Large-Scale Structures Laboratory (LSSL)

NEES@UNR

SITE SAFETY PLAN

University of Nevada, Reno

September 2011
### Revision History

<table>
<thead>
<tr>
<th>Revision #</th>
<th>Date</th>
<th>Description</th>
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<tr>
<td>0</td>
<td>7/20/2004</td>
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| 1          | 10/15/2008 | - Added multiple sections per Risk Consultants Inc. initial evaluation  
- Added reference to UNR - EH&S websites in some of the revised sections |
| 2          | 5/10/2009  | - Add a detailed Accident Analysis section  
- Added detailed Job hazard Analysis section  
- Added Blood Borne Pathogens section  
- Add revision history |
| 2.1        | 6/28/2010  | Added details on working in confined space |
| 2.5        | 9/26/2011  | Added details on compressed gas  
Added hand tools section  
Added Appendix E: proper use of hand tools |
EMERGENCY PHONE NUMBERS and QUICK REFERENCE GUIDE

<table>
<thead>
<tr>
<th>Emergency Number</th>
<th>9-911 (on-campus)</th>
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<tr>
<td>Non-emergency service calls for Reno Police</td>
<td>(775) 334-2121</td>
</tr>
<tr>
<td>University Police</td>
<td>(775) 334-COPS [2677]</td>
</tr>
<tr>
<td>University Police Main Office (Non-Emergency)</td>
<td>(775) 784-4013</td>
</tr>
<tr>
<td>Reno Police Department - Non-Emergency Dispatch:</td>
<td>Office Hours: 8 a.m. to 5 p.m.</td>
</tr>
<tr>
<td>Sparks Police - Non-Emergency Dispatch:</td>
<td>(775) 334-2121</td>
</tr>
<tr>
<td>Student Heath Center</td>
<td>(775) 784-6598</td>
</tr>
<tr>
<td>Environmental Health &amp; Safety (EH&amp;S): For support related to urgent events involving lab materials or environmental releases call</td>
<td>(775) 327-5040</td>
</tr>
<tr>
<td>Facilities Services: Broken pipes, hazards, etc. Staff on-call evenings and weekends</td>
<td>- (775) 784-8020</td>
</tr>
</tbody>
</table>

Working in the LSSL is a potentially hazardous experience. With the right precautions, it is possible to manage hazards and avoid injuries. It is the responsibility of the user to:

- Inform coworkers/staff when performing hazardous tasks and assist them in gathering the necessary protective equipment if they are to remain in the work area;
- Secure the work area to prevent any injury to visitors, observers or tour groups; and
- Keep visitors a safe distance from the work area.

Upon your arrival to your jobsite in the LSSL:
- STOP: assess your surroundings;
- LOOK: for hazards and hazard conditions;
- LISTEN: investigate sounds that are not typical to your jobsite.

Always ask: “Where are the danger zones?” and “Is this the safest way to do this?”

We often create unique and often one-of-a-kind situations, therefore, the dangers we are exposed to are not uniform. Always question your assumptions.

1. Try to eliminate risk/hazard
2. Use safeguarding applications
3. Use signage to warn others
4. Perform safety training
5. Use personal protection

A. In Case of an Injury

A primary purpose of this plan is to provide information on how to avoid injuries. However, if an injury should occur in the Large-Scale Structures Laboratory (LSSL):

1) First Aid kits are available just outside the LSSL Control Room.

2) An emergency eye wash kit is available just outside the LSSL Control Room.
3) Utilize the following Emergency Response
If an employee is injured or ill from a work-related accident and the employee or the active supervisor in the LSSL believes that the condition needs emergency medical treatment, immediately call 911. Always err on the side of caution. If there is any question about the severity of an injury, call 911. If an employee wants 911 called even though the injury may not appear serious, make the call.
If immediate or urgent care is needed, it is suggested that the injured person go to the Specialty Health Clinic. It is located at 350 West Sixth Street, Suite 2D in Reno, which is across the street from St. Mary’s Hospital. They do not need an appointment to access medical care at the Specialty Health Clinic. The injured person should tell that they are an employee of the university system. They will have the injured person complete a form necessary to initiate the workers’ compensation claim. The Specialty Health Clinic is open from Monday through Friday from 8-5. If care is needed after hours or it is an emergency, the injured person can go to any hospital including Renown, St. Mary’s or Northern Nevada Regional.

4) Urgent Care
If the employee needs immediate medical treatment, but it is not a medical emergency, arrange to transport the employee to the nearest urgent care facility. If the injury is minor and only requires first aid treatment, provide first aid. The employee has a right to seek medical treatment if they wish. If the employee declines medical treatment, and the active supervisor in the LSSL strongly feels that medical treatment is necessary, the supervisor may direct the employee to obtain medical treatment.

5) Reporting
Report the injury to acting LSSL supervisor as soon as possible and complete a C-1 form (Notice of Injury or Occupational Disease). The form is available in Lab Manager’s office. Have the acting supervisor review and sign the C-1 form and fax it to the BCN Workers' Compensation Office. The form DOES NOT need to be filled out before seeking medical attention.

B. In Case of Chemical Spill
1) Small spills that do not immediately threaten waterways, wildlife, or humans, should be contained by LSSL staff. A spill of a known substance that can be wiped up with one rag or paper towel is ok to handle on your own. For anything bigger call your supervisor. No chemical waste (including oily rags) can go in the trash or sink.
2) Larger spills should be viewed with caution. Take care to warn others in the immediate area of the danger. Contain the spill, if possible, using spill absorbent pads, booms and granular oil absorbent particulates stored in a blue bin down stairs and call the appropriate number listed above.
For further information refer to the “Spill prevention & emergency provision plan” Specific guidance on chemical and radiological hazards can be found in the UNR Chemical Hygiene Plan and UNR Radiation Safety Manual, respectively. Copies of these manuals are available in the LSSL Control Room.
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Management Commitment to Safety

As Director I confirm the commitment of the Large-Scale Structures Laboratory to the safety, health and well-being of all personnel including faculty, staff, students, and visitors, working in, or visiting the Laboratory. This commitment is in accordance with the campus-wide safety policies of the University of Nevada Reno an excerpt of which is reproduced below:

“*It is a goal of the University of Nevada, Reno, to ensure safe and healthy learning, research, work entertainment, and student living environments for faculty, staff, students and visitors. In support of this policy, the University gives high administrative priority, applies appropriate financial support, and provides professional expertise in the ongoing effort to eliminate or reduce facility and operational hazards that could threaten the health and safety of persons, property or the environment. Along with the highest quality of teaching, research and community service, safety of individuals and protection of the environment are core values of this institution.*”

Ian Buckle  
Professor and Director, Large-Scale Structures Laboratory
I - Administrative Safety Plan Elements

1. INTRODUCTION

The Large Scale Structures Laboratory (LSSL) at the University of Nevada, Reno (UNR) includes three biaxial, multiple-shake-tables and one 6 Degree-of-Freedom shake table which are suitable for conducting research on long, spatially distributed, structural and geotechnical systems. The facility is also capable of testing conventional structural and non-structural systems by using the tables in large-table-mode, and operating them as a single unit. The laboratory also includes a large number if independent actuators that are capable of testing a large array of experimental configurations of various loading conditions. The University of Nevada, Reno – NEES Shake-Table Equipment site is funded in part by the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) Program of the National Science Foundation under Award Number CMS-0086624.

A Laboratory User is any person working in the Lab on a research project or service-to-industry project. It also includes any contractor who may be in the Lab servicing or installing equipment. All Users have a responsibility to know and follow the rules and procedures provided in this document.

In this document the term “Laboratory Personnel” and “Safety Staff” refers to the following people:

- Laboratory Director, Ian Buckle (Office is SEM 111)
- NEES Site Co-PI, David Sanders (Office is SEM 110)
- NEES Site Operations Manager, Sherif Elfass (Office is SEM 124C)
- Senior Laboratory Manager and Safety Officer, Patrick Laplace (Office is HREL 105A)
- Research Engineer, Robert Nelson (Office is HREL 105B); and
- Development Technicians include Chad Lyttle and Todd Lyttle (Office is HREL 105B)

The document also refers to the Active Supervisor. In general, this will be Patrick Laplace. If Patrick Laplace is not available then progression of responsibility will be Robert Nelson, then Chad Lyttle, then Todd Lyttle then Sherif Elfass, then Ian Buckle and then David Sanders. The first available person on the list must be contacted in case of an incident or inspection. In all cases, Site Operations Manager, Sherif Elfass, should be contacted and notified.

2. LABORATORY HOURS

Laboratory hours are 7:30 am to 4:30 pm, Monday through Friday, except official university holidays. All work is to stop at 4:00 pm to allow ample time for cleanup. Any user wishing to work after hours, on weekends, or official holidays, must check out a key and get all work pre-
approved by Lab Personnel. There must always be more than one person working in the Lab at all times, including after hours, unless the activity has been designated 'low risk' by Lab Personnel.

3. SAFETY STATEMENT

The Large Scale Structures Laboratory (LSSL) is a unique work environment with multiple hazards. Laboratory safety has traditionally been synonymous with chemical safety; however, true laboratory safety is achieved only when all hazards in the laboratory environment are considered. Laboratory safety is much more than a written safety manual and regulations; it is a daily work philosophy that is incorporated into all laboratory activities. Laboratory safety entails identifying and understanding the hazards present in the laboratory, assessing risks associated with those hazards, managing risk through the use of safe work practices and preplanning emergency response actions.

The University of Nevada, Reno requires all university personnel including faculty, staff, students and visitors to follow safe working procedures. The UNR Office of Environmental, Health and Safety (EH&S) is the department principally responsible for assisting in the implementation of University workplace health and safety principles and policies.

**All NEES@UNR personnel are required to comply with UNR EH&S policies and regulations.** In addition to the policies and regulations set forth by UNR EH&S, the NEES@UNR Site Safety Plan has been developed to manage laboratory risks so as to permit cutting edge laboratory research while ensuring the health and safety of personnel (including faculty, staff, student, contract employees and visitors). The NEES@UNR Safety Plan is intended to establish a framework for identifying and mitigating workplace hazards, while addressing legal requirements for a formal, written Injury and Illness Prevention Program.

This Safety Plan was developed for students, faculty, staff and/or visitors using the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) facility at the University of Nevada, Reno (NEES@UNR). This plan is intended to be a supplement to the UNR EH&S Handbook for all users of NEES@UNR lab facilities. Note that prior to engaging in any activities involving NEES@UNR resources, users must complete a safety orientation session provided by LSSL staff in addition to review of this Safety Plan. In addition, users must sign a form verifying that they have received the safety orientation and understood the material contained in the safety documents. All safety documents are available on line at [http://nees.unr.edu](http://nees.unr.edu). Hard copies of the safety documents and the signed forms will be kept on site in the office of the Lab Manager/Site Safety Officer (HREL 105A).
4. STATEMENT OF RESPONSIBILITY

4.1. Site Safety Officer
The Safety Officer has the primary authority and responsibility to develop and ensure implementation of a safety plan to ensure the health and safety of the faculty, staff, students, and other visitors to the NEES@UNR Site. This is accomplished by performing the following tasks:

- Analyze work procedures to identify potential hazards and then implement measures to eliminate or control those hazards.
- Communicate work place hazards and safety policies to employees and visitors.
- Establish and enforce safe operating procedures for job tasks.
- Ensure that Material Safety Data Sheets (MSDS) are present for chemicals used in the department.
- Provide proper safety equipment and personal protective equipment to employees.
- Report work-related fires, accidents, injuries, near accidents, illnesses, property damage, and unusual occurrences to both EH&S and the Office of Insurance & Risk Management.
- Encourage prompt reporting of health and safety problems without fear of reprisal.
- Serve as a liaison with EH&S and other campus safety resources on issues the department cannot resolve
- Maintain copies of safety briefing minutes and other safety-related records
- Review self-audits conducted using the NEES@UNR Safety Self-Audit Checklist on an annual basis to assess both compliance with, and effectiveness of the NEES@UNR Safety Plan.

4.2. All Employees, Visitors and Guests
Every employee, student, or other person authorized to conduct NEES@UNR activities has the responsibility to comply with all University EH&S and LSSL policies, rules and procedures. These responsibilities include:

1) All safety, health, rules, policies, regulations, procedures and directions will be followed
2) All hazardous conditions will be reported to facility staff
3) Protective equipment will be worn as required
4) No personnel will operate equipment or conduct any procedure without proper training and authorization
5) All job related injuries or illnesses are to be promptly reported to facility staff. Prompt and appropriate medical treatment will be sought.

4.3. Rights of Laboratory Personnel
Lab Personnel have the right to stop, alter, or refuse any task or operation of any piece of equipment that is being performed by any Lab User.
5. LABORATORY VISITORS

All visitors must be accompanied by a University host such as a member of the University Administration, Deans Office, Engineering Faculty, Mackay School of Mines, Seismology Laboratory, and Nevada Bureau of Mines. Active research students may also act as hosts. Advance notice of any visit should be given to Lab Personnel, whenever possible. Host must notify Lab Personnel as soon as visit begins. Visitors are not recommended in the basement and only with the express approval of Lab Personnel on each occasion. Keep visitors away from congested areas, especially on test days. Advise visitors of all safety hazards in the Lab. There is no limit to the overall size of a group, but for safety reasons and because the acoustics in the Lab are poor, large groups should be divided into smaller ones with a guide for each group.

6. TRAINING

No employee is permitted to operate any piece of equipment without having received the appropriate training. Training in the use of equipment and certain tasks is, for the most part, given by your supervisor.

No employee (or student) is permitted to use equipment or materials without training and appropriate documentation. Do not exceed your individual comfort level, if you are unsure of yourself or are not certain of the hazards and proper procedures associated with your tasks – get help from a qualified person. Lab tools and equipment require careful attention.

The safety orientation is mandatory for any visitor working in the lab. All Users must attend a safety meeting at the beginning of their project. This meeting will be held for undergraduate and graduate students at the beginning of each semester and in late May for summer projects.

7. SAFETY DURING TESTING

During Testing, barriers are to be implemented around hazardous areas. All personnel and visitors are to be informed by lab staff of the situation and how to proceed safely. When green lights are on the main laboratory hydraulic system is pressurized. When amber lights are on, the individual hydraulic systems are active, and can begin motion at any time. When red lights are flashing destructive testing is in progress. During Amber and/or red warnings, do not approach any hydraulic line, shake table, actuator, or test specimen; maintain a minimum of 10-ft perimeter unless approved by Lab Personnel. All other project work may be limited by Lab Personnel on a test day.
8. ACCIDENT ANALYSIS, INVESTIGATION AND RECORD KEEPING

8.1. Accident Analysis
The lab manager will keep a safety log. The safety log will include all injuries, property damage incidents, environmental incidents and near misses. Supervisors will investigate all accidents, injuries, occupational illnesses, and near-miss incidents to identify causal factors or hazards. Appropriate repairs or procedural changes will be implemented promptly by supervisors and followed up to mitigate identified hazards.

8.2. Reporting Requirements
The site adheres to Nevada System of Higher Education (NSHE) Workers’ Compensation Policies and Procedures for incident reporting. A copy of the document is available in the Laboratory Manager’s office and/or at http://www.bcn-nshe.org/downloads/workerscomp/NSHEWCPolicy.7-11-07.pdf. For additional information contact BCN- Workers’ Compensation at 784-4394

Serious occupational injuries, illnesses or exposures to hazardous substances must be reported to NSHE BCN (Business Center North) no later than 8 hours after they become known to the supervisors. Supervisors should call the UNR Injury Reporting Hotline immediately after notification at 775-784-4394. Supervisors will need to state the name of the injured employee, a brief summary of the incident, the injuries obtained by the employee, and a number where the reporting supervisor can be reached. EH&S will contact OSHA if necessary. Supervisors are responsible for conducting the accident investigation with the assistance of BCN

8.3. Investigation Process
After each accident, an investigation and review of the accident will be conducted by the Laboratory Manager. The goal of the investigation is to determine:
   1) what UNSAFE CONDITIONS contributed to the accident
   2) what UNSAFE ACTS contributed to the accident
   3) what MANAGEMENT OR PROGRAM FAILURES caused or contributed to the accident
   4) what corrective actions should be taken to prevent a reoccurrence, and
   5) what specifically s/he has already done to carry out this corrective action

The investigation will be completed in writing by the acting supervisor in charge at the time of the accident, with review by Laboratory Manager and Laboratory Director. The Incident Report Form (must be filled out for each incident and then a copy is kept by the Laboratory Manager and the Laboratory Director. This should be done within 2 days of the incident. The form is provided in Appendix A and available for download at www.bcn-nshe.org/downloads/workerscomp/SupervisorAccidentInvestigationReport.pdf

Within one week of the incident, a meeting shall occur between the Laboratory Manager, the Operations Manager and the Laboratory Director to determine if any corrective actions are necessary to promote safety and prevent future incidents. The Incident Response Form shall be filed with the Laboratory Manager, the Operations Manager and the Laboratory Director within
2 weeks of the incident. A copy shall also be presented to the people involved in the incident. The same form (provided in Appendix A) shall be used.

All completed accident investigation forms with the supervisor’s signature should be turned to the BCN office.

**8.4. Filing the Proper Paper Work**
To ensure timely filing of Workers’ Compensation claims, employees must notify supervisors immediately of an injury. The Supervisor must then complete their respective portions of the UNR Employee claim form for Workers’ Compensation Benefits (refer to page 12 of the Worker’s Compensation Policies and Procedures Manual).

Forms are available from the HR website at [http://www.unr.edu/hr/forms/documents/Workers_Compensation/c-1.MR.pdf](http://www.unr.edu/hr/forms/documents/Workers_Compensation/c-1.MR.pdf).

**9. SAFETY MEETINGS**
Managers and supervisors will provide time at weekly staff meetings to review safety topics. Safety meetings are intended to: emphasize the importance of completing a task safely, to discuss newly identified hazards or accidents, to analyze historical accident trends to predict and prevent future accidents. Status reports will be given on safety inspections, hazard mitigation projects, accident investigation results, and previous employee suggestions. Attendance and topics of discussion shall be recorded.

**10. HAZARD COMMUNICATION**
The site adheres to UNR EH&S written hazard communication program which can be downloaded at [http://www.ehs.unr.edu/Website/LinkClick.aspx?fileticket=BUIx0CYS1yo%3d&tabid=61&mid=484](http://www.ehs.unr.edu/Website/LinkClick.aspx?fileticket=BUIx0CYS1yo%3d&tabid=61&mid=484). The goals of Hazard Communication are to:

a. Help ensure a healthy and safe work experience at NEES@UNR,
b. Reduce the risks involved in working with hazard materials,
c. Provide vital information to employees about the hazards of substances in the workplace,
d. Reduce the incidence and cost of illness and injury resulting from hazardous substances,
e. Encourage the use of substances which are less toxic, and
f. Encourage a reduction in the volume of hazardous substance.

A site specific industrial chemical inventory is also maintained by LSSL staff and is located in the front page of the MSDS binder. Note that no laboratory grade chemicals are stored at this site.
11. EMERGENCY RESPONSE PLAN

Planning ahead for disasters is critical for being able to recover safely and quickly. Understand and know the location and proper use of fire extinguishers, fire alarms, emergency exits, telephones, eyewash fountains and safety showers. It is the responsibility of the Site Safety Office to provide for periodic training of staff members and periodic practice and drills. Personnel should be prepared to respond safely to the following:

- Fire or evacuation alarm;
- Accidental spills or release of radioactive, chemical or other toxic materials;
- Injury of a co-worker;
- Earthquake; and
- Other natural or man-made disaster.

UNR EH&S has developed an emergency response plan for all University Employees, and other visitors and participants on site. The plan is available for download at [http://www.unr.edu/emergency/guide/](http://www.unr.edu/emergency/guide/). Copies of the plan can be obtained from the Safety Officer or by contacting the EH&S office at (775) 327-5040. All staff and visitors at the site will comply with the emergency response plan as directed by EH&S.

12. EMPLOYEE PARTICIPATION

The safety practices described in this plan apply to all University personnel who are working and utilizing the NEES@UNR facility equipment, including faculty, staff, students and visitors, and require everyone to follow safe working practices and procedures. All full time on site personnel will attend a weekly safety briefing where any issues and problems the previous week are discussed, and solutions implemented where appropriate. At the same meeting, all personnel are alerted to activities that may present new safety concerns. Any staff member is authorized to immediately stop all operations should any practices be deemed unsafe. Resumption of activity will occur only when concerns are addressed and only with the explicit approval from facility staff or director.

Employees can help with inspections, investigations, hazard analysis, and safety. Employees are highly encouraged to provide safety suggestions to any of the laboratory staff and faculty.

13. JOB HAZARD ANALYSIS PLAN

Where appropriate, a formal Job Hazard Analysis (JHA) should be done. However, personal protective equipment should always be used to protect workers from hazards, with or without formal JHA.
The Job Hazards Analysis process consists of:

1. Identifying Workers for whom a JHA will be completed;
2. Identifying the scope of the Work to which the JHA will apply;
3. Collecting Work-related data to enable identification of tasks, hazards, and controls making up the work;
4. Preparing a Hazards Profile consisting of the tasks, hazards and controls;
5. Holding a JHA Development Work Session between the Worker and Safety Officer to discuss, modify (if necessary) and validate the Hazards Profile.

The EH&S maintains a comprehensive job hazard analysis catalogue (called Job Safety Analysis) that can be found at [http://www.ehs.unr.edu/website/ProgramAreas/OccupationalSafety/FacilitiesJSAListing/tabid/241/Default.aspx](http://www.ehs.unr.edu/website/ProgramAreas/OccupationalSafety/FacilitiesJSAListing/tabid/241/Default.aspx). Specific job hazards identified at the site are listed below.

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead crane operation</td>
<td>All personnel in the vicinity will wear hardhat</td>
</tr>
<tr>
<td>Overhead crane accident</td>
<td>Operators must be trained and all personnel must wear hardhats</td>
</tr>
<tr>
<td>Chemicals, dust, dirt, grease, heat, cold</td>
<td>Use appropriate PPE</td>
</tr>
<tr>
<td>Loud noises from power tools/equipment/other</td>
<td>Wear ear protection</td>
</tr>
<tr>
<td>Operating power tools,</td>
<td>Use appropriate PPE</td>
</tr>
<tr>
<td>Entanglement with a machine or rotating or moving part</td>
<td>No loose clothing, long hair tied back</td>
</tr>
<tr>
<td>Flammable, ingestion, chemical burns</td>
<td>Hazardous materials stored in cabinets</td>
</tr>
<tr>
<td>Accidental chemical exposure</td>
<td>MSDS Sheets available</td>
</tr>
<tr>
<td>Forklift accident/injury</td>
<td>Must be trained and certified annually</td>
</tr>
<tr>
<td>Other heavy equipment accident/injury</td>
<td>Only trained and certified operators allowed</td>
</tr>
<tr>
<td>LSSL manlift accident</td>
<td>Operators must be trained. Hardhats are not required.</td>
</tr>
<tr>
<td>Electrocution hazard</td>
<td>GFI, inspections of electrical wiring with respect to contact with water</td>
</tr>
</tbody>
</table>

More specific JHAs shall be discussed during the safety orientation if needed

**14. OSHA ACTION PLAN**

The University EH&S will act as a liaison with all regulatory agencies inspecting campus facilities. NEES@UNR staff should immediately contact the Safety Officer, Operations Manager or PI if contacted by OSHA compliance officer. If no one is available, staff member should contact EH&S hotline at (775) 327-5040 for instructions. Additional EH&S contacts can be found at the EH&S web site.
(http://www.ehs.unr.edu/website/AboutUs/StaffContacts/tabid/55/Default.aspx). NEES@UNR staff should not respond to OSHA questions or requests directly.

