Site Safety Plan

O.H. Hinsdale Wave Research Laboratory
Structural Engineering Laboratory
Geotechnical Research Facility

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Chapter 1

ADMINISTRATIVE SAFETY PLAN ELEMENTS

Management Statement

The Network for Earthquake Engineering Simulation (NEES) Tsunami Research Facility at the O.H. Hinsdale Wave Research Laboratory (HWRL) adheres to the policy guidelines as set forth by the Oregon State University (OSU) Health and Safety rules and regulations. It is the responsibility of the Environmental Health and Safety (EHS) unit at the University to assist departments in maintaining a safe and healthy university environment for staff, faculty, students, and visitors. A copy of the Oregon State University safety policy and procedure manual including their policy statement can be found at http://oregonstate.edu/fa/manuals/saf. In addition to any University policies and procedures, this manual outlines policies and procedures specific to the facility.

Anyone planning to work at the facility must sign a form indicating that they have read and understood the site safety plan and safety rules, and participate in a walk-through safety training session prior to the start of any operations. If users are not employees of the University, they must also sign a volunteer waiver. This document describes the comprehensive and proactive safety plan in use at this facility. The plan is built upon the principles of involvement, identification, rules, and training. A white paper developed by the NEES consortium (appendix D) further provides an outline for safe operations at the site.

Safety Policy

The O.H. Hinsdale Wave Research Laboratory (HWRL) adheres to the University’s safety policy described below. The policy applies to all University personnel including faculty, staff, students and visitors and requires everyone to follow safe working practices and procedures. The policy states:

*Effective management of health and safety at Oregon State University is fundamental to delivering excellence in research and teaching. Health and safety should be a concern to everyone since our mutual efforts and vigilance are necessary to eliminate incidents that result in personal injury and loss of property. The majority of injuries and property loss are costly and preventable. Through the dedicated efforts of everyone involved, we can maintain a safe and healthy environment while accomplishing the mission of the University.*

*Oregon State University will make reasonable efforts to provide a safe and healthful working environment for all employees, students and others who may utilize the*
University's facilities and grounds. All University departments/units will develop and implement safety policies and procedures that promote an injury free environment.

Anyone engaged in University related activities must exercise personal responsibility and care to prevent injury and illness to themselves and others who may be affected by their acts or omissions. No person shall intentionally interfere with or misuse anything provided by the University in the interests of health and safety. Only properly trained individuals are permitted to use tools or operate equipment, vehicles and machines that require specific safety training for safe operation. Faculty and staff administrators will be held accountable for fulfilling their safety responsibilities. Flagrant disregard of the University safety policies and procedures may result in the disciplinary actions.

Priority should be given to safe working conditions and job safety practices in the planning, budgeting, direction and implementation of University activities.

The OSU Health and Safety Policy should be read in conjunction with SAF 103: OSU Safety Program and other safety policies contained in the OSU Safety Policy and Procedure Manual.

http://oregonstate.edu/fa/manuals/saf/101
Accident Analysis, Investigation, and Record Keeping

OSU EHS is to be alerted of all reportable accidents. EHS contacts are listed in page 6 and in Appendix A. Records of accidents are kept on-site in the office of the Lab Manager / Site Safety Coordinator, in compliance with federal and state statutory requirements (http://oregonstate.edu/ehs/bulletin/si18.html). EHS is also able to access the SAIF database for accident history. The EHS website accident/illness form is maintained at (http://oregonstate.edu/admin/hr/document/pdf/roa). Accident investigation procedures including timelines are outlined at http://oregonstate.edu/fa/manuals/saf/203.

Besides following standard University EHS procedures, all accidents or near-misses are to be reviewed during the safety portion of the weekly laboratory meeting. A follow-up analysis with involvement by OSU EHS will lead to a clear understanding of what occurred and what could have been done differently to avoid the accident. Scenarios will be discussed and preventative measures will be put into place to avoid future problems. If appropriate, the safety training procedure will be modified to incorporate any new findings.

Emergency Plan

OSU EHS has developed an emergency response plan for all University Employees, and other visitors and participants on site. The plan is detailed in Appendix B. All staff and visitors at the site will comply with the emergency response plan as directed by EHS. Emergency flip charts are posted throughout the facility.

Employee Participation

The safety practices described in this plan apply to all University personnel who are working and utilizing the NEES Tsunami Research Facility equipment, including faculty, staff, students and visitors. Everyone must follow safe working practices and procedures. 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 of facility staff or director. All employees, visitors, and students have the responsibility to comply with all University EHS and HWRL 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) All job-related injuries or illnesses are to be promptly reported to facility staff. Prompt and appropriate medical treatment will be sought.
5) No personnel will operate equipment or conduct any procedure without proper training and authorization.

All visitors and students must read the site safety plan and the safety rules, and sign a form verifying that they have read and understood the material contained in these documents. These documents will be kept on site along with other safety documents in the office of the Lab Manager/Site Safety Coordinator.
Job Hazard Analysis

The EHS maintains a comprehensive job hazard analysis manual (http://oregonstate.edu/ehs/sites/default/files/pdf/hazardanalysis.pdf). 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 hazards (crane, hoist, flume walls)</td>
<td>Wear a hard hat when conditions warrant</td>
</tr>
<tr>
<td>Chemicals, dust, dirt, grease, heat, cold</td>
<td>Use appropriate PPE</td>
</tr>
<tr>
<td>In the Large Wave Flume (LWF)</td>
<td>Wear hard hat at all times</td>
</tr>
<tr>
<td>Tsunami Wave Basin (TWB) bridge crane operation</td>
<td>All personnel in the vicinity will wear hard hat</td>
</tr>
<tr>
<td>Loud noises from power tools/equipment/other</td>
<td>Wear ear protection</td>
</tr>
<tr>
<td>Operating power tools, using aerosol chemicals</td>
<td>Wear eye protection</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>TWB bridge crane accident</td>
<td>Operators must be trained and all personnel must wear hard hats</td>
</tr>
<tr>
<td>LWF cart/hoist accident</td>
<td>Operators must be trained. Hard hats are not required.</td>
</tr>
<tr>
<td>Drowning</td>
<td>Buddy system and rescue equipment</td>
</tr>
<tr>
<td>Hypothermia/heatstroke</td>
<td>PPE, heaters, blankets, hot shower, water breaks, work stoppage</td>
</tr>
<tr>
<td>Electrocution hazard</td>
<td>GFI, inspections of electrical wiring with respect to contact with water</td>
</tr>
</tbody>
</table>
OSHA Action Plan

The University EHS will act as a liaison with all regulatory agencies inspecting campus facilities. No special action is required of HWRL facility staff in the event of an inspection by an OSHA compliance officer. EHS contacts are provided below or can be found at the EHS website: http://oregonstate.edu/ehs/staff.

Environmental Health & Safety
100 Oak Creek Building
3015 SW Western Blvd
Corvallis, Oregon 97331-7405
Phone: (541) 737-2273
Fax: (541) 737-9090

For emergency safety concerns, call Public Safety at 541-737-7000.

For routine service requests or questions during business hours, call the Work Coordination Center 737-2969 and ask for the EH&S ON-CALL person.

**Environmental Health & Safety Personnel**

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone</th>
<th>Email</th>
<th>Position Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrew Gray</td>
<td>541-737-7651</td>
<td></td>
<td>Asbestos Management, Surveys, &amp; Abatement Services, Construction Safety</td>
</tr>
<tr>
<td>Daniel Harlan</td>
<td>541-737-7082</td>
<td></td>
<td>Assistant Radiation Safety Officer</td>
</tr>
<tr>
<td>Dan Kermoyan</td>
<td>541-737-2505</td>
<td></td>
<td>Assistant Director of EH&amp;S, Environmental Protection, Ergonomics, Occupational Safety, Agricultural safety</td>
</tr>
<tr>
<td>Kay Miller</td>
<td>541-737-7083</td>
<td></td>
<td>Safety Training Coordinator</td>
</tr>
<tr>
<td>Lance Jones</td>
<td>541-737-2274</td>
<td></td>
<td>Chemical Safety, Exposure Assessments, Indoor Air &amp; Water Quality, Occupational Health</td>
</tr>
<tr>
<td>Matt Philpott</td>
<td>541-737-4557</td>
<td></td>
<td>Biological Safety Officer</td>
</tr>
<tr>
<td>Pete Schoonover</td>
<td>541-737-3127</td>
<td></td>
<td>Hazardous Materials Disposal Services, Haz-Mat Shipping, DEA Materials</td>
</tr>
<tr>
<td>Rainier Farmer</td>
<td>541-737-7080</td>
<td></td>
<td>Radiation Safety Officer</td>
</tr>
<tr>
<td>Terese Keller</td>
<td>541-737-7688</td>
<td></td>
<td>Dosimetry, Radiation Safety Administrative Support</td>
</tr>
</tbody>
</table>

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 are logged in the weekly minutes until corrective action has taken place.

**Safety Rule Enforcement**

Any willful violation of the facility safety rules and policies or refusal to follow the directions of facility staff will result in an immediate suspension of the right to work within the facility. It is recognized that most violations of safety policy and rules are inadvertent. In these cases, the offending worker will

1) Receive a verbal warning and an explanation, and be asked to correct the improper action
2) If the problem continues, the person will forego his right to work with the equipment or in the area where the problem occurred. Staff and director will be informed.

**Safety Rules**

Rules are posted at several locations throughout the facility. Safety orientation for all personnel is required before participation in any work at the facility.

**General Facility**
- Authorized personnel only
- No horseplay
- Focus on the task at hand
- No cell phones or other mobile devices to be used while operating shop tools, driving or heavy equipment operator
- Do not distract shop tool operator, driver or heavy equipment operator
- Use appropriate safety gear provided
- All personnel will wear a hard hat when conditions warrant
- Protective clothing and equipment will be worn whenever conditions warrant
- Closed toe shoes required for any personnel working on the laboratory floor.
- Training/checkout required for all power equipment and tools.
- Eye protection will be used when power tools, aerosol paints and chemicals are used anywhere in the facility

**Large Wave Flume (LWF)**
- Anyone working within the confines of the LWF must wear a hard hat at all times
- Nothing will be placed on the LWF walls that creates an overhead hazard
- Anyone working in the LWF should be aware of falling hazards

**Tsunami Wave Basin (TWB)**
- Whenever the bridge crane is in operations, all personnel will wear hard hats.
Shop Safety (EHS [http://oregonstate.edu/ehs/LP-L-shop](http://oregonstate.edu/ehs/LP-L-shop))

- Use of equipment requires training and authorization prior to use
- No cell phones or other mobile devices to be used while operating shop tools
- Eye protection must be worn when working in and operating shop equipment and power tools.
- Ear protection will be at facility staff discretion and direction
- Loose clothing should not be worn
- Long hair should be tied back
- Machine guarding for the grinder will be checked and in place if in use

Hazardous Materials

- Hazardous materials are kept in a specifically identified cabinets
- MSDS sheets are available for all hazardous materials either with the safety officer, or at the EHS chemical safety website site, [http://oregonstate.edu/ehs/msds](http://oregonstate.edu/ehs/msds)

Operation of facility owned heavy equipment

- Forklift operation
  - Operators must be trained
  - No cell phones or other mobile devices to be used while driving the forklift
  - Do not distract forklift operator
  - A form certifying training must be signed and kept with the safety officer
- TWB Bridge crane operation
  - Operators must be trained
  - No cell phones or other mobile devices to be used while operating the crane
  - Do not distract crane operator
  - Operators must be aware that hard hats are mandatory while bridge crane is in use.
- LWF cart and hoist
  - Operators must be trained
  - No cell phones or other mobile devices to be used while operating the cart and hoist
  - Do not distract cart and hoist operator

Facility Cleanliness

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

Drowning and hypothermia hazard

- Any personnel working in the LWF or TWB while filled with water is required to have a buddy present.
- If any personnel are working in the tanks when cold water conditions exist, they will wear appropriate protective clothing. If necessary, heaters, blankets, and a hot shower are available.
Electrocution hazard
- Whenever electrical cords are used, frequent inspection of the cords is required to ensure they are not in contact with water.

Self-Audits, Self-Inspections

EHS supplies the site annually with a safety audit that the site can refer to when conducting self-audits and self-inspections. Any areas identified as needing attention are brought up at the weekly safety meeting. Results of the walk-through and safety audit are available upon request.

On a monthly basis, the designated safety officer will conduct or assign staff to conduct a self-inspection. The self-inspection form is site specific and shown in Appendix C. 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 Coordinator.

Safety Staffing

EHS is in charge of and oversees the University safety committee which includes this facility. Tim Maddux is the designated Safety Officer/Coordinator. 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 verifying that the plan was read and understood
- signed waivers for any non-OSU visiting personnel who are involved in work at the site
- monthly self-inspection forms
- OSU vehicle authorization forms
- forklift safety training checklist
- safety walkthrough form
Chapter 2

UNIVERSAL OSHA-MANDATED SAFETY PLAN ELEMENTS

Blood Borne Pathogens

No research work or instructional training with human blood products occurs at this facility. For cases where there is potential for human blood contact, EHS maintains a comprehensive website describing University policy and exposure control (http://oregonstate.edu/ehs/sites/default/files/pdf/OSHA-Bloodborne-Pathogen-Standard.pdf), which the facility adheres to. Particularly relevant sections of the website include “occupational exposure control, definitions, universal precautions, work practices, personal protective equipment, and post exposure follow-up.”

Gloves and other protective gear are stored with the emergency first aid equipment. Staff and visitors will be shown protection gear and explained on proper use to avoid transmission of blood borne pathogens. In the event of an emergency, staff will use provided PPE gear (gloves, masks) and either contact EHS for further instructions (see Appendix A for contact information) or if life threatening, immediately summon emergency personnel via 911. Any further instructions involving protection will be under the direction of EHS or the 911 dispatcher and emergency personnel. Follow up and decontamination procedures are detailed at the EHS website.

Chemicals

A written communication plan for industrial and laboratory chemical hazards exists at the EHS website (http://oregonstate.edu/ehs/chemical). A site specific chemical inventory also is maintained at the EHS website: http://oregonstate.edu/ehs/cheminv.

Fire and Life Safety

The facility has posted safety maps denoting first aid stations, exit routes, fire extinguisher locations, and special hazard areas. A copy of the map is attached in Appendix G. The facility is routinely inspected by the City of Corvallis Fire Department for compliance.

Lockout/Tagout

The site adheres to the EHS lock-out/tag-out policy as detailed at their website (http://oregonstate.edu/fa/manuals/saf/208). No staff or visitor will inspect, repair or perform maintenance on any facility electrical systems. If service on the building electrical system is required, the site staff will contact University facility electricians who are responsible for lock-out/tag-out procedures.
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 wavemaker equipment. All facility staff will be trained in 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. **Notify all** employees within the immediate affected area that a lockout or tagout is going to be utilized and the reason why
2. If the equipment is operating, shut it down by the normal stopping procedure
3. Operate the switch, valve, or other energy isolating device(s) so that the equipment is isolated from its energy source(s)
4. Lockout and/or tagout the energy isolating devices with **assigned** individual lock(s) or tag(s)
   - Lockout devices and tagout devices are to indicate the identity of the employee applying the device(s)
   - Following the application of lockout or tagout devices, all potentially hazardous stored or residual energy shall be relieved, disconnected, restrained, or otherwise rendered safe
5. At this point the equipment is considered to be locked or tagged out
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
Personal Protective Equipment (PPE)

The EHS PPE policy is detailed at [http://oregonstate.edu/fa/manuals/saf/202](http://oregonstate.edu/fa/manuals/saf/202). The Use of personal protective equipment specific to the facility is outlined in the Job Hazard Analyses section. All employees and visitors will be trained in proper use of personal protective equipment during the safety walkthrough training. Visitors and students sign both the safety walkthrough and a form certifying that they had read the safety plan. The site maintains the following PPE and the location of this equipment clearly marked on the site map (appendix F) and pointed out during training.

<table>
<thead>
<tr>
<th>Leather gloves</th>
<th>Hard hat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical resistant gloves</td>
<td>Hearing protection</td>
</tr>
<tr>
<td>Safety shoes</td>
<td>Goggles</td>
</tr>
<tr>
<td>Safety glasses with side shield</td>
<td>Protective clothing</td>
</tr>
<tr>
<td>Rubber boots</td>
<td>Waders</td>
</tr>
<tr>
<td>Dust masks</td>
<td>Harness for heights</td>
</tr>
</tbody>
</table>

Hard hats must be worn when
- overhead crane operations are underway and whenever conditions warrant
- working in the confines of the LWF
- 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.

If any personnel are working in the tanks when cold water conditions exist, they will wear appropriate protective clothing. If necessary, heaters, blankets, and a hot shower are available.
Chapter 3

CONDITIONAL OSHA-MANDATED SAFETY PLAN ELEMENTS

Compressed Gasses

University EHS policy and procedures for handling compressed gas cylinders at the facility are outlined at [http://oregonstate.edu/ehs/sd0022](http://oregonstate.edu/ehs/sd0022). A list of safe handling rules at the website is outlined below.

Safe Handling

- Ensure contents of cylinders are properly identified
- Don’t accept unidentified cylinders and don’t rely on color codes; read the label
- Don’t destroy or remove identification tags or labels
- Check to see cylinder valves are protected with protective caps
- Leave caps on until the gas is about to be used.
- Move cylinders only with a suitable hand truck
- Do not roll or drop cylinders, or let them bump violently against each other.
- Secure cylinders with a chain or strap positioned around the upper third of the cylinder
- Small cylinders may be put on their side and blocked to prevent rolling
- Clear cylinder valves of any dust or dirt before attaching proper regulators
- Some regulators are only for specific gases; regulators should not be interchanged
- Do not force connection fittings and never tamper with safety devices in cylinder valves or regulators
- Release adjusting screw on regulator before opening cylinder valve
- Stand to the side of the regulator when opening cylinder valve
- Open cylinder valve slowly
- Store cylinders in a well-ventilated area away from all sources of heat or flames
- Do not store flammable gases next to exit or oxygen cylinders
- Before returning cylinder, close the valve and replace the protective cap
- Separate empty and full cylinders during storage
- Mark empty cylinders "EMPTY" or "MT"
- Know safety and first-aid requirements for gases being used.
- Review Safety Bulletins, MSDS sheets, and read the warning labels

Confined Spaces

No permit requiring spaces are present at the facility.

Crane and Hoist Safety

All personnel at the facility who are working and directing crane operations are required to complete crane hoist training that includes controls, rigging, pre-operation inspection and basic
safety. The facility requires staff to read the two documents in Appendix E, Overhead Crane Manual, Safe Rigging, and Standard Hand Signals as part of the training and then the hoist training checklist shown in Appendix C must be filled out and signed prior to using or directing crane operations. Additional information can be found at the EHS website http://oregonstate.edu/ehs/sd0050.

Overhead cranes will be inspected at least monthly during the facility safety walkthrough. An overhead crane inspection checklist is provided in Appendix C. Annual inspections and certifications of facility overhead cranes are required.

**Drowning**

Facility staff will determine if a drowning hazard is present. If it is determined to be a hazard, personnel in the water will be required to work with an observer “buddy”. Additionally, the observer will have access to rescue hooks, flotation devices, and be able to perform a water rescue. Location of rescue hooks and flotation devices are part of the site safety training procedure.

**Elevated Work**

See EHS website on elevated work surfaces (http://oregonstate.edu/ehs/SD0037 ) which covers all elevated work at the facility. Fall protection is required wherever employees are working on unprotected surfaces more than 6 feet above a lower level, or at ANY height above dangerous equipment. An unprotected side or edge means any side or edge (except at entrances to points of access) of a walking/working surface, e.g., floor, roof, ramp, or runway where there is no wall or guardrail system at least 39 inches (1.0 m) high. Prior to start of elevated work, facility staff will inspect all harnesses, webbing, lanyards and anchorage. Retractable lanyards must only be attached to a stationary tie-off point and fall protection harness. Never tie into an additional lanyard, rope, rigging strap etc. A checklist for this purpose is provided in Appendix C.

**Excavation**

Not applicable to the facility.

**Explosives**

Not applicable to the facility.

**Flammables Storage**

Materials will be handled at the facility per MSDS specifications. Training is provided to all staff, students and visitors who will work with any of these materials. A handbook entitled Working Safely with Hazardous Materials by the University EHS office is included in Appendix E and can
be found at http://oregonstate.edu/ehs/sites/default/files/pdf/osuhazcombook.pdf and is available as part of safety training at the site.
Forklifts

Training Program Implementation
All operator training and evaluation will be conducted by certified site staff that have the knowledge, training, and experience to train and evaluate potential operators. 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. All operators will be recertified annually.

Training Program Content
Trainees must be trained in the following forklift-related and workplace-related topics.

Forklift training checklist

FORKLIFT FAMILIARITY:
- Fuel (Electric, Propane, Diesel)
- Parking brake
- Safety features (lights, seatbelt, Horn)
- Data plate
- Fork Controls
- Pedals
- Directional control
- Tire Inspection
- Daily Maintenance Check
- Attachments and Use
- 

GENERAL FORKLIFT OPERATIONS:
Demonstrates:
- Correct pre-operation check of the lift truck.
- Operation control of the lift truck.
- Ignition, Directional control, Lift control, Tilt control.
- Proper driving skills.
- Checks visibility, Use of horn
- Correctly Move objects
- Secure load, Load center,
- Stacking loads.
- Steering and maneuvering techniques.
- Knowledge of load center and capacity.
- Aware of driving surface.
- Vehicle Stability

LIFT TRUCK SAFETY
- Drives slow and deliberate.
- Watches for pedestrians
- Looks behind prior to backing up
- Wears seatbelt
- Sounds horn at blind intersection, entering exiting building
Safe Forklift Operation Rules

- 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 at any time.
- Fill fuel tanks out of doors while engine is off.
- Do not exceed the safe load capacity of a forklift 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 on the load being carried.
- A forklift 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 should be driven on the right side of the road or aisle-way.
- Operators shall cross railroad tracks diagonally whenever possible.
- Forklifts 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 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.
- 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 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 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 shall not be left on an incline unless it is safely parked and the wheels blocked.

Use of Personal Protective Equipment when Changing out Propane Tanks
Operator must use appropriate PPE equipment when changing out the forklift propane tank.
Heavy Equipment

The site owns and maintains several pieces of heavy equipment:

1. Neussen Whacker Wheel Loader
2. Ingersoll Rand Telescoping Forklift
3. Nissan Stubby 2.5T Forklift
4. Yale GLP100 10,000lb Forklift

Only OSU staff and students are authorized to operate rental equipment, and only after approval from an experienced HWRL staff member who has reviewed the equipment documents.

In the case of rented equipment, prior to any use, a thorough review of the operation and safety manuals is done. Only OSU staff and students are authorized to operate rental equipment, and only after approval from an experienced HWRL staff member who has reviewed the equipment documents.

Language Barrier

All facility personnel are fluent in English.
Manual Lifting

Any load in excess of 50 lbs. should be mechanically lifted whenever possible. The EHS provides training and training videos for proper back care and how to lift properly. Any staff member, student or visitor may request training by contacting the facility safety officer.

### Back problems: Proper lifting

No one is immune to back injury. Whether you have a strong back or have hurt your back before, it is well worth it to:

- **Stop** yourself before casually picking up a light or heavy load.
- **Plan** in your mind for the best way to lift what's in front of you. This could include enlisting help from one or more people.
- **Lift and move** slowly and carefully.

The time you take to use the right lifting mechanics is far less than the days, weeks, or months it can take to heal from a back injury.

### What types of lifting can cause injury?

Before focusing on the right way to lift, review the following common lifting mistakes that easily lead to a back injury:

- Allowing the back to curve forward while you grasp an object, then lifting by straightening the back
- Bending at the hips but keeping the legs straight while grasping and lifting
- Twisting the back while lifting or holding, usually by turning the shoulders, but not the hips
- Holding an object away from the body
- Lifting a heavy object (or child) above shoulder level
- Attempting to lift an object that's too heavy or awkward for one person to safely lift

### How can I lift without hurting my back?

Follow these basic rules to protect your back while lifting:

- **Keep a wide base of support.** Your feet should be shoulder-width apart, with one foot slightly ahead of the other (karate stance).
- **Squat** down, bending at the hips and knees only. If necessary, put one knee to the floor and your other knee in front of you, bent at a right angle (half kneeling).
- **Maintain good posture.** Look straight ahead, and keep your back straight, your chest out, and your shoulders back. This helps keep your upper back straight while maintaining a slight arch in your lower back.
- **Slowly lift** by straightening your hips and knees (not your back). Keep your back straight, and don't twist as you lift.
- **Hold** the load as close to your body as possible, at the level of your belly button.
- **Use your feet** to change direction, taking small steps.
- **Lead with your hips** as you change direction. Keep your shoulders in line with your hips as you move.
- **Set down** your load carefully, squatting with the knees and hips only.

**Mechanical Lifting**

Forklift use and safety is addressed in the forklift section of the document. Site specific operation of the TWB bridge crane and the LWF hoist requires training by an experienced and
authorized staff member to be designated by the Site Safety Officer. More information can be found in the Crane and Hoist Safety section. All lifting equipment at the site is inspected and certified annually. Load ratings are clearly marked and visible to the operator. 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. Slings will be stored and maintained in good condition.

**Machine Guarding**

The only piece of fixed power tool equipment requiring use of a machine guard at the facility is a grinder. Use of this tool requires the machine guarding to be in place. Prior to operation of this equipment, the machine guarding will be checked to ensure that proper guarding is in place.

**Noise Exposure**

Whenever noise exceeds the OSHA-mandated “action level”, the facility will immediately initiate a hearing conversation program. See [http://oregonstate.edu/ehs/bulletin/si44.html](http://oregonstate.edu/ehs/bulletin/si44.html) for more information. 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. The facility has bay doors that can be closed to isolate noise from where personnel are working.

**Powered Platforms and Vehicle-Mounted Work Platforms**

University EHS regulations are outlined at [http://oregonstate.edu/ehs/SD0050](http://oregonstate.edu/ehs/SD0050). Operation of powered platforms and vehicle-mounted work platforms (typical examples include LWF cart, cherry pickers, scissor lifts) can only be operated by trained HWRL staff.
Fixed and Portable Power Tools

A comprehensive shop safety policy and program is in place and detailed at the University EHS website (http://oregonstate.edu/ehs/LP-L-shop). Safety training includes proper and safe use of all facility specific fixed and portable power tools. All users will receive safety instructions if using tools unfamiliar to them. Prior to first time use of any new tools, the operations and safety manuals will be reviewed by a staff member, and this person will also train any users. Facility staff regularly evaluates and monitors safe use of this equipment, taking corrective action as needed. The following is a list of tools at the site:

<table>
<thead>
<tr>
<th>Fixed power tools</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clausing</td>
<td>Upright drill press</td>
</tr>
<tr>
<td>Delta</td>
<td>Upright drill press</td>
</tr>
<tr>
<td>Delta</td>
<td>Bench grinder (x3)</td>
</tr>
<tr>
<td>Spyglass</td>
<td>Band saw (wood blade only)</td>
</tr>
<tr>
<td>DeWalt</td>
<td>Compound miter saw (chop saw)</td>
</tr>
<tr>
<td>DeWalt</td>
<td>Cabinet saw</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Handheld power tools</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dewalt</td>
<td>Cordless drill</td>
</tr>
<tr>
<td>Bosch</td>
<td>Cordless drill</td>
</tr>
<tr>
<td>Porter Cable</td>
<td>Round head framing nailer</td>
</tr>
<tr>
<td>Bosch</td>
<td>Hammer drill</td>
</tr>
<tr>
<td>Milwaukee</td>
<td>Sawzall</td>
</tr>
<tr>
<td>Milwaukee</td>
<td>Deep cut band saw</td>
</tr>
<tr>
<td>Porter Cable</td>
<td>Router</td>
</tr>
<tr>
<td>Skil</td>
<td>Worm drive circular saw</td>
</tr>
<tr>
<td>Porter Cable</td>
<td>Belt sander</td>
</tr>
<tr>
<td>Stanley</td>
<td>Belt sander</td>
</tr>
<tr>
<td>Dewalt</td>
<td>Jigsaw</td>
</tr>
<tr>
<td>Skilisaw</td>
<td>Jigsaw</td>
</tr>
<tr>
<td>Various</td>
<td>5 corded drills</td>
</tr>
<tr>
<td>Various</td>
<td>shop vacs</td>
</tr>
<tr>
<td>Campbell-Hausfield</td>
<td>Air compressor</td>
</tr>
</tbody>
</table>
Radiation

Not applicable to this site. No isotope use is planned at the facility. EHS regulates all isotope work at the University.

Remote Operations

Not applicable.

Respirators

Should the site and EHS determine that a respirator is required for a specific activity, EHS will oversee medical clearance, training and fit test. If excessive dust is present, dust masks will be used by all affected workers.
Dust mask form:

Respirator questionnaire:
http://oregonstate.edu/occupationalhealth/sites/default/files/docs/respirator_questionaire_2010.pdf

Scaffolding

Facility scaffolding must be assembled and inspected by trained certified staff. The scaffolding must be inspected daily utilizing the checklist in Appendix C.

Temperature Stress

There are no documented temperature extremes at the site. The site maintains a reasonable level of inside temperatures for personnel. Should any site personnel experience temperature stress, they should immediately cease the activity and seek proper remediation. Report any temperature stress to facility staff. Any facility staff member can immediately stop all research and operational activity if temperature stress to personnel is observed. Activity cannot resume until facility staff have evaluated the situation and put controls in place to prevent excess exposure.
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 1/4 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 Occupational Medicine Clinic for observation and possible treatment.</td>
</tr>
<tr>
<td>Heat Stroke</td>
<td>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. Rapid cooling of the body should begin immediately (immerse in chilled water accompanied by vigorous massage of the skin, loosen clothing, move to shade, spray with cool water &amp; fan). Call 2222 for emergency transport to hospital.</td>
</tr>
<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 prevented and treated by resting in a cool place and regularly bathing and drying the skin.</td>
</tr>
</tbody>
</table>
Below is a table listing symptoms of cold stress and actions that should be taken.

<table>
<thead>
<tr>
<th>Hypothermia Symptoms</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Uncontrollable shivering (although, at extremely low</td>
<td>• Change wet clothing to dry</td>
</tr>
<tr>
<td>body temperatures, shivering may stop)</td>
<td>• Go to a heated office or laboratory space</td>
</tr>
<tr>
<td>• Weakness and loss of coordination</td>
<td>• Add heat using portable heaters</td>
</tr>
<tr>
<td>• Confusion</td>
<td>• Immerse in hot shower located in the</td>
</tr>
<tr>
<td>• Pale and cold skin</td>
<td>facility</td>
</tr>
<tr>
<td>• Drowsiness – especially in more severe stages</td>
<td>• Increase exercise</td>
</tr>
<tr>
<td>• Slowed breathing or heart rate</td>
<td>• Get into a pre-warmed sleeping bag or</td>
</tr>
<tr>
<td></td>
<td>blankets</td>
</tr>
<tr>
<td></td>
<td>• Drink hot drinks, followed by candy or</td>
</tr>
<tr>
<td></td>
<td>other high-sugar foods</td>
</tr>
<tr>
<td></td>
<td>• Apply heat to neck, armpits and groin</td>
</tr>
<tr>
<td></td>
<td>• Seek medical attention</td>
</tr>
<tr>
<td></td>
<td>• Summon Emergency Response Team</td>
</tr>
</tbody>
</table>

**Hypothermia signs that can be observed by others**

- Slowing of pace, drowsiness, fatigue
- Stumbling
- Thickness of Speech
- Amnesia
- Irrationality, poor judgment
- Hallucinations
- Loss of perceptual contact with environment
- Blueness of skin
- Dilation of pupils
- Decreased heart and respiration
- Stupor

**Symptoms requiring IMMEDIATE emergency attention**

- Poor articulation of words
- Disorientation
- Decrease in shivering followed by rigidity of muscles
- Cyanosis (Blueness of Skin)
- Slowness of pulse, irregular or weak pulse
Vehicle Exposure

The facility participates in the University vehicle driving safety training program that can be obtained via the Oregon Department of Transportation (ODOT). The OSU Motor Pool does not require ODOT training. The University is responsible for all maintenance of vehicles and keeps inspection logs.

Use of the OSU vehicle (HWRL truck) is restricted to personnel who are certified by the OSU motor pool. All OSU personnel must have a current driver’s authorization form. Copies of this form are kept on site by the Lab Manager / Site Safety Coordinator.

Welding - Hot Work

The facility owns and maintains a Lincoln Electric Wire Feed Welder, and a (need input from Mike). Welding supplies and PPE specific equipment are available and must be used during welding operations. EHS website provides general safety information for welding at http://oregonstate.edu/ehs/SD0057.

A “hot work permit” checklist in Appendix C details the required actions when welding or conducting other types of “hot work” in the facility. The following safety instructions apply to the facility when undertaking hot work..

- All welding, cutting, and burning shall be performed in the shop area whenever possible. For work performed in other areas a fire extinguisher stand-by is required. In addition, sufficient ventilation must be provided. Do not weld in any area unless you are sure it is safe to do so. Make sure that you know exactly how to contact the closest fire department before welding or cutting is started.
- Do not weld, burn, or braze without appropriate eye protection. Be sure that co-workers wear equivalent protection. Provide for the safety of others who could be exposed to sparks or heat. A light resistant shield should be provided whenever bystanders may be visually exposed to the arc.
- Do not perform welding or burning operations unless you are wearing appropriate protective clothing.
- Do not weld galvanized pipe or burn lead unless you are using a forced air ventilation system, or are wearing approved respiratory equipment.
- Never use oxygen as a substitute for compressed air. Do not use oil on gauges or regulators for oxidizing gases. Oxygen under pressure reacts violently with oil or grease.
- Never use oxygen or acetylene from a cylinder without a reduction of pressure through a suitable pressure regulator.
- Pressure adjusting screws on regulators shall always be FULLY RELEASED BEFORE the regulator is attached to a cylinder. Always open the valves on cylinders slowly. Do not stand in front of pressure regulator gauge faces when opening cylinder valves.
- Do not strike valves with tools, or use excessive force in making connections.
• Do not interchange acetylene or oxygen regulators or equipment.
• Avoid mixtures of acetylene and oxygen or air prior to use except at a standard torch.
• Do not open an acetylene cylinder more than 1 and 1/2 turns of the valve.
• Cylinders not provided with fixed handwheel valves shall have keys or handles provided on valve stems at all times when cylinders are in use.
• Do not use recessed tops of acetylene cylinders as a resting place for tools or other articles, and do not allow the recess to fill with water.
• Never support work on compressed gas cylinders or other containers.
• Cylinders should not be dropped, bumped violently, skidded or rolled horizontally. Compressed gas cylinders are high pressure vessels and should be handled accordingly.
• Acetylene cylinders should be stored and used with valve end up, never horizontally.
• Cylinders shall always be secured by chains or suitable metal keepers.
• Do not store cylinders in direct sun, or in boiler or furnace rooms.
• Cylinders shall not be transported except in an approved welding cart. Be sure protective cap is in place when cylinders are moved or transported.
• When cylinders must be handled by a crane or hoist, they should be carried in a cradle rather than in a sling. Extreme care should be exercised so that they are not dropped.
• Do not place welding cable over steam lines or moving machinery, or on stairs or across traffic aisles unless protection and appropriate warning devices are provided.
• Be sure electric welding machines are electrically grounded.
• Try to prevent sparks from falling upon persons, cylinders, or hoses.
• Do not weld or burn on any container that has held a toxic or flammable material. Such work requires clearly outlined purging and cleaning procedures.
• Do not weld, burn, or heat any closed tank, container or pipeline which is under pressure. This is extremely dangerous.
• Do not weld or burn in areas where spray painting is being performed.
• Welding, cutting, or burning shall not be performed in tanks or other confined space without adequate ventilation that will keep the air free of toxic and flammable gases.
• All torches shall be equipped with flashback protection.
Chapter 4

RELATED NON-SAFETY PLAN ELEMENTS

General Environmental Waste

All environmental wastes generated at the facility are handled by EHS.

Basin or Flume Water Contamination

Contamination of the basin water with hydraulic fluid or other foreign substances requires cleanup of the water prior to drainage. An environmental cleanup firm will be contracted for cleanup services as deemed necessary. EHS will be notified and they have final authority over the suitability of water quality for drainage.

Water being drained from the basin or flume must meet the regulatory standard for chlorine (< 0.1 mg/L). The facility measures chlorine concentration prior to discharge. If levels are too high, a combination of chemical dechlorination and aeration is undertaken. Chlorine discharge levels are the responsibility of EHS and they periodically sample and analyze facility water quality.
Appendix A
ENVIRONMENTAL HEALTH AND SAFETY CONTACTS

Environmental Health & Safety
100 Oak Creek Building
3015 SW Western Blvd
Corvallis, Oregon 97331-7405
Phone: (541) 737-2273
Fax: (541) 737-9090

For emergency safety concerns, call Public Safety at 541-737-7000.

For routine service requests or questions during business hours, call the Work Coordination Center 737-2969 and ask for the EH&S ON-CALL person.

Environmental Health & Safety Personnel

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone Number</th>
<th>Contact Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrew Gray</td>
<td>541-737-7651</td>
<td>Asbestos Management, Surveys, &amp; Abatement Services, Construction Safety</td>
</tr>
<tr>
<td>Daniel Harlan</td>
<td>541-737-7082</td>
<td>Assistant Radiation Safety Officer</td>
</tr>
<tr>
<td>Dan Kermoyan</td>
<td>541-737-2505</td>
<td>Assistant Director of EH&amp;S, Environmental Protection, Ergonomics, Occupational Safety, Agricultural safety</td>
</tr>
<tr>
<td>Kay Miller</td>
<td>541-737-7083</td>
<td>Safety Training Coordinator</td>
</tr>
<tr>
<td>Lance Jones</td>
<td>541-737-2274</td>
<td>Chemical Safety, Exposure Assessments, Indoor Air &amp; Water Quality, Occupational Health</td>
</tr>
<tr>
<td>Matt Philpott</td>
<td>541-737-4557</td>
<td>Biological Safety Officer</td>
</tr>
<tr>
<td>Pete Schoonover</td>
<td>541-737-3127</td>
<td>Hazardous Materials Disposal Services, Haz-Mat Shipping, DEA Materials</td>
</tr>
<tr>
<td>Rainier Farmer</td>
<td>541-737-7080</td>
<td>Radiation Safety Officer</td>
</tr>
<tr>
<td>Terese Keller</td>
<td>541-737-7688</td>
<td>Dosimetry, Radiation Safety Administrative Support</td>
</tr>
</tbody>
</table>
Appendix B
OREGON STATE UNIVERSITY - MASTER EMERGENCY MANAGEMENT PLAN
OVERVIEW

This document provides a management framework for responding to incidents that may threaten the health and safety of the Oregon State University community (hereafter referred to as The University), or disrupt its programs and operations. The plan addresses all hazards.

