NLCTA OPERATIONS
SAFETY AUDIT REPORT 2001

SUMMARY

The audit committee found the NLCTA operations staff very aware of safety and that they managed safety issues with an appropriate level of attention in all areas reviewed. All of the NLCTA staff have extensive experience with accelerator operation and are extremely capable. The committee was impressed with the presentations given by NLCTA personnel and discussions with them. The NLCTA, being an accelerator research facility, is a continuously changing facility. We reviewed the operation in its present configuration. Planning for future changes, such as the eight-pack test are in an early stage and not reviewed in any detail by the committee. The audit findings and minor concerns are listed below:

Findings:

1. There is insufficient documentation of line responsibility for safety and requirements for training.

Minor Concerns:

1. There appears to be no documentation of the Safety Overview Committee's review of the change in operation to unattended testing of high power rf, which is a modification from the approved SAD.
2. Although documented radiation surveys have demonstrated that the shielding is sufficient for the current operations, there is insufficient documentation that the shielding is adequate for planned future operations within the parameters of the SAD.
3. The BSOIC alarm response procedure should be updated to make first action to verify proper operation of shutoffs and determine source of the trip.
4. There are a number of lead-plywood boxes on top of the tunnel structure, which begins to be a combustible fire load if the number of these increase.
5. Spill Control for Modulator Oil and Low-Conductivity Water may exceed containment.
6. Potential activation of fluorescent lights in the NLCTA tunnel.
7. The relationship between the SHA liaison to NLCTA and NLCTA staff should be enhanced and strengthened to improve communication and safety.
8. Atypical use of cryogens in the NLCTA beam enclosure should be reviewed by the SHA department in advance of work.
9. Safety considerations for low average power pulse microwave transmissions should be studied by NLCTA operations and the Klystron Department.
10. NLCTA klystrons and waveguides need to be secured better to prevent damage during an earthquake.

11. Emergency contact information needs a wider and more systematic distribution.
12. Existing vacuum ion pump power supplies are not arc-suppressing.

AUDIT PROCESS

The Chair of the Safety Overview Committee, Ken Moffeit requested this Accelerator Operations Safety Audit for NLCTA in Feb 2001. The purpose of the audit was to determine safety in the NLCTA facility in the following areas:

- Assessment of the facility's safety systems.
- Assessment of compliance with SLAC safety policies and procedures.
- Evaluation of safety training programs and records.
- Evaluation of conduct of operations.

The scope of the audit included the NLCTA accelerator housing and power components in End Station B and the adjacent control building. No lasers are used in NLCTA so laser safety was not considered in the review. The Audit Committee Members are listed below along with their areas of responsibility:

Stan Ecklund	Audit Committee Chair
Ken Kase	Radiation & Operations
Jack Fry	Electrical
Frank O'Neill	Fire
Saul Gold	Non-ionizing radiation
Joe Kenny	Occupational
Paul Miller	PPS
Scott DeBarger	Seismic, Pressure & Vacuum Vessel
Ali Farvid	Environmental
Rich Cellamare	Environmental

The audit activity consisted of tours of the NLCTA facility, review of relevant documents, discussions with NLCTA staff, mostly with Keith Jobe, the safety officer, discussions with relevant support staff, and a full day of presentations from NLCTA staff and supporting groups. The agenda of presenters and subjects covered are listed below:

Dave Burke	NLC Project, NLCTA Mission, Organization, Physics Goals
Marc Ross	Operational review, MAC Endorsement, Achievements (uptime, Safety, Control system), Staffing, Procedures control
Ralph Nelson	Radiation state, Safety systems (PPS, BCS)
Scott Anderson	8-pack project review, Engineering paradigm, Identify recognized issues
Keith Jobe	Safety oversight, Role of ADSO, Role of Research Division

Sandy Pierson	Crane, Research Division perspective
Robert Reek	Fire status
Mike Saleski	Procedures and their practice
Brad Youngman	Seismic buildings, Accelerator
John Krzaszczak	Lock and Tag, ELP, Tunnel hazards, DC hazards
Keith Jobe	Environmental, Occupational
Keith Jobe / Marc Ross	Other items, Follow-up questions

FINDINGS – DETAILED DESCRIPTION

FINDING #1: There is insufficient documentation of line responsibility for safety and requirements for training.

