LEVEL I: Incidental Crane Operator's and Incidental Rigger's Manual

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TERMINOLOGY AND DEFINITIONS

This section presents a glossary of specialized terms usually used when discussing hoisting and rigging operations. Many terms are included for general information but not all are used in this Manual. The terms are arranged in alphabetical order. Illustrations are included for clarity. Figure 1 illustrates the major components of lifting equipment.

APPOINTED:	Assigned specific responsibilities by the employer or the employer's representative.
AUTHORIZED:	Assigned by a duly constituted administrative or regulatory authority.
AUXILIARY HOIST:	Supplemental hoisting unit of lighter capacity and usually higher speed than provided for the main hoist.
BRAKE:	A device used for retarding or stopping motion by friction or electromagnetic means.
BRAKE, HOLDING, or PARKING:	A brake that automatically sets and prevents motion when power is off.
BRAKING, MECHANICAL:	A method of retarding motion by friction.
BRIDGE:	That part of the crane consisting of girders, walkways, railings, trucks, and drive mechanisms that carry the trolley or trolleys.
BRIDGE TRAVEL:	Horizontal travel of the crane parallel with runway rails.
BUMPER (BUFFER):	An energy-absorbing device for reducing impact when a moving bridge or trolley reaches the end of its permitted travel, or when two moving bridges or trolleys come into contact.
CHOKER ROPE:	A short wire-rope sling used to form a slip noose around the object to be moved or lifted (see Figure 2).
CLEVIS:	A "U-shaped" fitting with pins.
CLIP:	Fitting for clamping two parts of wire rope.
COME-ALONG:	Device for making a temporary grip and exerting tension on a wire rope.
CORE:	Core member of a wire rope about which the strands are laid. It may be fiber, a wire strand, or an independent wire rope.
CRANE:	A machine for lifting and lowering a load vertically and moving it horizontally with the hoisting mechanism, an integral part of the machine.
CRANE SERVICE TYPES:	
<i>Normal Service:</i>	That service which involves operating at less than 85% rated capacity and not more than 10 lift cycles per hour, except for isolated instances.

Figure 1: Primary and Secondary Lifting Equipment

Figure 2. Single and Double Choker Hitches

<i>Heavy Service:</i>	That service which involves operating at 85-100% of rated capacity or in excess of 10 lift cycles per hour as a regular specified procedure.
<i>Severe Service:</i>	That service which involves normal or heavy service with abnormal operating conditions.
CRANE TYPES:	
<i>Cab-Operated Crane:</i>	A crane controlled by an operator in a cab located on the bridge or trolley.
<i>Floor-Operated Crane:</i>	A crane controlled by an operator on the floor using a pendant or non conductive rope.
<i>Overhead Crane:</i>	A crane with a movable bridge carrying a movable- or fixed- hoisting mechanism and traveling on an overhead fixed- runway structure.
<i>Power-Operated Crane:</i>	A crane whose mechanism is driven by electricity, air, hydraulic, or internal combustion.
<i>Wall or Jib Crane:</i>	A crane having a jib with or without trolley, and supported from a side wall or line of columns of a building.
CRITICAL DIAMETER:	Diameter of the smallest bend for a given wire rope which permits the wires and strands to adjust themselves by relative movement while remaining in their normal position.
CRITICAL ITEM:	A part, assembly, component, or piece of equipment designated as critical by a purchaser or facility operator, because the dropping, upset, or collision of it could: (a) cause damage that would result in schedule delay; (b) cause undetectable damage that could jeopardize future operation or safety of the facility; and (c) result in significant release of radioactivity or other undesirable condition. Critical items may include pumps, head exchangers, piping subassemblies, other primary-system components, fuel assemblies, large radiation-shielded shipping casks, or other items which require special care in handling because of size, weight, installation in close tolerance receptors, fragility, extreme susceptibility to damage, or other unusual factors.
DECELERATION STRESS:	Additional stress imposed on a wire rope due to decreasing the velocity of the load.
DESIGNATED:	Selected or assigned by the employer or the employer's representative as being qualified to perform specific duties.
DRIVE:	Motor, coupling, brake and gear case, or gear cases to propel bridge, trolley, or hoist.
DRUM:	A cylindrical-flanged barrel of uniform (cylindrical drum) or tapering (conical drum) diameter on which the cable is wound for operation or storage. It may be smooth or grooved.

ELASTIC LIMIT:	Limit of stress above which a permanent deformation takes place within the material. This limit is approximately 55-65% of breaking strength of steel-wire ropes.
EQUALIZING SLINGS:	Slings composed of wire rope and equalizing fittings.
EYE OR EYE SPLICE:	A loop with or without a thimble formed in the end of a wire rope.
FACTOR OF SAFETY:	Ratio of ultimate strength to the design working stress.
FAIL-SAFE:	A provision designed to automatically stop or safely control any motion in which a malfunction occurs.
FITTING:	Any accessory used as an attachment for wire rope.
GUY LINE:	Strand or rope, usually galvanized, for holding a structure in position.
HANDLING FIXTURE:	A cradle, handling structure, shipping fixture, or container designed specifically to facilitate support, lifting, or handling of a component during fabrication, loading, shipping, storage, or installation.
HIGH-CONSEQUENCE/ HIGH VALUE LIFT:	High-Consequence/High Value Lifts and items are parts, components, assemblies, or lifting operations designated as such by the customer or program organizations, because the effect of dropping, upset, or collision of items could: (a) cause significant work delay; (b) cause undetectable damage resulting in future operational or safety problems; (c) result in significant release of radioactivity or other undesirable conditions; (d) present a potentially unacceptable risk of personnel injury or property damage.
HOIST:	A device which applies a force for vertical lifting or lowering.
HOOK LOAD:	The total live load supported by the hook of a crane, derrick, or other hoisting equipment, including the load, slings, spreader bars, and other tackle not part of the load but supported by the hook and required for handling of the load.
INCIDENTAL OPERATOR:	A person whose work assignment in part requires the operation of an overhead, pendant-controlled crane. Such a person is required to receive specialized training and to demonstrate through written and operational tests the ability to operate safely a specific crane.
INDEPENDENT WIRE-ROPE CORE:	Wire rope used as the core of a larger rope.
KINK:	Permanent distortion of the wires and strands resulting from sharp bends. Causes permanent damage which causes unequal distribution of load with some strands being overloaded resulting in failure.