The OSU Master Emergency Management Plan uses the Incident Command System (ICS) as the basis for emergency management response. The ICS Team establishes response strategies and tactics, deploys resources, and initiates the emergency recovery processes. An Incident Commander (IC) is established at the start of the incident, ascertains the scope of an incident and advises The University stakeholders.

Emergency response actions are guided by the following goals:

• Protect life safety
• Secure and preserve The University’s assets
• Preserve and resume teaching and research programs

The ICS Team mobilizes at a central Emergency Operations Center (EOC), located in either its primary location (Cascade Hall) or its secondary location (the campus Energy Center). Alternatively, the EOC can be staged in other locations at the discretion of the Incident Commander.

The EOC gathers emergency information from a number of sources:

1) Emergency Support Functions
2) Satellite Operation Centers (SOC)
3) Volunteer units (deployed to support activities)

The Office of the University V.P. for Advancement is responsible for providing the campus EOC with the OSU Public Information Officer (PIO). This officer is responsible for the preparation and dissemination of emergency bulletins, announcements and information to the public and campus community.

OSU Network Services is responsible for all communications infrastructure, including radio, telephony and data transmissions and all protocols associated with such.
EMERGENCY LEVELS

An emergency event at OSU may be designated as a Level 1, Level 2, or Level 3 situation:

**Level 1**
A minor incident that is quickly resolved with internal resources or limited help. The OSU Emergency Management Plan is **not** activated.

**Level 2**
A major incident that impacts sizable portions of the campus, or that may affect life safety or mission-critical functions. The IC initiates the OSU Emergency Management Plan and an **EOC is activated**.

**Level 3**
A disaster that involves a major portion of campus and surrounding community where the emergency is substantial. The IC initiates the OSU Emergency Management Plan and an **EOC is activated**.

EMERGENCY PLANNING

Oregon State University's Emergency Management Plan includes the following:
The OSU Master Emergency Management Plan outlines the planning process for emergency preparedness, response and recovery. At a basic level, it sets up a command structure and emergency support functions to respond to emergencies.

Plans are developed in College/Units and Departments across campus to outline strategies for protecting department personnel, property and programs, and for coordinating with the SOC and EOC.

In addition, Emergency Support Functions provide specific aid for the campus. These include:

- Transportation
- Communications
- Health & Medical
- Media
- Food, Water and Housing
- Hazardous Materials
- Public Safety/Crowd Control and Management
- Rescue
- Public Works
- Volunteers
- Tracking Location of Students and Faculty
- Building Assessment
- Animal Welfare
- Asset Protection
- Academic Welfare

Members of the Campus Emergency Management Steering Committee (EMSC) review all plan documents annually, and meets regularly to provide general oversight for related policies and procedures. The EMSC is chaired by the Campus Emergency Coordinator. The Emergency Plans will be exercised regularly.
DEFINITIONS AND ABBREVIATIONS

ATC-20: Applied Technology Council (process 20)
Procedures for post earthquake safety evaluation of buildings.

DOC: Department Operations Center
A management center, at the department level, used to prepare for and respond to emergencies; reports to their Satellite Operations Center.

EAA: Emergency Assembly Areas
Established locations on campus; used by departments as a gathering place for personnel.

Emergency:
Not reasonably foreseeable circumstances that create a substantial risk of loss, damage, interruption of services, or threat to the public health or safety that requires prompt execution of a contract to remedy the condition.

Emergency Information Hotline: 541-737-1000 or 541-737-8000

Emergency Levels:
A ranking that classifies emergencies according to their severity and potential impact to OSU:
- Level 1: Minor, localized incident
- Level 2: Major incident that threatens life safety and/or disrupts operations
- Level 3: Disaster involving the campus and community

EMT: Emergency Medical Technician

EOC: Emergency Operations Center
A management center where the Incident Commander and General Staff execute the University’s emergency management plan.

EPSC: Emergency Preparedness Steering Committee
Provides general oversight for the entire planning process and meets regularly to address emergency preparedness, response, and recovery issues.

Essential Employees:
Employees identified to be admitted onto campus during the event of a campus emergency to carry out essential functions,

Essential Functions:
Mission critical functions needed to meet the prime directives and continue critical operations of the campus.
Field Command Posts:
A mobile utility structure used to coordinate emergency operations on site and in remote locations.

FEMA: Federal Emergency Management Agency

General Staff:
OSU personnel trained and appointed to respond to campus emergencies. This group operates under the direction of the Incident Commander.

HAZMAT: Hazardous Material

IC: Incident Commander
The Incident Commander determines whether to activate the emergency plan and whether to activate all or part of the ICS Staff after emergency conditions have been verified by Public Safety, Facilities Operations, or Environmental Health & Safety and, if necessary, after consulting with the OSU Policy Group.

ICS: Incident Command System
An emergency management model that has been adapted for use at the OSU EOC to respond to any level of emergency.

NIMS: National Incident Management System
A systematic approach for response to emergency situations.

OSP: Oregon State Police

PIO: Public Information Officer

Policy Group
University personnel consisting of the President, Vice President of Administration and the Provost and Executive Vice President that provide executive supervision for the entire emergency response process

SOC: Satellite Operations Center
A management center that is used to communicate to various Colleges/Units and Departments from the EOC and vice versa. The SOC is responsible for informing the EOC of current status and updates of their locations.
INTRODUCTION

PURPOSE

The Master Emergency Management Plan outlines Oregon State University’s (hereafter referred to as the University) procedures for managing major incidents that may threaten the health and safety of the campus community or disrupt its programs and operations. The Plan identifies colleges, units, departments and individuals that are directly responsible for emergency response and critical support services, and it provides a management structure for coordinating and deploying essential resources.

At the University, planning ahead for emergencies is part of normal business planning and campus life, and all members of the campus community share a responsibility for preparedness. An emergency incident can strike anytime or anywhere, and a disaster will affect everyone.

All employees and students have a personal responsibility for knowing what to do before, during, and after an emergency to protect their safety, their property and their work.

The University should maintain a comprehensive emergency preparedness education and training program to mitigate potential hazards, and to familiarize students and employees with emergency procedures.

The Master Emergency Management Plan will be written, reviewed, and amended by the University Emergency Management Steering Committee (EMSC). The EMSC provides general oversight for the entire emergency planning process and it meets regularly to address ongoing preparedness, response, and recovery issues.

SCOPE

The Master Emergency Management Plan guides preparedness, response, and recovery actions. It applies to a broad range of emergency incidents, and may be activated during:

- Earthquakes
- Hazardous material releases
- Floods
- Fires or explosions
- Extended power outages
- Mass casualty events
- Infectious disease events
PLAN FUNDEMENTALS

The Master Emergency Management Plan may also be activated during a community or regional crisis that may impact University personnel or business operations. For example, a utility outage in nearby areas, a serious toxic spill on a major highway, or a brushfire in a local area may necessitate a plan activation to coordinate safety precautions or emergency information and support services for personnel.

The University maintains that a major incident in the community affecting our students, faculty, and staff is a University emergency.

EMERGENCY RESPONSE MISSION & PRIORITIES

In any emergency situation the University’s overriding mission is to:

- Protect life safety
- Secure and preserve the University’s assets including critical infrastructure and facilities
- Resume and preserve the teaching and research programs

General emergency response priorities follow from these goals. The contextual characteristics of a particular emergency event (such as the time or day when an incident occurs) may require some adjustments within the following priority categories:

**EMERGENCY RESPONSE PRIORITIES**

1. **Buildings used for emergency operations.**

2. **Buildings used for dependent populations**
   - Residences, occupied classrooms and offices, childcare centers, occupied auditoriums, arenas and special event venues

3. **Buildings critical to health and safety**
   - Medical facilities, emergency shelters, food supplies, sites containing potential hazards

4. **Facilities that sustain emergency response**
   - Energy systems and utilities, communications services, computer installations, transportation systems

5. **Classroom and research buildings**

6. **Administrative buildings**

EMERGENCY RESPONSE LEADERSHIP (Incident Command System)
The Incident Command and General Staff coordinate the campus response to major incidents.

- The Policy Group (including the President, Vice President of Administration and the Provost and Executive Vice President) provides executive supervision for the entire emergency response process.
- The Incident Commander serves as the emergency response team leader and is responsible for the operational direction of the response.

The Incident Commander determines how to manage the emergency and whether to activate all or part of the ICS staff, after emergency conditions have been verified by Public Safety, Facilities Operations, or Environmental Health & Safety and, if necessary, after consulting with the Policy Group.

The Incident Commander may instruct the Department of Public Safety (DPS) dispatch to call and/or alert the Incident Command and General Staff that a mobilization is required. DPS dispatch notifies team members.

*Exception:* After a catastrophic natural event (such as an earthquake), Team members report to campus as soon as safety and family commitments permit, without receiving a call back from DPS dispatch.

When the Incident Commander and General Staff assemble, its responsibilities are to:

- Prioritize emergency actions
- Deploy and coordinate resources and equipment
- Communicate critical information and instructions
- Monitor and re-evaluate conditions
- Coordinate with other agencies or emergency groups

When emergency conditions abate, the Incident Commander, in coordination with the Policy Group, determines the appropriate time to demobilize and transition to recovery operations.
THE EMERGENCY OPERATIONS CENTER (EOC)

Incident Command and General Staff members report to a central Emergency Operations Center (EOC) to coordinate decisions and resources.

- The EOC is located in Cascade Hall.
- The alternate EOC site is the Energy Center.
- Other alternative locations may be used as determined by the Incident Commander.
- EOC equipment and supplies are to be maintained at designated locations.

When the Incident Commander activates the Master Emergency Management Plan and convenes the ICS Staff, the Department of Public Safety opens the EOC facility.

SATELLITE OPERATIONS CENTERS (SOC)

SOCs are located in Colleges/Units, and serve as the pivotal communications interface between the EOC and the Colleges/Units during a major incident or disaster. SOCs gather emergency impact data from their Department Operation Centers (DOCs) and account for their personnel, transmit reports to the EOC, and disseminate emergency instructions.

SOCs also have oversight for their preparedness, response, and recovery planning and training. SOCs also help communicate the location of Emergency Assembly Areas (EAA’s) to their departments, and are expected to conduct exercises to practice using these locations.

Satellite Operation Centers include:

Operational Services SOCs
1. Department of Public Safety/Oregon State Police
2. Facilities Services
3. Information Services
4. University Housing & Dining Services
5. University Advancement
6. Student Health Services

Academic & Administrative SOCs
1. College of Oceanic and Atmospheric Sciences
2. College of Engineering
3. College of Liberal Arts
4. College of Health and Human Sciences
5. College of Veterinary Medicine
6. College of Business
7. College of Pharmacy
8. College of Forestry
9. College of Education
10. College of Science
11. College of Agricultural Sciences
To prepare for their critical roles and responsibilities, all SOCs should:

- Coordinate effective emergency preparedness planning in their jurisdictions.
- Prepare a written SOC emergency plan that addresses preparedness, response, and business recovery and business continuity.
- Communicate the plans and procedures to their units.
- Identify a primary and alternate SOC site for emergency response.
- Establish DOC Coordinators within each departmental unit (as necessary).
- Establish communications strategies and resources to support SOC functions: including emergency hotlines, faxes, telephone trees/notification lists, wireless telephone or ham radio support, etc.
- Determine essential functions and personnel to perform them.
- Arrange appropriate preparedness training for SOC personnel.
- Participate in campus SOC training and emergency management exercises.

Documents to supplement the Master Emergency Management Plan and help implement it at the local level will be developed through the Emergency Preparedness Workbook and the Business Continuity Workbook.

These workbooks contain information to assist in the development and organization of SOCs. Emergency Management Steering Committee members provides preparedness planning consultations to Deans, Directors, Vice Provosts/ Vice Presidents at the SOCs, along with technical support to their departments.
EMERGENCY LEVELS

At the University, emergency incidents are classified according to their severity and potential impact, so that emergency response operations can be calibrated for actual conditions.

LEVEL 1  A minor localized department or building incident, which is quickly resolved with existing resources or limited outside help. A Level 1 emergency has little or no impact on personnel or normal operations outside the locally affected areas.

Examples: Gas leak, localized chemical spill, minor fire, tree hazard

Level 1 incidents do not require activation of the Master Emergency Management Plan. Impacted personnel or departments coordinate directly with operational department personnel from Public Safety, Environmental Health & Safety, Risk Management or Facilities Operations or other Units to resolve Level 1 conditions.

LEVEL 2  A major event that disrupts a portion of the campus community. Level 2 emergencies may require assistance from external organizations. These events may escalate quickly, and have serious consequences for mission-critical functions, and/or life safety.

Examples: A large Building fire or explosion; bio-terrorism threat; major chemical spill; extensive power or utility outage; severe flooding.

The Master Emergency Management Plan is automatically activated and General Staff will be assembled at the discretion of the Incident Commander. Field Command Posts may be set up to support the distribution of resources, personnel, or information.

LEVEL 3  A significant event that happens and with which the University will not likely receive aid from the city, county or state. This would be a disaster involving a major portion of campus and surrounding community. Normal University operations are suspended (decided within the ICS). The effects of the emergency are wide-ranging and complex. A timely resolution of disaster conditions requires University wide cooperation and extensive coordination with external jurisdictions.

Example: Severe earthquake.

The Master Emergency Management Plan is automatically activated and all EOC General Staff report to campus. Field Command Posts may be set up to support the distribution of resources, personnel, or information.

Assumption: Outside agency support will not be available for up to 96 hours following a level 3 disaster.
EMERGENCY RESPONSE

EOC COMMAND STRUCTURE

The University coordinates its emergency preparedness planning with the City of Corvallis, Benton County, The Oregon Emergency Management Division, and other agencies and organizations to ensure that campus procedures are compatible with current standardized government operations, and Oregon State University is able to maintain effective emergency communications and coordination during an incident.

The organization of the campus Emergency Operations Center (EOC) is based on the Incident Command System.

The Master Emergency Management Plan also partitions emergency decision-makers into functional groups at the EOC. The University EOC Team is divided into functional working groups including:

- Operations Group
- Planning Group
- Logistics Group
- Finance Group

The EOC Leader is the “Incident Commander” and interfaces between the EOC Team and the Policy Group. The Incident Commander designates a Section Chief for each EOC Group appropriate to the nature of the emergency event. Liaison personnel are also appointed to facilitate coordination between the University, City, County, and State response agencies. The organization and basic roles of the EOC Groups are shown below.
EMERGENCY INFORMATION AND COMMUNICATIONS

In any emergency, the Incident Commander is responsible for notifications to affected students, faculty, researchers, and staff to begin at once, as the emergency response itself begins.

At the University, the delivery of internal and external emergency information is planned and coordinated by the Public Information Officer (PIO). This coordinated approach to disseminating critical emergency announcements will provide quick, reliable and consistent information to our community and will reduce general demand on vital emergency communication lines.
During a limited Level 1 incident, response units simply alert College/Unit and/or Department managers of the situation and provide updates throughout the course of the event. (In some cases, the EOC Public Information Officer may issue bulletins to affected units). Making timely internal and external emergency announcements during a Level 2 or Level 3 emergency requires a much broader approach involving many participants. Students, faculty, researchers, staff, and visitors must know what happened, where it happened, and what to do next.

In the event that emergency conditions disrupt power and telephone service, emergency information, along with all emergency communications, may be profoundly restricted. Messengers, radios, cellular phones, and ham radio may be used until systems can be restored.

**RESPONSE PLANS FOR SPECIFIC EVENTS**

The Emergency Management Steering Committee, in partnership with other campus stakeholders, will continue to develop specific supplemental plans to address the following:

- Utility outages
- Weather phenomenon
- Earthquakes
- Pandemic Flu
- Terrorist activity
RECOVERY

PLAN DE-ACTIVATION

When emergency conditions are stabilized and normal University operations can resume, the EOC Incident Commander, along with the Policy Group determine the appropriate time to demobilize and transition to recovery operations. A formal announcement will be disseminated, through the PIO.

If the nature of the incident requires an extension of some emergency services, special EOC work groups may be appointed to coordinate those continuing. Continuing issues may include:

• Ongoing repairs and their staging
• Academic or administrative space adjustments
• Support services for impacted students, faculty, or staff
• Community relief efforts

After Action Review

Immediately following the cessation of Level 2 or Level 3 emergency operations, a formal review with EOC Team members and campus constituents will be conducted to evaluate the effectiveness of the response. This debrief will help determine any necessary modifications of the Master Emergency Management Plan due to the emergency experience. The Campus Emergency Coordinator will prepare a written “after action report” summarizing post-event observations, and will coordinate appropriate Emergency Management Plan revisions.

COST RECOVERY

One of the final EOC actions will be to transition cost recovery to an emergency cost recovery work group, led by OSU Risk Management. The composition of the work group will be related to the nature and magnitude of the emergency, but may include a core membership representing:

• The Provost Office
• Office of Finance & Administration
• Office of the General Counsel
• The affected SOC/DOC

Recovery for costs associated with emergencies is submitted to the State of Oregon Self Insurance Fund (SOIF) in accordance with the Property Self Insurance Manual 125-7-101. Appropriate documentation is needed to support the loss.
Colleges/Units and Departments should have advance copies of internal cost and loss documentation forms in their Department Emergency Planning Guidelines to help prepare them for the post-event claims process. Additional materials and guidance documents from external funding sources, such as the Oregon Office of Emergency Services, FEMA, or other agencies will be distributed as needed.

Payment for losses will equal the SOIF findings of Restoration Cost, Actual Cash Value, or other valuation method as described in the Property Self Insurance Manual. The appropriate deductible will be applied. Alternative use of these funds is allowed under ORS 278.050(2) to apply loss payments to alternative uses, with the approval of the SOIF.

**BUSINESS CONTINUITY**

All Colleges/Units shall develop business continuity plans to safeguard their essential programs, properties and records. While developing these plans, SOCs should involve the appropriate academic program and financial managers in the planning process. Business continuity procedures should be a part of the University’s annual emergency exercises.

The business continuity plan at a minimum will address the following:

- Essential personnel
- Communications strategies
- Business interdependencies
- Critical and time sensitive operations
- Alternative business locations
- Essential equipment
- Critical data stores and record security
- Cost recovery

This document is intended to provide guidance and awareness to campus leadership personnel and assist them in their emergency preparedness efforts.

For more information, contact the **Campus Emergency Coordinator @ 541-230-4261.**
Appendix C

FACILITY CHECKLISTS
## Safety Self-inspection Checklist

O.H. Hinsdale Wave Research Laboratory, NEES Tsunami Research Facility

| Signature and Date: |  |

<table>
<thead>
<tr>
<th>#</th>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Are first aid and protective gear storage accessible and fully stocked?</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Are pool rescue hooks and lifeguard floats functional and accessible?</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Are work areas adequately lit?</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Are all tools and unused extension cords stored?</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Is the rack and pallet accessible with all contents stored properly and safely?</td>
<td></td>
</tr>
<tr>
<td><strong>Large Wave Flume</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Are fenced areas around the wave maker accessible and secured?</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Is there pressure on board seals and is the sump water level low?</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Are oil levels in the HPUs normal? Are the systems free of oil leaks?</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Are fastener or structural members free of any signs of failure?</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Are linear bearing rails free of corrosion or damage?</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Has the wave maker been free of unusual noises? Is it operating normally?</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Are the oil drain pumps tested &amp; operating? Are their reservoirs low and filters clean?</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Did you lubricate all 8 wave maker bearings with the board in motion?</td>
<td></td>
</tr>
<tr>
<td><strong>Tsunami Wave Basin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Are fastener or structural members free of any signs of failure?</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Has the wave maker been free of unusual noises? Is it operating normally?</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Are desiccant containers inside the TWB controller cabinets filled?</td>
<td></td>
</tr>
<tr>
<td><strong>Machine Shop</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Is the shop area clean and adequately lit?</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Are tools well maintained, free of unusual noise, and stored safely?</td>
<td></td>
</tr>
<tr>
<td><strong>Heavy Machinery</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Are the forklifts stored properly?</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Are the crane and hoist operating normally and stored properly?</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Are the crane and hoist hooks free of cracks or deformation? Are the hoist chains or cables free of deformation or wear?</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Is the LWF cart cord free from being frayed, pinched, buried, or snagged?</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Is the LWF cart cord free from risk of being caught?</td>
<td></td>
</tr>
<tr>
<td><strong>Chemicals &amp; Hazardous Materials</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Are flammables placed in provided locker?</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Are paint cans in provided locker/shelves?</td>
<td></td>
</tr>
<tr>
<td><strong>Operations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Are straps and lift cables inspected after use and stored properly?</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Are all electrical extension cords free from splash risk or water immersion?</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Is all electrical equipment protected from being splashed?</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Are all orange power outlets free of non-instrumentation equipment?</td>
<td></td>
</tr>
</tbody>
</table>

**Last revised on:** September 7th, 2011
# Overhead Crane Inspection Checklist

<table>
<thead>
<tr>
<th>Operator:</th>
<th>Date:</th>
</tr>
</thead>
</table>

- [ ] Locate Crane Main Disconnect Switch
- [ ] Check Pendant Controls or Controllers or Selector
  - (Up, Down, East, West, North and South)
- [ ] Check Wire Rope or Chain for Damage *Documented 30-Day inspection required*
  - (check rope/chain for worn, cut, kinked, crushed, spooling, or bird caged cable)

**Obtain baseline hook throat measurement:** date__________

**measurement:**__________

- [ ] Check Hook *Documented 30-Day Inspection required*
  - (Bent, spread, cracked, and safety latch)
- [ ] Check Upper Limit Switch (Hook block stop)
- [ ] Check for Reverse Reieving (Hoist cable direction)
- [ ] Check Brake System (Trolley, bridge, and hoist)
- [ ] Check Trolley and Bridge Travel
  - (Make sure stops are in place and limits working, make sure travel path is clear)
- [ ] Check Hoist Gearing System (Any unusual noises)
- [ ] Check Rails During Operation (Unusual wear or noise)
- [ ] Check Lubrication (Leaks, excess grease)
- [ ] Check line lubrication
- [ ] Review Weight Limits
  - (Weight to be lifted must be calculated or measured if unknown)
- [ ] Inspect Rigging Equipment to be Utilized
  - (Slings, shackles, guide ropes, use personnel protection equipment)

**CAUTION: IF ANY MALFUNCTIONS OR UNUSUAL NOISES ARE OBSERVED, STOP USING CRANE/HOIST AND CONTACT YOUR SUPERVISOR**

| Notes: |
Crane and Hoist Operator Training Checklist

Crane and hoist training

Crane operator manual read and understood

Safety
- No cell or mobile device usage by operator
- Do not distract the operator
- Wear a hard hat while crane is in use
- Never get under the load
- Never ride a load or hook

Pre-operation inspection
- Check hook for signs of deformation or cracks
- Check hoist chain or cable for signs of deformation or excessive wear
- Check for correct operation of hoist, trolley, bridge
- Check rigging for wear before use

Rigging
- Ropes, straps, cables, rings, and shackles
- Check load ratings and inspect for wear before use
- Remove any damaged rigging from service
- Store all rigging and equipment after use

Controls
- Interlocks and stop button
- Variable speed controls
- Hoist, trolley, and bridge motions and limits
- Storage of hook and remote when not used

Operations
- Know locations and proper use of emergency power disconnects
- Determine load weight before any lift
- Pick only one load at a time
- Use only proper and rated rigging
- Use rigging wear or cut protection on corners/angles/edges
- Know picking types and angles and effects on rating
- Operate at safe travel/pick speeds, use tag lines
- Keep the hoist line plumb and the hook above the load Cg
- Use proper hand signals for hoisting operations
- Watch yourself, your load, and bystanders

Cranes
- Structures lab 20-ton bridge crane
- Tsunami Wave Basin 7.5-ton bridge crane
- Large Wave Flume cart and 5-ton hoist

Name: ___________________________    Sign and date: ___________________________
Standard Hand Signals for Telehandler Forklift and Mobile Cranes

**Hoist:** With forearm vertical, forefinger pointing up, move hand in small horizontal circle.

**Lower:** With arm extended downward, forefinger pointing down, move hand in small horizontal circles.

**Bridge Travel:** Arm extended forward, hand open and slightly raised, make pushing motion in direction of travel.

**Trolley Travel:** Palm up, fingers closed, thumb pointing in direction of motion, jerk hand horizontally.
Stop: Arm extended, palm down, move arm back and forth horizontally.

Emergency Stop: Both arms extended, palms down, move arms back and forth horizontally.

Multiple Trolleys: Hold up one finger for block marked "1" and two fingers for block marked "2." Regular signals follow.

Move Slowly: Use one hand to give any motion signal and place other hand motionless in front of hand giving the motion signal.
The main signals that will be used for the Telehandler Forklift are:

- Emergency Stop
- Retract Boom, two hands and one handed
- Extend Boom, two hands and one handed
## Daily Stationary Scaffold Inspection Checklist

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
<th>ACTION/COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaffold components and planking in safe condition for use and planks graded for scaffold use?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frame spacing and sill size capable of carrying intended loading?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competent person in charge of erection and inspection?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sills properly placed and adequate sized?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screw jacks been used to level and plumb scaffold instead of unstable objects?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base plates and/or screw jacks in firm contact with sills and frame?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scaffold is level and plumb?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scaffold legs braced with braces properly attached?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guard railing in place on all open sides and ends?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead protection or wire screening been provided where necessary?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scaffold been tied to structure at least every 30' in length and 26' in height?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free standing towers been guyed or tied every 26' in height?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brackets, tube and clamp, and accessories been properly placed with nuts and bolts tightened?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scaffold free of makeshift devices or ladders to increase height?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planks have minimum 12&quot; overlap and extend 6&quot; beyond supports?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toe boards properly installed?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conditions such as power lines, wind loading, etc. controlled?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe way to get on and off the scaffold without climbing on cross braces?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front face within 14 inches of the work or within three feet for outrigger scaffolds?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Fall Protection Inspection Checklist

**Employee:** ______________________  **Date:** ______________________

**Harness Manufacturer:** ___________  **Serial Number:** ___________

<table>
<thead>
<tr>
<th>HARNESS</th>
<th>LANYARD (CONTINUED)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ITEM</strong></td>
<td><strong>INSPECTION</strong></td>
</tr>
<tr>
<td><strong>Labels</strong></td>
<td>Present</td>
</tr>
<tr>
<td>N-action</td>
<td>Legible</td>
</tr>
<tr>
<td>Webbing</td>
<td>Cuts/Frags</td>
</tr>
<tr>
<td>Y-action</td>
<td>Heat Damage</td>
</tr>
<tr>
<td>Holes/Burns</td>
<td><strong>Corroded</strong></td>
</tr>
<tr>
<td>Chemical Damage</td>
<td><strong>Sharp Edges</strong></td>
</tr>
<tr>
<td>UV Damage/Faded</td>
<td><strong>Bent/Damaged</strong></td>
</tr>
<tr>
<td>Stitching</td>
<td>Cut/Broken</td>
</tr>
<tr>
<td>Y-action</td>
<td>Pulled/Missing</td>
</tr>
<tr>
<td>Rivets</td>
<td>Corroded</td>
</tr>
<tr>
<td>Y-action</td>
<td>Missing</td>
</tr>
<tr>
<td>Loose</td>
<td><strong>Corroded</strong></td>
</tr>
<tr>
<td><strong>Back Pad</strong></td>
<td><strong>D-Rings</strong></td>
</tr>
<tr>
<td><strong>Y-action</strong></td>
<td><strong>D-Rings</strong></td>
</tr>
<tr>
<td><strong>Keepers</strong></td>
<td><strong>Y-action</strong></td>
</tr>
<tr>
<td><strong>Service Date</strong></td>
<td><strong>Y-action</strong></td>
</tr>
<tr>
<td><strong>Keepers</strong></td>
<td><strong>Damaged</strong></td>
</tr>
<tr>
<td><strong>Service Date</strong></td>
<td><strong>Y-action</strong></td>
</tr>
<tr>
<td><strong>Keepers</strong></td>
<td><strong>Over 5 Yrs</strong></td>
</tr>
</tbody>
</table>

---

C-9
<table>
<thead>
<tr>
<th>LANYARD</th>
<th>Y-action</th>
<th>Bent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labels</td>
<td>Present</td>
<td>Corroded</td>
</tr>
<tr>
<td>N-action</td>
<td>Legible</td>
<td>Sharp Edges</td>
</tr>
<tr>
<td>Webbing</td>
<td>Cuts/Frays</td>
<td>Service Date Over 5 Years</td>
</tr>
<tr>
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**COMMENTS**
If a Y or N response corresponds to the item then remedial Action is required.

Retractable lanyards must only be attached to a stationary tie-off point and fall protection harness. Never tie into an additional lanyard, rope, rigging strap etc.
Hot Work Permit Checklist

This Hot Work Permit is required for any Temporary operation involving open flames or producing heat and/or sparks.
This includes; but is not limited to: brazing, cutting, grinding, soldering, torch-applied roofing, and welding.

Required Precautions Checklist:
1. Check that available sprinklers, hose streams and fire extinguishers are in service and operable.
2. Hot work equipment is in good working condition.

Requirements within 35 ft. (11m) of Hot Work:
1. Flammable liquid, dust, lint and oil deposits are removed.
2. Explosive atmosphere in the area is removed.
3. Floors are swept clean.
4. Combustible floors are wet down, covered with damp sand or fire-resistant sheets.
5. Remove other combustible material where possible. Otherwise, protect them with a FM Approved welding Pad blanket, curtain, fire-resistant tarpaulins or metal shields.
6. All wall and floor openings covered.
7. FM Approved welding pad, blankets and curtains are installed under and around work.
8. Protect or shut down ducts and conveyors that might carry sparks to distant combustible material.

Hot Work on Walls, Ceilings, or Roofs:
1. Construction is noncombustible and without combustible coverings or insulation.
2. Combustible material on the other side of walls, ceilings, and roofs are moved away.

Hot Work on Enclosed Equipment:
1. Enclosed equipment is cleaned of all combustible material.
2. Containers are purged of flammable liquids or vapors.
3. Pressurized vessels, piping, and equipment is removed from service, isolated and vented.

Fire Watch/ Hot Work Area Monitoring:
1. Fire watch will be provided during hot work operations and for 60 minutes after work including any break activity.
2. Fire watch is supplied with a sustainable fir extinguisher and where practical, a small charge fire hose.
3. Fire watch is trained in the use of equipment and sounding alarms.
4. Fire watch may be required in adjoining areas, above and below hot work activities.

Other Precautions Taken:
Welding curtains in use, proper ventilation, and proper PPE selection/use.
Appendix D

WHITE PAPER – SAFETY: A CORE VALUE FOR NEES CONSORTIUM, INC.
SAFETY: A CORE VALUE FOR NEES CONSORTIUM, INC.¹

Thomas L. Anderson

1. Introduction

“To be successful, safety must be more than a program or a book or a procedure. It must be a company philosophy – an attitude that is unquestioned.”

Les McGraw, Fluor Corporation Chairman and CEO

Fluor Corporation achieves a consistently outstanding safety performance of 50 times better than the industry average. The single most important task the company has on any project is to ensure that its team members work safely at the construction site and in the office. Integrating successful safety principles into existing systems requires a tactical plan driven by a vision. Specific goals and activities are needed to change behavior. This, in turn leads to culture transformation that fulfills the vision. This white paper addresses the issues that must be considered when drafting a plan for and implementing an effective institutional safety philosophy.

2. Safety Culture Overview

Evidence of a strong safety culture is seen in many ways within an organization. Safety is on everyone’s mind. It is not considered just something for the cleaning crew, site operations manager or safety coordinator. Everyone in the workplace is properly trained, including managers and supervisors, outside contractors, part-time and temporary employees, volunteers, researchers and students. When new people are first introduced to the organization a high priority is given to educating them about commitment to safety. They are solidly trained on safety procedures, made aware of the consequences of ignoring safety practices or engaging in unsafe behavior, and enforcement. They perceive the commitment to safety in the language, customs and behavior that take place on a regular basis.

There are two major theories² ³ about accidents. The Normal Accident Theory, which emphasizes the ever-present possibility of accidents in organizations that exhibit complexity and coupling of processes and the inevitability of accidents, and High Reliability Theory, which holds that all accidents and injuries can be prevented through organizational design and management.

Regardless of the underlying theory, all aspects of human endeavor are vulnerable to accidents and errors. A sweeping disaster such as a nuclear accident fits the conditions for Normal Accident Theory. But for NEESinc, with its experimental earthquake engineering research activities, accidents will tend to occur one person or isolated incident at a time. This fits the

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¹ A white paper submitted to NEESinc under Independent Contractor Agreement ICA-06-07
Organizations with an effective safety culture share a continuing commitment to safety as a value, which permeates the entire organization. Noted components of a safety culture within the leadership of an organization include the following:

1. Acknowledgement of the risk or unsafe practices of the organizations activities,
2. Blame-free environment where individuals are able to report errors and close calls without punishment and take corrective actions to improve safety performance,
3. Expectation of collaboration across ranks and grade levels to seek solutions to vulnerabilities and a ready willingness to do so with a positive attitude, and
4. Readiness of the organization to direct resources to address safety concerns.

Safety experts recognize that most occupational injuries have a strong behavioral component, typically rooted in the safety culture. Clearly, change in behavior as well as attitude is required to change culture. Appendix A lists specific behaviors, attitudes, procedures, expectations and systems that are typically part of a dynamic safety culture environment, both for normal operations and for emergencies.

A cornerstone in a dynamic safety culture is regular, well-attended safety meetings. These can be specific safety meetings, or as part of a team meeting where safety is an item on the agenda. Time is spent identifying and discussing any accidents, near misses or unsafe practices observed during the period, and corrective actions to be taken to eliminate the problem in the future. Such discussions are informative and excellent learning experiences that build and strongly reinforce the organization’s commitment to safety.

In a strong safety culture there is often an active safety committee with meetings scheduled on a regular basis. The committee offers regular training in basic safety methods, and also specialized in-service training to deal with safety issues specific to the entity, site or program. A safety committee would be a good idea for NEESinc, but rather than directly offering training, it would focus on safety-related discussions between NEES Equipment Sites. This would raise important safety issues up the chain of command for resolution and subsequent action.

Safety should be a core value, not viewed or stated simply as a ‘priority.’ Priorities of an organization can change, but values, at the heart of a culture, do not. To say that safety is a priority means that it will change based on the needs of the moment and may not always be at the top of the priority list.

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3. Doing Nothing

In a worst-case scenario, suppose NEESinc does not take decisive action in working to create a real safety culture. And suppose further that a serious accident or a series of accidents, resulting in debilitating injury or death of one or more technicians, graduate students or observers were to happen. Perhaps the accident might unfold during live streaming video of a test where many viewers would watch. It would be a disaster for all involved – the injured or killed and their families and friends, university officials, sponsors and NEESinc, including the Board of Directors. The latter would be expected to speak about the accident to the media, responding to questions about “What have you done to promote safety practices?” with the possible backdrop of a video of the accident played over and over again.

This scenario can be prevented. Zero accidents can be a realistic goal. Continuous safety improvements can be made. Even a near miss can be rendered very unlikely in the first place, its collateral effects reduced, and its impact lessened. Certainly the organization could be on much higher moral ground in having done everything it could do to create a safe work environment by embracing a strong dynamic safety culture.

4. Features and Challenges Unique to NEESinc.

Building a culture of safety is a challenge for any organization. It requires leadership vision and implementation that involves all members of the organization. NEESinc is not, however, a traditional organization. Rather, NEES Equipment Sites can be thought of as a site embedded within a site. They likely have split allegiance between NEESinc and the parent site; they receive their support from both organizations; they are subject to a variety of management systems, including reporting, that likely are vastly different -- and may be in conflict -- with one another; and the parent site has traditions, legacy (maybe of inaction or even disinterest) and practices entrenched6 that make change, driven by NEESinc, hard to do.

It is within this challenging context that a safety culture needs to be created. NEESinc can be the catalyst to create the safety culture within the NEES Equipment Site.7 This will assist the larger parent site to embrace that same culture. At least one NEES Equipment Site has used the signed Research Participation Agreement (RPA) between NEESinc and the university as a vehicle to begin to implement safety changes throughout the laboratory by giving the site operations manager the “teeth” to act.

6 Unfortunately, many managers in a variety of organizations believe that accidents are something that happen to other people, and therefore, workplace safety is not very important to them. No news is good news. Or facility managers may see safety as a matter of risk -- willing to accept higher risk behaviors at their discretion for activities they view as acceptable.
7 Some may believe that the university research laboratory environment with largely untrained student labor creates a special hurdle to implementation of a safety culture. It shouldn’t. Workers in other walks of life when they first come on to a job are in many cases untrained. That’s the purpose of training programs, orientation programs and enforcement, pure and simple. As one site operations manager put it, “If you want to work here, you will do it this way.” That’s how you change attitudes.
Once safety rules are established enforcement makes or breaks the safety culture. If someone is observed cutting with a masonry saw without wearing safety glasses, they should be stopped immediately. They must get the proper glasses or stop cutting. This applies to all safety regulations, without exception. This is a tough decision if the project has a strict deadline, but if you do not intervene, the rest of the personnel will know that you are not serious about safety. It must be common knowledge that safety violations will not be tolerated.

It is recognized in the above example that if a superior, a PI or faculty member for example, does not fully support these tough calls, building a safety culture may be doomed. It is crucial to success for leadership at all levels to buy into the vision, support its implementation and be accountable for its success.

NEESinc finds itself in a situation similar to a project manager with a team of people who don’t technically report to you. The challenge is to get results without much or any authority. Situations abound where there is insufficient project control such as lack of authority, geographically distributed teams, competing priorities and inadequate planning. There are, however, three elements of control that are available to NEESinc -- process, influence and metrics.

For NEESinc the RPA is a key project process that should specify safety practices flowing down from NEESinc that the site and PI agree to be held accountable to implement.

**Influence** refers to enlisting cooperation, not ordering people to do something. Malicious compliance could be the risky result. Rather, a two-way relationship of trust and respect is needed. If safety is not important to a NEES Equipment Site PI, you must work to create interest in it. This is where people skills come into play. Often, the tools of influence rely on reciprocity – an exchange of something that the individual wants for the commitment to embrace the safety practices desired.

**Metrics** for the NEES Equipment Sites involves setting clear safety objectives, then following up with regular progress assessments and reports. To be effective the measures must be well defined, capture the performance objectives and be credibly related to the stated goals. It is an axiom of business that ‘what gets measured gets done.’

The following are examples of practices that have facilitated successful organizational change to a culture of workplace safety.

1. Create a clear, enabling safety vision and goal with equity buy-in from leadership. Communicate this vision with passion to all stakeholders frequently (see the following section on implementation).
2. Create a safety coordinator position or hire a consultant with authority to enforce safety standards. Look for ways to share responsibility for safety within the organization. Often there may be an active safety committee to conduct periodic reviews, training and suggest policy improvements. For NEESinc this might manifest itself as local site safety committees, chaired by the site operations manager. A safety coordinator resource person resource might be available on call, either as a part-time assignment or an outsourced expert.
3. Make accident or near miss investigation forward looking rather than punitive. It is essential to maintain a level of openness and receptivity to determine the root cause of an incident.

