory's Materials pillar; George Dominquez and Peggy Vigil at command central outside the review in the Study Center; Amy Clarke presents research on in situ imaging of solidification during a poster session; Irene Beyerlein discusses her LDRD project with the committee; the Materials Dynamics poster session was held at CINT; the MCR Review Committee (from left, Richard Lesar, Alexandra Navrotsky, Jeffrey Lynn, Christine Orme, Gary Was, Barbara Jones (chair), Michael Kaufman, and Adam Schwartz.

Lienert cont.

metallurgy, physics, chemistry, and heat transfer.
Given the national security mission of Los Alamos, far-reaching solutions often come out of seemingly simple technical challenges. With colleagues at Los Alamos, the Y-12 National Security Complex in Tennessee, and the Pantex Plant in Texas, Lienert helped determine why a laser weld was cracking and devised a laser-alloying method to prevent cracking in the newly formed weld. The patented solution, a valveless laser processing technique, was so novel that *R&D Magazine* lauded it as one of the top 100 innovations in 2012.

The solution, using a laser that can remotely drill and re-weld a hermetically sealed container, is attractive to the private manufacturing industry because of its cost-savings potential. But the primary purpose of the technology is for scientists and engineers who study the aging processes and overall reliability of the nuclear weapons stockpile. Besides saving production costs, the technique is expected to reduce worker exposure to hazardous materials.

In his latest project, Lienert and colleagues are working to develop a procedure for using electron beam welding to fabricate aluminum-clad/uranium alloy fuel plates. The U.S. Department of Energy is looking for solutions that would allow research reactors to burn low-enriched uranium fuel instead of highly enriched uranium fuel. The aim is to minimize or eliminate fuels that can be used in weapons of mass destruction. "When we get this process to work," Lienert said, "it will save the fuel plate manufacturer over $1 million per year in production and labor costs."

How Lienert found his passion
Surrounded by manufacturing smokestacks in his hometown of Buffalo, New York, Lienert pictured a career in the automobile industry and earned an associate's degree in materials science technology at the local community college. However, the gas crisis paralyzed the region's economy, spurring him west to become a welding research technician at Sandia National Laboratories in Albuquerque.

After spending the next decade under welding metallurgist Mike Cieslak at Sandia, Lienert concluded "laser welding was cool" and headed to graduate school. At Ohio State University he characterized inertia-friction welds on aluminum metal matrix composites (Al-MMCs) for his master's thesis, and he studied the microstructural evolution in laser and electron beam welds on Al-MMCs for his dissertation. At his first job, with Edison Welding Institute, he gained an international reputation for his advancement of friction stir welding of high temperature materials.

Laser welding returned as his focus when Lienert joined Los Alamos in 2002. "Laser welding plays a key role in Los Alamos National Laboratory production activities," he said. He now is managing a project to modernize lasers at the Plutonium Facility.

Throughout his career, Lienert has made a point to shepherd others into the field, which suffers from a chronic shortage of workers. In addition to serving as director-at-large on the American Welding Society's board of directors, he has invested years on the education committee and education scholarship committee.

"In the last several decades, welding has evolved into an interdisciplinary activity; it requires synthesizing knowledge from many disciplines and incorporating the most advanced tools of basic and applied sciences," Lienert said. "It's not an art," he emphasized. "It's a science."

Tom Lienert's Favorite Experiment

What: Development of friction stir welding (FSW) for titanium and steel alloys

When: 1998. At that time, friction stir welding of Al & Mg alloys was well developed, and there was considerable interest in extending the process to alloys with higher temperature capabilities like steel, Ti, and Ni alloys.

Where: Edison Welding Institute, Columbus, Ohio

Who: My technician, Dave LaPolla, and I

How: EWI was conducting "plunge" tests to evaluate tool materials, and I happened to observe some of the tests. All the tests failed, as a large "mushroom" of workpiece material was attached to the tools when they were withdrawn.