Figure 3. The Length of One Lay

LAY:	The lengthwise distance on a wire rope in which a strand makes one complete turn around the rope (see Figure 3).
LIFT:	(a) Maximum safe vertical distance through which the hook can travel without two blocking; (b) The hoisting of a load.
LINE:	Rope used for supporting and controlling a suspended load.
LOAD:	Total superimposed weight on the load block or hook.
LOAD-BEARING PARTS:	Any part of a material-handling device in which the induced stress is influenced by the hook load. The failure of a primary load-bearing part could result in dropping, upset, or uncontrolled motion of the load. Load-bearing parts which fail and result in no more than stoppage of the equipment without causing dropping, upset, or loss of control of the load are not considered to be primary load-bearing parts.

LOAD BLOCK:	The assembly of hook or shackle, swivel, bearing, sheaves, pins, and frame suspended by the hoisting ropes.
MAGNET:	An electromagnetic device carried on a crane hook to pick up loads magnetically.
MAIN HOIST:	The hoist mechanism provided for lifting the maximum-rated load.
MOUSING:	A method of bridging the throat opening of a hook to prevent the releasing of load lines and slings, under service or slack conditions, by wrapping with soft wire, rope, heavy tape, or similar materials.
NON ROTATING WIRE ROPE:	An 18 x 7 wire rope consisting of a left-lay, lang-lay inner rope covered by 12 seven-wire strands right-lay, regular-lay.
OVERHAULING:	An out of control condition in which the weight of the load under the force of gravity overspeeds the electric motor. Control depends on braking.
PERSON-IN-CHARGE:	The manager or other responsible person (other than the crane operator) appointed to be responsible for the safe handling of critical loads and for the safe handling of non critical items in, around, or above spaces in which critical items are located.
QUALIFIED:	A person who by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work.
QUALIFIED ENGINEER or QUALIFIED ENGINEERING ORGANIZATION:	An engineer or engineering organization whose competence in evaluation of the type of equipment in question has been demonstrated to the satisfaction of the cognizant manager.
QUALIFIED INSPECTOR:	One whose competence is recognized by the U. S. Department of Labor, and U. S. Army Corps of Engineers, the State in which inspections are carried out, or the cognizant manager. The cognizant manager shall have the right of review (including right to approve or reject) all qualifications.
QUALIFIED OPERATOR:	One whose competence to operate equipment safely and effectively (including the ability to accurately spot and control loads) has been demonstrated by extensive experience or operational tests.
QUALIFIED RIGGER:	One whose competence in this skill has been demonstrated by experience satisfactory to the appointed person. The term "Rigger" or "Qualified Rigger" in this Manual refers to the function performed, and in no way relates to the worker's classification in any union or, bargaining unit.

RATED CAPACITY:	The manufacturer's rated capacity. The maximum hook load which a piece of hoisting equipment is designed to carry; also the maximum load which a sling, hook, shackle, or other rigging tackle is designed to carry.
REEVING:	The act or method of threading rope around the drum and sheaves.
ROPE DIAMETER:	Measure diameter of wire rope as shown in Figure 4.
SAFE-WORKING LOAD:	Weight of load which the rope may carry economically and safely.
SHACKLE:	A type of clevis normally used for lifting (see Figures 5 and 6).
SHEAVE:	A grooved pulley.
SIDE PULL:	That portion of the hoist pull acting horizontally when the hoist lines are not operated vertically. This is not an acceptable technique.
SLINGS:	Wire ropes, chains, or other materials made into forms, with or without fittings, for handling loads.
SWITCH, LIMIT:	A switch which is operated by some part or motion of a power-driven machine or equipment to alter the electrical circuit associated with the machine or equipment.
SWITCH, MAIN:	A switch controlling the entire power supply to the crane, often called the disconnect switch.
TAG LINE:	A rope used to prevent rotation of a load.
THIMBLE:	Grooved-metal fitting to protect the eye of a wire rope.
TROLLEY:	the unit consisting of frame, trucks, trolley drive, and hoisting mechanism moving on the bridge rails in a direction at right angles to the crane runway.
TURNBUCKLE:	Device attached to wire rope for making limited adjustments in length. It consists of a barrel and right- and left-hand threaded bolts.
TWO-BLOCKING:	The act of continued hoisting in which the load-block and head-block assemblies are brought into physical contact, thereby preventing further movement of the load block and creating shock loads to the rope and reeving system.
WIRE ROPE:	A plurality of strands laid helically around an axis or a core.

Figure 4: How to measure maximum diameter of a wire rope

Figure 5: Shackles and Shackle Pins

SHACKLE INSPECTION AREAS

ECCENTRIC SHACKLE LOADS

POOR PRACTICE

Never allow shackle to be pulled at an angle - the legs will open

GOOD PRACTICE

Pack the pin with washers to centralize the shackle

DO NOT USE SCREW PIN SHACKLES IF THE PIN CAN ROLL UNDER LOAD AND UNSCREW

Figure 6: Shackle Inspection and Safe Practice Tips

I. LEVEL I - INCIDENTAL CRANE OPERATOR'S AND INCIDENTAL RIGGER'S SAFETY ORIENTATION

A. Department of Energy Standards

The following Department of Energy Standards shall apply:

1. Incidental operator and incidental rigger training is required. It shall include:
 - a. General information.
 - b. Specific information for crane to be operated:
 - 1.) Idiosyncrasies of operation
 - 2.) Disconnect power switch location
 - 3.) Storage location of bridge
 - 4.) Storage location of pendant
 - 5.) Log location and use procedures
 - 6.) Main disconnect switch location
 - 7.) Lockout procedures
 - c. Specific information for fork-lift to be operated:
 - 1.) Activating and securing electrically powered trucks
 - 2.) Activating and securing internal-combustion engine-powered trucks
 - 3.) Using an exhaust-emission-device and safety equipment
 - 4.) Basic handling of loads for stacking, traveling, or maneuvering
 - 5.) Operating over ramps
 - 6.) Using forklifts in trucks, semitrailer-tractor, and semitrailers without tractor
 - 7.) Using fork extensions and special attachments
 - 8.) Determining load limits, effect of load and highlift effect of load center of gravity, and irregular working surfaces
 - 9.) Learning the operation risk in hazardous areas, such as Flammable Liquids or Combustible Dusts
 - 10.) Lifting of personnel
2. Incidental Operator and Incidental Rigger Training Qualifications
 - a. Must be at least 18 years of age.
 - b. Must easily understand written and spoken English.
 - c. Must meet physical requirements of operators and riggers.
 - 1.) Personnel assigned to operate equipment and rig for safe handling of material should be considered for physical capability on two separate bases: (1) permanent physical conditions that apply to newly assigned employees and continuing assignment of employees already in this classification; and (2) temporary physical circumstances that restrict or modify the scope of an employee's assignment in these work situations.

- a.) The employee shall not have a detectable or known disease or physical restriction that would render the employee incapable of safe operation or rigging duties. Where any loss or loss of function of an upper or lower extremity exists, the acceptability of the candidate shall be the decision of the supervisor, after consulting with the designated physician.
 - b.) Qualified incidental operators and incidental operator trainees should have normal depth perception, field of vision, reaction time, manual dexterity, and coordination.
- 2.) Personnel working in these categories are required to be reexamined at least every three years.
- 3.) All hoist/crane operators and riggers must have government identification cards. (Federal Form 46.)
- d. Knowledge
 - 1.) The hoist/crane operator shall demonstrate basic knowledge of specific crane operating characteristics, capabilities, and limitations including equipment-rated capacity and effect of variables on capacity, safety features, and required rigging and operating procedures.
 - 2.) The rigger shall demonstrate basic knowledge of equipment-operating characteristics, capabilities, and limitations and shall understand rigging principles as applied to the job for which they are to be qualified.
- e. Skill
 - 1.) The operators shall demonstrate skill in manipulation and control of equipment through all phases of operation.
 - 2.) The riggers shall demonstrate skill in utilizing rigging principles.
- f. Initial qualifications of operators and riggers shall include:
 - 1.) Training with the equipment for which workers are to be qualified, under the direction of a Qualified Operator or Qualified Rigger designated by management.
 - 2.) Reviewing the applicants' knowledge, including written or oral examinations, and witnessing a demonstration of their skills by the instructors.
 - 3.) Inserting a written record of training, competency, and authorization in the employee's training record (by the supervisor). The record shall include identification of the equipment which the individual is qualified to operate.
- g. Qualification is for a period of three years, unless the qualification is revoked sooner by the manager. If operators or riggers are disqualified, their manager shall enter the actions in their files.
- h. The program for the maintenance of qualification shall include:
 - 1.) Verification by the managers that the individuals are required either to operate powered hoisting equipment or to do the rigging in the performance of their duties, and that they have been doing so safely and competently.
 - 2.) Completion of a written test relevant to the type of equipment used.
 - 3.) Completion of field training, if required by the manager.

B. LBL Requirements

The following LBL standards shall apply:

1. **Laboratory and Departmental Responsibilities.**
 - a. Maintain crane, rigging equipment, and all material handling equipment (e.g., fork lifts) in safe operating condition.
 - b. Test and certification of the crane in compliance with CFR 1910.179 and CAL-OSHA Title 8.
 - c. Provide necessary equipment and tools for safe use of the crane and rigging equipment.
 - d. Provide for training of crane operators and riggers.
2. **Incidental Crane Operator Responsibilities.**
 - a. Use only the cranes on which training has been received and to lift only those loads for which he has been authorized.
 - b. Use the crane in a safe manner and in accordance with stipulated procedures.
 - c. Return the crane to its designated storage place, open the disconnect switch, and sign off the log promptly after using crane. This assures that it is immediately available for others use.
 - d. Report any defective conditions in log and/or daily inspection tag. Take necessary action to have defects corrected.
3. **Operating Practices.**
 - a. The operator shall not engage in any practice which will divert his attention while actually operating the crane.
 - b. The operator shall respond to "movement" signals only from the appointed signal person, but shall obey a "stop" signal at any time and from anyone.
 - c. The operator shall be responsible for those operations under his direct control. Whenever he doubts the safety of a movement, the operator shall stop the operation until he is assured it can be made safely.
 - d. Workers shall be warned of approaching loads. Loads shall not be passed over workers.
 - e. Before leaving any suspended load unattended the operator shall:
 - 1.) Land or properly support the load by independent means, with permission of the building manager.
 - 2.) Place all switches in "off" position.
 - f. If there is a warning sign on crane, the crane shall not be used until the warning has been removed by the person who placed it there.
 - g. If power fails during operation, the operator shall:
 - 1.) Barricade area under load to keep workers away,
 - 2.) Notify supervisor and building manager.

- h. If defects or malfunction of the crane or any of its components is observed, the condition shall be reported in writing promptly to the designated person in the building. Persons coming to work on next shift shall also be notified in the prescribed manner.
- i. All controls shall be tested by the incidental operator at the start of operation on a new shift.
- j. All loads shall be lifted only with the hook centered over the center of gravity of the load. This will prevent:
 - 1.) Damaging the cable
 - 2.) Removing the cable from the sheave groove
 - 3.) Dislocating or twisting the trolley or bridge

4. Log

Each crane is required to have a log (or daily inspection tag record) that is readily available to crane users and maintenance personnel. Daily inspections (each shift that the crane is used) by incidental operators or regular operators shall be recorded. Periodic inspections by maintenance personnel shall be entered. Defective or unusual conditions observed during inspection or operation shall be entered. Repairs or adjustments shall be recorded. (See Appendix A.)

