# JNRC
# Survey and Engineering Subcommittee

# Guideline for Auditing a Manufacturing Facility and the Implementation of Manufacturer's QA and QC procedures

**FOREWORD AND ACKNOWLEDGEMENTS:**

This document has been produced by the Survey and Engineering Subcommittee of the Lloyd's Market Association's Joint Natural Resources Committee to provide guidance to insurers on exposures concerning the design and operation of a manufacturer's quality control and assurance practice.

Key areas of interest are summarised, and key recommendations are suggested to prevent and mitigate against potential claims by adopting best practice. The guideline highlights the need for operators, design and fabrication contractors to ensure that the design, construction and operation of each element of the asset considers means by which potential damage scenarios are minimised.

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**DISCLAIMER:**

Nothing in this Guideline, which is entirely voluntary, shall relieve any party of any legal obligations existing in the absence of this document and nothing contained in this Guideline shall take precedence over any provisions of any policy issued by a party who has chosen to adopt this Guideline.

**DOCUMENT REVISION HISTORY:**

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# 1.0 Introduction

## 1.1 Overview

The aim of JNRC Technical Documents is to assist the insurer and assured to prevent and mitigate incidents, accidents and other failures that could lead to an insurance claim.

Offshore oil & gas and renewable energy project claims, generally, take three forms:

1. Those caused by a physical accident at the fabrication site or operational location resulting in material damage and/or commercial loss (PD).
2. Those causing a production delay resulting in a direct or indirect consequential loss and DSU.
3. Claims resulting from defective products that became apparent on the operational location resulting in commercial delays and potentially physical damage (PD, BI, CBI).

All three of these categories can be as a result of a poor-Quality Management System (QMS), Quality Assurance (QA) or Quality Control (QC).

QA and QC procedures, of interest to the insurer, are usually associated with the details of product quality during manufacture and are equally applicable at a component or assembled system level at all stages of the supply chain .

Additionally, QA/QC should also be used to understand risks in general and larger potential pitfalls throughout manufacturing extending to wider QA/QC considerations within a manufacturing location or assembly yard.  For example:

- the effect of cranage bottlenecks on schedules and crane capacity, the increased risk of multiple handling and the increased risks of lifting heavier (and more costly) modules and blocks.
- navigational hazards in the approaches to a port where the factory or yard is located may result in the total loss of a product, such as a ship, module, cable reel or transformer, delaying a project by months or years.
- dock gate condition and overhandling materials, logistics and material supply for the yard and manpower are also all related to the assurance of factory or yard quality.

## 1.2 Current Policy Wording

QA/QC requirements are currently very generally addressed in the WELCAR 2001 wording, without being specific, as follows:

*2. SPECIAL CONDITIONS FOR OTHER ASSUREDS*

*It is a condition precedent for any party identified in Other Assureds definition clause iii. and iv. above to benefit from the Other Assureds status under the Policy that they perform their operations according to Quality Assurance/Quality Control system(s) which comply with the Quality Assurance/Quality Control provisions passed on by the Principal Assureds through each and every written contract awarded within the scope of insured works as scheduled under the Policy.*

With respect to shipyard inspection the JH143 (Joint Hull (Committee) 143), effective from November, 2003 and updated on the 15th June, 2009 as JH 2009/004, was developed to provide relevant titles around which a shipyard assessment report could be written without providing guidance as to where the greatest risks may be or to provide a wider context for identifying risks by addressing the potential magnitude of losses.

