LIGO Safety Review

September 25, 1996

Ben Lucas, Safety Officer

Purpose: To provide a means to systematically identify and eliminate or control identified safety risks and to provide an assessment of the safety risks involved in the operational use of LIGO.

Agenda:

1. Review and discussion of the seven hazard reports generated.
2. Discuss the PSI vacuum system hazard reports.
3. Discussion of the Project Safety Plan and Laser Safety Plan
4. Discussion and possible viewing of Safety Training and documentation.
5. Possible tour of beam tube enclosure and vacuum chamber mockups.
6. Review Panel Outbrief.

Panel Members:

Dr. Rich Orr, Chairman, was project leader for the Tevetron Project at Fermilab.
Mr. Tom Beat, Lawrence Livermore Laboratory vacuum equipment background.
Mr. Larry Combes, JPL, considerable systems safety experience.

Documents/Requirements used in establishing operational safety:

o Federal Law
29 CFR Occupational Safety and Health Administration (OSHA) General Industry Standards.
49 CFR Department of Transportation (DOT).

o Standards/Requirements

MIL-STD-882C	Systems Safety Program Requirement
NFPA-75	Fire Protection for Essential Electronic Equipment
ANSI Z136.1	Safe Use of lasers

American National Standards Institutes (ANSI) Safety Standards.
National Fire Protection Association (NFPA) Fire Codes and Handbook Of Fire Protection.
Life Safety Code Handbook.
National Electrical Code (NEC).
Uniform Building Code (UBC), a national and regionally applicable document for facilities
National Safety Council (NSC), Accident Prevention Manual for Industrial Operations.
Toxic Substances Control Act (TSCA).

o Organizations/Guidelines
American Society of Mechanical Engineers.
American Society of Steel Constructors.
American Welding Society.

TABLE 3.1. HAZARD SEVERITY CATEGORIES

Description	Category	Definition
Catastrophic	I	Death or permanent total disability, system loss, major property damage or severe environmental damage.
Critical	II	Severe injury, severe occupational illness, major system or environmental damage.
Marginal	III	Minor injury, lost workday accident, minor occupational illness, or minor system or environmental damage.
Negligible	IV	Less than minor injury, First aid or minor supportive medical treatment type of occupational illness, or less than minor system or environmental damage.

TABLE 3.2. HAZARD LEVELS

Description*	Level	Individual Item
Frequent	A	Likely to occur frequently or continuously experienced
Probable	B	Will occur several times in the life of an item.
Occasional	C	Likely to occur some time in the life of an item
Remote	D	Unlikely but possible to occur in the life of an item
Improbable	E	So unlikely, it can be assumed occurrence may not be experienced

TABLE 3.3. HAZARD RISK ASSESSMENT MATRIX

Hazard Category / Frequency	(1) Catastrophic	(2) Critical	(3) Marginal	(4) Negligible
(A) Frequent	1A	2A	3A	4A
(B) Probable	1B	2B	3B	4B
(C) Occasional	1C	2C	3C	4C
(D) Remote	1D	2D	3D	4D
(E) Improbable	1E	2E	3E	4E

Hazard Risk Index	Risk Code Criteria
1A, 1B, 1C, 2A, 2B, 3A	Unacceptable
1D, 2C, 2D, 3B, 3C	Undesirable (Project Manager decision required)
1E,2E,3D,3E,4A,4B	Acceptable with review by Project Manager
4C, 4D, 4E	Acceptable without review

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LIGO System Hazard Report HR Number: 1.0-001

TITLE: Personnel Contact Hazard

SYSTEM/SUBSYSTEM: All Areas of the system.

HAZARD GROUP: Personnel Injury

DESCRIPTION OF HAZARD: LIGO equipment provide hazards that could injure personnel by contact with low overhangs, sharp edges, points, or rough surfaces. Rotating equipment or moveable structure can cause pinch-points or entanglement injuries. Hot/cold spots can cause injuries when they have exceeded acceptable bare hand touch temperatures.

HAZARD RISK INDEX: 3B

HAZARD CAUSE:
1. Low overhangs, sharp edges, points, or rough surfaces.
2. Pinch points or entanglement.
3. Hot/cold spots and areas.