4. The President of the NEESinc Board of Directors must include safety as an agenda item at each quarterly Board meeting. S/he needs to know the progress that is being made in establishing a culture of workplace safety.

5. Reporting near misses are invaluable in establishing a safety culture. Document safety violations by means of a standardized form. Analysis of the documented near misses or unsafe practices can reveal patterns which will provide clues to possible larger problems.

5. Implementation -- Vision and Path Forward

“Vision without action is a daydream. Action without vision is a nightmare.”

*Japanese proverb*

Vision is the force behind the action. It is crucial for the leader (or leadership in the case of NEESinc) to state the vision and preach the mission early and often.

A safety vision statement might be as simple as: We are committed to ensuring NEESinc-related safety operations for all individuals are consistently followed as a core value and create a role model for our diverse constituents to emulate.

Once the vision is clear one needs to create a tactical plan to implement the vision. The traditional approach follows two broad steps.

1. Work backward from the vision breaking it down into a series of realistic time-related goals. Example goals might be to evaluate the workplace environment at the various NEES Equipment Sites, and to determine the framework for operations of a NEESinc Safety Officer resource.

2. Take each goal and break it down even further into a series of necessary, workable, daily to-do tasks. These would be clearly defined projects of limited duration. Examples might be to visit a site and gather information by talking with operations and management personnel, and to draft an overall safety policy.

The leader and the organization must take action and keep constant, gentle pressure on progress towards meeting the goals. They should be viewed as vital to the organization, not just a paper target. The goals and tasks must become the drivers towards implementing the vision. Progress must be monitored and corrective action must be taken to ensure each of the steps toward fulfilling the vision is achieved. In time, the necessary change in culture will occur. Often additional goals and to-do lists are added as the organization plows this new ground.

Clearly, the fate of any vision rises and falls on the shoulder of its leader. In the case of NEESinc this should be interpreted as the shoulders of its many leaders. All should have equity ownership in the vision – both in its creation and in its communication. A safety mission must be clearly understandable and accessible. The flow of communication can be controlled to

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ensure that no ambiguity exists in anyone’s mind. Successful vision keepers literally preach the vision.

Enabling a good safety culture requires a clear, empowering vision statement along with firm, unwavering commitment by all to the goal envisioned by the statement. Creating and sustaining the safety culture also requires policies, rules and procedures. It requires availability of and training in the proper use and maintenance of personal protective equipment, enforcement and recognition. Sources for policies and procedures may be found in some of the best practices9 at NEES Equipment Sites. Links to government and industry safety regulations and best practices are provided in Appendix B, Resources.

Training cannot be over emphasized. Knowledge of how to do a job safely is as important as having the proper tools, time, resources and management support to do it. Positive reinforcement from leadership at all levels is critical to success.

Waiting too long for NEESinc leadership to communicate the intention to build a safety culture could prove to be very costly. As several site operations managers have noted, “If something isn’t done fairly soon about safety, resignation may set in: I’m done raising my voice. Inaction is wearing me out.” These local champions for safety at the sites need protection and support in the form of NEESinc leadership to build the safety culture that they will be responsible for implementing at the sites. Action – if action is to be taken on safety – needs to be taken without undue delay.

Accordingly, it is therefore recommended that the first ten steps to creating a safety culture for NEESinc be the following, and taken in this priority order:

1. Create a vision with goal(s) by the NEESinc Board of Directors with their unanimous buy in,
2. Create a tactical plan and schedule to implement the vision,
3. Create a safety liaison assignment for a member of the Board of Directors,
4. Communicate the vision constantly,
5. Create a safety resource position within NEESinc home office or retain an independent third party safety consultant who is free of conflicts of interest,
6. Form a Safety Committee10 whose first activity is collecting best practices (see Appendix B, Resources)
7. Establish safety performance metrics and reporting requirements. These should be established by the Safety Committee with input from the safety consultant and concurrence by NEESinc headquarters staff and NEESinc Board of Directors,
8. Rework the RPA and NEES Equipment Site Policies Compliance Check (ESPCC) to include required NEESinc flow down safety practices and reporting,
9. Hold PIs accountable for safety practices spelled out in the RPA and ESPCC, and establish safety practice noncompliance consequences, and

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9 It is highly likely that collectively, among the NEES Equipment Sites, many if not most or all of the needed safety polices, rules and procedures already exist.
10 Initially, in the interest of time, this function might be served by a small focus group until a permanent Safety Committee and its charter can be formed.
10. Charge the EOT Committee to incorporate safety culture, behavior and practices into their EOT activities in a timely manner.

Creating a safety culture and institutionalizing it as part of NEESinc philosophy will be memorable, honorable, sometimes challenging, but always rewarding work. But don’t look for short cuts; it will take leadership and the willingness to take action. Start creating the NEESinc Safety Vision now by using Appendix B, Resources. They’ll give you a jump start on the creative process.

**Appendix A – Safety Culture Features**

Specific behaviors, attitudes, procedures, expectations and systems that are part of a dynamic safety culture environment, both for normal operations and for emergencies, include the following.

- Everyone acknowledges that top management provides the essential safety improvement leadership.
- Achieving the culture requires consistent leadership and repetition.
- The organization has clearly defined safety policies.
- Everyone can explain the organization’s safety policies.
- Everyone knows which personal protective equipment (PPE) to use for which task, how to use the appropriate equipment to do the task, how to keep the PPE well maintained, when to dispose of it and how to dispose of it safely.
- Everyone can explain desired results and measures of success.
- Everyone takes ownership of work areas.
- Components and work areas are kept clean.
- Everyone focuses efforts beyond compliance.
- No-fault approach to error.
- Negative housekeeping issues kept to a minimum.
- Foreign material control is maintained.
- Strict procedural adherence, verbatim compliance and no “workarounds” permitted.
- All work is planned, not done by trial and error.
- Everyone is involved in identifying and resolving safety concerns, and feels comfortable in doing so.
- Everyone can explain how their personal performance affects safety.
- All people believe they have the necessary authority and resources to meet their responsibilities for safety.
- All meetings begin with a safety topic.
- Safety meetings are held on a regular basis.
- Safety performance for everyone is measured against goals, clearly displayed, and rewarded.
- A review of safety is conducted at least annually and there is a process in place that drives continuous improvement.
- Regular workplace hazard analyses are conducted to identify personnel safety improvement opportunities. The results are used to make changes in work activities.
- Everyone is empowered to correct safety hazards as they are identified.
- A comprehensive system exists for gathering information on safety hazards. The system is positive, rewarding and effective – and people use it.
- All injury-producing incidents, unsafe practices and significant “near misses” are investigated for root cause, with effective preventive actions taken.
• Everyone who operates equipment is trained to recognize maintenance needs and performs or requests timely maintenance.
• Everyone knows immediately how to respond to an emergency because of effective planning, training and drills.
• Facilities are fully equipped for safe operations and for emergencies. All necessary systems and equipment are in place and regularly inspected or tested. All people know how to use safety–related equipment and communications during operations. All people know how to use emergency equipment and communication during emergencies.
• All supervisors and managers assist in safety workplace analyses; ensure physical protections and availability and use of personal protective equipment; reinforce training; enforce discipline; and can explain how to conduct and perform all operations safely.

Appendix B - Resources

One must be aware of good safety practices before you can instruct others. The NEES Equipment Sites collectively have a good start at safety practices. Further, there are many books on safety practices. The local U.S. Department of Labor, Occupational Safety & Health Administration (OSHA) office is an excellent source. There are also companies that specialize in preparing and administering safety programs, but they are expensive and may not be suited to NEESinc operations and conditions.

In order to take optimum advantage of individual NEES Equipment Site experience a small focus group should be formed to collect the best practices followed at the NEES Equipment Sites, and also at a few selected other structural testing laboratories and facilities. This will include universities, aircraft manufacturing testing facilities, national11 laboratories and contract research12 facilities. The interactions and discussions between the sites will be beneficial to building the safety culture. The culled best practices will find their way as a requirement in the language of the RPA forms, in the RPA example and in the ESPCC process as a means to communicate and ensure safety planning and practices on all NEESR projects.

The following URLs are links to a selection of government and private sector safety-related resources:

U.S. Dept of Labor, Occupational Safety & Health Administration

http://www.nonprofitrisk.org/ws-ps/concepts/framework-ps.htm
Workplace Safety Toolkit

http://www.nsc.org/issues/compliance/index.htm
National Safety Council

http://www.cdc.gov/niosh/homepage.html
National Institute for Occupational Safety and Health

11 Examples include Sandia Shock Tube Test Facility; White Sands Proving Ground; US Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory; Pacific Northwest National Laboratory; Lawrence Livermore National Laboratory and Idaho National Engineering Laboratory.
12 Examples include Battelle Memorial Institute, Stanford Research Institute and Franklin Research Institute.
http://www.uos.harvard.edu/ehs/abo_pol.shtml
Harvard University Safety Management Policy

Creating a Safety Culture

http://www.occupationalhazards.com/
Appendix E
OVERHEAD CRANE MANUAL
Crane Operator's Manual

Prepared and Published by

CMAA®
CRANE MANUFACTURERS ASSOCIATION OF AMERICA, INC.

8720 Red Oak Blvd., Suite 201
Charlotte, NC  28217-3992
Foreword

This booklet has been prepared to provide information and suggestions for Crane Operators in their operation of cranes. Overhead cranes generally handle materials over working areas where there are personnel. Therefore, it is important for the Crane Operator to be instructed in the use of the crane and to understand the severe consequences of careless operation.

It is not intended that the suggestions in this booklet take precedence over existing plant safety rules and regulations, OSHA regulations, or instructions issued by the Crane Manufacturer. However, a thorough study of the following information should provide a better understanding of safe operation and afford a greater margin of safety for people and machinery on the plant floor.

It must be recognized that this is a booklet of suggestions for the Crane Operator’s use. It is the responsibility of the owner to make personnel aware of all federal, state and local rules and codes and to make certain operators are properly trained.

It should be clearly understood that under no circumstances does the Crane Manufacturers Association of America, Inc. (CMAA) assume any liability for the use of these suggestions. CMAA makes no warranty whatsoever in connection with these suggestions. There are no implied warranties of merchantability or of fitness for any particular use. Further, CMAA shall not be liable in tort or otherwise—whether based on negligence, strict liability or any other theory of liability—for any action or failure to act in connection with these suggestions. It is the user’s intent to absolve and protect CMAA from any and all liability, in tort or otherwise.

The Crane Manufacturers Association of America, Inc. (CMAA) is an independent incorporated trade association affiliated with Material Handling Industry.

MHI provides CMAA with certain services and, in connection with this booklet, arranges for its production and distribution. Neither MHI, or its officers, directors or employees have any other participation in the development and preparation of the information contained in this booklet.

All inquiries concerning The Crane Operator’s Manual should be directed in writing to the Crane Manufacturers Association of America, Inc., 8720 Red Oak Blvd., Suite 201, Charlotte, NC 28217-3992.
Introduction

Qualifications
Crane operation, to be safe and efficient, requires skill, the exercise of extreme care and good judgement, alertness and concentration, and a rigid adherence to proven safety rules and practices as outlined in applicable and current ANSI and OSHA safety standards.

In general practice, no person should be permitted to operate a crane:
(a) Who cannot speak the appropriate language or read and understand the printed instructions;
(b) Who is not of legal age to operate this type of equipment;
(c) Whose hearing or eyesight is impaired (unless suitably corrected—with good depth perception);
(d) Who may be suffering from heart or other ailments which might interfere with the operator’s safe performance;
(e) Unless the operator has carefully read and studied the operation manual supplied by the Crane Manufacturer;
(f) Unless the operator has been properly instructed;
(g) Unless the operator has demonstrated his instructions through practical operation;
(h) Unless the operator is familiar with hitching equipment and practices.

Operation
Before operating the crane, the crane operator should carefully read and study the operation manual supplied with the crane by the Crane Manufacturer and note any special instructions not given previously by the proper instructor or supervisor.

With the mainline switch open (power off) the crane operator should operate each master switch or push button in both directions so as to get the "feel" of each device and also determine that they do not bind or stick in any position. If any of them do, before doing anything else, the operator should report the condition to the proper supervisor.

Learning the Controls
Having observed the feel of the controllers, the crane operator is now ready to try the crane with power applied.

After checking to be sure no one is on or near the crane, close the crane disconnecting means and press the "ON" or "RESET" button so that the power is "on."

Try the hoisting motion first. The hook should be in an intermediate position. Move the master or push button slowly in the "up" direction or press the "UP" button in the pendant in the same manner. The resultant movement should correspond with master switch or push button markings for all motions. Observe the speed increase in relation to the steps in the controller. Try to feel the steps in a pendant-type controller. Move the hook to a position near the upper hook position and slowly inch the hook into the upper limit stop position. The limit switch should cause the hoisting motion to stop at the upper limit of travel. If any malfunction of either the hoist brake or the limit switch is suspected, this condition should be reported to the supervisor before proceeding. The hoist limit switch should never be used as an operating control for stopping the load. It is to be considered as an emergency limit switch only.

Repeat this procedure with the trolley controller. If the trolley is not equipped with a brake, note how it can be stopped by momentarily operating the control in the first point of the reverse direction. This is known as "plugging." Next try the bridge motion, first making sure that the first movement is in the direction the bridge is free to travel. Check the stopping of the bridge by means of the brake and by plugging.
GOOD operators should always remember and follow four simple rules:

1. Start all motions slowly, by moving the controller handle or push button step by step until the fastest safe speed is reached.

2. Stop slowly, by bringing the master switch or push button to the "off" position step by step so as to minimize "swinging" of the load and unnecessary wear of the brakes.

3. Learn to judge the drift of each motion of the crane after power is removed. Proper use of this drift will facilitate spotting of the load and minimize wear of crane components.

4. Handle the load in a safe manner with the area free of personnel and other obstructions.

Handling the Bridge Travel Motion

Before using the trolley or bridge of the crane, the operator should be sure the hook is high enough to clear any obstruction. Before a load is handled by the crane, the bridge should be brought in position so that it is directly over the load. Otherwise it will be impossible to "spot" the trolley and hoist hook over the load.

In addition to other operating controls, the bridge has a brake, usually operated by a foot pedal in the cab or an electric brake where push button floor control is used. The purpose of this brake is to permit stopping the bridge exactly where desired. After the operator has learned the distance that the bridge travels after power is removed, the operator should be able to judge distances so that the need to use the bridge brake will be greatly reduced. On floor-controlled cranes, the electric brake will set automatically when the push button is released.

Start the bridge slowly and bring it up to speed gradually. Approaching the place where it is desired to stop the bridge, reduce the bridge speed. If the operator finds that the crane is going to "overrun" the point where the bridge is to be stopped, apply the bridge brake. If extra fine control or creeping speed is not provided, follow the practice of " inching," namely: Move the controller handle or button on and off the point that produces a minimum of motion. This practice should be followed only as necessary because it causes extra wear on the controller contacts and the electric brake. Skidding of wheels when stopping will result in flat spots on the wheels and rough bridge action.

Handling the Trolley Travel Motion

Before a load is handled, the hoist should be brought directly over the load that is to be handled. When the slack is taken out of the slings, if the hoist is not directly over the load, bring it directly over the load before hoisting is continued. Failure to center the hoist over the load may cause the load to swing upon lifting.

If the trolley is equipped with a brake, follow the instruction given for controlling the bridge.

If the trolley is not equipped with a brake, this motion may require more skillful handling than any other motion of the crane. As the operator becomes familiar with the crane, he can gauge the amount of "drift" and allow for it. This will eliminate the necessity of quickly reversing power to the trolley motor to bring the trolley to a stop.

Always start the trolley motion slowly and reduce the trolley speed gradually. For very slight trolley movements, follow the practice of " inching" as described in "Handling the Bridge Travel Motion."

Handling the Hoist Motion

After the hook has been brought over the load, lower it until the load can be attached to the hook. As the hook approaches this level, reduce the speed so that the lowering can be stopped smoothly and quickly.

If load slings are used to handle the load, the slings should be fully seated in the saddle of the hook. With the hook latch closed (if equipped with hook latch), the hook should be started upward slowly until all slack has been taken out of the slings. Then the load should be lifted slowly until it is clear and it has been determined that the load is properly balanced and the slings properly placed. The hoisting speed may then be increased and maintained until the load is clear of all obstructions or if a hitcher gives the signal to stop.
When lowering loads, the lowering speeds should be gradually decreased until the load is near the place where it is to be stopped. If a hitcher is used it is very important that the operator pay particular attention to the directions of the hitcher. When the operator is signaled to continue lowering, it should be done at the slowest possible speed. If extra fine control is not provided, final spotting should be accomplished by following the practice of "inching" described in "Handling the Bridge Travel Motion."

When it is necessary that loads be raised or lowered extremely short distances, particularly when raising loads off the floor or out of machine tools or fixtures, the practice of "inching" may be followed if extra fine control is not provided. Note: A good operator should minimize the number of inching operations.

The operator should check the hoist brake by raising the load a short distance and stopping. Check the load for drift. If no drift, lower the load halfway to the floor and stop. Again check for drift. If load drift is noticed in either step, lower the load to the floor and report the situation immediately to the supervisor.

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General Suggestions

Know Your Crane

Crane operators should be familiar with the principal parts of a crane and have a thorough knowledge of crane control functions and movements. (See Figure 1)

Both the crane operator and the person hitching (or rigging) the load should be required to know the location and proper operation of the main runway conductor disconnecting means for all cranes in the area. The crane operators should be thoroughly familiar with the operating manual provided by the Crane Manufacturer.

Responsibility

Each crane operator should be held directly responsible for the safe operation of the crane. Whenever there is any doubt as to SAFETY, the crane operator should stop the crane and refuse to handle loads until: (1) safety has been assured or (2) the operator has been ordered to proceed by the supervisor, who then assumes all responsibility for the SAFETY of the lift.

Do not permit ANYONE to ride on the hook or a load.

Don't Argue

Cab-controlled crane operators should never argue with personnel on the floor. The crane operator's job requires close cooperation with the hitcher.

All disagreements concerning crane operation should be called to the attention of the supervisor.

Entering a Crane (Cab-Operated Cranes)

Crane operators should enter and leave cranes only at designated places using the platform, steps or ladder provided—unless otherwise authorized by the supervisor.

Both hands should be used when ascending or descending a crane ladder. Keep hands free. A handline should be used for lifting or lowering material, tools, lunch buckets, etc. Operators should fasten handlines securely to the crane or building structure, not to themselves.
Figure 1—Bridge Crane
Housekeeping

Good housekeeping should be maintained at all times. The crane operator should keep the crane cab and access clear and clean. Do not permit loose objects such as tools, bolts, boards, etc. around the cab or on the crane because they represent a safety hazard.

Inspection

Test all controls on the crane at the beginning of each shift. Be sure the limit switches, brakes, ropes, hooks and other protective devices are in good working order. Check crane for such things as proper functioning of all controls, and check for loose or damaged parts.

Whenever the operator finds anything wrong or apparently wrong, the problem should be reported immediately to the proper supervisor.

Signals

Standard crane signals (See Figure 2) should be accepted only from ONE authorized person—except where it is apparent that to do so would result in an accident.

Obey a STOP signal at all times, no matter who gives it.

Loads should not be moved unless the standard crane signals are clearly given, seen and understood.

Unusual signals are seldom required, but if used they should be thoroughly understood by the crane operator and authorized person giving the signal.
Standard Hand Signals (Courtesy of ANSI)
Operator Should Wear Proper Safety Clothing

**Figure 2**

Stay Alert

The crane operator should keep hands on the handles of the controller or master switches which control the motions in operation so stops can be made quickly in case of an emergency. Stand up, when necessary to improve vision, when making a lift or when moving a load in any direction. Be especially alert for any unusual sounds or warnings. Danger may be present that the crane operator cannot see.
Operating Suggestions

One measure of a good crane operator is the smoothness of the crane operation. Jumpy and jerky operation, flying starts, quick reversals and sudden stops are the "trademarks" of a poor operator. The good operator should know and follow these proven suggestions for safe, efficient crane handling:

1. Crane controls should be moved smoothly and gradually to avoid abrupt, jerky movements of the load. Slack must be removed from the sling and hoisting ropes before the load is lifted.

2. Center the crane over the load before starting the hoist to avoid swinging the load as the lift is started. Loads should not be swung by the crane to reach areas not under the crane.

3. Crane hoisting ropes should be kept vertical. Cranes shall not be used for side pulls.

4. Never lower the block below the point where less than two full wraps of rope remain on the hoisting drum. Should all the rope be unwound from the drum, be sure it is rewound in the correct direction and seated properly in the drum grooves or otherwise the rope will be damaged and the hoist limit switch will not operate to stop the hoist in the high position.

5. Be sure everyone in the immediate area is clear of the load and aware that a load is being moved. Sound the warning device (if provided) when raising, lowering or moving loads wherever people are working to make them aware that a load is being moved.

6. Do not make lifts beyond the rated load capacity of the crane, sling chains, rope slings, etc.

7. Do not operate the crane if limit switches are out of order, or if ropes show defects or wear.

8. Make certain that before moving the load, load slings, load chains, or other lifting devices are fully seated in the saddle of the hook with hook latch closed (if equipped with hook latch).

9. When a duplex hook (double saddle hook) is used, a double sling or choker should be used to assure that the load is equally divided over both saddles of the hook.
10. On all capacity or near capacity loads, the hoist brakes should be tested by returning the master switch or push button to the "OFF" position after raising the load a few inches off the floor. Check the load for drift. If no drift, lower the load halfway to the floor and stop. Again check for drift. If load drift is noticed in either step, lower the load to the floor and report the situation immediately to the supervisor.

11. Check to be sure that the load and/or bottom block is lifted high enough to clear all obstructions when moving bridge or trolley.

12. At no time should a load be left suspended from the crane unless the operator is at the master switches or push button with the power on, and under this condition keep the load as close as possible to the floor to minimize the possibility of an injury if the load should drop. When the crane is holding a load, the crane operator should remain at the master switch or push button.

13. When a hitcher is used, it should be the joint responsibility of the crane operator and the hitcher to see that hitches are secure and that all loose material has been removed from the load before starting a lift.

14. Do not lift loads with any sling hooks hanging loose. (If all sling hooks are not needed, they should be properly stored, or use a different sling.)

15. All slings or cables should be removed from the crane hooks when not in use. (Dangling cables or hooks hung in sling rings can inadvertently snag other objects when the crane is moving.)

16. Crane operators should not use limit switches to stop the hoist under normal operating conditions. (These are emergency devices and shall not be used as operating controls.)

17. Do not block, adjust or disconnect limit switches in order to go higher or lower than the switch will allow.

18. Upper limit switches (and lower limit switches, when provided) should be tested in stopping the hoist at the beginning of each shift, or as frequently as otherwise directed.

19. Operators shall not carry loads and/or empty bottom blocks over personnel. Particular additional caution should be practiced when using magnet or vacuum devices. Loads, or parts of loads, held magnetically could drop. Failure of power to magnets or vacuum devices can result in dropping the load. Extra precaution should be exercised when handling molten metal in the proximity of personnel.

20. If the electric power goes off, place your controllers in the "OFF" position and keep them there until power is again available.

21. Before closing main or emergency switches, be sure that all controllers are in the "OFF" position so that the crane cannot start unexpectedly.

22. If plugging protection is not provided, always stop the controllers momentarily in the "OFF" position before reversing—except to avoid accidents. (The slight pause is necessary to give the braking mechanism time to operate.)

23. Whenever the operator leaves the crane this procedure should be followed:
   (a) Raise all hooks to an intermediate position.
   (b) Spot the crane at an approved designated location.
   (c) Place all controls in the "OFF" position.
   (d) Open the main switch to the "OFF" position.
   (e) Make visual check before leaving the crane.

   Note: On yard cranes (cranes on outside runways), operators should set the brake and anchor securely so the crane will not be moved by the wind.
24. When two or more cranes are used in making one lift, it is very important that the crane operators take signals from only one designated person.

25. Never attempt to close a switch that has an "OUT OF ORDER" or "DO NOT OPERATE" card on it. Even when a crane operator has placed the card, it is necessary to make a careful check to determine that no one else is working on the crane, before removing the card.

26. In case of emergency or during inspection, repairing, cleaning or lubricating, a warning sign or signal should be displayed and the main switch should be locked in the "OFF" position. This should be done whether the work is being done by the crane operator or by others. On cab-operated cranes when others are doing the work, the crane operator should remain in the crane cab unless otherwise instructed by the supervisor.

27. Never move or bump another crane that has a warning sign or signal displayed. Contacts with runway stops or other cranes shall be made with extreme caution. The operator should do so with particular care for the safety of persons on or below the crane, and only after making certain that any persons on the other cranes are aware of what is being done.

28. Do not change fuse sizes. Do not attempt to repair electrical apparatus or to make other major repairs on the crane unless specific authorization has been received.

29. Never bypass any electrical limit switches or warning devices.

30. Load limit or overload devices shall not be used to measure loads being lifted. Since this is an emergency device, it shall not be used as a production operating control.
SAFE RIGGING MANUAL
In the past, members of the public have used printed information that was outdated by subsequent improvements in knowledge and technology. We therefore make the following statement for their protection in future.

The information presented here was, to the best of our knowledge, current at time of printing and is intended for general application. This publication is not a definitive guide to government regulations or to practices and procedures wholly applicable under every circumstance. The appropriate regulations and statutes should be consulted. Although the Construction Safety Association of Ontario cannot guarantee the accuracy of, nor assume liability for, the information presented here, we are pleased to answer individual requests for counselling and advice.
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INTRODUCTION

Purpose of this Manual

This manual is intended as a working guide for training workers and supervisors in the fundamentals of safe rigging and hoisting.

The information covers not only ropes and knots but hoisting equipment from cranes to chainfalls and rigging hardware from rope clips to spreader beams. Equally important is the attention paid at every point to correct procedures for inspection, maintenance, and operation.

Knowledge of the equipment and materials with which we work is one of the most important factors in occupational health and safety. Each item has been designed and developed to serve a specific purpose. Recognizing its capabilities and limitations not only improves efficiency but minimizes hazards and helps prevent accidents.

This manual identifies the basic hazards in rigging and hoisting, explains the safeguards necessary to control or eliminate these hazards, and spells out other essential safety requirements.

The information should be used in conjunction with the applicable regulations by contractors, supervisors, operators, riggers, and others delivering or receiving instruction in the basics of safe rigging and hoisting.

Health and Safety Law

Occupational Health and Safety Act

Safety legislation for Ontario construction in general consists of the Occupational Health and Safety Act, which came into force on 1 October 1979. Its purpose is to protect workers against health and safety hazards on the job.

The Occupational Health and Safety Act is based on the “internal responsibility” concept for management and workers. This encourages both groups to work out solutions to health and safety problems with the guidance of the Ministry of Labour.

The Act provides us with the framework and the tools to achieve a safe and healthy workplace. It sets out the rights and duties of all parties in the workplace. It establishes procedures for dealing with job-site hazards and provides for enforcement of the law where compliance has not been achieved voluntarily.

Over the years the Act has been revised to meet the changing requirements of Ontario’s workplaces.
Regulations

There are various regulations under the Act for construction in particular.

The most extensive are the *Regulations for Construction Projects* (Ontario Regulation 213/91). There are also special regulations for controlled products under the Workplace Hazardous Materials Information System (WHMIS) and for designated substances such as asbestos.

Construction regulations are generally based on health and safety problems that have recurred over the years. In many cases, the regulations have been proposed jointly by management and labour groups as a means of controlling or eliminating problems that have historically resulted in fatalities, lost-time injuries, and occupational diseases.

The *Regulations for Construction Projects* have been periodically revised over the years.

Review Ontario's *Occupational Health and Safety Act, Regulations for Construction Projects*, and other applicable health and safety regulations to make sure that you know what to expect from others on the job – and what others expect from you.
Section 1

Hoisting and Rigging Hazards

- Procedures and Precautions
- Determining Load Weights
- Weights of Common Materials
Section 1

Hoisting and Rigging Hazards
All too often we read of crane and rigging accidents that cause death and extensive property damage.

Most crane and rigging accidents can be prevented by field personnel following basic safe hoisting and rigging practices.

The single most important precaution in rigging and hoisting is to determine load weight before attempting any lift.

Labour and management both have a responsibility to ensure the safety of all parties involved in hoisting and rigging. Major rigging operations must be planned and supervised by competent personnel to guarantee that the best methods and most suitable equipment are employed.

It is imperative that all workers who prepare, use, and work with or around hoisting and rigging equipment are well trained in both safety and operating procedures. All hoisting equipment should be operated only by trained personnel.

This section

• identifies common hazards and causes of hoisting and rigging accidents
• specifies the procedures and precautions necessary for the safe rigging, lifting, and landing of loads
• explains methods of determining load weight
• provides weight tables for common construction materials.
Procedures and Precautions

Remember: The single most important precaution in hoisting and rigging is to determine the weight of the load before attempting to lift it.

At the same time, riggers must also
- determine the available capacity of the equipment being used
- rig the load so that it is stable (unless the centre of gravity of the load is directly below the hook, the load will shift)
- make allowances for any unknown factors.

In addition, riggers must be aware of common hazards, factors that reduce capacity, the inspection and use of slings, and safe practices in rigging, lifting, and landing loads.

Common Hazards

Working Load Limit (WLL) not known. Know the working load limits of the equipment and tackle being used. Never exceed these limits.

- **Defective components.** Examine all hardware, equipment, tackle, and slings before use. **Destroy** any defective components. Equipment merely discarded may be picked up and used by someone unaware of its defects.

- **Unsafe equipment.** Do not use any equipment that is suspected to be unsafe or unsuitable until its suitability has been verified by a competent person.

- **Hazardous wind conditions.** Never carry out any hoisting or rigging operation when winds create hazards for workers, the general public, or property. Assess load size and shape to determine whether high winds may cause problems. In particular, avoid handling loads that present large wind-catching surfaces. Even though the weight of the load is within the normal capacity of the equipment, high or gusting winds may prevent proper control during the lift. Wind-loading can be critical to how the load is rigged, lifted, and landed, with consequences for the safety of everyone involved. When winds reach 25-30 mph, consider limiting hoisting operations.

- **Hazardous weather conditions.** When the visibility of riggers or hoist crew is impaired by snow, fog, rain, darkness, or dust, strict supervision must be exercised and, if necessary, the lift should be suspended. At sub-freezing temperatures, supervision must ensure that no part of the hoisting device or tackle is shock-loaded or impacted, since brittle fracture of the steel may result.

- **Electrical contact.** One of the most frequent killers of riggers is electrocution caused by an electrical arc or contact between the hoist, load line, or load and a live overhead powerline. When a crane is operating near a live powerline and the load, hoist lines, or any other part of the hoisting operation could encroach on the minimum permitted distance (see table below), specific measures described in the Construction Regulation must be taken. For example, constructors must have written procedures to prevent contact whenever equipment operates within the minimum permitted distance from a live overhead powerline. The constructor must have copies of the procedure available for every employer on the project.
Keep the Minimum Distance from Powerlines

<table>
<thead>
<tr>
<th>Normal phase-to-phase voltage rating</th>
<th>Minimum distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>750 or more volts, but no more than 150,000 volts</td>
<td>3 metres</td>
</tr>
<tr>
<td>Over 150,000 volts, but no more than 250,000 volts</td>
<td>4.5 metres</td>
</tr>
<tr>
<td>More than 250,000 volts</td>
<td>6 metres</td>
</tr>
</tbody>
</table>

Beware:
The wind can blow powerlines, hoist lines, or your load. This can cause them to cross the minimum distance.

• **Hoist line not plumb.** The working load limits of hoisting equipment apply only to freely-suspended loads on plumb hoist lines. If the hoist line is not plumb during load handling, side loads are created which can destabilize the equipment and cause structural failure with no warning.

• **Factors that Reduce Capacity**
The working load limits of all hoisting and rigging equipment are based on almost ideal conditions seldom achieved in the field. Riggers must therefore recognize the factors that can reduce the capacity of equipment.

  • **Swing.** The rapid swinging of suspended loads subjects equipment to additional stresses that can cause collapse. The force of the swinging action makes the load drift away from the machine, increasing the radius and side-loading the equipment. The load must always be kept directly below the boom point or upper load block.

  • **Condition of equipment.** The rated working load limits apply only to equipment and hardware in good condition. Any equipment damaged in service should be taken out of service and repaired or destroyed.
• **Dynamic forces.** The working load limits of most rigging and hoisting equipment are determined from static loads and the appropriate design factor is applied to account for dynamic motions of the load and equipment. To ensure that the working load limit is not exceeded during operation, allow for wind loading and other dynamic forces created by the normal operational movements of the machine and its load. Always avoid the sudden snatching, swinging, and stopping of suspended loads. Rapid acceleration and deceleration can only increase the stresses on both the machine and the tackle.

• **Weight of tackle.** The rated loads of most hoisting equipment do not generally account for the weight of hook blocks, hooks, slings, equalizer beams, and other parts of the lifting tackle. Their combined weight must be subtracted from the load capacity of the equipment to determine the maximum allowable load to be lifted.

---

**Slings**

After the hoist rope, the sling is the most commonly used piece of rigging equipment. Observe the following precautions with slings.

- Never use damaged slings. Inspect slings regularly to ensure their safety. Check wire rope slings for kinking, wear, abrasion, broken wires, worn or cracked fittings, loose seizings and splices, crushing, flattening, and rust or corrosion. Pay special attention to the areas around thimbles and other fittings.

- Slings should be marked with an identification number and their maximum capacity on a flat ferrule or permanently attached ring. Mark the capacity of the sling for a vertical load or at an angle of 45°. Ensure that everyone is aware of how the rating system works.
• Avoid sharp bends, pinching, and crushing. Use loops and thimbles at all times. Corner pads that prevent the sling from being sharply bent or cut can be made from split sections of large-diameter pipe, corner saddles, padding, or blocking.

Ensure that Slings are Protected at All Sharp Corners on Heavy Items

• Never allow wire rope slings, or any wire rope, to lie on the ground for long periods of time or on damp or wet surfaces, rusty steel, or near corrosive substances.
• Avoid dragging slings out from underneath loads.
• Keep wire rope slings away from flame cutting and electric welding.
• Never make slings from discarded hoist rope.
• Avoid using single-leg wire rope slings with hand-spliced eyes. The load can spin, causing the rope to unlay and the splice to pull out. Use slings with Flemish Spliced Eyes.
• Never wrap a wire rope completely around a hook. The sharp radius will damage the sling.
- Avoid bending the eye section of wire rope slings around corners. The bend will weaken the splice or swaging. There must be no bending near any attached fitting.
- Ensure that the sling angle is always greater than 45°. When the horizontal distance between the attachment points on the load is less than the length of the shortest sling leg, then the angle is greater than 60° and generally safe.

**Check on Sling Angle**

If $L$ is greater than $S$ then sling angle is OK.

**Never Wrap a Rope Around a Hook**

**Do Not Permit Bending Near Any Splice or Attached Fitting**
• **Multi-leg slings.** Do not assume that a multi-leg bridle sling will safely lift a load equal to the safe load on one leg multiplied by the number of legs. There is no way of knowing that each leg is carrying its fair share of the load. With slings having more than two legs and a rigid load, it is possible for some of the legs to take practically the full load while the others merely balance it.

As a result, when lifting rigid objects with three- or four-leg bridle slings, make sure that at least two of the legs alone can support the total load. In other words, consider multi-leg slings used on a rigid load as having only two legs. Where the load is flexible and can adjust itself to the sling legs, assume that each leg can take its own share of the load.

When using multi-leg slings to lift loads in which one end is much heavier than the other, the tension on the most heavily loaded leg is much more important than the total weight. The sling must be selected to suit the most heavily loaded leg rather than the total weight.
• When using choker hitches, do not force the eye down towards the load once tension is applied. Rope damage is the invariable result.

• Whenever two or more rope eyes must be placed over a hook, install a shackle on the hook with the shackle pin resting in the hook and attach the rope eyes to the shackle. This will prevent the spread of the sling legs from opening up the hook and prevent the eyes from damaging each other under load.

Incorrect – Cutting action of eye splice on running line.

Correct – Use thimbles in the eyes.

Incorrect – Shackle pin bearing on running line can work loose.

Correct – Shackle pin cannot turn.
Rigging, Lifting, and Landing Loads

- Rig loads to prevent any parts from shifting or dislodging during the lift. Suspended loads should be securely slung and properly balanced before they are set in motion.
- Keep the load under control at all times. Where personnel may be endangered by a rotating or swaying load, use one or more taglines to prevent uncontrolled motion.

Whenever 2 or more ropes are to be Placed Over a Hook – Use a Shackle

- Loads must be safely landed and properly blocked before being unhooked and unslung.
- Lifting beams should be plainly marked with their weight and designed working loads and should only be used for their intended purpose.
- Never wrap the hoist rope around the load. Attach the load to the hook by slings or other rigging devices adequate and suitable to the load being lifted.
- The load line should be brought over the load's centre of gravity before the lift is started.
- Keep hands away from pinch points as slack is being taken up.
- Wear gloves when handling wire rope.
- Make sure that everyone stands clear when loads are being lifted, lowered, and freed of slings. As slings are being withdrawn, their hooks may catch under the load and suddenly fly loose.
• Before making a lift, check to see that the sling is properly attached to the load.
• Never work under a suspended load.
• Never make temporary repairs to a sling. Procedures for proper repair should be established and followed.
• Secure the unused legs of a multi-leg sling before it is lifted.

Secure All Unused Sling Legs

• Never point-load a hook unless it is designed and rated for such use.
• Make sure that the load is free before lifting and that all sling legs are taking the load.
• When using two or more slings on a load, ensure that they are all made from the same material.
• Prepare adequate blocking before loads are lowered. Blocking can help prevent damage to slings.
• Operators: Avoid impact loading caused by sudden jerking during lifting and lowering. Take up slack on the sling gradually. Avoid lifting or swinging the load over workers below.
Determining Load Weights

The most important step in any rigging operation is determining the weight of the load to be hoisted.

This information can be obtained from shipping papers, design plans, catalogue data, manufacturer's specifications, and other dependable sources. When such information is not available, it is necessary to calculate the load weight.

Let’s take **steel** as our example.

On erection plans, the size of steel beams is usually supplied together with their weight per length and the length of the member. Consequently it’s easy to compute the weight of any member to be lifted.

Where angle, plate, or built-up members are involved, however, the weights must be calculated. Memorizing one basic weight and two formulas will give the rigger a reasonably accurate estimate of weight.

The basic weight is that of 1 square foot of steel an inch thick – about 40 pounds. So two plates of steel each measuring 1 1/2” by 3’ by 6’ would weigh a total of

\[
2 \times 1.5 \times 3 \times 6 \times 40 = 2,160 \text{ pounds}
\]

The weights of angles can also be figured with results close enough for safe job use. An angle is a structural shape which can be considered a bent plate with some additional metal at the centre for strength and a lesser amount of metal at the tips for ease of rolling. If the angle is flattened out, the result is a plate.

For example, a 5 by 3 by 1/4 inch angle would flatten out to approximately an 8 by 1/4 inch plate. This should weigh 40 pounds x 8/12 x 1/4 or 6.65 pounds per foot.
Weights of any structural shape can be computed in this manner by separating the parts or flattening them into rectangles which, in turn, become parts of multiples of a square foot of steel an inch thick.

