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Advanced LIGO Supplier Quality Requirements

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LIGO Scientific Collaboration

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1. Quality Program Guideline

1.1. Purpose of this Document

The purpose of this document is to provide guidance, requirements and general procedures for a Quality Assurance and Quality Control program (QA/QC) as it applies to procurements and contracted effort. It provides recommendations on the policies and phrases to be used in all “Request for Proposal” (RFP) or “Request for Quote” (RFQ) solicitations to be sent to prospective suppliers and vendors for Advanced LIGO components, parts, or services. The audience for this document is the LIGO technical and procurement staff. Example language (templates) are also provided in the appendices for use by LIGO staff in tailoring for a particular RFP, RFQ, contract or Purchase Order (PO).

Advanced LIGO is a project undertaken by the LIGO Laboratory (or simply ‘LIGO’). LIGO is a joint effort of the California Institute of Technology (which is the contractually responsible organization) and the Massachusetts Institute of Technology.

This document is intended for use when the supplier is manufacturing and/or assembling components, or providing services, which require a LIGO review of the supplier QA/QC monitoring. LIGO engineering, projects, procurement and QA teams will make determinations on the applicability of this document on a case by case basis.

1.2. Purpose of a Quality Program

A Quality Program is a framework for ensuring completeness, correctness, reliability and maintainability of a system and its components. The specific goals and deliverables of a Quality program for Advanced LIGO are:

- 1.2.1. All designs are to be carefully reviewed and finalized through an Advanced LIGO Design Review process.
- 1.2.2. The supplier has an accurate and complete set of design specifications, drawings, and material and performance characteristics.
- 1.2.3. The supplier maintains an internal quality program to ensure systems are fabricated, assembled, and tested to specifications provided by LIGO.
- 1.2.4. The supplier ensures appropriate workmanship, including but not limited to certification, safety, handling, cleanliness and documentation.
- 1.2.5. The supplier will provide appropriate packaging and shipping methods to protect the component(s) from damage in transit.
- 1.2.6. The supplier shall provide reliability estimates, maintenance procedures and schedules, if applicable.

1.2.7. Both LIGO and the supplier may, in general (depending upon the particular aspects and criticality of the effort), participate in pre-award audits, in process inspections; post-assembly and post-install inspections and acceptance testing. Enable LIGO and the supplier to establish specific expectations, and mechanisms, up front on remedying issues which arise during fabrication and testing, where the component does not meet design, assembly or performance specifications due to improper manufacturing, faulty sub-components, or improper fit or performance of critical interfaces, or improper packaging and shipping methods. An example is a Material Review Board (MRB)

1.3. Relevant Documents

LIGO-E010613-02, Generic Requirements & Standards for Detector Subsystems [in particular section 9]

LIGO-M960076-A, LIGO Project Quality Assurance Plan

LIGO-E030350-A, Drawing Requirements

LIGO-M080036-01, Advanced LIGO Project Procurement Guidelines

LIGO-M050220-09, Guidelines for Advanced LIGO Detector Construction Activities

LIGO-E960022-B, LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures

2. Procurement Process

2.1. Pre-Procurement Activities

RFPs and RFQs shall be written to use contractor/vendor existing QA systems to the fullest extent possible consistent with the provisions outlined in LIGO Quality Assurance Plan M960076-P. Should a contractor lack an existing quality system, the contractor shall develop a quality assurance plan in compliance with the requirements negotiated at contract award.

2.2. LIGO Procurement Documentation

LIGO will provide the supplier with the following documentation in support of the bid process (if and as applicable):

- 2.2.1. Technical documents, drawings, and specifications, identified by revision.
- 2.2.2. Preservation, packaging, storage, and shipping requirements.
- 2.2.3. Requirements for component longevity.
- 2.2.4. Specific Inspection and Test requirements.
- 2.2.5. End Item Data Package requirements.
- 2.2.6. Requirements for source inspection by customer.
- 2.2.7. Safety Performance requirements.