The aha moment: I hypothesized that the RPM used for the tests was too high. When I pointed out my observation, I was told by the other engineer in charge of the project to mind my own business. I fished a tungsten tool out of the scrap bin and asked my technician to machine away the mushroom material to bring the tool back to its original geometry. The next day we met after work hours, turned down the RPM, and produced the first sound friction stir weldings on a Ti alloy. Similar sound welds were subsequently produced on a low-alloy steel. This work was published in the *Welding Journal Research Supplement* and received an award for the best paper published that year on the welding of steels.

MST-6's Gibbs earns AISI Finalist Medal for research benefitting development of high strength steels

Paul Gibbs (Materials Science: Metallurgy, MST-6) and Bjørn Clausen (Lujan Center-LANSCE-LC) are among the recipients of an American Iron and Steel Institute (AISI) 2013 Finalist Medal for their paper that drew upon the Lujan Neutron Scattering Center's neutron diffraction capability and set forth a methodology for producing a family of transformation-induced plasticity (TRIP) steels with desirable austenite stability conditions.

Since 1927, AISI has given awards for technical papers having special merit and importance in connection with the activities and interests of the iron and steel industry. Papers are judged on the potential value to future prosperity of the industry, technical excellence and originality, effective communication, and breadth of interest to AISI members.

There is an interest in developing new advanced high strength steel (AHSS) grades to meet the evolving demands of the automotive industry. It is anticipated that these so-called "Third Generation AHSS" microstructures will consist of high volume fractions (20-40 vol pct.) of metastable retained austenite (i.e., austenite that transforms to a harder phase with deformation) displaying controlled deformation-induced transformation to martensite in a high strength matrix.

The authors developed a methodology for the work to utilize manganese enrichment of austenite from ferrite during annealing to produce a set of steels with systematically varied microstructures. The resulting structures are shown in the figure for a 7.1 wt% Mn steel annealed between 575°C and 650°C for 168 hr.


Paul Gibbs (left) and Bjørn Clausen (right) received an American Iron and Steel Institute Finalist Medal for their research performed at the Lujan Neutron Scattering Center.

Using the SMARTS (Spectrometer for Materials Research at Temperature and Stress) instrument at the Lujan Center, the researchers measured the mechanical stability of the austenite during deformation using in situ neutron diffraction. A correlation between austenite stability for each of the annealing conditions and the mechanical behavior was observed, as shown in figure (d), leading them to conclude that the development of new steels to meet Third Generation AHSS demands must take into consideration the mechanical stability of austenite, as well as the total amount of austenite in the steel.

Co-authors included researchers from the Advanced Steel Processing and Products Research Center at the Colorado School of Mines (CSM), of which MST-6 is an active sponsor institution, and the United States Steel Corporation Research and Technology Center. Gibbs, who participated

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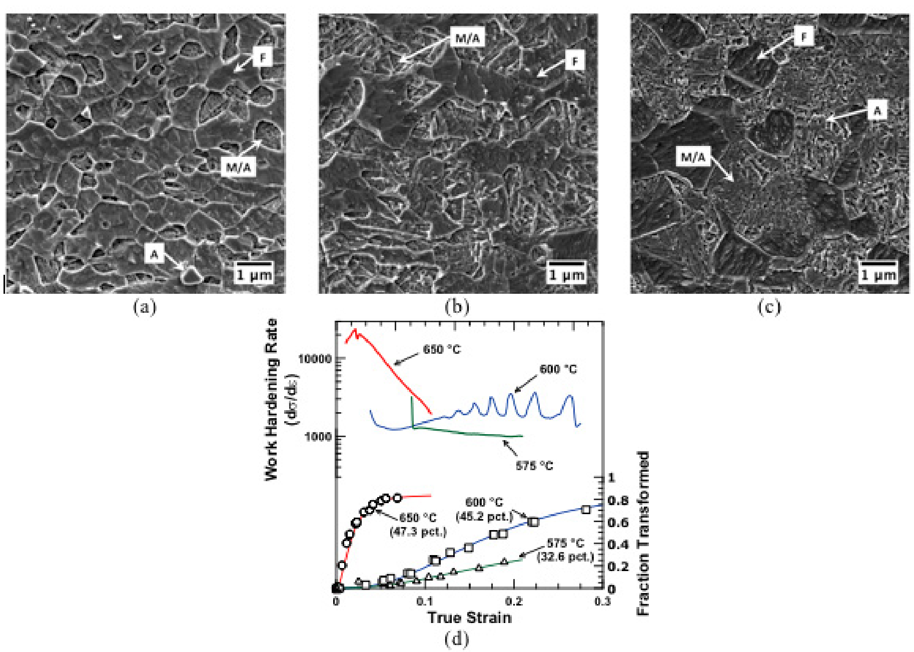


