

Inspection and Test Plan for Standard Features

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Abstract

As part of the EIC project, inspection and test plans are required for assessing the quality of components that are procured or manufactured in-house. While the specific evaluation criteria for unique components are represented in the product inspection and test plans, there are often common criteria that may exist across multiple systems. Rather than repeating this information in each document, all of these standard criteria will be incorporated in this inspection and test plan.

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PURPOSE AND SCOPE

1. PURPOSE

This document identifies general/standard criteria that may require quality control tests or inspections, but do not warrant a document of their own. Because these criteria are generic in nature, this document will identify the criteria categories and the types of evaluation or measurements that are required. However, specific evaluation criteria may also be included in either an a) individual component inspection check list or b) contract or statement of work. Documents that reference this inspection and test plan for general/standard criteria **MUST** also identify where the specific evaluation criteria can be found.

2. SCOPE

This document may be used for any system, sub-system, or component that exists within the EIC Detector System. It should only be used for criteria that is generic in nature and may be applied to multiple types of components. This document may be expanded as needed to include new criteria.

3. STANDARD LOCATION OF EVALUATION CRITERIA

The following categories are extracted directly from the EIC Detector Individual Quality Control Plan. For each category, the location of the evaluation criteria for general/standard measurements is identified. Documents that refer to this inspection and test plan should comply with this structure when possible. If evaluation criteria are not in the standard location, the actual location should be specifically identified.

3.1. In-Process Inspection and Test

In-process inspections and tests are for components that are **built in-house**. Specific evaluation criteria will be included in the design documents.

3.2. Outsourcing: Vendor/Partner/Contributors In-Process

In-process inspections and tests for outsourced components are specified in contracts, formal agreements, and statements of work.

3.3. Incoming Inspection and Acceptance Tests

Incoming inspections and acceptance tests are used to confirm that materials or products provided by a vendor or partner institution have been produced in accordance with the plans and specifications. Specific evaluation criteria are specified in contracts, formal agreements, and statements of work.

GENERAL INSPECTION CRITERIA

4. STRUCTURAL CHARACTERISTICS

4.1. Shipping and Packaging

- **Packaging**

Inspect packaging for visible damage that might indicate mishandling during the shipping process.

- **Shipping Restraints**

Verify that all internal transit ties, bracing, and locking bolts are identified for removal prior to placing the system into operation.

4.2. Condition

- **Deformation**

Inspect walls, spans and viewports for structural deflection or deformation.

- **Viewport Clarity**

Check all transparent viewports or windows for fractures, scratches, or stress cracks at their seams.

- **Visual Defects**

Check the surfaces for scratches, gouges, discoloration, dents, creases, delamination, or surface roughness.

- **Surface Treatment and Corrosion Protection**

Verify that required surface finish, coating, plating, anodizing, passivation, sealant, paint, or other surface treatment has been applied and inspected. Verify corrosion protection and galvanic isolation where dissimilar materials are used.

- **Debris and Contamination**

Inspect the unit for residual manufacturing dust, metal shavings, grease, or other debris in critical areas.

- **Handling and Lifting Features**

Verify that lifting lugs, hoist rings, lifting fixtures, temporary supports, shipping restraints, and center-of-gravity or lift-point information are identified, rated, and acceptable for handling, shipment, installation, or removal.

4.3. Dimensionality

- **Dimensional and Geometric Verification**

Verify critical dimensions and geometric features, relative to the applicable datum reference frame, against the drawing, specification, or interface control document. This includes applicable GD&T requirements such as position, profile, flatness, parallelism, perpendicularity, runout, hole diameters, or coaxiality where specified

- **Thread Specifications**

Verify pitch, major diameter, minor diameter, and thread angle.

- **Critical Interfaces and Envelope**

Verify that mounting surfaces, bolt patterns, inserts, pins, slots, dowels, fiducials, alignment features, component envelopes, and keep-out zones meet the applicable interface requirements.

- **Fastened Joints**

Verify that fasteners match the specified type, size, material, grade/class, coating, and thread designation. Where controlled tightening is required, verify torque, torque sequence, preload, locking features, and witness marks as applicable.

- **Welded, Brazed, and Bonded Joints**

Verify that welded, brazed, soldered, adhesive-bonded, or epoxy-bonded joints conform to the applicable drawing, procedure, or fabrication requirement. Where required, verify joint size, location, visual quality, qualified process use, and nondestructive examination results.