The procedure for using the crane, the log, reporting incidents and various conditions and procedures for responding to foreseeable emergencies together with names of persons to be notified and their phone numbers shall be permanently fixed at the front of the log for each crane.

C. Excerpts from Code of Federal Regulations (CFR) 1910.179 and CAL-OSHA Title 8

- 1. "Periodic inspection" means visually observing an object to determine if there is a defect. Observations shall be entered in the log (or daily inspection tag) on each shift the crane is used and shall include:
 - a. All operating mechanisms.
 - b. Leakage of oil, etc.
 - c. Deformed, corroded, or cracked members.
 - d. Loose bolts, nuts, or rivets
 - e. Cracked or worn sheaves or drums
 - f. Worn, cracked, or distorted parts, such as:
 - 1.) Pins
 - 2.) Bearings
 - 3.) Shafts
 - 4.) Gears
 - 5.) Rollers
 - 6.) Locking devices
 - 7.) Clamping devices
 - 8.) Hooks
 - 9.) Cables

- g. Excessive wear on brake system parts that might permit loads to drift downward.
 - h. Improper performance of electric drive motors.
2. Enter in the log the incidental operator's name, date and time of inspection, and any defects observed together with action taken.

II. GENERAL OPERATING PROCEDURES AND SAFETY

A. Crane Procedures

1. Sign out and in crane book. (See Appendix A.)
2. Check limit switches (interlocks).
3. Signal to operator.
4. Look for best direction to go.
5. Provide maintenance lookout.
6. Never leave load on hook.
7. Assign responsibility for the lift to authorized operator.
8. Designate person or persons in charge for critical lifts.

B. Safe Operating Practices

1. Determine weight of load. (Maximum limit for incidental operators is 2 tons or '5' x 5' x 5'.)
 - a. Calculate weight. (See illustration in Appendix B.)
 - b. Weight of materials. (See LBL Rigging Handbook.)
2. Determine center of gravity (CG).
 - a. CG is that point at which the object will balance.
 - b. A stable load is one in which the CG is directly under the hook and below the lowest point of attachment of the sling.
3. Select rigging tackle of suitable rated capacity.
 - a. Sling capacity (rated capacity)
 - 1.) Angle of sling
 - 2.) Examine sling before using.
 - b. Shackle size for capacity
 - 1.) Size is diameter of bail stock.
 - 2.) How to use in lifting load. (See Figures 5 and 6.)
 - c. Eye Bolts
 - 1.) Use only eye bolts with shoulder and then only for straight lifts. (See Figure 7.)
 - 2.) How to use in lifting load.
 - d. Turnbuckles
 - 1.) Eye and Jaw end fittings
 - 2.) How to use in lifting a load
 - e. American Safety Hoist Ring. (See Figure 8.)

- 1.) Use whenever possible instead of eyebolts.
- 2.) Capacity is stamped in top surface of bushing.
4. Attach the sling securely to the load.
 - a. Using safety hoist rings
 - b. Using shackles
 - c. Attaching sling to hook
 - d. Pad or protect sling from sharp corners.
5. Making lift, two person
 - a. Center the hook over the load center of gravity.
 - 1.) Never pull sideways.
 - 2.) Movement of load is indicative of CG.
 - b. Equalize load on sling legs and angle of sling.
 - c. Start lift slowly to avoid shock loading.
 - d. Use tag line and signal.
6. Lower load, two person
 - a. Lower load slowly.
 - b. Block load up before pulling sling out.
 - c. Always put rigging away.

C. Tips on Safe Practice

1. Cable clamps correct usage and placement (See Appendix C.)
 - a. Number
 - b. Spacing
 - c. Placement
2. Hooks
 - a. Inspection
 - b. Placement
3. Wire rope
 - a. Components (See Figure 9)

Figure 7: Eye Bolts with shoulder (A) and without shoulder (B)

Figure 8: American Safety Hoist Ring

Figure 9: Components of Wire Rope

III. HIGH-CONSEQUENCE / HIGH-VALUE LIFTS

A. High-Consequence/High-Value Lifts

High-Consequence/High-Value Lifts are parts, components, assemblies, or lifting operations designated as such by the customer or program organizations, because the effect of dropping, upset, or collision of items could:

- Cause significant work delay.
- Cause undetectable damage resulting in future operational or safety problems.
- Result in significant release of radioactivity or other undesirable conditions.
- Present a potentially unacceptable risk of personnel injury or property damage.

B. High-Consequence/High-Value Lift Personnel

Each person involved in a high-consequence/high-value lift shall be familiar with the procedure before beginning work.

A prelift meeting with all participating personnel shall be held before the lift. The procedure shall be thoroughly reviewed by the LBL Hoist/Crane Engineer.

C. High-Consequence/High-Value Lift Procedure Approval

The procedure shall, at a minimum, be approved by the LBL Hoist/Crane Engineer. Any change to the procedure shall be reviewed and approved as if it were an original procedure.

D. High-Consequence/High-Value Lift Requirements

A detailed, step-by-step procedure shall be prepared for high-consequence/high-value lifts. While high-consequence/high-value lift procedures are customarily prepared for one-time use, general high-consequence/high-value lift procedures may be employed to accomplish routine recurrent high-consequence/high-value lift operations. For example, a general high-consequence/high-value lift may be used to lift cover blocks in a canyon or to lift a frequently lifted item in a shop. The procedure shall contain the following:

- Identification of the item to be moved.
- Special precautions.
- Weight of the item.