Plates, however, are often rolled into tanks or other shapes. You must determine the square foot area of such parts before you calculate their weight.

This requires learning the two simple formulas for computing the circumference and the area of a circle. The circumference (or distance around the edge of a circle) is found by multiplying the diameter by 3.14.

A stack 6 ft. in diameter would have a circumference of 6 ft. x 3.14, or 18.84 ft. To compute the weight of this stack, if it were 30 ft. high and made of 3/8 in. plate, mentally unroll it and flatten it out (Fig. 1.1). This gives a plate 18.84 ft. wide by 30 ft. long by 3/8” thick. The weight is:

\[
\text{Weight} = 18.84 \times 30 \times 3 \times 40 = 8,478 \text{ lbs.}
\]

radius \( (r) = \text{diameter divided by 2} \)

area = \( \pi r^2 \) \( (\pi = 3.14) \)

The second formula gives the area of circular objects.

\[
\text{AREA} = 3.14 \times \frac{\text{diameter}}{2} \times \frac{\text{diameter}}{2}
\]

Thus, if the stack had an end cap 3/8” thick and 6 ft. in diameter, it would have a surface area:

\[
\text{AREA} = 3.14 \times 6 \times 6 = 28.3 \text{ sq. ft.}
\]

and would weigh

\[
28.3 \times 3 \times 40 = 425 \text{ lbs. (Figure 1.2)}
\]
For other materials the weights are normally based on their weight per cubic foot, so you have to determine how many cubic feet of material (the volume) you are hoisting in order to estimate the weight.

For example, suppose you have a bundle of spruce lumber to hoist and the bundle is 12 ft. long, 3' high and 4' wide. (Fig. 1.3) The weight per cubic foot from Table 1.2 is 28 lbs., so the weight of this bundle is $12 \times 3 \times 4 \times 28 = 4,032$ lbs.

The time taken to calculate the approximate weight of any object, whether steel, plates, columns, girders, castings, bedplates, etc., is time well spent and may save a serious accident through failure of lifting gear. The following tables of weights of various materials (Tables 1.1, 1.2, 1.3) should enable any rigger to compute the approximate weight of a given load. When in doubt, do not hesitate to seek advice from an engineer or foreman on the job.
### Table 1.1 – APPROXIMATE WEIGHT PER FOOT OF LENGTH
OF ROUND STEEL BARS AND RODS

<table>
<thead>
<tr>
<th>Diameter (Inches)</th>
<th>Weight (Lbs.) Per Ft. of Length</th>
<th>Diameter (inches)</th>
<th>Weight (Lbs.) Per Ft. of Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/16</td>
<td>.094</td>
<td>1 3/8</td>
<td>5.05</td>
</tr>
<tr>
<td>1/4</td>
<td>.167</td>
<td>1 1/2</td>
<td>6.01</td>
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<tr>
<td>5/16</td>
<td>.261</td>
<td>1 5/8</td>
<td>7.05</td>
</tr>
<tr>
<td>3/8</td>
<td>.376</td>
<td>1 3/4</td>
<td>8.18</td>
</tr>
<tr>
<td>7/16</td>
<td>.511</td>
<td>1 7/8</td>
<td>9.39</td>
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<td>.668</td>
<td>2</td>
<td>10.68</td>
</tr>
<tr>
<td>9/16</td>
<td>.845</td>
<td>2 1/8</td>
<td>12.06</td>
</tr>
<tr>
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<td>1.04</td>
<td>2 1/4</td>
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</tr>
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<td>1.50</td>
<td>2 3/8</td>
<td>15.06</td>
</tr>
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<td>2.04</td>
<td>2 1/2</td>
<td>16.69</td>
</tr>
<tr>
<td>1</td>
<td>2.67</td>
<td>2 5/8</td>
<td>18.40</td>
</tr>
<tr>
<td>1 1/8</td>
<td>3.38</td>
<td>2 3/4</td>
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</tr>
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<td>1 3/16</td>
<td>3.77</td>
<td>2 7/8</td>
<td>22.07</td>
</tr>
<tr>
<td>1 1/4</td>
<td>4.17</td>
<td>3</td>
<td>24.03</td>
</tr>
</tbody>
</table>

### Table 1.2 – WEIGHTS OF MATERIAL (Based on Volume)

<table>
<thead>
<tr>
<th>Material</th>
<th>Approximate Weight Lbs. Per Cubic Foot</th>
<th>Material</th>
<th>Approximate Weight Lbs. Per Cubic Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>METALS</td>
<td></td>
<td>TIMBER, AIR-DRY</td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>165</td>
<td>Cedar</td>
<td>22</td>
</tr>
<tr>
<td>Brass</td>
<td>535</td>
<td>Fir, Douglas, seasoned</td>
<td>34</td>
</tr>
<tr>
<td>Bronze</td>
<td>500</td>
<td>Fir, Douglas, unseasoned</td>
<td>40</td>
</tr>
<tr>
<td>Copper</td>
<td>560</td>
<td>Fir, Douglas, wet</td>
<td>50</td>
</tr>
<tr>
<td>Iron</td>
<td>480</td>
<td>Fir, Douglas, glue laminated</td>
<td>34</td>
</tr>
<tr>
<td>Lead</td>
<td>710</td>
<td>Hemlock</td>
<td>30</td>
</tr>
<tr>
<td>Steel</td>
<td>490</td>
<td>Pine</td>
<td>30</td>
</tr>
<tr>
<td>Tin</td>
<td>460</td>
<td>Poplar</td>
<td>30</td>
</tr>
<tr>
<td>MASONRY</td>
<td></td>
<td>Spruce</td>
<td>28</td>
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<tr>
<td>Ashlar masonry</td>
<td>140-160</td>
<td>LIQUIDS</td>
<td></td>
</tr>
<tr>
<td>Brick masonry, soft</td>
<td>110</td>
<td>Alcohol, pure</td>
<td>49</td>
</tr>
<tr>
<td>Brick masonry, common (3 tons per thousand)</td>
<td>125</td>
<td>Gasoline</td>
<td>42</td>
</tr>
<tr>
<td>Clay tile masonry, average</td>
<td>140</td>
<td>Oils</td>
<td>58</td>
</tr>
<tr>
<td>Rubble masonry</td>
<td>130-155</td>
<td>Water</td>
<td>62</td>
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<td>Concrete, cinder, haydite</td>
<td>100-110</td>
<td>EARTH</td>
<td></td>
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<tr>
<td>Concrete, slag</td>
<td>130</td>
<td>Earth, wet</td>
<td>100</td>
</tr>
<tr>
<td>Concrete, stone</td>
<td>144</td>
<td>Earth, dry (about 2050 lbs. per cu. yd.)</td>
<td>75</td>
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<tr>
<td>Concrete, stone, reinforced (4050 lbs. per cu. yd.)</td>
<td>150</td>
<td>Sand and gravel, wet</td>
<td>120</td>
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<tr>
<td>ICE AND SNOW</td>
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<td>Sand and gravel, dry</td>
<td>105</td>
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<tr>
<td>Ice</td>
<td>56</td>
<td>River sand (about 3240 lbs. per cu. yd.)</td>
<td>120</td>
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<td>Snow, dry, fresh fallen</td>
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<td>VARIOUS BUILDING</td>
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<td>Snow, dry, packed</td>
<td>12-25</td>
<td>MATERIALS</td>
<td></td>
</tr>
<tr>
<td>Snow, wet</td>
<td>27-40</td>
<td>Cement, portland, loose</td>
<td>94</td>
</tr>
<tr>
<td>MISCELLANEOUS</td>
<td></td>
<td>Cement, portland, set</td>
<td>183</td>
</tr>
<tr>
<td>Asphalt</td>
<td>80</td>
<td>Lime, gypsum, loose</td>
<td>53-64</td>
</tr>
<tr>
<td>Tar</td>
<td>75</td>
<td>Mortar, cement-lime, set</td>
<td>103</td>
</tr>
<tr>
<td>Glass</td>
<td>160</td>
<td>Crushed rock (about 2565 lbs per cu. yd.)</td>
<td>90-110</td>
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<tr>
<td>Paper</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>Approximate Weight Lbs. Per Square Foot</td>
<td>Material</td>
<td>Approximate Weight Lbs. Per Square Foot</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------</td>
<td>--------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td><strong>CEILINGS</strong></td>
<td></td>
<td><strong>FLOORING</strong></td>
<td></td>
</tr>
<tr>
<td>(Per Inch of Thickness)</td>
<td></td>
<td>(Per Inch of Thickness)</td>
<td></td>
</tr>
<tr>
<td>Plaster board</td>
<td>5</td>
<td>Hardwood</td>
<td>5</td>
</tr>
<tr>
<td>Acoustic and fire resistive tile</td>
<td>2</td>
<td>Sheathing</td>
<td>2.5</td>
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<tr>
<td>Plaster, gypsum-sand</td>
<td>8</td>
<td>Plywood, fir</td>
<td>3</td>
</tr>
<tr>
<td>Plaster, light aggregate</td>
<td>4</td>
<td>Wood block, treated</td>
<td>4</td>
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<tr>
<td>Plaster, cement sand</td>
<td>12</td>
<td>Concrete, finish or fill</td>
<td>12</td>
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<tr>
<td><strong>ROOFING</strong></td>
<td></td>
<td>Mastic base</td>
<td>12</td>
</tr>
<tr>
<td>Three-ply felt and gravel</td>
<td>5.5</td>
<td>Mortar base</td>
<td>10</td>
</tr>
<tr>
<td>Five-ply felt and gravel</td>
<td>6.5</td>
<td>Terrazzo</td>
<td>12.5</td>
</tr>
<tr>
<td>Three-ply felt, no gravel</td>
<td>3</td>
<td>Tile, vinyl inch</td>
<td>1.5</td>
</tr>
<tr>
<td>Five-ply felt, no gravel</td>
<td>4</td>
<td>Tile, linoleum 3/16 inch</td>
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</tr>
<tr>
<td>Shingles, wood</td>
<td>2</td>
<td>Tile, cork, per 1/16 inch</td>
<td>0.5</td>
</tr>
<tr>
<td>Shingles, asbestos</td>
<td>3</td>
<td>Tile, rubber or asphalt 3/16 inch</td>
<td>2</td>
</tr>
<tr>
<td>Shingles, asphalt</td>
<td>2.5</td>
<td>Tile, ceramic or quarry 3/4 inch</td>
<td>11</td>
</tr>
<tr>
<td>Shingles, 1/4 inch slate</td>
<td>10</td>
<td>Carpeting</td>
<td>2</td>
</tr>
<tr>
<td>Shingles, tile</td>
<td>14</td>
<td><strong>DECKS AND SLABS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>PARTITIONS</strong></td>
<td></td>
<td>Steel roof deck 1 1/2&quot; – 14 ga.</td>
<td></td>
</tr>
<tr>
<td>Steel partitions</td>
<td>4</td>
<td>– 16 ga.</td>
<td>4</td>
</tr>
<tr>
<td>Solid 2&quot; gypsum-sand plaster</td>
<td>20</td>
<td>– 18 ga.</td>
<td>3</td>
</tr>
<tr>
<td>Solid 2&quot; gypsum-light agg. plaster</td>
<td>12</td>
<td>– 20 ga.</td>
<td>2.5</td>
</tr>
<tr>
<td>Metal studs, metal lath, 3/4”</td>
<td>18</td>
<td>– 22 ga.</td>
<td>2</td>
</tr>
<tr>
<td>plaster both sides</td>
<td></td>
<td><strong>Steel cellular deck 1 1/2&quot; – 12/12 ga.</strong></td>
<td>11</td>
</tr>
<tr>
<td>Metal or wood studs, plaster</td>
<td>18</td>
<td>– 14/14 ga.</td>
<td>8</td>
</tr>
<tr>
<td>board and 1/2&quot; plaster both sides</td>
<td>4</td>
<td>– 16/16 ga.</td>
<td>6.5</td>
</tr>
<tr>
<td>Plaster 1/2”</td>
<td>4</td>
<td>– 18/18 ga.</td>
<td>5</td>
</tr>
<tr>
<td>Hollow clay tile 2 inch</td>
<td>13</td>
<td>– 20/20 ga.</td>
<td>3.5</td>
</tr>
<tr>
<td>3 inch</td>
<td>16</td>
<td><strong>Steel cellular deck 3&quot; – 12/12 ga.</strong></td>
<td>12.5</td>
</tr>
<tr>
<td>4 inch</td>
<td>18</td>
<td>– 14/14 ga.</td>
<td>9.5</td>
</tr>
<tr>
<td>5 inch</td>
<td>20</td>
<td>– 16/16 ga.</td>
<td>7.5</td>
</tr>
<tr>
<td>6 inch</td>
<td>25</td>
<td>– 18/18 ga.</td>
<td>6</td>
</tr>
<tr>
<td>Hollow slag concrete block 4 inch</td>
<td>24</td>
<td>– 20/20 ga.</td>
<td>4.5</td>
</tr>
<tr>
<td>6 inch</td>
<td>35</td>
<td>Concrete, reinforced, per inch</td>
<td>12.5</td>
</tr>
<tr>
<td>Hollow gypsum block 3 inch</td>
<td>10</td>
<td>Concrete, gypsum, per inch</td>
<td>5</td>
</tr>
<tr>
<td>4 inch</td>
<td>13</td>
<td>Concrete, lightweight, per inch</td>
<td>5-10</td>
</tr>
<tr>
<td>5 inch</td>
<td>15.5</td>
<td><strong>MISCELLANEOUS</strong></td>
<td></td>
</tr>
<tr>
<td>6 inch</td>
<td>16.5</td>
<td>Windows, glass, frame</td>
<td>8</td>
</tr>
<tr>
<td>Solid gypsum block 2 inch</td>
<td>9.5</td>
<td>Skylight, glass, frame</td>
<td>12</td>
</tr>
<tr>
<td>3 inch</td>
<td>13</td>
<td>Corrugated asbestos 1/4 inch</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>MASONRY WALLS</strong></td>
<td></td>
<td>Glass, plate 1/4 inch</td>
<td>3.5</td>
</tr>
<tr>
<td>(Per 4 Inch of Thickness)</td>
<td></td>
<td>Glass, common</td>
<td>1.5</td>
</tr>
<tr>
<td>Brick</td>
<td>40</td>
<td>Plastic sheet 1/4 inch</td>
<td>1.5</td>
</tr>
<tr>
<td>Glass brick</td>
<td>20</td>
<td>Corrugated steel sheet, galv. – 12 ga.</td>
<td>5.5</td>
</tr>
<tr>
<td>Hollow concrete block</td>
<td>30</td>
<td>– 14 ga.</td>
<td>4</td>
</tr>
<tr>
<td>Hollow slag concrete block</td>
<td>24</td>
<td>– 16 ga.</td>
<td>3</td>
</tr>
<tr>
<td>Hollow cinder concrete block</td>
<td>20</td>
<td>– 18 ga.</td>
<td>2.5</td>
</tr>
<tr>
<td>Hollow haydite block</td>
<td>22</td>
<td>– 20 ga.</td>
<td>2</td>
</tr>
<tr>
<td>Stone, average</td>
<td>55</td>
<td>– 22 ga.</td>
<td>1.5</td>
</tr>
<tr>
<td>Bearing hollow clay tile</td>
<td>23</td>
<td><strong>Wood Joists – 16&quot; ctrs.</strong></td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 x 12</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 x 10</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 x 8</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Steel plate (per inch of thickness)</strong></td>
<td>40</td>
</tr>
</tbody>
</table>
Section 2

Fibre Ropes, Knots, Hitches

- Fibre Rope Characteristics
- Inspection of Fibre Rope
- Working Load Limit (WLL)
- Care, Storage, Use
- Knots
- Hitches
Section 2

Fibre Ropes, Knots, Hitches

Fibre rope is a commonly used tool which has many applications in daily hoisting and rigging operations.

Readily available in a wide variety of synthetic and natural fibre materials, these ropes may be used as

- slings for hoisting materials
- handlines for lifting light loads
- taglines for helping to guide and control loads.

There are countless situations where the rigger will be required to tie a safe and reliable knot or hitch in a fibre rope as part of the rigging operation.

Fastening a hook, making eyes for slings, and tying on a tagline are a few of these situations.

This section addresses the correct selection, inspection, and use of fibre rope for hoisting and rigging operations. It also explains how to tie several knots and hitches.

Characteristics

The fibres in these ropes are either natural or synthetic. Natural fibre ropes should be used cautiously for rigging since their strength is more variable than that of synthetic fibre ropes and they are much more subject to deterioration from rot, mildew, and chemicals.

**Polypropylene** is the most common fibre rope used in rigging. It floats but does not absorb water. It stretches less than other synthetic fibres such as nylon. It is affected, however, by the ultraviolet rays in sunlight and should not be left outside for long periods. It also softens with heat and is not recommended for work involving exposure to high heat.

**Nylon** fibre is remarkable for its strength. A nylon rope is considerably stronger than the same size and construction of polypropylene rope. But nylon stretches and hence is not used much for rigging. It is also more expensive, loses strength when wet, and has low resistance to acids.

**Polyester** ropes are stronger than polypropylene but not so strong as nylon. They have good resistance to acids, alkalis, and abrasion; do not stretch as much as nylon; resist degradation from ultraviolet rays; and don’t soften in heat.

All fibre ropes conduct electricity when wet. When dry, however, polypropylene and polyester have much better insulating properties than nylon.
**Inspection**

Inspect fibre rope regularly and before each use. Any estimate of its capacity should be based on the portion of rope showing the most deterioration.

Check first for external wear and cuts, variations in the size and shape of strands, discolouration, and the elasticity or “life” remaining in the rope.

Untwist the strands without kinking or distorting them. The inside of the rope should be as bright and clean as when it was new. Check for broken yams, excessively loose strands and yarns, or an accumulation of powdery dust, which indicates excessive internal wear between strands as the rope is flexed back and forth in use.

If the inside of the rope is dirty, if strands have started to unlay, or if the rope has lost life and elasticity, do not use it for hoisting.

Check for distortion in hardware. If thimbles are loose in the eyes, seize the eye to tighten the thimble (Figure 2.1). Ensure that all splices are in good condition and all tucks are done up (Figure 2.2).

![Figure 2.1](image1.png)

If rope or eye stretches – thimble will rock.

![Whip rope to tighten up thimble in eye.](image2.png)

Whip rope to tighten up thimble in eye.

![Check for Tucks popping free.](image3.png)

Check for Tucks popping free.

![To secure splice – use whipping.](image4.png)

To secure splice – use whipping.

Figure 2.1

Figure 2.2
Defective or damaged fibre rope should be destroyed or cut up so that it cannot be used for hoisting.

**Design Factors**

Fibre rope must have a design factor to account for loads over and above the weight being hoisted and for reduced capacity due to:
- wear, broken fibres, broken yarns, age, variations in size and quality
- loads imposed by starting, stopping, swinging, and jerking
- increase in line pull caused by friction over sheaves
- decreases in strength caused by bending over sheaves
- inaccuracies in load weight
- getting wet and drying out, mildew and rot
- strength reductions caused by knots
- yarns weakened by ground-in dirt and abrasives.

The design factor for all fibre rope is 5. For hoisting or supporting personnel, the design factor is 10.

The design factor does not provide extra usable capacity. Working load limits must never be exceeded.

**Working Load Limits**

Working load limits (WLLs) can be calculated as shown in Figure 2.3.

\[
\text{WLL} = \frac{\text{Breaking Strength}}{\text{Design Factor}} = \frac{\text{Breaking Strength}}{5}
\]

For example, a rope rated at 1500 lbs. breaking strength has a working load limit of 300 lbs.

\[
\frac{1500 \text{ lbs.}}{5} = 300 \text{ lbs.}
\]

**Figure 2.3**

The tables in Figure 2.4 are for purposes of illustration only. Check manufacturer's ratings for the WLL of the rope you are using, which may well differ from what is shown in these tables.

WLLs are for the common three-strand fibre ropes generally used for rigging. Figures are based on ropes with no knots or hitches.
## Sample Working Load Limits of Fibre Ropes

### APPROXIMATE WORKING LOAD LIMITS OF NEW FIBRE ROPES – POUNDS

#### 3 Strand Ropes

Design Factor = 5

<table>
<thead>
<tr>
<th>Nominal Rope Diameter (Inches)</th>
<th>Manila</th>
<th>Nylon</th>
<th>Polypropylene</th>
<th>Polyester</th>
<th>Polyethylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/16</td>
<td>100</td>
<td>200</td>
<td>150</td>
<td>200</td>
<td>150</td>
</tr>
<tr>
<td>1/4</td>
<td>120</td>
<td>300</td>
<td>250</td>
<td>300</td>
<td>250</td>
</tr>
<tr>
<td>5/16</td>
<td>200</td>
<td>500</td>
<td>400</td>
<td>500</td>
<td>350</td>
</tr>
<tr>
<td>3/8</td>
<td>270</td>
<td>700</td>
<td>500</td>
<td>700</td>
<td>500</td>
</tr>
<tr>
<td>1/2</td>
<td>530</td>
<td>1,250</td>
<td>830</td>
<td>1,200</td>
<td>800</td>
</tr>
<tr>
<td>5/8</td>
<td>880</td>
<td>2,000</td>
<td>1,300</td>
<td>1,900</td>
<td>1,050</td>
</tr>
<tr>
<td>3/4</td>
<td>1,080</td>
<td>2,800</td>
<td>1,700</td>
<td>2,400</td>
<td>1,500</td>
</tr>
<tr>
<td>7/8</td>
<td>1,540</td>
<td>3,800</td>
<td>2,200</td>
<td>3,400</td>
<td>2,100</td>
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<td>1</td>
<td>1,800</td>
<td>4,800</td>
<td>2,900</td>
<td>4,200</td>
<td>2,500</td>
</tr>
<tr>
<td>1 1/8</td>
<td>2,400</td>
<td>6,300</td>
<td>3,750</td>
<td>5,600</td>
<td>3,300</td>
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<td>1 1/4</td>
<td>2,700</td>
<td>7,200</td>
<td>4,200</td>
<td>6,300</td>
<td>3,700</td>
</tr>
<tr>
<td>1 1/2</td>
<td>3,700</td>
<td>10,200</td>
<td>6,000</td>
<td>8,900</td>
<td>5,300</td>
</tr>
<tr>
<td>1 5/8</td>
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<td>12,400</td>
<td>7,300</td>
<td>10,800</td>
<td>6,500</td>
</tr>
<tr>
<td>1 3/4</td>
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<td>15,000</td>
<td>8,700</td>
<td>12,900</td>
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<td>2</td>
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<td>17,900</td>
<td>10,400</td>
<td>15,200</td>
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</table>

### APPROXIMATE WORKING LOAD LIMITS OF NEW BRAIDED SYNTHETIC FIBRE ROPES – POUNDS

Design Factor = 5

<table>
<thead>
<tr>
<th>Nominal Rope Diameter (Inches)</th>
<th>Nylon Cover Nylon Core</th>
<th>Nylon Cover Polypropylene Core</th>
<th>Polyester Cover Polypropylene Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>420</td>
<td>–</td>
<td>380</td>
</tr>
<tr>
<td>5/16</td>
<td>640</td>
<td>–</td>
<td>540</td>
</tr>
<tr>
<td>3/8</td>
<td>880</td>
<td>680</td>
<td>740</td>
</tr>
<tr>
<td>7/16</td>
<td>1,200</td>
<td>1,000</td>
<td>1,060</td>
</tr>
<tr>
<td>1/2</td>
<td>1,500</td>
<td>1,480</td>
<td>1,380</td>
</tr>
<tr>
<td>9/16</td>
<td>2,100</td>
<td>1,720</td>
<td>–</td>
</tr>
<tr>
<td>5/8</td>
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<td>2,400</td>
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<tr>
<td>3/4</td>
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<td>3,800</td>
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<td>5,600</td>
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<tr>
<td>1 1/8</td>
<td>8,000</td>
<td>7,000</td>
<td>–</td>
</tr>
<tr>
<td>1 1/4</td>
<td>8,800</td>
<td>8,000</td>
<td>–</td>
</tr>
<tr>
<td>1 1/2</td>
<td>12,800</td>
<td>12,400</td>
<td>–</td>
</tr>
<tr>
<td>1 5/8</td>
<td>16,000</td>
<td>14,000</td>
<td>–</td>
</tr>
<tr>
<td>1 3/4</td>
<td>19,400</td>
<td>18,000</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>23,600</td>
<td>20,000</td>
<td>–</td>
</tr>
</tbody>
</table>

Figure 2.4

**Caution:** These tables are for purposes of illustration and comparison only. Check manufacturer’s ratings for the WLL of the specific fibre rope you are using.
When load tables are not available, the following procedures work well for **new** nylon, polypropylene, polyester, and polyethylene ropes. Since rope on the job is rarely new, you will have to judge what figures to use. If you have any doubt about the type of rope or its condition, don’t use it. There is no substitute for safety.

### MANILA ROPE

- Change the rope diameter into eighths of an inch.
- Square the numerator and multiply by 20.

**Example:**
(a) 1/2 inch manila rope = 4/8 inch diameter.
   
   \[
   WLL = 4 \times 4 \times 20 = 320 \text{ lb.}
   \]
(b) 5/8 inch manila rope
   
   \[
   WLL = 5 \times 5 \times 20 = 500 \text{ lb.}
   \]
(c) 1 inch manila rope = 8/8 inch diameter.
   
   \[
   WLL = 8 \times 8 \times 20 = 1280 \text{ lb.}
   \]

### NYLON ROPE

- Change the rope diameter into eighths of an inch.
- Square the numerator and multiply by 60.

**Example:**

1/2 inch nylon rope = 4/8 inch diameter.

\[
WLL = 4 \times 4 \times 60 = 960 \text{ lb.}
\]

### POLYPROPYLENE ROPE

- Change the rope diameter into eighths of an inch.
- Square the numerator and multiply by 40.

**Example:**

1/2 inch polypropylene rope = 4/8 inch diameter.

\[
WLL = 4 \times 4 \times 40 = 640 \text{ lb.}
\]

### POLYESTER ROPE

- Change the rope diameter into eighths of an inch.
- Square the numerator and multiply by 60.

**Example:**

1/2 inch polyester rope = 4/8 inch diameter.

\[
WLL = 4 \times 4 \times 60 = 960 \text{ lb.}
\]

### POLYESTER ROPE

- Change the rope diameter into eighths of an inch.
- Square the numerator and multiply by 35.

**Example:**

1 inch polyethylene rope = 8/8 inch diameter.

\[
WLL = 8 \times 8 \times 35 = 2240 \text{ lb.}
\]
Care

• To unwind a new coil of fibre rope, lay it flat with the inside end closest to the floor. Pull the inside end up through the coil and unwind counterclockwise.

• After use, recoil the rope clockwise. Keep looping the rope over your left arm until only about 15 feet remain. Start about a foot from the top of the coil and wrap the rope about six times around the loops. Then use your left hand to pull the bight back through the loops and tie with a couple of half-hitches to keep the loops from uncoiling (Figure 2.5).

![Figure 2.5](image1)

• Remove kinks carefully. Never try to pull them straight. This will severely damage the rope and reduce its strength.

• When a fibre rope is cut, the ends must be bound or whipped to keep the strands from untwisting. Figure 2.6 shows the right way to do this.

![Figure 2.6](image2)
Storage

- Store fibre ropes in a dry cool room with good air circulation – temperature 10-21°C (50-70°F) humidity 40-60%.

- Hang fibre ropes in loose coils on large diameter wooden pegs well above the floor (Figure 2.7).

- Protect fibre ropes from weather, dampness, and sunlight. Keep them away from exhaust gases, chemical fumes, boilers, radiators, steam pipes, and other heat sources.

- Let fibre ropes dry before storing them. Moisture hastens rot and causes rope to kink easily. Let a frozen rope thaw completely before you handle it. Otherwise fibres can break. Let wet or frozen rope dry naturally.

- Wash dirty ropes in clean cool water and hang to dry.

Use

- Never overload a rope. Apply the design factor of 5 (10 for ropes used to support or hoist personnel). Then make further allowances for the rope’s age and condition.

- Never drag a rope along the ground. Abrasive action will wear, cut, and fill the outside surfaces with grit.

- Never drag a rope over rough or sharp edges or across itself. Use softeners to protect rope at the sharp comers and edges of a load.

- Avoid all but straight line pulls with fibre rope. Bends interfere with stress distribution in fibres.

- Always use thimbles in rope eyes. Thimbles cut down on wear and stress.

- Keep sling angles at more than 45°. Lower angles can dramatically increase the load on each leg (Figure 2.8). The same is true with wire rope slings.
• Never use fibre rope near welding or flame cutting. Sparks and molten metal can cut through the rope or set it on fire.

• Keep fibre rope away from high heat. Don’t leave it unnecessarily exposed to strong sunlight, which weakens and degrades the rope.

• Never couple left-lay rope to right-lay.

• When coupling wire and fibre ropes, always use metal thimbles in both eyes to keep the wire rope from cutting the fibre rope.

• Make sure that fibre rope used with tackle is the right size for the sheaves. Sheaves should have diameters at least six – preferably ten – times greater than the rope diameter.

---

*Figure 2.8*
Knots

Wherever practical, avoid tying knots in rope. Knots, bends, and hitches reduce rope strength considerably. Just how much depends on the knot and how it is applied. Use a spliced end with a hook or other standard rigging hardware such as slings and shackles to attach ropes to loads.

In some cases, however, knots are more practical and efficient than other rigging methods, as for lifting and lowering tools or light material.

For knot tying, a rope is considered to have three parts (Figure 2.9).

![Figure 2.9](image)

The **end** is where you tie the knot. The **standing part** is inactive. The **bight** is in between.

Following the right sequence is essential in tying knots. Equally important is the direction the end is to take and whether it goes over, under, or around other parts of the rope.

There are overhand loops, underhand loops, and turns (Figure 2.10).

![Figure 2.10](image)

**WARNING** – When tying knots, always follow the directions *over* and *under* precisely. If one part of the rope must go under another, do it that way. Otherwise an entirely different knot – or no knot at all – will result.

Once knots are tied, they should be drawn up slowly and carefully to make sure that sections tighten evenly and stay in proper position.
Bowline

Never jams or slips when properly tied. A universal knot if properly tied and untied. Two interlocking bowlines can be used to join two ropes together. Single bowlines can be used for hoisting or hitching directly around a ring.

Bowline on the Bight

Used to tie a bowline in the middle of a line or to make a set of double-leg spreaders for lifting pipe.
Pipe Hitch

Reef or Square Knot
Can be used for tying two ropes of the same diameter together. It is unsuitable for wet or slippery ropes and should be used with caution since it unties easily when either free end is jerked. Both live and dead ends of the rope must come out of the loops at the same side.

Two Half Hitches
Two half hitches, which can be quickly tied, are reliable and can be put to almost any general use.

Running Bowline
The running bowline is mainly used for hanging objects with ropes of different diameters. The weight of the object determines the tension necessary for the knot to grip.

Make an overhand loop with the end of the rope held toward you (1). Hold the loop with your thumb and fingers and bring the standing part of the rope back so that it lies behind the loop (2). Take the end of the rope in behind the standing part, bring it up, and feed it through the loop (3). Pass it behind the standing part at the top of the loop and bring it back down through the loop (4).
Figure-Eight Knot

This knot is generally tied at the end of a rope to temporarily prevent the strands from unlaying. The figure-eight knot can be tied simply and quickly and will not jam as easily as the overhand knot. It is also larger, stronger, and does not injure the rope fibres. The figure-eight knot is useful in preventing the end of a rope from slipping through a block or an eye.

To tie the figure-eight knot, make an underhand loop (1). Bring the end around and over the standing part (2). Pass the end under and then through the loop (3). Draw up tight (4).
Section 3

Hardware, Wire Rope, Slings

- Wire Rope
- Sling Configurations
- Sling Angles
- Centre of Gravity
- Sling WLLs
- Sling Types
- Rigging Hardware
- Hoisting Tips
Hardware, Wire Rope, Slings

The rigger must be able to rig the load to ensure its stability when lifted. This requires a knowledge of safe sling configurations and the use of related hardware such as shackles, eyebolts, and wire rope clips.

Determining the working load limits of the rigging equipment as well as the weight of the load is a fundamental requirement of safe rigging practice.

Do not use any equipment that is suspected to be unsafe or unsuitable until its suitability has been verified by a competent person.

The working load limits of all hoisting equipment and rigging hardware are based on almost ideal conditions seldom achieved in the field. It is therefore important to recognize the factors such as wear, improper sling angles, point loading, and centre of gravity that can affect the rated working load limits of equipment and hardware.

This section describes the selection and safe use of various types of slings and different kinds of rigging hardware. Subjects include factors that can reduce capacity, inspection for signs of wear, calculating safe sling angles, and requirements for slings and hardware under the Regulations for Construction Projects.

Wire Rope

Selection

In selecting equipment, we must consider not only how to get the job done as economically as possible but also how to eliminate hazards to personnel, public, and property for as long as the rope will be used and under all anticipated conditions of exposure and operation.

Although nothing can take the place of experience in making these decisions, it is possible to summarize some of the main points to consider.

Many factors influence the selection of wire rope. Rope strength, although of major importance, is only one factor. Pay attention to the other factors such as size, grade, type, and construction that are specified by equipment or rope manufacturers who base their recommendations on actual working conditions.
Always consider six basic requirements when selecting wire rope:

1. The rope must possess enough strength to take the maximum load that may be applied, with a design factor of at least 5 to 1 – and 10 to 1 when the rope will be used to carry personnel.

2. The rope must withstand repeated bending without failure of the wires from fatigue.

3. The rope must resist abrasion.

4. The rope must withstand distortion and crushing.

5. The rope must resist rotation.

6. The rope must resist corrosion.

Types of Construction

The number of wires in a rope is an important factor in determining a rope’s characteristics. But the arrangement of the wires in the strand is also important.

Basic Types

The four basic constructions are illustrated in Figure 1:

1. Ordinary – all wires are the same size.

2. Warrington – outer wires are alternately larger and smaller.

3. Filler – small wires fill spaces between larger wires.

4. Seale – wires of outer layer are larger diameter than wires of inner layer.

On ropes of Ordinary construction the strands are built in layers. The basic seven-wire strand consists of six wires laid around a central wire. A nineteen-wire strand is constructed by adding a layer of twelve wires over a seven-wire strand. Adding a third layer of eighteen wires results in a 37-wire strand.

In this type of construction the wires in each layer have different lay lengths. This means that the wires in adjacent layers contact each other at an angle. When the rope is loaded the wires rub against each other with a sawing action. This causes eventual failure of the wires at these points.
BASIC WIRE ROPE CONSTRUCTIONS
Figure 1
Wire Rope Inspection

It is essential to have a well-planned program of regular inspection carried out by an experienced inspector. All wire rope in continuous service should be checked daily during normal operation and inspected on a weekly basis. A complete and thorough inspection of all ropes in use must be made at least once a month. Rope idle for a month or more should be given a thorough inspection before it is returned to service. A record of each rope should include date of installation, size, construction, length, extent of service and any defects found. The inspector will decide whether the rope must be removed from service. His decision will be based on:

1. details of the equipment on which the rope has been used,
2. maintenance history of the equipment,
3. consequences of failure, and
4. experience with similar equipment.

Conditions such as the following should be looked for during inspection.

**Broken Wires**

Occasional wire breaks are normal for most ropes and are not critical provided they are at well spaced intervals. Note the area and watch carefully for any further wire breaks. Broken wire ends should be removed as soon as possible by bending the broken ends back and forth with a pair of pliers. This way broken ends will be left tucked between the strands.

Construction regulations under The Occupational Health and Safety Act establish criteria for retiring a rope based on the number of wire breaks.

**Worn and Abraded Wires**

Abrasive wear causes the outer wires to become “D” shaped. These worn areas are often shiny in appearance (Figure 2). The rope must be replaced if wear exceeds 1/3 of the diameter of the wires.

**Reduction in Rope Diameter**

Reduction in rope diameter can be caused by abrasion of outside wires, crushing of the core, inner wire failure, or a loosening of the rope lay. All new ropes stretch slightly and decrease in diameter after being used.

![Figure 2](image-url)
CRUSHED, JAMMED AND FLATTENED STRANDS

Figure 3

Snagged wires resulting from drum crushing

Rope that has been jammed after jumping off sheave

Rope subjected to drum crushing. Note the distortion of the individual wires and displacement from their original position. This is usually caused by the rope scrubbing on itself.

Localized crushing of rope

Drum crushing

With no more than 2 layers on drum, use any kind of rope.

With more than 2 layers on drum, there is danger of crushing. Use larger rope or IWRC rope.
**Rope Stretch**

All steel ropes will stretch during initial periods of use. Called “constructional stretch”, this condition is permanent. It results when wires in the strands and strands in the rope seat themselves under load. Rope stretch can be recognized by increased lay length. Six-strand ropes will stretch about six inches per 100 feet of rope while eight-strand ropes stretch approximately 10 inches per 100 feet. Rope stretched by more than this amount must be replaced.

**Corrosion**

Corrosion is a very dangerous condition because it can develop inside the rope without being seen. Internal rusting will accelerate wear due to increased abrasion as wires rub against one another. When pitting is observed, consider replacing the rope. Noticeable rusting and broken wires near attachments are also causes for replacement. Corrosion can be minimized by keeping the rope well lubricated.

**Crushed, Flattened or Jammed Strands**

These dangerous conditions require that the rope be replaced (Figure 3). They are often the result of crushing on the drum.

**High Stranding and Unlaying**

These conditions will cause the other strands to become overloaded. Replace the rope or renew the end connection to reset the rope lay (Figure 4).
Bird Caging

Bird caging is caused by the rope being twisted or by a sudden release of an overload (Figure 5). The rope, or the affected section, must be replaced.

Multi-strand rope “birdcages” because of torsional unbalance. Typical of buildup seen at anchorage end of multi-fall crane application.

A birdcage caused by sudden release of tension and resulting rebound of rope from overloaded condition. These strands and wires will not return to their original positions.

A birdcage which has been forced through a tight sheave.

BIRD CAGING

Figure 5
**Kinks**

Kinking is caused by loops that have been drawn too tightly as a result of improper handling (Figure 6). Kinks are permanent and will require that the rope, or damaged section, be taken out of service.

**Core Protrusion**

Core protrusion can be caused by shock loads and/or torsional imbalance (Figure 7). This condition requires that the rope be taken out of service.

**Electrical Contact**

Rope subjected to electrical contact will have wires that are fused, discoloured or annealed and must be removed from service.

An open kink like this is often caused by improper handling and uncoiling as shown.

These ropes show the severe damage resulting from the use of kinked ropes. Local wear, distortion, misplaced wires, and early failure are inevitable.
Figure 8 illustrates examples of rope damage, while Table 6 identifies likely causes of typical faults.

