Engineering News

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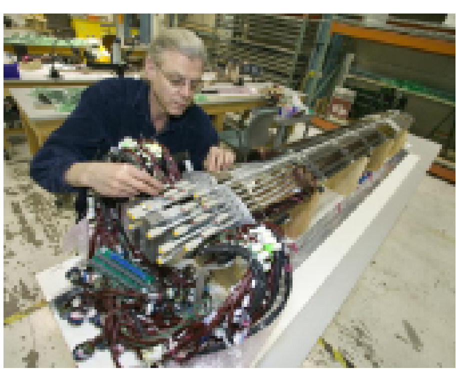
BERKELEY LAB ENGINEERING DIVISION

ADVANCING SCIENTIFIC DISCOVERY: DESIGNING AND BUILDING SCIENTIFIC APPARATUS

Can great scientific research exist without great scientific equipment? Ask any scientist on the Hill that question, and you'll probably get a puzzled look, because they all know that scientific breakthroughs go hand-in-hand with cutting-edge equipment, much of it custom-made at the Lab by engineers and craftsmen in the Engineering Division's Fabrication Shops.

Located in Building 77, the Fabrication Shops have been in existence almost as long as Berkeley Lab itself, and have grown with the Lab to include a truly comprehensive set of skills. Today, the Fabrication Shops provide traditional, numerically controlled, and electron discharge machining as well as optics, vacuum coating, vacuum brazing, photo fabrication, silk screening, nickel plating, anodizing, welding, R&D sheet-metal work, specialty assembly, and metrology. This broad range of capabilities, along with onsite accessibility and unmatched engineering and technical experience, makes the Fabrication Shops the builders of choice for many Berkeley Lab researchers.



Rodney Post working on a prototype of a 90-degree service corder panel for ATLAS.

Where quality and innovation are required, it is often difficult to work with a private-sector engineering and fabrication contractor. In contrast, the Fabrication Shops are equipped to provide cost-effective and prompt support for Berkeley Lab's research goals. Being on site means the Shops can offer real-time design and assembly, unique materials and processes, specialized fabrication services, and direct communication with the people who actually perform the engineering, fabrication, and research work.

For example, Andy Wolski of the Accelerator and Fusion Research Division (AFRD) relied on Daniel Lee, who heads the Vacuum Coating Shop, to produce multiple, precise test samples of materials with low secondary electron yield for work on the International Linear Collider (ILC). As Wolski explained, "One of the problems we anticipate is the electron cloud instability. One way to kill this effect is to coat the inside of the [vacuum] chamber with a material that doesn't release 'secondaries' when electrons hit it."

Having Lee's shop on site has proven invaluable in providing precision samples to Wolski's group, who compared the effectiveness of coatings such as titanium nitride and titanium vanadium zirconium with a variety of compositions, thicknesses, and roughnesses. "We needed [aluminum substrate] samples of coatings with various parameters and various thicknesses," explained Wolski. "A rough surface could have a lower secondary yield, but for other reasons we want to produce a smooth surface. These samples we produced at the Lab were measured with our collaborators at the Stanford Linear Accelerator Center to see how they performed."

In addition, Lee adapted a deposition process called magnetron sputtering to produce coatings on a large scale, which will come in handy when it's time to build the 6-km-long vacuum chamber for the ILC's positron damping ring.

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Q: Kem, Engineering has been going through some changes in the last few years, and one of those was triggered by changes in program and project requirements in the ALS and General Sciences. How has this affected Engineering's approach to project planning?

Kem Robinson (KR): In an attempt to reach a stable level of staffing, we adopted a rigorous approach to interacting with the division management of scientific divisions with whom we partner, which are principally the ALS and General Sciences, and also Life Sciences and the Joint Genome Institute. Two years ago, we were able to reach equilibrium; this means that even though AFRD, Physics, Nuclear Science, and the ALS all went through a Reduction in Force (RIF) last year, Engineering did not need to go through a RIF. Instead, we were actually able to achieve stability in our workforce staffing, and we're back in a period of targeted growth for those positions requiring unique skills, knowledge, and abilities not available in the programs or projects.