15. REMEDIAL ACTION

Any identified safety hazard will receive immediate attention from site staff. If necessary, all work will cease until the hazard has been remediated. The hazard will be discussed at the weekly meeting, and if the solution is temporary, a permanent solution will be determined and implemented. Weekly updates on the progress will occur and logged in the weekly minutes until corrective action has taken place.

16. SAFETY RULE ENFORCEMENT

NEES@UNR expects all faculty and staff to abide by established workplace safety rules and regulations. These rules and regulations follow federal, state and UNR rules and regulations governing workplace safety. Members of the NEES@UNR community are expected to conduct themselves with due care at all times, and to abide by established workplace safety rules and regulations. It is the responsibility of all members of the NEES@UNR community to enforce safety rules and regulations.

Violation of safety rules and regulations is a serious offense and may endanger the life of the violator and the lives of others. Employees and supervisors will be held accountable for violations and action may be taken which includes, but is not limited to:

   1. Written and/or (documented) verbal warnings for minor violations.
   2. Evaluation of the need for (re)training.
   3. Further action for flagrant or repeated violations.

17. SAFETY RULES

Safety orientation for all personnel is required before participation in any work at the Large Scale Structures Laboratory (LSSL) or any subsequent facility. Documentation verifying receipt of LSSL safety and cleanliness rules is required from all personnel upon orientation completion.

General Facility Safety
   a. Authorized personnel only
   b. No horseplay
   c. Rules must be followed at all times
   d. Use appropriate PPE and clothing while operating the following:
      i. Hardhat (when operating crane)
      ii. Power tools and some hand tools
ii. Welders and cutting torches

iv. Any other items warranting the use of PPE

e. Steel toe work boots are required while performing any work in the LSSL

f. Training is required for ALL LSSL power tools and equipment

Hazardous Materials
- a. Hazardous materials are to be kept in appropriate cabinets
- b. MSDS sheets are available for all hazardous materials with the safety officer

Operation of LSSL heavy equipment
- a. Forklift operation – operators must be trained by EH&S program and have the certificate on file with the safety officer
- b. Overhead crane operation – operators must complete LSSL training program and pass a written exam. Note: hard hats are mandatory while near a crane in operation.
- c. Man Lift Operation - operators must be personally trained buy LSSL staff and must be on record as a qualified operator with the safety officer

Facility Cleanliness
- a. Attention to overall facility cleanliness promotes environmental awareness which is directly related to everyone’s safety!

Electrocution Hazard
- a. Whenever electrical cords are used, frequent self inspection is required to ensure they are not in contact with water or other potential shorting hazards

18. SELF AUDITS, SELF INSPECTIONS

UNR EH&S performs biannual safety inspection/audit of the LSSL and surrounding grounds, as well as yearly fire code enforcement. A record of any violations is made available to the LSSL Director and staff. Any areas identified as needing attention are brought up during the weekly safety meeting. Results of the biannually walk through and safety inspection/audit are logged and kept with Site Safety Officer and can be made available upon request.

On a monthly basis, the designated safety officer will conduct or assign staff to conduct a self inspection. These inspections will evaluate the condition of all forklifts and cranes according to manufactures recommendations, and will ensure inspection logs are current. All power tools and pertinent hand tools will be inspected according to individual tool safety guidelines and the LSSL hydraulic system will be inspected for leaks and damaged components. A general review will also be performed at this time to insure the LSSL is generally clean, free of tripping hazards, and free of any project specific hazards. Lab Staff should always be on the lookout for any safety hazards in addition to those stated here. The self inspection form is shown in Appendix B. The self inspection form will be updated regularly whenever new items are identified. The completed self inspection checklists will be kept on file by the Lab Manager / Site Safety Officer.
No less than twice annually the Lab Director or the Operations Manager will meet with the Safety Officer to evaluate thoroughness of record keeping in regards to inspections, certifications, accident reporting.

19. SAFETY STAFFING

EH&S is in charge of and oversees the University laboratory safety committee which includes LSSL. The LSSL Facility Laboratory Manager, Patrick Laplace, is the designated Safety Officer. The Safety Officer is responsible for maintaining the safety records at the facility. The following records and documents specific to the facility are kept on site:

- site safety plan
- signed forms for recipients of safety orientation
- log of trainee on special equipment
- signed waivers for any non UNR visiting personnel who are involved in work at the site
- monthly self inspection forms
- safety walkthrough forms
- forklift safety training checklist
II - Universal OSHA-Mandated Safety Plan Elements

1. BLOOD BORNE PATHOGEN CONTROL

No work with human blood products occurs at this facility. In the event human body fluids require clean up due to an injury, only trained personnel are allowed to clean up spills with approved clean up kits. If no trained personnel are present, secure the area and notify the University EH&S department for instructions.

You are responsible for keeping your immediate work area clean and sanitary. If you become aware of needs beyond general housekeeping, report your concern to your supervisor.

All equipment and working surfaces must be cleaned and decontaminated using sanitizing cleanser after contact with blood or OPIM.

If you get blood or other potentially infectious materials in your eyes, nose, mouth, or on broken skin:

1) Immediately flood the exposed area with water and clean any wound with soap and water or a skin disinfectant if available.
2) Report this immediately to your supervisor.
3) Seek immediate medical attention at the UNR Medical Center.

More information regarding UNR policies for blood borne pathogens exposure guidelines can be found at the following link:
http://www.hhs.unr.edu/osn/docs/Blood_Borne_Pathogen_Exposure_Guidelines.doc

1.1. First Aid

This section will familiarize you with guidelines for treatment of minor injuries and for the application of first-aid for more serious injuries in the period of time before professional medical staff are able to treat the injured person

1.1.1. Wounds

A wound is caused when a tissue in our body is torn or cut. Types of wounds:

- Incised wounds caused by sharp instruments. These wounds bleed extensively.
- Contused wounds caused by crushing. These wounds look bruised.
- Lacerated wounds caused by rough surfaces. These wounds bleed less. Wounds pose two dangers, namely bleeding and infection.

1.1.2 Treating bleeding

a. Press the sides of the wound together.
b. Raise the injured part of the body above the heart (only if fracture is not suspected).
c. With your palm, gently press a pad bigger than wound until bleeding reduces.
d. If bleeding continues, add new pads without removing original pad.
e. Bandage firmly but not too tightly.

1.1.3. Avoiding Infection

a. The first aid provider must wash own hands thoroughly with soap and water.
b. External wounds should be cleaned thoroughly with potable water and should be dried with sterile gauze.
c. Wound should be covered with sterile or dry sterile gauze and bandaged once bleeding is controlled
d. Cotton should not be allowed to be in direct contact with wound.
e. Antiseptic cream applied to a wound should not be mixed with water.

2. SAFE HANDLING OF CHEMICAL HAZARDS

Chemical Hazards are of utmost concern at the LSSL, both in terms of the health of the employee and the preservation of the environment. A minor spill such as a very small quantity of hydraulic oil should be contained and then reported to your supervisor. Containment includes installation of appropriate barricades to prevent slip-and-fall injuries. Inform other employees so that they are not at risk from exposure to the spill. Be familiar with the location of absorbent materials available in the lab to aid in containing minor spills. DO NOT ORDER OR BRING ANY CHEMICAL into the lab without first consulting with lab personnel. You will need to get a copy of the MSDS for our review prior to ordering. Getting rid of unwanted chemicals is very expensive, difficult and time consuming this is a burden you will be responsible for.

Protection: Always wear the appropriate protection for the material you are working with.

Material Safety Data Sheet - Material Safety Data Sheets (MSDS) for all of the chemicals in use are stored in HREL Building, Room 105 - outside of the control room. Your supervisor can train you on the proper use of MSDS’s and help answer questions. Become familiar with the hazards for each chemical: exposure limits, symptoms of exposure, and necessary protective equipment for use when handling the particular chemical. Only partial information is given below for each chemical in use at the lab. Your supervisor may specify additional protection for your specific applications. The MSDS should be reviewed with each new shipment of chemicals. LSSL staff is responsible for labeling any unmarked chemical containers according to OSHA standards.

Monitoring and Prevention - A trained permanent employee is appointed monitor the general conditions and usage. His/Her job is to check for problems. Inform your supervisor of any problems, or in a situation which requires it, call the Environmental Health & Safety at (775) 327-5040. No employee shall ever use equipment or materials with which he/she is not comfortable. This also means paying attention to your own body and taking symptoms of any exposure seriously. Report any symptoms-of-exposure (from any lab chemicals) to the person in charge and promptly discontinue work with suspect chemicals. If symptoms start after work hours, seek medical attention and notify Active Supervisor the next day.
**Solvents, Flammables, Combustibles** - Solvents, Flammables, and Combustibles all present inhalation hazards as well as flammability hazards. All flammables (higher risk of explosion than combustibles) should be stored in the steel cabinet in outside of the Control Room. All solvents and combustibles should be purchased in small enough quantities to be easily and properly stored.

**Acetone** - Acetone is used to clean steel before gauging. It is extremely volatile, meaning it generates fumes that are both toxic and may impair mental faculties. It can also be absorbed through the skin. Advise other employees in the area when using acetone. Keep cap on the can when not actually pouring the chemical. Return can to the proper cabinet after use. **Protection:** Nitrile gloves required. Adequate ventilation required. Organic vapor respirator recommended safety glasses or goggles are always required.

**Propane** - Propane (forklift fuel) is a flammable compressed with explosive properties. Assure the valve is closed when not in use. Use with caution and keep away from an ignition source. When propane is burned, carbon monoxide is produced. **Protection:** Adequate ventilation required.

**Hydrocarbon based solvents** - Solvents used to clean steel and other equipment at the lab. Consult with lab staff before you purchase and use this class of solvents. Fumes are toxic. As always, Read the MSDS. **Protection:** Nitrile gloves required. Organic vapor respirator recommended. Safety glasses are required.

**Oils and Lubricants** - Lubricants are necessary to keep equipment in safe operating condition. In particular, we use motor oil, common grease, low hazard hydraulic oil, special weight oils, and anti-seize coatings for tools and equipment. The most important thing is to avoid spills and excessive contact with skin. There is a drum for recycling used motor and hydraulic oil. Contact your supervisor for an explanation of how to use this resource. Read the labeling. **Protection:** Nitrile gloves recommended. Safety Glasses are required.

**Cement & Grout** - Unmixed cement and grout are corrosive fine powers. They are most corrosive when in contact with water. Most often when dealing with cement and grout you will be using a bagged, pre-mixed product. Cement products can irritate respiratory tissues when inhaled. It is crucial that you wear your particulate respirator while batching and mixing. Dry powder or wet grout and cement can burn your skin (chronic and acute exposure can be very damaging to your skin and respiratory tract). For this reason it is important that you have adequate coverage – coveralls, rubber boots and nitrile gloves and particulate respirator. Please note that latex gloves do not protect against cement. The cured mix poses greatly reduced health risks. Extended handling of cured cement products, debris, blocks etc is corrosive as well as abrasive to unprotected hands. NEVER STORE POWERS ABOVE FACE LEVEL (bags, bins, boxes and tubs can be stacked up to a height of 4 feet above the ground). **Protection:** Nitrile gloves or leather gloves, long sleeved clothing (coveralls), particulate respirator, and safety goggles are required.
Wet grout and wet concrete are hazardous wastes. Clean up concrete-soiled equipment only in the designated outdoor area. **Never dump or clean up mixed or un-mixed materials into a sink or outside drain.** As well as contaminating the water draining into the river, cement products will damage pipes. Once concrete is dry it has no safety or environmental hazards and can be discarded as ordinary trash.

**Admixtures** - Admixtures are naturally -or chemically- produced additives to cement mixes. Some of the admixtures cause the cement hardening process to speed up or slow down and others cause the cement to set harder or softer than what would result from a normal mix. Many of the admixtures are not toxic, but care should be taken when dealing with them. Some admixtures are corrosive and can cause respiratory irritation if inhaled and skin and eyes irritation if there is contact. Also avoid getting the materials on your clothes. Wear particulate mask, safety goggles and nitrile gloves. If you have questions about these materials please contact a lab staff person and read the MSDS. **Protection:** Nitrile gloves and long sleeved clothing (coveralls), particulate respirator, and safety goggles are required.

**Epoxy** - We use a variety of thermo-plastics for the gluing of instrumentation as well as in some structural applications. Nitrile gloves and safety glasses should be worn at all times when using this material. Also provide adequate ventilation. Epoxy purchased from a hardware store is commonly listed as a skin sensitizer and eye irritant. However, there many industrial types of epoxy ALWAYS read labels. In case of contact with skin, wash thoroughly with water and soap. Contact your physician if irritation or rash develops. Consult MSDS for further information. Even if you are familiar with a particular product, manufacturers periodically change the labeling: READ the package and consult the appropriate MSDS. Watch for changes. **Protection:** Nitrile gloves and safety glasses are recommended.

**Laboratory Dust** - Although Lab Dust is largely seen as a nuisance, significant problems may arise with short and long-term exposure. Over the short term, exposure may cause dry eyes, sneezing, and other similar dust-related problems. Over the long term, lung problems can arise such as silicosis, a lung disease linked to the intake of rock dust (silica) into the lungs. The proper way to avoid these hazards is to wear particulate respirator. **Protection:** Particulate respirator recommended. If possible use a vacuum over a broom when cleaning the floor.

### 3. FIRE AND LIFE SAFETY

As a general rule, UNR does not expect its employees to fight fires. Just sound the alarm – pull the fire alarm or call 911(9-911 from on campus) – and get out of the building as quickly as possible and report to your group’s emergency assembly area. Do not re-enter the building until you have been notified by the authorities to do so.

The purpose of the Fire Extinguisher Safety Program is the inform employees with the general principles of Fire Extinguisher use and the hazards involved with incipient stage fire fighting. The facility has posted safety maps denoting first aid stations, exit routes, fire extinguisher
locations, and special hazard areas. The facility is routinely inspected by the City of Reno Fire Marshall for compliance. More details are provided in the Fire Extinguisher Safety Program Handbook that is available in the Laboratory Manager Office and for download from EH&S web site at http://www.ehs.unr.edu/Website/LinkClick.aspx?fileticket=1A4gkqEijyH%3d&tabid=61&mid=987.

4. LOCKOUT/TAGOUT

The site adheres to the EH&S lock out/tag out policy as detailed at their website (http://www.ehs.unr.edu/Website/LinkClick.aspx?fileticket=%2bA9%2fBfBM%2f77c%3d&tabid=61&mid=898). The purpose of the Lockout/Tagout (LOTO) Program is to ensure specific practices and procedures to safeguard employees from the unexpected activation or startup of machinery and equipment, or the release of hazardous energy during service or maintenance activities. This program requires that a trained, authorized employee turns off and disconnects the machinery or equipment from the energy source(s) before performing service or maintenance.

Site has tagouts and emergency stop switches that are engaged when needed for personnel safety when personnel are working in or near the vicinity of major equipment. All facility staff will be trained on lockout/tagout procedures. The safety officer or a designated authorized staff member will be in charge of tagouts and emergency stop switches when service is required. The following sequence of procedures will be followed during lockout or tagout:

1.1 Notify all employees within the immediate affected area that a lockout or tagout is going to be utilized and the reason why
1.2 If the equipment is operating, shut it down by the normal stopping procedure
1.3 Operate the switch, valve, or other energy isolating device(s) so that the equipment is isolated from its energy source(s)
1.4 Lockout and/or tagout the energy isolating devices with assigned individual lock(s) or tag(s)
   i. Lockout devices and tagout devices are to indicate the identity of the employee applying the device(s)
   ii. Following the application of lockout or tagout devices, all potentially hazardous stored or residual energy shall be relieved, disconnected, restrained, or otherwise rendered safe
1.5 At this point the equipment is considered to be locked or tagged out
1.6 If lockout is the energy control method utilized, the authorized employee is to keep the key in his/her possession for the duration of the lockout period

Before lockout/tagout devices are removed and energy is restored to the equipment, the following steps shall be taken by the employee:
1. Inspect the work area to ensure that non essential items have been removed and ensure that machine or equipment components are operationally intact
2. Check the work area to ensure that all employees have been safely positioned or removed
3. Before lockout or tagout devices are removed and before the equipment is energized, affected employees in the immediate area shall be notified that the lockout or tagout device will be removed

5. PERSONAL PROTECTIVE EQUIPMENT

Laboratory personnel are required to use Personal Protective Equipment (PPE), when warranted. PPE is selected and used to protect laboratory personnel from hazards and potential hazards that are likely to be encountered. PPE includes all clothing and work accessories. PPE should not be used as a substitute for engineering, work practices and/or administrative controls to protect personnel from laboratory hazards. Details are given in the Personal Protective Equipment Program which is available in the Laboratory Manager Office and at
http://www.ews.unr.edu/Website/LinkClick.aspx?fileticket=ychEDPQczJ4%3d&tabid=61&mid=9

Prior to conducting work requiring the use of personal protective equipment, employees and users shall be trained to know:
- When PPE is necessary
- What type is necessary
- Employee PPE comfort & fit considerations
- How to properly use and wear the PPE
- What are the limitations of the PPE
- Proper care, maintenance, useful life, and disposal of the PPE

The site maintains the following PPE:

| gloves (including chemical resistant gloves) | Hardhat |
| Safety glasses with side shield | Hearing protection |
| Respiratory protection (Dusk masks) | Goggles |
| Harness for heights |

Hardhats must be worn when
- overhead crane operations
- working underneath large specimens on the shake tables
- whenever conditions warrant as directed by facility staff

Protective clothing will be worn whenever conditions warrant. Protective clothing includes leather gloves, chemical resistant gloves, safety shoes, safety glasses, dust masks, goggles.
Eye and ear protection must be used when operating shop equipment. Dust masks should also be utilized if conditions warrant.

There are many specific laboratory practices that require the use of PPE; these are covered during the safety orientation. Appendix C provides more information on the PPE and their proper use.

PPE shall be inspected, cleaned, and maintained at regular intervals so that PPE provides the requisite protection.
III - Conditional OSHA-Mandated Safety Plan Elements

1. COMPRESSED GASSES

Safety is critical when handling compressed gasses whether used in the process of welding, cutting, or as a fuel source for forklift operations. University EH&S policy and procedures for handling compresses gas cylinders at the facility are outlined at [http://www.ehs.unr.edu/Website/LinkClick.aspx?fileticket=eCEmXdN9QdA%3d&tabid=61&mid=870](http://www.ehs.unr.edu/Website/LinkClick.aspx?fileticket=eCEmXdN9QdA%3d&tabid=61&mid=870). All personnel who handle any compressed gas cylinders must be trained in the hazards and operation of high-pressure gas cylinders. This training must include storage, handling procedures, protection of the valves (valve caps or valve protectors), security and tagging / labeling of the cylinders (full or empty), and the authority to move or access any compress gas cylinders.

**Combustible Materials Separation** - Cylinder storage and use locations must be kept clear of all weeds, grass, brush, and trash, as well as any other combustible materials, for a minimum distance of 5 m (15 ft) from all cylinders. **Exception:** an approved noncombustible barrier, cabinet, or hood may be used instead.

**Cylinder Transportation** - Only standard DOT cylinders will be used for transporting compressed gas. Personnel who are trained to use compressed gases may use standard cylinder carts to transport cylinders within buildings and between adjoining buildings. Carts are preferred, but cylinders weighing 11 kg (25 lb) or less may be hand-carried. Valve-protection caps and plugs must be in place during movement of cylinders. Lecture bottles and other cylinders without protective caps must be transported in standard shipping crates, or an equivalent container. Gas cylinders must be transported between non-adjoining buildings by a person properly trained, licensed, and equipped to transport gas cylinders.

**Cylinder Position** - Gas cylinders must be stored in a (valve end up) upright position, which includes conditions where the cylinder is inclined as much as 45 degrees from the vertical. Exceptions include cylinders designed for use in a horizontal position, and cylinders with non-liquefied compressed gas that have a water volume less than 5 L (0.18 cf or 1.3 gal).

**Cylinder Securing** - Gas cylinders must be secured to prevent falling due to accidental contact, vibration, or earthquakes. Cylinders must be secured in one of the following ways:

a. By a noncombustible, two-point restraint system (e.g., chains) that secures the cylinder at the top and bottom one-third portions. **Exception:** cylinders less than 1 m (3 ft) tall require only one restraining point.

b. By a noncombustible rack, framework, cabinet, approved strapping device, secured cylinder cart, or other assembly that prevents the cylinder from falling.

**Cylinder Valves, Caps, and Plugs** - Gas cylinders designed to have valve-protection caps and valve-outlet caps and plugs must have these devices in place. **Exception:** when the cylinder is in
use or being serviced. Gas cylinder valves must have a handwheel, spindle key, or other approved control handle on the valve stem while the cylinder is in use. Cylinder valves should be opened slowly. Cylinder valves seat in both the closed and open position and are likely to leak unless left in the fully open or fully closed position.

**Unauthorized Cylinder Modification or Use** - All labels, markings, and tags provided on the gas cylinder by the manufacturer must be maintained in good condition. Gas cylinder parts must not be modified, tampered with, obstructed, removed, repaired, or painted by the gas user.

**Empty Cylinders** - Gas cylinders should be left with residual pressure (i.e., typically 200 kPa or 30 psi) to prevent contamination of cylinder contents. Cylinders considered to be empty should be handled with the same precautions as cylinders filled with gas because so-called “empty” cylinders still contain residual gas and pressure. Empty gas cylinders must be labeled “Empty.”

**Cylinder Changing** - Two people must be present during hazardous gas purge and cylinder change procedures. Reconnected gas fittings must be checked for leaks using a leak-detection fluid or other approved method.

**Cylinder Temperature Control** - Gas cylinders should be stored in the shade and must not be exposed to temperatures exceeding 50°C (125°F).

2. **CONFINED SPACES**

Work in confined spaces presents unusual and severe hazards to a sizable portion of the maintenance work force. Common tasks, such as welding, use of solvents and adhesives, live electrical work, or painting can quickly become lethal in a confined space. OSHA defines a confined space as a space that has the three following characteristics:

1. Is large enough and configured such that an employee can enter and perform work;
2. Has limited or restricted openings for entry and exit; and
3. Is not designed for continuous employee occupancy.

A confined space is further defined as a space that meets both of the following conditions:

1. Existing ventilation is insufficient to remove dangerous air contaminants and/or correct oxygen deficiency; and
2. Access to or exit from the space is difficult.

Although LSSL facilities do not include any confined space as defined by OSHA, lab personnel may be required to engage in projects where field work is mandated and equipment installation in confined space is necessary. UNR EH&S coordinates the campus Confined Space Entry Program. This responsibility entails providing technical consultation and guidance for testing and monitoring confined space environments, controlling potential hazards in confined spaces (such as ignition sources, electrical and machinery lockout, purging and temporary ventilation), providing employee training about potential hazards, and cooperating with the campus Fire Department in rescue procedures. Testing and training requirements may be delegated to other departments that have EH&S-approved confined space entry programs and required
instrumentation. All lab personnel engaged in activities which require working in confined space shall receive proper training through UNR EH&S. Copies of training certificates shall be retained by the lab safety officer.