Secondary electron scanning electron micrographs of 7.1 wt% Mn steel annealed at (a) 575°C, (b) 600°C and (c) 650°C for 168 hr. and water quenched. Representative phase regions are labeled ferrite (F), martensite (M), austenite (A), and mixed martensite and austenite (M/A). The figure in part (d) shows a comparison between instantaneous hardening rate (dσ/dε) and austenite transformation as a function of sample deformation for the three structures highlighted in parts (a-c). Significant austenite transformation occurs where high strengthening is observed. The initial amount of metastable austenite in the steels is listed below the annealing temperature.

Medal cont.

in the Lujan Center's 2009 Neutron Scattering School, performed the work as a CSM graduate student.

The National Science Foundation supported Gibbs's PhD work under award CMMI-0729114. The Lujan Neutron Scattering Center at LANSCE is funded by the Office of Basic Energy Sciences (DOE) contract No. DE AC5206NA25396. Donald W. Brown and Thomas A. Sisneros (Materials Science in Radiation and Dynamics Extremes, MST-8) assisted with neutron experiments. The work is in alignment with the Laboratory's Energy Security mission and Materials for the Future pillar.

Reference: "Austenite Stability Effects on Tensile Behavior of Manganese-Enriched-Austenite Transformation-Induced Plasticity Steel," *Metallurgical and Materials Transactions A*, **42** 12 3691-3702 (2011).

Technical contacts: Paul Gibbs and Bjørn Clausen

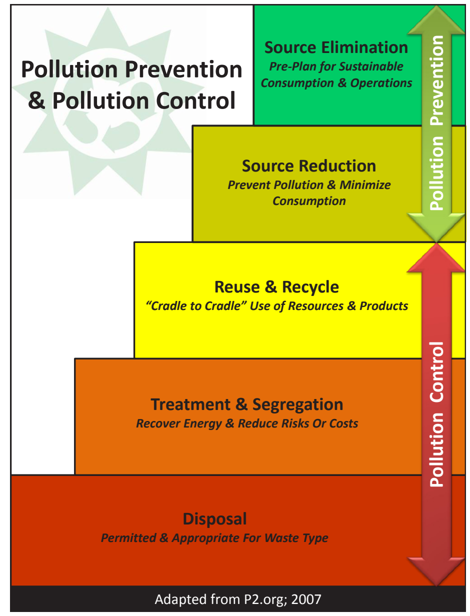
MST employees receive Pollution Prevention Awards

Members of Materials Science & Technology Division were recognized for protecting the environment and saving taxpayer dollars at LANL's annual Pollution Prevention Awards ceremony, which was held on Earth Day.

Bev Aikin, Timothy Beard, Barry Bingham, Isaac Cordova, Jim Foley, Jeffrey Robison, Tim Tucker, and Victor Vargas (all MST-6) were part of a team that won a silver award in the Cradle to Cradle Recycling category for "To Be or not to Be." And a 47-member team, the majority of whom were members of Polymers & Coatings (MST-7), received a silver award in the Change Agents category for the "Target Fabrication Facility's 30th Anniversary Housekeeping Initiative."