2.3. Supplier Bid Package Requirements

As part of the bid package, and for consideration in contract award, the supplier shall confirm the intent to comply with the following Quality Program requirements (if and as applicable):

- 2.3.1. Provide with the deliverables all supplier-generated technical documents, drawings, and specifications, identified by revision, with all red line items updated in electronic format (source files and Adobe Acrobat) for the as-built system or component.
- 2.3.2. Adhere to all shipping, packaging and cleanliness requirements as required in the Advanced LIGO design documents.
- 2.3.3. Submit all tests and inspection reports to LIGO immediately following completion, in agreed upon electronic format.
- 2.3.4. Fulfill requirements for source inspection by customer, which can include a pre-award inspection, in process audits, as well as a pre-ship inspection.
- 2.3.5. Provide a copy of their existing QA/QC program, with a strategy for implementing in conformance to Advanced LIGO requirements, if necessary.

3. Manufacture, Assembly and Receiving Inspection Requirements

3.1. Pre-Award Inspection

Prior to contract award LIGO staff may perform an audit of the prospective supplier quality programs. The need to perform an audit will be determined by the Contracting Officer's Technical Representative (COTR), the subsystem leader and/or the chief engineer, based on criticality, cost, and use case of components. The audit scope includes but is not limited to:

- Calibration program review.
- Maintenance and reliability programs for manufacturing equipment.
- Critical worker certification levels (i.e., welding, electrical, CNC, etc.).

- Supplier QA/QC program and how it will be implemented for Advanced LIGO contracts.
- Manufacturing methodologies, especially as regards cleanliness and use of approved materials and fluids.
- Cleaning and packaging methodologies compared to RFP/RFQ requirements.

3.2. Supplier in Process Quality Control

Critical processes shall be controlled using manufacturing travelers or procedures established and qualified prior to LIGO equipment production. As an example, these manufacturing procedures shall include:

- Equipment to be used including calibration requirements.
- Identification of operational constraints.
- Workmanship standards.
- Call-outs for inspections, tests, and other verification processes.
- Acceptance criteria.

3.3. In Process Inspection

In-process inspections shall be performed where subsequent assembly stages will prevent/limit inspection access, and to detect defects early in the process. In-process inspections shall be identified in fabrication and assembly by planning Mandatory Control Points (MCPs). Suppliers shall document all deficiencies and discrepancies, and report immediately to LIGO. Electronic format, via email transmission, is the preferred method of report delivery.

3.4. Pre-Shipment Inspection

Supplier shall inspect and validate system integrity prior to shipment of equipment to any LIGO site. LIGO may choose to send a representative to participate in inspections deemed critical. Pre-shipment inspection of equipment to be delivered to the LIGO observatories shall include the following (as appropriate):

- End Item Data Package review.
- Certificate of Compliance, where required.
- Shipping documentation such as the manifest or shipper.
- LIGO property control documentation, when LIGO materials are in possession of a supplier.
- Verification of the adequacy of the shipment packaging and weather protection.
- Evidence of contractor quality assurance acceptance.
- Evidence of safety requirements compliance.
- Verification that transportation environmental controls and monitoring requirements will be satisfied.

3.5. Receiving Inspection

Receiving inspection will be performed to ensure that articles procured by LIGO, or its suppliers, conform to contractual or procurement document requirements prior to release of payment to supplier. This will be a time-critical activity. Receiving inspection includes the following (as applicable):

- Inspection of incoming hardware and documentation for compliance to applicable Drawings, Specifications, and/or other documentation specified by the procurement documentation.
- Evidence of acceptance by contractor/supplier inspection.
- Evidence of source inspection acceptance as applicable.
- Identification of deviations from requirements specified in the procurement documentation.
- Securing dispositions of discrepant materials.
- Verification that equipment complies with shipping, handling and safety constraints.
- Identification of hardware acceptance status with appropriate labels.
- Documentation of receiving inspection, one copy stored at site and a second sent to procurements for potential release of payments, shall be completed by LIGO personnel.

3.6. Discrepant Material

When an article does not conform to applicable engineering design documentation it shall be identified as non-conforming. It shall be segregated from on-going work operations, and held for further action. When a discrepancy has been identified and documented it shall be reported immediately to the responsible LIGO science or engineering personnel and the LIGO Quality Assurance Officer.