<table>
<thead>
<tr>
<th>TYPICAL ROPE DAMAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 8</td>
</tr>
</tbody>
</table>

| Narrow path of wear resulting in fatigue fractures caused by working in a grossly oversized groove or over small support rollers. | Breakup of IWRC from high stress. Note nicking of wires in outer strands. |
| Two parallel paths of broken wires indicate bending through an undersize groove in the sheath. | Wire fractures at the strand or core interface, as distinct from crown fractures, caused by failure of core support. |
| Fatigue failure of wire rope subjected to heavy loads over small sheaves. In addition to the usual crown breaks, there are breaks in the valleys of the strands caused by strand nicking from overloading. | Wire rope shows severe wear and fatigue from running over small sheaves with heavy loads and constant abrasion. |
| Rope failing from fatigue after bending over small sheaves. | Wire rope that has jumped a sheave. The rope is deformed into a curl as though bent around a round shaft. |
| Mechanical damage due to rope movement over sharp edge under load. | Rope break due to excessive strain. |
A single strand removed from a wire rope subjected to "strand nicking". This condition is the result of adjacent strands rubbing against one another and is usually caused by core failure due to continued operation of a rope under high tensile load. The ultimate result will be individual wire breaks in the valleys of the strands.

**TABLE 6**

<table>
<thead>
<tr>
<th>FAULT</th>
<th>POSSIBLE CAUSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerated Wear</td>
<td>Severe abrasion from being dragged over the ground or obstructions.</td>
</tr>
<tr>
<td></td>
<td>Rope wires too small for application or wrong construction or grade.</td>
</tr>
<tr>
<td></td>
<td>Poorly aligned sheaves.</td>
</tr>
<tr>
<td></td>
<td>Large fleet angle.</td>
</tr>
<tr>
<td></td>
<td>Worm sheaves with improper groove size or shape.</td>
</tr>
<tr>
<td></td>
<td>Sheaves, rollers and fairleads having rough wear surfaces.</td>
</tr>
<tr>
<td></td>
<td>Stiff or seized sheave bearings.</td>
</tr>
<tr>
<td></td>
<td>High bearing and contact pressures.</td>
</tr>
<tr>
<td>Broken Wires or Undue Wear on One Side of Rope</td>
<td>Improper alignment.</td>
</tr>
<tr>
<td></td>
<td>Damaged sheaves and drums.</td>
</tr>
<tr>
<td>Broken Wires Near Fittings</td>
<td>Rope vibration.</td>
</tr>
<tr>
<td>Burns</td>
<td>Sheave groove too small.</td>
</tr>
<tr>
<td></td>
<td>Sheaves too heavy.</td>
</tr>
<tr>
<td></td>
<td>Sheave bearings seized.</td>
</tr>
<tr>
<td></td>
<td>Rope dragged over obstacle.</td>
</tr>
<tr>
<td>Rapid Appearance of Broken Wires</td>
<td>Rope is not flexible enough.</td>
</tr>
<tr>
<td></td>
<td>Sheaves, rollers, drums too small in diameter.</td>
</tr>
<tr>
<td></td>
<td>Overload and shock load.</td>
</tr>
<tr>
<td></td>
<td>Excessive rope vibration.</td>
</tr>
<tr>
<td></td>
<td>Rope speed too high.</td>
</tr>
<tr>
<td></td>
<td>Kinks that have formed and been straightened out.</td>
</tr>
<tr>
<td></td>
<td>Crushing and flattening of the rope.</td>
</tr>
<tr>
<td></td>
<td>Reverse bends.</td>
</tr>
<tr>
<td></td>
<td>Sheave wobble.</td>
</tr>
<tr>
<td>Rope Chilled</td>
<td>Excessive heat.</td>
</tr>
<tr>
<td>Corrugation and Excessive Wear</td>
<td>Rollers too soft.</td>
</tr>
<tr>
<td></td>
<td>Sheave and drum material too soft.</td>
</tr>
<tr>
<td>Distortion of Lay</td>
<td>Rope improperly cut.</td>
</tr>
<tr>
<td></td>
<td>Core failure.</td>
</tr>
<tr>
<td></td>
<td>Sheave grooves too big.</td>
</tr>
<tr>
<td>Pinching and Crushing</td>
<td>Sheave grooves too small.</td>
</tr>
<tr>
<td>Rope Broken Off Square</td>
<td>Overload, shock load.</td>
</tr>
<tr>
<td></td>
<td>Kink.</td>
</tr>
<tr>
<td></td>
<td>Broken or cracked sheave flange.</td>
</tr>
<tr>
<td>Rope Chatters</td>
<td>Rollers too small.</td>
</tr>
<tr>
<td>Strand Break</td>
<td>Overload, shock load.</td>
</tr>
<tr>
<td></td>
<td>Local wear.</td>
</tr>
<tr>
<td></td>
<td>Slack in 1 or more strands.</td>
</tr>
<tr>
<td>Rope Chatters</td>
<td>Rollers too small.</td>
</tr>
<tr>
<td>Rope Unlays</td>
<td>Swivel fittings on Lang Lay ropes.</td>
</tr>
<tr>
<td></td>
<td>Rope dragging against stationary object.</td>
</tr>
<tr>
<td>Crushing and Nicking</td>
<td>Rope struck or hit during handling.</td>
</tr>
<tr>
<td>Corrosion</td>
<td>Inadequate lubricant.</td>
</tr>
<tr>
<td></td>
<td>Improper type of lubricant.</td>
</tr>
<tr>
<td></td>
<td>Improper storage.</td>
</tr>
<tr>
<td></td>
<td>Exposure to acids or alkalis.</td>
</tr>
<tr>
<td>High Stranding</td>
<td>Fittings improperly attached.</td>
</tr>
<tr>
<td></td>
<td>Broken strand.</td>
</tr>
<tr>
<td></td>
<td>Kinks, dog legs.</td>
</tr>
<tr>
<td></td>
<td>Improper seizing.</td>
</tr>
<tr>
<td>Kinks, Dog Legs, Distortions</td>
<td>Improper installation.</td>
</tr>
<tr>
<td></td>
<td>Improper handling.</td>
</tr>
<tr>
<td>Reduction in Diameter</td>
<td>Broken core.</td>
</tr>
<tr>
<td></td>
<td>Overload.</td>
</tr>
<tr>
<td></td>
<td>Corrosion.</td>
</tr>
<tr>
<td></td>
<td>Severe wear.</td>
</tr>
<tr>
<td>Excessive Wear in Spots</td>
<td>Kinks or bends in rope due to improper handling in service or during installation.</td>
</tr>
<tr>
<td></td>
<td>Vibration of rope on drums or sheaves.</td>
</tr>
<tr>
<td>Bird Cage</td>
<td>Sudden release of load.</td>
</tr>
<tr>
<td>Crushing and Flattening</td>
<td>Overload, shock load.</td>
</tr>
<tr>
<td></td>
<td>Uneven spooling.</td>
</tr>
<tr>
<td></td>
<td>Cross winding.</td>
</tr>
<tr>
<td></td>
<td>Too much rope on drum.</td>
</tr>
<tr>
<td></td>
<td>Loose bearing on drum.</td>
</tr>
<tr>
<td></td>
<td>Faulty clutches.</td>
</tr>
<tr>
<td></td>
<td>Rope dragged over obstacle.</td>
</tr>
<tr>
<td>Core Protrusion</td>
<td>Core failure due to continued operation under high load.</td>
</tr>
<tr>
<td>Stretch</td>
<td>Overload.</td>
</tr>
<tr>
<td></td>
<td>Untwist of Lang Lay ropes.</td>
</tr>
<tr>
<td>Core Protrusion</td>
<td>Shock loading.</td>
</tr>
<tr>
<td></td>
<td>Disturbed rope lay.</td>
</tr>
<tr>
<td></td>
<td>Rope unlays.</td>
</tr>
<tr>
<td></td>
<td>Load spins.</td>
</tr>
</tbody>
</table>
Procedures and Precautions with Wire Rope

- Ensure that the right size and construction of rope is used for the job.
- Inspect and lubricate rope regularly according to manufacturer's guidelines.
- Never overload the rope. Minimize shock loading. To ensure there is no slack in the rope, start the load carefully, applying power smoothly and steadily.
- Never use frozen ropes.
- Take special precautions and/or use a larger size rope whenever
  - the exact weight of the load is unknown
  - there is a possibility of shock loading
  - conditions are abnormal or severe
  - there are hazards to personnel.
- Use softeners to protect rope from corners and sharp edges.
- Avoid dragging rope out from under loads or over obstacles.
- Do not drop rope from heights.
- Store all unused rope in a clean, dry place.
- Never use wire rope that has been cut, kinked, or crushed.
- Ensure that rope ends are properly seized.
- Use thimbles in eye fittings at all times.
- Prevent loops in slack lines from being pulled tight and kinking. If a loop forms, don’t pull it out-unfold it. Once a wire rope is kinked, damage is permanent. A weak spot will remain no matter how well the kink is straightened out.
- Check for abnormal line whip and vibration.
- Avoid reverse bends.
- Ensure that drums and sheaves are the right diameter for the rope being used.
- Ensure that sheaves are aligned and that fleet angle is correct.
- Sheaves with deeply worn or scored grooves, cracked or broken rims, and worn or damaged bearings must be replaced.
- Ensure that rope spools properly on the drum. Never wind more than the correct amount of rope on any drum. Never let the rope cross-wind.
Slings

General
Slings are often severely worn and abused in construction. Damage is caused by:
• failure to provide blocking or softeners between slings and load, thereby allowing sharp edges or comers of the load to cut or abrade the slings
• pulling slings out from under loads, leading to abrasion and kinking
• shock loading that increases the stress on slings that may already be overloaded
• traffic running over slings, especially tracked equipment.

Because of these and other conditions, as well as errors in calculating loads and estimating sling angles, it is strongly recommended that working load limits be based on a design factor of at least 5:1.

For the same reasons, slings must be carefully inspected before each use.

Sling Angles
The rated capacity of any sling depends on its size, its configuration, and the angles formed by its legs with the horizontal.

For instance, a two-leg sling used to lift 1000 pounds will have a 500-pound load on each leg at a sling angle of 90°. The load on each leg will go up as the angle goes down. At 30° the load will be 1000 pounds on each leg! See Figure 9.

Keep sling angles greater than 45° whenever possible. The use of any sling at an angle lower than 30° is extremely hazardous. This is especially true when an error of only 5° in estimating the sling angle can be so dangerous.

Sling Configurations
Slings are not only made of various material such as wire rope and nylon web. They also come in various configurations for different purposes. Common configurations are explained on the following pages.
Sling Configurations

The term “sling” covers a wide variety of configurations for fibre ropes, wire ropes, chains and webs. Correct application of slings commonly used in construction will be explained here because improper application can be dangerous.

The **Single Vertical Hitch** (Figure 10) supports a load by a single vertical part or leg of the sling. The total weight of the load is carried by a single leg, the sling angle is 90° (sling angle is measured from the horizontal) and the weight of the load can equal the maximum working load limit of the sling and fittings. End fittings can vary but thimbles should be used in the eyes. The eye splices on wire ropes should be Mechanical-Flemish Splices for best security.

The single vertical hitch must not be used for lifting loose material, lengthy material or anything difficult to balance. This hitch provides absolutely no control over the load because it permits rotation. Use single vertical hitches only on items equipped with lifting eyebolts or shackles.

**Bridle Hitch** (Figs 11, 12, 13.). Two, three or four single hitches can be used together to form a bridle hitch for hoisting an object with the necessary lifting lugs or attachments. Used with a wide assortment of end fittings, bridle hitches provide excellent load stability when the load is distributed equally among the legs, the hook is directly over the load’s centre of gravity and the load is raised level. To distribute the load equally it may be necessary to adjust the leg lengths with turnbuckles. Proper use of a bridle hitch requires that sling angles be carefully measured to ensure that individual legs are not overloaded.
Because the load may not be distributed evenly when a four-leg sling lifts a rigid load, assume that the load is carried by two of the legs only and "rate" the four-leg sling as a two-leg sling.

The **Single Basket Hitch** (Figure 14) is used to support a load by attaching one end of the sling to the hook, then passing the other end under the load and attaching it to the hook. Ensure that the load does not turn or slide along the rope during a lift because both load and rope can be damaged.
The **Double Basket Hitch** (Figure 15) consists of two single basket hitches passed under the load. They must be placed under the load so that it is balanced. The legs of the hitches must be kept far enough apart to provide balance but not so far apart that low angles are created and the legs pull in toward the centre. The angle between the load and the sling should be approximately 60° or greater to avoid slippage. On smooth surfaces, both sides of the hitch should be snubbed against a change of contour to prevent the rope from slipping as load is applied. Otherwise use a double wrap basket hitch.

The **Double Wrap Basket Hitch** (Figure 16) is a basket hitch wrapped completely around the load and compressing it rather than merely supporting it, as does the ordinary basket hitch. The double wrap basket hitch can be used in pairs like the double basket hitch. This method is excellent for handling loose material, pipe, rod or smooth cylindrical loads because the sling is in full 360° contact with the load and tends to draw it together.
DOUBLE WRAP BASKET HITCH

Figure 16

The Single Choker Hitch (Figure 17) forms a noose in the rope. It does not provide full 360° contact with the load, however, and therefore should not be used to lift loads difficult to balance or loosely bundled. The single choker can also be doubled up to provide twice the capacity or to turn a load. (Doubling a single choker hitch is not the same as using a double choker hitch.)

NOTE: Choker hitches are not suited to long loose bundles.

Chokers do not provide full support for loose loads – material can fall out.

SINGLE CHOKER HITCHES
The **Double Choker Hitch** (Figure 18) consists of two single chokers attached to the load and spread to provide load stability. Like the single choker, the double choker does not completely grip the load. But because the load is less likely to tip, the double choker is better suited for handling loosely bundled items.

![Double Choker Hitch](image)

**DOUBLE CHOKER HITCHES**  
Figure 18

A **Double Wrap Choker Hitch** (Figure 19) is formed by wrapping the sling completely around the load and hooking it into the vertical part of the sling. This hitch is in full 360° contact with the load and tends to draw it tightly together. It can be used either singly on short, easily balanced loads or in pairs on longer loads.

![Double Wrap Choker Hitch](image)

**DOUBLE WRAP CHOKER HITCHES**  
Figure 19

**Endless Slings or Grommet Slings** (Figure 20) are useful for a variety of applications. Endless chain slings are manufactured by attaching the ends of a length of chain with a welded or mechanical link. Endless web slings are sewn. An endless wire rope sling is made from one continuous strand wrapped onto itself to form a six-strand rope with a strand core. The end is tucked into the body at the point where the strand was first laid onto itself. These slings can be used in a number of configurations, as vertical hitches, basket hitches, choker hitches and combinations of these basic arrangements. They are very flexible but tend to wear more rapidly than other slings because they are not normally equipped with fittings and thus are deformed when bent over hooks or choked.

![Endless Slings or Grommet Slings](image)
NOTE: Ensure that the splice is always clear of the hooks and load.

_Braided Slings_ (Figure 21) are usually fabricated from six to eight small-diameter ropes braided together to form a single rope that provides a large bearing surface, tremendous strength, and flexibility in every direction. They are easy to handle and almost impossible to kink. The braided sling can be used in all the standard configurations and combinations but is especially useful for basket hitches where low bearing pressure is desirable or where the bend is extremely sharp.
Sling Angles

The loading in any type of sling is affected by the angle of the legs. If possible, keep leg angles greater than 45° from the horizontal. Sling angles approaching 30° are extremely hazardous and must be avoided at all costs. The sharp increase in loading at low angles is clearly shown in Figure 22.
Low sling angles also create large, horizontal compressive forces in the load which may be sufficient to cause buckling, especially in long, flexible loads.

Some load tables list sling angles as low as 15° but the use of any sling at an angle less than 30° is extremely dangerous. Not only are the loads in each leg high at these low angles but an error in measurement as little as 5° can affect the load in the sling drastically. Data in Figure 23 illustrates the effect of a 5° error in angle measurement on the sling load. Notice that there is a 50% error in the assumed load at the 15° sling angle.

**Figure 23**

<table>
<thead>
<tr>
<th>Assumed Sling Angle</th>
<th>Assumed Load (Pounds Per Leg)</th>
<th>Actual Angle (is 5° Less Than Assumed Angle)</th>
<th>Actual Load (Pounds Per Leg)</th>
<th>Error %</th>
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<td>2,880</td>
<td>49.0</td>
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</table>
Centre of Gravity

It is always important to rig the load so that it is stable. The load's centre of gravity must be directly under the main hook and below the lowest sling attachment point before the load is lifted (Figure 24).

Centre of gravity is the point around which an object's weight is evenly balanced. The entire weight may be considered concentrated at this point. A suspended object will always move until its centre of gravity is directly below its suspension point. To make a level or stable lift, the crane or hook block must be directly above this point **before the load is lifted**. Thus a load which is slung above and through the centre of gravity will not topple or slide out of the slings (Figure 25).
An object symmetrical in shape and uniform in composition will have its centre of gravity at its geometric centre. With odd-shaped objects, the centre of gravity can be more difficult to locate. Often the rigger must guess where it lies, rig accordingly, signal for a trial lift and then, by watching the suspended load, determine the centre of gravity more exactly, adjusting hook, load and sling suspension for the best balance and stability. The centre of gravity will lie somewhere along a line drawn vertically from the hook down through the load.

Remember that when the centre of gravity is closer to one sling attachment point than the other, the sling legs must be of unequal length, which means that their angles and loads will also be unequal.

When a lifted load tilts and rigging is not corrected, the tension will sharply increase on one sling leg and decrease on the other. If any load tilts more than 5° after it is lifted clear of the ground it should be landed and rigged over again.

It is equally important to ensure that the support points of a load (i.e. where the slings are attached to the load) lie above its centre of gravity. Under suspension, an object’s centre of gravity will always seek the lowest level below the point of support. This knowledge is especially important for lifting pallets, skids or the base of any object since they all have a tendency to topple. But this type of load will be inherently stable if the attachments are above the centre of gravity.
Working Load Limits

Knowledge of working load limits (WLLs) is essential to the use of ropes, slings, and rigging hardware. As indicated in previous sections, the working load limit should be stamped, pressed, printed, tagged, or otherwise indicated on all rigging equipment.

Field Calculation Formula

The field calculation formula can be used to compute the working load limit of a wire rope in tons of 2,000 pounds. The formula applies to new wire rope of Improved Plow steel and a design factor of 5.

\[ \text{WLL} = \text{DIAMETER} \times \text{DIAMETER} \times 8 \]
\[ \text{(where DIAMETER = nominal rope diameter in inches)} \]
\[ \text{OR} \]
\[ \text{WLL} = D^3 \times 8 \]

Examples:

(a) 1/2 inch diameter rope
\[
\text{WLL} = \frac{1}{2} \times \frac{1}{2} \times 8 = 2 \text{ tons}
\]

(b) 5/8 inch diameter rope
\[
\text{WLL} = \frac{5}{8} \times \frac{5}{8} \times 8 = 3.125 \text{ tons}
\]

(c) 1 inch diameter rope
\[
\text{WLL} = 1 \times 1 \times 8 = 8 \text{ tons}
\]
Sling Angle and WLL

Sling angles are crucial in determining working load limits (WLLs) for many sling configurations. In tables of WLLs, capacities are given for bridle and basket hitches at angles of 60°, 45°, and 30°. Measuring these angles can be difficult on a construction site since the measuring tools required are generally not available.

There are, however, two angles you can easily determine before consulting tables. The first is a 90° angle formed by two legs of a bridle or basket hitch at the crane hook or master link (Figure 26). This corresponds to a 45° sling angle.

![45° Sling Angle](image)

The second angle easy to identify is a 60° sling angle (Figure 27). For a bridle hitch, a 60° sling angle can be recognized when the distance between the attachment points is equal to the length of a sling leg; for a basket hitch, when the distance between the points where the sling first contacts the load is equal to the length of one inclined leg of the sling.

![60° Sling Angle](image)
Estimating Sling WLLs

Because it is difficult to remember all load, size, and sling angle combinations provided in tables, some general rules can be used to estimate working load limits for common sling configurations.

Each rule is based on the working load limit of a single vertical hitch of a given size and material and on the ratio $\frac{H}{L}$.

$H$ is the vertical distance from the saddle of the hook to the top of the load. $L$ is the distance, measured along the sling, from the saddle of the hook to the top of the load (Figure 28).

If you cannot measure the entire length of the sling, measure along the sling from the top of the load to a convenient point and call this distance $I$. From this point measure down to the load and call this distance $h$. The ratio $\frac{h}{l}$ will be the same as the ratio $\frac{H}{L}$ (Figure 28).

$\frac{H}{L}$ or $\frac{h}{l}$ will apply equally to the following rules for different sling configurations. The efficiencies of end fittings must also be considered to determine the capacity of the sling assembly.

REMEMBER: the smaller the sling angle, the lower the working load limit.
Bridle Hitches (2-Leg) (Figure 29)

\[ WLL = WLL \text{ (of Single Vertical Hitch)} \times H/L \times 2 \]

DETERMINING CAPACITY OF 2-LEG BRIDLE HITCHES

Figure 29

Bridle Hitches (3- and 4-Leg) Figures 30 and 31

Three- and four-leg hitches are rated equally to account for the possibility of unequal load distribution in a four-leg hitch.

\[ WLL = WLL \text{ (of Single Vertical Hitch)} \times H/L \times 3 \]

Three-leg hitches are less susceptible to unequal distribution since the load can tilt and equalize the loads in each leg. However, lifting an irregularly shaped, rigid load with a three-leg hitch may develop unequal loads in the sling legs. To be safe, use the formula for a two-leg bridle hitch under such circumstances.

\[ WLL = WLL \text{ (of single vertical hitch)} \times H/L \times 3 \]

DETERMINING CAPACITY OF 3-LEG BRIDLE HITCH

Figure 30
DETERMINING CAPACITY OF 4-LEG BRIDLE HITCH

Figure 31

Remember that the rated capacity of a multi-leg sling is based on the assumption that all legs are used. If this is not the case, de-rate the sling assembly accordingly and hook all unused legs to the crane hook so they will not become snagged during the lift.

Single Basket Hitch Figure 32

For vertical legs – WLL = WLL (of Single Vertical Hitch) x 2
For inclined legs – WLL = WLL (of Single Vertical Hitch) x H/L x 2
Double Basket Hitch
For vertical legs:
WLL = WLL (of single vertical hitch) x 3

For inclined legs:
WLL = WLL (of single vertical hitch) x H/L x 3

Double Wrap Basket Hitch
Depending on configuration, WLLs are the same as for the single basket or double basket hitch.

Single Choker Hitch
For sling angles of 45° or more –
WLL = WLL (of Single Vertical Hitch) x 3/4

Sling angles of less than 45° are not recommended. If they must be used the formula is:
WLL = WLL (of Single Vertical Hitch) x A/B

Endless and Grommet Slings
Although grommet slings support a load with two legs, their working load limit is usually taken as 1.5 times the working load limit of a single vertical hitch. This reduction allows for capacity lost because of sharp bends at the hook or shackle.
Double Choker Hitch
For sling angles of 45° or more (formed by the choker) –
WLL = WLL (of Single Vertical Hitch) x H/L x 3/4

Sling angles of less than 45° (formed by the choker) are not recommended. If they must be used the formula is:
WLL = WLL (of Single Vertical Hitch) x A/B x H/L x 2.

DETERMINING CAPACITY OF DOUBLE CHOKER HITCH

Double Wrap Choker Hitch
Depending on configuration, working load limits are the same as for the Single Choker Hitch or the Double Choker Hitch.
**Types of Slings**

Wire rope slings should be inspected frequently for broken wires, kinks, abrasion and corrosion. Inspection procedures and replacement criteria outlined in the session on wire rope apply and must be followed regardless of sling type or application.

All wire rope slings should be made of improved plow steel with independent wire rope cores to reduce the risk of crushing. Manufacturers will assist in selecting the rope construction for a given application.

**It is recommended that all eyes in wire rope slings be equipped with thimbles, be formed with the Flemish Splice and be secured by swaged or pressed mechanical sleeves or fittings.** With the exception of socketed connections, this is the only method that produces an eye as strong as the rope itself, with reserve strength should the mechanical sleeve or fitting fail or loosen.

The capacity of a wire rope sling can be greatly affected by being bent sharply around pins, hooks or parts of a load. The wire rope industry uses the term “D/d ratio” to express the severity of bend. “D” is the diameter of curvature that the rope or sling is subjected to and “d” is the diameter of the rope.

**Wire Rope Slings**

The use of wire rope slings for lifting materials provides several advantages over other types of sling. While not as strong as chain, it has good flexibility with minimum weight. Breaking outer wires warn of failure and allow time to react. Properly fabricated wire rope slings are very safe for general construction use.

On smooth surfaces, the basket hitch should be snubbed against a step or change of contour to prevent the rope from slipping as load is applied. The angle between the load and the sling should be approximately 60 degrees or greater to avoid slippage.

On wooden boxes or crates, the rope will dig into the wood sufficiently to prevent slippage. On other rectangular loads, the rope should be protected by guards or load protectors at the edges to prevent kinking.

Loads should not be allowed to turn or slide along the rope during a lift. The sling or the load may become scuffed or damaged.
Caution: This table is for purposes of illustration and comparison only. Check manufacturers’ ratings for the WLLs of the specific slings you are using.
### WIRE ROPE SLINGS

**6 x 19 Classification Group, Improved Plow Steel, IWRC**

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If used with Choker Hitch multiply above values by 3/4.

For Double Basket Hitch multiply above values by 2.

**Note:** Table values are for slings with eyes and thimbles in both ends, Flemish Spliced Eyes and mechanical sleeves.

**Caution:** This table is for purposes of illustration and comparison only. Check manufacturers’ ratings for the WLLs of the specific slings you are using.
Chain Slings

Chain slings are suited to applications requiring flexibility and resistance to abrasion, cutting and high temperatures.

Alloy steel chain grade 80 is marked with an 8, 80, or 800; grade 100 is marked with a 10, 100, or 1000. Alloy steel chain is the only type which can be used for overhead lifting.

As with all slings and associated hardware, chain slings must have a design factor of 5. In North America, chain manufacturers usually give working load limits based on a design factor of 3.5 or 4. Always check with manufacturers to determine the design factor on which their working load limits are based.

If the design factor is less than 5, calculate the working load limit of the chain by multiplying the catalogue working load limit by the manufacturer’s design factor and dividing by 5.

\[
\text{CATALOGUE WLL} \times \text{MANUFACTURER’S D.F.} = \text{WLL} \quad \text{(based on design factor of 5)}
\]

Example – 1/2” Alloy Steel Chain

Catalogue WLL = 13,000 lbs.  
Design Factor = 3.5  
\[
\frac{13,000 \text{ lbs} \times 3.5}{5} = 9,100 \text{ lbs.}
\]

This chain sling must be de-rated to 9,100 lbs. for construction applications.

Wherever they bear on sharp edges, chain slings should be padded to prevent links from being bent and to protect the load. Never tie a knot in a chain sling to shorten the reach. Slings can be supplied with grab hooks or shortening clutches for such applications.

Inspect chain slings for inner link wear and wear on the outside of the link barrels (Figure 33). Manufacturers publish tables of allowable wear for various link sizes. Many companies will also supply wear gauges to indicate when a sling must be retired or links replaced. Gauges or tables from a particular manufacturer should only be used on that brand of chain since exact dimensions of a given nominal size can vary from one manufacturer to another.

![Extreme Wear at Bearing Surfaces](image)

**INSPECT ALL LINKS FOR WEAR AT BEARING SURFACES**  
*Figure 33*

A competent worker should check chain slings for nicks and gouges that may cause stress concentrations and weaken links (Figure 34). If nicks or gouges are deep or large in area, or reduce link size below allowable wear, remove the chain from service. Any repairs must be done according to manufacturers’ specifications.
Never use repair links or mechanical coupling links to splice broken lengths of alloy steel chain. They are much weaker than the chain links. Never use a chain if the links are stretched or do not move freely.

### ALLOY STEEL CHAIN

**MAXIMUM WORKING LOAD LIMITS – POUNDS**

(Design Factor = 5 per OH&S Regulations)

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*Strength based on ISO Standards and adjusted to reflect a design factor of 5.*

- If used with Choker Hitch multiply above values by 3/4.
- For Double Basket Hitch multiply above values by 2.
- Discard if more than 10% wear at bearing surfaces.

**Caution:** This table is for purposes of illustration and comparison only. Check manufacturers’ ratings for the WLLs of the specific slings you are using.
**Synthetic Web Slings**

Web slings are available in two materials – nylon and polyester (Dacron). Nylon is resistant to many alkalis whereas polyester is resistant to many acids. Consult the manufacturer before using web slings in a chemical environment. Nylon slings are more common but polyester slings are often recommended where headroom is limited since they stretch only half as much as nylon slings.

Synthetic web slings offer a number of advantages for rigging purposes.

- Their relative softness and width create much less tendency to mar or scratch finely machined, highly polished or painted surfaces and less tendency to crush fragile objects than fibre rope, wire rope or chain slings (Figure 35).

![SYNTHETIC WEB SLINGS DO NOT DAMAGE OR CRUSH LOADS](image)

**Figure 35**

- Because of their flexibility, they tend to mold themselves to the shape of the load (Figure 36).

![WEB SLINGS MOLD THEMSELVES TO THE LOAD](image)

**Figure 36**

- They do not rust and thus will not stain ornamental precast concrete or stone.
- They are non-sparking and can be used safely in explosive atmospheres.
- They minimize twisting and spinning during lifting.
- Their light weight permits ease of rigging, their softness precludes hand cuts, and the danger of harm from a free-swinging sling is minimal.
- They are elastic and stretch under load more than either wire rope or chain and can thus absorb heavy shocks and cushion loads. In cases where sling stretching must be minimized, a sling of larger load capacity or a polyester sling should be used.

Synthetic web slings are available in a number of configurations useful in construction.
**Endless or Grommet Slings** – both ends of one piece of webbing lapped and sewn to form a continuous piece. They can be used as vertical hitches, bridle hitches, in choker arrangements or as basket hitches. Because load contact points can be shifted with every lift, wear is evenly distributed and sling life extended (Figure 37).

![Endless or Grommet Slings](image)

**Standard Eye-and-Eye** – webbing assembled and sewn to form a flat body sling with an eye at each end and eye openings in the same plane as the sling body. The eyes may be either full web width or tapered by being folded and sewn narrower than the webbing width (Figure 38).

![Standard Eye-and-Eye Slings](image)

**Twisted Eye** – an eye-and-eye with twisted terminations at both ends. The eye openings are at $90^\circ$ to the plane of the sling body. This configuration is available with either full-width or tapered eyes (Figure 39).

![Twisted Eye Slings](image)
In place of sewn eyes, web slings are available with metal end fittings. The most common are triangle and choker hardware. Combination hardware consists of a triangle for one end of the sling and a triangle/rectangle (choker attachment) for the other end. With this arrangement, choker and basket as well as straight hitches may be rigged. Such attachments help reduce wear in the sling eyes and thus lengthen sling life (Figure 40).
Despite their inherent toughness, synthetic web slings can be cut by repeated use around sharp-cornered objects and abraded by continually hoisting rough-surfaced loads.

Protective devices offered by most sling manufacturers can minimize these effects.

- **Buffer strips** of leather, nylon, or other materials sewn on the body of the sling protect against wear (Figure 41A). Leather pads are most resistant to wear and cutting, but are subject to weathering and deterioration. They are not recommended in lengths over six feet because their stretch characteristics differ from those of webbing. On the other hand, nylon web wear pads are more resistant to weathering, oils, grease and most alkalis. Moreover they stretch in the same ratio as the sling body.

- **Edge guards** consist of strips of webbing or leather sewn around each edge of the sling (Figure 41B). This is necessary whenever sling edges are subject to damage.

- **Sleeve or sliding tube wear pads** are available for slings used to handle material with sharp edges. The pads are positioned on the sling where required, will not move when the sling stretches, adjust to the load and cover both sides of the sling (Figure 41C).

- **Reinforcing strips** sewn into the sling eyes double or triple the eye thickness and greatly increase sling life and safety.

- **Coatings** provide added resistance to abrasion and chemicals as well as a better grip on slippery loads. Coatings can be brightly coloured for safety or load rating.

- **Cotton-faced nylon webbing** affords protection for hoisting granite and other rough-surfaced material.

The rated capacity of synthetic web slings is based on the tensile strength of the webbing, a design factor of 5 and the fabrication efficiency. Fabrication efficiency accounts for loss of strength in the webbing after it is stitched and otherwise modified during manufacture. Fabrication efficiency is typically 80 to 85% for single-ply slings but will be lower for multi-ply slings and very wide slings.

Although manufacturers provide tables for bridle and basket configurations, these should be used with extreme caution. At low sling angles one edge of the web will be overloaded and the sling will tend to tear (Figure 42).
EFFECT OF LOW SLING ANGLE ON WEBBING
Figure 42

Slings with aluminum fittings should never be used in acid or alkali environments. Nylon and polyester slings must not be used at temperatures above 194°F (90°C).

Inspect synthetic web slings regularly. Damage is usually easy to detect. Cuts, holes, tears, frays, broken stitching, worn eyes and worn or distorted fittings, and burns from acid, caustics or heat are immediately evident and signal the need for replacement. Do not attempt repairs yourself.

Synthetic web slings must be labelled to indicate their load rating capacity.
Metal Mesh Slings

Metal mesh slings, also known as wire or chain mesh slings, are well adapted for use where loads are abrasive, hot or tend to cut fabric slings and wire ropes. They resist abrasion and cutting, grip the load firmly without stretching and can withstand temperatures up to 550° (288°C). They have smooth, flat bearing surfaces, conform to irregular shapes, do not kink or tangle and resist corrosion (Figure 43).

For handling loads that would damage the mesh, or for handling loads that the mesh would damage, the slings can be coated with rubber or plastic. See Table 7 for working load limits.

Note that there is no reduction in working load limit for the choker hitch. This is because the hinge action of the mesh prevents any bending of individual wire spirals.
**TABLE 7**

**METAL (WIRE OR CHAIN) MESH SLINGS**

<table>
<thead>
<tr>
<th>Sling Diameter (Inches)</th>
<th>MAXIMUM WORKING LOAD LIMITS – POUNDS (Design Factor = 5)</th>
<th>2-Leg Bridle Hitch &amp; Single Basket Hitch (Vertical Legs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single Vertical Hitch</td>
<td>Single Choker Hitch</td>
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</tbody>
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**HEAVY DUTY CLASSIFICATION (10 GAUGE MESH)**

<table>
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<td>8,000</td>
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</table>

For Double Basket Hitch multiply above values by 2.

**MEDIUM DUTY CLASSIFICATION (12 GAUGE MESH)**

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<td>9,000</td>
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**LIGHT DUTY CLASSIFICATION (14 GAUGE MESH)**

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<td>6,000</td>
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<td>5,000</td>
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<td>6,900</td>
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<td>4,200</td>
<td>5,700</td>
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<tr>
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<td>4,200</td>
<td>5,700</td>
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<td>8,500</td>
</tr>
</tbody>
</table>

For Double Basket Hitch multiply above values by 2.

Note: Values for a single choker hitch are the same as values for a single vertical hitch.

**Caution:** This table is for purposes of illustration and comparison only. Check manufacturers’ ratings for the WLLs of the specific slings you are using.
**Fibre Rope Slings**

Fibre rope slings are preferred for some applications because they are pliant, grip the load well and do not mar its surface. They should be used only on light loads, however, and must never be used on objects that have sharp edges capable of cutting the rope or in applications where the sling will be exposed to high temperatures, severe abrasion or acids.

The choice of rope type and size will depend on the application, the weight to be lifted and the sling angle. Before lifting any load with a fibre rope sling, be sure to inspect the sling carefully. Fibre slings, especially manila, deteriorate far more rapidly than wire rope slings and their actual strength is very difficult to estimate.

Like other slings, fibre rope slings should be inspected regularly. Look for external wear and cutting, internal wear between strands, and deterioration of fibres.

Open up the rope by untwisting the strands but take care not to kink them. The inside of the rope should be as bright and clean as when it was new. Check for broken or loose yarns and strands. An accumulation of powder-like dust indicates excessive internal wear between strands as the rope is flexed back and forth during use.

*Open Up Rope During Inspections*

*Proper Method of Opening Up the Rope*
Rigging Hardware

Know what hardware to use, how to use it, and how its working load limits (WLL) compare with the rope or chain used with it.

All fittings must be of adequate strength for the application. Only forged alloy steel load-rated hardware should be used for overhead lifting. Load-rated hardware is stamped with its WLL (Figure 44).

Inspect hardware regularly and before each lift. Telltale signs include:
- wear
- cracks
- severe corrosion
- deformation/bends
- mismatched parts
- obvious damage.

Hoisting Hooks

- Should be equipped with safety catches (except for sorting or grab hooks).
- Should be forged alloy steel with WLL stamped or marked on the saddle.
- Should be loaded at the middle of the hook. Applying the load to the tip will load the hook eccentrically and reduce the safe working load considerably.
- Should be inspected regularly and often. Look for wear, cracks, corrosion, and twisting – especially at the tip – and check throat for signs of opening up (Figure 45).
Safety Tip
Whenever two or more ropes are to be placed over a hook, use a shackle to reduce wear and tear on thimble eyes.

Wire Rope Clips
Wire rope clips are widely used for making end terminations. Clips are available in two basic designs: U-bolt and fist grip.

When using U-bolt clips, make sure you have the right type of clip. Forged alloy clips are recommended. Always make certain that U-bolt clips are attached correctly. The U-section must be in contact with the dead end of the rope. Tighten and retighten nuts as required by the manufacturer.

To determine the number of clips and the torque required for specific diameters of rope, refer to Figure 46. For step-by-step instructions on attaching clips, refer to Figure 47.

<table>
<thead>
<tr>
<th>Rope Diameter (inches)</th>
<th>Minimum Number of Clips</th>
<th>Amount of Rope Turn Back from Thimble (inches)</th>
<th>Torque in Foot-Pounds Unlubricated Bolts</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/16</td>
<td>2</td>
<td>5 1/2</td>
<td>30</td>
</tr>
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<td>3/8</td>
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<td>45</td>
</tr>
<tr>
<td>7/16</td>
<td>2</td>
<td>7</td>
<td>65</td>
</tr>
<tr>
<td>1/2</td>
<td>3</td>
<td>11 1/2</td>
<td>65</td>
</tr>
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<td>9/16</td>
<td>3</td>
<td>12</td>
<td>95</td>
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<td>5/8</td>
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<td>12</td>
<td>95</td>
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<tr>
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<td>130</td>
</tr>
<tr>
<td>7/8</td>
<td>4</td>
<td>19</td>
<td>225</td>
</tr>
</tbody>
</table>
STEP 1
APPLY FIRST CLIP one base width from dead end of wire rope. U-Bolt over dead end. Live end rests in clip saddle. Tighten nuts evenly to recommended torque.

STEP 2
APPLY SECOND CLIP as close to loop as possible. U-Bolt over dead end. Turn nuts firmly but DO NOT TIGHTEN.

STEP 3
APPLY ALL OTHER CLIPS. Space evenly between first two and 6-7 rope diameters apart.