Recommended Action: Line responsibility for determining training requirements should be clearly specified. The training requirements for all personnel associated with the NLCTA should be reviewed and specified. Training records must be updated and maintained current. The Employee Training Assessment should be used to determine required safety training assuming it can be upgraded to include department specific training needs. Some of the department specific training may need to be satisfied by experience or course work other than ES&H training courses.

MINOR CONCERNS – DETAILED DESCRIPTION

1. There appears to be no documentation of the Safety Overview Committee's review of the change in operation to unattended testing of high power rf, which is a modification from the approved SAD. Of concern is an extension of the hazard evaluation for non-ionizing radiation. Although the committee does not expect there to be a increased hazard, the actions of the SOC should be documented including an updated statement of the non-ionizing radiation hazard.

2. Although documented radiation surveys have demonstrated that the shielding is sufficient for the current operations, there is insufficient documentation that the shielding is adequate for planned future operations within the parameters of the SAD. If existing radiation surveys are adequate, the information should be scaled to the maximum running conditions permitted by the SAD to demonstrate the adequacy of the shielding as installed. If additional measurements are needed to do this, they should be scheduled before beam operations are extended beyond those already measured. The results of this analysis should be documented by the Radiation Physics Department.

3. The BSOIC alarm response procedure should be updated. The first action in response to an alarm should not be to reset the alarm, but to verify proper operation of beam shutoffs. Then the source of the trip should be investigated.
4. The lead lined plywood boxes on top of the tunnel structure seem to be multiplying. There are 9 such boxes and likely to be of order 18 with the coming 8-pack installation. This begins to be enough of a combustible load to cause concern. A simple solution might be to paint the boxes inside and out with a fire retardant paint.
5. Spill Control for Modulator Oil and Low-Conductivity Water may exceed containment. A number of control measures have been put in place to detect and alleviate potential spill of modulator oil. The concern is that while the containment is large enough for the inventory of oil, a coincident water leak could cause an overflow. A detailed discussion is given below in the "other comments" section. Additional review of the modulator secondary containment and spill countermeasures is desirable to assure that the NLCTA program will prevent oil and low-conductivity water spills from reaching the nearby storm drains. It is recommended that the Environmental Safety Citizen Committee further review this area to help provide a comprehensive review and recommendations to the NLC Program.
6. Potential activation of fluorescent lights in the NLCTA tunnel. It is recommended that NLCTA work with OHP to monitor radiation levels in the NLCTA tunnel see if the levels are sufficient to activate the fluorescent light components. It is likely that because of the small amount of actual beam running, that NLCTA is not a significant activation source compared to other areas at SLAC. The generation of a mixed (hazardous and radioactive) waste can be costly. While this may be an institutional issue, it seems that SLAC can take advantage of some knowledge gained from the operation of NLCTA to determine the measures needed to avoid the generation of mixed waste in the future.
7. The Safety, Health, and Assurance Department has an official liaison to the Next Linear Collider Project, but the specific involvement in NLCTA needs to be increased. For example, most occupational safety concerns are addressed in informal discussions between the NLCTA safety officer, the ESB building manager and the SH&A occupational specialist. The communication between SH&A and NLCTA should be improved. This could enhance the discovery of potential safety problems and finding workable solutions. The Safety, Health, and Assurance Department should review with NLCTA staff the needs for a liaison and the expectations on both sides. An active SH&A professional specifically as NLCTA liaison to would be salutary and is recommended.
8. Calculations performed soon after NLCTA commissioning showed that typical use of cryogens for leak checking in the beam enclosure did not depress airborne oxygen concentrations to unsafe levels. To prevent oxygen deficiency hazards, any atypical use of cryogens in the NLCTA beam enclosure should be reviewed

by the Safety Health, and Department as required in chapter 36, section 2.4 of the *SLAC ES&H Manual* before work begins.