Only LIGO personnel responsible for the item submitted to the discrepancy evaluation process, or their designees are authorized to issue dispositions for the discrepant item. Initial discrepant hardware dispositions include the following:

- Rework to drawing or specification.
- Repair: Articles that are modified to a useable state but remain nonconforming to drawing or specification requirements.
- Return to vendor.
- Use-as-is: Articles that are useable in the present state without further processing.
- Suspended Action: Articles of which resolution is determined after drawing or specification change, or after hardware fit check.
- Scrap.

LIGO quality assurance representative concurrence is required for all LIGO science or engineering personnel discrepant material dispositions.

3.7. Material Review Action

The Material Review Action shall determine dispositions of nonconforming articles that cannot be resolved by the initial discrepant hardware disposition. For discrepant articles submitted to Material Review Action the LIGO Project Manager shall, with the concurrence of the LIGO Quality Assurance Officer, determine the final disposition.

3.8. Material Review Actions at Contractor

Material Review Actions conducted at a contractor are the responsibility of that contractor. LIGO personnel will not participate as members of the contractor's Material Review Board. However, Contractor Material Review Actions will be subject to review and concurrence by LIGO engineering and quality assurance personnel. Contractor Material Review Actions shall become a part of the EIDP.

3.9. Discrepant Material Storage

Discrepant Material shall be identified and to the degree possible, separated from acceptable material until the disposition action has been completed.

3.10. Quality Records

The LIGO Quality Assurance Office will maintain quality records which provide evidence of inspections, tests, as built configuration, and Material Review Actions.

The LIGO Project Office will establish a facility and procedures for the long term storage of LIGO project QA documentation and other related records. Satellite record storage facilities may also be established at the observatory sites for equipment or materials located at or peculiar to the site. This data shall be maintained for at least the duration of the 20 year operational life of the observatories.

3.11. Drawing and Specification Change Control

All drawings and specifications will be controlled by the suppliers Quality Assurance Department, including receipt and distribution. Upon receiving the order/contract, all drawings will be verified as to correct number and revision.

All such documents shall be marked to indicate that they have been included in the system. Supplier shall ensure distributed copies of master documents must be marked as controlled or uncontrolled. Controlled documents should be numbered serially (1,2,3...n) and recorded in the contract file.

A controlled document must be kept updated at every document change or engineering change. The contract administrator under the guidance of QA will insure that all controlled documents, whether in house or out, will be updated.

Controlled documents must be returned to QA or the contract administrator at the end of their use. At that time they will be removed from the controlled list.

The supplier shall take appropriate measures to control obsolete and uncontrolled documents from contaminating the contract work. This includes a method of marking, checking out, or destroying.

Upon receipt of drawing and specification changes, the supplier Quality Assurance or other appropriate personnel will remove obsolete drawing specification and issue the latest drawing specification to proper personnel. Obsolete drawings will be marked “obsolete” if needed for record or destroyed.

3.12. Welding Certifications

For any work on Advanced LIGO parts or components that requires welding, Caltech will require any contractor to supply certifications for the welders performing the work. Certifications must show valid dates, as well as certified welding type/class for the work to be done. All welders who will be performing work will be required to be certified for the work, and samples of work may be requested.

3.13. End Item Data Package

The end item data package is the set required documents to be supplied to LIGO upon delivery of ordered parts or services, which may include but is not limited to the following items:

- As Built Modifications (with approval of the LIGO Contracting Officer) as markups to the drawings
- Material Certifications
- Dimensional and QC reports, including all test procedures and results
- Certificate or Statement of Compliance with all contract and process restrictions
- Welding Certifications

Specific items above pertinent to a given contract will be called out in the statement of work, as well as any additional EIDP requirements not listed above.

4. Supplier Quality Assurance Review: Definitions

4.1. Design Verification

At appropriate stages of the design process, design verification shall be performed to ensure that the proposed design meets the requirements (see M0500220). This will normally be accomplished through the Design Review process. However, additional design verifications may be instituted where critical elements are involved, or where a potential for errors may have significant impact to functional performance, cost or schedule. In particular if a supplier/contractor/vendor is tasked with design effort, LIGO must plan to review the delivered design before authorization to fabricate.

4.2. Raw Material Procurement

Suppliers of raw materials shall provide certifications and country of origin indicating that materials being provided are in compliance with requirements specified in the procurement documents. Reports of chemical and physical tests are required for critical usage materials to verify conformance to applicable specifications and drawings.