- Total hook load (all component parts of the item plus tackle and load-measuring devices).
- Determination of the center of gravity.
- A list of each piece of equipment and each accessory (e.g., slings, spreader bars, yokes) to be used in the lift. Each shall be identified by type and rated capacity. If a portable item to be used has no serial number, one shall be assigned by the Person-In-Charge (PIC) and affixed to the item.
- Surveillance procedures, checkpoints, and estimated instrument readings shall be listed to enable confirmation that the lift is proceeding as planned.
- Checkpoint for the adequacy of the attachment point of the item to be lifted.
- A rigging sketch or sketches which include the following:
 - 1) Lifting points.
 - 2) Load vectors.
 - 3) Sling angles.
 - 4) Accessories used.
 - 5) Method(s) of attachment.
 - 6) Other factors affecting the capacity of the equipment or accessories.
 - 7) Identification of the capacity (or limit) of equipment and load.
 - 8) Identification of the expected load in each item of equipment and each accessory.
- A load-path sketch of the load path with the expected height of the load at each point in the lift. Where appropriate, floor loading diagrams shall be included to provide for setting the load down at any point in the path if that should be necessary.
- A travel sketch as a part of the load-path sketch or a separate sketch indicating lifting and travel speeds.
- A sign-off for the PIC acknowledging the PIC's supervision of the lift. There shall be a space for the PIC to initial the procedure at each step, as it is completed. Provide space for date and time of item completion and initials of PIC.
- Load tests and practice lifts, if required, shall be included in the procedure.
- Verification that equipment and tackle are within the current inspection/test time requirements in this manual.

When repetitive lifts are to be performed, lifting items which are designed with special lifting features that do not allow variation of the parameters listed above, such as center of gravity, lift point, sling angle, maximum weight, do not have to be specified in the procedure; however, the specific type of equipment to be lifted and the specific lifting equipment must be specified. Where the design of the facility permits no significant variation in the travel path, it does not have to be specified. The procedure must, however, clearly define the limits to the procedure. Also, when there is limited access to the crane operational view and control, the PIC responsibility may be delegated to a specified operator.

IV. SLING SAFETY

This section presents a brief overview of the rules for the safe use of slings. Slings are designed to be tough and durable and to compensate for misuse, but good sense calls for working within safety margins. By following a few basic rules, pain and suffering and costs from damage to equipment and products can be minimized.

A. Chains

Chains must pass manufacturers' chemical, metallurgical, and other quality tests plus various visual inspections.

Nevertheless, they should be treated with care. To avoid abusing the chains, workers on the floor should be aware of working load limits and proper sling hitches.

Tables showing working load limits of chains of specific alloys are available from the manufacturer. The tables often show the working limits, proof test loads, and minimum break loads as related to the size of the chain in inches.

Information on working load limits is also available from chain fabricators. The limits vary according to the angle between the arms of the sling and the load. As a rule of thumb, the flatter the angle, the lighter the load that can be carried safely.

Load limits with triple and quadruple slings are also available from the manufacturer. In short, there is no excuse for overloading a chain sling because of guessing wrong. Such data are also on the sling. Hoist operators and hookers should be trained to always select a chain that is within the safety margin for the particular job. They should be trained to recognize that the smaller the angle of inclination, the smaller the safety margin.

The factors of working load limits and angles of inclination are true for slings of all materials.

Before use, the chain should be visually checked to see that it is free from twists, knots, and kinks. Workers should know that although a kinked or knotted chain may be OK for one shift, it could fail on the next. Workers coming on shift should first check the chain for nicked or damaged links for their own safety.

The following points are general rules that should be applied to slings of all materials:

- Be sure the load is properly seated in the hook.
- Avoid jerking when lifting or lowering the sling because this increases the actual weight of the load due to inertia of load. Make sure the load is balanced to avoid overstress on one arm or the load slipping free.
- Use pads when the load has sharp corners that could damage the sling.
- Avoid crushing the sling when lowering the load.

Some points more specific to chains include:

- Never splice a chain by inserting a bolt between links.
- Do not force a hook over a link by hitting it with a hammer.
- Do not remove the permanent identification tags placed on the chains by the manufacturer.

- Only use attachments designed for the chain in question.
- Store chain sling arms on racks where they cannot be run over and damaged by plant vehicles.

When chains must be used in corrosive atmospheres, use those made with special alloys, such as stainless steel, Monel Metal, bronze, and other materials.

Never use proof coil chain hardware for slings.

Alloy steel chains are suitable for high temperature operations, up to 800°F (425°C). This is the highest temperature for which continuous operation is advised. But the working load limit of chain slings should be reduced by 30%.

At 1,000°F (535°C), chains are limited to 50% of the load limit and must have their limit permanently lowered by 15%.

B. Fiber and Wire Rope

The first consideration in deciding whether to use fiber rope as slings is how the strength of the fiber can be affected. The strength can be affected by chemicals, freezing, high temperatures, and sharp bends.

Slings made of fiber rope are usually suitable where the load could be damaged by slings made of harder material.

Wire rope slings are usually made of improved or extra improved plow grade steel.

Overloading is a prime safety consideration when using wire rope slings.

Wire rope manufacturers provide tables and data on rated capacities for their products. However, the figures are based on newly manufactured slings and do not take into account losses in capacity due to deformation from wear and tear. The figures come from experience and computations; slings are proof-tested at higher than specified loading but never tested to breaking strength.

Slings should always be used at rated capacities because the effects of shock loads or wire rope deformation are unpredictable.

The most common types of wire rope slings are single part, multi-part, and grommet (endless loop).

The single part sling is a length of wire rope with eyes at either end. They can be used in a vertical, choker, or basket hitch. The eyes at either end are formed by splices made either by hand or mechanical means.

The stress on single part slings is concentrated at the eye and where the sling contacts the load. A sling eye should never be used on a hook with a larger diameter than the width of the eye. In short, never force an eye onto a hook.

The minimum hook diameter should be at least the nominal diameter of the rope. Anything less could mean a 50% loss in efficiency.

The use of either type of splice will result in a certain loss in rated capacity. If the splice is made by the manufacturer, the loss will be reflected in the rated capacity table.

A single leg hitch should not be used on a load where rotation cannot be controlled. Rotation of the load could untwist the lay of the wire rope strands, thus weakening the rope.