There are three sections to the JH143 as follows:

- JH143 A includes the option to look at an individual project as well as the shipyard
- JH143 B includes an option to cancel
- JH143 C is an annual review and compliance audit

The risk assessment guidance part of the JH143 wording is as follows:

*The shipyard and/or project risk assessment shall include review and assessment of the actual implementation of the safety management, quality assurance, and quality control of shipyard systems and procedures  It shall include but not be limited to:*

- *Geographical and Environmental Risks*
- *General Site Condition*
- *Processes and Procedures*
- *Quality Assurance/Quality Control of the production process*
- *General Housekeeping*
- *Management of Subcontractors*
- *Permit to Work Systems*
- *Emergency Response Plan*
- *Fire Fighting Capability*
- *Shipyard Equipment*
- *Atmospheric Monitoring & Control of Industrial Gases*
- *Launching & Sea Trials*
- *Site Safety*
- *Casualty History*

*Underwriters shall be entitled to require follow-up surveys to be carried out during the course of the construction of an individual vessel or during the period of insurance of the shipyard. This is to monitor compliance with earlier recommendations and to assess the safety management, quality assurance and quality control of the individual vessel project or the shipyard.*

*Any recommendations made by the surveyor shall be provided to the Assured on completion of the shipyard and/or project risk assessment and on completion of any follow-up surveys.*

*The cost of the shipyard and/or project risk assessment and any follow-up surveys will be borne by Underwriters, but any expenses incurred to comply with the surveyor's recommendations will be at the expense of the Assured.*

*Underwriters shall be entitled to receive a copy of any recommendations and/or reports directly from the surveyor.*

### 1.3 Use of this Document

This document is intended to:

1. **Provide** a structure for the QA/QC auditing of shipyards, factories and fabrication yards.
2. Provide suggestion to be used in conjunction with JH 143, to **enlarge** the scope of the JH143 to include factories and fabrication yards, in addition to shipyards.
3. **Identify**, as an aid to surveyors and auditors, where to focus, pre-binding  Underwriting and Risk Engineering activity to reduce and mitigate potential claims by providing a list of areas that:

    - are likely to cause quality related incidents,
    - are areas of greatest risk,

- provide sufficient information for the underwriter to gain confidence in the project QA/QC procedures,
- provide a detailed picture and overview of the facility being insured.

## 2.0 General (applicable to all manufacturing facilities)

Although each factory, fabrication yard and shipyard has its own products and standards, a typical facility audit will consider items in this section, Section 2.0 and then add requirements from the relevant Sections; 3.0, 4.0 or 5.0, for the facility being audited:

### 2.1 General

- **Company details:** Name, type of business, turnover, annual sales.

- **Audit details:** Audit dates, names of those present; auditors and company representatives.

- **Overall description of facilities:** Geographical location (address, latitude and longitude), layout, purpose of facility and products produced, and material flow.

- **Facility summary:**
  History of manufacturing facility: Origins, years in business, major changes (physical, owner, operator), experience.
  Site: Flexibility of manufacturing/construction on the site (greenfield, brownfield or older) and effects on the business.
  Ownership: Number of owners and percentage ownership, ultimate owners, experience of owners.
  Legality: Is the company a legal entity, registered in the country of residence and has no legal claims against it? Have the accounts been signed off?
  Order book: current, future and historic: Not too full or too empty for the facilities available.
  Production: Throughput of tonnage and products compared to potential capacity. Percentage use of facilities.
  Housekeeping: General tidiness of facilities, discipline of individuals.
  Claims history: Identify trends, main causes, failures of equipment, personnel or 3rd Parties.
  Building fabric: Quality of the buildings; leaking roofs and pipes, insulation, adequate and maintained lighting, space to operate safely, gap between storage shelves, separation of hazardous and non-hazardous areas, ventilation, fire hazardous and fire prevention (sprinklers, water/foam tanks, alarms, extinguishers etc.)
  Natural hazards: Summary of location specific natural hazards.
  Location hazards: Third Party proximity both within and external to facility boundary.
  Political hazards: What is the political situation of the country where the facility is based? Is it stable, unstable or subject to sanctions, for instance?