ADDRESSING THE HAZARD:

1.0 CAUSE: Physical personnel injury from facilities or equipment with low overhangs, sharp points, edges or rough surfaces that personnel may come in contact with during operations or maintenance.
1.1 CONTROL: Exposure elimination/mitigation can be accomplished by system design criteria (all metal should be free from burrs and sharp edges per OSHA 29 CFR 1910.219, i.e. rounded edges & corners or covers etc.). Marking of hazardous areas that would generate personnel injury shall be accomplished during acceptance of facilities/equipment thus controlling access to hazardous areas to make them inaccessible during personnel operations, or provide permanent protective coverings. An evaluation may be performed to determine the most cost effective way to prevent exposure, i.e. personel protective equipment (hard hats, gloves, safety toe shoes, etc.). Areas that require occasional access may have temporary covers, blankets, gloves, etc., that are placed and removed during personnel operations to meet the exposure control.
1.2 VERIFICATION: QA shall make this a special interest inspection item. The inspection shall locate areas that require protective measures to be accomplished or required (i.e. tape, covers, blankets, etc.). The task leader and safety shall determine the corrective measures to be employed to provide protection to personnel.

2.0 CAUSE: Personnel injury from entanglement, entrapment and/or pinch-points caused by operating/moving equipment.
2.1 CONTROL: All mechanical operating equipment shall have hazardous parts enclosed, proper guarding or keep-out zones for personnel safe operation and maintenance areas as required by OSHA 29 CFR 1910.219. When required for operation and maintenance of equipment, provide such items as catwalks, platforms, ladders, guard rails and identified keep-out zones.
2.2 VERIFICATION: QA and task leaders shall inspect equipment during receipt to determine compliance before acceptance. Prior to operating equipment, review operating procedures to assure that hazard is addressed and controlled. Discovery of non-compliance shall require safety and the task leader to determine the type of corrective measures to be employed to provide personnel protection.

3.0 CAUSE: Uncontrolled equipment temperatures or locations of hot and cold spots that would provide personnel injury from exposure to temperatures greater than 45 deg C (110 deg F) or less than 4 deg C (40 deg F).
3.1 CONTROL: Require equipment to provide covers, insulation or other methods to assure that hot/cold spots exceeding acceptable touch temperatures are not accessible. Locate, identify and mark areas and equipment that provides temperatures extremes outside of the acceptable range. Mark these areas as keep-out zones and provide operational procedures for areas that require occasional access to use temporary insulation covers, gloves, etc., that are placed and removed during personnel operations to meet the exposure control.
3.2 VERIFICATION: QA and task leaders shall inspect equipment during receipt to determine compliance before acceptance. Prior to operating equipment, review operating procedures to assure that hazard is addressed and controlled. Discovery of non-compliance shall require safety and the task leader to determine the type of corrective measures to be used to provide personnel protection.

TITLE: Over pressurization or contamination of Vacuum Areas

SYSTEM/SUBSYSTEM: Vacuum Equipment (Includes Beam Tube)

HAZARD GROUP: Explosion (pressure release), Contamination, Temperature Extremes

DESCRIPTION OF HAZARD: Any vacuum area that will be brought back to atmosphere for entry or maintenance with pressurized control gas has the potential of causing an over pressure condition to possible rupture and/or contaminated with potential for major material damage and loss of LIGO Capability.

HAZARD RISK INDEX: 1C

HAZARD CAUSE:
1. Over pressure due to failure to control purge air during back to ambient procedure.
2. Failure to control flow and pressure of purge air may present a personnel injury hazard, equipment damage and loss of contamination control during vacuum section closure for return to vacuum operation.
3. Contaminated or insufficient air purge allows open vacuum area to become contaminated, providing a risk to the detector system and vacuum system.
4. During local or global high temperatures (i.e. bakeout procedure), failure to control pressure increase of vacuum system while system is closed could present a positive pressure condition that would stress the material in other than expected design mode and could prevent required contamination removal.
5. Failure to remove support equipment and other miscellaneous items that could contaminate the vacuum area when closed for pump down, providing a contamination risk to the vacuum system and detector equipment.