The vertical sling without choke uses the full rated capacity (or strength) of the wire rope, but again

no rotation should be permitted. The choker hitch can mean a loss in rated capacity of as much as 25%. The noose effect of the hitch affects the ability of the strands to adjust to the load and can damage the rope at the point of choke. The basket hitch increases the capacity rated for the vertical hitch. The increase is not twice the amount of the vertical hitch because the two legs of the sling are at an angle.

The angle of the legs of a multi-part wire rope sling will affect its capacity. The flatter the angle at the hook, the greater the lifting capacity loss. If necessary to compensate, use as long sling parts as headroom will permit.

Multi-part (more than one leg) wire rope slings may be used safely:

- When the diameter of the bend that the sling must experience is less than 20 times the sling body diameter which may cause kinking.
- When extreme flexibility is required, such as fitting up close to the load, or when easy handling of the load is required.
- When the sling can damage the load. Stress is more evenly distributed among several contact points; nevertheless, use of pads is also recommended.
- When greater load stability is required.

Strictly speaking, a grommet is an endless loop of wire rope formed by hand-tucked splices. Grommets have slightly lower rated capacities than mechanically made loops but have the advantage of being smooth throughout the length. Mechanically made loops have attachment hardware, such as sleeves that can contact the hook or the load. Because wear and stress can be evenly distributed over the length of the endless loop, they are likely to have a longer safe lifetime.

Safety points in using wire rope slings include:

- The right sling and hitch for the job, determined by the weight, shape, and bulk of the load.
- The right sling length as determined by the power of the lifting device and headroom.
- Protection of the rope strands from sharp corners by the use of clamps, wooden blocks, pads, etc.
- Careful examination of the rope for damage before every lift.
- Minimizing stress and shock to the rope with slow starts and stops.
- Avoiding moisture, acid fumes, caustics, and handling hot material.
- Using the hook properly by placing eyes in the well of the hook rather than the point and pulling straight up in the line of lift.
- Storing slings on racks in dry rooms to avoid damage from dropped objects and vehicles.

C. Web and Mesh

Synthetic web slings are used primarily for lifting loads with easily damaged surfaces. Metal mesh slings are used to handle sharp-edged metal, pre-stressed concrete, and materials with temperatures up to 500°F (260°C).

Web slings are usually made of nylon or polyester and are used for moving tubular objects, such as

rollers, or loads with surfaces that are non-ferrous, ceramic, painted, polished, highly machined, or are fine or delicate in some manner.

As with other types of slings, tables showing rated capacities are available from manufacturers for web slings. The tables indicate capacities in relation to design of sling in pounds per inch and hitch configuration (vertical, choker, or basket).

Keep in mind that web slings are designed primarily to protect the product. They are easily cut and have little resistance to abrasion when compared to chain and wire rope slings.

Manufacturers can also provide tables on the effect of sling arm angles on the slings' rated capacities. Here the rating loss factor is sometimes expressed as the relationship of the sling arm angle to the vertical, rather than the horizontal.

Web slings also bear identification data: manufacturer, sling code number, and rated capacity. Such identification should stay on the sling throughout its life.

Web slings are sensitive to various types of environments. Nylon slings should not be used in acid environments, but they resist most caustics. Polyester is damaged by caustics but is resistant to acids. Both can be damaged by sunlight, moisture, and temperatures above 200 F (93 C). Aluminum fittings of web slings can be damaged by fumes, vapors, sprays, mists, and liquids of caustics and acids.

To assure safe use of web slings:

- Choose the right sling for the job, considering load shape, hitch used, and working environment.
- Consider the load weight, sling angle, and type of hitch.
- When a choker hitch is used with a sling with fittings, be sure the choke action falls upon the webbing, not the fitting.
- When a basket hitch is used, make sure the load is balanced.
- Do not drag slings across the floor or other abrasive surfaces, and be careful not to drop slings with metal fittings.
- Do not allow web slings to be twisted or knotted or joined by knotting.
- When unloading, do not pull slings from under loads resting on them.
- Protect the webbing from sharp corners, sharp edges, protrusions, or abrasive surfaces.
- Do not place webbing laps at the bearing point on hooks, around corners, or at choker hitch bearing points.

Manufacturers of metal mesh slings also provide information on safe working load limits. In addition, they classify their products as heavy-duty, medium-duty, or light-duty. Metal mesh slings are proof-tested to 150% of their rated capacities by the manufacturer.

Any danger from the use of metal mesh slings comes from improper use. The mesh, and its load bearing capacities, can be damaged by faulty loading or by dragging a sling from under a load. Such actions abrade the spirals of the mesh and reduce the wire diameter.

Safety pointers specific to metal mesh slings include:

- Do not shorten the sling with knots, bolts, etc. Consult the manufacturer.
- Never twist or kink the legs of a metal mesh sling or use one with the spirals locked.

- Do not straighten a spiral or cross lock by hammering on it.

General rules for the safe use of metal mesh slings are much the same as those for other types of slings mentioned previously. Although the manufacturers of all types of slings go to some lengths to provide users with ample safety margins, operators should know the prescribed safety limits and work within them. Many errors made many times can overcome the safety margins. The result of errors—weakened slings, damaged splices, etc.—can have their effects long after the original error is made. The results can be worse than “outrageous.” They can be disabling, or even fatal.

Adapted from: “Slings and Errors,” February 1982, National Safety News.

V. BASIC RULES OF HITCHING AND RIGGING

A. Know Rated Capacity

Be sure the sling you intend to use is strong enough for the job. Know the weight of the load. Bear in mind that various hitches have different rated capacities. Complete charts of rated capacities for various slings and fittings are given in the Wear-Flex catalog. That chart is also available free in wall chart size and pocket size, to make the ratings easy to find. If in doubt, check it out.

B. Keep Load Under Control

Use a hitch that will keep the load under control at all times. A hitch that allows the load to become unbalanced or to rotate introduces the possibility of losing control and thus causing an accident.