- **Management:**
  Subcontractors: Their management and supervision.
  Personnel: Organogram of key people, number of staff, number of contractors, turnover of staff and retention, training, apprenticeships, absenteeism, average age of staff, gaps in skills of personnel, language spoken, country of origin of the workforce, tidiness and bearing and moral of personnel.
  Expertise: Address retention of expertise and identify skill gaps. Is there an apprenticeship scheme, training facilities, ongoing training, continuity training and opportunities for advancement?
  Contractors: List the main contractors: Products and services supplied, quality of products and services, how long they have been contracted? Do they have their own QA/QC procedures and what are they? Lines of communication for purchase and quality issues. Pre-qualification and execution auditing conducted in regards to both products and service.
  Change Management: The altering of processes (MoC - Management of Change).
  Vetting: Procedures for vetting contractors and 3rd party suppliers.
  Third Party Inspection: Use of 3rd parties vs Operator Technical expertise.
  Emergency Preparedness: Emergency Response Plan, Emergency Response Training & Responders, Emergency Response Equipment,

- **QA/QC procedures**:
  QA/QC policy document, procedures and specifications both generally and for insured project.
  Are both internal and external audits conducted on its premises?
  What is the audit frequency (annual audits are usually recommended)?
  Compare inspection rates and nonconformance reports with repair and rework rates against planned?
  Are audits announced (usually for routine checks) or unannounced (usually after suspecting non-compliances or to monitoring high risk aspects of non-compliance).
  Are key performance indicators (KPIs) realistic and have they been achieved?
  Do the procedures identify the methods of workflow and provide for the resolution of defects?
  State the QA certification (e.g. ISO 9001) available.
  State the QA/QC standards being used for this audit.
  Examine the QA/QC records, reports, logs, audits (regularity and ensure compliance with QA/QC standards).

- **Project Specific QA/QC reporting:**

  This section is intended to cover the Project Specific QA/QC scope and adequacy focusing on the PMT (Project Management Team) QA/QC team and management of the QA/QC interface with the various contractor fabrication facilities.

  Areas it would be useful to cover are as follows:
  - Quality Management Plan: Does it cover all of the critical issues?
  - What standards to be used on the project for QA/QC auditing?
  - Project QA/QC team: Staffing, qualifications, experience, organisation chart, management of turnover (high on renewables projects).
  - Attendance at different project facilities and yards. Full time, part-time and criteria for attendance etc.
  - Is attendance prioritized to match the risk?
  - Critical areas:
    Material management
    Vendor/OEM supply of machinery and equipment
    Weld inspection at site/weld repair rates
    Non Conformance Reports (NCR's) management
    Site query management
    Sharing of relevant info from NCRs and Site Queries with other contractors, vendors
    Ensure all relevant inspection and testing activities (and required repairs) are carried out prior to departure of the structure/module/vessel from the fabrication facility/yard
  - Enhanced QA/QC for lower TRL (Technology Readiness Level) items. TRL level to be agreed (based on IEA definitions).
  - Project documentation management. Critical for renewables projects with large numbers of components producing a high volume of documents.
  - Project certification by a third party.
  - Review of criteria for issue of Provisional Acceptance Criteria/Sign off.

- **Non-Destructive Testing (NDT):**
  - Compare material and workmanship quality with production rates, specification, material certificates and repair frequency.
  - Check NDT methods used (procedures, good practice, level of testing and competence): Such methods may include:

| | | |
|---|---|---|
| X-ray | Ultra Sonics (UT) | Magnetic Particle Inspection (MPI) |
| Dye penetrant | Visual | Pressure testing (air, water, soapy water). |

- **Production:**
  Production capacity: What is the capacity of the facility and what is it's optimum running efficiency for the given manpower, expertise and equipment?
  Delivery: What percentage of products are delivered on time, to budget and with no quality problems?
  Workflow: Examine all workflows, machine efficiencies and overall production rates including instances of unnecessary multiple handling, unnecessary product movements, level of advanced outfitting, ability to turn modules to ease access and production rate and quality (to enable downhand welding, for instance). Identify bottlenecks in production.
  Efficiency: Is the number of work faces maximised? This refers to efficient planning such that the work force is not waiting, due to other teams already working there, for access to a workface thus minimising downtime.
  Workforce: Estimate level of initiative, teamwork, idleness, management/worker relationships amongst the work force.

- **Accident statistics:**
  Examine accident statistics, incident statistics and down time due to delays from any cause (for both Company and Contractors).
  Recording of near misses.
  Lessons learned and actions implemented from past incidents.