ADDRESSING THE HAZARD:

1.0 CAUSE: Purge air pressure and volume flow present personnel hazard during opening procedure and/or exceeds the vacuum system design pressure.
1.1a CONTROL: PSI Vacuum System - SUGGESTED :: Assure that purge air pressure is positively controlled with systems to prevent over pressure during back to ambient by use of operating procedures, CDS control system and/or automatic relief valves with CDS alarms in case operational procedures are inadequate (temporary or permanent installation). All these steps must keep the vacuum system below the max. positive pressure allowed by design and protect personnel during vacuum system opening procedure.
1.1b CONTROL: Beam Tube System - Beam tube is not normally brought back to ambient and is not planned for opening operations. If back to ambient would be required then a similar operation would be accomplished (only using bottled gas) as is for normally opened areas.
1.2 VERIFICATION: TBD -- Either generate a Operation procedure and/or modify the designed to prevent occurrence.

2.0 CAUSE: Incorrect control of purge air allows loss of contamination control, potential equipment damage and personnel injury during close-up procedure due to over pressurization hazard.
2.1 CONTROL: SUGGESTED :: Assure that purge air pressure is positively controlled with CDS systems to prevent external air flow into open vacuum area and prevent over pressure during system close-up by use of operating procedures and automatic relief valves with alarms in case operational procedures are inadequate (temporary or permanent installation). The combination of controls must keep the vacuum system below the max. positive pressure allowed by design and protect personnel during work within the vacuum system and during the closing procedure.
2.2 VERIFICATION: TBD -- Either Operation procedure or Designed to prevent occurrence.

3.0 CAUSE: Contaminated purge air or allowing of contaminated air causing damage to detector thus requiring parts of the detector to be replaced.
3.1 CONTROL: SUGGESTED:: Assure that contamination is monitored by a redundant CDS system with positive detection of failed monitors with controls to assure that contamination does not enter the vacuum area. PRESENT PLAN:: Has 3 mechanisms ensuring clean air; oil free pumps with intake from LVEA, desiccant drier (molecular sieve removing many different molecules, and charcoal getter. Question, how do we know when this system is not

operating correctly? Also, plan to have a purge gas hydrocarbon monitor. If this is our monitor how do we know if working correctly or do we need to have three so if one reads different then hopefully two read same.
3.2 VERIFICATION: TBD

4.0 CAUSE: During bakeout or other temperature increase, need to control pressure changes to safe levels to prevent damage to vacuum system and assure that contamination removal is accomplished.
4.1a CONTROL: PSI Vacuum System - SUGGESTED:: Assure that pressure changes are known by monitoring with redundant CDS system capability and controlled by some form of redundant method. Monitoring my require three sensors with voting requirements to determine when a sensor needs to be replaced. PRESENT PLAN:: Pressure gauge indicating vacuum, roughing valve indicating open with roughing pump on. Question becomes which of these would stop the bakeout operation? Should it be a procedure or automated? Is any of these items reliable to prevent overpressure and loss of contamination removal?
4.1b CONTROL: Beam Tube System - Beam Tube design would allow a worse case pressure caused by 200C starting at atmospheric pressure without exceeding the structural design safety factor required by ASME design requirements.
4.2 VERIFICATION: TBD

5.0 CAUSE: Miscellaneous items are left in an isolated open part of the vacuum system during normal change out of equipment thus causing damage to detector and depositing of contamination on previously clean areas of the vacuum system.
5.1 CONTROL: SUGGESTED:: Establish checkout, monitoring CDS capability and cleanup procedures that prevent the unwanted items to be closed and evacuated area. Determine if monitoring of pump down by sensors could determine if unwanted contaminates may be present before the area would be opened to the rest of the vacuum system, thus allowing a reentry for search of the contaminate.
5.2 VERIFICATION: TBD

TITLE: Uncontrolled Venting of Vacuum Areas

SYSTEM/SUBSYSTEM: Vacuum Equipment, Beam Tube

HAZARD GROUP: Collision (Includes structural failure), Explosion (pressure release or implosion), Contamination

DESCRIPTION OF HAZARD: Any vacuum area that has an uncontrolled return from vacuum conditions to atmosphere due to incorrect opening of valves, structural failure, seal failure, or puncture/collision damage, has the potential of implosion, and/or contamination with subsequent equipment damage and loss of LIGO Capability. Personnel hazard potential exists if anyone is in the near vicinity of the opening allowing return from vacuum operations.