In "To Be or not to Be," MST-6 took the initiative to recycle excess machined chips and beryllium that could not be used for its intended purpose. The achievement: shipping 79 drums (7,639 kilograms) of unclassified beryllium metal for recycling and averting an estimated disposal cost of $603,685. Success of this project will enable recycling and sanitization routes for the rest of the US Department of Energy laboratories.

Through a Cooperative Research and Development Agreement with Ohio-based Materion Corporation, MST-6 received about $1.8 million over two years to recycle beryllium. First-year funds covered the costs of sorting, classifying, and shipping unclassified beryllium. Second year funds were used to coordinate the security and logistics requirements for shipping of classified material. The remaining funds will be used to characterize typical recycled material from the project. Materion, meanwhile, is setting up the capability to sanitize classified beryllium.



In the past, MST-6 had stored unwanted material at the Beryllium Technology Facility (BTF). The facility was operating at the upper limit of its Material At Risk (MAR) requirements and was, therefore, limited on programmatic projects that could be performed. Reducing the MAR has increased the programmatic capability of the BTF and reduced the environment, health, and safety risk to LANL personnel, the public, and the environment.

Other team members include John Breiner, Cynthia Zelic (Deployed Services, HS-DS); Darryl Garcia (Waste Generator Services, WM-WGS); Dane Knowlton (Intelligence Analysis & Technology, IAT-DO); Beverly Neal-Clinton (Security Integration, SO-2); and Steven G. Gonzales (Prototype Fabrication-Fabrication Services, PF-FS). Garcia nominated the project.

The "Target Fabrication Facility's 30th Anniversary Housekeeping Initiative" required MST-7 employees and other residents of the 85,000-square-foot facility to change their environment as well as their work culture. For details, please see Heads Up! on page 9. For a complete list of participants, please see int.lanl.gov/environment/p2/awards/index.shtml.

Atomistic modeling featured in journal's 2012 best papers compilation

A journal issue of the best papers published during 2012 in the *Journal of Physics: Condensed Matter* includes an article describing modeling of the thermodynamic equilibrium and polymorphism of iron. An international editorial board chose the papers based on referee comments, downloads from readers, and scientific impact.

Correct predictions of the relative stability and transitions among multiple phases of a given material are of fundamental importance. The computational cost of such first-principles calculations is demanding, and their application is typically limited to comparatively small systems with simple

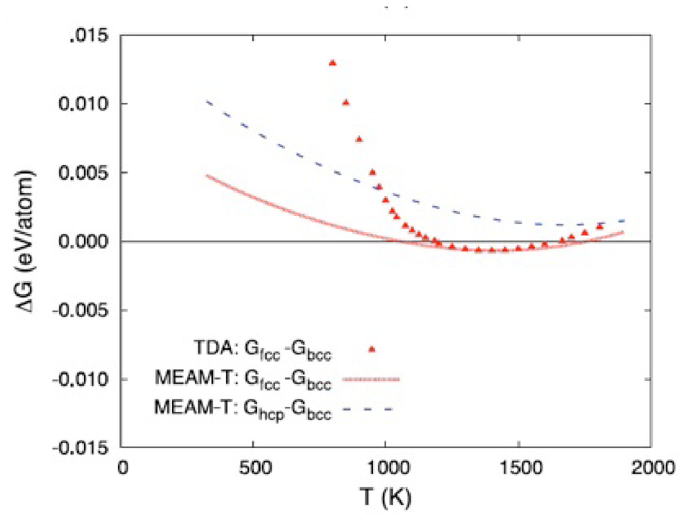
continued on next page

Modeling cont.

configurations at zero temperature. Simulation at the atomic level with an effective interatomic potential can be an efficient technique using the Monte Carlo (MC) method or molecular dynamics (MD). These methods enabled the team to compute both the thermodynamic equilibrium and long-time scale dynamics of physical properties for a sufficiently large system with arbitrarily complicated geometry.