STEP 4
APPLY TENSION and tighten all nuts to recommended torque.

STEP 5
CHECK NUT TORQUE after rope has been in operation.

Figure 47
**Swivels**
- Reduce bending loads on rigging attachments by allowing the load to orient itself freely.
- Should be used instead of shackles in situations where the shackle may twist and become eccentrically loaded.
- Can provide approximate capacities shown in Figure 48. See manufacturer’s table for the exact WLL of the swivel you are using.

<table>
<thead>
<tr>
<th>SWIVELS (ALL TYPES)</th>
<th>Max. Working Load Limit (Pounds)</th>
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</thead>
<tbody>
<tr>
<td>Stock Diameter (Inches)</td>
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</tr>
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<td>5/8</td>
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<td>18,000</td>
</tr>
<tr>
<td>1 1/2</td>
<td>45,200</td>
</tr>
</tbody>
</table>

**Shackles**
- Available in various types (Figure 49).
- For hoisting, should be manufactured of forged alloy steel.
- Do not replace shackle pins with bolts (Figure 50). Pins are designed and manufactured to match shackle capacity.
- Check for wear, distortion, and opening up (Figure 51). Check crown regularly for wear. Discard shackles noticeably worn at the crown.
- Do not use a shackle where it will be pulled or loaded at an angle. This severely reduces its capacity and opens up the legs (Figure 52).
- Do not use screw pin shackles if the pin can roll under load and unscrew (Figure 53).
Don’t use a screw pin shackle if the pin can roll under load and unscrew.

If load shifts, sling will unscrew shackle pin

Never replace a shackle pin with a bolt

The load will bend the bolt

Check for wear
Check for wear and straightness
Check that pin is always seated
Check that shackle is not “opening up”

Never allow shackle to be pulled at an angle – the legs will open up.

Pack the pin with washers to centralize the shackle.

Poor Practice

Good Practice

Packings

Hook

Figure 49

Figure 50

Figure 51

Figure 52

Figure 53
Eye Bolts

- For hoisting, use eye or ring bolts of forged alloy steel.
- Use bolts with shoulders or collars. Shoulderless bolts are fine for vertical loading but can bend and lose considerable capacity under angle loading (Figure 54). Even with shoulders, eye and ring bolts lose some capacity when loaded on an angle.
- Make sure that bolts are at right angles to hole, make contact with working surface, and have nuts property torqued (Figure 55).
- Pack bolts with washers when necessary to ensure firm, uniform contact with working surface (Figure 55).
- Make sure that tapped holes for screw bolts are deep enough for uniform grip (Figure 55).
- Apply loads to the plane of the eye, never in the other direction (Figure 55). This is particularly important with bridle slings, which always develop an angular pull in eye bolts unless a spreader bar is used.
- Never insert the point of a hook in an eye bolt. Use a shackle instead (Figure 55).
- Do not reeve a sling through a pair of bolts. Attach a separate sling to each bolt.

![Correct Shoulderless eye and ring bolts are designed for vertical loads only. Incorrect Shoulderless eye and ring bolts are pulled at an angle as shown, they will either bend or break.](Figure 54)
Snatch Blocks

- A single or multi-sheave block that opens on one side so a rope can be slipped over the sheave rather than threaded through the block (Figure 56).
- Available with hook, shackle, eye, and swivel end fittings.
- Normally used when it’s necessary to change the direction of pull on a line. Stress on the snatch block varies tremendously with the angle between the lead and load lines. With both lines parallel, 1000 pounds on the lead line results in 2000 pounds on the block, hook, and anchorage. As the angle between the lines increases, the stress is reduced (Figure 57).
- To determine the load on block, hook, and anchorage, multiply the pull on the lead line or the weight of the load being lifted by a suitable factor from the table in Figure 19.33 and add 10% for sheave friction.

Figure 55

Correct Orientation – Load is in the plane of the eye.

Incorrect Orientation – When the load is applied to the eye in this direction, it will bend.

Correct Orientation – Use a shackle

Incorrect

Correct – Use a shackle

Incorrect

Correct for Shoulder Type Eye & Ring Bolts
Providing loads are reduced to account for angular loading.

Nut must be properly torqued.

Ensure that bolt is tightened into place.

Ensure that tapped hole is deep enough.

Pack with washers to ensure that shoulder is firmly in contact with surface.

Shoulder must be in full contact with surface.

Figure 56

When Open

Correct for Shoulder Type Eye & Ring Bolts
Providing loads are reduced to account for angular loading.

Correct Orientation – Load is in the plane of the eye.

Incorrect Orientation – When the load is applied to the eye in this direction, it will bend.

Correct Orientation – Use a shackle

Incorrect

Correct – Use a shackle

Incorrect

Correct for Shoulder Type Eye & Ring Bolts
Providing loads are reduced to account for angular loading.

Correct Orientation – Load is in the plane of the eye.

Incorrect Orientation – When the load is applied to the eye in this direction, it will bend.

Correct Orientation – Use a shackle

Incorrect

Correct – Use a shackle

Incorrect

Correct for Shoulder Type Eye & Ring Bolts
Providing loads are reduced to account for angular loading.

Correct Orientation – Load is in the plane of the eye.

Incorrect Orientation – When the load is applied to the eye in this direction, it will bend.

Correct Orientation – Use a shackle

Incorrect

Correct – Use a shackle

Incorrect

Correct for Shoulder Type Eye & Ring Bolts
Providing loads are reduced to account for angular loading.

Correct Orientation – Load is in the plane of the eye.

Incorrect Orientation – When the load is applied to the eye in this direction, it will bend.

Correct Orientation – Use a shackle

Incorrect

Correct – Use a shackle

Incorrect

Correct for Shoulder Type Eye & Ring Bolts
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Correct – Use a shackle

Incorrect

Correct for Shoulder Type Eye & Ring Bolts
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Correct – Use a shackle

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Correct for Shoulder Type Eye & Ring Bolts
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Correct – Use a shackle

Incorrect

Correct for Shoulder Type Eye & Ring Bolts
Providing loads are reduced to account for angular loading.

Correct Orientation – Load is in the plane of the eye.

Incorrect Orientation – When the load is applied to the eye in this direction, it will bend.

Correct Orientation – Use a shackle

Incorrect

Correct – Use a shackle

Incorrect
### MULTIPLICATION FACTORS FOR SNATCH BLOCK LOADS

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<td>1.41</td>
</tr>
<tr>
<td>100°</td>
<td>1.29</td>
</tr>
<tr>
<td>110°</td>
<td>1.15</td>
</tr>
<tr>
<td>120°</td>
<td>1.00</td>
</tr>
<tr>
<td>130°</td>
<td>.84</td>
</tr>
<tr>
<td>135°</td>
<td>.76</td>
</tr>
<tr>
<td>140°</td>
<td>.68</td>
</tr>
<tr>
<td>150°</td>
<td>.52</td>
</tr>
<tr>
<td>160°</td>
<td>.35</td>
</tr>
<tr>
<td>170°</td>
<td>.17</td>
</tr>
<tr>
<td>180°</td>
<td>.00</td>
</tr>
</tbody>
</table>

---

**Figure 57**

- **2000 POUNDS**
  - 10°: 1.99
  - 20°: 1.97
  - 30°: 1.93
  - 40°: 1.87
  - 45°: 1.84
  - 50°: 1.81
  - 60°: 1.73
  - 70°: 1.64
  - 80°: 1.53
  - 90°: 1.41
  - 100°: 1.29
  - 110°: 1.15
  - 120°: 1.00
  - 130°: .84
  - 135°: .76
  - 140°: .68
  - 150°: .52
  - 160°: .35
  - 170°: .17
  - 180°: .00

- **1840 POUNDS**
  - 10°: 1.87
  - 20°: 1.84
  - 30°: 1.81
  - 40°: 1.73
  - 45°: 1.64
  - 50°: 1.53
  - 60°: 1.41
  - 70°: 1.29
  - 80°: 1.15
  - 90°: 1.00
  - 100°: .84
  - 110°: .76
  - 120°: .68
  - 130°: .52
  - 140°: .35
  - 150°: .17
  - 160°: .00

- **1410 POUNDS**
  - 10°: 1.53
  - 20°: 1.41
  - 30°: 1.29
  - 40°: 1.15
  - 45°: 1.00
  - 50°: .84
  - 60°: .76
  - 70°: .68
  - 80°: .52
  - 90°: .35
  - 100°: .17
  - 110°: .00

- **760 POUNDS**
  - 10°: 1.00
  - 20°: .84
  - 30°: .76
  - 40°: .68
  - 45°: .52
  - 50°: .35
  - 60°: .17
  - 70°: .00
**Turnbuckles**

- Can be supplied with eye end fittings, hook end fittings, jaw end fittings, stub end fittings, and any combination of these (Figure 58).
- Rated loads are based on the outside diameter of the threaded portion of the end fitting and on the type of end fitting. Jaw, eye, and stub types are rated equally; hook types are rated lower.
- Should be weldless alloy steel.
- When turnbuckles are exposed to vibration, lock frames to end fittings. This will prevent turning and loosening. Use wire or manufacturer-supplied lock nuts to prevent turning (Figure 59).
- When tightening a turnbuckle, do not apply more torque than you would to a bolt of equal size.
- Inspect turnbuckles frequently for cracks in end fittings (especially at the neck of the shank), deformed end fittings, deformed and bent rods and bodies, cracks and bends around the internally threaded portion, and signs of thread damage.

![Turnbuckle End Fittings](image1)

![Jaw and Eye Combination](image2)

![Jaw and Jaw Combination](image3)

![Hook and Hook Combination](image4)

![Hook and Eye Combination](image5)

![Manufacturer-supplied lock nut](image6)

![Wire](image7)

**Figure 58**

**Figure 59**
Table 8 gives the working load limits for turnbuckles based on the diameter of the shank. Note how the use of hook end fittings reduces capacity.

### Table 8

<table>
<thead>
<tr>
<th>End Fitting, Stock Diameter (Inches)</th>
<th>WLL of Any Combination of Jaw End Fittings, Eye End Fittings and Stub End Fittings (Lbs)</th>
<th>WLL of Any Turnbuckle Having a Hook End Fitting (Lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>500</td>
<td>400</td>
</tr>
<tr>
<td>5/16</td>
<td>800</td>
<td>700</td>
</tr>
<tr>
<td>3/8</td>
<td>1,200</td>
<td>1,000</td>
</tr>
<tr>
<td>1/2</td>
<td>2,200</td>
<td>1,500</td>
</tr>
<tr>
<td>5/8</td>
<td>3,500</td>
<td>2,250</td>
</tr>
<tr>
<td>3/4</td>
<td>5,200</td>
<td>3,000</td>
</tr>
<tr>
<td>7/8</td>
<td>7,200</td>
<td>4,000</td>
</tr>
<tr>
<td>1</td>
<td>10,000</td>
<td>5,000</td>
</tr>
<tr>
<td>1 1/4</td>
<td>15,200</td>
<td>5,000</td>
</tr>
<tr>
<td>1 1/2</td>
<td>21,400</td>
<td>7,500</td>
</tr>
<tr>
<td>1 3/4</td>
<td>28,000</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>37,000</td>
<td>–</td>
</tr>
<tr>
<td>2 1/2</td>
<td>60,000</td>
<td>–</td>
</tr>
<tr>
<td>2 3/4</td>
<td>75,000</td>
<td>–</td>
</tr>
</tbody>
</table>

Figure 60 shows the areas of a turnbuckle that require special attention during inspection.

---

**INSPECTION AREAS**

*Figure 60*
**Spreader and Equalizer Beams**

Spreader beams are usually used to support long loads during lifts. They eliminate the hazard of the load tipping, sliding, or bending as well as the possibility of low sling angles and the tendency of the slings to crush the load.

Equalizer beams are used to equalize the load in sling legs and to keep equal loads on dual hoist lines when making tandem lifts.

Spreader and equalizer beams are both normally fabricated to suit a specific application. If a beam is to be used which has not been designed for the application, make sure that it has adequate width, depth, length, and material.

The capacity of beams with multiple attachment points depends on the distance between the points. For example, if the distance between attachment points is doubled, the capacity of the beam is cut in half.

Spreader Beam

Equalizer Beams

Loads in A & B do not change when beam angle changes.

Loads in C & D will change if beam angle changes.
Hoisting Tips

- Never wrap a wire rope sling completely around a hook. The tight radius will damage the sling.
- Make sure the load is balanced in the hook. Eccentric loading can reduce capacity dangerously (Figure 61).

![Point Loading](image)

**CAPACITY IS SEVERELY REDUCED**

*Figure 61*

- Never point-load a hook unless it is designed and rated for such use. Point-loading can cut capacity by more than half.
- Never wrap the crane hoist rope around the load. Attach the load to the crane hook by slings or other rigging devices.
- Avoid bending wire rope slings near attached fittings or at eye sections.
- Understand the effect of pull angle on beam load (Figure 62).

![Angle of pull affects load on beam.](image)

<table>
<thead>
<tr>
<th>Angle of Pull</th>
<th>Load on Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>90°</td>
<td>200 lbs</td>
</tr>
<tr>
<td>60°</td>
<td>187 lbs</td>
</tr>
<tr>
<td>45°</td>
<td>171 lbs</td>
</tr>
</tbody>
</table>

*Figure 62*
Section 4

Rigging Tools and Devices

- Jacks (ratchet, hydraulic)
- Blocking and Cribbing
- Rollers
- Inclined Planes
- Lever-Operated Hoists
- Chain Hoists
- Grip-Action Hoists (Tirfors)
- Electric Hoists and Pendant Cranes
- Winches
- Anchorage Points
Rigging Tools and Devices

The Regulations for Construction Projects require that an inspection and maintenance program be implemented to ensure that rigging equipment is kept in safe condition. Procedures must ensure that inspection and maintenance have not only been carried out but have been duly recorded.

Rigging operations often involve the use of various tools and devices such as jacks, rollers, hoists, and winches. Each has its own unique features, uses, and requirements for safe operation and maintenance.

The construction regulations also require that the manufacturer’s operating instructions for such tools and devices be available on site. The rigger must read and follow all of these instructions to operate and maintain the equipment properly. The rigger must also read any warning information which may be stamped, printed, tagged, or attached to the rigging device.

This section identifies some of the commonly used rigging tools and devices and explains procedures for their safe operation and maintenance.
Jacks

While there are a great many types of jacks, the ratchet jack and heavy duty hydraulic jack are the two types most commonly used in construction.

Ratchet jacks are usually limited to capacities under 20 tons because of the physical effort required to raise such a load. They do, however, have a much longer travel than hydraulic jacks and can therefore lift loads higher without having to re-block. Most ratchet jacks have a foot lift or “toe” near the base to lift loads which are close to the ground. Lifts can be made from the “head” or the “toe” of the jack. These jacks are often called toe jacks or track jacks (Figure 1).

Do not use extensions or “cheaters” on the handles supplied with ratchet jacks. If cheaters are necessary the jack is overloaded.

Hydraulic jacks are very popular in construction because they are quite compact and can lift very heavy loads. They are readily available in capacities ranging from a few tons to 100 tons. Some specialty units have capacities up to 1,000 tons. Lift heights are usually limited to approximately 8 inches or less but some can go as high as 36 inches (Figure 2).
Hydraulic jacks are also available in low profile models that can be positioned under a load close to the ground (Figure 3). Also known as “button jacks”, these are useful for lifting a load high enough to get a regular jack in place.

Like ratchet jacks, hydraulic jacks are available with toe lifts (Figure 4).

The pumps powering hydraulic jacks may be contained in the jacks or be separate external power units. Separate units may be hand-operated or electrically powered, but the self-contained pumps are always hand-operated.

With all types of hydraulic jacks it is critical that no further force be applied after the ram has run its full travel. The resultant high pressure in the hydraulic fluid can damage the seals and, in the case of external power units, burst the hoses.

Most external power units are equipped, however, with pressure relief valves. At the factory one valve will be set at the absolute maximum pressure while another will be adjustable to lower settings by the user. Make sure you are familiar with the operation of this safety feature.

Most hydraulic jacks can be fitted with a gauge on the housing or at the pump to monitor hydraulic pressure. When used with a given jack, the gauges can be calibrated to measure the approximate load on the unit.
Hoses connecting pumps to jacks require careful attention. Make sure they are free of kinks and cracks. Check the couplings, especially at the crimp. This area is prone to cracking and is often the weak link in the hose assembly. Threads should also be checked for damage, wear, cross-threading and tightness. Remember that these hoses have to withstand pressures up to 10,000 psi.

Don’t use hoses that are unnecessarily long. Shorter hoses will leave the area less congested and reduce the chance of accidental damage.

The handles on jacks or hand-operated pump units are designed so that the rated capacity and pressure can be obtained with little physical effort. Don’t use extensions or “cheaters” on the handles. Again, if the load can’t be raised with the handle supplied the jack is overloaded.

Jacks should only be used in a true vertical position for lifting. Otherwise side-loading can cause the piston to rub against the housing. If this happens, the piston will be scored and allow fluid to leak at the seal which may cause the jack to slip.

Be extremely careful when using hydraulic jacks in welding areas or around corrosive chemicals. Sparks or acids can cause pitting on the ram or damage hoses.

Hydraulic jacks are generally not equipped with check valves. But check valves can be installed in the hoses of an external pump and are recommended. Alternatively, some hydraulic jacks have retaining nuts that can be screwed against the housing to hold the load for a short time.

Jacks should never be used for long-term support of a load. Blocking is much more stable and safe. Whenever possible, the load should be progressively blocked as jacking proceeds. This will allow for the unexpected.

Always jack loads one end at a time. Never jack loads one side at a time as this will be far less stable than jacking the ends.

If it is necessary to work or even reach under a load on jacks, place safety blocking under the load as a precaution.

Make sure timbers used for blocking or cribbing are long enough to distribute the load over a large enough area and provide sufficient stability. Crib height should not exceed the length of timbers used.

All jacks should be thoroughly inspected periodically, depending on how they are used. For regular use at one location they should be inspected every six months or more frequently if the lifts approach capacity. Jacks sent out for special jobs should be inspected when received and when returned. Jacks subjected to high loads or shock should be inspected immediately.

Because jack bases are relatively small, care must be taken to ensure that the floor or ground can withstand the high pressures often associated with jacking operations. Blocking or matting under the jacks will distribute the load over a greater area and reduce bearing pressure.
**Jacks – Inspection**

Whether ratchet or hydraulic, all jacks should be inspected before each shift or use. Check for:

- improper engagement or extreme wear of pawl and rack
- cracked or broken rack teeth
- cracked or damaged plunger
- leaking hydraulic fluid
- scored or damaged plunger
- swivel heads and caps that don’t function properly
- damaged or improperly assembled accessory equipment

**Remember:** When using jacks, always try to block as you go. Never use jacks for long-term support. Block properly instead.

**Blocking and Cribbing**

Blocking or cribbing must

- be sufficient to support load
- be set on firm, level ground or floor
- be close together
- be dry and free of grease
- be stacked no higher than the length of the timbers used
- follow the jacking process
- distribute load over enough area to provide stability.

*Note:* In some cases, solid blocking may be required.
Rollers can be used for moving loads horizontally or on slight inclines, provided the surface is firm and even. Rollers may be aluminum or steel round stock, heavy steel pipe, or a manufactured caster unit (Figure 5).

Cylinder rollers are useful for short distances or where the load will have to negotiate corners. The rollers can be placed on angles to swing the ends of the load, allowing turns in tight areas (Figure 6).

Cylinder rollers should be round, true and smooth to minimize the force required to move the load. Caster rollers can be supplied in a number of configurations for flat surfaces, tracks, I-beams or channels. They create very little friction and allow heavy loads to be moved with little force. In fact, the rigger may sometimes require more friction to provide an extra measure of control.

The most important aspect in rolling is control of the load. Make sure that all equipment including slings and hardware is sufficient to handle the loads that will be developed at each stage of the operation. Always attach a second means of restraint such as a tirfor or winch to the load to allow for the unexpected. The possibility of shock loads should be considered when sizing winches or tirisors for back-up protection.

Check the condition of floors or ground before using rollers. Bearing pressure can be reduced by using more rollers and large steel or aluminum plate to distribute the load. Make sure the joints in the plates or skids are staggered. It is often necessary to assess the structure supporting floors. Temporary shoring may be necessary.
Inclined Planes

The method used to calculate the required pull up an incline is only approximate. Though widely used because of its simplicity, the method yields values higher than the actual force required. The formula is more accurate for slight inclines (1:5) than steep inclines (1:1). Table 1 shows the difference between the actual pull required and the pull calculated with friction of 5%.

\[
F = W \times \frac{H}{L} + 0.05W
\]

where
- \(F\) = Required Force
- \(H\) = Height
- \(L\) = Length
- \(W\) = Weight of Load

Table 2 lists some examples of coefficients of friction. Note that some of the combinations of materials have a considerable range of values.

<table>
<thead>
<tr>
<th>Examples of Friction Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel on Steel</td>
</tr>
<tr>
<td>Leather on Metal</td>
</tr>
<tr>
<td>Wood on Stone</td>
</tr>
<tr>
<td>Iron on Stone</td>
</tr>
<tr>
<td>Grease Plates</td>
</tr>
<tr>
<td>Load on Wheels or Rollers</td>
</tr>
</tbody>
</table>
**Lever-Operated Hoists or Come-Along**

Come-alongs are a very portable means of lifting or pulling loads short distances. They can be used vertically, horizontally or on an angle. Otherwise all points covered in the section on chain hoists apply equally to come-alongs.

A come-along that requires the use of a cheater or the help of another worker to move a load is inadequate for the job. Use a come-along with a larger capacity.

<table>
<thead>
<tr>
<th>Lever-Operated Hoist – Safety Precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Inspect for defects.</td>
</tr>
<tr>
<td>• Do not use cheater on hoist handle.</td>
</tr>
<tr>
<td>• Do not overload. Working load limit (WLL) should be marked on device.</td>
</tr>
<tr>
<td>• Do not apply the load to the tip of the hook.</td>
</tr>
<tr>
<td>• Do not use the hoist chain as a sling or choker.</td>
</tr>
<tr>
<td>• Make sure of your footing before operating the hoist.</td>
</tr>
<tr>
<td>• Do not leave the suspended load unattended.</td>
</tr>
<tr>
<td>• Keep hoist chain straight.</td>
</tr>
<tr>
<td>• Stand clear of load and pulling path of hoist chain.</td>
</tr>
<tr>
<td>• Keep upper and lower hooks in a straight line so that the frame is free to swivel.</td>
</tr>
<tr>
<td>• Do not use a hoist with a twisted, kinked, damaged, or worn chain.</td>
</tr>
<tr>
<td>• Ensure that anchorage and structure will support the load.</td>
</tr>
</tbody>
</table>

**CHAIN HOISTS**

Chain hoists are useful because the load can be stopped and kept stationary at any point. Because of their slow rate of travel, chain hoists also allow precise vertical placement.

Chain hoists should be rigged so that there is a straight line between the upper and lower hooks. They are intended for use in a vertical or near vertical position only. If rigged at an angle, the upper hook can be damaged at the shank and the throat may open up. If the gear housing is resting against an object while under load it can be damaged or broken (Figure 10).

Always make sure that the hoist is hanging freely.
Before using the hoist, inspect the chain for nicks, gouges, twists, and wear. Check the chain guide for wear. Hooks should be measured for signs of opening up. Ensure that the hooks swivel freely and are equipped with safety catches. If the hoist has been subjected to shock loads or dropped, it should be inspected thoroughly before being put back in service. Check the load brake by raising the load a couple of inches off the ground and watching for creep.

If the hoist chain requires replacement, follow the manufacturer’s recommendations. Different manufacturers use different pitches for their load chain. Chain intended for one brand of hoist will not mesh properly with the lift wheel of another brand and the hoist will not operate properly, if at all.

The load chain on chain hoists is case-hardened to reduce surface wear and is unsuitable for any other use. Load chain will stretch 3% before failing, whereas Grade 8 alloy chain will stretch at least 15%. Load chains are too brittle for any other application. Any load chain removed from a hoist should be destroyed by cutting it into short pieces. Never try to repair a load chain yourself. Welding will destroy the heat treatment of the chain entirely.

**Chain Hoist – Safety Precautions**

- Inspect for wear and damage regularly.
- Do not overload.
- Do not leave a suspended load unattended.
- Do not stand under the load.
- Do not use the hoist chain as a sling or choker.
- Do not apply the load to the tip of the hook.
- Avoid hoisting on angles.
- Chain hoists must be used in the vertical position.
- Only one operator should pull on a single hand chain at one time.
- Ensure that load chain is properly seated in wheels or sprockets before lifting.
- Ensure that anchorage and structure will support the load.
- Maintain the chain hoist according to manufacturer’s specifications.
Grip Action Hoists or Tirfors

Grip-action hoists, commonly known by the trade name Tirfor, are useful for long lifts or pulls since they act on a continuous length of wire rope. Like the come-along, they can be used in any orientation. The tirfor can draw rope through the unit, as a come-along draws chain, or pull itself along a fixed rope, as on a swingstage (Figure 11).

Tirfors are available with capacities ranging from 3/4 to 3-1/2 tons. The rope can be reeved through a block system to gain mechanical advantage and increase the capacity of the unit.

Tirfors are operated by two levers – one for forward motion, the other for reverse. The levers operate two jaws which alternately grip and draw the rope through the unit. Figure 12 illustrates the action of the jaws on the rope. A third lever releases both jaws to allow rope to be installed, tensioned, or disengaged.
Tirfors can be fitted with hydraulic rams to operate the levers. Up to four units can be operated simultaneously from a single hydraulic power supply (Figure 13).

Another type of grip-action hoist uses discs to clamp and drive the rope in a continuous motion (Figure 14). These are available with electric, air, or hydraulic motors. Disc type hoists provide greater rope speed but less capacity than the jaw type.

Tirfor ropes are specifically designed for the clamping and pulling forces applied to them. The ropes are galvanized and unlubricated and have very tight diameter tolerance. No other rope should ever be used on tirfors.

Handle tirfor rope carefully to ensure that it does not kink. Kinked rope will jam in the mechanism and prevent the rope from passing through the hoist. Ropes must be kept free from dirt and oil to ensure smooth, safe operation.

Like chain falls and come-alongs tirfors should be tested under load to ensure that the unit functions properly in both directions and that there is no slippage.
Electric Wire Rope Hoists, Electric Chain Hoists, Pendant Cranes

Electric wire rope and electric chain hoists may be suspended from a fixed point or a trolley. The trolley may be motorized but very often the hoist is moved by tugging gently on the pendant. These units can only move along a fixed straight line (beam).

Pendant cranes, on the other hand, trolley along a bridge (east-west) which travels on rails (north-south). Pendant cranes have greater capacity than the other hoists and usually have two or more parts of line.

Apart from these differences, the devices are quite similar in operating procedures and precautions. Hoist operators must adhere to the following points.

- Know and never exceed the working load limit of the hoisting equipment.
- Ensure that controls work properly without excessive play, delay or effort.
- Check pendant control cable for cuts, kinking, or signs of wear.
- Check hoist cables for fraying, kinking, crushing, and twisting between the cable and the drum.
- Look at the hoist drum for proper alignment and stacking of the cable.
- Inspect the hook for cracks, bending, or distortion, and the safety latch for proper operation.
- Don’t try to lengthen or repair the load chain or rope.
- Read and follow manufacturer’s instructions and all instructions and warnings on the hoist.
- Position the hoist directly over the load.
- After the hook is placed in the lifting ring, apply slight pressure to the hoist to ensure that the lifting ring is seated in the bottom of the hook and that the hook is properly aligned.
- Between lifts, check whether the rope is properly seated on the drum.
- Ensure that the intended path of travel is clear of people and obstructions and that the intended destination is ready to receive the load.
- Check brakes for excessive drift.
- Ensure proper clearance for movement.
- Position yourself on the pendant side of the hoist to get maximum clearance from the load and to prevent entanglement of cables.
- Avoid sudden starts, stops, or reverses.
- Raise the load only high enough to avoid obstructions.
- Do not hoist loads over workers; wait until the area is vacated.
- Be alert for any variation in hoist operation and any possible malfunction.
- Do not leave a load suspended in the air. If a short delay is unavoidable, lock the controls.
- Do not allow unqualified personnel to operate hoists.
- Never operate hoist to extreme limits of chain or rope.
- Avoid sharp contact between two hoists, between hoist and end post, and between hooks and hoist body.
- Never use the hoist rope or chain as a sling.
- Never use chain or rope as a ground for welding or touch a live welding electrode to the chain or rope.
- Avoid swinging the load or hook when travelling the hoist.
- Pull in a straight line so that neither hoist body, load chain nor rope is angled around anything.

Some hoists are equipped with limit switches. Generally these devices stop the wind automatically at its maximum allowable up position, down position and travel limits (if rail-mounted). Check limit switches daily for correct operation.
Whenever the operator does not have a clear view of the load and its intended path of travel, a signaller must direct operations. Signals for pendant cranes differ from those for mobile and tower cranes since machine movements are different (Figure 15). Make sure that everyone involved knows the signals required for pendant cranes.

**Figure 15**

**STOP.**
Arm extended, palm down, move hand right and left.

**DOG EVERYTHING.**
Clasp hands in front of body.

**MOVE SLOWLY.**
Use one hand to give any motion signal and place other hand motionless in front of hand, giving the motion signal. (HOIST SLOWLY SHOWN AS EXAMPLE).

**HOIST.**
With forearm vertical, forefinger pointing up, move hand in small horizontal circles.

**LOWER.**
With arm extended downward, fore–finger pointing down, move hand in small horizontal circles.

**MULTIPLE TROLLEYS.**
Hold up one finger for block marked “1”, and two fingers for block marked “2”. Regular signals follow.

**TRAVEL.**
Arm extended forward, hands open and slightly raised, making pushing motion in direction of travel.

**TROLLEY TRAVEL.**
Palm up, fingers closed, thumb pointing in direction of motion, jerk hand horizontally.

**signals for pendant cranes**

100
Winches

Base-mounted winches, or tuggers, are a compact, versatile tool for many hoisting and pulling operations. They are particularly useful in areas not accessible to mobile cranes or where there is not enough headroom for a crane to operate. Figure 16 shows a tugger and snatch block arrangement for hoisting. Make sure that the rope leaves the drum at a downward angle and that the loose end is securely anchored.

The forces on snatch blocks and their anchorage points depend on the angle by which the direction of pull is changed. The diagrams below indicate how snatch block loads vary with rope angle.

Wire rope used on tuggers should have an independent wire rope core to resist crushing as it is compressed by successive layers of rope on the drum.
Anchorage Points

Hoists, winches, tifors, and other rigging devices require secure anchorage points. Anchors may be overhead, in the floor, or at lateral points in walls or other structures. The arrangement may involve columns, beams, beam clamps, welded lugs, slings, or block and tackle. Whatever the method, riggers must be certain of the loads involved and the anchorage required.

Load on Structure

The following examples illustrate how to calculate the load on the structure in two typical applications.

<table>
<thead>
<tr>
<th>Lead Line Load</th>
<th>= Load + Parts of Line at Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead Line Load A</td>
<td>= 500 ÷ 1</td>
</tr>
<tr>
<td>Lead Line Load B</td>
<td>= 6000 ÷ 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Load on Structure</th>
<th>= Load + Lead Line Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load on Structure A</td>
<td>= 500 + 500</td>
</tr>
<tr>
<td>Load on Structure B</td>
<td>= 6000 + 1500</td>
</tr>
</tbody>
</table>
Columns
Columns are generally not designed to withstand significant lateral forces. Anchorage points should be placed at the base, near a connection to a beam or other lateral support (Figure 1). Because the member is already in compression, the effect of a small deflection is amplified and the column could buckle.

![Anchor Placement on Columns](image)

**ANCHOR PLACEMENT ON COLUMNS**
**Figure 1**

Beams
Load beams near column or other vertical support points to minimize bending (Figure 2). If the beam is an L section, it may be necessary to weld stiffeners to the web to withstand the additional shear force applied (Figure 3).

![Anchor Placement on Beams](image)

**ANCHOR PLACEMENT ON BEAMS**
**Figure 2**

![Web Stiffener](image)

**WEB STIFFENER**
**Figure 3**
Beam Clamps

Beam clamps provide a very secure anchorage point if used correctly. They are commonly available with capacities up to 12 tons and have various jaw widths. Figure 5 shows different types.

The jaws are usually designed for a range of flange widths. For example, one clamp might fit flanges 4-1/2” to 9” wide. Clamps should never be used on flanges outside the range specified as they will not afford sufficient grip on the member.

Most beam clamps are designed for use at 90° to the flange. For applications requiring an angle loading, make sure that the clamp is designed for it and that the beam can withstand it (Figure 6).

Be particularly careful that the load does not deform the flange. This is most likely to occur with light sections where the flange is wide and thin.

Beam clamps should be centred on the flange and properly seated.

Manufacturers are required to mark beam clamps with working load limits. But the ratings apply only to the clamps. The capacity of the beam must be evaluated separately.
Slings

Slings are a common method of anchoring equipment to a structure. The double wrap basket hitch is the preferred method since the load in the sling is shared on two legs and the double wrap distributes the load on the member. It is also less prone to slippage than a single choker or single basket hitch. Make sure that the sling is long enough to avoid sharp angles in the legs (Figure 7).

The use of softeners will protect the member and the sling from damage and increase the radius of bending in the sling. Figure 8 shows how strength diminishes as wire rope is bent around smaller and smaller diameters.
Welded Lugs

Lugs welded to a beam or column must be compatible with the member in metallic composition. The appropriate welding rod must also be used. The lug should be welded on the centre line of the flange, in line with the web (Figure 9). Keep loading in line with the lug. Avoid side loading.

Whatever the method of attachment, it is important to realize that the structure is usually not designed for the additional loads applied. The only way to be sure is through evaluation by a structural engineer.
Section 5

Introduction to Crane Operations

- Responsibilities
- Basic Types and Configurations
- Hazards in Crane Operating Areas
- Working near Powerlines
- Factors Affecting Crane Capacity
- Setup Summary
- Machine Selection
- Signalling
Crane operation carries with it a greater potential for disaster than nearly any other activity on a construction project. Crane accidents are often the most costly construction accidents when measured either in lives or in dollars. All personnel involved in crane operations must understand their jobs, their responsibilities, and their part in the overall safety of each lift.

Preparation begins with a clear definition of responsibilities. No single set of guidelines can cover every detail of the many different types of crane operations. But this section spells out primary responsibilities for the major parties involved – owners, operators, site supervision, and workers.

Responsibilities entail knowledge. Riggers must be trained and experienced. They must know how to:

- establish weights
- judge distances, heights, and clearances
- select tackle and hardware suitable to the load
- rig the load safely.

Signallers must be competent and capable of directing the crane and load to ensure safe, efficient operation. Knowledge of the hand signals for hoisting is a must, as it is for operators.

The crane operator is generally responsible for the safety of the operation as soon as the load is lifted clear of the ground. Whenever there is reasonable cause to believe that the lift may be dangerous or unsafe, the operator must refuse to proceed until the concern has been reported to the supervisor, any hazard has been corrected, and safe conditions have been confirmed.

This section includes information of use to riggers, operators, and others involved either directly or indirectly in crane operations. The information covers major responsibilities, hazards and safeguards in crane operating areas, factors that affect crane capacity, pinch points and other hazards around equipment, considerations for safe setup, requirements for providing signallers, and the international hand signals for hoisting.
Responsibilities

**Crane Owner**

The crane owner must ensure that
- safe, suitable equipment is provided to meet the requirements of the job
- operators are capable and aware of their responsibilities
- maintenance, repair, transport, assembly, and other personnel are trained and experienced to handle their specific jobs
- training and upgrading are provided for all personnel
- responsibilities and authority are clearly designated for each crew
- a thorough equipment maintenance and inspection program is in operation, including logbooks and other required documentation
- client and site supervision are capable and aware of their responsibilities
- equipment is maintained and inspected in accordance with manufacturer's requirements and applicable regulations.

**Operator**

The operator is generally responsible for the safety of the crane operation as soon as the load is lifted. Operators must know:

- the particular model of crane they operate, its characteristics, functions, and limitations
- the information in the crane’s operating manual
- the crane’s load chart, including all notes and warnings, and how to calculate or determine the crane’s actual net capacity in every possible configuration
- proper inspection and maintenance procedures to be followed in accordance with the guidelines of manufacturer and owner
- any site conditions that may affect crane operation, including the presence of overhead powerlines
- basic load rigging procedures.

In addition, the Operator must:

- inform the owner, in writing, of any problems with the machine, preferably in the machine’s logbook
- record in the logbook all inspection, maintenance, and work done on the crane in the field
- check that the site is properly prepared for crane operation
- review plans and requirements with site supervision
- find out the load and rigging weight and where the load is to be placed.
Although operators are NOT responsible for determining load weights, they become responsible if they do so or if they lift the load without checking the weight with site supervision.

- determine the number of parts of hoist line required
- check the load chart to ensure that the crane has enough net capacity for each planned lift
- select the best boom, jib, and crane configuration to suit load, site, and lift conditions
- assume responsibility for assembling, setting up, and rigging the crane properly
- follow the manufacturer’s operating instructions in accordance with the load chart
- consider all factors that may reduce crane capacity and adjust the load weight accordingly
- maintain communication with signallers
- ensure that the oiler is in a safe place during operation
- operate in a smooth, controlled, and safe manner
- shut down and secure the machine properly when leaving it unattended.

**Site Supervision**

Site supervision (foreman, rigger foreman, lead hand of the trade involved, etc.) has overall responsibility for the lift and must therefore plan all phases of the operation. Specifically, site supervisors must:

- supervise all work involving the crane
- determine the correct load weight and radius and inform the operator
- ensure that the rigging crew is experienced and capable of establishing weights; judging distances, heights, and clearances; selecting tackle and lifting gear suitable to the loads; rigging the load safely and securely
- supervise the rigging crew
- ensure that the load is properly rigged
- ensure that signallers are capable of directing the crane and load, including use of the international hand signals where other forms of communication are not possible
- designate signallers and identify them to the operator
- ensure the safety of the rigging crew and other personnel affected by crane operations
- keep the public and all non-essential personnel clear of the crane during operation
- control the movements of all personnel in the area affected by the lift
- ensure all required precautions when the lift is near powerlines
- ensure that all personnel involved in the operation understand their jobs, responsibilities, and their role in the overall safety of each lift.
**Basic Types and Configurations**

The evolution of the mobile crane has led to many types and designs to satisfy both the general as well as the specific needs of construction and industrial operations. This manual is concerned with mobile cranes used for construction purposes as well as industrial applications.

The basic operational characteristics of all mobile cranes are essentially the same. They include:

- Adjustable boom lengths
- Adjustable boom angles
- Ability to lift and lower loads
- Ability to swing loads
- Ability to travel about the job site under their own power.