The Physics Division's involvement with the Daya Bay Reactor Neutrino Experiment has been picking up, and we're expecting some amount of funding during fiscal year 2007. We have engaged an engineer skilled in scientific project management on this project, and LBNL will be the lead institution.

Some very exciting activities have been taking place for the Sanford Underground Scientific and Engineering Laboratory at Homestake [formerly known as the Deep Underground Scientific Engineering Laboratory at Homestake]. There's a banker in South Dakota who has donated $70 million toward this project. The State of South Dakota itself has put in $40 million towards this project. So we're talking about a state with a population the size of Oakland that has assembled $110 million for this laboratory. Berkeley has been teaming with South Dakota in this endeavor for a number of years, and the planning is finally coming forward. This will be quite a large activity; it's a very important activity for a number of scientific areas including nuclear physics, high-energy physics, and earth sciences.

Q: What changes have you made to make sure the Engineering Division workforce continues to get the resources they need to do their job well?

KR: That's always a challenge. Director Steve Chu has published his support for the continuing growth of the Engineering Division. Director Chu recognizes the value our Division adds to scientific discovery, and remains committed to targeted institutional investments. This is allowing us to make sure we have the tools and infrastructure necessary to be successful. For example, if group leaders have identified areas that require growth or change in order for Engineering to grow with the Lab, we'll find the resources to address that need. Recently, vacuum deposition has been identified as a specific area to improve Engineering's capabilities and to make us more applicable to work being done at the Molecular Foundry, so we have to find the resources to do that. We try to do things as close to the state-of-the-art as possible.

Q: Has the DOE Office of Science (SC) had much of a role in Engineering's technology direction and choices?

KR: Certainly the Office of Science is familiar with us. Whether they have a direct impact on which capabilities we choose is less obvious. But SC is certainly aware of the Engineering Division at Berkeley Lab. As a result of that knowledge and the role that we play here at the Laboratory, I was asked to brief the Office of Science Director Ray Orbach on issues specifically associated with the Engineering workforce.

Q: Is Engineering's role in the physical sciences more recognized today than it has in previous years?

KR: I think that people have understood it, but they haven't always paid attention to what's implied by it. Up until recently, and very much even now, there's a very strong desire in many laboratories

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SAFETY CORNER

How Can I Take Responsibility for Working Safely?

The SAFETY CORNER is designed to promote awareness of safe work practices for employees of the Engineering Division.

Team Players: A Safety Case Study

It's a sunny summer afternoon when a piece of equipment arrives at the loading dock. A small group of employees has been asked to uncrate the apparatus and move it into the building. It is clear the equipment weighs hundreds of pounds and is quite large in addition to being clearly marked with its weight and dimensions in metric units.

Soon, a forklift operator lifts the crate over the loading dock and holds it at the same height as a receiving table. Staff members who had been expecting the equipment gather their colleagues to remove the large apparatus from the crate and place it on the receiving table.

After the employees removed the top and front panel of the crate, they attempt to move the equipment out of the crate and onto the receiving table, inch by inch, using only their combined "muscle power."

The majority of the group had performed a very similar task just six months before.

In the process of grabbing and pulling around the remaining crate sides, one of the five employees involved in the move stretches across the receiving table to grasp and tug on the equipment. As the employee did so, a muscle injury (strain) was suffered. The work continued until the equipment was on the table and moved into the adjoining lab. Because of the injury, the employee was unable to return to work the next day.

If you were part of this small group, exactly how would you approach and accomplish this task?

Lessons Learned: An Integrated Safety Management (ISM) Approach

1. What will I be doing? (Define work.)
2. Do I know what the hazards are? (Analyze hazards.)
3. Do I have everything I need to do the job safely: training, tools, time, and authorization? (Develop controls.)
4. Am I doing the job safely? (Perform work.)
5. What can we do better? (Obtain feedback and improve.)

These questions are part of the Engineering ISM checklist and badge card created to help you perform your work safely.

According to LBNL employees who use ISM to perform their work, this task as well as all tasks performed at Berkeley Lab are best approached by asking and answering the five simple questions noted above.