4.3. Traceability of Materials

Materials considered critical for LIGO observatories' successful operations, or used in the vacuum system, shall require identification and country of origin by lot, batch or production run. Materials process records shall be delivered by the supplier and retained in the LIGO Documentation Control Center. Questions regarding traceability requirements for specific items should be directed to the LIGO Quality Assurance Officer.

4.4. Calibration Program

The supplier shall maintain a calibration program of all instruments and tools requiring calibration. Schedules of calibration shall be in accordance with the instrument or tool manufacturers' recommendations. Labels on the instrumentation and tools or their cases shall be in plain view, and have a calibration record referenced to a report on file with the supplier, as well as a date of performed calibration, due date for next cycle, as well as a signature and disposition of calibration (pass or fail). All instruments that have failed calibration will be required to have on file a document showing repair, repair facility, reason for out of spec, and recalibration report showing unit has passed. Out of calibration is defined as a device that is not only out of spec on measurement accuracy, but also one that may function properly but has not sustained an up to date calibration certification.

4.5. Critical Interfaces

A Critical Interface is defined as that particular junction between systems or components which have a specific design characteristic and/or requirement, which are critical to the proper function of the overall LIGO system. If these design requirements or characteristics are not met then there could be an increased likelihood of improper functioning, system failure, and/or damage to itself and/or other attached systems or components. It is the responsibility of the LIGO teams to identify and call out all critical interfaces in the design documents and drawings, and to ensure that appropriate standards of inspection and testing are applied to the systems at these interfaces.

The supplier shall perform levels of inspection as defined by the LIGO teams during the manufacturing and assembly process, including verification to design specifications and (if appropriate) interface tests for fit, function and/or performance. Development and performance of the test plan will be in accordance with the negotiated contract, and the final test plan will be reviewed by the supplier and the LIGO team(s). The supplier shall provide LIGO teams with the results from all tested critical interfaces, and the LIGO team(s) shall work with the supplier to assess the results and review discrepancies and proposed solutions.

4.6. Cleanliness

All components are to meet cleanliness standards as outlined in the technical documents provided to the vendor. Cleanliness and contamination control will be particularly sensitive with systems and components installed in the vacuum chambers. As part of the bid package, all suppliers of in-vacuum components must include detailed plans for achieving and maintaining cleanliness of manufactured items during the manufacturing process, through the final cleaning process, as well as processes to maintain this state during transport and storage.

4.7. Packaging

Guidelines shall be developed for packaging to provide sufficient protection for LIGO equipment from the point of manufacture to the delivery at the LIGO observatory sites. Suppliers must ensure that all packaging will meet requirements as defined in the RFP or RFQ, and any deficiencies are reported immediately to LIGO representatives. This includes packaging to protect against environmental, shock, transport noise and vibration, as well as protection from ESD and contamination as required in the negotiated contract or PO. LIGO staff will inspect all packaging upon arrival at a LIGO facility for damage and deficiencies. Note that components and assemblies which have been cleaned for in-vacuum service have special packaging requirements as defined in E960022.

All packaged items shall have appropriate labels attached to properly identify the following:

- Destination Site
- LIGO Subsystem team
- Boldly identify components as clean or environmentally sensitive to prevent opening and contamination in receiving area.
- List any special handling notifications or warnings
- LIGO Contact person and information
- Part ID, serial number or other identifying data
- Shipping manifest with long text description of enclosed items

4.8. Storage

Supplier shall protect system or components against environmental damage or unauthorized personnel access prior to shipment of finished goods. All items shall be stored with appropriate labeling to ensure removal from storage and transport of item is accurate.

4.9. Transport

Transport of items to LIGO facilities shall be handled via LIGO approved shipper, and will be insured as directed in the LIGO-Supplier's contract. All critical and/or environmentally sensitive items must be shipped in a manner that will minimize damage in transit. Supplier and shipping company shall utilize proper ride mechanism (air ride or other specific suspension types, isolation techniques, etc), container types and handling methods to protect sensitive items, such as optics and electronics, from vibration, shock pulse, impacts and crushing, as defined by LIGO. Shipping containers and the items they contain shall be properly secured for transport to avoid falling and shuffling of goods internally.