Within the broad category of mobile cranes there have evolved the following basic types and configurations:

- Boom Trucks
- Industrial Cranes
- Carrier-Mounted Lattice Boom Cranes
- Crawler-Mounted Lattice Boom Cranes
- Carrier-Mounted Telescopic Boom Cranes
- Crawler-Mounted Telescopic Boom Cranes
- Rough Terrain Cranes
- Mobile Tower Cranes
- Heavy Lift Mobile Cranes.
Boom Trucks

Unlike all other mobiles, these cranes are mounted on carriers not designed solely for crane service. They are mounted on a commercial truck chassis that has been specially strengthened to accept the crane. They are, however, a type of mobile crane with respectable capacity and boom length.

Included in this basic type of machine are two common configurations.

**TELESCOPING BOOM**

Boom sections are usually telescoped either manually or hydraulically.

**KNUCKLE BOOM**

The boom articulates (folds) under hydraulic pressure and may or may not be equipped with a powered drum and wire rope.
Industrial Cranes

These cranes are primarily intended for operation in industrial locations where working surfaces are significantly better than those found on most construction sites.

Although these cranes will not be analyzed specifically, their characteristics are basically identical to those of telescopic boom mobiles, which are covered in detail.
Carrier-Mounted Lattice Boom Cranes

This “truck type” carrier must not be confused with the ordinary commercial truck chassis. It is specially designed for crane service and the heavy loads these cranes are required to withstand.

Carrier-mounted cranes are also commonly referred to as “Truck Cranes”, “Conventional Cranes”, “Friction Cranes”, “Mobile Cranes”, etc.
The entire rotating structure of the crane above the swing circle is called the upperworks, upper, superstructure or revolving superstructure.

The square frame at each end of a boom insert is commonly referred to as the picture frame.
Except for their base and method of load rating, the upperworks of these machines are identical to the carrier-mounted units.

Illustration shows a unit with traction shaft and chain drive but hydrostatic track drive systems are also available.
Carrier-Mounted Telescopic Boom Cranes

These machines are also mounted on specially designed carriers. They can be equipped with a variety of jibs and boom extensions which can be stowed on or under the heel section of the main boom.
Luffing jib can be raised or lowered independently of the boom. In this case the crane's auxiliary winch is used as the jib hoist.
Carrier-mounted telescopic boom cranes are subdivided by the type of head section (boom tip section) they are equipped with.

### FULL POWER BOOMS

On full power hydraulic booms the end section (tip or fly) extends through its full range as the whole boom extends.

### PINNED BOOMS

On “pinned booms”, the end (tip or fly) section is either fully retracted at all times (regardless of main boom length)...

...or fully extended at all times. Its length cannot be varied with the total boom length.

These sections extend and retract under power through their full range.
The upperworks of these cranes are identical to the carrier-mounted telescopic boom units. Their bases and the method used to load rate them differ, however.
Rough Terrain Cranes

The rough terrain crane’s oversized tires facilitate movement across the rough terrain of construction sites and other broken ground. Their short wheel base and crab-steering improve maneuverability. In “pick and carry” operations on rough terrain, however, they are still subject to the same operating restrictions that apply to other cranes.

Like carrier-mounted telescopic boom cranes, rough terrain units are available with either full power booms or pinned booms and the same types of jibs and boom extensions. There are two basic configurations.

**FIXED CAB**
Rough Terrain Cranes (continued)

ROTATING CAB

- Main Winch
- Auxiliary Winch
- Counterweight
- Outrigger Box
- Outrigger Beam
- Boom Extension in Stowed Position
- Boom Hoist or Lify Cylinders
- Operator’s Cab Rotates with Upperworks
- Engine “On Carrier”
- Pads, Floats, Pontoons
- "A" Frame Jib in Stowed Position
- Operator’s Cab Rotates with Upperworks
- Engine
- Cantilever Type Outriggers
Rough Terrain Cranes (continued)

Like the carrier-mounted telescopic boom cranes, rough terrain cranes can be equipped with either full power booms or pinned booms as well as with a variety of jibs and boom extensions which can also be stowed on or under the heel section of the main boom.
Heavy Lift Mobile Cranes

These cranes combine the best features of derricks and lattice boom mobile cranes. Typically they use very large extended counterweights, masts and often roller rings that move the boom’s fulcrum and the crane’s tipping axis further away from the center of gravity.
Tower Cranes

Fixed (non-stewing) tower

Stewing ring

Fixed Tower Configuration

Fixed Tower with Luffing Boom
Hazards in Crane Operating Areas

Over 50% of all mobile crane accidents are the result of mistakes made when the crane was being set up.

All of these accidents can be prevented by following the manufacturer’s recommendations for assembly and dismantling, by using the correct components, and by observing the precautions outlined in this section.

**Remember:** Improvising or taking shortcuts in assembly and setup can be fatal.

Use the checklist on the next page for reviewing the factors to consider in planning for crane and hoisting operations.
PRE-JOB CHECKLIST

Whoever requires that a crane be used-project engineer, site superintendent, foreperson, building owner, contractor, architect, or consultant – is as responsible for its safe operation as the operator.

If a working area has not been adequately prepared for the crane, the operation will be unsafe, regardless of machine capacity or operator skill. Consider the following factors.

- Can the machine get onto the site? Is the access road adequately graded and compacted? Is the access ramp too steep?
- Will the machine have to travel over buried pipes, sewers, mains, etc., that might be crushed?
- Is there room for the crane to maneuver in its designated position on site? Is there room to erect or extend the boom? Can trucks hauling boom sections get into position and be unloaded safely? Is there enough room and timber blocking to store boom sections properly?
- Will an area be designated and roped off for use by the erection crew? Will it be large enough for components to be stacked, handled, and assembled without endangering other site personnel?
- Has the crane’s position been identified for every lift? What will the maximum operating radius be? Will there be at least two feet of clearance between the counterweight and nearest object? What obstacles or other hazards might be posed by existing buildings or structures?
- Are operating areas graded, compacted, and levelled? Are they away from shoring locations, excavations, slopes, trenches, embankments, etc., which could subside under machine weight and vibration? Are operating areas over cellars, buried pipes, mains, etc., that may collapse?
- Will clearance and visibility be problems where other cranes, hoists, or equipment will be operating? Will operators have a clear view of other equipment to avoid collisions and keep hoisting ropes and loads from fouling? Will operators be provided with direct communication to warn one another of impending danger? Will the overall lifting program be laid out, controlled, and prioritized by one person in contact with all operators and each rigging crew?
- Will crane operating areas be away from public traffic and access? Will signallers and warning signs be provided when crane operations may overlap with public areas? Has police cooperation been arranged to provide traffic and pedestrian control?
- Have operators been warned and have provisions been made to keep cranes from working within a boom’s length of powerlines without
  a) shutting off power
  b) having the powerlines insulated, or
  c) providing signallers to warn the operator when any part of the crane or load nears the limits of approach specified by the Regulations for Construction Projects?

<table>
<thead>
<tr>
<th>Voltage Rating of Powerline</th>
<th>Minimum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>750 to 150,000 volts</td>
<td>3 metres (10')</td>
</tr>
<tr>
<td>150,001 to 250,000 volts</td>
<td>4.5 metres (15')</td>
</tr>
<tr>
<td>over 250,000 volts</td>
<td>6 metres (20')</td>
</tr>
</tbody>
</table>
Mark the location of all underground services that could be crushed by the weight of the crane.

Fence or barricade areas in which personnel could be trapped and crushed.
WHENEVER THERE IS THE DANGER OF PERSONNEL BEING TRAPPED OR CRUSHED BY THE COUNTERWEIGHT WHEN THE CRANE SWINGS, THE AREA SHOULD BE BARRICADED.

MIN. CLEARANCE OF 2 FEET

Between counterweight and carrier

Machinery deck

Outrigger during lowering

Between upper works and carrier

No unauthorized personnel in swing area during operation

Try to keep personnel out of this area

KEEP THIS AREA CLEAR OF UNNECESSARY PERSONNEL.
Working Near Powerlines

High voltage electrocution is the largest single cause of fatalities associated with cranes. All can be prevented. The power company or utility may consider (if given advance notification) shutting down the line temporarily or moving the line. If it is not possible to have the line moved or the power shut off the following procedures should be enforced by the project supervisor and strictly followed by all operators.

1. KEEP YOUR DISTANCE. Surrounding every live powerline is an area where an electric arc is capable of jumping from the powerline to a conductor of electricity. So you must keep all of your equipment and its load at least the minimum permitted distance away from the powerline (see page 6 for distances). If there is a chance for any part of the hoisting operation to encroach on that distance, protective measures must be taken to prevent this encroachment. You must take these measures unless you have controlled the hazard by de-energizing or moving the lines, or by re-routing the electricity around the work.

Note: The only exception to these requirements occurs under both of these conditions:
- the powerline cannot be de-energized or moved, or the electricity re-routed, and
- under the authority of the owner of the electrical conductor, protective devices and equipment are installed and written procedures are implemented that are adequate to protect equipment operators from electrical shock and burn.

This absolute limit of approach varies according to local, provincial, state and federal laws or crane manufacturer's recommendations, but is generally as shown:

2. Treat all powerlines as live until reliable information assures you that the lines are de-energized.
3. Identify the voltage of the service by checking markings on the utility pole and calling the utility. When equipment or its load can encroach on the minimum permitted distance from a powerline, the constructor must have written procedures in place to prevent the equipment or its load from encroaching on the minimum distance.

4. Have powerlines moved, insulated, de-energized, or follow the precautions in the Construction Regulation. Insulating or “rubberizing” powerlines offers some protection in case of brush contact in some circumstances. Your local utility may provide this service.

5. Place enough warning devices (such as signs) near the hazard so that the equipment operator can always see at least one of them. The operator must be able to see them under all possible environmental conditions (e.g., night, rain, fog). Signs must be specific about the hazard. They should state, for example, “Danger! Electrical powerlines overhead.” CSAO recommends that you include the voltage on the sign.

6. The operator’s station (e.g., driver’s cab) must have a sign (such as a sticker) warning of the hazard. The machine may come with a warning sticker in the cab. Make sure it’s still legible.

7. A competent worker must be designated as a signaller to warn the operator when any part of the equipment, load, or hoist line approaches the minimum permitted distance to a powerline. The signaller must be in full view of the operator and have a clear view of both the equipment and the electrical conductor.
8. Avoid using tag lines. Unless it is necessary to prevent the load from spinning into the minimum distance to a powerline, the tag line itself can be a hazard because it can swing into the minimum distance.

**Note:** All ropes are capable of conducting electricity, but dry polypropylene has better insulating properties than most commercially-available ropes.

9. Slow down the operating cycle of the machine by reducing hoisting, booming, swinging, and travel speeds.

10. Exercise caution when working near overhead lines having long spans as they tend to swing laterally in the wind and accidental contact could occur.

11. Exercise caution when travelling the crane as uneven ground can cause the boom to weave or bob into the lines.

12. Ensure that whenever cranes must repeatedly travel beneath powerlines a route is plainly marked and "rider poles" are erected on each side of the crossing approach to ensure that the crane structure is lowered to a safe height.
Working near Powerlines (continued)

IF YOU MAKE ELECTRICAL CONTACT WITH A POWERLINE

• **Stay on the equipment.** Don’t touch the equipment and the ground at the same time. In fact, touching anything in contact with the ground can be fatal. If a new hazard develops that could be life-threatening, such as a fire, use the “bailout procedure” (next page).

• **Keep others away.** No one else should touch the equipment or its load – including buckets, outriggers, load lines, or any other part of the machine. Beware of time-delayed relays: Even after electrical contact trips the breakers, relays may still try to restore power. They may come on automatically two or three times.

• **Break contact.** If possible – while remaining inside the machine – the operator should try to break contact by moving the equipment clear of the wires. This may be impossible if contact has welded conductors to the equipment.

• **Call the local utility.** Get someone to call the local electrical utility for help. Stay on the equipment until the utility shuts down the line and confirms that the power is off.

• **Report the contact.** Report every incident of electrical contact to the local electrical utility – they’ll check for damage that could cause the line to fail later.

When the powerline is rated at 750 volts or more:

1. report the contact to the inspection department of the Electrical Safety Authority within 48 hours.

2. provide notice in writing to the Ministry of Labour and to the joint health and safety committee, health and safety representative, and trade union.

• **Inspect the crane.** The crane must undergo a complete inspection for possible damage caused by electrical contact. The electric current could take several paths through the crane, damaging bearings, electronic controls, valves, and the crane’s cable. Wire rope should be replaced. Damage to the wire rope – such as welding, melting, or pitting – may not be visible.
**Working near Powerlines** (continued)

**BAILOUT PROCEDURE**

If the operator decides to leave the machine, he must *jump* clear. He must never step down allowing part of his body to be in contact with the ground while any other part is touching the machine.

**WRONG**

**RIGHT** (BUT STILL DANGEROUS)

The operator should never leave the machine unless absolutely necessary.

HIGH VOLTAGE CONTACT will result in electrical current flowing down the boom and through the crane to ground. The ground will then be energized with a high voltage near the crane and lower voltage farther away.

Because of the hazardous voltage differential in the ground, the operator should jump with his feet together, maintain balance and shuffle voltage slowly across the affected area. Do not take large steps because it is possible for one foot to be in a high voltage area, and the other to be in a lower voltage area. The difference between the two can kill.
Working Near Transmitters

When operating near radio, TV or microwave transmitters the crane boom and load can become electrically charged. The boom acts like an antenna and becomes “hot”. The charge is not electrically dangerous when compared with the effect of contacting electricity but it can cause burns to personnel handling loads. The greatest danger to personnel exists when they “jump” from the effect of this shock and fall or trip.

Grounding the crane will not likely have any effect. The only real solution is to insert a synthetic web sling between the crane’s load block and the load. This will isolate the riggers from the crane and protect them from burns. The crane operator will not be affected when in the machine but should wear rubber gloves when getting on and off the crane.
Factors Affecting Crane Capacity

Capacities and other information included in the load charts for cranes are based on almost perfect conditions seldom achieved under actual operation.

It is vital to know not only how to determine capacity correctly from the chart but also to recognize the factors that can reduce a crane’s capacity below the chart ratings.

These factors, described on the following pages, include:

- poor machine condition
- variations in boom angle
- variations in load radius
- errors in boom angle indicators during critical lifts
- quadrants of operation
- sweep area
- tires not clear of the ground
- division of sweep area into quadrants
- improper use of outriggers
- soft footing
- crane not level
- sideloading
- increase in load radius
- rapid swing rate
- impact loading
- rapid acceleration or deceleration of load
- duty cycle operations
- high wind speeds.

The information concludes with an illustration of proper setup.
Poor Machine Condition

Load chart ratings apply only to cranes maintained in condition as good as new and as stipulated by the manufacturer. The boom is one of the more critical elements of the crane and must be in perfect condition at all times.

Never use a boom section with a bent lattice member; the bent members draw in the main chords.

Check end fittings for cracks.

Picture frame must be square.

Check all welds for cracks and corrosion.

Welds can be the initiation point for cracks.

Dents can reduce boom strength considerably.

If a chord is even slightly damaged or bent, don’t use it. Don’t try to repair it. Chords are so vital to the strength of the boom that it is not practical to attempt repairs.

Check telescopic booms for conditions such as:
- Sway
- Droop
- Cracks around the hinge pin
- Rust (could be sign of crack)
- Flaking or cracked paint (could be sign of overload)
- Bulges, creases or waviness of the plates in the boom (could be signs of overload)
- Worn pads.

Check condition of all pendants & end fittings and look for broken wires around the sockets.

Check sheaves.

Boom must be straight and not twisted.

Check condition of all boom hoist ropes and sheaves.
Boom Angle

The capacities listed in the load chart are also based on and vary with the boom angle of the machine.

On telescopic boom cranes the boom angle is the angle between the base (bottom) of the heel section of the main boom and the horizontal while the boom is under load.

Because of boom and machine deflection (and pendant stretch on lattice booms) expect the boom angle to lower somewhat from its unloaded condition once a load is applied. Expect even larger boom angle reductions when the crane is “on rubber” because of tire deflection.
Load Radius

The capacities listed in the load chart also depend on and vary with the crane's load radius. The load radius is the horizontal distance measured from the center of rotation of the crane (center pin) to the load hook (center of gravity of the load) while the boom is loaded.

Because of boom and machine deflection and pendant stretch, expect the load radius to increase when the load is lifted off the ground. Expect even larger increases in radius when the crane is "on rubber" because of tire deflection.
Boom Angle Indicators and Critical Lifts

Boom angle indicators are required on all mobile cranes but they must not be relied on for accuracy during critical lifts because:

- They can give as much as a 2° reading error in boom angle which can substantially affect the gross capacity reading on the load chart.
- The indicators are mounted on the base section of the boom and may not register the deflection of the extended sections under heavy load particularly if the wear pads are worn excessively. Consequently the boom angle may actually be lower than the indicator reads.

For these reasons, using boom angle indicator readings during critical lifts can be misleading. Rely on load radius (where possible) or if the boom angle must be used (for example when lifting from a jib) assume the correct reading to be lower than what the indicator actually says.
Importance of Quadrants

The leverage and capacity of a crane change during rotation of the upperworks. Leverage and capacity are also affected by the location of the tipping axis. For these reasons the crane’s stability can change during operation.

To provide uniform stability, regardless of the position of the upperworks relative to the carrier, the crane’s capacity is adjusted by the manufacturer according to the quadrant of operation.

These capacity changes are identified in the load chart by the quadrant of operation.
**Sweep Area**

The sweep area is the total area that the crane boom can swing over.

The sweep area is divided into operating areas called quadrants of operation. The crane's capacity is then based on the quadrants.
Division of Sweep Area into Quadrants

The crane is said to be in a particular quadrant of operation when the load hook is located over that portion of the sweep area.

**Caution:** Not every make and model of crane can be operated in all of these quadrants. The diagrams are for reference only. Consult load charts to determine quadrants of operation for particular makes and models.
Improper Use of Outriggers

The load chart ratings of carrier-mounted and rough terrain mobile cranes apply to three base configurations:

- “On Outriggers”
- “On Tires”
- Partially Extended Outriggers

“On Outriggers”

Full chart ratings apply only when:

- all outrigger beams are fully extended, and
- all tires are clear of the ground.

Partially Extended Outriggers

In special circumstances a crane may be operated on outriggers that are not fully extended. In this situation the crane must be equipped with load charts coinciding with this partial extension of the outriggers and there must be a method of measuring the outrigger extension.
Improper Use of Outriggers (continued)

“ON TIRES” RATING
Full “on outrigger” ratings do not apply because the carrier wheels are touching the ground.

PARTIALLY EXTENDED OUTRIGGERS
Load charts must be supplied for this partial extension. Otherwise use “On Tires” rating.

“ON OUTRIGGER” RATING
Full “on outrigger” ratings apply because
• all beams are fully extended
• all tires are clear of the ground.

“On Tires”
Full chart ratings apply only when:
• tires are per manufacturer’s specifications
• tires are in good condition
• specified tire pressure is maintained, and
• crane speed does not exceed manufacturer’s specifications.

Tires should be just clear of the ground to keep ram length as short as possible and thus minimize rocking action.

For working “on rubber” some manufacturers recommend extending the outrigger beams but keeping the rams partially retracted so that the floats are just clear of the ground.
Soft Footing

Load chart ratings apply only when the ground conditions are firm enough to support the crane and keep it level during the lift. If the ground is soft or unstable, the tires, crawlers or outriggers will sink or subside causing loss of capacity. In almost all cases, heavy duty blocking having large bearing areas will be necessary to prevent sinking and provide a solid base for the crane.
Crane Not Level

All load chart ratings are based on the machine being perfectly level in all directions. This applies to cranes “on crawlers”, “on tires”, “on outriggers” and when travelling with load.

One of the most severe effects of being out-of-level is that side loads develop in the boom. Because of side loads all mobile cranes lose capacity rapidly as the degree of out-of-level increases.

The following table for a particular lattice boom crane indicates the possible capacity loss due to being out of level.

<table>
<thead>
<tr>
<th>Boom Length and Lift Radius</th>
<th>Chart Capacity Lost When Crane Out of Level By</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1°</td>
</tr>
<tr>
<td>Short Boom, Minimum Radius</td>
<td>10%</td>
</tr>
<tr>
<td>Short Boom, Maximum Radius</td>
<td>8%</td>
</tr>
<tr>
<td>Long Boom, Minimum Radius</td>
<td>30%</td>
</tr>
<tr>
<td>Long Boom, Maximum Radius</td>
<td>5%</td>
</tr>
</tbody>
</table>

Similar information can be obtained from the manufacturers for all cranes. Machines that are used on barges are provided with “list charts” that identify crane capacity with barge list (expressed as degrees). Capacity loss due to barge list is the same as capacity loss due to an out-of-level condition on ground.
Crane Not Level (continued)

**Caution:** If the crane is not level the load chart does not apply. You must either level the crane by using its outriggers or level the ground the machine is resting on. Even though the crane might have been properly levelled during set-up, ground subsidence during operation can cause an out-of-level condition. Check level frequently.

It is also important to note that when a crane is set up off level, swinging from the high side to the low side increases the operating radius. It also increases the load on the turntable, on the outriggers and on the supporting frame structure.

**Caution:** A boom at maximum elevation (minimum radius) on the low side cannot be swung over to the high side without risking collapse of the boom over the cab.
Sideloading

Load chart ratings apply only when the load is picked up directly under the boom tip. If the load is to either side of the boom tip, sideloading occurs and decreases capacity. This applies to both lattice and telescopic booms and is one of the most common causes of boom failure. It usually causes structural failure and always occurs without warning.

• Sideloading occurs when the crane is not level.

• Sideloading occurs when a load is dragged or pulled sideways.

This can buckle the boom, damage the swing mechanism or overturn the crane if the boom is at a high angle.
• Sideload occurs whenever a load is swung rapidly or when the swing brake is applied suddenly.

• Tilt-up operations can cause sideloading of the boom.
Increase of Load Radius

Load chart ratings apply only when the hoist line is vertical at all times and the load is freely suspended during the lift. If the line is not vertical, regardless of the reasons, capacity is lost. In addition to the examples relating to sideloading (see previous pages), the following conditions produce non-vertical hoist lines which result in increased load radius and reduced capacity.

- Reaching beyond the vertical extends the load radius and tends to draw the boom forward and decreases the crane's capacity. It will tip or fail more easily and with a lower hook load than listed in the load chart for the boom tip radius.

- Rapid swing causes increased load radius which decreases stability and reduces capacity.

- Lifting inside the boom tip radius puts a load component on the boom that acts to tip it backward. After the load is clear of the ground, it will swing out increasing the radius and tend to tip the crane forward.
Increase of Load Radius (continued)

- Working "on rubber" can also produce an increase of load radius. When lifting a heavy load "over the rear", "on rubber" the crane will lean slightly toward the load. This is caused by boom, tire and carrier deflection. This lean increases when picking "over the side" "on rubber". The lean will increase operating radius so the load will swing outward once it clears the ground. This outswing is dangerous to anything in the path of the load. The increase in load radius may also overload the machine. To overcome outswing, boom up as the load is lifted to maintain a constant radius.

- Swinging a load from "over the end" to "over the side" will increase lean. This is especially noticeable when operating "on tires". Since tilt acts to increase load radius, it must be compensated for when swinging the load. Swing slowly. Change boom angle (raise or lower boom) while swinging to maintain a constant radius and prevent inswing or outswing of load.
Rapid Swing Rate

Load chart ratings apply only when the load is vertically in line with the boom tip at all times. Rapid swing rates make this an impossible condition to meet.

Therefore, load chart capacities do not allow for fast swings. The swing rate must be adjusted to keep the load directly below the boom tip at all times.

(1) START SWING

When the swing is started the load will lag behind the boom tip causing sideloading and reducing capacity.

(2) DURING SWING

Rapid swinging of a load causes it to drift away from the machine increasing the load radius and reducing capacity; the load will also lag behind the boom tip causing sideloading.

(3) STOP SWING

When the crane’s swing is stopped, the load will keep going causing sideloading and reducing capacity.
Rapid Swing Rate (continued)

**Caution:** On long boom mobile cranes, rapid swing rates, rapid swing acceleration, or rapid application of the swing brake can overturn the crane or collapse the boom *with or without load on the hook.*

- Moving the dead weight of the boom at the start of a swing or trying to stop it at the end of a swing causes the boom to sideload itself.
- The centrifugal force of the boom during a high speed swing creates a high forward tipping load.
- At high boom angles, the boom can collapse over the back of the machine if the boom is accelerated or decelerated rapidly.
Impact Loading and Rapid Acceleration or Deceleration of Load

Load chart capacities do not allow for sudden starting or stopping of the load, impact loading or sudden machine movements.

The following situations create such conditions and reduce crane capacity below the chart ratings.

- Sudden release of a load causes a rapid change in load and impact loading. Crane will recoil initially, then full weight of load will suddenly be applied to the hook. The result can be overturning or structural failure. The same thing can happen when a frozen, caught or stuck load is pulled and suddenly breaks free.

- Sudden snatching of a load causes impact loading and the hoist rope or boom can fail. Ease into all loads to avoid impact loading.

- Rapid hoist acceleration produces hook loads higher than the actual load weight.

- Sudden release of a load causes the boom to recoil and perhaps topple. Place all loads gently to allow boom deflection and pendant stretch to gradually return to normal.
Impact Loading and Rapid Acceleration or Deceleration of Load (continued)

- Rapid stopping of the load produces hook loads higher than the actual load weight (see table).

- “Pick and Carry” operations subject the carrier and boom to shock loads. In order to ensure that the chart capacities are not exceeded, move the crane and load as smoothly as possible.

- Don’t extract pilings, casings or similar loads by yanking or jerking on them. The practice of pulling on the load until the machine has tipped, then releasing the hoist line, allowing the machine to drop back and catching the hoist line on a clutch or brake may break the boom. If the piling or casing won’t dislodge with a smooth, steady pull, use an extractor, pulling frame or similar device.

- Demolition work can be particularly hazardous. Shock loadings and sideloadings during work with demolition balls and clamshell buckets can be severe. The repetitive nature of such work imposes heavy demands on all parts of the machine. Restrict demolition ball weights to not more than 50% of capacity (“on rubber” capacities for truck cranes) at the maximum radius at which you handle the ball, with the boom length you are using. In addition to this requirement, ensure that the ball weight never exceeds 50% of the available line pull.

Sudden brake application during lowering will increase the hook load by the percentage shown according to the lowering speed and stopping distance. Note how rapidly the loads increase as the stopping distance decreases.

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<td>400</td>
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</table>
**Duty Cycle Operations**

Full load chart ratings may not apply when cranes are used in high speed production operations (duty cycle operations) such as concrete placing, steel erection, draglining, clam, magnet or grapple work.

The manufacturer will either specify in the load chart that lift crane ratings be reduced by a percentage (usually 20%) for duty cycle operations or will supply a separate load chart for such operations.

The capacity reduction is recommended because the speed of these operations produces increases in crane loads from sideload, swing-out and impact as well as higher temperatures in critical components such as brakes, clutches, pumps and motors.

The following are duty cycle operations:

- Draglining, Clam, Grapple and Magnet Operations
- High Speed, High Volume Concrete Placement
- High Speed, High Volume Steel Erection
High Wind Speeds

Almost all crane manufacturers specify in the load chart that chart ratings must be reduced under windy conditions, and they may also recommend a shut-down wind velocity. In almost all cases, when the wind speed exceeds 30 mph, it is advisable to stop operations.

Wind affects both the crane and the load, reducing the rated capacity of the crane. Never make a full capacity lift if it is windy. Use a great deal of discretion even when lifting under moderate wind conditions of 20 mph.

It is advisable to avoid handling loads that present large wind-catching surfaces. The result could be loss of control of the load and crane even though the weight of the load is within the normal capacity of the crane.

A 20 mph wind exerts a force of only 1 1/8 lb/ft$^2$ on a flat-surfaced load (the force on a 4 ft. by 8 ft. sheet of plywood = 36 lbs.) so only loads having very large sail areas would require crane capacity derating. At 30 mph, however, the wind exerts a force of 2.53 lb/ft$^2$ of flat surface area (equals 80 lbs. on a sheet of 4 ft. by 8 ft. plywood). This wind force on the load at 30 mph is enough to cause non-vertical hoist lines and loads that are very difficult to control.

Boom strength is most affected when the wind is from the side.

SAE XJ1093 specifies that booms be designed to withstand their full rated load plus a side load equal to 2% of the rated load plus a 20 mph wind from the side. Boom strength is therefore adequate to handle winds from the side up to 20 mph but no allowance is made for the effect of the wind on the load.
Setup Summary

A crane is properly set up for lifting when the following conditions are met.

For Cranes Operating “On Outriggers”

- The hook is directly above the load’s C of G.
- Load weight is known.
- Rigging is correct.
- Outrigger pads are on solid footing or blocking.
- All wheels are clear of ground.
- All outrigger beams are extended as prescribed by manufacturer.
- Boom angle, boom length and load radius are known and the crane’s rated capacity is known.
- Crane is level.

For Crawler-Mounted Cranes or When Lifting “On Rubber”

- The hook is directly above the load’s C of G.
- Load weight is known.
- Rigging is correct.
- Crane is set up level on firm, stable ground or blocking.
- Boom angle, boom length and load radius are known and the crane’s rated capacity is known.
Machine Selection

One basic requirement for any crane safety program is making sure that the right machine is selected for the job. If crane characteristics do not match job requirements, unsafe conditions are created before any work is done. Job site personnel are forced to “make do” and improvise in a rush – a surefire recipe for accidents.

CHECKPOINTS

No machine should be selected to do any lifting on a specific job until its size and characteristics are considered against:

- the weights, dimensions, and lift radii of the heaviest and largest loads
- the maximum lift height, the maximum lift radius, and the weight of the loads that must be handled at each
- the number and frequency of lifts to be made
- how long the crane will be required on site
- the type of lifting to be done (for example, is precision placement of loads important?)
- the type of carrier required (this depends on ground conditions and machine capacity in its various operating quadrants: capacity is normally greatest over the rear, less over the side, and non-existent over the front)
- whether loads will have to be walked or carried
- whether loads will have to be suspended for lengthy periods
- the site conditions, including the ground where the machine will be set up, access roads and ramps it must travel, space for erection, and any obstacles that might impede access or operation service availability and unit cost
- the cost of operations such as erection, dismantling, on- and off-site transport, and altering boom length.
RESULTS

The selected machine should:

- be able to make all of its lifts in its standard configuration (that means having the capacity and boom length to do all known tasks, with jib, extra counterweight, and special reeving held in reserve for any unexpected problems)
- have at least a 5% working margin with respect to the load capacity of every lift
- be highly mobile and capable of being routed with a minimum amount of tearing down
- have enough clearance between load and boom and adequate head room between the load and whatever rigging is required to make the lift.
Those responsible for equipment selection must ensure that the crane is going to be safe and reliable for as long as it will be used, and under all anticipated conditions to which it will be exposed during operation.

Certain equipment considerations and requirements apply to all cranes. These requirements can be specified in purchase orders and rental agreements. Machines should be rented only from reputable suppliers. Note that all cranes of the same model number may not have the same capacity rating. The correct rating should be determined from the manufacturer through the serial number.

Any changes in counterweight and boom inserts made by the owner should be checked. After such changes, capacities and other data in the load chart may no longer apply.

A machine designed, manufactured, inspected, tested, and maintained in accordance with Canadian Standards Association Standard Z150-1998 Mobile Cranes should meet the requirements of all major codes and regulations.

**Signalling**

Signalling is an important part of crane operation, but is often not treated with the respect it deserves. Signallers must be used whenever:

- the operator cannot see the load
- the operator cannot see the load's landing area
- the operator cannot see the path of travel of the load or of the crane
- the operator is far enough away from the load to make the judgment of distance difficult
- the crane is working within a boom’s length of the approach limits to powerlines or electrical equipment.

Where loads are picked up at one point and lowered at another, two signallers may be required – one to direct the lift and one to direct the descent.

Hand signals should be used only when the distance between the operator and the signaller is not great and conditions allow for clear visibility. The international hand signals for hoisting appear on the following page.

Telephone or radio communications between operator and signaller can be extremely effective.
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No response should be made to unclear signals.
Working Safely with Hazardous Materials

A Handbook for Employees

Environmental Health & Safety
Oregon State University, Corvallis, Oregon
Emergency Numbers

Fire 911
Ambulance 911
Police 911
Public Safety 7-7000

Environmental Health & Safety

Main Office (541) 737-2273
Manager (541) 737-2276
Web Page oregonstate.edu/ehs

Other Numbers

Facilities Services (541) 737-2969
Human Resources (541) 737-3103

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1. Introduction

This handbook for University employees is designed to increase awareness of hazardous materials in the workplace, their potential health effects, safe work practices, and emergency procedures. It describes legislation which gives employees the “right to know” about hazardous chemicals, and shows how to use a Material Safety Data Sheet. A video presentation is also available from Environmental Health & Safety (EH&S).

Oregon State University has employees in many different occupations. In their job, employees may work with or around potentially hazardous materials. Here are a few examples.

- Custodians use cleaning agents, bleach, and floor finishes.
- Office employees work with copying machine chemicals, cleaners, and disinfectants.
- Facilities maintenance employees work with paints, glues, acids, cutting fluids, metals and solvents.
- Automotive mechanics can be exposed to carbon monoxide, petroleum products, solvents, and degreasers.
- Gardeners and groundskeepers may apply or work in areas where pesticides have been applied. They may also use fertilizers and other agricultural chemicals.
- Food service employees use cleaning products and disinfectants.
- Photographers and graphic artists work with developers, fixatives, toners, inks, and many other chemicals.
- Laboratory employees may work with everything from viruses to radioactive materials, solvents, and rare metals.

2. The “Right to Know” Law

The purpose of Oregon’s Hazardous Communication rules (also called the RIGHT TO KNOW LAW) is to give both employees and employers access to important up-to-date information about thousands of regulated chemicals used in the workplace.

Manufacturers and distributors of hazardous chemicals are required to provide a Material Safety Data Sheet (MSDS) for each hazardous chemical or chemical product they distribute. The MSDS describes the chemical, its potential health and safety hazards, and safe work procedures. Employers must make this information available to employees.

There are other occupational hazards not covered by the Right to Know law, such as biohazards and radiation. Specific campus policies are contained in the OSU Administrative Policies and Procedures manual located on the OSU web page. EH&S provides information and training on these as well.

The OSU Hazard Communication program involves a series of steps:

Identifying Hazardous Chemicals on Campus.
- Departments inventory hazardous chemicals used in each work area.
- EH&S will make sure an MSDS is available for all chemicals.

Informing employees.
- Supervisors are responsible for informing employees of the hazardous chemicals present in the workplace.
- This will be accomplished (a) when an employee begins employment, or (b) when a new chemical is introduced into the workplace.

Training.
- EH&S will work with departments to provide training to employees on hazardous chemicals in their work areas.
- Training will cover health hazards, special handling precautions and disposal, personal protective equipment required, and emergency procedures to be followed for spills, fire, and first aid.
Access to MSDS’s

Most Material Safety Data Sheets (MSDS) are available in electronic format. EH&S keeps a copy of all MSDS received from manufacturers. Employees have access to MSDS by means of:

- Web search – MSDS sites must be bookmarked to meet OSHA rules.
- Requesting a specific MSDS from EH&S
- EH&S website access: http://oregonstate.edu/ehs/msds.php
- In an emergency, contacting OSU Public Safety, who will then contact EH&S

3. What is a Hazardous Material?

A hazardous material is any substance, chemical, or mixture of chemicals which can harm the body, either at the time of exposure or later. These materials may be in the form of a solid, liquid, gas or vapor, dust, fume, or mist and may be either a physical hazard or a health hazard.

Physical Hazards

Physical hazards associated with a material run the gamut from minor injury, such as burns, to major injury, such as from an explosion. Examples of chemicals presenting a physical hazard are compressed gases, oxidizers, flammables, and unstable or reactive materials.

Health Hazards

The extent to which a substance will cause harmful health effects is called the toxicity of that substance. The degree of health hazard depends on several factors:

- **Chemical Makeup.** Certain substances are inherently more hazardous than others because of their chemical ingredients or structure.
- **Amount.** How much of a substance an individual is exposed to (the DOSE) affects the degree of hazard.
- **Type of contact.** Substances can enter the body through the skin, eyes, lungs, or oral routes. Each of these routes of entry may cause a different effect.
- **Length of exposure.** For some substances, short-term exposure may cause no effect, but long-term exposure may be harmful.
- **Chemical combinations.** Often two or more chemicals react with each other to produce new substances, with health effect different from the original chemicals. They can be more hazardous. In some cases, the health effects of two substances in combination can be much greater than the combined effects of each chemical acting alone. This effect is called synergism.
- **Personal Susceptibility.** Individuals may have personal traits which put them at risk. These can include diet, smoking, sensitization or allergy, and pregnancy.

Health Effects of Hazardous Chemicals

Common terms and concepts used in discussing health effects of hazardous chemicals are presented in this section. Understanding these basic principles should help with interpretation of information found on an MSDS. A more complete list can be found in the glossary.

Acute and Chronic Effects

**Acute effects** are symptoms that show up soon after a single exposure to a chemical, and include rashes, burns, headaches, and nausea. These effects vary according to the nature and dose of a chemical. Acute effects are often reversible when exposure ceases.

**Chronic effects** are not seen right away, but occur later. They result from repeated, cumulative exposure over a period of time, and may take weeks, months, or even years to show up. The effects depend
on the nature of the substance and the level of exposure. Examples of chronic effects are liver and kidney disease, nerve and brain damage, and reproductive disorders. Often, chronic effects cannot be reversed even if exposure ends.

Combined acute and chronic effects are produced by some chemicals. One example is the solvent trichloroethylene. Acute effects may include dizziness, drowsiness, nausea, vomiting, and blistering of skin, while it may also cause chronic effects such as liver damage and cancer.

Latent effect is a special type of chronic effect, in which an adverse condition or disease arises many years after the original exposure to a hazardous substance. Certain cancers have latency periods of 20-40 years after exposure to a cancer-causing substance.

Local and Systemic Effects

Local effects are expressed when a chemical causes harm at its original contact point with the body, usually the skin, eyes, or lungs.

Symptoms of skin exposure may include: dryness and whitening; redness and swelling; rashes, blisters, and itching.

Eye exposure may result in irritation or burning.

Symptoms of respiratory tract exposure may include: headache, nose and throat irritation, increased mucus, dizziness, and disorientation.

Systemic effects are expressed when chemical pass through the original point of contact with the body and cause harm to other organ systems, such as the liver, kidneys, heart, nervous system, and muscles.

The Liver and Kidneys are commonly affected sites when chemicals get beyond the original entry points. The liver modifies many chemicals, detoxifying many in the process. The kidneys filter impurities from blood for elimination from the body. As they perform these functions, the liver and kidneys may themselves be damaged by the chemicals.

The Central Nervous System is made up of the brain and spinal cord. These organs connect with thousands of nerves, extending throughout the body, which control all sensation and activity. Brain functions can be affected by a lack of oxygen, caused by inhaling certain chemicals such as solvents or carbon monoxide. The first symptoms are typically dizziness and drowsiness, which may lead to unconsciousness. Nerve function can be altered or stopped by certain chemicals which block nerve impulses, especially some pesticides and heavy metals (mercury, lead). The result may be loss of reflexes, loss of feeling, tremors, or even paralysis. These effects may be temporary or permanent.