- **Wall Thickness**
Ensure wall thicknesses meet specifications. Confirm uniform thickness across hollow or molded parts.
- **Clearances and Gaps**
Confirm the size of interior clearances, gaps, and pathways.
- **Interferences**
Ensure that there are no interferences that obstruct internal/external pathways.

4.4. Fit and Finish

- **Misalignment**
Visually check for parts that are crooked, unevenly spaced, or out of square.
- **Gaps and Flushness**
Check for unequal seams or joints that fail to meet flushness tolerances.
- **Loose Fasteners**
Check for screws, bolts, or rivets that are missing, cross-threaded, or not fully seated.
- **Cracks and Fractures**
Check for visible fractures in structural welds, plastics, or cast metal components.
- **Weld Flaws**
Check for excess splatter, porosity, slag inclusions, or insufficient weld penetration.

4.5. Materials

- **Material Certification and Traceability**
Verify that required material certifications are provided and traceable to the delivered component by heat number, lot number, batch number, serial number, roll number, or other required identifier.
- **Construction Materials**
Confirm that the construction materials for the component match the design specification.
- **Special Material Properties**
Where required, verify material properties such as magnetic permeability, hardness, conductivity, radiation tolerance, low-outgassing performance, cryogenic compatibility, flammability rating, or other specified properties.
- **Fastener Grade**
Verify structural bolts, nuts, and washers match the specified grade.
- **Material Substitution Control**
Verify that any material substitution has been reviewed and approved prior to acceptance.
- **Suspect Counterfeit Items**
Check for suspect counterfeit items for parts or components that are susceptible to counterfeiting.

4.6. Cleanliness, Contamination Control, and Preservation

- **Cleanliness and Foreign Object Debris**

Verify that the component meets the specified cleanliness requirement and is free from foreign object debris, loose hardware, metal chips, composite dust, fiber debris, wire clippings, packaging material, or other contamination.

- **Critical Surface Protection**

Inspect sealing surfaces, optical surfaces, vacuum surfaces, electrical contact surfaces, precision interfaces, bond surfaces, composite surfaces, and bearing surfaces for contamination or damage.

- **Vacuum, Low-Outgassing, and Process Residue Control**

For vacuum or detector-adjacent components, verify that materials, cleaning processes, adhesives, coatings, lubricants, residues, and packaging are compatible with the applicable vacuum cleanliness or low-outgassing requirements.

- **Packaging and Preservation**

Verify that protective caps, covers, plugs, barrier bags, desiccant, humidity indicators, shock indicators, edge protection, ESD protection, or other preservation controls are installed where required.

5. COOLING, VACUUM, AND PRESSURE SYSTEMS

- **Instrumentation**

Verify that gauges, transducers, flow meters, temperature sensors, and related instrumentation are installed, identified, calibrated, and within the specified operating range.

- **Pressure Rating and Protective Devices**

Verify that pressure-retaining components, hoses, fittings, tubing, valves, manifolds, chambers, vessels, relief valves, burst disks, regulators, and protective devices are rated and configured for the specified pressure, temperature, and fluid service.

- **System Integrity**

Where possible, inspect for leaks on fluid systems.

- **Pressure and Leak Testing**

Where required, verify that pressure testing, vacuum testing, or leak testing is completed using the specified method, pressure, hold time, leak rate, and acceptance criteria.

- **Flow, Pressure Drop, and Thermal Performance**

Where required, verify that fluid flow rate, pressure drop, inlet temperature, outlet temperature, component temperature, or heat-removal performance meets the specified requirements.

- **Fluid Compatibility and Cleanliness**

Verify that wetted materials, seals, lubricants, coolants, and process fluids are compatible with the specified service and meet applicable cleanliness requirements.

- **Seal Integrity**

Inspect O-rings, gaskets and mechanical seals for proper seating.

- **Fluid Levels**

Verify baseline factory oils, coolant, or lubricant are present at proper levels.

6. ELECTRICAL COMPONENTS

6.1. Capacity and Rating

- **Conductor Sizing**
Verify wire gauges and insulation types match design specifications.
- **System Capacity**
Confirm that breakers, fuses, switches and other components are compatible with conductor sizes and meet design specifications.
- **Protective Device Rating**
Verify that fuses, breakers, disconnects, and protective devices have the specified ratings, settings, and interrupt capacity.