C. Prevent Sling Damage

It is often said that a rigger is as good as his tools. Take good care of your slings.

Use sliding sleeves or other forms of sling protection when the sling must touch sharp edges. Remember: If the sling isn't protected, can your feet be far behind?

D. Lift Loads Carefully

Accelerate lifting devices smoothly. Don't jerk the load off the ground. Jerking can produce terrific shock loads to the sling ... often loads greater than the rated capacity of the sling. It could break the sling.

E. Keep Load Balanced

Always try to lift the load in a level position, with the crane hook directly over the center of gravity of the load. Careful adjustment of the lengths of the various legs is necessary to do this, but it pays off in excellent control of the load.

F. Know the Condition of Your Slings

Slings, shackles, hooks, and other lifting tools should be examined carefully before each use. Is the sling damaged? If in doubt, throw it out. Remember that crushed sections, cuts, burns, and knots all affect the strength of slings.

G. Use Eyebolts Carefully

Many loads are equipped with eye bolts for easy attachment of the sling. Properly designed eyebolts are excellent when the pull is transmitted to them on a straight line with that of the shank of the bolt. Take care not to pull on eyebolts at a sharp angle. They are not designed to stand side pulls. Use only eyebolts with shoulders for straight lifts or safety hoist rings for straight and angle lifts.

H. Keep Rigging in a Proper Place

Lifting devices should have their proper place. Inside, they should be hung up, off the floor. Outside, nylon slings should have a covered box to keep them out of sunlight. Remember that ultraviolet light damages them without leaving any mark.

VI. COMMON ERRORS IN HITCHING

A. Single Leg Hitches

Single leg hitches, such as the single leg vertical (eye and eye) and the single choker hitch (eye and eye), do not provide optimum control over the load. In these hitches, only one sling supports the load. This is dangerous for two reasons:

- Poor load control
- The possibility of dropping the load because of imbalance

With a single leg hitch, it is difficult to control the level of the load. The rigger must first find dead center to place the sling, but any sudden stop or other erratic action could cause the entire load to fall.

When hitching bundles of material such as pipe, bar stock, angle iron, or re-bar rods, it is much safer to use a double wrap or "full wrap" choke. Another way is to use an endless sling, which gives the user the option of spreading the legs that are around the load.

B. Basket Hitches

Basket hitches, whether single or double, may be used successfully in a variety of applications. However, they have inherent limitations, as illustrated in Figure 10.

Loads should never be turned in a basket hitch. This might cause relative motion between load and sling, which may result in serious damage to both.

C. Double Choker Hitch

When turning a load, always use a choker hitch. The doubled choker hitch is preferred by many good riggers because it is twice as strong as a single choker hitch, in the same nylon sling material. An endless type sling is ideal for use here, since its legs will always equalize, and both legs will share the load. In an eye and eye configuration, there is a right and a wrong way to secure this choke. See Figure 11.

If the turning hitch is made wrong, the turning action of the load will loosen the hitch causing it to slip. When the hitch is choked correctly, the turning action of the load will keep it tight and prevent slippage. See Figure 12.

Figure 10: Basket Hitches

Figure 11: Double Choker Hitches and Double Wrap Choker Hitches

Figure 12: Proper Load Turning

APPENDIX A. HOIST/CRANE LOG

The U. S. Department of Energy requires the implementation of DOL/OSHA Standards. The Code of Federal Regulations safety standards for overhead cranes (CFR 1910.179) require a signed and dated record for each crane on a number of items. These records must be kept "readily available to appointed personnel."

A log is not required by safety standards but is strongly recommended by EH&S as a convenient means of meeting the requirements. The log is a good way to make the following information available to crane users, along with other records.

Contents of Log

A separate log should be kept for each crane. Each log should address the following:

- *Emergency telephone numbers*
- *Instructions for using the crane*

These instructions should address the following:

- Location of main disconnect switch.
- Location of key for disconnect switch and instruction on lockout procedure.
- Where to store bridge, trolley, hoist hook(s), and pendant when finished using crane.
- Instructions on storing slings and fixtures.
- Other instructions as needed.
- *Instructions for use of log*
 - Only authorized persons who have completed EH&S Course 211 may operate this crane.
 - If you are planning to use this crane, check the log to verify its availability and readiness for use.
 - Make appropriate entry in log.
 - Check hoist limit switches and brakes at beginning of use on each shift.
 - Reserve crane for future use, including inspections, maintenance, and tests. Cancel if not needed.
 - Sign out for present use and expected release time.
 - Record time and initials of person making log entry for any inspection (daily, monthly, C&M), routine use, maintenance, repairs, taking out of service, or return to service.

APPENDIX B. HOIST/CRANE DAILY INSPECTION TAG PROCEDURE

This appendix provides a copy of the C&M Administrative Procedure ADMN-046-C along with a sample copy of the *Hoist/Crane and Secondary Lifting Equipment Daily Inspection Tag* (Figures B-1 and B-2). The procedure provides instructions for filling out the tag by operators and supervisors. All C&M personnel who operate hoists and cranes should be familiar with this procedure.

C&M DEPT PROCEDURE

HOIST/Crane DAILY INSPECTION TAG COMPLETION

UNCONTROLLED

COPY

HILL

BLDG/LOCATION

PURPOSE

This procedure outlines the steps for proper completion of the *Hoist/Crane and Secondary Lifting Equipment Daily Inspection Tag*. The tag is largely self-explanatory, but this procedure explains some of the less obvious parts of each section.

INTRODUCTION

The *Hoist/Crane and Secondary Lifting Equipment Daily Inspection Tag* is to be filled out by the operator every day during every shift that the hoist or crane is in operation. If the hoist or crane is not operated, inspection need not be performed. The inspections are intended to be thorough visual and functional checks of the major hoist/crane components.