- **Delays:**
  Non inherent delays:
  Strikes, equipment failure, contract disputes, unreliable suppliers, inefficient storage and production.
  Inherent delays:
  Weather and nat. cats. – flooding, rainfall, cyclones, tsunami's, earthquakes, temperature and humidity extremes (can affect welding and some outfitting).

- **Reception:**
  Security, openness, co-operation, safety briefing.

- **Security:**
  Active, passive security to prevent unauthorised entry, theft, vandalism or the onset of an inherent risk.

- **Contingencies:**
  Contingency procedures: Power failure and back-up power generation and pumping capacity, availability of emergency services (fire and ambulance).
  Suppliers: Dependence on single suppliers and variation in supplier quality.
  Redundancy: Single point of failure for any process.

- **Summary:**
  Summarise findings with a benchmarked assessment displayed in a preferably visual manner (heatmap or chart) graded for severity (likelihood and consequences) with prioritised risk improvement recommendations clearly stated with time limit for compliance.

  At the end of the facility audit checklist, it is recommended to include a sign-off portion for the dedicated staff, quality control staff, factory manager and other relevant people involved in the process to verify the audit and its findings. This also helps with the documentation process.

## 3.0 Factories

- **External checking:**
  QA/QC procedures for raw materials, components and products entering site.  For instance:

  - checking documentation (perform visual check or testing as required for item(s)).
  - quality of materials being supplied from a 3rd party.
  - does the supplier of materials or services have an acceptable QA/QC plan to which they work?

- **Cleanliness of facilities:**
  Cleanliness generally but especially where sterile environments are required.
  Contamination:  Identify areas where defects may enter the products.
  Materials handling:  Areas where unusual processes may result in defects.  Cable extrusion and insulation, for instance.
  Housekeeping in general:  Are working areas and aisles clear, rubbish properly disposed of, tools returned to racks and storage after use and cleaning equipment available for the processes involved at workstations.

- **Loadouts:**
  Storage:  Storage of products before loadout:  Outside or warehoused, environmentally protected.
  Support:  Physical support (cradles, chocks, on a slope or the flat, near a car park or forklift route, where damage is probable or otherwise vulnerable to impact), care of handling.
  Quayside condition:  Loadout and transportation facilities including quay capacity, water depth, navigation.

- **Operations:**
  Handover between shifts.  Is there an overlap for debriefing from previous shift?

- **Maintenance and inspection:**
  Reliability of equipment.
  Maintenance records.
  Redundancy of critical processes.
  Spares; is critical equipment duplicated or spares readily available, properly catalogued and maintained.

- **Certification (wind turbine factories only)**
  For wind turbine manufacturing facilities:
  Has the wind turbine model being insured been issued with a type certificate?
  Was this facility assessed as part of the manufacturing surveillance element of that type certificate?
  Was the Independent Verification Body (IVB) IACS accredited?

- **Final testing and signoff:**
  Ensure all tests are carried out accurately, with the correct amount of testing material, to the agreed specification and are witnessed by the client representative.
  Final testing and sign off.
  FAT and IFAT testing, See Section 6.0 Factory and Site Acceptance Testing.

## 4.0 Fabrication yards

- **Ground conditions and bearing capacities of laydown and loadout areas:**
  Quay and ground bearing capacity, drainage, previous use (greenfield clearance, brownfield site).
  Is the site chemically contaminated?

- **Bearing capacity of laydown area:**
  What is the load bearing material?
  Is it adequate for the structures/ modules/construction blocks/other heavy components, etc. being stored at different phases of the project?
  Availability of clearly defined layout drawing?
  Have any laydown areas been strengthened e.g. by piling?
  Laydown area congestion
  How are the laydown areas managed?
  Current storage of live project components v laydown requirements for the new project(s)

  *Note: At times some fabrication yards are very congested due to project delays and the volume of components being produced*.