4.10. Customs

Customs documentation will be filled out appropriately to ensure proper handling, contamination controls and timely throughput while in possession of customs agents. This includes labeling which clearly defines contents, hazards, valuation and contact information. For all customs requirements please contact Rod Luna at Caltech, email luna_r@ligo.caltech.edu

5. System Integration and Commissioning Inspection Requirements

5.1. System Integration Inspection Process

With few exceptions, system installation, integration and commissioning are LIGO Laboratory responsibilities with no supplier involvement. Final inspection shall consist of the following:

- Verification of the product (subsystem or subassembly) against requirements and test parameters identified as requirements in the subsystem documentation.
- Verification of key physical and interface parameters.
- Verification of Configuration.
- Verification of quality of workmanship.
- Verification of a complete set of as-built documentation

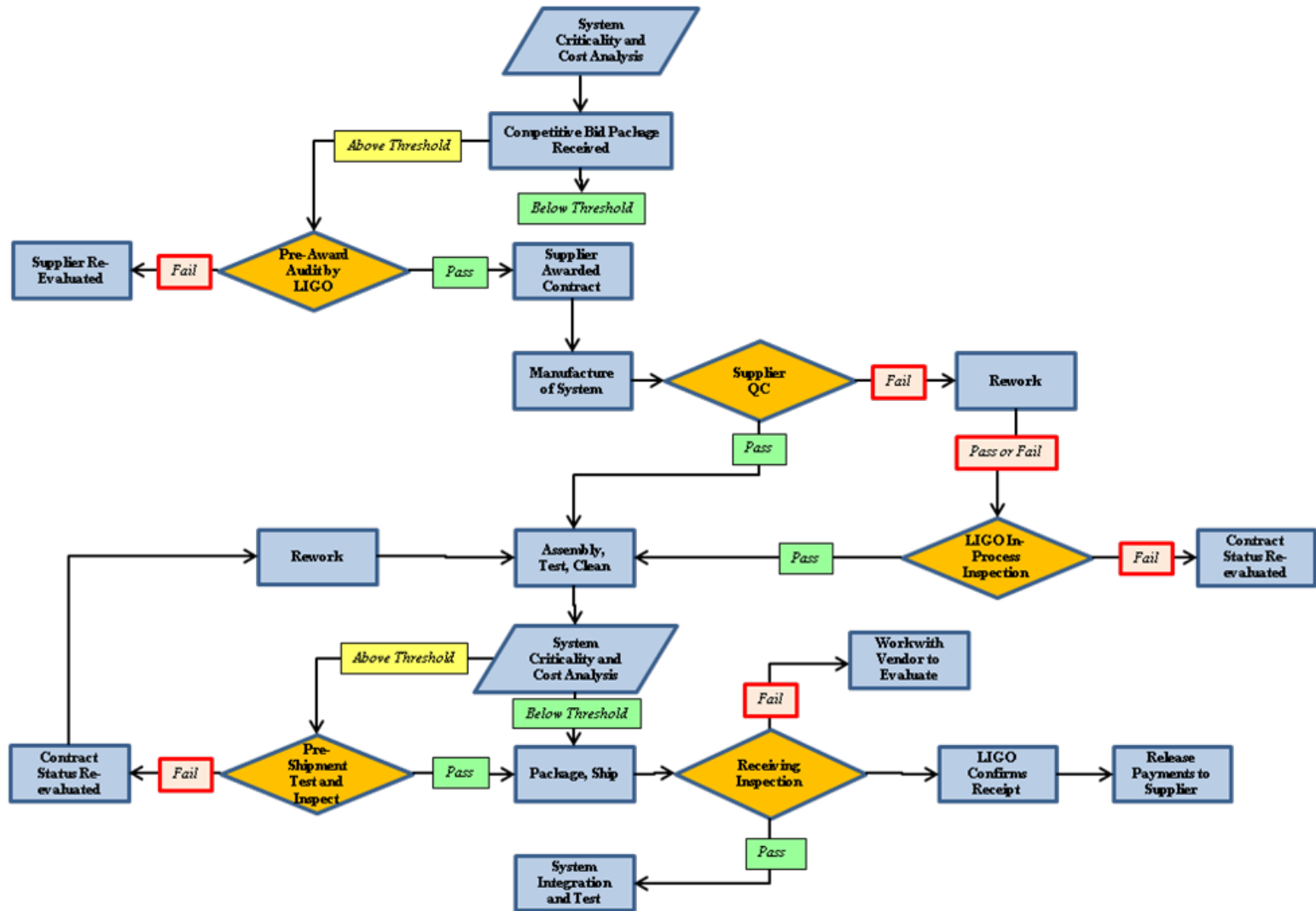
5.2. System Integration Acceptance Test

System integrated acceptance testing is a LIGO Laboratory responsibility. Acceptance testing shall be performed after completion of all required operations. LIGO final acceptance testing requirements are as follows:

- Commissioning acceptance testing plans and reports shall be reviewed and approved (and witnessed if possible) by LIGO QA personnel.
- The test shall be performed in accordance with the current version of the appropriate test procedure.
- Instruments and gages used to determine performance characteristics must be within the range of acceptable calibration parameters, including inspection cycles and tested against known standards.
- Tests shall be conducted in the order specified by the test procedure unless otherwise authorized by responsible LIGO engineering personnel.
- Completed test results shall be documented on authorized summary forms or test data sheets.
- Any deviations from the test procedure or discrepancies noted during the conduct of the test shall be documented.
- If appropriate, and to the extent practical, a post-test inspection shall be conducted of the item under test, for the purpose of identifying and recording any changes that may have occurred as a result of the test.



6. Advanced LIGO QA Inspection Workflow Chart





7. Glossary

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| Quality Assurance | QA is defined as a procedure or set of procedures intended to ensure that a product or service under development (before work is complete, as opposed to afterwards) meets specified requirements. |
| Quality Control | Quality control (QC) is a procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the client or customer. |