HAZARD RISK INDEX: 1C

HAZARD CAUSE:
1. Uncontrolled return from vacuum to atmosphere by improper use of tools or support equipment that impact and generate a puncture or other major collision damage with vacuum equipment.
2. Uncontrolled return from vacuum to atmosphere by incorrect opening of valves or damage to valves while working in or having an open chamber.
3. Structural failure under vacuum of any part of the vacuum system and Beam Tube.
4. Seal or port failure of the vacuum system while under vacuum.
5. Fail to control temperature extremes during bakeout, resulting in material failure.

ADDRESSING THE HAZARD:

1.0 CAUSE: Personnel error in working with or incorrectly operating laser systems, tools and equipment that would puncture various parts of the vacuum system (example would be use of a forklift around the vacuum system and running the forks into the bellows or other easily damaged areas).
1.1 CONTROL: NEED:: Pre-operational briefings that review procedures with the workers to increase awareness of the hazards that exist when working on the vacuum system. Generate procedures that limit access of hazardous operational equipment or provide two person control while operating equipment with damage potential near the vacuum system. Installation of floor guides or protective padding to prevent special equipment or sharp tools used near easily damaged vacuum equipment from causing damage. Provide marked-off keep away zones that limits access for hazardous hardware near the vacuum system. Protective cage system should be considered/provided for easily damaged areas such as the vacuum bellows connectors and chamber ports. Monitoring of pressure though out the vacuum system with redundant voting sensor systems (**CDS**) that generates alarms and indication of leak/damage location and allow isolation of the area by valve closure under positive control.
1.2 VERIFICATION: TBD

2.0 CAUSE: Incorrect opening of valves by operational procedures, personnel error, or incorrect computer command brings the vacuum system or portion of the system, to an uncontrolled return to atmosphere.
2.1 CONTROL: NEED TO SHOW:: Positive control procedures must be generated to assure that valve openings are performed as a highly hazardous operation. Either redundant valves or proof of safety factor that valves won't sustain damage to cause failure, have a structural failure and can't open under any pressure differential across the valve. Enough sensors or positive controls (CDS Systems) must be in place to prevent operation of valves with pressure differential across the valve, while portions of system are at atmosphere. Specific operational procedures must be establish to prevent any possible damage to valves when personnel are working near them along with special valve protective equipment that would preclude any possible damage during worker operations.
2.2 VERIFICATION: TBD

3.0 CAUSE: Structural failure of the vacuum system due to incorrect design, incorrect safety factor or failed to manufacture according to design.
3.1 CONTROL: NEED DATA:: Reviewed and approved design of PSI (vacuum chambers, pumps, etc.) and CBI (beam tube) structural analysis of their respective vacuum loads on DATE/MEETING (need to list data package and if we had an outside agency review the analysis). The safety factor for PSI vacuum system is ____(document

number__). CBI safety factor for the Beam Tube is ____ (document number__). Manufactures QC system was reviewed with spot checks by LIGO QC and accepted as providing positive proof that equipment was manufactured as designed (document number___).
3.2 VERIFICATION: TBD

4.0 CAUSE: Seal or port failure due to incorrect installation or failure to detect aging requiring replacement seals or ports.
4.1 CONTROL: Provide scatter shields (protective screens) to be in place when chamber is starting pump down and at all times when chamber is in a vacuum condition. Establish replacement procedures and determine a replacement schedule and damage criteria requiring replacement that will prevent failures under vacuum. After replacement need an operational check of system before laser operations are restarted.
4.2 VERIFICATION: TBD

5.0 CAUSE: Bakeout procedure exceeds Beam Tube and vacuum system material temperature capability or allows local hot spots, resulting vacuum system structural failure either during bakeout or after during operation.
5.1 CONTROL: Establish that the bakeout procedure is a high risk seldom accomplished special procedure that requires a special safety review (requires safety hazard analysis) each time it is to be accomplished. The bakeout equipment and procedures requires controls to prevent personnel and vacuum equipment damage(will need to list types of equipment and controls). Monitoring of the vacuum system is needed to assure that structure is not being damaged. Special personnel procedures will be required to prevent electrocution, high temperature damage, possible heat stroke and asphyxiation.
5.2 VERIFICATION: TBD