3. ELEVATED WORK

In the LSSL, there is often a need to work at elevations. The Fall Protection Plan clearly identifies general fall hazards and specifies the appropriate methods to control those hazards. The personnel using the fall protection systems will be trained in the use, inspection, and limitations of the equipment before being utilized. Details about Fall Protection Program is available in the Laboratory Manager Office and for download at http://www.ehs.unr.edu/Website/LinkClick.aspx?fileticket=p%2fFQ%2fRTg7BU%3d&tabid=61&mid=980. Scaffolds should be erected, moved, dismantled or altered only under the supervision of the Acting Supervisor.

Lab specific fall hazards vary as the laboratory is reconfigured on a weekly basis. Fall protection is absolutely required when working on any surface above OSHA mandated limit, including but not limited to:
   a. Reaction blocks
   b. Test specimens
   c. Shake table actuator covers
   d. Snorkel man lift

Personnel and visitors are required to complete fall restrain training from qualified lab staff before working at elevation in the LSSL. Personnel can protect themselves from falls by going through proper ladder safety and by using the following restraining devices:
   a. Movable chain railings
   b. Harness and lanyard
   c. Mobile working platforms

3.1. Ladders
Safety hazards in the use of ladders can be substantially reduced by observing certain basic safety precautions as noted below:
   • Painters' stepladders longer than 3.7 m (12 ft) must not be used.
   • Wood ladders must not be painted.
   • Ladders must be stored to prevent weathering, blistering, or cracking.
   • All metal ladders must be legibly marked with signs reading "Caution - Do not use around electrical equipment."
   • Portable straight and extension ladders must be equipped with slip-resistant shoes.
   • Straight or extension ladders must be placed against a support at an angle such that the distance from the ladder base to the base of the support is one-fourth the working length of the ladder.
   • Lash straight or extension ladders when used for access to high places.
   • Face ladders when ascending or descending.
   • Do not use a ladder as a scaffold.
• Do not place a ladder in front of a doorway, unless the door is blocked open, locked, or guarded.
• Do not place ladders on boxes or unstable bases to obtain additional height.
• Do not climb higher than the second step from the top of a ladder.
• Ladders with broken rungs or missing steps must not be used.
• Inspect all ladders before use.
• Report any defective ladders to your supervisor.
• Supervisors must ensure that any ladder reported as defective or unsafe is removed from service.
• The use of a safety harness and lanyards is recommended when working higher than 8 ft. on a ladder or other high place.

Details about Ladder Safety Program is available in the Laboratory Manager Office and for download at http://www.ehs.unr.edu/Website/LinkClick.aspx?fileticket=iBXJZQ9BHrs%3d&tabid=61&mid=981

4. FLAMMABLES STORAGE

Flammable materials will be handled and stored at the facility per MSDS specifications. Training shall be provided to all staff, students and visitors who will work with any of these materials. Training shall cover the hazards of these materials and the appropriate use of containers when transferring into or through the site. Flammable storage cabinets are clearly marked and easily accessible for containers that are not being used at the active work site. The authority to use or move any flammable liquids at this facility rests with the Laboratory Manager or the Development Technicians.

5. EQUIPMENT OPERATING MANUALS

All equipment is to be operated in accordance with the manufacturer’s instructions, as specified in the equipment’s operating manual. Copies of operating manuals must be kept with each piece of equipment in the NEES facility. Each person intending to use any equipment in the NEES facility must attend a safety training session. No equipment can be operated without specific authorization based on evidence of past training (e.g. valid operator’s certification) or training provided on site.

6. FORKLIFTS

Operation of forklifts and other powered industrial trucks is restricted to trained personnel who have completed the required training. Only Lab Personnel may use the Large Forklift ('Bertha'). Only users who have been trained and certified by EH&S may use the Small Forklifts after familiarization with lab specific equipment. Training includes a combination of formal
instruction, demonstrations and practical exercises performed by the trainee, and an evaluation of the operators' performance. Practical exercises must be performed under the direct supervision of trainers. For information regarding forklift certification policies and training classes, contact the UNR EH&S Hotline at (775) 327-5040 or on the web at http://webapps.ehs.unr.edu/traininglibrary/.

A training program consists of the following elements and materials:
- a. Operating instructions, warnings and precautions for type of truck
- b. Similarities and differences to automobiles
- c. Control and instrumentation location and use
- d. Engine or motor operation
- e. Steering and maneuvering
- f. Visibility
- g. Fork and attachment limitations and use
- h. Vehicle capacity
- i. Vehicle stability
- j. Vehicle inspection and maintenance
- k. Refueling or charging batteries
- l. Operating limitations
- m. Other operating instructions, warnings or precautions listed in the operator’s manual

The Small Forklifts shall not be used in the basement, except by Lab Personnel. When operating the lift inside the labs, ventilation fans must be turned on, as needed, to minimize exposure to carbon monoxide and to prevent any buildup of carbon monoxide gases in the confined space areas. The LP gas must be shut off when the Forklift is not in use. Use caution when operating the all forklifts around hydraulic actuators, controllers, data acquisition systems or hydraulic lines. Personnel approved for using a lift basket will need to wear fall protection equipment.

Each forklift is inspected before each use and is formally inspected weekly by laboratory staff. Inspections assess the visible hydraulic lines and fittings, as referenced in the inspection sheet. Maintenance is performed by a certified forklift mechanic at intervals specific to each piece of equipment. Records of inspections and maintenance are available with the Laboratory Manager. The three diesel forklifts are refueled by a petroleum distributor and fuel for the propane forklift is stored and transported by LSSL staff according to Section III, Subsection 1. Operator must use appropriate PPE equipment when changing out the forklift propane tank.

6.1. Safe Forklift Operation Rules
The following rules apply to all use of forklifts and other Powered Industrial Trucks (PITs) at the Lab:
- Only authorized, trained personnel shall operate lift trucks.
- Before use, a visual inspection must be made to ensure that horn, lights, brakes, tires, gas supply, hydraulic lines, etc. are in safe working condition. Employees shall not operate an unsafe forklift or PIT at any time.
• Fill fuel tanks out of doors while engine is off.
• Do not exceed the safe load capacity of a forklift or PIT at any time. Do not counterweight a forklift to increase lifting capacity.
• Operators shall drive with both hands on the steering wheel. Horseplay is prohibited.
• No person shall ride as a passenger on a forklift or PIT or on the load being carried.
• A forklift or PIT will not be used to elevate a platform or pallet with persons on it, except work platforms especially designed for this purpose. Work platforms must have standard guard rails, and must be securely fastened to the forks.
• No person shall stand or walk under elevated forks.
• Operators should avoid making jerky starts, quick turns, or sudden stops. The operator will not use reverse as a brake.
• Forklifts or PITs should be driven on the right side of the road or aisle way.
• Operators shall cross railroad tracks diagonally whenever possible.
• Forklifts or PITs shall be operated at a safe speed with due regard for traffic and conditions. Maximum speed limits: inside buildings, 5 mph; outside buildings in work areas, 7 mph; on roads, 10 mph.
• Slow down on wet and slippery surfaces and at cross aisles or locations where vision is obstructed.
• Operators entering a building or nearing a blind corner shall make their approach at reduced speed. Sound horn and proceed carefully.
• Standard arm signals will be used at all times.
• Operators shall give pedestrians the right of way at all times.
• Operators shall not drive toward any person who is in front of a fixed object or wall.
• Operators shall not overtake and pass another forklift or PIT traveling in the same direction, at intersections, blind spots, or hazardous locations.
• Operators should not put their fingers, arms, or legs between the uprights of the mast, or beyond the contour of the forklift or PIT.
• When the forklift is not carrying a load, the operator shall travel with the forks as low as possible. When carrying a load, it should be carried as low as possible (consistent with safe operation, 2 to 6 inches above the surface.)
• Forks should always be placed under the load as far as possible.
• No load should be moved unless it is absolutely safe and secure.
• The operator's view should not be obstructed by the load. In the event of a high load, the forklift or PIT will be driven backward.
• Operators shall look in the direction of travel.
• The forks should not be operated while the forklift is traveling.
• On a downgrade, the load shall be last, and the forks raised only enough to clear the surface.
• On an upgrade, the load shall be first, and the forks raised only enough to clear the surface.
• Use extra care when handling long lengths of bar stock, pipe, or other materials.
• Avoid sharp or fast end swing.
• Compressed gas cylinders shall be moved only in special pallets designed for this purpose.
• When unloading trucks or trailers, the brakes on the vehicle will be set (locked).
• Forklifts or PITs must be safely parked when not in use. The controls shall be neutralized, power shut off, brakes set, and the forks left in a down position flat on the surface, and not obstructing walkways or aisles.
• A forklift or PIT shall not be left on an incline unless it is safely parked and the wheels blocked.

7. HEAVY EQUIPMENT

The site does not own any heavy equipment. When situations require use of heavy equipment, the work is either contracted out, or equipment is rented. Equipment most often rented includes shooting boom forklifts, cherry pickers, scissor lifts, and bobcats. In the case of rented equipment, prior to any use, a thorough review of the operation and safety manuals is done. Only UNR staff and students are authorized to operate rental equipment, and only after approval from an experienced LSSL staff member who has reviewed the equipment documents.

8. MANUAL LIFTING

Manual material handling involves lifting, lowering, and carrying objects. If ergonomics principles are ignored, stresses on the muscles, joints, and disks in the back can eventually lead to or aggravate a work related musculoskeletal disorder (WRMSD). For objects that are too heavy (in excess of 100 lbs) or bulky for safe manual handling by employees, mechanical lifting devices must be used for lifting and moving. The EH&S provides training and training videos for proper back care and how to lift properly. Check EH&S training library at http://webapps.ehs.unr.edu/traininglibrary/ for the next available training session.

8.1. Best Practices for Lifting

1. Assess the situation.
   i. How far will you have to carry the load? Is the path clear?
   ii. Once the load is lifted, will it block your view?
   iii. Can the load be broken down into smaller parts?
   iv. Should you wear gloves to get a better grip?

2. Size up the load.
   v. Test the weight by lifting or sliding one corner. If it is too heavy or awkward, STOP!
   vi. Can you use a mechanical lift or hand truck?
vii. Can you lift the load safely, or is it a two- or more person lift? If you doubt you can lift the load safely, ask for help.

3. Use good lifting techniques.
   viii. Get close to the load with your feet shoulder-width apart.
   ix. Get a good handhold, and pull the load close to you
   x. Bend at your knees and hips, keep the inward curve in your back, and lift with your legs.
   xi. If you need to lean forward, support your upper body weight with one hand.

Shown in Figures 1a&b: Improved work practices and work layouts that can help reduce risk for work related injuries.

![Fig. 1a Bend the knees and hips instead of the low back.](image1.png)

![Fig. 2b Store heavier loads between knee and shoulder height. Very heavy loads (50 lbs. or more) should be stored where they won’t have to be manually lifted. Lighter and less frequently moved items should be placed on higher shelves.](image2.png)

A more detailed guidelines and illustration on Lifting Techniques can be found at [http://www.bcn-nshe.org/downloads/workerscomp/ProperLifting1-28-03_000.pdf](http://www.bcn-nshe.org/downloads/workerscomp/ProperLifting1-28-03_000.pdf).

9. MECHANICAL LIFTING

Crane and hoist safety operations and procedures are detailed at the EH&S website [http://www.ehs.unr.edu/Website/LinkClick.aspx?fileticket=vKIY%2fJhGz7k%3d&tabid=61&mid=899](http://www.ehs.unr.edu/Website/LinkClick.aspx?fileticket=vKIY%2fJhGz7k%3d&tabid=61&mid=899). Forklift use and safety is addressed in the forklift section of the document. Site specific operation of the LSSL overhead crane requires training by an experienced and authorized staff member to be designated by the Site Safety Officer. Simultaneous use of both cranes is not allowed unless specifically approved by Lab Personnel. Heavy and/or large items are to be
craned only by Lab Personnel. All lifting equipment at the site is inspected and certified annually. Load ratings are clearly marked and visible to the operator. Cranes shall not be left unattended while still attached to a specimen or test fixture. Avoid crane use above hydraulic actuators, controllers, data acquisition systems or hydraulic lines. Prior to and after lifting operations, lifting cables and sling will be inspected for wear as well as monthly as part of the self inspection audit. Any defects in rigging shall be immediately reported to Laboratory Manager. Slings will be stored and maintained in good condition.

All personnel operating a crane or hoist, participating in the lift or within 15 feet of the vertical plane of the load, where the under carriage of the bridge is more than 12 feet from the ground, must wear ANSI-approved hard hats.

10. MACHINE GUARDING

It is the Safety Officer’s responsibility to ensure that machine tool and machine equipment guarding is adequate. Never remove factory-installed guards unless they are designed to be removed for a particular operation, and equivalent means of protection are used (e.g., table saw guards are removed for fence cuts; when appropriate, push sticks are used).

Guard all reasonably accessible points of operation, pinch and nip points, rotating parts, and flying chip or spark hazards that may expose an employee to injury. In general, guarding prevents inadvertent contact with these hazards. Guarding may be achieved by one or more methods, such as isolation, barriers, shields, devices, or distance.

At this site, there are several machines that may need safety guarding, including but not limited to:

a. Shake table systems
b. Actuator and ram systems
c. Stationary power tools

Large moving systems such as shake tables and actuator systems require the use of barriers. It is the responsibility of LSSL staff to place these barriers at a distance deemed safe by the safety officer before testing may proceed. These systems also have programmable electronic interlocks that are set based on the parameters of each test. It is LSSL standard operating procedure to check and set these limits prior to running equipment. Hazardous hydraulic system components have permanent guarding in place.

Stationary power tools located in the lab include those listed in Section III, Subsection 13. All of these tools have original manufacturer’s guarding in place and are maintained according to manufacturer’s specifications.
11. NOISE EXPOSURE

Whenever noise exceeds the mandated “action level” (85 decibels or above) measured on the A scale (dBA) over a time weighted average of 8 hours, the facility will immediately initiate a hearing conversation program. The first level of defense is for all exposed personnel to don protective hearing equipment. Equipment at the facility includes formable ear plugs and ear muffs. It is recommended that protective equipment be used during operation of many shop tools and hand tools. More information on Hearing Conservation Program can be found with the Lab Manager or can be downloaded at http://www.ehs.unr.edu/Website/LinkClick.aspx?fileticket=kh2AS107Jo%3d&tabid=61&mid=992.

12. POWERED PLATFORMS AND VEHICLE MOUNTED WORK PLATFORMS / TELESCOPING BOOM LIFT

Only authorized persons are allowed to operate any such machinery. The authority to operate any powered equipment at this facility shall be determined by a the Laboratory Manager who will assess and document the operators ability to handle the equipment efficiently and safely. Under the circumstances of the piece of equipment and this laboratory, signals are not considered necessary since the operator is located inside the moving basket. In all efforts to reduce accidents, operators are required to use a safety harness while working at elevation. However, in the event of an equipment failure, cranes can be used in conjunction with a bosun’s chair to reach the stranded operator. In the event of an emergency rescue, call 911 and prepare to assist emergency personnel.

Before the boom lift is used, the Laboratory Safety Officer must review the circumstances to ensure proper use of equipment and approve its use. Proper use of equipment must be within the parameters of the vehicle’s manufacturer manual.

Operating Conditions - Extensible boom work platform must be operated under the following conditions:

a. Two operators must be present at all times. One operator must be present on the work platform and the other stationed on the ground to assist in the operation and perform any emergency duties.

b. This unit must be inspected prior to each shift’s use and must not be operated if found to be unsafe.

c. All personnel occupying the work platform must wear an approved safety harness and lanyard properly attached to the equipment.

d. Unless recommended for such use by the manufacturer, no extensible boom work platforms are to be used on an inclined surface. This equipment shall be used inside the LSSL on level ground.

e. Unit must have upper and lower control devices.
Identification - The following must be displayed on all work platforms in a permanent manner:
   a. Special warnings, cautions, or restrictions necessary for safe operation.
   b. Make, model, and manufacturer's name and address.
   c. Rated work load capacity.
   d. Maximum platform height.
   e. Instructions to study operating manual.
   f. Chart, schematic, or scale showing capacities of all combinations in their operating 
      positions and cautions or restrictions, or both, regarding operation of all alternate 
      configurations or combinations of alternate configurations.

Inspections
   a. Daily Inspection: Units must be inspected prior to each shift’s use. Inspections must 
      include all items recommended by the manufacturer's manual.
   b. Preventive Maintenance: All maintenance on this piece of equipment is performed by a 
      licensed mechanic at intervals no longer than recommended in the manufacturer's 
      manual.

13. POWER TOOLS; FIXED AND PORTABLE

The use of power tools should be limited to personnel who demonstrated a knowledge of the 
safe use of the equipment and who have been specifically authorized. The authority to operate 
any powered equipment at this facility shall be determined by the Laboratory Manager who will 
assess and document the operators ability to handle the equipment efficiently and safely. The 
following is a list of tools at the site:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Manufacture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed</td>
<td>Drill press</td>
<td>Vulcan</td>
</tr>
<tr>
<td></td>
<td>Bench Grinder</td>
<td>Reliant</td>
</tr>
<tr>
<td></td>
<td>Bench Grinder</td>
<td>Delta</td>
</tr>
<tr>
<td></td>
<td>Milling Drill Press</td>
<td>Jet</td>
</tr>
<tr>
<td></td>
<td>Lathe</td>
<td>Jet</td>
</tr>
<tr>
<td></td>
<td>Lathe</td>
<td>Monarch</td>
</tr>
<tr>
<td></td>
<td>Band Saw</td>
<td>Jet</td>
</tr>
</tbody>
</table>

Continued on next page
<table>
<thead>
<tr>
<th>Portable</th>
<th>Cordless Drill</th>
<th>Dewalt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cordless Hammer Drill</td>
<td>Dewalt</td>
</tr>
<tr>
<td>Chop Saw</td>
<td>Black &amp; Decker</td>
<td></td>
</tr>
<tr>
<td>Small Hammer Drill</td>
<td>Bosch</td>
<td></td>
</tr>
<tr>
<td>Large Hammer Drill</td>
<td>Bosch</td>
<td></td>
</tr>
<tr>
<td>Portable Band Saw</td>
<td>Milwaukee</td>
<td></td>
</tr>
<tr>
<td>Small Mag Drill</td>
<td>Jancy</td>
<td></td>
</tr>
<tr>
<td>Large Mag Drill</td>
<td>Jancy</td>
<td></td>
</tr>
<tr>
<td>Power Drill</td>
<td>Milwaukee</td>
<td></td>
</tr>
<tr>
<td>4&quot; Grinder</td>
<td>Makita</td>
<td></td>
</tr>
<tr>
<td>6&quot; Grinder</td>
<td>Hitachi</td>
<td></td>
</tr>
<tr>
<td>Sawzal</td>
<td>Milwaukee</td>
<td></td>
</tr>
<tr>
<td>Reciprocating Saw</td>
<td>Bosch</td>
<td></td>
</tr>
<tr>
<td>Orbital Sander</td>
<td>Dewalt</td>
<td></td>
</tr>
<tr>
<td>Orbital Sander</td>
<td>Porter Cable</td>
<td></td>
</tr>
<tr>
<td>Circular Saw</td>
<td>Skillsaw</td>
<td></td>
</tr>
<tr>
<td>Circular Saw</td>
<td>Craftsman</td>
<td></td>
</tr>
</tbody>
</table>

For further operation, maintenance, and safety procedures, refer to Appendix D.

**Inspection and Maintenance** - Machine tools, machine equipment, and power tools should be routinely inspected to verify that they are not damaged, that the controls function as designed, and that all guarding and shields are securely installed and adjustable. Servicing, including cleaning, lubrication, preventive maintenance, and adjustment of machine equipment and machine tools can help prevent performance and safety problems. Only qualified technicians or qualified vendors are permitted to service equipment. Service equipment only when all electrical, hydraulic, compressed air, and stored energy sources are secured in accordance with Lockout/Tagout requirements.

**General Safety Rules for Use/Maintenance of Power Tools, Machine Tools and Machine Equipment** - The following general rules apply to the use and/or maintenance of machine tools and machine equipment, regardless of their location.

a. Permit only qualified personnel who have necessary skills, through experience and/or training, to operate or maintain machine tools or machine equipment.

b. Equip all machine tools, power tools, and machine equipment with all required guarding, and prohibit (lock and tag) their operation unless such guarding is in place and fully functional.

c. Operate/maintain machine tools, and machine equipment in accordance with the manufacturer’s requirements, and the requirements of this section.

d. Anchor and electrically wire all machinery and machine equipment designed by the manufacturer to be stationary. Only qualified electricians are permitted to install and remove wiring for hardwired shop machinery and machine equipment. Machine tools and machine equipment designed to be electrically connected by cord and plug are not subject to this requirement.
e. Permit only qualified personnel or vendors to repair or otherwise service machine tools or equipment.

f. Only operate machine tools when a second person is within sight or earshot of the tool user. This is an essential requirement in the case of personnel who get caught in machinery or suffer traumatic injuries. The second person need not be qualified to operate the equipment but does need to know how to turn off the equipment and how to call for emergency assistance. This second person must also agree ahead of time to perform such duties should the need arise. Establish a check-in and check-out protocol.

g. Ensure that all machine and tool guards are installed in place, in good working order, properly adjusted, and most importantly, used for their intended purpose. This includes the use of chip shields for any drilling or cutting operations.

h. Wear (at a minimum) safety glasses with side shields while in the vicinity of operating machine tools. This applies both to workers and to visitors. Wear face shields or goggles as required by work authorization for specific operations.

i. Wear substantial closed-toe footwear of sturdy construction, made of leather or other heavy, solvent-resistant material. Wear approved safety shoes when there is a risk of crushing or piercing. Prohibit personnel, including visitors, from entering the work area with sandals or open-toed shoes.

j. Wear appropriate clothing.

k. Wear hearing protection and/or respiratory protection as required by work authorization for operations that generate harmful noise, or airborne emissions. Contact the Industrial Hygiene Group for assistance in determining which operations require such protection.

l. Do not use audio equipment that obstructs the ear canal (e.g., iPods) or cell phone Bluetooth headsets while operating machine or power tools. Such devices distract the operator and can prevent him or her from hearing sounds that could provide warning of an unusual operating condition or someone calling out for assistance.

m. Prohibit personnel under the age of 18 from operating any machine or power tools.

n. Tie back or otherwise secure long hair; cuff or roll up long sleeves, and remove or tape down loose jewelry when working with rotating machinery.

o. Do not prepare or consume food or beverages in areas where hazardous materials (including oils, solvents, chemicals, cuttings, filings, and sawdust) are handled or generated. Designate a food and drink preparation/consumption area, if necessary, in an area that is kept free of hazardous materials at all times.

p. Where applicable, secure and clamp down work pieces in work-holding devices and machines, preventing the work from being lifted or dislodged.

q. Use appropriate push sticks or other approved methods as indicated in the work authorization to keep hands and fingers well away from moving or rotating cutters, blades, and other points of operation.

r. Turn off the machine before using a brush or wooden dowel (not hands!) to remove chips from the machining area. Chips are not only very sharp but can be hot and can snag.

s. Maintain good housekeeping. Work is not complete until cleanup is done. Debris, coolants, and lubricants put workers at risk of cuts or slipping, and can be a skin irritant.
Clean up the work area with a broom, brush, and dustpan, and clean up all spills with absorbents and/or degreasers. Avoid using compressed air to blow chips off machinery. Not only is this a hazard to the eyes, it forces material into the precision inner workings of the machine and often distributes coolant, oil, and chips over a larger area. Clean up the machine and sweep the floor area of any remaining chips.