- **Lifting:**
  <u>General:</u>
  Are lifting and /or yard move operations contracted out?
  Controls in place to manage contractors during key lifting and yard move operations.
  Competent third party review of yard lifts and quayside lifts (if out of scope for the MWS) and interface management.
  Establishment of “No Go Zones” to manage dropped object risk during major lift/move operations – ensure only critical personnel allowed in high risk areas.
  <u>Cranes:</u> Coordination of multiple crane lifts, lifting expertise, understanding of crane curves, crane capacity and crane limitations.
  Lifting procedures – safety control adequacy during a lifting operation.
  <u>SPMT’s:</u> Describe the SPMT’s and other modular transporters in the yard, their type, quantity, maintenance schedule, problems encountered, how they are operated and redundancy.

- **Certification:**
  Certification of rigging and quality of all lifting gear. Rigging register. Examination of rigging and lifting gear.
  Contractor/sub-contractor pre-qualification and appointment
  KPIs used to manage contractor/sub-contractor performance

- **Maintenance and inspection:**
  How is the condition of all heavy lifting equipment managed?
  Describe recording maintenance and defects and the inspection schedule.

- **Final testing and signoff:**
  Ensure all tests are carried out accurately, with the correct amount of testing material, to the agreed specification and are witnessed by the client representative.
  Final testing and sign off.
  SAT and ISAT testing, See Section 6.0 Factory and Site Acceptance Testing.
- Tool box talks/Job Safety Analysis (JSA) prior to critical lift/yard move/load-out operations.

## 5.0 Shipyards

- **Cranage:**
  Quality, reach, capacity (and capacity curves), number, usage, operation, maintenance and certification.

- **Drydock(s):**
  Dock gates maintenance, opening type and reliability.
  Pumping capacities, usage and frequency of use including multiple vessel drydocks and security of vessel openings when simultaneous drydocking's take place.
  Qualifications and experience of those operating the drydocks, docking calculations and repairs and incidents.

- **Shipyard approaches:**
  Navigation hazards within and outside of the shipyard.
  Departure procedures: Identify departure procedures, tugs, pilotage, navigational restrictions, water depth.

- **Weather:**
  Weather forecasting for the yard. Identify lightning, hail, excessive rain (and drainage), earthquakes, landslides strong winds and crane limitations in certain wind speeds.

- **Planning:**
  What assumptions are made regarding the shape of the planning curves for different vessel types and are these realistic?
  Examine the yard/project KPIs to establish if they are being met and accurately reflect the production rate and quality of production.
  Identify material flow and handling.
  Is the manpower realistic for the schedules? Examine the manpower curves and identify the number of staff and contractors.
  Is there a separate onsite training establishment with personnel continuity?

- **Efficiency:**
  Is multiple handling carried out or is the lifting capacity of equipment sufficient to orientate the unit with minimal movement?
  Level of outfitting and testing:
    Are the work faces optimized and maximised or are there delays waiting on space to work due to poor planning, low levels of advanced outfitting, restrictive fabrication space or lack of manpower?

- **Firefighting:**
  Does the yard and local fire brigade familiarise themselves with changing layout of vessels, especially outfitting, every couple of weeks?
  Describe, in general, the firefighting capability, independent pumping capacity and medical and recovery capabilities of the yard.
  What is the adequacy of firewater system in terms of capacity, redundancy and coverage?
  At what point are vessel active safety systems live?
  Fire risk management document review to ensure fire risk is managed throughout project life cycle.
  Fire scenario planning.
  Hydrocarbon management and of flammable liquids and gases e.g. propane (used for FLNG liquefaction) that might be introduced in the yard.

- **Lifting:**
  Lifting procedures. Safety control adequacy during a lifting operation.

SPMT procedures.  Safety control adequacy during a SPMT yard move operation.
Establishment of “No Go Zones” to manage dropped object risk during major lift operations.
Ensure only critical personnel allowed in high risk areas.
Are lifting and/or yard move operations contracted out ?
Controls in place to manage contractors during key lifting and yard move operations.
Competent third party review of yard lifts and quayside lifts (if out of scope for the MWS).