6.2. General Conditions

- **Termination Tightness**
Inspect all hard-wired connections to ensure that they are tight and have appropriate strain relief.
- **Outlets and Switches**
Ensure that switches and outlets are appropriately located, have tight connections, and operate smoothly.
- **Cords and Cables**
Confirm that there are no frays, cuts, or damaged insulation on power cords and cables.
- **Wire Routing**
Ensure that cables are bundled neatly without sharp bends or pinch points.

6.3. Grounding

- **Connector Grounding**
Plugs and grounding pins should be present and functional.
- **Bonding Jumpers**
Where required, confirm green/bare copper jumpers connect all metal doors and panels.
- **Continuity**
Verify electrical continuity of conductors, shields, bonding jumpers, grounding paths, and conductive structures where required. Verify that grounding and bonding resistance meet the specified limit.
- **Grounding Bus**
Verify the presence and sizing of the main equipment grounding busbar.

6.4. Component Conditions

- **Insulation Resistance and Dielectric Withstand**
Where required, verify insulation resistance, dielectric withstand, leakage current, or other electrical safety tests using the specified voltage, duration, and acceptance criteria.
- **Polarity, Pinout, and Identification**
Verify correct polarity, connector pinout, keying, contact arrangement, cable identification, wire labels, connector designations, and circuit identification against the applicable drawing or wiring diagram.

- **Cable Routing, Shielding, and Termination**

Verify that wires, cables, harnesses, shields, drain wires, backshells, strain reliefs, clamps, and locking features are correctly routed, terminated, protected, and maintained within bend-radius requirements.

- **Controls Configuration**

Where applicable, verify software, firmware, programmable logic, interlock settings, alarm setpoints, addresses, limits, or control parameters against the approved configuration.

7. INTERFACE CHARACTERISTICS

7.1. Size and Placement

- **Interface Dimensions**

Confirm size of connection points, flanges, and bolt-hole patterns.

- **Interface Placement**

Confirm that the proper number of interfaces/connections are provided and they are in the correct location.

7.2. Mechanical and Physical Mating

- **Form Factor Compliance**

Verify the connector matches the specified configuration, so that connectors align with the receptacle.

- **Locking Engagement**

Confirm that the connector inserts fully, twists smoothly, and locks firmly into place without binding.

- **Retention Force**

Ensure the locking mechanism prevents accidental disconnects when the connection is pulled or vibrated.

7.3. Functionality

- **Smooth Operation**

Ensure that buttons, knobs, handles, and hinges operate smoothly with no binding.

- **Noise and Vibration**

Where possible, confirm that the system does not display an inappropriate amount of noise or vibration when operating.

8. SAFETY SYSTEMS

- **Compliance**

Ensure that systems comply with applicable industry standards.

- **Machine Guards**

Confirm that safety guards are installed, firmly attached and operational.

- **Protective Guarding, Interlocks, and Emergency Stops**

Verify that guards, covers, barriers, interlocks, and emergency stop devices are installed, accessible, labeled, functional, and tested according to the applicable requirement.

- **Stored Energy and Lockout/Tagout Provisions**

Verify that electrical, pneumatic, hydraulic, gravitational, thermal, spring, magnetic, vacuum, and pressure energy hazards are identified and controlled. Verify that disconnects, isolation valves, bleed points, and lockout/tagout provisions are present where required.

- **Personnel Exposure Hazards**

Inspect for exposed energized parts, hot or cold surfaces, pinch points, crush points, shear points, sharp edges, composite splinters, fiber dust hazards, pressure hazards, and other personnel exposure hazards.

- **Hazard Labels and Signage**

Verify that required safety labels, caution signs, warning signs, hazard markings, and operating limit labels are present, legible, and appropriately located.

9. DOCUMENTATION

- **Drawing and Revision Verification**

Verify that inspections are performed against the correct drawing, specification, traveler, procedure, procurement document, or interface control document revision.

- **Certificates and Required Records**

Verify that required certificates of conformance, material certifications, special process records, coating records, calibration records, inspection reports, and test reports are provided and reference the correct part number, revision, serial number, lot number, batch number, or purchase order.

- **As-Built Configuration**

Verify that as-built drawings, redlines, configuration records, serial numbers, installed component lists, approved deviations, and nonconformance dispositions are provided where required.

- **Installation, Operation, and Maintenance Documentation**

Verify that required installation procedures, operating manuals, maintenance instructions, spare parts lists, and special handling instructions are provided.

- **User Manuals**

Confirm that user manuals and operational guides are provided for all systems and sub-systems.