14. HAND TOOLS

Hand tools are tools that are powered manually. Hand tools include anything from axes to wrenches. The greatest hazards posed by hand tools result from misuse and improper maintenance.

Some examples include the following:

- If a chisel is used as a screwdriver, the tip of the chisel may break and fly off, hitting the user or other employees.
- If a wooden handle on a tool, such as a hammer or an axe, is loose, splintered, or cracked, the head of the tool may fly off and strike the user or other employees.
- If the jaws of a wrench are sprung, the wrench might slip.
- If impact tools such as chisels, wedges, or drift pins have mushroomed heads, the heads might shatter on impact, sending sharp fragments flying toward the user or other employees.

All hand tools will be kept in a safe operating condition. Lab personnel shall not permit the use of unsafe hand tools. Students will be trained in the proper use and handling of hand tools. Staff and students, when using saw blades, knives, or other tools, should direct the tools away from aisle areas and away from other students working in close proximity. Knives and scissors must be sharp; dull tools can cause more hazards than sharp ones. Cracked saw blades must be removed from service. Wrenches must not be used when jaws are sprung to the point that slippage occurs. Impact tools such as drift pins, wedges, and chisels must be kept free of mushroomed heads. The wooden handles of tools must not be splintered. Iron or steel hand tools may produce sparks that can be an ignition source around flammable substances. Where this hazard exists, spark-resistant tools made of non-ferrous materials should be used where flammable gases, highly volatile liquids, and other explosive substances are stored or used.

For further operation, maintenance, and safety procedures, refer to Appendix E.

15. RADIATION

Not applicable to this site. No isotope use is planned at the facility. EH&S regulates all isotope work at the University.
16. REMOTE OPERATIONS

Not applicable.

17. RESPIRATORS

Should the site and EH&S determine that a respirator is required for a specific activity, EH&S will oversee medical clearance, training and fit test. If excessive dust is present, dust masks will be used by all affected workers. (http://www.ehs.unr.edu/Website/LinkClick.aspx?fileticket=SBX4%2bnaONyY%3d&tabid=61&mid=862)

18. SCAFFOLDING

Although, the site uses scaffolding to attach instruments only and is not intended to hold any personnel, any landing, stair platform, or balcony more than 48” above a surface must have guard rails 36” high, and intermediate rail and a toe rail. A scaffold competent person shall supervise the erection, alteration, moving, or dismantling of scaffolding. Scaffolding shall be constructed in conformance with manufacturers’ requirements. The installation should be on a solid surface, plumb and secured to a solid structure; the scaffold and, if needed, scaffold walk surface should be solid and constructed from materials specifically designed for that purpose.

For more information, check Scaffolding JHA/JSA at http://www.ehs.unr.edu/website/ProgramAreas/OccupationalSafety/FacilitiesJSAListing/Welding/tabid/250/Default.aspx

19. TEMPERATURE STRESS

Self-awareness is one of the key steps to reducing heat-related disorders. Although, the site maintains a reasonable level of inside temperatures for personnel, should any site personnel experience temperature/heat stress, they should immediately cease the activity and seek proper remediation. Supervisors should consider a worker’s physical condition when determining heat stress conditions. Obesity, lack of conditioning, medical conditions, use of medications, pregnancy, and inadequate rest can increase susceptibility to heat stress even in indoor office environments. Activity cannot resume until facility staff have evaluated the situation and put controls in place to prevent excess exposure.
Additional industrial hygiene practices and administrative and engineering controls are listed below.

1. Wear lightweight, light colored, loose clothing that allows free movement of cool dry air over the skin’s surface to allow the removal of heat from the body by evaporation. Evaporation of sweat from the skin is the body’s predominant heat removal system.
2. Drink plenty of chilled hydrating fluids such as water or commercial hydrating fluids to prevent dehydration. Since thirst is not a sufficient indicator of fluid replacement, workers are encouraged to drink about 1 cup of cool water every 15 to 20 minutes during heat stress conditions.
3. To increase evaporation and cooling of the skin, use general ventilation or fans for spot cooling.
4. Work demands should be made lighter by taking frequent breaks in a cooler area, completing them over a longer time period, and setting the work pace with the least heat-tolerant worker in mind.
5. Heavy workloads should be scheduled during cooler times of the day (i.e., early morning).
6. Employees should report to Health Services if they feel they are suffering from the onset of a heat-related disorder. In emergency situations, call 911.

Below is a table listing symptoms of heat stress and actions that should be taken.

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Health Effects, Signs &amp; Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fainting</td>
<td>Also called Heat Syncope, is a temporary condition occurring in un-acclimated workers. Blood pools in the extremities rather than returning to the heart to be pumped to the brain. Workers usually recover after lying down briefly. After recovery, moving around will help prevent further fainting.</td>
</tr>
<tr>
<td>Heat Cramps</td>
<td>Temporary conditions characterized by painful muscle spasms of the arms, legs, or abdomen during or after work. Reversible with prompt treatment. Cramps are caused when a person sweats and drinks water, but does not replenish salts (electrolytes) lost in the sweat. Treatment consists of rest, drinking electrolyte fluids or water contain ¼ tablespoon of table salt per quart, and removal from further heat exposure.</td>
</tr>
<tr>
<td>Heat Exhaustion or Heat Stress</td>
<td>Heat-induced illness that can cause serious injury. It occurs in workers who do not replace fluids and electrolytes lost through sweating. Symptoms include tiredness, weakness, thirst, and dizziness, with occasional headache, nausea, vomiting, diarrhea, and fainting. The skin is clammy and moist, complexion pale or flushed. Body temperature is normal or slightly high. Treatment includes rest, drinking balanced electrolyte fluids, and removal from further heat exposure. Employee should report to UNR Medical Center for observation and possible treatment.</td>
</tr>
</tbody>
</table>

continued on next page
<table>
<thead>
<tr>
<th>Heat Stroke</th>
<th>Heat stroke may be fatal unless promptly and adequately treated. Caused by a failure of the body perspiration mechanism resulting in accelerating rise in body core temperature. Symptoms include confusion, loss of consciousness, convulsions and coma. The skin is hot and dry, temperature is 104-106° F, pulse is rapid, and blood pressure falls. <strong>Call 9-911 immediately.</strong> The victim’s body temperature must be lowered as quickly as possible. Applying damp, cool towels, or ice packs to armpits, elbows, wrists, or backs of knees may help. Stay with the victim until medical help arrives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Rash</td>
<td>Also known as prickly heat, occurs in hot, humid environments where sweat cannot easily evaporate from the skin. A temporary, discomforting rash develops. Can be <strong>prevented and treated</strong> by resting in a cool place and regularly bathing and drying the skin.</td>
</tr>
</tbody>
</table>

### 20. VEHICLE EXPOSURE

The site does not own a vehicle, but uses a vehicle owned by the Department of Civil and Environmental Engineering. It is the responsibility of the department to regulate the use of the vehicle. The vehicle shall only be used for authorized official business and driven by qualified and authorized personnel in a safe and courteous manner. Smoking in the vehicle is strictly prohibited. The vehicle shall not be used for private use. Drivers must be an employee of the University.

### 21. WELDING SAFETY

**Policy** - Employees performing cutting and welding operations (commonly referred to as “hot work”), as well as their supervisors, are required to be suitably trained in the safe operation of the equipment used. Outside contractors and service personnel are expected to follow all OSHA requirements.

**Purpose** - Potential health, safety, and property hazards result from the fumes, gases, sparks, hot metal and radiant energy produced during hot work. The purpose of this policy is to prevent any fires or injury that may result from hot work processes, and to comply with OSHA regulations (29 CFR 1910.Subpart Q; 29 CFR 1926 Subpart J; 29 CFR 1926.350-354).

**Safety Requirements** - Prior to hot work being performed, several tasks must be completed. This includes, but is not limited to: Isolating the HVAC system for interior work, posting the hot work permit in a highly visible area, identifying and removing any fire hazards in the work area, and covering sprinkler heads and smoke or heat detectors to prevent accidental triggering.

Proper personal protective equipment (PPE) must be in use while performing hot work. This includes welding helmets, gloves, jackets, etc.
General Arc Welding Safety
a. Before starting any arc welding operation, a complete inspection of the welder should be made.
b. Read all warning labels and instructions manuals.
c. Remove all potential fire hazards from the welding area.
d. Always have a fire extinguisher ready for immediate use.
e. Equip welding machines with power disconnect switches which can be shut off quickly.
f. The power to the machine should be disconnected before making repairs.
g. Proper grounding of welding machines is essential.
h. Electrode holders should not be used if they have loose cable connections, defective jaws, or poor insulation.
i. An arc should not be struck if someone without proper eye protection is nearby.

Personal Protective Equipment
a. Infrared radiation is a cause of retinal burning and cataracts. Protect your eyes and face with a welding helmet properly fitted and with the proper grade of filter plate.
b. Protect your body from welding spatter and arc flash with protective clothing. Such as:
   i. Woolen clothing
   ii. Flame-proof apron
   iii. Gloves
   iv. Properly fitted clothing that is not frayed or worn.
v. Shirts should have long sleeves.
vi. Trousers should be straight-legged and covering shoes when arc welding.
    vii. Fire resistant cape or shoulder covers are needed for overhead work.

c. Check protective clothing equipment before each use to make sure it is in good condition.
d. Keep clothes free of grease and oil.

Proper Ventilation - Be sure there is adequate ventilation available when welding in confined areas or where there are barriers to air movement. Natural drafts, fans and positioning of the head can help keep fumes away from the welder's face.

Ventilation is sufficient if:
a. The room or welding area contains at least 10,000 cubic feet for each welder.
b. The ceiling height is not less than 16 feet.
c. Cross ventilation is not blocked by partitions, equipment, or other structural barriers.
d. Welding is not done in a confined space.

If these space requirements are not met then the area needs to be equipped with mechanical ventilating equipment that exhausts at least 2000 cfm of air for each welder, except where local exhaust hoods or booths, or air-line respirators are used.
Avoiding Electrical Shock - Electrical shock can kill. To prevent electrical shock:
  a. Use well insulated electrode holders and cables.
  b. Make sure welding cables are dry and free of grease and oil.
  c. Keep welding cables away from power supply cables.
  d. Wear dry hole-free gloves.
  e. Clothing should also be dry.
  f. Insulate the welder from the ground by using dry insulation, such as a rubber mat or dry wood.
  g. Ground frames of welding units.
  h. Never change electrodes with bare hands or wet gloves.
Appendices
Appendix A: Supervisor Accident Investigation Report

State of Nevada
SUPERVISOR ACCIDENT/INJURY/INCIDENT INVESTIGATION REPORT

Department/Division
Employee's Name
Sex
Age
Employment Status: Full Time
Part Time
Seasonal
Temporary
Regular assigned position
Length of time in this position
Was employee performing regular job duty?
If not, explain
Was employee working overtime?
If yes, explain
Does employee work a rotating shift?
Was there a recent change in the shift?
Location of accident
Time of Day
Day of Week
Body part injured
Type of injury
Severity of injury
First Aid
Dr. Visit
Emergency Care
C-1 completed
Yes
No
C-3 completed
Yes
No
Restricted Duty
Lost Time
Describe in detail what happened

Has this employee received training in the prevention of this type of injury?
Date

Describe any equipment damage/estimate cost

Page 1 of 3

WITNESSES: (Attach written statements. If non-State employee, include work or home address)

<table>
<thead>
<tr>
<th>Name</th>
<th>Job Title</th>
<th>Telephone</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Employee’s Supervisor at time of injury

CAUSES OF ACCIDENT/INJURY: Mark all that apply  D=Direct Cause  C=Contributing Factor

<table>
<thead>
<tr>
<th>Environmental:</th>
<th>Work Conditions:</th>
<th>Personal Factors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather conditions</td>
<td>Poor housekeeping/clutter</td>
<td>Unsafe act</td>
</tr>
<tr>
<td>Heat</td>
<td>Defective equipment/tools</td>
<td>Lack of knowledge/skill</td>
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<td>Cold</td>
<td>Inadequate work space</td>
<td>Improper motivation</td>
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<tr>
<td>Noise</td>
<td>Uneven/wet walking surface</td>
<td>Inadequate planning</td>
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<tr>
<td>Smoke/fumes</td>
<td>Inadequate prot. equip.</td>
<td>Fatigue/stress</td>
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<td>Dust</td>
<td>Inadequate lighting</td>
<td>Deviation from procedure</td>
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<tr>
<td>Third Party</td>
<td>Inadequate ventilation</td>
<td>Violation of safety rule</td>
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Other: |

Job Factors: |

Management Issues: |

Other Factors: |

Inadequate design | Insufficient training |
Inadequate equip/tools | Inadequate planning |
Inadequate procedures | Lack of program support |
Inadequate maintenance | Lack of enforcement |
Inadequate inspection | Budgetary constraints |
Inadequate purchasing | Understaffed |

WAS A NOTICE OF INJURY (C-1) FORM COMPLETED BY EMPLOYEE?  Date
CORRECTIVE ACTION PLAN (include immediate, short term and long term plan)

Immediate Action

Assigned To __________________________ Date Completed __________________________

Short Term Plan

Assigned To __________________________ Date Completed __________________________

Long Term Plan

Assigned To __________________________ Date Completed __________________________

ADDITIONAL INFORMATION:

Investigation completed by __________________________ Date __________________________

Reviewed by __________________________ Date __________________________

Note: Send copy of reports to Risk Management

Form RM-ACCINV (07-06)

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Appendix B: NEES@UNR Self Inspection Checklist

<table>
<thead>
<tr>
<th>Cables</th>
<th>Cranes</th>
<th>Forklifts</th>
<th>General Safety</th>
<th>Power Tools</th>
<th>All Power Cords</th>
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**Name:** ____________________________  **Date:** __________

### Safety Inspection Check List (Check All Shaded Boxes)

#### Cranes

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<th>North</th>
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<tr>
<td>Main</td>
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#### Forklifts

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<th>Brakes / Fluid Level</th>
<th>Engine Oil Level</th>
<th>Hydraulic Oil Level</th>
<th>Coolant Level</th>
<th>Lights / Gauges</th>
<th>Battery / Cable</th>
<th>Hydraulic Hoses</th>
<th>Lift Chain</th>
<th>Lift Bearings</th>
<th>Lift Operation</th>
<th>Throttle Operation</th>
<th>Propane System</th>
<th>Drain Air Tank</th>
<th>Roll Over Protection</th>
<th>Maintenance Due?</th>
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#### Power Tools

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All other Power tools are locked in a cage or keyed, and must be inspected every time upon their use.
Appendix C: Personal Protective Equipment (PPE)

Listed below are general types of PPE and situations in which they should be implemented. There are many specific laboratory practices that require the use of PPE; these are covered in individual training documents for all LSSL equipment and tools, which are available in the Laboratory Manager Office.

Gloves - Gloves are essential to many tasks in the laboratory. They can protect the hands from cuts, heat, chemicals, and abrasion. There are three main types of gloves used in the LSSL: Leather or canvas work gloves, impermeable nitrile gloves and heavy lined insulating gloves.

Leather or Canvas Work Gloves - Leather gloves are worn when performing tasks requiring the use of a shovel or broom or similar tool, material handling, rigging, driving the forklift, and a variety of other tasks. They will prevent cuts, blisters, abrasion and reduce pinching of the hands. Be careful to select a pair that fits properly and is durable enough for the task. Many employees use leather gloves for hot applications, when the temperature is not so hot as to require heat gloves, e.g. welding, cutting, heat-treating, etc.

Nitrile Gloves- Nitrile Gloves are chemically resistant as well as impermeable to water. They are absolutely required when there is a chance of skin coming in contact with acetone, xylene, kerosene, oils and other hydrocarbon based liquids or strain gauging chemicals. They may also provide comfort when wet cutting and grinding, as well as mixing or using cement products. Many employees like to wear a pair of Nitrile Gloves under a pair of Leather Gloves when seeking protection from abrasion and cold water.

Insulating Gloves - Heat Gloves are necessary when handling extremely hot steel or other hot materials. They provide excellent insulation from hot, dry surfaces, but provide very poor protection from liquids, and greatly limit dexterity.

Respiratory Protection - It is important to note that respirators serve to reduce the exposure to specific hazards but they do not eliminate them. There are three basic types of respiratory protection used in the Labs: Dust Mask, Particulate Respirator, and Organic Vapor Respirator. Dust masks are used voluntarily when performing some tasks. Situations which require the use of a disposable particulate respirator include grinding and mixing grout or concrete. The organic vapor respirator is used voluntarily for comfort when using chemicals with offensive odors. If a respirator is essential to your work, you must get fitted and tested by EH&S personnel. A respirator is a mask with a NIOSH rating. Some respirators are reusable and require cleaning and maintenance. Please consult the Laboratory Manager to obtain proper documentation and care procedures.

Dust Mask - A dust, or “nuisance” mask is a passive filter which traps dust particles by the wearer’s breathing action. It is effective only in low-hazard situations. It is not
effective against any chemical mists or fumes nor will it provide any protection from ultra fine dusts.

**Particulate Respirator** - The particulate respirator is a more snug version of the dust mask constructed of better filtering materials. Use this one when sweeping or working with cement, grout or fly ash, or when the dust mask is insufficient. These masks all must be sized and fitted to your face; they all have a NIOSH rating printed on the straps and/or the mask. Look for a “N or P95” or better.

**Organic Vapor Respirator** - The organic vapor respirator contains particulate pre-filter for specified dusts and mists and a charcoal filter (other types are also specified) to clean the air you breathe. Primarily, it is used to filter fumes from hydrocarbon-based solvents (such as mineral spirits etc.) and while gluing with non-water-based glues or when using many paints esp. spray paints.

**Hearing Protection** - There are many situations for which hearing protection is recommended in the lab. Much of our equipment and tools make enough noise to require hearing protection. Many variables, such as an individual’s ear shape or the type of noise being protected against, can lower the actual protection offered by a device by as much as 8dB. There are two basic types of hearing protection: in the earplugs and over-the-ear muffs.

**Plugs** - Plugs are rolled into a narrow cylinder and then inserted into the ear. Take care that your hands are clean and do not re-use earplugs more than for a day or two to prevent ear infection. The advantages of earplugs are that they permit the employee to wear other protection such as glasses, a hat, or a dust mask easily whereas earmuffs do not. In addition, they generally provide more hearing protection in terms of their NRR (Noise Reduction Rating) than do earmuffs. They can, however, cause some wearers discomfort.

**Muffs** - Ear muffs are useful when the employee cannot use plugs and/or where other protection is not necessary, for instance, going to get someone for a phone call or to answer a question. They are not generally recommended for longer term use. If you only use muffs, be sure you know the rating, proper use, and upkeep procedures.

**Eye/Face Protection** - Eye and face protection is necessary when using compressed air devices, any power tools, any cutting tools, hammers, and anywhere else where objects might be flying or chipping. There are three types of protection discussed here: safety glasses, safety goggles, and face mask.

**Safety Glasses** - Safety Glasses are plastic glasses with shatter resistant lenses. They must be stamped with a “Z87” mark to be NIOSH compliant. Safety glasses are worn for many of our operations at the lab. Prescription glasses are not sufficient to protect against injury from flying objects and are not considered adequate protection unless
they have the Z87 stamp and the side shields have not been removed. If your work requires use of safety glasses, be sure others in your vicinity are also protected.

**Safety Goggles**- The protection safety goggles provide surpasses that of safety glasses. Safety goggles fit close to the face and have a plastic flange to form a seal around the eyes. Many goggles will protect against wet debris or chemicals splashing into the eyes. Some workers, especially those with prescription glasses, should choose to use goggles instead of safety glasses because of their comfort and efficiency. *A NIOSH “Z87” stamp must be on the goggles used in the labs.*

**Face Shield** - A Face Shield is a shatter resistant lens that covers the whole face much like a welder’s visor in shape. It is useful for sawing and essential for some grinding applications and should be used along with safety glasses or goggles. Safety glasses/goggles are primary protection, *a face shield is secondary – protection to be worn over the primary protection.*

**Coveralls** - Coveralls are a helpful personal protection device. They are not required for any operation, although it is required that employees wear long sleeves and pants when working with hot materials grinding or wet concrete, and coveralls are the most convenient way to do this without ruining personal clothing. They may also give limited protection against chemical splashes.

**Foot, Head & Knee Protection** - Rubber boots are can be made available in the lab for wet or oily operations such as cutting, hydraulic plumbing, washing tools, or mixing concrete. Generally, the heavier the work, the heavier the shoe. Leather, *steel toed boots or shoes are required for all lab work.* Special protectors can be purchased for welding, cutting or to provide metatarsal protection. *Hardhats are always worn in any environment where anyone is working above you and when you are performing any kind of work that could result in a head injury from falling debris, tools rigging etc.* Knee protection is very important if you will be kneeling for extended periods of time or for activities like tying steel.
Appendix D: Proper Use of Power Tools and Lab Equipment Activities

Grinder Wheels, Abrasives & Diamond Blades - Diamond blades and bits, cut-off wheels and grinding wheels are a chemical hazard and as such are supplied with an MSDS. The main concern is the matrix used to hold the blades together or to bond the abrasives to the blade. When cutting or grinding, a potentially hazardous dust is created. If possible, use a wet cutting method, meaning that water is used to cool the blade and in addition minimize the amount of dust created.

For protection, wear a dust mask or particulate respirator when cutting or grinding metals and concrete or cleaning grout in addition to the other protection equipment listed in the physical hazards section of this manual. Cutting and grinding is to be done outside whenever possible. It is important to cover your skin to prevent grinding particles from embedding in your skin. Always wear Safety Glasses and hearing protection.

Physical Hazards / Physical Operations - There are numerous pieces of equipment and tasks which may constitute a physical hazard. Never operate any equipment or perform any task with which you are not trained and familiar. Protection: Always wear the appropriate protection for the equipment you are working with.

Drilling - Drilling is a safe operation when certain guidelines are followed. For hand-held and portable drills before each use inspect the electrical cords for unbroken insulation and insure that a grounding plug is in place. Double insulated tools will have no grounding plug. Cords must be kept out of water and must be the correct gauge for the tool and length used. Check the MSDS on cutting materials for chemical hazard information. It is essential to the success of your operation to learn to identify cutting tool defects: the bits must be properly sharpened with the correct geometry for the material you wish to machine. Protection: Safety glasses and leather gloves are required. Hearing protection is recommended. Dust mask is optional for metals. With dry drilling nonmetals, a particulate respirator is recommended. Appropriate boots and clothing for the task and conditions.

Rotary Hammers - These are extremely versatile tools for drilling and chipping concrete and scraping. They are high torque, heavy tools. Match the speed to the task. Start with a slow speed to center the bit. Bits can and will bind when they hit rebar BE SURE the tool is properly braced to avoid injury to your limbs. Do not attempt to force the bit through rebar, if you cannot reposition the hole, you must use a special rebar cutter.

Handheld Cordless Drills – These drills are to be use for light duty application, and are available upon special request only. Use should be limited to screw driving, small fastener assembly, and drilling holes smaller than 3/8” in soft material.