- **Launching:**
  Launching methods; drydock float-off, slipway or lifting.

- **Commissioning:**
  Establish that the KPI’s for sea trials and quality are clear and there is a realistic and unambiguous method for assessing them.
  Is the marine staff qualified (Master Mariners, local pilots) and tugs are readily available if required.
  Moorings alongside.  Number of bollards of suitable capacity spaced to provide good balanced moorings. Protection of mooring berth.

- **Continued development:**
  Is research and development caried out or is there a dependency on consultants for specialized software and the operation of specialist equipment?

- **Final testing and signoff:**
  Sea trials and handover.  Check specification and criteria against historic achievements with the examination of the defect list, functional testing, speed trials, maneuvering performance and owners satisfaction.
  Tool box talks/JSAs prior to critical lift/yard move/launch operations.

## 6.0 Factory and Site Acceptance Testing

FAT, IFAT, SAT, ISAT (SIT and String testing) are intended to reduce malfunctions and non-conformities of equipment manufactured at a facility which, if not done, would increase the risk of failure, or impact a project schedule resulting in project delays.

These could include compulsory statutory and contractual requirements and performed in both the clients' and manufacturers' interests, especially with highly complex, high value critical equipment packages, equipment with new technology or when site installation is complicated.

### 6.1 FAT – Factory Acceptance Testing[1]

Definition: Factory Acceptance Testing[1] is a process conducted at the manufacturer's facility (factory or workshop) before the equipment or system is shipped to the client.

Objective: The primary goal is to verify that the equipment or system meets the design specifications and functional requirements as outlined in the contract or purchase order which benefits both the manufacturer and client. FAT testing will reduce time and expense rectifying problems on site. It is also used to demonstrate that it is capable of meeting the URS either during the FAT or later, possibly during the SAT or at final installation.

Participants: Typically involves representatives from the client or end user, along with engineers or technicians from the manufacturer.

Activities: Functional testing, performance testing, verification of documentation and demonstration of system capabilities. Permission given, on successful completion for shipping to site. Sometimes successful completion triggers a payment.

Outcome: The client formally accepts the equipment or system for shipment to the installation site. FAT serves as a comprehensive evaluation of the equipment at the manufacturing site.

On acceptance of a FAT some items to look out for include:

- Performed FAT protocol
- Maintenance and user's manual
- Recommended spare parts list
- Certificate of compliance
- As built technical drawings (electrical, mechanical, pneumatic and process schemes)
- Materials certificates/data sheets
- QA scan results (such as ultrasonic scans of completed wind turbine blades)
- Main equipment's data sheets
- Instruments calibration certificates
- Welding processes qualification

### 6.2 IFAT – Integrated Factory Acceptance Testing[1]

Definition: Integrated Factory Acceptance Testing[1] is an extension of FAT that specifically focuses on the integration of multiple systems or components.

Objective: Ensures that various subsystems or components work together seamlessly as an integrated whole.

Participants: Similar to FAT, with additional involvement from parties responsible for different subsystems.

Activities: Emphasis on testing the interfaces and interactions between subsystems to verify integrated functionality.

Outcome: A successful IFAT indicates that the integrated system is ready for shipment. It provides as much confidence as possible without performing a SAT.

## 6.3 SAT – Site Acceptance Testing[1]

Definition: Site Acceptance Testing[1] is conducted at the installation site after the equipment or system has been delivered and installed. It may often contain elements of FAT as well and include hot testing.

Objective: Ensures that the equipment or system functions correctly within the actual operating environment and under site specific conditions.

Participants: Involves representatives from the client or end user, along with engineers or technicians from the system integrator or supplier.

Activities: Testing functionality, performance, safety features and documentation verification.

Outcome: A successful SAT indicates that the equipment or system is ready for commissioning and start-up. Its intention is to ensure the equipment meets specification. Until completed successfully the equipment is not accepted and the job is not complete. On successful completion the equipment will be signed off using a handover certificate. SAT is the final test of equipment in its intended environment.