The workers involved in this case study are good employees. They worked as a team, with everyone contributing to the main goal, which was to uncrate the heavy piece of equipment and get it inside the building by the end of the day.

But an injury occurred in the process of meeting this goal. Could this injury have been avoided? Is there a tool the employees could have used to identify a better way to accomplish the task safely?

Injuries such as back strain can be prevented when employees, supervisors, matrix supervisors, and line managers make an intentional choice to use ISM.

Following ISM prevents past "luck" from influencing a safe, or unsafe, outcome. Employees do not have to rely on probability by saying, "It went OK six months ago." Employees have at least five questions that, if regularly asked and answered, will help promote safe outcomes each and every time.

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Intervention Averts Possible Accident

Recently, Wayne Greenway of the Engineering Division helped avoid a possible accident when he asked a contractor to stop working in an unsafe manner. The contractor was working approximately 15 feet above the ground with no fall protection on a crane that wasn't locked out at Building 58. If the crane had been inadvertently activated, the contractor could have been hit by the crane's wheels or pushed off the girder by the moving bridge. After assessing the hazards — working without fall protection on an active crane — Greenway told the contractor to stop work immediately. The incident reveals how the Lab's culture of safety, and specifically the notion that safety is everyone's responsibility, helps avoid accidents and makes the Lab a safer place.

[Note: This article first appeared in Today at Berkeley Lab, 9/26/06]

Engineering's Partnership with Science

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to try to acquire all their staffing for all their needs, for a large project, exclusively within that same project. This gives rise to very large fluctuations in workforce volatility, which has the downside of actually diminishing the ability to recruit and retain the best workforce and keep them at the state-of-the-art, because large fluctuations tend to be very disruptive. We're looking at ways to get a better use of our resources and people through expanded training and multiple assignments to broaden and deepen skill sets.

DOE has acknowledged that any of the large projects coming in have to be collaborative projects, simply because they're just too big and too spread apart to merit new staffing, and once a project ends, you'd have to remove staff and capabilities, which can be very inefficient, and is not cost-effective.

Q: What would you like the Lab community to know about the Engineering Division and how it adds value to the scientific community?

KR: The Engineering Division's mission is one to provide help in the development of scientific apparatus, and our technical and engineering capabilities are such that many times we can help greatly improve the design of a scientific apparatus that forms part of a research program. We've recently received a laudatory email from a scientific research partner who was quite ecstatic by the level of support and help we were able to provide him.

One recent successful Engineering–scientific division collaboration that has received a lot of press involved Carl Haber, of the Physics Division, who recently received an R&D 100 award in 2005 for his work on the Berkeley Lab Optical Sound Restoration System. That whole process had actually been realized with the Engineering Division through Jian Jin's Instrumentation group, which was involved in building and designing prototypes, and making the devices operational.

SAFETY CORNER

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There is an added benefit. When asking and answering the five simple ISM questions, it is possible that new questions will arise that will help get the job done without injury. Some of the new questions could include the following:

- What work, step by step, will I be doing?
- What work will I be assigning?
- When my direct reports are matrixed to other organizations, what work am I permitting my employees to do?
- What are the hazards?
- How do I eliminate or control the hazard to achieve zero injury?
- Do I (or my employees) have everything needed to do the job safely?
- Am I qualified to do this work?
- Is my required safety training current?
- When the job/task/project is complete, how do I solicit or offer feedback for the sake of improving how work is done in the future?

It is a "culture shift" to make a choice and intentionally ask the five ISM questions. However, the need for such a culture shift becomes obvious when considering this sobering fact: For every 60 near misses, there is one minor injury; for every 60 minor injuries, there's one major injury; and for every 60 major injuries, there is one fatality.

Because many staff assignments alternate between projects, programs, and divisions, the need to eliminate the "1 in 60" incident from occurring becomes a matter of life and health.

To help protect Engineering employees from workplace injuries, no matter where they are at the Lab, Division Director Kem Robinson expects Engineering employees to recognize their role in taking responsibility for their safety by asking the five ISM questions as part of their decision-making process before they begin their work.