Scientists in MST-8 and a collaborator proposed two new modified embedded-atom method (MEAM) potentials for iron to reproduce the experimental phase stability with respect to both temperature and pressure. They fitted these simple interatomic potentials to a wide variety of material properties of body-centered cubic (bcc) iron in close agreement with experiments. The researchers used Monte Carlo simulation at finite temperatures to examine these models. The team attempted to reproduce the experimental iron polymorphism at finite temperature by means of explicit free energy computations.

They used two MEAM potentials to represent the observed structural phase transitions in iron. The scientists concluded that the correct reproductions of iron phase stability with respect to both temperature and pressure are incompatible with each other due to the lack of magnetism in this class of empirical potentials. The MEAM potentials correctly predicted the self-interstitial in the <110> orientation to be the most stable configuration in the bcc structure, and the screw dislocation to have a non-degenerate core structure. The findings are in contrast to many embedded-atom method potentials for bcc iron in the literature.



Temperature dependence of relative free energies calculated at zero external pressure using one of the MEAM potentials developed in this study. Thermodynamic assessment (TDA) data are also shown for comparison.

Reference: "Atomistic Modeling of Thermodynamic Equilibrium and Polymorphism of Iron," *Journal of Physics: Condensed Matter* **24,** 225404 (2012). MST-8 researchers include Tongsik Lee, Steven Valone, and Michael Baskes (also University of California, San Diego), collaborating with J D Doll (Brown University). NNSA funded the work, which supports the Nuclear Deterrence mission area and the Information, Science, and Technology and Materials for the Future science pillars.

Technical contact: Tongsik Lee

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To submit news items or for more information,
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To read past issues, see www.lanl.gov/orgs/mst/mst_enews.shtml.

Los Alamos NATIONAL LABORATORY EST.1943

Celebrating service

Congratulations to the following MST Division employees celebrating a service anniversary recently:

Troy Nothwang, MST-16................................ 30 years
Mark Paffett, MST-6....................................... 30 years
Jason Lashley, MST-6 .... 20 years
Richard Salazar, MST-16................................ 15 years
David Dombrowski, MST-6 .... 10 years
James Foley, MST-6....................................... 10 years
Gail Roach, MST-7 .... 10 years
Douglas Safarik, MST-6.................................. 10 years

New small sample transport method proves successful

From left: Jeremy Mitchell, Franz Freibert, Paul Tobash (MST-16), Nyana Sanchez (RP-1), Manuel Chavez (MST-7), and Tom Venhaus (MST-16). First hand carry transfer from PF-4 to the NHMFL.

MST-16 has recently completed development of a new hand-carry method of transporting small, analytical samples of radioactive material between laboratories located along Pecos Road (TA-55, TA-50, and TA-35).

Until this process was approved, movement of containers with samples as small as a few hundred micrograms were required to be packaged in additional DOT-approved drums for over-the-road transport by OS-PT to the various laboratories located along Pecos Road. These laboratories, located within a few hundred yards of each other, include PF-4, the Target Fabrication Facility (TFF), and the National High Magnetic Field Laboratory (NHMFL). The hand-carry option provides scheduling flexibility, as well as a method for rapid sample transport for time-sensitive experiments. The process has also reduced the need for additional OS-PT vehicle entry into and exit from the TA-55 Protected Area for these small sample shipments.

The process has been exercised several times, and has proven itself as a viable option for sample transport. The form, quantity, and isotope of radioactive material that is approved for hand carry is ultimately determined by the Facility Safety Plan, the Material-At-Risk (MAR) inventory, and the specific radiological authorizations of the receiving facility.

The hand-carry option provides scheduling flexibility, as well as a method for rapid sample transport for time-sensitive experiments . . . The process has been exercised several times, and has proven itself as a viable option for sample transport.

This approach was a logical one, as these controls are in place and apply to an OS-PT shipment as well.

The development of this hand-carry Integrated Work Document (IWD) allowing safe, secure, and efficient transport of containerized material was a year-long effort, led by Tom Venhaus (Nuclear Materials Science, MST-16), involving SO-2, SAFE-4, OS-PT, RP-1, SB-CS, MST-7, MST-16, NPI-7, NPI-2, the Nuclear Material Storage and Disposition Board, and FODs for both TA-35 and TA-55. This work was funded jointly by LDRD programs and the Gemini Project.