Specific Agents

Carcinogens

Carcinogens are chemicals which are known or suspected to cause cancer. There are many human carcinogens which are subject to special regulation in Oregon, and more than 1000 other suspected carcinogens. Many mutagens are also carcinogens. EH&S can provide more information on carcinogen requirements.

Reproductive toxins

Certain materials may create reproductive hazards by affecting either the female or male reproductive system or the fetus. Reproductive effects may results from exposure to certain types of chemicals, biological agents, or ionizing radiation.

A mutagen is a chemical which directly affects the genetic material in human cells, causing changes in the cells called mutations. Mutagens can present two kinds of hazards: reproductive damage and cancer. Reproductive damage can affect both men and women. Exposure to a mutagen may damage or kill sperm or egg cells, which may prevent conception. If conception does occur, there may be a miscarriage or a fetus with genetic defects. Many mutagens are also carcinogens.

A reproductive toxin is a chemical which interferes with the reproductive system. It may, for example, prevent conception by causing menstrual problems in women, or lowered sperm count or sperm motility in men. In either, sex, it may cause decreased sex drive.

A teratogen is a chemical that affects the developing fetus. The fetus may be more sensitive to some chemicals than its pregnant mother, and may be exposed to chemicals through the mother’s bloodstream. The
fetus may suffer damage even if the mother experiences no problems. Reducing fetal exposure to chemicals is especially important.

**Biological agents** cause infections that are of particular concern for pregnant women. Most of these are viral infections such as rubella (German measles), varicella (chicken pox) or human parvivirus B19.

**Ionizing radiation** can cause impairment of testicular and ovarian function and cause gene mutation and chromosomal damage. This damage is usually related to a high dose of ionizing radiation. Individuals who work with ionizing radiation are trained how to keep exposure as low as possible. Given proper precautions, most pregnant women can work with ionizing radiation without harm to themselves or their unborn child.

**Fetal protection.** All employees of childbearing age should be aware of known or suspected reproductive hazards in the workplace and take necessary actions to minimize risks to themselves or their unborn child. Pregnant employees are encouraged to discuss their work environment and duties with their personal physician.

**Bloodborne Pathogens**

Bloodborne pathogens are micro-organisms that are present in human blood that can cause disease in humans. The two most common of these are the Human Immunodeficiency Virus and Hepatitis B Virus. Although both of these viruses are found in other body secretions and excretions, blood and semen have been shown to be the most infectious. The primary means of work place exposure is through contact with infected blood as a result of a needle stick, splash to the eyes, nose or mouth, or through existing skin cuts or lesions. The University has established a Bloodborne Pathogens Exposure Control program which has specific procedures that must be followed by employees who have a reasonably anticipated exposure resulting from the performance of their duties. As a general rule, all blood or body fluids should be considered contaminated and handling should be avoided without appropriate protective equipment.

**Asbestos**

Asbestos is a naturally occurring mineral that was heavily used between 1950-1970 in building products such as thermal insulation on pipes, ceiling tiles, sprayed on roofing, cement asbestos board (transite), floor tile and mastic (glue), linoleum and its backing. Buildings at OSU have been surveyed for asbestos containing material (ACM). The report is located in the EH&S Office and is available for review during working hours. OSU has developed an Asbestos Management Plan consistent with the EPA’s philosophy of managing asbestos in place. The goal is to maintain ACM in good condition by using an active inspection and repair program. The plan will significantly diminish the potential hazard from inhaling asbestos fibers. You can help:

- DO NOT hang items from any insulation or ceiling tiles
- DO NOT store items on top of any insulated pipes
- DO NOT disturb or damage ACM while moving or transporting items
- DO NOT drill, cut or perforate ACM
- DO NOT use brooms, dry brushes, or standard vacuums in the vicinity of damaged asbestos-insulated pipe.
- DO call Facility Services Customer Service about any damaged areas.

**Radioactive Materials**

Radioactive materials are used extensively in OSU laboratories. Exposure to high levels of ionizing radiation has been shown to increase the risk of cancer and reproductive effects. Prior to working with or in the near vicinity of radioactive material, employees must receive additional training. Contact EH&S for more information.

4. **Material Safety Data Sheets**

A Material Safety Data Sheet (MSDS) is intended to provide important information about chemical products and their ingredients. EH&S can help interpret an MSDS if needed.

The ANSI MSDS format, shown here, is becoming more common internationally. A manufacturer may use a different style and layout, but must include equivalent information.

The ANSI format has sixteen sections. Here’s what they tell you:
Section 1  Chemical Product and Company Identification
Links the chemical name on the label to the MSDS. Also lists the name, address and the phone number of the company, manufacturer or distributor who provides the chemical.

Section 2  Composition, Information or Ingredients
Identifies all the hazardous ingredients of the material. May also include OSHA Permissible Exposure Limits (PELs) and ACGIH Threshold Limit Values (TLVs).

Section 3  Hazard Identification
 Discusses the health effects one may encounter when exposed to the material. Describes the appearance of the material, the potential health effects and symptoms associated with exposure, routes of entry, target organs that could be affected, etc.

Section 4  First-aid measures
Describes possible first aid procedures for each route of entry. The procedures will be written so that untrained individuals can understand the information.

Section 5  Fire-fighting measures
Describes information on the fire and explosive properties of the material, extinguishing items, and general fire-fighting instructions.

Section 6  Accidental release measures
Gives information on how to respond when a material spills, leaks or is released into the air. This information may include how to contain a spill or the types of equipment that may be needed for protection.

Section 7  Handling and storage
Discusses information on handling and storage of the material. Topics that could be described are: general warnings to prevent overexposure, handling procedures, and hygiene instructions to prevent continued exposure.

Section 8  Exposure controls/personal protection
Discusses engineering controls and personal protective equipment that would help reduce exposure to the material. The necessary personal protective equipment should be considered for eye/face protection, skin protection and respiratory protection.

Section 9  Physical and Chemical Properties
Includes information about the physical and chemical properties of the material, including: appearance, odor, physical state, pH, vapor pressure, vapor density, boiling point, freezing/melting point, solubility in water and specific gravity or density.

Section 10  Stability and Reactivity
Requires potentially hazardous chemical reactions be identified. Addresses chemical stability, conditions to avoid, incompatibility with other materials, hazardous decomposition and hazardous polymerization.

Section 11  Toxicological Information
Discusses data used to determine Section 3 the hazards, including: acute data, carcinogenicity, reproductive effects, target organ effects, etc.

Section 12  Ecological Information
Helps determine the environmental impact should the material ever be released into the environment.

Section 13  Disposal Considerations
Gives important information that may be helpful in the proper disposal of the material. The information can cover disposal, recycling and reclamation.

Section 14  Transport Information
Designed to give basic shipping information, including: hazardous materials description, hazard class and the identification number (UN or NA numbers).

Section 15  Regulatory Information
Discusses information on the regulations under which the material falls. Examples: OSHA, TSCA, CERCLA, SARA Title III.

Section 16  Other Information
Includes any other important information concerning the material. This information can include: hazard ratings, preparation and revisions of the MSDS, and label information.
5. Chemical Information

Common Types of Hazardous Chemicals

Three common types of hazardous chemicals used in OSU workspaces are organic solvents, corrosives, and compressed gases. These chemicals can be used safely when their effects are understood and proper precautions are taken. The adverse health effects described usually result from overexposure, when chemicals are not handled properly, or when protective equipment or other controls are not used. Proper procedures for handling, storage, and disposal of these and other types of hazardous chemicals are described in Section 6.

Organic Solvents

Organic solvents are the most common industrial chemicals. They are found in almost all workplaces. Solvents are present in paints, lacquers, varnishes, paint removers, adhesives, pesticides, plastics, textiles, rubber products, and floor finishes. They are used to dissolve oils, greases, and resins. They have many other uses in laboratories.

All organic solvents can cause skin problems. Repeated skin contact with a solvent can cause the skin’s protective fats and oils to dissolve, resulting in reddening, itching, blistering, and pain. Exposure to solvent vapors can irritate the respiratory tract and mucous membranes. Inhalation can cause dizziness, drowsiness, headache, lack of coordination, and nausea. Overexposure for a prolonged period may result in damage to the liver, kidneys, lungs, blood, nervous system, and other organs.

Many organic solvents are flammable. Some can produce an explosive atmosphere. Some can react with heat or other substances to create different hazardous chemicals.

Corrosives

Corrosives (acids and bases) are also very common. They may be either liquid or solid and are found in laboratories and in cleaning agents used on metal, clothing, dishes, and drains.

Corrosives can seriously harm body tissue on contact. They can cause dermatitis and eye damage. Exposure to vapors or mists can affect the respiratory tract and mucous membranes. Ingestion can damage the throat and stomach, and may be fatal. Corrosives are not flammable, but some can react with each other and with other chemicals to produce heat, fire or explosion.

Compressed Gases

Compressed gases are found in many university workplaces, including laboratories, maintenance areas, and service areas. Many of these gases are flammable, corrosive, or toxic. There is also the danger of a powerful propellant effect, sufficient to drive the cylinder through a wall, if the pressurized gas within a cylinder should suddenly escape.

Hazardous Chemicals Resource Information

- Check with your supervisor for the correct way to handle any chemical you use.
- Contact EH&S for the most up-to-date information about a specific chemical.
- Check EH&S website for safety instruction on chemical use.
- Check reference books and resources.

Hazard Information Labels

Many chemical suppliers use a system originally developed by the National Fire Protection Association (NFPA) to label the relative hazard of materials. The system uses a combination of colors and numbers to rate the hazard of a material in a way that is easily interpreted. The original NFPA system is arranged as four
squares mounted inside a larger square-on-point. Modifications include four colored rectangles drawn in a vertical pattern.

The system provides information on the **health, flammability, instability, and special hazards** of materials and indicates the severity of each hazard by use of a numerical ranking of 0 (no hazard) to 4 (extreme hazard). The numerical NFPA system is based on chemical hazards in fire situation. A similar system, called the HMIS, uses numbers based on normal use conditions.

### Blue – Health Hazard
4 **Deadly:** Very short exposure may cause death or major residual injury even though prompt medical treatment is given.
3 **Extreme Danger:** Short exposure may cause serious injury. Do not expose any body surface to this material.
2 **Dangerous:** Exposure may be hazardous to health. Protective measures are indicated.
1 **Slight Hazard:** Exposure may cause irritation or minor injury.
0 **No Hazard:** Exposure offers no significant risk to health.

### RED – FLAMMABILITY HAZARD
4 **Flash Point (FP) below 73 F:** Materials are very flammable, volatile or explosive depending on state; will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature.
3 **FP below 100 F:** Liquids or solids that are flammable, volatile or explosive under almost all normal temperature conditions.
2 **FP below 200 F:** Moderately heated conditions may ignite these substances.
1 **FP above 200 F:** Materials must be preheated to ignite; most combustible solids are in this category.
0 **Material will not burn.**

### YELLOW – REACTIVITY HAZARD
4 **May Detonate:** Substances that are readily capable of detonation or explosion at normal temperatures and pressures.
3 **Explosive:** Substances that are readily capable of detonation or explosion by a strong initiating source, such as heat, shock or water.
2 **Unstable:** Violent chemical changes are possible at normal or elevated temperatures and pressures. Potentially violent or explosive reactions may occur when mixed with water.
1 Normally Stable: Substances that may become unstable at elevated temperatures and pressures or when mixed with water.

0 Stable: Substances which will remain stable when exposed to heat, pressure, or water.

WHITE – SPECIAL HAZARD

W = water reactive (refer to reactivity)
OX = oxidizer
COR = corrosive
ACD = acid
ALK = alkali
⚠️ = radioactive

6. Chemical Handling, Storage, and Disposal

Chemical Handling

1. Know what you are working with and how to use it safely. Ask yourself these questions before using a chemical:
   - Is it dangerous to inhale?
   - Is skin contact dangerous?
   - Is it flammable?
   - Is it reactive?
   - What is recommended to handle it safely?
   - Get the answer to these questions from the container label, MSDS, your supervisor, or EH&S

2. Use the right protective clothing and equipment for the job.
   - Protective clothing and equipment includes eye protection (safety glasses, goggles, face shield); gloves to protect the hands; safety shoes; impermeable suits; and various types of respirators.
   - Contact your supervisor or EH&S if you have questions about what is required.

3. Prevent ingestion of chemicals.
   - Wash your hands thoroughly before eating or smoking.
   - Do not carry food or cigarettes into an area where chemicals are present.
   - Never smoke or eat around chemical use areas.
   - Never store food or cigarettes near chemicals. They can be contaminated by fumes or vapors, or hands can be contaminated and then cross-contaminate food or cigarettes.

4. Keep the workplace clean and uncluttered. Follow good housekeeping practices.

5. Be aware of warning signs, which may read “Caution”, “Danger”, “Restricted Area”, “Do Not Enter”, “Hearing Protection Required”, or “Eye Protection Required”. If it is unclear what a sign means, ask for clarification.

   Know what to do in an emergency. (Section 7.)

Personal Protective Equipment

Personal protective equipment (PPE) for employees is necessary in compliance with state safety laws. The general rule is that PPE is required when there is a reasonable probability that injury can be prevented by such equipment. In cases where PPE is required, the cost of the equipment is considered a departmental expense.
Full-time or part-time OSU employees who require eye protection in their job activities may participate in the OSU Safety Glasses Program. The program provides for procurement of safety glasses at a reduced cost to the employing department. OSU employees can also participate in the Safety Shoe Program.

Another type of PPE available through EH&S is respirators. Respirator use requires participation in the respiratory protection program.

EH&S can also recommend PPE based on protection against specific chemicals.

**Chemical Storage Guidelines**

1. **Know** what chemicals you have and what their hazards are.
2. **Label** ALL chemical containers and storage areas, including waste containers. Containers must be labeled with chemical name, and major hazard(s), and should be labeled with the owner’s name and date. Storage areas should be clearly marked with hazard classifications (e.g., acids, flammable, inorganic).
3. **Separate** chemicals according to their hazard class. Do not arrange them alphabetically, except within hazard classes. Separate flammables from oxidizers, corrosives, and toxics; separate acids and bases. Some materials may react dangerously with each other if they are stored together. For example, acids stored near metal dust can produce hydrogen gas.
4. **General guidelines:**
   - Use secondary containment for liquids.
   - Shelving should be sturdy and secured to a wall.
   - Storage areas and cabinets should be ventilated when feasible.
   - Store chemicals away from direct sunlight and heat. Some chemicals are light or heat sensitive and may breakdown into other chemicals, build up pressure in containers, or pose a fire hazard.
   - Protect chemicals from movement during seismic activity by providing a lip on shelving.
   - Date all chemical containers when received. Some chemicals, such as ethers, become unstable 3-6 months after opening, and may become explosive.
   - Never store flammables near any potential source of ignition (spark or flame).
   - Don’t smoke in areas where chemicals are stored.
5. **Solvent storage** areas should be clean and well ventilated. Drums should always be stored upright in a cool, dry place away from direct sunlight and heat sources. Bottles and cans should be kept in fireproof storage cabinets. Make sure metal solvent containers are grounded when transferring flammable solvents. Don’t use gravity feed when dispensing solvents from drums, because failure of valves will cause a solvent to spill.
6. **Corrosives** (acids and bases) should be stored separately. Storage areas should be clean and well ventilated. Acid drums and carboys should be stored in a cool, dry place away from direct sunlight and heat sources. Store below eye level. Always use secondary containment. Acids and bases in dry form should be kept in airtight containers.
7. **Compressed gas** cylinders must be secured by chain, rack or other means to prevent falling or rolling. Valve protection caps should be securely in place when the cylinder is not in use. Store away from direct sunlight and heat sources. Full and empty cylinders should be separated and clearly marked. Separate cylinders based on hazard class.
8. **Other chemicals.** EH&S can advise on storage of other types of chemicals and on special situations.

**Chemical Disposal**

OSU recognizes the importance of protecting the environment, along with protecting the health and safety of faculty, staff and students. It is OSU policy to reduce the use of toxic materials in University operations whenever reasonably possible and to reduce the amount of hazardous waste generated.

Disposal of hazardous materials should be considered only after attempts to recycle, recover or otherwise reuse the material. It is the responsibility of each employee to handle and dispose of hazardous material in a manner that is in accordance with the guidelines established by EH&S. These guidelines have been developed so that hazardous waste disposal at OSU will be in compliance with all state and federal regulations governing the handling and disposal of hazardous waste and in an environmentally sound manner.
1. All chemical waste must be properly prepared and labeled before EH&S can pick it up for disposal. Special guidelines are available from the EH&S web site.
2. Contact EH&S for advice and assistance on all questions regarding chemical waste disposal or to request removal of hazardous waste.
3. Do not pour potentially hazardous materials down the drain or toilet, even if they have been diluted. Never put them in regular trash containers or dumpsters.
4. EH&S must perform an official hazardous waste determination for all chemical waste that is disposed by OSU.
5. Discarded or broken glass can cause cuts and punctures, and may also be contaminated. Dispose of glass by packaging in impervious containers and placing in building trash dumpsters.
6. Needles and syringes (plastic or glass) must be incinerated as bio-hazardous waste; call EH&S to arrange disposal.
7. If any of your clothing (either street clothes or protective clothing) becomes contaminated, do not launder it with other clothing. Consult the MSDS and launder it separately or dispose of it entirely.
8. Call EH&S to arrange clean-up of all chemical spills.
9. Call Facilities Services for clean-up and repair of leaking fluorescent ballasts, which may contain PCB’s. For advice on PCB hazards, contact EH&S.

7. Emergencies and First Aid.

**Chemical Emergencies**

Responding quickly is important. Always be ready for an emergency:
- Know the location of the nearest emergency and first aid equipment, including eye washes, emergency showers, fire alarms and fire extinguishers.
- Be aware of those employees in your workplace or nearby who have special emergency training or skills.
- Know emergency phone numbers and the location of medical help. Post this information in the workplace.
- Be able to tell emergency personnel the exact name of the chemical(s) involved.

**Fire.** Never try to put out a fire unless you know what substance is involved and how to extinguish that type of fire, you know that you can safely put it out, you have already called for assistance, and you have been trained in fire extinguisher use. Remember that some materials become toxic when they burn. Evacuate the area and get help.

**Unconsciousness.** Call 911 for help. Before entering an area to help an unconscious person, make sure that you will not be in danger from hazardous fumes or inadequate oxygen. Respirators and lifelines may be needed but should only be used by individuals previously trained. Many respirators only provide protection against certain hazardous substances, and may not be adequate for all situations.

If you are able to enter the area remove the victim to fresh air immediately. Give artificial respiration and get medical personnel. If the victim’s eyes or skin are contaminated, flush with running water. Remove any contaminated clothing.

**Fumes.** If you work with chemicals, be aware of warning symptoms of overexposure to hazardous fumes. Get fresh air immediately if you sense a burning of irritation in your nose, throat, or lungs; have difficulty breathing; feel weak, dizzy or nauseous; or notice a strong odor. Close containers; open windows; turn on hoods or other ventilation. If these measures don’t help, leave the area.

**Eye Contact.** Flush your eye immediately with running water. Use an emergency shower or any other available source of water – eye wash, sink, fountain or hose. Hold your eyelids apart and roll your eyeballs. Do not use ointments or salves, which may be dangerous. Continue flushing for at least 15 minutes. Get immediate medical attention.

**Skin Contact.** Drench your clothing and skin thoroughly with plenty of water. Use any available source of water – even a faucet, fountain or hose. Remove contaminated clothing while drenching it and continue to flush skin with water for at least 15 minutes. Get medical attention.

**Spills.** If there is a leak or spill, keep away from it unless you know what it is and how to clean it up safely. Don’t try to deal with any large spills of hazardous material yourself - get help. In the case of a large solvent or
corrosive spill evacuate the immediate area but don’t leave the material unattended. If solvents are involved, remove sources of ignition. Don’t flush a spill with water in case it might be a substance which reacts with water. EH&S has proper protective gear and disposal equipment and will assist in the clean up of all spills.

### First Aid and Emergency Medical Care - Campus

Determine the extent of a person’s injury by checking airway, breathing, and signs of circulation. Other life-threatening conditions include unconsciousness, trouble breathing, persistent chest pain, severe bleeding, severe burns, persistent pain in the abdomen, vomiting blood, seizure, injury to the head, neck, or back, poisoning, and shock.

First aid or CPR should only be administered by trained individuals. Many employees have received this training. Departments should contact EH&S about obtaining adequate first aid equipment or training. If the seriously injured person is:

- **Unconscious or has other life-threatening conditions** – call 911 and provide care until emergency personnel arrive and take over.
- **Conscious and NON Life-threatening** – Care for the conditions found. For students, arrange for transportation to Student Health Services (SHS), during open hours, by calling Public Safety. For others, or when SHS is closed, arrange for transport to personal physicians, medical clinic immediate care facilities, or the local hospital, as desired by the injured or ill person.
- Employees should notify their supervisors if possible before leaving their job site.

Contact Human resources for more information on the Workers Compensation Program.

### 8. Glossary.

Listed below are many common terms used on a Materials Safety Data Sheet or in other reference materials about toxic chemicals.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACGIH</td>
<td>American Conference of Governmental Industrial Hygienists, a professional society which recommends exposure limits (TLVs) for toxic substances.</td>
</tr>
<tr>
<td>Acid</td>
<td>A substance which dissolves in water or certain other solvents, and releases hydrogen ions. For example, hydrogen chloride in solution is an acid, also referred to as hydrochloric acid. (See pH.)</td>
</tr>
<tr>
<td>Acute</td>
<td>Acute exposures and acute effects involve short-term exposures to high concentrations and show immediate results of some kind (illness, irritation, or death). Acute exposures are usually related to an accident. They typically are sudden and severe, and are characterized by rapid absorption of the material. The effect of a chemical is considered acute when it appears with little time lag, such as within minutes or hours.</td>
</tr>
<tr>
<td>Alkaline</td>
<td>Same as Basic. Having the ability to neutralize an acid and form a salt. Such a substance is called an alkali. (Also see Caustic and pH.)</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute, a private organization that recommends work practices and engineering designs pertaining to safety and health.</td>
</tr>
<tr>
<td>Asphyxiant</td>
<td>A vapor or gas that can cause loss of consciousness and death due to lack of oxygen.</td>
</tr>
<tr>
<td>Asthma</td>
<td>Constriction of the conducting airways (bronchial tubes) in the lungs in response to irritation, allergy, or other stimulus.</td>
</tr>
<tr>
<td>Basic</td>
<td>See Alkaline.</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>The temperature at which a liquid boils and changes rapidly to a vapor state at a given pressure. Often expressed in degrees at sea level pressure.</td>
</tr>
<tr>
<td>Carcinogen</td>
<td>A chemical or physical agent capable of causing cancer. Such an agent is often described as carcinogenic.</td>
</tr>
<tr>
<td>CAS</td>
<td>The Chemical Abstracts Service Registry Number (CASRN) is a numeric designation which uniquely identifies a specific chemical compound. This number may appear on the Material Safety Data Sheet, reference books, and chemical catalogs.</td>
</tr>
<tr>
<td>Caustic</td>
<td>Something that strongly irritates, corrodes, or destroys living tissue. (See Alkaline.)</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ceiling Limit</td>
<td>The maximum concentration of a material in air that should never be exceeded, even momentarily. (See PEL and TLV.)</td>
</tr>
<tr>
<td>Cell</td>
<td>The structured unit of which tissues are made. There are many types (e.g., nerve cells, muscle cells, blood cells), with each type performing a special function.</td>
</tr>
<tr>
<td>Chemical family</td>
<td>A group of single elements or compounds with a common general name, such as “Ketones”.</td>
</tr>
<tr>
<td>Chronic effect</td>
<td>An adverse effect with symptoms which develop slowly over a period of time, or which recur frequently.</td>
</tr>
<tr>
<td>Circulatory system</td>
<td>The heart and blood vessels.</td>
</tr>
<tr>
<td>Combustible</td>
<td>Able to catch fire and burn. Also used to describe a class of materials with a flash point above 100 degrees F (37.8 degrees C). (See Flammable.)</td>
</tr>
<tr>
<td>Concentration</td>
<td>The relative amount of one substance mixed into another substance.</td>
</tr>
<tr>
<td>Corrosive</td>
<td>A liquid or solid that causes visible destruction or irreversible alterations in human skin tissue at the site of contact.</td>
</tr>
<tr>
<td>Cubic centimeter (cc)</td>
<td>A metric unit of volume. One cc is equal to one milliliter (ml) in most instances.</td>
</tr>
<tr>
<td>Cubic meter</td>
<td>A metric unit of volume. Once cubic meter equals 35.3 cubic feet or 1.3 cubic yards. One cubic meter also equals 1000 liters or one million cubic centimeters.</td>
</tr>
<tr>
<td>Decomposition</td>
<td>Breakdown of a chemical (by heat, chemical reaction, etc.) into simpler parts, compounds, or elements.</td>
</tr>
<tr>
<td>Dermal</td>
<td>Pertaining to the skin.</td>
</tr>
<tr>
<td>Dose</td>
<td>The amount of chemical absorbed in a unit mass of tissue or in the whole body. Usually expressed in milligrams per kilogram (mg/kg).</td>
</tr>
<tr>
<td>Duration</td>
<td>The length of time you are exposed to a substance.</td>
</tr>
<tr>
<td>Edema</td>
<td>A swelling of body tissues due to water or fluid accumulation.</td>
</tr>
<tr>
<td>Evaporation</td>
<td>The process by which a liquid is changed into a vapor state and mixed into the surrounding air.</td>
</tr>
<tr>
<td>Evaporation rate</td>
<td>The ratio of the time required to evaporate a measured volume of a liquid chemical to the time required to evaporate the same volume of a reference liquid. In general, the higher the ratio, the lower the boiling point.</td>
</tr>
<tr>
<td>Excursion Limit</td>
<td>The maximum concentration allowed over a short time period (usually 5 to 30 minutes). It’s magnitude is above the 8-hour allowable limit. (see PEL.)</td>
</tr>
<tr>
<td>Flammable</td>
<td>Catches on fire easily and burns rapidly, with a flash point below 100 degrees F (37.8 degrees C).</td>
</tr>
<tr>
<td>Flash Point</td>
<td>The lowest temperature at which a liquid gives off enough flammable vapor to ignite and produce a flame when an ignition source is present.</td>
</tr>
<tr>
<td>Gram (g)</td>
<td>A metric unit of mass. One US ounce equals 28.4 grams; one US pound equals 454 grams.</td>
</tr>
<tr>
<td>Hazard</td>
<td>The probability that a person will be harmed due to working with a toxic substance under given conditions of use. “Hazard” is also used to refer to a dangerous agent, as in being exposed to a health hazard (example: benzene) or a physical hazard (example: heat).</td>
</tr>
<tr>
<td>IDLH</td>
<td>Immediately Dangerous to Life or Health. A term used to describe certain very hazardous environments, usually with high concentrations of toxic chemicals, insufficient oxygen, or both.</td>
</tr>
<tr>
<td>Ignition temperature</td>
<td>The lowest temperature at which a substance will catch on fire and continue to burn.</td>
</tr>
<tr>
<td>Incompatibles</td>
<td>Materials which could cause dangerous reactions from direct contact with one another</td>
</tr>
<tr>
<td>Inflammable</td>
<td>Same as Flammable.</td>
</tr>
<tr>
<td>Ingestion</td>
<td>Taking in a substance through the mouth.</td>
</tr>
<tr>
<td>Inhalation</td>
<td>Breathing in a substance.</td>
</tr>
<tr>
<td>Irritant</td>
<td>A substance which can cause an inflammatory response or reaction of the eye, skin, or respiratory system.</td>
</tr>
<tr>
<td>Kilogram (kg)</td>
<td>A metric unit of mass. Equals 1000 grams or about 2.2 pounds.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Latency</td>
<td>The time between exposure and the first manifestation of health damage.</td>
</tr>
<tr>
<td>Latent effect</td>
<td>An effect which occurs a considerable time after exposure to a toxic substance.</td>
</tr>
<tr>
<td>Lethal Concentration</td>
<td>A concentration of chemical in air that will kill a test animal inhaling it.</td>
</tr>
<tr>
<td>LD50 (Lethal Dose-50%)</td>
<td>The dose of a chemical that will kill 50% of the test animals receiving it. The chemical may be given by mouth (oral), applied to the skin (dermal), or injected (parenteral). A given chemical will generally show different LD50 values depending on the route of administration.</td>
</tr>
<tr>
<td>Liter</td>
<td>A metric unit of volume. One US quart is about 0.9 liters. One liter equals 1000 cubic centimeters.</td>
</tr>
<tr>
<td>Local effect</td>
<td>An effect which a toxic substance causes at its original contact point with the body, e.g., eye damage.</td>
</tr>
<tr>
<td>Local exhaust ventilation</td>
<td>A system for capturing and exhausting contaminants from the air at the point where the contaminants are produced (as in welding, grinding, sanding, laboratory experiments, etc.).</td>
</tr>
<tr>
<td>Melting Point</td>
<td>The temperature at which a solid substance changes to the liquid state.</td>
</tr>
<tr>
<td>Milligram (mg)</td>
<td>The metric unit of mass. One gram equals 1000 mg. One US ounce equals 28,400 mg.</td>
</tr>
<tr>
<td>Milligrams per cubic meter (mg/m³)</td>
<td>A measure of concentration, often used to express PEL’s and TLV’S.</td>
</tr>
<tr>
<td>mm Hg</td>
<td>Millimeters (mm) of the metal mercury (Hg). A unit of measurement for pressure. At sea level, the earth’s atmosphere exerts 760 mmHg of pressure.</td>
</tr>
<tr>
<td>MSDS</td>
<td>Materials Safety Data Sheet. A form listing the properties and hazards of a hazardous substance.</td>
</tr>
<tr>
<td>MSHA</td>
<td>Mine Safety and Health Administration, an agency in the US Dept. of Labor which regulates safety and health in the mining industry. Also tests and certifies respirators. (See NIOSH).</td>
</tr>
<tr>
<td>Mutagen</td>
<td>A chemical or physical agent that affects the genetic material in cells in such a way that it may cause an undesirable mutation to occur in some later generation. Such agents are called mutagenic. Many mutagens are also carcinogens.</td>
</tr>
<tr>
<td>Nervous system</td>
<td>The nerves, brain, and associated mechanisms in the body which control its processes.</td>
</tr>
<tr>
<td>NFPA</td>
<td>National Fire Protection Association. NFPA has developed a scale for rating the severity of fire, reactivity, and health hazards. References to these ratings frequently appear on MSDS’s.</td>
</tr>
<tr>
<td>NIOSH</td>
<td>National Institute for Occupational Safety and Health. NIOSH is a federal agency which conducts research on occupational safety and health questions and recommends new standards to federal OSHA. NIOSH, along with MSHA, tests and certifies respirators.</td>
</tr>
<tr>
<td>Oral</td>
<td>Pertaining to the mouth.</td>
</tr>
<tr>
<td>OSHA</td>
<td>Occupational Safety and Health Administration, an agency in the US Dept. of Labor, which regulates safety and health conditions in most of the nation’s private sector workplaces.</td>
</tr>
<tr>
<td>Oxidation</td>
<td>A reaction in which oxygen combines with a substance. (See Reduction).</td>
</tr>
<tr>
<td>Oxidizing Agent</td>
<td>A substance which brings about an oxidation reaction.</td>
</tr>
<tr>
<td>Oxygen Deficiency</td>
<td>An atmosphere having less than the normal oxygen content of air, which is 21% oxygen (volume-by-volume). When the oxygen concentration in air falls to 16%, many people become dizzy, experience a buzzing in the ears, and have a rapid heartbeat.</td>
</tr>
<tr>
<td>PEL</td>
<td>Permissible Exposure Limit. For federal purposes, PEL’s refer to three different types of exposure limits: a ceiling limit, an excursion limit, and an eight-hour time weighted average (TWA) limit. These have the force of law.</td>
</tr>
<tr>
<td>pH</td>
<td>A unit for expressing how acidic or how alkaline a solution or chemical is, on a scale of 1 to 14. A pH of 1 indicates a strongly acidic solution; pH indicates a neutral solution; and pH 14 indicates a strongly alkaline solution.</td>
</tr>
<tr>
<td>Polymerization</td>
<td>A chemical reaction in which small molecules combine to form much larger molecules. A hazardous polymerization is a reaction that occurs at a fast rate, releasing large amounts of energy.</td>
</tr>
<tr>
<td>ppm</td>
<td>Parts per million. A measure of concentration. (Usually parts of a substance per million)</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>------</td>
<td>------------</td>
</tr>
<tr>
<td>psi</td>
<td>Pounds per square inch. A unit of pressure. At sea level, the earth’s atmosphere exerts 14.7 psi.</td>
</tr>
<tr>
<td>Reaction</td>
<td>A chemical transformation or change.</td>
</tr>
<tr>
<td>Reactivity</td>
<td>The ability of a substance to undergo a chemical reaction such as combining with another substance.</td>
</tr>
<tr>
<td>Reducing Agent</td>
<td>A substance which brings about a reduction reaction</td>
</tr>
<tr>
<td>Reduction</td>
<td>A reaction in which oxygen is lost from a substance, or a chemical change in which an atom gains one or more electrons. A reduction reaction always occurs simultaneously with an oxidation reaction. One substance is oxidized while the other is reduced.</td>
</tr>
<tr>
<td>Reproductive toxin</td>
<td>A chemical which can interfere with the reproductive system.</td>
</tr>
<tr>
<td>Respirator</td>
<td>A device worn to protect against inhalation of hazardous substances.</td>
</tr>
<tr>
<td>Respiratory system</td>
<td>The breathing system. Includes lungs, air passages, larynx, mouth, nose, and the associated nerves and blood vessels.</td>
</tr>
<tr>
<td>Route of entry</td>
<td>The means by which a hazardous substance enters the body. Common routes are skin contact, eye contact, inhalation, and ingestion.</td>
</tr>
<tr>
<td>Sensitizer</td>
<td>A substance which on first exposure causes little or no reaction in a person, but which on repeated exposure may cause an intense response, not necessarily limited to the site of initial contact.</td>
</tr>
<tr>
<td>Solubility</td>
<td>The degree to which a chemical can dissolve in a solvent (such as water).</td>
</tr>
<tr>
<td>Solution</td>
<td>A mixture in which the components are uniformly dispersed. All solutions are composed of a solvent (water or other fluid) and the dissolved substance (called the solute).</td>
</tr>
<tr>
<td>Solvent</td>
<td>A substance (usually water or an organic compound) which dissolves another substance. See Solution.</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>The ratio of the mass of a volume of material to the mass of an equal volume of water, at a given temperature.</td>
</tr>
<tr>
<td>STEL</td>
<td>Short-Term Exposure Limit. The maximum average concentration allowed for a continuous 15-minute exposure period. (See TVL).</td>
</tr>
<tr>
<td>Susceptibility</td>
<td>Increased risk of harm from toxic substances due to personal traits such as diet, smoking, drinking, allergy, and pregnancy.</td>
</tr>
<tr>
<td>Systemic effect</td>
<td>An effect of a hazardous material on a part of the body other than that at which it entered.</td>
</tr>
<tr>
<td>Teratogen</td>
<td>A chemical or physical agent which can lead to structural malformations in the fetus and birth defects in liveborn offspring. Such as agent is called teratogenic.</td>
</tr>
<tr>
<td>Thermal</td>
<td>Involving heat.</td>
</tr>
<tr>
<td>TLV</td>
<td>Threshold Limit Value. An exposure limit recommended by the ACGIH. There are three types of ACGIH TLVs: TLV-TWA: The allowable Time Weighted Average concentration for a normal eight-hour work day; TLV-STEL: The Short-Term-Exposure Limit or maximum average concentration for a continuous 15-minute exposure period; TLV-C: The Ceiling Limit, or maximum concentration that should not be exceeded even instantaneously.</td>
</tr>
<tr>
<td>Toxicity</td>
<td>The extent to which a substance will cause harmful effects.</td>
</tr>
<tr>
<td>Trade Name</td>
<td>The trademark name or commercial name used by the manufacturer or supplier for a material.</td>
</tr>
<tr>
<td>TWA</td>
<td>Time Weighted Average. The average concentration of a chemical in air over the total exposure time. (See PEL and TLV.)</td>
</tr>
<tr>
<td>Vapor Pressure</td>
<td>The pressure exerted by a saturated vapor above its own liquid in a closed container at given conditions of temperature and pressure.</td>
</tr>
</tbody>
</table>
9. Environmental Health and Safety

Environmental Health and Safety (EH&S) is responsible to help OSU units provide a safe and healthful University environment for all staff, faculty, and students.

EH&S staff includes specialists in chemical and laboratory safety, carcinogens, biohazards, asbestos, PCBs, industrial and office safety, video display terminals, fire, sanitation, pest management, hazardous waste disposal, and employee training.

Services Available Through EH&S

Consultation. EH&S offers information and advice on such issues as safe handling procedures for chemicals, asbestos hazards, and the design of VDT work stations. Staff provide assistance on health and safety questions or problems, and interpret regulations and standards, including special campus regulations for carcinogenic, radioactive and hazardous biological materials.

Evaluation and Control of Hazards. EH&S staff inspect, monitor, and evaluate hazardous materials and conditions; make recommendations for controlling or eliminating hazards; and suggest practices to minimize harmful exposure. EH&S also coordinates hazardous waste disposal for the campus.

Assistance to Departments. EH&S advises and supports the health and safety efforts of departments and departmental safety committees.

Worker’s Compensation and Risk Management. In cooperation with the Human Resources Department, EH&S staff investigate the causes and injuries and illnesses, and develop accident prevention programs. The Risk Management Program seeks to minimize the risks and losses on campus.

Education and Training. EH&S offers training programs and educational materials on a number of safety topics including chemical hazards, lab safety (biological, chemical, and radiological), fire safety, and the “right to know”.

University Safety Policies and Procedures. In cooperation with various campus safety committees, EH&S coordinates the documentation of OSU Safety Policies. These are contained in the Safety section of the Administrative Policies and Procedures Manual, available on the OSU web. In addition, EH&S provides Safety Instructions that detail specific practices that assist OSU units to comply with environmental, occupational health, and safety regulations.

Areas of Emphasis

- Asbestos
- Biological Safety
- Chemical Safety
- Ergonomics
- Hazardous Waste Disposal
- Radiation Safety
- Training
Appendix G
FACILITY SAFETY MAP

MEDICAL EMERGENCY DIAL 911
CAMPUS POLICE EMERGENCY 7-7000
CAMPUS SECURITY NON-EMERGENCY 7-3010

FIRST AID STATION
Automated External Defibrillator
FIRE EXTINGUISHER
ground floor
FIRE EXTINGUISHER
second floor
PHONE
Lifeguard Rescue Buoys and Hooks
HARDBAT AREA
working in Large Wave Flume
HARDBAT AREA
when bridge crane is in use
Personal Protective Equipment - PPE
NO ACCESS
during operation