APPLIES TO

All licensed LBL hoist/crane operators. *Note: contract personnel must not operate LBL hoists or cranes.*

PROCEDURE TABLE

	STEP	PERSONNEL	ACTION	SPECIAL INSTRUCTIONS
Section I (front side)	1	First Operator	In Section I, either enter a "√", "X", "n/a", or fill the box black, as per the instructions on the tag.	"P/L Tag" refers to the metal proof load tags that are attached to the hoist/crane. Do not operate a hoist/crane that has no proof load tag.
	2		Check that proof load tag has current quarterly sticker.	Do not operate equipment that has an invalid sticker.
	3		Check that slings, strongbacks have current yearly inspection stickers.	
Section I (back side)	4	First Operator	Enter in the "Special Hoist/Crane and Secondary Lifting Equip. Features" box any component or subcomponent specific to the hoist/crane and not covered elsewhere.	
	5		In the "Notice of Defects and Operator Inspection Signoff" section, either initial the box for "no defects found," or blacken that box and initial in the box above.	
Section II	6	Each Operator	In Section II, verify steps 1 through 6 and initial in the appropriate box.	If the first operator uses the crane a second time in the shift, he must complete this section again.
	7		Immediately notify supervisor of any defects found.	
Section III	8		Enter in section III any brief comments about inspection items that cannot be checked or remarks that are warranted for any reason.	
Section IV	9	Supervisor	Use Section IV to describe any defects and to identify the individual contacted for corrective action.	Report any defects to crane/hoist office, x5865.
	10		When hoist/crane is ready for use, sign in "OK TO USE" box.	

ADMN-046-C	PROCEDURE NO.	DATE OF LAST FIELD VALIDATION	9/29/92	REVISION	10/7/92	PAGE	1 of 1
APPROVAL <i>[Signature]</i> C&M DEPT HEAD SIGNATURE		DATE 11-2-92		VALIDATED BY K. Dallman		REVISIONS TO: B. Bagnoli W.F. Young D. Weber W. Steele	

[illegible]

II. EVERY HOIST OPERATOR (INCLUDING THE FIRST HOIST OPERATOR)

[illegible]

III. REMARKS

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<p>VERIFY REMOVAL FROM SERVICE OF ANY REPORTED DEFECTIVE HOIST OR ACCESSORY. VERIFY CORRECTIVE ACTION HAS BEEN REQUESTED FOR ANY MAINTENANCE OR MODIFICATIONS NEEDED. LIST EACH HOIST DEFECT, DISPOSITION, CORRECTIVE ACTION & REINSPECTION SIGNOFF BELOW. MAINTAIN INSPECTION RECORDS FOR EACH HOIST/CRANE FOR A MINIMUM OF 4 YEARS.</p>					
DEFECT DATE	DESCRIPTION OF DEFECTS AND CORRECTIVE ACTION TAKEN	SUPERVISOR DISPOSITION	CORRECTIVE ACTION		OK-TO-USE SIGNATURE
			INITIATED	COMPLETE	

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Figure B-2: Hoist/Crane Daily Inspection Tag (back side)

<p>HOIST. With forearm vertical, and forefinger pointing up, move hand in small horizontal circle.</p>	<p>LOWER. With arm extended downward, forefinger pointing down, move hand in a small horizontal circle</p>	<p>BRIDGE TRAVEL. Arm extended forward, hand open and slightly raised, make pushing motion in direction of travel.</p>
<p>TROLLEY TRAVEL. Palm up, fingers closed, thumb pointing in direction of motion, jerk hand horizontally.</p>	<p>STOP. Arm extended, palm down, move arm back and forth.</p>	<p>EMERGENCY STOP. Both arms extended, palms down, move arms back and forth.</p>
<p>MULTIPLE TROLLEYS. Hold up one finger for block marked "1" and two fingers for block marked "2." Regular signals follow.</p>	<p>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).</p>	<p>MAGNET IS DISCONNECTED. Crane operator spreads both hands apart, palms up.</p>

Figure C-1: Standard Hand Signals

APPENDIX D. CALCULATING LOAD WEIGHT ESTIMATE

If the load weight is not known, estimate it as follows. Select one or more figures in Figure D-1 to approximate the shape of your load. Using the formulas given, calculate the volume of the load. The LBL rigging book gives the weight in pounds per cubic foot and in pounds per square foot. Therefore take measurements in feet. Using the appropriate density, convert volume of load to weight of load. Do not guess. Know the load weight.

Figure D-1: Load Weight Estimates: Calculating the Areas of Plane Figures

Figure D-2: Load Weight Estimates: Calculating the Volumes of Solid Figures

RIGHT AND WRONG WAYS OF USING CABLE CLIPS

CORRECT
U-Bolt of all clips on dead end of rope

INCORRECT
Do not stagger clips

INCORRECT
U-Bolt of all clips on live end of rope

DOUBLE SADDLE CLIPS (FIST GRIP CLIPS)

PROPER METHOD OF INSTALLING CABLE CLIPS

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 - nearest loop as possible - U-Bolt over dead end - turn on nuts firm but **DO NOT TIGHTEN**.

Step 3

ALL OTHER CLIPS - Space equally between first two.

Step 4

Apply tension and tighten all nuts to recommended torque.

Step 5

Recheck nut torque after rope has been in operation.

Figure E-1: Correct Installation of Crosby Cable Clips

APPENDIX F. LOAD STABILITY

Unstable loads are sometimes associated with the use of a Spreader Bar with a two cable bridle sling and a four multi-cable sling. Figures F-1 and F-2 illustrate the critical dimensions involved for determining whether a load is stable. The general rule is that "A" must be 1-1/2 times greater than "B" (i.e., $A = 1.5 B$).

Figure F-1: Spreader Bar Configuration

Figure F-2: Four-Legged Sling Configuration

APPENDIX G. ALLOWABLE CABLE AND TOTAL ALLOWABLE SLING TENSILE LOAD

When the mass load (or weight) is known and the rigging is complete, just take the two other measurements shown in Figure G-1 (sling cable length and vertical distance A).

Figure G-1: Component and Resultant Vector Diagram Schematic for Each Cable