Handheld Power Drill – This drill is used for medium duty applications, and is the only drill you should use to with a mixing wand for mixing grout. Be sure to properly protect the drill body and controls from the grout mix. Always thoroughly clean after each use.
**Saw Cutting** - Cutting can be a physically hazardous operation at the lab. For all saws except the stationary saws, electrical cords must be inspected to verify unbroken insulation and proper grounding before use. Also insure that cords are kept out of reach of water and the cutting blade. Be sure to use appropriate extension cord gauge for the tool and the distance. Inspect all saws and blades before using. Look for proper functioning and placement of guards and make sure blades are not bent or chipped. If cutting generates dust, wear a particulate respirator. Check the MSDS to answer questions regarding the materials to be cut and dust generated by the cutting blades or wheels. **Protection:** Safety glasses are required. Hearing protection and dusk mask is recommended.

**Reciprocating Saw** - There are a huge variety of blade types and configurations for this tool. The blade may be reversed to allow difficult access cuts. Jig-saw type blades are available for this saw. Cuts with this saw can get extremely hot. It is very easy to pinch the blade with this tool. Be ready for this saw to kick-back, correctly position your hands and elbows to safely absorb this motion.

**Abrasive Chop Saw** - Do not use this saw inside the lab. Sparks from your cut can fly 30 feet; take the appropriate measures. Be sure your work is properly clamped. This is the saw of choice for cutting: rebar, all-thread and steel cables. Protect yourself from the noise, dust and sparks. Check the abrasive wheel for damage or cracks: replace damaged wheels. When you trigger this tool stay to the side of the abrasive wheel until the wheel comes up to speed. Follow this rule for using ANY tool that uses abrasive wheels of any type.

**Portable Band Saw** – This tool is fairly heavy and awkward, but useful for quick cuts on material that cannot be positioned in a chop saw. This tool is for metal only. Be sure the reaction bar is against the work piece and the bladed is not when beginning a cut. Also, great care must be taken to insure the blade is not binding in the cut.

**Circular Saw** – Used commonly for cutting form boards, frames and plywood sheeting, this tool is preferably for use outside. It is to be used on wood only for straight cuts. Be especially mindful of the proximity of the power cord to the blade, and be sure the blade depth setting is not such that it will impact the ground or working surface.

**Lathes & Mills** - To master the use of these tools requires professional vocational school and usually an apprenticeship of some kind. Both lathes and mills have many functions and moving parts usually with three ranges of motion: the X, Y, & Z axis. The power to these machines is turned off when setting up and fixing the work and when changing cutters. These machines need to be kept clean and the work area needs to be kept clean and dry. They are specifically for the scheduled use of Lab Staff only. **Protection:** Proper Shoes and clothing required.

**Cement & Grout Mixing** - Cement mixing and grouting includes: batching, mixing, pouring, finishing, filling molds, curing, and de-molding. Batching is the weighing or measuring and assembling of the dry ingredients. This is a dusty activity. Mixing is a short but intense process.
In most cases there is very little time to remove the mix (from the mixer or from the container or bucket) before it sets. Work crews must work very quickly while shoveling, pouring or troweling the wet mix. Always be aware of your body mechanics. Choose tools that fit your hand and shovels that match your height and arm length. Do not lift things that are too heavy for you; instead, get help from co-workers. Whenever possible use carts for transporting buckets or containers, take breaks as needed, and remember to bend from the knees.

Grouting and cement mixing is a messy process. The bagged mix is extremely fine grained and irritating to your eyes, nose, mouth, throat and lungs; you'll need to wear a particular respirator. The rocks and sand in aggregate based mixes are also very dusty. Since wet concrete is corrosive take care to avoid touching it or getting it on your skin or in your eyes. Always wear nitrile gloves, goggles, and coveralls. Wet cement and grout are harmful and dangerous to the environment. There are specific cleanup procedures to prevent concrete and grout from flowing into sinks or drains. Be sure to do all washing outside at wastewater collection tubs or create a berm using sandbags to prevent any mix from going into any storm drains. It is illegal and irresponsible to allow discharge into storm drains. Once concrete or grout is completely dry, it is no longer considered hazardous and thrown away as regular trash. Unused materials must never be stored above face height. **Protection:** Nitrile or leather gloves required as per job. Particulate mask is required when batching and mixing. Safety goggles required when mixing and pouring. Hearing protection recommended as per job. Hard Hat recommended as per job conditions.

**Concrete Mixers** - Only those who are experience and authorized should operate a concrete mixer. One person should be standing at the controller at all times. This is to insure that someone will be able to shut down the mixer in case of emergency. Do NOT touch the controller box unless instructed to do so by the mixer operator. Hard hats, nitrile gloves and ear protection are required at all times. Watch for moving parts and never attempt to catch falling barrels when they are full. When the mixing and placing is complete, clean the mixer, tools, containers and return them to their proper stations.

**Batching & mixing small quantities** - All the materials begin on the ground. Be aware of the dusty nature of all the materials. The cement and grout bags have a certain weight, (if used sand and aggregates will have to be weighed or measured) and liquid ingredients are measured proportional to your mix quantities. Be fully cognizant of your capabilities and proper physical mechanics when lifting, mixing, pouring, shoveling and trowelling. When making smaller batches, you may not necessarily use an entire grout or cement bag, so make sure that you properly open the bag so that it is easily resealed. Make every effort to minimize the dust. Once your pour is complete, you should immediately begin your clean up. It is critical clean up when your mix still in a plastic or at least uncured state so that you can minimize dust in or around the lab. Use water as needed taking note of the previous cautions. Unused materials must be restocked and NEVER stored above face height.

**Oxygen Acetylene Cutting & Welding** - Only professionally trained personal should ever use these tools and equipment. These tools require proper vocational education for safe, efficient
operation. This means you must demonstrate a working knowledge of safety and operation to use these tools. Compressed gasses, carbon monoxide, material handling, fire protection, leak detection and many more all are health and safety issues hazard. Acetylene bottles are to remain in the upright position. When transporting compressed gasses, all hoses and gauges must be removed from bottles or tanks. **Protection:** Safety glasses are required as primary protection. Under #5 or better lens goggles for torch work. Special clothing and shoes required leather heat-gloves required. Determine what type of respirator (and if this protection is needed) for the material or conditions.

Whenever possible, mechanically extract fumes and dust. Discontinue use if you develop any signs of carbon monoxide exposure such as headache, nausea or light headedness. Have a fire watch if needed. NEVER attempt to use these tools in confined space without the proper permits and protocol. It is a basic requirement to purge the lines and gauges after use and to stand to one side (of the gauges) when pressurizing. Fuel gasses will never be stored with accelerants (empty or full). Bottles will be secured with two chains (empty or full) and tagged ‘E’ or ‘F’ with chalk.

Be sure the area of operations is properly secured at all times when. Never begin without proper and appropriate communication with other employees and others in your area.

**Pre-stressing Tendons** - The process of pre-stressing (steel cable, rods or “tendons”) develops forces sometimes exceeding 100kips per rod. If a tendon breaks with these forces fully applied (vertically) the tendon will likely shoot through the roof of the lab or it will hit the bridge crane or framing members of the lab. Extreme caution is used during this process. The tendons are to be examined for defects if they are new or used. Be sure that no one is in the line of force when pre-stressing. Double check the calculations for the size rod you are using and be sure you are well within the safety factors. Be sure you are using the appropriately sized jack and that the hydraulic lines and fittings are in good condition. The jack pressures can reach 10,000psi. If oil is ever gets injected under your skin: this is a MEDICAL EMERGENCY: seek critical care. Be 100% confident that you have received enough training and have signed off on the appropriate training forms. The tools and jack must be properly supported when you are working overhead. Remember to stay out of the line of force when pre-stressing the tendons. Use appropriate lubricants and tools to tighten and loosen the nuts when stressing and un-stressing. Watch for pinch points. Be sure the chair is bearing fully on the plate. **Protection:** Hardhats, Safety glasses, and steel toed shoes required.

**Welding & Welding Machines** - To master the use of these tools requires professional vocational school and usually some sort of apprenticeship program. In general: use a fire-watch if necessary, be sure the smoke and fumes you generate are properly extracted, safety glasses are your primary protection and your helmet is secondary. Safety glasses also provide a measure of flash protection. Appropriate respiratory protection may need to be worn. If you are in a hardhat area be sure to use welders hardhat Never get between the arc and the ground i.e. if you are welding on top of a large plate, you must insulate yourself from the plate. Never weld in a confined space without a permit. Welding in a non-permit space automatically turns it into a permit-required space. Always erect arc protection in your work area. Never weld on top
of drums. **Protection:** Welders gloves, clothing, helmet, shoes, safety glasses, respirator and extensive skills training required.

**Hydraulic Wrench & Torque Multiplier** - The training for the hydraulic wrench is to protect both the operator as well as this very expensive tool. Use the same cautions as for the pre-stressing jacks. Before the hands on training you will read the manual. The head of the wrench articulates in several directions and the danger of being caught in a pinch-point is therefore increased: stay alert and vigilant. Be sure the socket is fully engaged with the fastener after each cycle. **Protection:** Safety glasses required. Gloves recommended.

**Torque multiplier** - This gear driven tool is actuated using a calibrated torque wrench and has a reaction bar that must be securely placed so as not to slip and injure the operator or damage the tool. The operating instructions will be read prior to the hands on training. If the square drive should fail (as it may do by design at maximum levels) be sure another one gets ordered BEFORE you install the spare and continue. To prevent a potentially serious injury: review the warnings in the manual each time you use this tool.

**Torque wrench** - This tool is for accurate loading and is not a general purpose wrench. You will only use this tool after you have been trained and only for setting torque values. Use of socket extensions and angle adaptors will change your torque values. !?!

**Testing Machines** - Most of the testing equipment at the lab requires extensive training in the software and hardware involved. They operate on programs with servo-hydraulic actuators (this means they can kill you without warning if you are not careful). Take care that hands and body parts are never in the direct path of any active component. The computer could malfunction and cause a serious injury. When more than one person is working with a particular machine, one person is in charge and keeps the other employees aware of the machine’s state. Everyone must know where the others are in relation to the danger zones.

**Construction of Specimens** - Construction trades and builders safety should be specifically addressed as part of the planning process of each project. The degree of your involvement will **determine the requisite training protocol.** One of the leading causes of serious injuries on the job are falls from ladders, scaffolds and platforms, followed closely by material handling injuries and injuries from falling objects, sharp objects and slips and trips (very often caused by dirty and disorganized job sites). Efficiency is greatly increased and the incidence of injuries is greatly reduced, by keeping the site clean and organized on a daily basis.

**Concrete Blocks** - Loading the specimens often requires the use of pre-made concrete blocks. The weight is marked on the side of these blocks. The condition of the rigging anchors needs to be determined before moving the blocks with the crane. Rigging will be done only by trained/skilled and experienced employees.
Lead - Loading the specimens often requires the use of lead ingots, bars and billets. Lead handling requires EH&S training as per university requirements in addition to the material handling training received in the lab.

Scaffolds - Any landing, stair platform, or balcony more than 48” above a surface must have guard rails 36” high, and intermediate rail and a toe rail. Experience professionals will erect scaffolding on a solid surface. The installation should be plumb and secured to a solid structure; the scaffold and scaffold walk surface should be solid and constructed from materials specifically designed for that purpose.

Ladders - There are many types of ladders used in the labs. Often, the least understood is the extension ladder: you will be trained how to place this ladder at the correct angle. Defective ladders will be repaired or thrown away. In general, an extension ladder should be extended 3’ above the landing point (such as the top edge of a test specimen) and then secured tightly to the landing area. Only one person is permitted on a ladder at a time. Tools and materials should not be carried up a ladder, use a rope, properly tied to the tools or materials and hoist them up.

Forklift - Only Lab Personnel may use the Large Forklift (‘Bertha’). Only Users who have been trained and certified by EH&S may use the Small Forklifts after familiarization with lab specific equipment. The Small Forklifts shall not be used in the basement, except by Lab Personnel. When operating the lift inside the labs, ventilation fans must be turned on, as needed, to minimize exposure to carbon monoxide and to prevent any buildup of carbon monoxide gases in the confined space areas. The LP gas must be shut off each time after the Forklift is operated. Use caution when operating the all forklifts around hydraulic actuators, controllers, data acquisition systems or hydraulic lines. Personnel approved for using a lift basket will need to wear fall protection equipment.

Each forklift is inspected before each use and is formally inspected weekly by laboratory staff. Inspections assess the visible hydraulic lines and fittings, as referenced in the inspection sheet. Maintenance is performed by a certified forklift mechanic at intervals specific to each piece of equipment. Records of inspections and maintenance are available with the Laboratory Manager. The three diesel forklifts are refueled by a petroleum distributor and fuel for the propane forklift is stored and transported by LSSL staff according to Section VII, Subsection F.

Air Compressors / Air Tools - The various air tools and the use of high pressure compressed air presents potential hazards. Check the pressure rating of tools prior to use. Check to ensure all fittings, hoses, tanks, and quick disconnects are in good order. Be sure you know where the emergency shut off is. When using ¾” or larger hoses, many connectors require a pin to secure the connections (some must be lashed together) be sure you know how to properly connect the style you are using. Understand how to properly oil and inspect tools and lines for damage or malfunction. **Protection:** Safety Glasses required. Hearing Protection recommended/required as per job.
Air hoses - All air hoses must not leak and must have undamaged fittings. If you cannot release or connect hoses by hand, find someone who is more familiar with the type of fittings being used to assist you. Never use pliers or wrenches with these connections. When setting up your job, always lay out your hoses in a manner that minimizes tripping hazards. After each use (and absolutely at the end of each day) carefully wrap up the hoses into 1’ dia. coils and hang them up (keep them off the ground).

Die grinders and high speed air tools - These tools require lower pressure than our system pressure: always use regulator to step down the line pressure. These tools operate at 10-50,000rpm thus, can be very hazardous if damaged. Always inspect the tool housing and tooling for any sign of damage and to be sure fittings and connections are secure. If seals are ruptured, housings cracked etc. Do Not Use. Tag all damaged tools and notify the person who can initiate the repair/replacement process.

Hydraulic Actuators - The hydraulic actuators in the labs come in many sizes. The plumbing is sophisticated and the installation is seldom easy or straight forward. Experienced professional lab personnel will direct the installation, service, plumbing and operation. The installation lead persons will most often need experience and expertise in many aspects of the lab operations.

Pry bars & Sledgehammers - Pry bars and sledgehammers are used to both assemble and disassemble, for alignment as well as for demolition. Inspect the integrity of their blades and handle-head connections before use. Their misuse can hurt other employees and can cause chips to fly into the eyes. You will be instructed on how to move your body correctly when you swing a heavy hammer to prevent the hammer from ever deflecting into your body or legs. Protection: Safety Glasses required. Leather Gloves recommended.
AXES AND HATCHETS

Axes are made in various patterns and head configurations. The more widely used types are illustrated. Hatchets are made in an even greater variety of patterns, since specific types are intended for use by various tradesmen (carpenters, roofers, dry wall installers, rig builders, etc.). Handles may be wood, tubular or solid steel, or fiberglass. Tubular steel, solid steel and fiberglass handles are generally furnished with rubber-type grips.

Proper Uses. The double bit axe is usually used to fell, trim or prune trees and to split and cut wood. It is also used for notching and shaping logs and timbers. The single bit axe, in addition to the above uses, is used to drive wood stakes with the face. Hatchets are used for cutting, splitting, trimming and hewing, and driving unhardened nails and stakes with the striking face.

Abuse/Misuse. The cutting edges of axes and hatchets are designed for cutting wood and equally soft materials. They should never be struck against metal, stone or concrete. The striking faces of hatchets are properly hardened for driving common nails but should never be used to strike chisels, punches, star drills or other hardened metal tools, or for striking stone or concrete. Never use an axe or a hatchet as a wedge or a maul. Never strike with the sides, and never use an axe or hatchet with loose or damaged handle.

WRONG

When to Replace. Discard any axe or hatchet if it shows deats, cracks, chips, mushrooming or excessive wear. If handle only is damaged, replace it with an equivalent new handle. Cutting edges may be redressed if properly done. See instructions in Section V.
BLACKSMITHS’ PUNCHING ROUND

Blacksmiths’ round and backing out punches are made from a solid piece of steel. The punch end of the round punch is tapered from point to body, whereas the punch end of the backing out punch is the same diameter from point to body. Both types are fitted with handles.

Proper Uses. Blacksmiths’ round punches are designed for drifting holes, aligning and driving pins.
Blacksmiths’ backing out punches are designed for backing out bolts, rivets and pins.
Abuse/Misuse. Never use a punch with a mushroomed struck face or a chipped or deformed point. Never use a punch with a loose or damaged handle.

When to Replace. Discard any punch if it is bent or shows dents, cracks, chips, mushrooming or excessive wear. If point end is deformed, it may be redressed as instructed in Section V. If handle only is damaged, replace it with an equivalent new handle.
DRIFT PINS

Drift pins are made from round steel stock. The Plug or Standard type has an abrupt taper at one end and a longer taper at the other end. The Barrel type has equal tapers at both ends.

Proper Uses. Drift pins are designed for aligning holes in metal.

Abuse/Misuse. Never use a drift pin as a punch. Never strike a drift pin if either end is chipped or mushroomed.

WRONG

When to Replace. Discard any drift pin if it is bent or either end shows dents, cracks, chips, mushrooming or excessive wear. Deformed points may be redressed as instructed in Section V.
ALL-STEEL WOOD AND RIPPING CHISELS

This type of wood chisel is made from a single piece of steel comprising blade, handle and struck face.

Proper Uses. These are heavy-duty wood cutting tools designed for rough work.

Abuse/Misuse. Never use an all-steel chisel with a mushroomed struck face or a chipped or dull cutting edge. Never use on metal.

When to Replace. Discard any chisel if it is bent or shows dents, cracks, chips, mushrooming or excessive wear. If cutting edge is dull, it may be redressed as instructed in Section V.
BRICK CHISELS AND BRICK SETS

These types of chisels and sets are made from a single piece of steel comprising blade, handle and struck face. The chisel has a double bevel, the set, a single bevel to form the cutting edge.

Proper Uses. These chisels and sets are designed for scoring and cutting, adjusting and trimming bricks or blocks. They should be struck with a hand drilling hammer or sledge-not a bricklayer’s hammer or a nail hammer.

Abuse/Misuse. Never use these tools on metal—they are strictly masonry tools. Never use a chisel or set with dull cutting edge or with chipped, battered or mushroomed struck face.

WRONG

When to Replace. Discard any chisel or set if it is bent or shows dents, cracks, chips, mushrooming or excessive wear. Dull cutting edges may be redressed as instructed in Section V.
COLD CHISELS

With the exception of the blacksmiths’ pattern, cold chisels may be made from round, square, hexagon or octagon steel stock. The blacksmiths’ cold chisel is fitted with a handle.

Proper Uses. Cold chisels have a cutting edge at one end for cutting, shaping and removing metal softer than the cutting edge itself such as cast iron, wrought iron, steel, bronze, copper, etc. and a struck face on the opposite end.

Abuse/Misuse. Never use cold chisels for cutting or splitting stone or concrete. Never use a dull chisel or one with a mushroomed head. Never use a blacksmiths’ cold chisel with a loose or damaged handle.

WRONG

When to Replace. Discard any chisel if it is bent or shows dents, cracks, chips, mushrooming or excessive wear. If handle only is damaged, replace it with an equivalent new handle. If cutting edge is dull, it may be redressed as instructed in Section V.
Hand punches are made in the various patterns illustrated from square, round, hexagon or octagon steel stock.

Proper Uses. Punches are designed to mark metal and other materials softer than the point end, drive and remove pin and rivets, and align holes in different sections of material.

RIGHT

Abuse/Misuse. Never use a punch with a mushroomed struck face or with a dull, chipped or deformed point.

When to Replace. Discard any punch if it is bent or shows dents, cracks, chips, mushrooming or excessive wear. If point is dull or deformed, it may be redressed as instructed in Section V.
HOT CHISELS

Hot chisels or hot cutters are very similar to blacksmiths' cold chisels except that the cutting edge or bit is wider and the blade is thinner.

Proper Uses. Hot chisels are designed for cutting hot steel.

Abuse/Misuse. Never use hot chisels for cutting cold metal, stone or concrete. Never use a dull chisel or one with a mushroomed head. Never use a chisel with a loose or damaged handle.

WRONG

When to Replace. Discard any chisel if it is bent or shows dents, cracks, chips, mushrooming or excessive wear. If handle only is damaged, replace it with an equivalent new handle. If cutting edge is dull, it may be redressed as instructed in Section V.
STAR DRILLS

The cutting end of a star drill resembles four chisels joined at their cutting edges to form a cross.

Proper Uses. Star drills are designed for drilling holes in masonry (stone, concrete, brick, etc.). They should be struck squarely with a hand drilling hammer or sledge, and the drill should be rotated after each blow.

RIGHT

Abuse/Misuse. Never use a star drill on anything but masonry. Never use a star drill with a dull cutting edge or with a chipped, battered or mushroomed struck face.

When to Replace. Discard any star drill if it is bent or shows dents, cracks, chips, mushrooming, or excessive wear. If cutting edges are dull, they may be redressed as instructed in Section V.
DO'S AND DON'TS WHEN USING CLAMPS

- Store C-clamps by clamping them in a rack, not in a drawer.
- Use pads with C-clamps to avoid marring the work.
- Discard any clamp that has a bent frame or a bent spindle.
- Do not use a wrench, pipe, hammer, or pliers, to gain extra tightening; a wrench should be used only on those clamps especially designed for tightening with a wrench.
- Keep all moving parts lightly oiled and clean; however, make sure there is no dirt or oil on any part that will come in contact with the work.
- Make sure swivel at end of the screw is turning freely before using.
- Never use a C-clamp for hoisting work. Special lifting clamps are made for this purpose.
- Avoid using extra large clamps just for the sake of their large throats; instead use deep-throat clamps.
- Never use a C-clamp for hoisting or for supporting a scaffold or platform that may be used to carry people.
- Do not use C-clamps for securing a load that may be carried over a public highway; vibration may cause the clamps to loosen and the load to break loose.
- Always remove clamps as soon as the required job is finished. Clamps serve only as temporary devices for holding work securely in place.

FIG. 64. Careful Cal knows enough to use the right size clamp and he places scrap wood under the clamps to avoid marring the surface of the work.

RIGHT

FIG. 65. Too big a clamp, and too much pressure will leave a dimple in the work. Hazardous Harry never seems to have heard that pads should be used with C-clamps to avoid dimples.

WRONG
DEEP THROAT C-CLAMPS

As a general rule, the larger the clamp, the deeper the throat. However, there is no need to go to extra large C-clamps just for the sake of the extra wide throat capacity that may be needed. The job can quite often be accomplished by using special C-clamps that have an extra deep throat, even though their overall size may be quite small in relation to its throat.

FIG. 49. How a number of C-clamps can be used to apply pressure to the center of a panel. The 1x2-in. boards transmit the pressure applied to them by the C-clamps to the 1x3-in. board in the middle. This technique is useful when gluing up large panels for veneering a door.
HANDSCREW CLAMP

The hand screw can be used to clamp work whose sides are not parallel to each other. This clamp has two screws, one with a left-hand thread and the other with a right-hand thread. The openings through which the screws pass are slightly elongated so that the jaws can assume a non-parallel position – if necessary – to match the surfaces of the work. The jaws move in opposite directions due to the action of the right-and-left hand threads as the handles are turned.