TITLE: Hazard control of Occupied Facilities

SYSTEM/SUBSYSTEM: Civil Construction Facilities

HAZARD GROUP: Collision or Impact, Explosion (pressure release or implosion) or Fire, Electrical, Environmental or Weather (Lighting, Rain, Wind, etc.), Loss of Environment, Temperature Extremes

DESCRIPTION OF HAZARD: LIGO Facilities have the potential for providing many different hazards for equipment and personnel. For evaluation purposes these have been bought together under one hazard report for evaluation and control due to the design contractor responsibility and the specific design requirements for civil construction facilities.

HAZARD RISK INDEX: 2C

HAZARD CAUSE:
1. Facility Operating procedures not followed.
2. Proper Facility design practices not used.
3. Failure to discover and correct the non employment of required Facility safety design features.
4. Failure to monitor (by CDS?) various facility safety systems (i.e. fire, oxygen content, power , temperature, air flow, etc.).

ADDRESSING THE HAZARD:

1.0 CAUSE: Personnel injury and equipment damage may occur during operations due to failure to follow applicable operating procedures in the corner, mid and end stations.
1.1 CONTROL: Safety and QC review facility operational instructions and assure that they are in place and personnel have been trained in the facilities various functions.
1.2 VERIFICATION: TBD

2.0 CAUSE: Failure to use the correct safety design requirements.
2.1 CONTROL: During facilities design the contractor (Parsons) used the Uniform Building Code, NFPA 101 Life Safety Code and applicable OSHA requirements.
2.2 VERIFICATION: The Facilities Final Design Requirements review held on April 26, 1996 and supporting documentation verify that the proper requirements have been incorporated into the facilities design.

3.0 CAUSE: LIGO Management, Safety and QC failed to discover or assure that correct safety design features were employed during the design and build process.
3.1 CONTROL: All applicable personnel are required to review the Facilities Final Design Requirements and verify that the design implements the safety requirements. QC and the facility manager will perform a receiving inspection to assure that the as built did incorporate the design requirements.
3.2 VERIFICATION: Facility receiving inspection on TBD date under document number TBD.

4.0 CAUSE: Non-monitoring of the various facility safety systems allows personnel injury and loss of observatory equipment.
4.1 CONTROL: Emergency response training and CDS monitoring of the various safety systems for alarms allowing response times to prevent loss of non-replaceable equipment and possible injury and loss of life.
4.2 VERIFICATION: Emergency response procedures, numbers ____ in place and documented recurring safety training in document number ___ . CDS modified to incorporate monitoring of facility safety systems to provide the proper alarm and response to consider automated response systems.

LIGO System Hazard Report HR Number: 1.1-005

TITLE: Confined Spaces

SYSTEM/SUBSYSTEM: Facilities and Vacuum Systems

HAZARD GROUP: Loss of Habitable Environment (high levels of dust/sand or water, mold, living/dead critters), Weather Extremes (Lighting, Rain, Wind, etc.), Temperature Extremes, Explosion or Fire

DESCRIPTION OF HAZARD: Any enclosed area that has an unknown or uncontrolled environment with continuous operating equipment or requires entry by personnel may allow hazards of asphyxiation, flammability, and temperature extremes to occur over time causing a potential loss of equipment or personnel injury.

HAZARD RISK INDEX: 1C

HAZARD CAUSE:
1. The Beam Tube Enclosure (BTE) is a large above ground tunnel type facility that does NOT have any environmental controls or requirements to meet the Uniform Building Code or the NFPA 101 Life Safety Code.
2. Powered equipment in enclosed/confined space (i.e. BTE) that is not environmentally controlled or not properly isolated from lighting generated EMI or line spikes, can have equipment damage potential and an explosive/flammability hazard.
3. Personnel exposed to weather extremes while going to, from, or inside the confined space can suffer personnel injury and unprotected checkout equipment may receive damage causing operation disruptions and costs to project.
4. Loss of habitable environment due to use of LN2 within the various facility areas.