The choice to not use ISM represents an intentional decision to invite/risk injury, and a prescription for the "1 in 60" incident to occur much sooner rather than later.

Attending regular safety meetings, keeping your safety training (JHQ) current, participating in safety walk-a-rounds, and asking the five ISM questions are all choices and decisions you can make to accept responsibility for working safely. It is the best means to assure that you always go home the same way you arrived — healthy and uninjured.

Advancing Scientific Discovery

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It's not uncommon for the Fabrication Shops to capitalize on its broad range of capabilities to advance a project. Lee can turn to the Optics Shop, headed by Rodney Post, to clean or polish a material such as a glass ceramic composite before he vacuum-coats it with layers of chromium and gold films. According to Post, the Optics Shop polishes crystals and hard and soft metals to "finishes that are far beyond your average hubcap."

Post can also take a commercially made surface material such as a prism and customize it to the specifications of each researcher. Requests have included drilling 1-mm holes through the material, grinding very fine grooves into it, changing an angle, and making precision knife edges out of tungsten carbide for the ALS beams.

A versatile technician, Post has been working almost full-time on the ATLAS detector for the Large Hadron Collider, a particle accelerator that's being built in Switzerland at CERN, the world's largest particle physics center. Murdock Gilchriese, of the Physics Division, says Post has been instrumental in the ATLAS project. Along with others from the Engineering Division, Post assembled the numerous parts that make up the 20-foot-long ATLAS pixel support structure.

Post is still working on the final assembly, a challenging task that involves placing all cooling heat exchangers and electrical connections onto the support structure, which has clearances of a fraction of an inch. Post has also figured out how to construct and assemble custom heat exchangers for the ATLAS pixel cooling system. "Rodney played a very important role in making sure the parts fit together to meet very tight tolerances," says Gilchriese.

Daniel Lee checking vacuum system base pressure (in Tank 8) prior to thin film deposition.

In the Photofabrication and Silk Screening Shop, Rudy Bartolo can make customized parts on a very short notice for scientists such as Al McInturff, a senior physicist from AFRD. Bartolo has helped McInturff's group on nearly all of the Lab's high-field magnet programs. For magnets like the RD3B and D20, a set of world-record high-field devices, Bartolo made photo etchings, using polyimide (Kapton®) film and type 304 stainless steel material, for the protection heaters and voltage tap circuits. After applying the photosensitive resist to the magnet's surface, he exposes the coating to the pattern for the heater and voltage systems. Bartolo then uses a chemical (etch) milling process to leave the stainless steel in the desired pattern. Photoetching stainless steel into a pattern on the Kapton® insulates the magnet, and controls its energy flow transition from the superconducting state.

"I can give Rudy a CAD drawing, and in return I get a working toy to put on a device," says McInturff. "It's just short of an art form to do that etching properly. And the fact that we can sit down with Rudy on site is invaluable to the unique demands of each project. Unlike the outside world, our production demands are not repetitive. Each etching is one or very few of a kind."

Fabrication Shops typically clean their materials at the Ultra High Vacuum Cleaning (UHVC) Facility and newly revived Plating Facility, also located in Building 77, before they are etched, polished, or vacuum coated or brazed. The 10-year-old UHVC can run as many as eight operations at once. While Fabrication Shops use the UHVC and Plating Facility's tanks to clean their materials, anyone at the Lab can submit a job to the Facility. "We get anything from cleaning, stripping, to plating. We like to look at the part to come up with the best procedure, and then give [our customers] an estimate. We ask customers, How clean or how much plating do [you] want? What material is it made of? When's the due date? Each operation could go through eight different tanks, or up to 14 tanks to clean and plate," says Guy Pulsifer, Supervisor of the Fabrication Shops.

Locating these specialty Fabrication Shops to Building 77 has made it easier for the Engineering Division to support scientists on the Hill, but that's only one of several steps Engineering has taken to advance their design, engineering, fabrication, and assembly services for both the present and the long term.

Explains Pulsifer, "We want to build for the future. Everything we're doing is to make things better for the Lab."