9. NLCTA Operations and the Klystron Department should propose RF Analysis and Safety Considerations for: Low Average Power Pulsed Microwave Transmission Systems. It is proposed that this work be performed and approved by the first week in April of 2002.
10. NLCTA klystrons are not secured and could damage themselves or other equipment in the event of an earthquake. Likewise, RF waveguides within the NLCTA housing need better support to prevent damage during an earthquake. We recommend an engineering review and design of a proper seismic restraint for klystrons and waveguide within the housing.
11. Emergency contact information needs a wider and more systematic distribution. The broader issue of institutional dissemination of emergency contact information is also a concern. NLCTA poses a special challenge in that it is a small group with key members who are often absent from SLAC for extended periods. The specific concern could probably be managed by having an emergency pager or mobile phone which is given to the appropriate operator.
12. Existing vacuum ion pump power supplies are not arc-suppressing. A suitable arc-suppressing power supply exists and has been installed in the PEP-II machine. The danger is that of a fire started by an arc due to a cable failure. This is a site-wide issue, or maybe not a significant issue given that proper procedures are followed.

OTHER COMMENTS

OPERATIONS (K. Kase)

Comments: Evaluation of the NLCTA operations encompassed a review of several relevant documents, a tour of the facility and a discussion with the NLCTA Safety Officer, Keith Jobe. The documents reviewed included the Safety Assessment Document – Next Linear Collider Test Accelerator, 1996 (SAD) the NLCTA Operations Directives, April 9, 2001, the NLCTA Operator Safety Training Reference Manual, March 28, 2001, the NLCTA Operations Log, the PPS Log, the NLCTA Daily Inspection Checklist for Unattended Operation without Beam, the Weekly NLCTA Inspection and several recent Beam Authorization Sheets. Keith Jobe also provided a demonstration of the standard search and access control interlock check process.

With a few exceptions the NLCTA operational directives and procedures are complete and in order. Operations are conducted in accordance with those directives and procedures and within the limits set by the SAD and the Accelerator Safety Envelope (ASE). Plans for the next phase of operation, the 8-Pack System tests, include full safety reviews by all relevant Citizen Committees. The staff is to be commended for a well-run and safety-conscious organization.

RADIATION (K. Kase)

Evaluation of radiation safety at the NLCTA encompassed a review of the SAD and the subsequent communications from Radiation Physics regarding radiation surveys taken during operations, records of the routine radiation surveys made by Operational Health Physics, Radiation Safety Work Control Forms, and discussions with Keith Jobe (NLCTA) and Ralph Nelson (Radiation Physics). The radiation safety program for the NLCTA is excellent and is functioning well with good communications and cooperation among the NLCTA, Operational Health Physics and Radiation Physics staffs. Radiation measurements to evaluate the radiation conditions related to high power rf testing have been made and documented. The Radiation Safety Committee has reviewed the radiation safety impact of this change in operation and the operation is within the ASE.

ES&H (R. Cellamare)

The audit of NLCTA for environmental issues was based on the following information:

- Group visit to the facility on 11/7/01
- NLCTA Safety Audit 1.1 Background Document
- Presentations by NLC Program Staff and Supporting Contributors
- NLCTA Web Site
- Discussions with K. Jobe on 11/12 and 11/14/01
- Brief discussion with K. Stoddard, EPR, on 11/12/01 on Storm Drain Drawings and awareness of NLCTA current and future plans
- Brief discussion with Security at Sector 30 on ESB Alarm Response
- Brief discussion with S. Frey, OHP, on 11/14/01 on concern with the activation of fluorescent lights in NLCTA tunnel

In terms of Environmental Safety and Hazardous Materials, no findings were identified, two concerns. I believe the two above concerns (5 and 6) are institutional in scope but we mention them in this report so more consideration is given to such concerns in future projects, such as the addition of the eight-pack modulator system.

NLCTA has provided for spill control through the following measures:

- Secondary containment of mineral oil (about 2000 gallons) used as dielectric insulation in the pulse tanks of three modulators.
- A level sensor and alarm to signal the Sector 30 Gate if the oil liquid level rises beyond an inch or two in the secondary containment
- Periodic walkthroughs of the modulator area and associated controls area by Security to check for leaks (Review of Security Logs indicated walkthroughs about once every two hours.)
- Additional spill control measures include availability of a 55-gallon wet-dry vacuum and several hundred pounds of absorbent to clean up relatively small

spills as well as berming of tunnel access to prevent liquid from running down into subterranean tunnels in ESB.

NLCTA has developed a reasonable approach to the prevention of oil spills from the use and maintenance of the modulators. Some review is needed to determine if there oil or water leakages that can result in a tenuous cleanup effort or endangerment of spill to a nearby storm drain.