Keep the threaded rods of these clamps lightly oiled. But make certain that there is no oil on the jaws; and keep the jaws smooth to protect the work.

FIG. 66. The hand screw can be adjusted to clamp work whose sides are not parallel to each other. The smooth, hard wood jaws protect the finish of the work by spreading the pressure over a broad surface. One end of each spindle has a left-hand thread, the other end, a right-hand thread.
MACHINIST’S CLAMPS

Machinist’s Clamps somewhat resemble C-clamps but are made entirely of drop-forged steel. Their jaws are parallel to each other; they cannot be set to non-parallel positions. Two screws, one in the center and one at the end are used to tighten the clamp against the work.

Always choose a clamp in relation to the work involved. Too large a clamp may prove to be an awkward obstruction causing hazardous working conditions, while too small a clamp will not provide adequate pressure to hold the work securely.

FIG. 48. The Machinist’s Clamp, designed for pattern-making and machine shop use, is made of tough steel and heat treated for extra strength.
MITER CLAMPS

The Miter Clamp is used to apply pressure to all four joints of a square or rectangular frame simultaneously. Two fairly common types are illustrated. However, ordinary C-clamps can also be used rather effectively to glue up corner joints as shown in the drawing on the next page.

Caution: Test for squareness at each corner before applying final pressure.

FIG. 57. This clamp is especially designed to apply pressure while gluing up mitered corners (such as picture frames). A thumb nut is at each corner. This clamp can also be dismantled for use when all four clamps are not needed as shown in the drawing to the right.

FIG. 59. How ordinary C-clamps can be used to apply pressure for gluing up a mitered corner.

FIG. 60. The three-way Clamp. An ingenious clamping device that allows pressure to be applied in two directions as shown. Extremely handy for applying veneers to table edges.

FIG. 61. Types of handles used to tighten C-clamps and bar clamps.
PIPE CLAMPS

A close relative of the bar clamp is the pipe clamp or gluing clamp. It is used with ½-inch or ¾-inch threaded pipe. The pipe is screwed into a fixed jaw and a movable adjustable jaw is installed on the other end of the pipe. In use, the adjustable jaw is pushed up to the work and the handle or crank of the clamp is turned to secure the work. The capacity of the pipe clamp is only limited to the length of the pipe available.

FIG. 53. These pipe clamps operate on the same principle. Their mechanism is mounted on half-inch or three-quarter-inch pipe. The clamp has its threaded part screwed to the end of the pipe while the back-up part can be slid along the pipe to the desired spot.
SPRING CLAMPS

While most people associate spring clamps with light-duty work, some spring clamps exert so much pressure that two hands are needed to open their jaws. These clamps range in capacity from one to four inches and are available with vinyl padded jaws to protect the work. Use them only where moderate pressure is required for gluing or for holding work in place while some other operation is to take place.

FIG. 56. The spring clamps are not to be sneezed at — they are for clamping! They range in capacity from one to four inches and are generally used for light-duty clamping. The holes at the handle ends are for hanging them up when not in use.

FIG. 58. The Corner Clamp has a dual function. It can be used to hold mitered corners together while the glue sets and it can also be used as a jig for cutting 45 degree miters.
WEB CLAMPS

These clamps have a heavy-duty nylon strap which is wrapped around the work to be glued or held together. By means of a ratchet, the web, or strap is drawn together to apply the required pressure. The web clamp is especially useful for gluing up large work (such as the outside edge of a table) as its capacity is limited only to the length of the strap.

Caution: Inspect the web for fraying or cuts before applying pressure as the ratchet action of the clamp develops tremendous pressure.

Keep these clamps rolled up when not in use. Be sure you remove all tangles and knots before applying to the work. The nylon belts are tightened with a small wrench while the heavy-duty canvas belts are tightened with their own built-in clamping handles.

FIG. 54. The Web or Strap Clamp is made of nylon. Its great advantage is that it can be used to apply pressure to large and oddly shaped work.
WELDER’S C-CLAMPS

Welder’s C-Clamps are specially protected to prevent welding spatter from adhering to and eventually ruining the clamp. Its parts may be coated with a splatter-resist plating (copper or cadmium). In addition, welder’s C-clamps are made with shields to protect the crew against damage.

FIG. 50. The Welder’s Clamp.

FIG. 51. Another type of welder’s clamp especially handy for holding odd-shape work.
WELL DRILLER’S CLAMPS

This clamp is specially designed for holding and lifting pipe vertically. Pipe jaws are corrugated perpendicular to pipe. Do not exceed manufacturers’ recommended limits for holding or lifting pipe.
BAR CLAMPS

A variation of the C-clamp is the bar clamp which consists of a steel bar with a fixed jaw at one end and a sliding or adjustable part that has a screw with a handle and swivel. In use, the sliding part that has the screw is pushed up to the work and then the handle is turned to tighten the clamp. Bar clamps vary in size from six inches to six feet in length.

Many bar clamps have disc clutches in the sliding jaw to engage the clamp at any place on the bar. These clutches provide rapid adjustment in addition to secure hold. Certain bar clamps use an "T" shaped bar which provides great strength for its weight. A crank handle is used for applying the final pressure.

FIG. 52. The bar clamp is extremely useful for gluing up extra wide work, as shown above.
C-CLAMPS

The most common clamp is the C-clamp. C-clamps vary in size and strength from a 3 oz. aluminum clamp with a 3/4" opening to a 40 lb. heavy-duty drop forged steel C-clamp with a 12" opening. C-clamps generally have four parts: the frame, the screw, the handle and the swivel pad. The frame is usually made from stampings, castings and drop forged steel. Generally drop forged steel provides the most strength. Most clamps have a sliding crosspin handle or a wing nut for tightening the clamp. Certain heavy-duty clamps have screws that end in a square head and the tightening is done with a wrench. The swivel pad at the end of the screw allows the clamp to position itself on non-parallel work and prevents work from being marred. Certain C-clamps designed for heavy-duty applications are designed without swivel pads.

The C-clamps, like any fine tool, can be damaged by rough handling, improper job selection, and overloading. Keep C-clamps in racks when not in use to protect them from damage. Use clamps of the proper capacity. You wouldn’t drive a railroad spike with a tack hammer – and neither should you use a light-duty clamp for a heavy-duty application or a large, heavy-duty clamp where a small light-duty clamp would do the job.

FIG. 46. This type of extra heavy-duty forged steel clamp uses a wrench for tightening.

FIG. 47. Typical C-clamps.
CLAMPS

Clamps are versatile tools that serve as temporary devices for holding work securely in place. They are used for many applications including carpentry, woodworking, furniture making, welding, construction and metal working. There are many clamp styles including C-clamps, bar clamps, pipe clamps, hand screws, etc. In selecting the proper clamp style and size, match the work-holding requirements of the application with the following clamp features:

- strength and weight
- opening-length of reach
- throat depth – depth of reach
- ease of adjustment
- clamping surface – material used and size
CUTTERS

INTRODUCTION
There are many types and sizes of cutters used to cut selected ferrous and non-ferrous metals described below. Each cutter is designed for a specific type and size of material to be cut. Always use the proper cutter for the job.

TYPES OF CUTTERS
There are different head styles and tool configurations ranging in length from 9" to 42" for cutting different materials. Models which have blades that pass each other normally cut only non-ferrous cable.

Proper Use. Cutters are used to cut ferrous materials such as steel wire and cable, rod wire rope, aircraft cable, guy strand, fencing, bolts and steel strapping. Other cutters are used for cutting non-ferrous material such as copper and aluminum. Cutters are used in plant maintenance, construction, electrical construction and maintenance, and other operations. Be certain to select the proper cutter for the job. Follow manufacturers’ instructions or obtain professional advice.

Proper Care. Cutters should be adjusted and lubricated daily when in use. Jaws may be sharpened according to instructions shipped with the cutter.

When to Replace. Attempts to repair cutters are not recommended. Discard any cutter which is cracked, broken or shows signs of looseness or play due to wear in the compound leverage toggle.
DO'S AND DON'T'S WHEN USING CUTTERS

Wear protective gloves and safety goggles when using cutter.

Wear safety shoes.

Keep cutting tools in good repair; lubricate moving parts only.

Don't attempt to use a cutting tool until its proper and safe uses are fully understood.

Remember that metal flies when cut. The harder the metal, the farther it will fly. One way to prevent injury from flying metal is to wrap a burlap bag, wiping cloth or rag around the cutting jaws so metal pieces cannot fly.

When using a cutter, warn those in the area to take precautionary measures to avoid possible injury from possible flying metal pieces.

Don't cut diagonally.

Remember that the hardness of the stock being cut is as important as its size.

Use all tools as recommended:

- Do not exceed rated capacity of tool as shown on jaws.
- Do not pry or twist with tool when cutting. Keep material being cut at right angles to the cutting edges of jaws.

Improper cutting may contribute to personal injury or damage to tool.
BALL PEEN HAMMERS

Ball peel hammers are one of the most commonly used hammers. They have a rounded, slightly crowned striking face with bevelled edges and a round, ball-shaped peen. Handles may be wood, solid steel, or fibreglass. The solid steel and fibreglass types are generally furnished with rubber-type grips which are occasionally used on wood handles.

Proper Uses. Ball peel hammers of the proper size are designed for striking chisels and punches, and for riveting, shaping and straightening unhardened metal. When striking a struck tool (chisel or punch), the striking face of the hammer should have a diameter approximately 3/8” larger than the struck face of the tool.

Abuse/Misuse. Never use a hammer with a loose or damaged handle. Avoid glancing blows to minimize chipping of the hammer. Never strike with the side or cheek of the hammer.

WRONG

When to Replace. Discard any hammer if it shows dents, cracks, chips, mushrooming, or excessive wear. If handle only is damaged, replace it with an equivalent new handle.
BLACKSMITHS’ HAND HAMMERS AND SLEDGES, STRAIGHT AND CROSS PEEN

These heavy-duty hammers are designed for blacksmiths’ use in striking metal. Striking face is crowned with beveled edge.

Proper Use. The striking face is designed for general blacksmith work in striking unhardened metal. The peens are used for shaping (fullering) and beading unhardened metal.

RIGHT

Abuse/Misuse. Never use a sledge to strike a hammer, sledge, hatchet, axe or maul. Never use a sledge with loose or damaged handle.

When to Replace. Discard any sledge if it shows dents, cracks, chips, mushrooming or excessive wear. If handle only is damaged, replace it with an equivalent new handle.
BRICKLAYERS' HAMMERS

Bricklayers’ hammers are special-purpose tools. The striking face is flat with beveled edges. The blade has a sharp, hardened cutting edge. Handles may be wood, solid steel or fiberglass and may be furnished with rubber-type grips.

Proper Uses. Bricklayers’ hammers are designed for setting and cutting (splitting) bricks, masonry tile and concrete blocks, and for chipping mortar from bricks.

Abuse/Misuse. Never use these tools to strike metal or to drive struck tools (including brick sets and chisels). Use a hand drilling, blacksmith or engineer’s hammer.

WRONG

When to Replace. Discard any hammer if it shows dents, cracks, chips, mushrooming, excessive wear or dulling. If handle only is damaged, replace it with an equivalent new handle. Cutting edge may be redressed. See instructions in section V.
BUSH HAMMERS

This is a striking tool of compact, rectangular design having striking faces with sharp, hardened teeth.

Proper Uses. Bush hammers are designed for a single purpose-roughing and chipping concrete.

RIGHT

Abuse/Misuse. Never use this tool for striking anything but concrete. Never use a hammer with loose or damaged handle.

When to Replace. Discard the tool if teeth are dull and/or flattened. If handle only is damaged, replace it with an equivalent new handle.
ENGINEERS’ HAMMERS AND SLEDGES, DOUBLE FACE

This is the most commonly used type of sledge hammer and is made in slightly different head configurations. All patterns have crowned striking faces with beveled edges.

Proper Uses. Sledges are designed for general slogging operations in striking wood or metal. Common uses are drifting heavy timbers and striking spikes, cold chisels, star drills and hardened nails.

Abuse/Misuse. Never use a sledge to strike a hammer, sledge, or maul. Never use a sledge with a loose or damaged handle.

When to Replace. Discard any sledge if it shows dents, cracks, chips, mushrooming or excessive wear. If handle only is damaged, replace it with an equivalent new handle.
HAMMERS

Hammers and other striking tools are perhaps the most widely used, and probably the most often abused of all hand tools. They are made in various types, sizes and configurations for specific purposes. They should be selected for their intended uses and used only for those purposes for which they are designed. Misuse can cause the striking face to chip, possibly resulting in eye or other serious injury. Proper use of virtually all types involves certain basic rules:

- A hammer blow should always be struck squarely with the hammer striking face parallel with the surface being struck. Always avoid glancing blows and over and under strikes.

- When striking another tool (chisel, punch, wedge, etc.), the striking face of the proper hammer should have a diameter approximately 3/8" larger than the struck face of the tool.

RIGHT

- Always use a hammer of suitable size and weight for the job. Don't use a tack hammer to drive a spike, nor a sledge to drive a tack.

- Never use one hammer to strike another hammer or a hatchet.

WRONG
HAND DRILLING OR MASH HAMMERS

These heavy, short-handled hammers are made in slightly varying configurations by different manufacturers. The double-faced head has crowned and beveled striking faces.

Proper Uses. These hammers are designed for uses with chisels, punches, stabs, drills and hardened nails. Their design permits heavy blows with limited swing—especially advantageous in restricted working areas.

Abuse/Misuse. Never use these tools for sledge or stone work. Avoid glancing blows against other hardened surfaces. Never use a hammer with loose or damaged handle.

WRONG

When to Replace. Discard any hammer if it shows dents, cracks, chips, mushrooming or excessive wear. If handle only is damaged, replace it with an equivalent new handle.
MAGNETIC HAMMERS

Magnetic hammers are usually made in the patterns illustrated. One end of the head is magnetized to hold tacks. Handles are usually wood.

Proper Uses. Primary use of these light-duty hammers is holding and driving tacks. The tack hammer has a long thin claw for pulling tacks in corners and along walls; also used for removing light mouldings. The heads of the other two patterns are designed for starting and driving tacks only. The magnetic end is used for starting the tack; the opposite end, for driving.

Abuse/Misuse. Never use these hammers for driving other than tacks and upholstery nails. Never use a hammer with loose or damaged handle.

When to Replace. Discard any hammer if it shows dents, cracks, chips, mushrooming or excessive wear. If handle only is damaged, replace it with an equivalent new handle.
**NAIL HAMMERS**

Description. Nail hammers are made in two patterns: curved claw and straight or ripping claw. The face is slightly crowned with the edges beveled, although certain heavy-duty patterns may have checkered faces designed to reduce glancing blows and flying nails. Handles may be wood, tubular or solid steel, or fiberglass. Tubular steel, solid steel and fiberglass are generally furnished with rubber-type grips which are occasionally used also on wood handles.

Proper Use. Nail hammers are designed for driving unhardened common and finishing nails only and nail sets, using the center of the hammer face. The claws are for pulling common and finishing nails and ripping woodwork and should not be struck against metal.

Abuse/Misuse. Never strike one hammer with another hammer or a hatchet. Never strike concrete, steel chisels or similarly hard objects with a nail hammer as the hammer face may chip, possibly resulting in eye or other serious bodily injury.

Wrong

Never use a hammer with loose or damaged handle. Never strike with the side or cheek of a hammer.

**WARNING:** Hardened steel-cut, pole barn and masonry nails should never be driven with a nail hammer. These nails may shatter or may cause a hammer face to chip with an indirect or glancing blow, and should never be driven unless safety goggles are worn. When not driven through a piece of wood, a hole should be started with a small star drill or masonry bit. A hand drilling hammer or sledge is the proper tool to use.

When to Replace. Discard any hammer if the striking face or its bevel show dents, chips, mushrooming or is excessively worn, or if the claws show indentations or nicks inside the nail slot, or if claw is broken. If handle only is damaged, replace it with an equivalent new handle.
PROSPECTING PICKS

These are special-purpose tools used by geologists and prospectors. The striking face is flat with beveled edges. The long pick is pointed and may be either round or square. Handles may be wood, solid steel or fiberglass, and may be furnished with rubber grips.

Proper Uses. Prospecting picks are designed for splitting rock and for digging and prying out rock with the pick. The pick is also used as an aid in climbing.

Abuse/Misuse. Never use these tools to strike metal or to drive struck or hammered tools. Never use a pick with loose or damaged handle.

When to Replace. Discard the pick if it shows dents, cracks, chips, mushrooming, excessive wear, or dulling. If handle only is damaged, replace it with an equivalent new handle.
RIVETING AND SETTING HAMMERS

These hammers are designed for machinists' and fitters' use. Handles are usually wood. The Machinists' Riveting hammer has a round poll with slightly beveled, flat striking face and rounded cross peen. The Fitters' Riveting hammer has an octagon poll with a flat striking face with slightly beveled edges. The cross peen is slightly rounded. The Fitters' Setting or Peening hammer's face has sharp corners and no bevels. The cross peen has a sharp beveled edge.

Proper Uses. The Riveting hammer is designed for driving and spreading rivets on sheet metal work. The Setting hammer is designed for forming sharp corners, closing and peening seams and lock edges, and for use by glaziers for inserting glazier points.

Abuse/Misuse. Never use these hammers for general purpose work—they are strictly specialized tools intended only for driving and spreading unhardened rivets and forming sheet metal. The square, sharp corners and sides of the setting hammer make it especially vulnerable to chipping if improperly used.

When to Replace. Discard any hammer if it shows dents, cracks, chips, mushrooming, or excessive wear. If handle only is damaged, replace it with an equivalent new handle.
SCALING AND CHIPING HAMMERS

Scaling and chipping hammers are special purpose tools and are made in varying configurations by different manufacturers. The two patterns illustrated are typical.

Proper Uses. These hammers are popular in iron foundries and welding shops. They are designed for chipping welds, scale, rust and paint from unhardened metal.

Abuse/Misuse. Never use these hammers for any but the above purposes. Never use a hammer with loose or damaged handle.

When to Replace. Discard any hammer if it shows dents, cracks, chips, mushrooming, excessive wear, or dulling. If handle only is damaged, replace it with an equivalent new handle.
SOFT FACE AND NON-FERROUS HAMMERS AND MALLETS

Soft face hammers and mallets are made of various non-ferrous materials (wood, rawhide, rubber, plastic, copper, brass, lead, etc.). Heads are cylindrically shaped with two flat striking faces. Handles are usually wood or fiberglass.

Proper Uses. Soft face hammers are intended for striking blows where steel hammers would mar or damage the surface of the work. Wooden mallets are properly used for striking wood and plastic-handled chisels, gouges, wood pins and small stakes, and to form or shape sheet metal. Rubber and plastic hammers are used for setting stone. Plastic hammers usually have replaceable tips, available in varying degrees of hardness.

Abuse/Misuse. Never use these tools to drive nails or crews, or to strike sharp metal objects. Never use a hammer or mallet with loose or damaged handle.

When to Replace. Discard any hammer or mallet if it shows dents, cracks, chips, mushrooming or excessive wear. If handle only is damaged, replace it with an equivalent new handle.
STONE SLEDGES AND SPALLING HAMMERS

These are stone masons' tools and are made in slightly varying configurations by different manufacturers. The sledge usually has a crowned, oval striking face with a napping face opposite. The spalling hammer may have a beveled or straight edged face.

Proper Use. Stone sledges are designed for breaking up stone and concrete. The spalling hammers are designed for cutting and shaping stone and concrete.

RIGHT

Abuse/Misuse. Never use these tools for striking metal. Never use a tool with loose or damaged handle.

When to Replace. Discard any sledge if it shows dents, cracks, chips, mushrooming or excessive wear. If handle only is damaged, replace it with an equivalent new handle.
DIAGONAL CUTTING PLIERS

Diagonal Cutters are made in several patterns ranging from the high leverage, heavy-duty pattern down to the midget pattern for electrical work. They are available with and without a top bevel on the cutting edges for flush cutting. Some have wire skinnning holes-some have coil springs to open the jaws. Handles may be plastic dipped, slip-on molded plastic, or plain. Sizes range from 4 to 8 inches in length.

Proper Uses. Diagonal Cutting pliers are designed for electrical, electronic, telephone, general and automotive work. Flush cutting edge pliers should be used only for cutting small soft wires used in electronic wire. It is recommended that the standard cutting edge pliers be used for all general cutting requirements except hard wire.

HEAVY DIAGONALS ARE FINE FOR CUTTING THE SPREAD ENDS OF COTTER PINS. RIGHT

Abuse/Misuse. Never expose pliers to excessive heat. Don’t rock pliers from side to side when cutting wire. Always cut at right angles. Never use pliers as a hammer, or drop on hard or paved surfaces.

When to Repair or Replace. Attempts to repair these pliers are not recommended. Discard any plier which is cracked, broken, sprang, or has nicked cutting edges. Dull cutting edges may be touched up with a small, medium grade honing stone.
END CUTTING PLIERS

End cutting pliers or zippers range in size from the heavy-duty, high leverage pattern down to the traverse end cutter designed for precision electronic work. Many are available with plain or plastic dipped handles. Sizes range from 4-1/2 to 8 inches in length.

Proper Uses. End Cutting pliers are designed for cutting soft wire, nails, rivets, etc. close to work.

END CUTTERS ARE IDEAL FOR CUTTING TIE WIRES CLOSE TO THE CONCRETE WALL.

Right

Abuse/Misuse. Never expose these pliers to excessive heat. Never use as a hammer.

When to Repair or Replace. Attempts to repair these pliers are not recommended. Discard any plier which is cracked, broken, sprung, or has nicked cutting edges. Dull cutting edges may be touched up with a small, medium honing stone.
FLAT NOSE PLIERS

Often referred to as "Duck Bill," these pliers have a flat nose in various widths. Available with plain or plastic dipped handles in sizes from 4½ to 8 inches in length.

Proper Uses. Flat Nose pliers have diverse uses in the electrical, telephone, electronic and other fields. They are extensively used in typewriter repair and assembly work and in textile weaving and knitting operations.

Abuse/Misuse. Never expose these pliers to excessive heat. Do not use as a hammer or as a pry.

DON'T USE FLAT NOSE PLIERS TO PRY OR TWIST.
WRONG

When to Repair or Replace. Attempts to repair these pliers are not recommended. Discard any plier that is cracked, broken or sprung.
IRONWORKER’S PLIERS

These pliers are very similar to Linemen’s pliers except that they have a hook bend on one handle and may have a coil spring to hold the jaws open. Sizes range from 7 to 9 inches in length. Available in standard and high leverage patterns.

Proper Uses. These wire cutting pliers are designed for tying concrete reinforcing bars and form work involving puling, twisting and cutting wire.

Abuse/Misuse. Never expose pliers to excessive heat. Don’t rock pliers from side to side when cutting wire. Always cut at right angles. Never use pliers as a hammer or drop on hard or paved surfaces.
LINEMEN’S SIDE CUTTING PLIERS

Two head patterns are available: Standard, also known as bevel nose, and New England, also known as round nose, which is more streamlined. Handles may be plain, slip-on molded plastic, plastic dipped or high dielectric. High leverage patterns are also available, as are pliers incorporating sleeve twisters and threaded bolt-holding openings. Sizes: range from 61/4 to 91/4 inches in length.

Proper Uses. These are heavy-duty tools designed for the professional engaged in electrical, communications and construction work.