| System Criticality and Cost Analysis | Evaluation taken place to determine whether a system being manufactured meets the minimum threshold for applying additional inspection criteria. Example: An in vacuum component may not meet minimum cost levels to add a supplier pre-award inspection; however since it is in vacuum it is a critical item that requires added inspections. Determination of criticality and cost thresholds is set by the LIGO teams. |
| Cost Threshold | A LIGO determined value of a component or system which triggers or precludes an audit or inspection point. LIGO sub-teams will determine this value on a case by case basis, and is evaluated in conjunction with criticality thresholds. In some cases criticality thresholds may require a triggered audit or inspection despite the cost being below a threshold. LIGO has sole determination of these values, however at any time LIGO may require an audit or inspection, and will communicate these to the supplier ahead of time. |
| Criticality Threshold | A LIGO determined level of importance assigned to a system or component. This assignment is based upon factors including but not limited to duty cycle, installation area, redundancy, availability of spares, lead time to manufacture, etc. LIGO sub-teams are solely responsible for assigning criticality levels to components, and will make the determination for inspections and audits based on criticality independent of cost. |
| Pre Award Audit | Audit/Inspection by LIGO performed to determine to ability of a supplier to meet to the system or component manufacturing requirements including QA/QC. Safety, capacity, cleanliness, skill and stability. |
| In Process Inspection | Any inspection that takes place during the manufacturing process. This inspection may be performed by supplier as part of its regular quality control processes, or by LIGO as a spot check of workmanship or as a result of a deficiency in the performance of the supplier or the manufactured component. |

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| Receiving Inspection | <p>Inspection at the LIGO site to verify that goods shipped arrive in good condition, without visible damage, contamination, or other problems that may have been caused during the packaging and shipping process. It is also the point at which LIGO team members look for problems related to improper packaging, as well as missing pieces or cartons. During a Receiving Inspection, LIGO team members will provide an inspection report noting any issues. If shipped item passes inspection it will be moved to the proper storage until its intended use. LIGO members will also submit a passed inspection report which authorizes procurements to release payments to supplier as agreed in contract.</p> <p>If the system does not pass receiving inspection, it will be at the discretion of the LIGO Project on how to handle the issues, which may include returning items to vendor, requiring vendor supported testing and rework, or additional testing at LIGO site before receiving inspection is signed off and payments are released to supplier.</p> |
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