There is slow, minor leakage of oil from the primary containment system into the secondary one. This oil is periodically removed within less than 45 days to meet hazardous waste control requirements. The level of oil that accumulates in the secondary containment is monitored. Should it exceed a level of approximately an inch or so, an alarm is activated at the Sector 30 Gate and Security investigates the area and is instructed to contact the NLCTA emergency response persons and the MCC, and to explain the situation to EOIC. SEM emergency staff or appropriate staff may be called in to shutoff of the water system if needed.

Although the secondary containment is sufficient to contain the oil in the modulator, there is a chance (probability unknown) that low-conductivity water (LCW) used to cool modulator components and the oil system, can also leak into the secondary containment. Three potential modes of LCW leakage to the secondary containment while not expected to be common are possible based on operation experience of this or other systems; they are: (1) pinhole leakage of high strength polymer hoses carrying LCW to modulator components, (2) unexpected disconnection of hoses due to faulty connection, and (3) a leak of water from the oil-LCW heat exchanger, which is also in the secondary containment.

While the probability of these leak modes might be low or can be responded to in time before a spill becomes significant, the potential leak modes that would result in oil or LCW leakage should be reviewed to determine if sufficient response time or contingency in system design is available to deal with these leaks so that a spill does not result in a painstaking cleanup effort.

Because leakage of oil into the secondary containment is common, the occurrence of LCW leak provides the additional risk of carrying oil in the water spill. Based on the proximity of the spill and the depending on the quantity spilled, the most likely environmental hazard is a storm drain that is located south of the tunnel and southeast of the NLCTA entrance.

The ongoing effort to review secondary containment options by NLCTA for the eight-pack modulator is admirable.

Electrical (J. Fry)

Site Electrical Description: The NLCTA is an approximately 150 ft. long accelerator enclosed in a concrete shielding structure. The accelerator electrical components consist of a gun, focusing magnets, steering magnets, ion pumps, and klystrons and their related power supplies, control racks, and a control room. Additional components such as collimators, beam position monitors, fire alarm, communication equipment, PPS, etc. were not considered electrically hazardous. Power for all devices comes from outside the accelerator housing.

The gun operates at 150kv, low current. The various magnets operate at voltages ranging from intrinsically safe to hazardous, and some of those operating at intrinsically save voltages operate at high currents where flash is a concern. The klystrons operate at 50kv high current. The ion pumps operate at several thousand volts, at low current. Hazardous voltages are controlled by disconnects, and interlocks. The Personnel Protection System (PPS) disconnects the gun and radiation producing devices, but not hazardous voltages. Of particular note are the gun power supply, magnet power supplies operating at intrinsically hazardous voltages, and the klystron power supplies and modulator cabinets, both of which have multiple energy feeds.

The electrical portion of the audit was conducted by interviewing project management, interviewing Power Conversion personnel, visiting and touring the site with project management, reviewing NLCTA and Power Conversion safety electrical safety documents, and reference to construction safety monitoring of the project during actual construction.

Selected Safety Systems and Procedures:

1. Wiring system: The wiring system appears to meet applicable codes. Cabling enters the accelerator housing via trays. Intrinsically hazardous voltage connections are covered.
2. PPS disconnects hazards associated with production of radiation and the gun, but does not disconnect hazardous voltage equipment.
3. Modulator interlocks short and ground hazardous voltages.
4. Power Conversion is in the process of assuming accelerator power equipment maintenance and is developing Equipment Lockout Procedures (ELP) for all equipment to be serviced. In the meantime, SLAC and OSHA procedures are followed for all equipment. The schedule is to have validated ELPs for all equipment by April 2002.
5. Modulator cabinets are opened by NLCTA staff only when de-energized and locked out at the supply breaker per ELP. NLCTA's ELP does not require the disconnection of klystron heater supplies when servicing modulator cabinets. Power Conversion's ELP does call for heater supplies to be disconnected. The heater supplies operate at intrinsically safe voltages. The modulator cabinet is equipped with an interlock that discharges the delay line capacitors and shorts the line to ground. The condition of the interlock short-out device

is visible to personnel entering the cabinets. The modulator cabinets also contain a grounding hook for additional safety.