Technical Contact: Thomas Venhaus, MST-16

Remaining safety aware

Two recent events within the Directorate underscore the importance of remaining vigilant in making safety integral to Laboratory operations. For each, HPI (Human Performance Initiative) Learning Teams were assembled. Thanks go to these members who spent much time and effort to produce valuable feedback, which is summarized and shared here.

In the first instance, an MPA-11 graduate student worker received minor splashing to the forehead and wrist from a 10% concentration of sodium hydroxide (NaOH) after failing to open an exit valve on an experiment. The resulting pressure build up caused a rubber stopper to pop off and discharge the chemical. After flushing face and eyes at an eyewash, the worker was transported to Occupational Medicine, ultimately being referred to an eye specialist for further evaluation of the minor injury.

The biggest contributing factor to this event was scope being added to an experiment (adding a NaOH bubbler/scrubber) and insufficient attention being paid to the new hazard and associated controls. This was an unusual experiment for this team in that a hazardous chemical (NaOH) was being used in the measurement lab, instead of the chemistry lab.

Main lessons learned from this event:

- Be aware of scope creep. Implement an experimental review process using a graded approach when experimental changes are made in R&D work, including consideration of the degree of thought required in planning the next experiment.
- Wear safety glasses or goggles as required; order prescription safety glasses if necessary.
- Explore/encourage the use of experimental plans/planning meetings to bridge the gap between IWDs (integrated work documents) and actual R&D work.

In the second instance, a hose on a subsystem of Physics Division's vertical shock tube burst while it was being tested after changes to a subsystem. Workers were wearing hearing protection per the recommendation in the IWD; however, adjacent workers were not, and the resulting noise was significant enough to cause two workers to go to occupational medicine. No one withstood permanent hearing loss.

A review of the event revealed that while the Pressure Safety Officer had inspected and approved the air subsystem change, a further modification was made–the addition of a nozzle to the system–afterwards, without a further PSO inspection. It was this nozzle that allowed pressure to build and overpressurize the hose past its rating.

Main lessons learned from this event:

- If you share space with multiple operations owned by different groups–as was the case here–ask the owner of the space to provide updates about activities, hazards, and details on what constitutes normal vs. off-normal events.
- Understand the formality of operations and follow change control processes.
- Know who your safety officers (pressure, electrical, and laser) are and what changes in work warrant an inspection.
- Ensure all components in a pressure system are rated to the highest achievable pressure in the system.
- Understand what constitutes an off-normal event and how to react to one, e.g., stop work and notify the PIC (person-in-charge) and/or group office.

HeadsUP!

Good housekeeping equals good safety

In this season of spring cleaning, the Target Fabrication Facility (TFF) has a success story to share.

Last year, TFF residents, which includes members of Polymers & Coatings (MST-7), began a massive cleanup effort in their 85,000-square-foot facility. In addition to recycling 15 tons of metal and 2 tons of wood, the group eliminated 170 boxes of documents, downsized from 45 to 9 safes, and sent 250 notebooks to Records Management. A new chemical stock room, where 3,000 chemicals were consolidated, reduces the number of chemicals needed to be ordered and promotes sharing common resources with other facilities.

In the process the residents changed the culture so excess materials won't pile up again. The group has restored a sense of pride in time for the TFF's 30th anniversary and set an example of how to Clean the Past, Control the Present, and Create a Sustainable Future, three long-term Laboratory Environmental Management System Environmental Stewardship & Sustainable Strategy goals in the FY13 Site Sustainability Plan.

Commonly used chemical supplies are now consolidated in a well-organized stock room.

In recognition of their efforts, the "TFF 30th Anniversary Housekeeping Initiative" received a Silver Award in the Change Agents category for the Laboratory's 2013 Pollution Prevention Awards.