Abuse/Misuse. Never expose pliers to excessive heat. Don’t rock pliers from side to side when cutting wire. Always cut at right angles. Never use pliers as a hammer, or drop on hard or paved surfaces.

DON’T DROP PLIERS ON HARD OR PAVED SURFACES.
WRONG
LOCKING PLIER-WRENCHES AND CLAMPS

Locking plier-wrenches are available in a variety of sizes with straight or curved jaws. Compound leverage systems lock jaws and hold various shapes and sizes of work.

Proper Uses. These wrenches are combination tools which function as pliers, wrenches, portable vises or clamps. They are not intended to replace open-end or box wrenches because of possible damage to the fitting or fastener.

Abuse/Misuse. Do not hammer to tighten jaws or to cut wire or bolts. Do not expose wrenches or clamps to heat from welding torches or to contact with welding electrodes. When subjected to severe vibration such as encountered during riveting, locking wrenches or clamps holding the work pieces should be wired or taped closed to prevent accidental opening. Do not use pipe, other extensions, or hammering to increase torque applied to these tools. They should never be used as steps or ladders to support personnel.

DON'T HAMMER ON PLIERS TO CUT WIRE OR BOLTS.
WRONG

When to Repair or Replace. Avoid excessive wear on working parts by frequent lubrication. Attempts to repair these tools are not recommended. Discard any damaged tool.
LONG NOSE PLIERS

This type of plier embraces three nose configurations: needle, round and chain. They are available with and without side cutters and with cutters notched for stripping insulated wire. Small and miniature sizes are designed for electronic work. Handles may be plain, slip-on plastic, or dipped. Certain patterns are made in both straight and curved nose design. Sizes range from 4 to 8 inches in length.

Proper Use. Most Long Nose Pliers are designed for electrical, telephone and electronic work involving smaller wire gauges. They will reach into awkward places and perform work difficult with any other tool. Their usefulness, however, is not limited to wire work.

Abuse/Misuse. Never expose these pliers to excessive heat. Don’t bend stiff wire with the plier tip. Never rock side to side when cutting. Cut at right angle to the wire. Never pry with the plier nose.

DON’T BEND STIFF WIRE WITH THE PLIER TIP.
WRONG

When to Repair or Replace. Attempts to repair Linemen’s side cutting, Long Nose and Ironworker’s pliers are not recommended. Discard any plier which is cracked, broken, sprung, or has nicked cutting edges. Dull cutting edges may be touched up with a small, medium grade honing stone. Serrations inside of nose may be cleared of foreign materials by brushing with a file card or stiff wire brush.
PLIERS

Pliers of various types are used by practically every tool user, both amateur and professional. There are many types and sizes; each designed for specific uses, although their versatility makes some pliers adaptable for many jobs. Choose the right pliers for the job.

Basic Safety Rules Which Apply to the Use of Pliers.

- Pliers should not be used for cutting hardened wire unless specifically manufactured for this purpose.
- Never expose pliers to excessive heat. This may draw the temper and ruin the tool.

NEVER EXPOSE PLIERS TO EXCESSIVE HEAT.

WRONG

- Always cut at the right angles. Never rock from side to side or bend the wire back and forth against the cutting edges.

ALWAYS CUT AT RIGHT ANGLES—DON’T ROCK SIDE TO SIDE WHEN CUTTING WIRE.

RIGHT

- Don’t bend stiff wire with light pliers. Needle nose pliers can be damaged by using the tips to bend too large a wire. Use a sturdier tool.
- Never use pliers as a hammer nor hammer on the handles. They may crack or break, or edges may be nicked by such abuse.
SLIP JOINT PLIERS

These widely used pliers are available in several patterns; standard, thin nose, bent nose and heavy-duty. Their slip joint capability increases the capacity range. Available with or without wire cutters in sizes from 5 to 10 inches in length. Also available with plastic dipped grips or slip-on plastic grips.

Proper Uses. These versatile tools are designed for a wide range of service involving gripping, turning and bending.

Abuse/Misuse. Never expose these pliers to excessive heat. Never use as a hammer. Never place a piece of pipe on plier to achieve more strength.

When to Repair or Replace. Attempts to repair these pliers are not recommended. Discard any plier that is cracked, broken or sprung.
SNAP RING-RETAINING RING PLIERS

PROPER USES. These pliers spread snap lock rings used on brakes, transmissions, pedalshafts, clutch shafts and machine tools. Can also be used to spread piston rings.

SAFETY TIPS

- First loosen circlip with punch or similar tool to remove bond from rust and accumulated dirt in groove.
- Use largest tips that fit in the holes in the circlip.
- Push tips as far as possible into circlip holes before squeezing plier handles.
- Use minimal pressure needed to remove or install ring.
- Never use your pliers for anything other than installing and removing circlips.
- Caution: Take care that circlips do not get dislodged from tips of pliers—always protect eyes. Wear safety goggles.
TONGUE AND GROOVE PLIERS

These wide-range capacity pliers are made with a tongue and groove adjustment design. Jaw capacities up to 4-1/4 inches are available. Jaws may be smooth, straight, or curved toothed. Sizes range from 4-1/2 to 16 inches in length.

Proper Uses. These pliers are widely used by plumbers, electricians, auto mechanics and professionals in the construction and industrial fields. They will grip round, square, flat and hexagonal objects and are capable of applying limited torque without damage to the work.

PLUMBERS, ELECTRICIANS AND MAINTENANCE WORKERS HAVE MANY JOBS WHERE TONGUE AND GROOVE PLIERS ARE INVALUABLE.

RIGHT

Abuse/Misuse. Never expose these pliers to excessive heat. Never use as a hammer.

When to Repair or Replace. Attempts to repair these pliers are not recommended. Discard any pliers that is cracked, broken or sprung.
SOCKETS

There are three types of sockets—hand, power and impact—all different in design and hardness. Hand sockets usually have a bright finish but may have a black finish. Power and impact sockets have a black finish and usually have thicker walls. This booklet is concerned only with hand sockets, which should never be used on power drive or impact wrenches.

Hand Power Impact Hand Socket wrenches are made in a wide range of sizes and capacities. All have square drives ranging from 1/4” to 1”. Drive size is a measure of capacity.

Sockets are made in regular length and deep length. Openings may be 12, 8, 6 point or square. Spark plug sockets have rubber inserts or other devices to hold the plug. Universal joint sockets are also available.
REDRESSING INSTRUCTIONS

The redressing and reshaping of tools having chipped battered or mushroomed striking or struck surfaces is not recommended. When a tool has reached this stage through normal use or abuse, it should be discarded.

There are three basic rules which apply to the redressing of dull cutting edges:

- Rigidly support the tool being dressed.
- Use a hand file or whetstone only, never a grinding wheel. File or stone away from the cutting edge.
- Original contour of cutting edge should be restored.

Axes. Use a hand file for redressing. Start 2 or 3 inches back from the cutting edge and file to about ½ inch from the edge. Work for a fan shape, leaving reinforcement at corners for strength. File the remaining ½ inch, blending into previously filed area preserving the original contour of the cutting edge. Remove all scratches with a whetstone or hone ½ inch back from the cutting edge. See cross section C illustration below for the "right" way to shape the edge in redressing axes. Other illustrations show "wrong" ways to redress axes.

Hatchets. Hatchets with double bevels should be redressed as illustrated in A below. Hatchets with single bevels should be redressed as illustrated in B below. Use a hand file for redressing, removing scratches with a whetstone.

Cold Chisels (Flat). Cold chisels are hardened on the cutting edge. Redressing may be done with a hand file or whetstone restoring to original shape or to an included angle of approximately 70 degrees (see illustration below).
Crosscut Saw or Rip Saw

Before you put saw to wood, you need to determine what sort of saw you’ll need for your job. In the pantheon of saws, two basic designs exist: the crosscut saw and the rip saw. Which one you use depends on whether you plan on cutting with or against the wood grain. Let’s take a closer look at the differences between the two saws and when you would use them.

Crosscut saw. If you’re cutting across the grain of the wood, you’ll want to use a crosscut saw. The teeth on a crosscut saw angle back and have a beveled edge. The teeth are also much smaller than those on a rip saw. This design allows the saw to act like a knife-edge that cleanly slices through the wood’s grain. The crosscut saw’s design also allows the saw to cut on both the push and pull stroke.

Rip saw. When you’re making a cut parallel to the direction of the grain of the wood, use a rip saw. Unlike a crosscut saw, the teeth on a rip saw don’t angle backwards nor are they beveled. Instead, the teeth bend left and right in an alternating pattern. This design allows each tooth to act like a chisel that chips away small pieces of wood on each push stroke. The chisel design ensures a clean cut as you saw along the grain. Also, unlike the crosscut saw, the rip saw only cuts on the push stroke, not on the pull stroke.

Different Handsaws for Different Jobs

While the crosscut saw and rip saw will cover most cutting jobs, sometimes you need an even more specialized handsaw. Here are a few handsaws you might consider adding to your toolbox arsenal.
HACKSAW

What should I know about using a hacksaw?

- Select correct blade for material being cut.
- Secure blade with the teeth pointing forward. Tighten the nut until the blade is under tension.
- Keep blade rigid, and frame properly aligned.
- Cut using steady strokes, directed away from you.
- Use entire length of blade in each cutting stroke.
- Use light machine oil on the blade to keep it from overheating and breaking.

- Cut harder materials more slowly than soft materials.
- Clamp thin, flat pieces requiring edge cutting.
- Keep saw blades clean and lightly oiled.
- Do not apply too much pressure on the blade as the blade may break.
- Do not twist when applying pressure.
- Do not use when the blade becomes loose in the frame.
CLEARANCE HOLES

Sometimes a clearance hole, in addition to a pilot hole should be drilled in order to do a workmanlike job. For example, when fastening a metal bracket to wood or when screwing two pieces of wood together, a clearance hole equal to the diameter of the crew body or shank is necessary. Without the clearance hole, the body or the threads of the screw will hang up on the metal, or the leading piece of wood, preventing them from being drawn together tightly. See Fig. 6.

FIG. 5. Screws are available in many lengths. However, the number by which a screw is designated, such as No. 10, always refers to its shank diameter. This drawing shows actual size screws and their corresponding number.

FIG. 6. A clearance hole is necessary when screwing two pieces of wood together.

FIG. 7. Cal is using the right technique in driving this screw home. The blade of the screwdriver is a snug fit in the slot of the screw and does not quite project to the edge.
MAGNETIC TIP SCREWDRIVER

Interchangeable Magnetic Tip Screwdrivers. These screwdrivers have a magnet in the shaft so that they not only hold the bit but can also hold the screw. In addition, the variety of bits for this type of screwdriver is limitless and the unused bits can be stored in the handy compartmented handle.

Interchangeable Blade Screwdrivers. The hollow handle of this type of screwdriver will accept a number of different type blades. Sometimes the blades are double-ended with a narrow tip on one end and a wider tip on the other end. Combinations of Phillips, conventional, Clutch Head, Scrulox, and hex head are available.

Insulated Screwdrivers. These are used by electricians and maintenance workers. As their name implies, the shank as well as the handle are completely insulated with a dielectric material intended only as a secondary protection. Never depend on an insulated screwdriver handle, shank cover, or blade to insulate you from electricity. Insulated blades are intended only as a protective measure against shorting out components.

FIG. 22. Careful Carl is using an insulated screwdriver. Handle and shank are covered with an insulated material that is intended only for secondary protection. Turn off current when doing this kind of work.

FIG. 23. Two types of screwdrivers that use interchangeable bits. The one at the left has a hollow handle that will accept any one of the four bits shown. The screwdriver at the right has two double-ended bits held in each end of a tube. The tube is reversible in the handle and the bits are reversible in the tube.

FIG. 24. As usual, Hazardous Harry is wrong again. But this time on two counts. First of all, he never bothered to turn off the current before starting to work on that outlet. Secondly he doesn't
RATCHET SCREWDRIVERS

One type of rapid-action screwdriver is the spiral ratchet screwdriver. This screwdriver has a spring-loaded mechanism in the handle. Pushing down on the handle causes the bit of the screwdriver to turn rapidly, thus driving the screw in a shorter time than could be accomplished with the use of a conventional screwdriver. Letting up on the handle allows the operator to continue the action. These screwdrivers come in several styles. Some have the mechanism as part of the handle; others have it as part of the shank. In either case a small lever is set so that even though the operator moves the handle back and forth -- or up and down -- the bit of the screwdriver moves in only one direction, to drive the screw. The lever can also be set so that the ratchet action removes the screw. And it also can be set so that the screwdriver can be used as a conventional screwdriver, with no ratchet action.

FIG. 11. Two types of ratchet screwdrivers. The one at the top has the ratchet mechanism in the handle. The lower screwdriver has the ratchet in the handle and operates with a spiral action.

When using any spiral ratchet screwdriver, it is best to push down firmly and slowly -- until the screw is properly started -- otherwise you may find that the bit has slipped out of the slot. These screwdrivers should be stored only in the extended position to prevent the possibility of a sudden, unexpected release by someone unfamiliar with the tool.

Large screws in tough wood can be easily driven by using special bits that fit into a carpenter’s brace. Because tremendous turning power is generated by the brace, make sure you have a proper pilot hole, as it is quite easy to shear off the head or even twist the screw in half if too much pressure is applied to a balky screw. Needless to say, it is always best to drill a pilot hole when driving large screws with a carpenter’s brace.

FIG. 12. Special screwdriver bit that can be chucked into carpenter’s brace.

FIG. 13. Hazardous Harry strikes out again. Please, Harry, don’t use pliers on the shank of a screwdriver in order to remove a stubborn screw.

WRONG
**DO'S AND DON'T WHEN USING SCREWDRIVERS**

- Don't hold the work in one hand while using the screwdriver with the other. If the screwdriver slips out of the slot (we told you to use the right size screwdriver!) you will be most likely to receive a gash on your hand.
- Don't use a screwdriver with rounded edges or tip; it will slip and cause damage to the work or yourself.
- A rounded tip should be redressed with a file; make sure the edges are straight.
- Don't use a screwdriver near a live wire or for electrical testing.
- Don't use a screwdriver to check a storage battery or to determine if an electrical circuit is live.
- Don't use a screwdriver for prying, punching, chiseling, scoring, or scraping.
- Use a screw-holding screwdriver to get screws started in awkward, hard-to-reach areas.
- Use an offset screwdriver in close quarters where a conventional screwdriver cannot be used.
- Use a ratchet-type screwdriver for speed and comfort when a great number of screws are to be driven.
- Don't use pipes on the handle of a screwdriver to get extra turning power. A wrench should only be used on the square shank or bolster of a screwdriver that is especially designed for that purpose.
- Don't expose a screwdriver blade to excessive heat as it may reduce the hardness of the blade.
- Don't use a screwdriver for stirring paint.
- Don't use a screwdriver with a split or broken handle.
- Screwdrivers used in the shop are best stored in a rack. This way, the proper selection of the right screwdriver can be quickly made.
- Keep the screwdriver handle clean, a greasy handle is apt to cause an accident.
- A screwdriver should never be used as a pry bar. If it is over-stressed in this manner, the blade might break and send a particle of steel into the operator's arm or perhaps even towards his eye.
SCREWDRIVERS

Next to the hammer, the screwdriver is probably the most abused tool in the homeowner's or professional's tool kit. Screwdrivers are available in a wide variety of shapes, sizes, and materials. But, they are all intended for one simple use: driving and withdrawing threaded fasteners such as wood screws, machine screws, and self-tapping screws. Unfortunately, the screwdriver is misused for prying, chiseling, scraping, scoring — and only sometimes for its intended use of driving screws!

However, the most common abuse is using a screwdriver that doesn't match or fit the screw. You wouldn't wear a pair of shoes that is too small or too big for your feet — you would be abusing your feet. For the same reason you should not use a screwdriver that is too small or too big for the screw it is to drive. Use the right screwdriver and you won't chew up the screw head, damage the screwdriver or bash your knuckles.

The abuse of a screwdriver — and the screw — is most often due to the fact that the homeowner or professional simply does not have a proper assortment of screwdrivers on hand.

A screwdriver should never be used as a pry bar. If it is over-stressed in this manner, the blade might break and send a particle of steel into the operator's arm or perhaps even into his eye.

Bear these points in mind when using a screwdriver, always match the size of the screwdriver to the job and always match the type of screwdriver to the head of the screw.

![Typical screwdrivers](image)

FIG. 1. Typical screwdrivers:

- Stubby screwdriver for working in close quarters.
- Screwdriver with a square shank to which a wrench can be applied to remove stubborn screws.
- Screwdriver for Phillips screws.
- Cabinet screwdriver has a thin shank to reach and drive screws in deep, counterbored holes.

After all, you wouldn't want to drive a large No. 12 screw with a small 3/32 or 3/16-inch screwdriver and neither would you drive a Phillips screw or other recessed screw with a conventional screwdriver.

Be careful not to confuse a Phillips screwdriver with other "cross point" screwdrivers. They are not interchangeable. See Page 41 for how they differ.
BASIC SAFETY RULES THAT APPLY TO THE USE OF A SCREWDRIVER

- Make sure that the tip fits the slot of the screw; not too loose and not too tight.
- Do not use a screwdriver as a cold chisel or punch.
- Do not use a screwdriver near live wires (or any other tool, for that matter).
- Do not expose a screwdriver to excessive heat.
- Redress a worn tip with a file in order to regain a good straight edge.
- Discard a screwdriver that has a worn or broken handle.
- A screwdriver should never be used as a pry bar. If it is over-stressed in this manner, the blade might break and send a particle of steel into the operator’s arm or perhaps even into his eye.

Fig. 2

- This tip is too narrow for the screw slot; it will bend or break under pressure.
- A rounded or worn tip. Such a tip will ride out of the slot as pressure is applied.
- This tip is too thick. It will only serve to chew up the slot of the screw.
- A chisel ground tip will also ride out of the screw slot. Best to discard it.
- This tip fits, but it is too wide and will tear the wood as the screw is driven home.
- The right tip. This tip is a snug fit in the slot and does not project beyond the screw head.

COMMON SLOTTED HEAD SCREWS

- Flathead
- Pozi-Top
- Pozi-Drill
- Slotted

DRIVING THE SCREW

Always make a pilot hole before driving a screw. This is especially important when driving a screw into hardwood or when the screw is near the edge of a board. Pilot holes can be made in softwood, and in some hardwoods, with an awl – if the screws to be used are small. However, if you are driving No. 6 and larger screws, it is best to drill a pilot hole or use a threaded screw hole starter. Pilot holes should always be made if the screws are to be driven into dense hardwoods.

If the screw is a flathead, the pilot hole should also be countersunk so the head of the screw will be flush with the work when it is driven home.

ALWAYS WEAR SAFETY GOGGLES TO PROTECT YOUR EYES
SCREWDRIVERS FOR SCREWS WITH RECESSSED OPENINGS

The most common screw with a recessed "slot" is the Phillips screw. These screws have what appears to be two slots at right angles to each other. But, a conventional screwdriver should never be used to drive a Phillips screw — or any other type of a screw with a specialized opening. Such screws are shown in Fig. 16. Always use the screwdriver especially designed to drive these fasteners.

RECESSED SCREWS AND SCREWDRIVERS

FIG. 16.
SCREWDRIVERS FOR SLOTTED STYLE SCREWS

Now that we have learned a little bit of how to use a screwdriver, let’s consider the various kinds of screwdrivers that are available and the right and wrong way to use – and abuse – these screwdrivers.

The so-called standard or conventional screwdriver is used for screws with slotted heads. These screwdrivers are usually classified according to tip width and blade length. Generally, the longer the length, the wider the tip – but not always as some rather long screwdrivers may have a narrow tip. Cabinet style screwdrivers, which have long shanks and narrow tips, are useful for driving screws into recessed and counter-bored openings in fine furniture and, obviously, cabinets. On the other hand there are short, stubby screwdrivers with rather wide tips for driving screws in confined quarters.

FIG. 8. Don’t use a screwdriver whose tip extends beyond the length of the slot in the screw. Too wide a tip will chew up the wood as the screw is being driven home.

WRONG

The great assortment of screwdrivers available today means that you can buy a screwdriver in practically any length and in any tip size desired.

Most screwdriver tips are tapered. The tip thickness determines the size of the screw that the screwdriver will drive without damaging the screw slot. The taper permits the screwdriver to drive more than one size of screw.

FIG. 9. Careful Cal knows enough to drill pilot and clearance holes when driving screws that are near the edge of a board. A little wax on the threads will ease the job.

RIGHT

Heavy duty screwdrivers are available with square shanks so that a wrench can be used on the shank for extra turning power. Never use pliers on a screwdriver shank when the going gets tough. You will only wind up by chewing up the shank. What to do in such a case? Use the largest possible screwdriver that
SPECIALTY SCREWDRIVERS

In addition to the types of screws and screwdrivers described so far, there are many screwdrivers whose use is quite specialized. Let us look at some.

Jeweler's Screwdrivers. These are distinguished by a rotating head which is held by the forefinger to steady the screwdriver while the thumb and middle finger turn the screwdriver to remove or install the small screws used by the jewelers, model railroad fans, and persons who work with tiny parts and screws.

FIG. 17. Jeweler's screwdriver, used with tiny screws, is steadied by placing forefinger on the free-turning knob.

Offset Screwdrivers. These screwdrivers are designed for removing and inserting screws in place where it is impossible to use a straight shank screwdriver. They are available in many combinations; narrow tip on one side and a wide tip on the other side; Phillips tip on one side and a conventional tip on the other side; with two Phillips tips (one large and one small); with same size tips at each end, but one tip is at right angles to the handle while the other tip is parallel to the handle (this arrangement makes the screwdriver extremely handy when turning area is limited).

FIG. 19. Offset screwdriver for driving screws in awkward places.

FIG. 20. A ratchet-type offset screwdriver for working in tight spots; it is reversible.

FIG. 21. The screw-holding screwdriver is a must for working in close quarters as shown. The type shown at the left uses clips to hold the screw. The one at the right has a sliding collar that spreads the split blade of the screwdriver to hold the screw. After the screw has been firmly started, further driving can be done with a conventional screwdriver.
SNIPS

Snips, sometimes called tinner’s snips, are used to cut sheet metal. They are used by the sheet metal worker, the automotive mechanic, in industrial plants, and by the home owner. While their primary purpose is to cut sheet metal, snips are also used to cut screening, chicken wire fencing, steel strapping, gasket, linoleum, canvas, and other hard to cut materials. However, some snips are designed to cut mild sheet metal up to 18 gauge thickness.

There are five basic types in common use today – straight pattern, combination, circular (or duckbill) pattern, compound leverage aviation, and compound leverage offset.

Straight pattern snips are generally used for making straight line cuts, although curved cuts can be made if the curve is not too sharp. When cutting with a straight pattern snip, a straight line can be easily maintained by guiding the material sliding it, butted firmly against the wall of the inside ground surface at the bolt hole. (See Figure 66) Their cutting edges are sharpened at an angle of 78 degrees to 85 degrees to the inside of the blade. The sizes range from 7 to 16 inches in overall length, with the most popular sizes being 7, 10, and 12-1/2 inches.

FIG. 66. The straight pattern snips are generally used for making straight cuts. They can also be used for making shallow cuts.