ADDRESSING THE HAZARD:

1.0 CAUSE: No control of the BTE environment presents personnel injury hazards due to possible loss of habitable environment.
1.1 CONTROL: Shall acquire and use from Caltech Safety the Caltech Confined Space Program (Caltech Document Dated May 14, 1996) to define and control entries into the BTE with specific entry and operational procedures (LIGO Procedure # TBD) and a security system that notifies of unauthorized entry with emergency response procedure (LIGO Procedure # TBD). **SUGGESTED:** Need to consider using CDS monitoring of various areas to include the BTE areas before entry procedures are to be used.
1.2 VERIFICATION: TBD -- QC review procedures.

2.0 CAUSE: No environmental control in the BTE enclosed space with electronic powered hardware introduces possible equipment damage and a potential flammability hazard.
2.1 CONTROL: Design the installed electronic hardware to survive the worst expected conditions and/or have it power down when conditions are outside its operating parameters. There can not be any safety critical equipment or readings required unless this equipment is redundant and can survive the worst case environment. **SUGGESTED:** Consider CDS monitoring and possible control of equipment in these areas to allow shutdown (automatic) when the equipment is outside its' design parameters.
2.2 VERIFICATION: TBD -- As a minimum will require testing and QC verification of results.

3.0 CAUSE: Personnel and hardware damage can occur due to exposure to weather extremes (lighting, hail, etc.).
3.1 CONTROL: The OSHA 29 CFR defines unacceptable conditions for working due to weather conditions and would prevent transitioning to or working in areas that have been documented as an unknown or uncontrolled environment condition not normally occupied (i.e. confined Space). Establish an operating procedure(s) that will prevent personnel exposure to hazardous weather environments. **SUGGESTED:** Consider using CDS to monitor weather conditions and provide go/no-go for personnel and equipment exposure.
3.2 VERIFICATION: TBD -- QC review procedure(s) to assure that personnel exposure is controlled.

4.0 CAUSE: There is enough LN2 stored on site to deplete oxygen from closed areas or parts of areas as the LVEA/VEA if uncontrolled flow rates occur, creating a personnel asphyxiation injury hazard.
4.1 CONTROL: Position tested and certified oxygen monitors in all locations that could be potential asphyxiation areas. Tie the monitors into the CDS for remote detection and determination when calibration is required.
4.2 VERIFICATION: TBD -- QC verify calibration dates.

TITLE: Observatory Laser Operations

SYSTEM/SUBSYSTEM: Interferometer Design, Laser Systems, Vacuum Equipment

HAZARD GROUP: Radiation, Contamination, Mechanical

DESCRIPTION OF HAZARD: Operational laser systems improperly used can cause personnel injury and/or vacuum system material damage and contamination with potential for major material damage and loss of LIGO Capability.

HAZARD RISK INDEX: 1C

HAZARD CAUSE:
1. Lack of Laser Safety Program.
2. Failure to follow a laser safety program.
3. Failure to generate required operational laser procedures using certified and qualified personnel.
4. Procedures were not written to consider all possible hardware damage before laser is powered.
5. Failure to follow operational laser procedure causes possible damage to vacuum and other miscellaneous equipment (gate valves, beam tube, chambers, laser equipment, etc.)

ADDRESSING THE HAZARD:

1.0 CAUSE: Failure to have a laser safety program allows uncontrolled use of lasers with potential for personnel injury and hardware damage.
1.1 CONTROL: LIGO Safety must generate a usable Laser Safety Program document acceptable to LIGO Management.
1.2 VERIFICATION: Completed, reference document number LIGO-M960001-A-P, dated March 25, 1996.

2.0 CAUSE: The Laser Program is not supported by management or workers thus, safety procedures are not established and followed, allowing the potential for personnel injury and hardware damage.
2.1 CONTROL: Reviews and updates are needed by the areas required to operate under the rules of the laser safety program followed by revisions of the program to assure that the program is functional and operational.
2.2 VERIFICATION: Management briefings are provided during the regular program reviews for identification of problem areas along with checks by Safety and QC to determine how well the Laser Program is being implemented.