6. The gun is serviced when its power supply is locked out and the gun is grounded by a hook permanently attached to the housing ground and within easy reach of the gun.
7. Ion pumps may be disconnected at the connection without locking out their supply.
8. Magnet power supplies are disconnected at the supplying breaker.
9. Hazardous voltages within the accelerator housing are locked out by the use of eight breakers with a single key that is locked to a ring in the accelerator control room. Personnel working within the housing affix their locks to a group lock locking this key to the ring. Since there is only one key to the eight locks, the locking of the single key to a ring falls under the ambit of the "Master Lockbox" Lockout strategy of SLAC's Lock and Tag Program for the Control of hazardous Energy, SLAC doc. SLAC-I-730-0A10Z-001

Conclusions: As evidenced by interview and written documentation, NLCTA and Power Conversion management evidence a high level of commitment to OSHA, SLAC, and ISMS safety principles.

The NLCTA is a living experimental environment with constant changes being made as engineering upgrades to the machine are made. Given this state of continuous research and development, safety systems are also in a constant state of development. A research machine in a constant state of flux is hard pressed to achieve the same level of safety as a finely tuned production line in a manufacturing environment. However, given the commitment of NLCTA and Power Conversion management, close management familiarity with the machine, worker training and feedback, and the high levels of intelligence, training, and focus on the safety of the experimental environment, the existing electrical safety system, continuously and conscientiously applied by all workers in contact with the machine yields an environment as safe as or equal to a similar manufacturing environment, as evidenced by audit and safety record.

Reference Documents include: Safety Inspection Checklist , PPS Interlock Check, NLCTA Safety Audit 11/1/2001, Lock and Tag Program for the Control of Hazardous Energy, NLCTA Procedures and Practice, safety and its role in the NLCTA 11/09/2001, The 8-Pack Project 11/09/2001, NLCTA Operations 11/09/2001, Power Conversion Department 's Equipment Lock and Tag Procedures for Test Facilities Revision and Status Record as of 11/28/2001

Persons Interviewed: Keith Jobe, Wayne Linebarger

Occupational (Joe Kenny)

Safety, Health, and Assurance Department personnel have performed occupational safety inspections of the NLCTA beam enclosure, control room, and support facilities on occasion since the Accelerator began operation. These inspections uncovered no

violations, and a cursory inspection of the control room and support facilities on 22 October 2001 showed good compliance with 29 CFR 1910 Subparts D (Walking-Working Surfaces), E (Means of Egress), O (Machinery and Machine Guarding), and P (Hand and Portable Powered Tools and Other Hand-Held Equipment). The work platform, hazardous-material (with the exception of lead, which is well addressed), and compressed-gas hazards presented by the NLCTA are minimal or nonexistent.

Of some concern is the End Station B bridge crane, for which no documentation of testing or certification can be found. This testing, certification, and documentation, however, is the responsibility of the Site Engineering and Maintenance Department, which is addressing this site wide problem.

Non-ionizing radiation: (S. L. Gold)

The high power microwave energy system from the klystrons to the accelerator structure is contained in high vacuum waveguide. The vacuum system is interlocked at a level of 10^{-7} to 10^{-8} scale vacuum. A small leak (much less than would be required to radiate microwave energy) turns off the klystron. If a klystron is disconnected the waveguide must be capped with a full vacuum seal precluding microwave energy being fed back through the waveguide from the accelerator.

The low-level klystron drive system, through the TWTA (Traveling Wave Tube Amplifier) into the klystron does not follow the SAD. The SAD called for wiring of the waveguide flanges to ensure connection. This system proved to be cumbersome in an experimental set-up. Presently, I believe visual inspection of the driveline waveguide is performed prior to initial turn-on.

The medium power pulsed driveline for X-band is in WR90 waveguide, which is similar to what is used in the Klystron Department Test Lab. The power levels are also very similar in the two installations. On the main linac the driveline is S-Band and is fed to the klystrons through a coaxial system. A coaxial system is also used in the Test lab for its 5045 testing. The average levels do not appear to be severe with respect to the safe levels as required by ACGIH (American conference of Governmental Industrial Hygienists), which is the secondary standard used by SLAC. SLAC does not have a primary standard at this time.

NLCTA Operations and the Klystron Department will propose RF Analysis and Safety Considerations for: Low Average Power Pulsed Microwave Transmission Systems. It is proposed that this work be performed and approved by the first week in April of 2002.

Seismic, Pressure vessels, & Vacuum (S. DeBarger)

The End Station B building is currently under review for seismic upgrading.