Combination and duckbill snips are used for cutting curves in either direction. They can be used for straight cutting, but will require slightly more effort to cut with than the straight pattern snip. The most popular sizes are 7, 10, and 12-1/2 inches, although 14- and 16-inch sizes are available. The thickness of the metal that can be cut is approximately the same as for the straight pattern snip.

FIG. 67. The duckbill snip can be used for straight cutting as well as cutting curves. Make certain that the bolt holding the blades together is tight; looseness between the blades will cause ragged cuts.

FIG. 68. The duckbill snip will cut smooth curves in sheet metal in either direction. They can also be used for straight cuts, but not as satisfactorily as the regular straight pattern snips.

There are other types of snips available, such as the curved blade, hawkbill, bulldog, light metal, jeweler’s, and pipe and duct. These are used mainly by the professional metal worker or in a specialized
DO’S AND DON’TS WHEN USING SNIPS

- Wear safety goggles when using snips.
- Be careful of the sharp edges on the cutting edges of these tools.
- Wear gloves when working with snips.
- Never cut sheet metal that is thicker than 0.062-inches.
- Use snips for cutting soft metal only. Hard, or hardened metal may damage the cutting edges of the snips.
- Use the right size and type of snips for the job on hand. Don’t try to cut sharp curves with straight cut snips.
- Avoid springing the blades. This is the result of trying to cut metal that is too thick for the snips you are using, or by trying to cut heavy wire or nails.
- Use only hand pressure for cutting. Never hammer, or use your foot to get extra pressure on the cutting edges. If you are resorting to such a technique, you are using too small a snip – the metal is too thick for the capacity of the snip.
- Oil the pivot bolt on the snips occasionally.
- Keep the nut and the bolt properly adjusted at all times.
- The average user does not have the proper equipment to resharpen snips. Do not attempt to resharpen a snip blade in a sharpening device designed for scissors, garden tools or cutlery.
- Do not use “cheater bars” on handles of snips. You are trying to cut material which is too thick if you have to resort to this.
- Don’t use snips as a hammer, a screwdriver or a pry bar. There are tools for such purposes – use them. If the snips you own have locking clips, use them when the tools are not in use.
- Snips should be carefully put away after use. Wipe the cutting edges with a lightly oiled rag. Don’t dump them in a drawer with other tools. Tools with cutting edges should always be treated with extra respect.
THE AUTOMOTIVE VISE

The automotive vise is specifically designed for the automobile aftermarket such as service stations, garages and automobile and truck agencies. This vise has the combined features of the machinist's and workshop vises. It has the pipe jaws and economy of the workshop vise with a machined bench plate having a 360 degree swivel and the positive lock feature of the machinist's vise.

FIG. 30. The Sheet Metal Vise has a deep throat and thin, tapered jaws to allow for close work. The jaws on this type of vise are smooth.

FIG. 31. The Clamp-on Vise can be quickly mounted at the edge of any convenient work surface.
CLAMP-ON VISES

These are generally used for light-duty work. Instead of being bolted to the workbench, they are clamped to the workbench with a sort of C-clamp arrangement. One of their benefits is their portability as they can be quickly moved from place to place.

Smaller vises for working with wood also have a C-clamp arrangement for mounting. These are known as saw horse vises, or carpenter’s vises. These vises usually have pre-drilled holes for attaching wood faces. This vise is “L” shaped which makes it ideal for holding work in either a vertical or horizontal position. These vises are favored by carpenters for use at a job site.

FIG. 33. Clamp-On Vise designed for woodworkers is portable and holds work horizontally or vertically.
THE DRILL PRESS VISE

As its name indicates this vise is used in conjunction with a drill press. The jaws are made so that it will accept round, square, or oddly shaped work and hold it firmly in place. Some have a quick release feature – the movable jaw can be quickly moved up to the work, or away from the work, without turning the handle. The handle is then used for the final half-turn or so to loosen or tighten the jaws.

FIG. 38. The Drill Press Vise should be securely bolted to the drill press table through the lugs provided in the base of the vise. Some drill press vises, as shown in upper drawing, are adjustable for drilling holes at an angle.
THE MACHINIST’S VISE

This designation applies to the strongest, heavy-duty vises made. They are designed to withstand the great strains in industrial work and similar applications. These vises are available in jaw widths of three to eight inches. Models are made with stationary bases, swivel bases, pipe jaws (combination vises), with replaceable jaw inserts, and even with jaws that swivel.

Special purpose vises include the sheet metal worker’s vise (thin, tapered jaws that allow close work) and hydraulic models with a rapped movement of the sliding jaw. Smooth jaw models and copper jaw caps are available to prevent possible marring of the work.

FIG. 28. The Machinist’s Vise should always be bolted, never screwed, to the workbench.
MILLING MACHINE VISE

These vises, used with milling machines, have a swivel base graduated in the degrees of a circle; also available with an air-hydraulic operating system.

FIG. 39. Milling machine vises, used in machine shops, are made with graduated swivel and stationary bases. They are also available for power operation using an air-hydraulic system. Caution: Make sure the base is securely bolted to the bed of the machine.
PIPE VISES

Pipe vises are especially designed to hold pipe or round stock. They are often mounted on trucks and beams as well as on workbenches. They are available with capacities to hold pipe up to eight inches in diameter. The two main types are the yoke vise and the chain vise, with the latter specially designed to hold irregular work. Both types are available with tripods and are called tripod vises. A clamp kit vise can be mounted without drilling holes for temporary attachment where light-duty work is to be performed.

Pipe vises are made in a number of different forms, including vises with bolt holes for permanent mounting and portable vises with clamp attachments for temporary mounting on benches, studs, posts, etc. Yoke pipe vises should not be used for holding or pulling vertical pipe.

FIG. 34. Yoke Type Pipe Vise is bolted to the workbench. Note the hinges at one end and the hook at the other so that the pipe need not be "threaded" through the vise jaws to worked on.

![Yoke Type Pipe Vise](image)

FIG. 35. The Chain Vise is designed to hold pipe as well as irregular work. Work is released from the vise by loosening the nut and then removing the pipe — or other work — from the vise. This allows the pipe to be installed or removed without having to slide its entire length through the vise.

![Chain Vise](image)

FIG. 37. The Clamp Kit Vise can be temporarily mounted without drilling holes, sometimes on the nearest 2x4, for light-duty work.

![Clamp Kit Vise](image)
SPECIALTY VISES

Hydraulic Vises. Two types are available. One kind has a built-in hydraulic booster-reservoir to multiply the power of your hand as the handle is turned. The other type, used in production work, operates by means of an air-hydraulic system controlled with a foot pedal. The big advantage with such a vise is the amount of time saved in installing and removing the work and the extra tightness with which they hold the work.

Model Maker’s Vise. (Also known as the Hand Vise). A light-duty vise with 2 inch jaws, hand held for use with small work. The jaws are tightened by means of a thumb nut. Model railroad fans and model airplane workers use these vises.

FIG. 40. The Model Maker’s Vise (also known as the Hand Vise) is usually hand held as shown for holding small parts to be assembled or worked on. It can also be mounted on a larger vise when the use of both hands is required. Caution: Do not over-tighten the jaws of the vise.

Vacuum Base Vises. These vises even require less work to mount than the clamp-on vises. Their base consists of a rubber pad which is arched into a concave shape by means of a lever. When the vise is placed on a smooth surface and the lever is turned, a vacuum is created that firmly holds the vise in place. These vises of course are designed for comparatively light-duty work.

FIG. 41. The Vacuum Base Vise can only be fastened to a smooth non-porous surface. A handle, moved as indicated, creates a vacuum that secures the vise to the table's surface. Such vises are used for light-duty work only.

FIG. 42. This type of vise is designed so that it can be flipped to hold the work in a vertical position as shown in the small illustration. After flipping, an auxiliary handle is used to keep the jaws in their new position.
THE UTILITY VISE

The utility, or workshop vise, is a lighter duty version of the machinist's vise. It usually has pipe jaws located below the flat jaw facings and comes in jaw widths from three to five inches. The Acme thread, or the screw that draws the jaws together, may or may not be exposed. Most models are made with swivel bases and replaceable jaw inserts.

FIG. 29. The Utility Vise, like the machinist's vise, should also be bolted to the workbench top, never screwed in place.
VISE

The vise, sometimes called the third hand (but no hand can grasp work as firmly as a vise) is the indispensable tool in the tool room or home workshop. Vises are usually mounted on a workbench or a similar firm support, to hold the material to be worked on. There are eight basic categories of vises and many special purpose vises. While most of these vises can be used for a wide variety of work, it is important to select the vise most suitable for the prime application and strong enough for any work required.

TYPE
Machinist's Vise
Utility or Workshop Vise
Automotive Vise
Woodworker's Vise
Clamp-On Vises
Pipe Vise
Milling Machine Vise
Drill Press Vise

FIG. 27. It is important to mount any vise with the stationary jaw projecting slightly beyond the edge of the workbench so that long work can then be clamped in the vise without interference from the edge of the workbench.

CHIEF APPLICATION
Heavy industrial work
For light work and home workshop
Service station work
Carpentry and general wood work
Light work requiring portability
Plumbing and pipe work
For milling machine work
To hold work on a drill press
DO'S AND DON'T'S WHEN USING A VISE

- Use bolts in all the holes in the base of the vise.
- Use lock washers under the nuts.
- Do not use the jaws of the vise as an anvil.
- When work is held in the vise for sawing, saw as close to the jaws as possible (to prevent vibration). Be careful not to cut into the jaws.
- When clamping extra long work, support the far end of work rather than putting extra pressure on the vise.
- Avoid clamping work with heavy pressure at the corner of the vise jaws as they may break off a corner of a jaw.
- Wear safety glasses when hammering or pounding on an object held by the vise.
- Replace a bent handle.
- Replace worn jaw inserts.
- Adjust for play between nut and screw or replace them when excessive play develops in the handle.
- Lightly oil all moving parts.
- Never use an extension handle for extra clamping pressure.
- Use jaw liners with a vise if there is any possibility of marring the work.
- If the threaded part of the vise is exposed, keep it free of chips and dirt.
- Discard any vise that exhibits the slightest hairline fracture.
- Never pound on the handle to tighten beyond hand pressure.
- Never try to repair a vise by welding or brazing.

FIG. 44. Use a vise large enough to hold the work without strain. Base of vise should be bolted to a smooth even surface to prevent unnecessary stresses to base when vise is in use. Note that Careful Cil has the vise bolted to the bench.

RIGHT
WOODWORKER’S VISE

The woodworker’s vise is used when working with wood. To protect the work, and to get a good grip on large pieces of wood, the jaws on these vises are much larger than the jaws on other vises, generally being four by seven inches and even larger — four by ten inches. This type of vise is available with a rapid-action nut which allows the movable jaw to be moved in and out quickly with the final tightening by turning the handle a half turn or so.

Woodworkers’ vises usually have drilled and tapped holes so that liners of wood can be mounted in the jaws to prevent marring the work.

A well-equipped shop may have a metal-working vise mounted at the left side of the workbench and a woodworking vise mounted at the right.

FIG. 32. The Woodworker’s Vise is bolted to the underside of the workbench. Mount it so the top of the vise jaw is flush with the surface of the bench and flush with the corner of the bench.
WOOD SPLITTING WEDGES

Wood splitting wedges are usually made from a solid piece of steel. They are made in various patterns, the ones illustrated being the most commonly used.

Proper Uses. Wood splitting wedges are designed for splitting logs, firewood, staves and other wood products. Always use a wood-choppers' maul or an axe to make a starting notch. Wedges should be struck with a sledge or wood-choppers' maul having a larger striking face than the struck face of the wedge.

Abuse/Misuse. Never use a wedge with a mushroomed or chipped struck face.

When to Replace. Discard any wedge if it shows dents, cracks, chips, mushrooming, or excessive wear. If splitting edge is dull it may be redressed as instructed in Section V.
WOODCHOPPERS' MAULS

Woodchoppers' mauls have a round, bevel-edged striking face with a splitting edge opposite.

Proper Use. These tools are designed for splitting wood. Also they are used in conjunction with wood splitting wedges by first making a notch with the splitting edge and then driving the wedge with the maul's striking face.

Abuse/Misuse. Never use this tool to strike concrete. Never drive one maul by striking with another maul, sledge or other striking tool. Never use a maul with a loose or damaged handle.

WRONG

When to Replace. Discard any maul if it shows dents, cracks, chips, mushrooming, or excessive wear. If handle only is damaged, replace it with an equivalent new handle. Redress the bit as instructed in section
ADJUSTABLE WRENCHES

Regular pattern Adjustable wrenches are available in lengths from 4 to 24 inches.

Proper Uses. Adjustable wrenches are designed to provide a wide range of capacity in a single tool and are a convenient service wrench for repairmen, linemen, etc. They are not intended to replace fixed opening wrenches for production or general service work. High dielectric insulated handle types are widely used by linemen and other electrical workers. WARNING. Ordinary plastic dipped handles are for comfort only; not electrical insulation.

Adjustable wrenches should be tightly adjusted to the nut and pull so that the force is on the side of the fixed jaw.

Abuse/Misuse. Do not use an Adjustable wrench to free a “frozen” nut or to final tighten a nut. Never pull on a wrench adjusted to a loose fit with a fastener. Never use a hammer or extension on this wrench.

THIS LOOSELY ADJUSTED WRENCH CAN DAMAGE THE NUT, WRENCH AND HARRY. WRONG.

When to Repair or Replace. Practically all manufacturers supply parts assortments, repair kits and instructions for their Adjustable wrenches. Periodic inspections should be made to detect damaged jaws, knurls, pins and springs. Damaged parts should be replaced. Discard any wrench with spread or damaged fixed jaw or bent handle.
BOX WRENCHES

Box wrenches are made in long and short patterns with double offset and 15 angle offsets. Twelve-point, hex and square openings are available in regular and heavy-duty patterns. Double head types have different openings in each head. The Ratcheting type has both hex and 12-point box openings. The Structural pattern is very similar to the Open-End pattern except that it has a 12-point box opening. The Striking Face wrench is made in both straight and offset patterns with 12-point openings.

Proper Uses. Box wrenches in the regular pattern are designed for general service. The Heavy-Duty and Striking Face patterns are designed for the service indicated. Ratcheting Box wrenches are for light duty and should not be used in heavy-duty applications. Split box and Flare Nut wrenches are for tubing fitting and should not be used for general nut and bolt applications.

THE STRUCTURAL BOX WRENCH IS THE SAFEST TOOL THE STEEL WORKER CAN USE.

Abuse/Misuse. Use only a sledge type hammer on a Striking Face wrench. Always wear safety goggles to protect your eyes. Never use an extension on the wrench handle.

When to Repair or Replace. Attempts to repair Box wrenches are not recommended. Discard any wrench with broken or battered points.
COMBINATION BOX-OPEN-END WRENCHES

The most widely used patterns are made in long and short types having a 15 angle open end and a 12-point box opening of the same size opposite. The box opening is offset at a 15 angle to the handle for clearance. Special service types including the following tool. The Split Box or Flare Nut pattern is for use on tube fittings and should not be used for high torque applications. This type has a 6- or 12-point opening offset 15 from the plane of the handle with a tube opening slot at an angle to the axis of the handle. This pattern is also available with openings of different size at each end.

Proper Uses. Combination Box-Open-End wrenches are designed for a wide variety of work. Their box opening adds to their versatility and strength. The Flare Nut pattern with its hex box opening is especially useful in air conditioning and refrigeration work where tubing terminates on flare nuts.

USE A SPLIT BOX WRENCH ON FLARE NUTS.

RIGHT

Abuse/Misuse. Do not use the open end of these wrenches to free a "frozen" nut or final tighten a hex nut. Use the box opening. Never use an extension on the wrench handle.

When to Repair or Replace. Attempts to repair Box-Open-End wrenches are not recommended. Discard any wrench with spread, nicked or battered jaws on the open end or rounded or damaged points on the box end. Discard wrenches with bent handles.
HANDLE TYPE WRENCHES

Handle types include Reversible ratchet, Sliding Tee, Speeder and Flex Head. Ratchets with dielectric insulation handles are available for linemen's use. Attachments include extension bars, adapters, flexible joints and various socket bits such as hex, slotted, Phillips screw, etc.

CAUTION: Reversible ratchet wrenches are rated among the strongest hand tool driver in their respective drive size. They are designed to interchange with the full range of all accessory and socket hand tools, also in their respective drive size.

The possibility exists for a lower torque rated accessory or socket or a combination of accessories and socket to be used in conjunction with a higher rated ratchet or drive tool.

Care should be exercised so as not to overload the weakest component.

Extra Heavy - Duty Ratchet Wrenches. These powerful wrenches are made in various lengths.

A - ADAPTER
B,C,E - EXTENSION BARS
D - SLIDING T HANDLE
F - DEEP 6-POINT SOCKET
G - DEEP 12-POINT SOCKET
H - SPARK PLUG SOCKET
I - SPEEDER HANDLE
J - RATCHET ADAPTER
K - REGULAR 6-POINT SOCKET
L - REGULAR 12-POINT SOCKET
M - HEX SOCKET SCREW SOCKET
N - UNIVERSAL 12-POINT SOCKET
O - FLEX HANDLE
P - FLEX HEAD RATCHET
Q - REVERSIBLE RATCHET
R - UNIVERSAL JOINT

Nut Drivers. Nut drivers are screwdriver-type tools which, in their simplest form, have a one-piece shank and socket secured in a fixed handle. Socket heads have openings for hex nuts, bolts and screws up to 3/4" nut size. Shafts may be solid, drilled part way or full hollow-plain or magnetic for holding small fasteners.
OPEN-END WRENCHES

The most widely used Open-End wrenches are made with openings at a 15° angle, which permits complete rotation of hex nuts with a 30° swing by flopping the wrench. They are available in both single and double head patterns; double head patterns have different openings in each head.

In addition to the above popular patterns, Open-End wrenches are made for special types of service. Ignition wrenches are small, thin wrenches having openings at 15° and 60°. Tappet wrenches, both single and double head, have openings at 15° angles, and are longer and thinner. Construction wrenches have a single 15° opening and a drift handle for aligning bolt holes. Structural wrenches are similar to the Construction pattern except they have straight openings and an offset handle. Set Screw and heavy "S" wrenches have openings at a 22-1/2, rather than a 15° angle.

Proper Uses. Open-End wrenches are designed for a wide variety of work. Special patterns are intended for the type of service which their name implies; e.g., Tappet, Ignition, Set Screw, Structural, etc.

Abuse/Misuse. Do not use an Open-End wrench to free a “frozen” nut or to final tighten a nut. Use a box wrench because it is stronger. Never use a hammer on this type of wrench. Never use an extension on the handle.

DON'T HAMMER ON THIS WRENCH.
WRONG

When to Repair or Replace. Attempts to repair Open-End wrenches are not recommended. Discard any wrench with spread, nicked or battered jaws, or bent handle.
SPANNER WRENCHES

Spanner wrenches are made in a variety of patterns as illustrated.

Proper Uses. Spanner wrenches are basically a machine shop tool. They are used on machine tools for adjusting collars, lock nuts, rings, spindle bearings, face plate draw nuts, etc.

Abuse/Misuse. Do not hammer on wrench handle. Do not use an extension on the handle.

When to Repair or Replace. Attempts to repair these wrenches are not recommended. If pins, hooks or forging are bent, deformed or cracked discard the tool.
TORQUE WRENCHES

Torque wrenches are designed to permit an operator to determine applied torque on bolts, nuts and other fasteners. They measure torque in ounce-inches, pound-inches and pound-feet, as well as metric measure. However, many manufacturers express torque in foot-pounds (rather than pound-feet) since this nomenclature is more familiar to the average tool user. Metric measure torque wrenches are available in Newton meters (N.m), are meter kilograms (mkG) and centimeter kilograms (cmkg), with N.m becoming the more modern, universally accepted calibration. Many torque wrenches are available with dual scales for conventional and metric measurements.

Two basic hand torque wrenches are audible signal and visual display. One type signals applied torque by momentarily releasing the wrench for a few degrees of free travel. The release is usually (but not always) accompanied by a click sound thus giving the wrench its popular names: Click Torque wrenches or simply Clickers. Torque value is set to a micrometer scale on the handle or preset by an adjusting screw in the handle cavity (which precludes accidental resetting).

A second type indicates, rather than signals, torque. Applied torque is indicated on a dial or electronic digital display. Some models have memory pointers which remain at the maximum reading attained until manually reset.

For low torque applications, torque screwdrivers are usually used. They are available in either the release (free wheeling) type, or in the indicating type.

The most widely used Torque wrenches have square drives to utilize standard detachable sockets. Both ratcheting and non-ratcheting types are available.

Torque Multipliers. Torque multipliers are multi-gear tools generally used with ratchets or ratcheting torque wrenches as the drive component. Input is multiplied through the gearing four or more times depending on the model used. A reaction bar, which locks into the head of the torque multiplier, must rest securely against an object sturdy enough to withstand the force that will be generated. When driving a torque multiplier with a torque wrench, a torque loss factor at the fastener, caused by frictional losses through the gear train, must be taken into consideration in determining the desired torque at the output side of the torque multiplier. Torque loss factors are available from most torque tool manufacturers. Torque wrenches are available which can be used between the output side of the torque multiplier and the fastener. When used in this manner, the actual torque on the fastener may be read without the need to compensate for frictional loss.

Proper Uses. Torque wrenches are used in various operations where proper torquing of nuts, bolts and other fasteners is critical. Such operations include assembly and inspection of gear trains and bearings, setting of clutches and brakes, maintenance repair, overhaul and experimental work.

Always work with clean threads that are free of corrosion. It is important to follow the product manufacturer’s instructions for specific torque loadings—particularly whether recommendations are for dry, oiled or plated threads, and other instructions which apply to a particular tool. Avoid overtightening a nut or bolt with a conventional wrench before applying a torque wrench. When not in use, the adjustable type wrench should be set to the lowest torque.

Abuse/Misuse. A Torque wrench is a precision instrument and should not be roughly handled. Never use it as a hammer, a pry or as a conventional wrench-use it only as a torque tool. Avoid dropping.
WRENCHES

- Never use a pipe extension or other form of "cheater" to increase the leverage of any wrench.

NEVER USE A LEVERAGE EXTENSION ON A WRENCH HANDLE.
WRONG

- Select a wrench whose opening exactly fits the nut. If the wrench is not exactly the correct size for the fastener, it is apt to damage the corners of the fastener, slip, or break. Care should be exercised in selecting only inch wrenches for inch fasteners and only metric sizes for metric fasteners. High strength fasteners - grades 5 and 8, 12 Pt. nuts and bolts, and many other aerospace fasteners require unusually high torques for their size and, therefore, require special care in the selection and use of wrenches.

- If possible, always pull on a wrench handle and adjust your stance to prevent a fall if sudden release occurs.

ADJUST YOUR STANCE AND PULL WHEN APPLYING HIGH TORQUE.
RIGHT

- The safest wrench is a box or socket type; both because it is stronger and because it has less chance of slipping off the fastener. Different types of wrenches are of different strengths and are designed for different purposes. Open end, flare nut, and adjustable wrenches are not as strong as the corresponding sizes of box or socket wrenches and are not intended for heavy loads, such as breaking loose frozen fasteners or final tightening.

- To free a "frozen" nut or bolt, use a striking-face box wrench or a heavy-duty box or socket wrench. Application of penetrating oil beforehand is recommended.

WEAR SAFETY GOGGLES AND USE A HEAVY SLEDGE TYPE HAMMER ON A STRIKING FACE.
RIGHT