3.0 CAUSE: Operation of laser equipment without operational procedures allows equipment damage and personnel injury.
3.1 CONTROL: Laser systems will NOT be allowed to be powered without an approved laser operating procedure. Any certified/qualified laser personnel will lose their certification if discovered operating a system without approved procedures.
3.2 VERIFICATION: Safety, QC, and all levels of management are responsible to verify and control this hazard and shall decertify any laser operator not in compliance with the LIGO Laser Safety Program.

4.0 CAUSE: Hardware damage occurs to vacuum system (gate valves, etc.) and/or other equipment because laser procedure did not consider collateral equipment damage.
4.1 CONTROL: Safety and QC must review operating procedures to assure that all hazards have been considered. Requires a formal approval process before procedure may be used, as required by section 4 and 5 of the Quality Assurance Plan.
4.2 VERIFICATION: QC with Safety support would be the lead for establishing an approval control process.

5.0 CAUSE: Laser operational procedures not followed or updated allows personnel and equipment damage.
5.1 CONTROL: The QC organization shall follow section 5 of the Quality Assurance Plan for in-process inspections. Any discrepancies shall be corrected before continued use of the operational laser procedure may occur.
5.2 VERIFICATION: Management support of QC and use of Quality Assurance Plan with proper documentation.

TITLE: Observatory Heavy Lift Operations

SYSTEM/SUBSYSTEM: All Areas of the System

HAZARD GROUP: Injury, Collision or Impact, Mechanical

DESCRIPTION OF HAZARD: Heavy lift operations (greater than 35 lbs) improperly performed can cause personnel injury and/or LIGO equipment material damage with potential for major material damage and loss of LIGO Capability.

HAZARD RISK INDEX: 1C

HAZARD CAUSE:
1. Facility bridge crane improperly designed/sized and built for required lifting allowing damage to crane and transported equipment.
1.0a Crane improperly (no operating/checkout procedures) used by untrained and uncertified personnel allowing personnel and equipment to be damaged due to incorrect lifting and moving operations.
2. Forklifts improperly sized for load or to large for the facility operating area may cause damage to the facility.
3. Failure to have lifting devices for smaller loads (i.e. 35 to 300 lbs) that are generally considered to small for standard size forklift may cause injury to personnel and equipment damage.

ADDRESSING THE HAZARD:

1.0 CAUSE: Bridge crane not designed or built to meet lifting requirements for facilities.
1.1 CONTROL: The civil construction for facilities Design Configuration Control Document final issue and OSHA standard number 1910.179 provide the requirements that the facility crane must meet to provide the defined lifting capability.
1.2 VERIFICATION: QC and Safety during facility acceptance must inspect the crane(s) to assure that they meet LIGO document number LIGO-C961574-00-0 and OSHA 1910.179 for lifting ability and standard crane requirements.

1.0a CAUSE: Lack of or not in use operating procedures and/or uncertified operating personnel can damage crane and equipment transported.
1.1a CONTROL: Assure that operating personnel are trained and certified for specific lifting devices and that operating procedures are present at each piece of lifting equipment.
1.2a VERIFICATION: QC and Safety will periodically (annually, minimum) have to review lifting devices and personnel certifications. QC and Safety shall verify that operating procedures have been reviewed, updated and current on a annual basis at a minimum.

2.0 CAUSE: Wrong forklift for the job may damage equipment and facility.
2.1 CONTROL: Assure that weight marking is on all movable equipment and procedures are in place that define the correct lifting/forklift equipment for the moving operation.
2.2 VERIFICATION: QC and Safety have to review and certify that only specific forklifts and other lifting equipment is available and located on site. Assure that movable equipment is weight marked.

3.0 CAUSE: Movable equipment greater than 35 lbs allow personnel injury and equipment damage.
3.1 CONTROL: Assure that equipment heavier than 35 lbs is marked with weight and the statement that lifting hardware is required for movement. Assure that lifting hardware is available at all times equipment movement is required. Hardware procured over this weight limit must have lift gear as a part of the procurement or proof that it can be handled by the other lifting hardware already available on site.
3.2 VERIFICATION: QC and Safety have to review all movable equipment (including test gear) with specific consideration for equipment within the 35 to 100 + lbs range to assure they are marked properly and that they have lifting hardware for their movement about the facility.