Performed at site as if fully commissioned. Customer accepts item and final invoice sent. Further work may be required by the supplier but this should be agreed and defined in change notices or deviations to original specifications probably for an additional fee.

Below is a list of some items that should be considered when performing a SAT:

- Finishing visual check
- Main components visual check
- Utilities functionality and setting check
- Functionality/Interlocks Verification (Mechanical & Software)
- Safety devices and interlocks check
- Operator's training

## 6.4 ISAT – Integrated Site Acceptance Testing[1]

Definition: Integrated Site Acceptance Testing extends SAT and focuses on the integrated functionality of multiple systems at the installation site.

Objective: Ensures that all integrated systems function correctly together in the actual operating environment.

Participants: Representatives from the client or end user, along with engineers or technicians from different subsystems or system integrators.

Activities: Testing interfaces, interactions and overall integrated functionality at the site.

Outcome: A successful ISAT indicates that the entire integrated system is ready for commissioning and full-scale operation.

These testing phases are crucial in ensuring successful implementation of complex systems, particularly in industries such as manufacturing, process control and automation. Each phase serves a specific purpose in verifying the functioning, performance and integration of the systems, leading to a smooth transition from manufacturing to installation and operation. IFAT and ISAT are regarded as being carried out by the most diligent vendors and customers and are highly regarded by insurance companies as they test the integrated systems, not just the components.

## 6.5 Other terms used

Other terms sometimes used are:

SIT: Integration Testing: The factory or site testing of complete equipment packages and its control systems (hard and software). An example is subsea production systems. This is a term which is, effectively, covered by IFAT and ISAT.

String testing: The factory functional testing of entire equipment trains such as pumps plus turbines and compressors and their support systems. This is, effectively, another term for IFAT.

UAT: User Acceptance Test: Same meaning as SAT.

USR: User System Requirement This should be a document stating the customer requirements.

URS: User Requirements Specification: Not how it's going to work but what it's going to do. This should be signed off between supplier and customer at the outset to ensure agreed deliverables are provided.

FDS: Functional Design Specification: This specification defines how an object is to be produced and how the URS is to be achieved. This document should also define a test specification.

Punch List (or Snag List): Refers to a list of items that require fixing before a final payment is made. Generally, these items do not stop the use of the equipment but do have to be fixed to bring it fully up to specifications.

Wind turbine tests Once connected to the grid, the wind turbine installer must carry out a number of performance and functional tests over a pre-defined period to confirm all safety, control, power and related compliance functions are performing to specification. The turbine must be run through a range of wind speeds.

Each test usually triggers a payment on successful completion.

This distinction is crucial in ensuring seamless integration and optimal functionality. Companies that prioritise both FAT and SAT and the above variations not only have a very high probability of adhering to industry standards but also commit to reliable delivery.

**Ref:**


1. Institutional Information for Quality Assessment (IIQA)

# 7.0 QA/QC reporting and auditing

## 7.1 Principle elements of a QA system

This section provides guidance on QA and QC principles defining each followed by listing the main principles used for QA/QC auditing and providing guidance notes on conducting an audit.

In general:

- **QMS (Quality Management System):**
  This is the all-encompassing framework for a QA and QC system.

Probably the most widely used Quality Management System is ISO 9001. In all cases ISO 9001 (or equivalent) should be an inherent part of the QMS system using the principles stated below or similar. It is based around seven Quality Management Principles (QMP). These are:

- QMP 1 - Customer focus: Customers are at the heart and the sole purpose for the existence of a business. Meeting and exceeding their requirements ensures the company grows.
- QMP 2 - Leadership: Leadership is not management. Management is following a process. Leadership is following a vision. The correct form of strong leadership ensures better quality and consistency. This provides a strong foundation for management to provide a consistent, high quality, products.
- QMP 3 - Engagement of people: Everyone, across all levels of the business, should concentrate and prioritise on delivering a good quality product based on following processes and procedures in a disciplined manner.
- QMP 4 - Process approach: Processes across a business must all be interconnected. This will ensure an ethos of efficiency, good quality and adherence to good standards.
- QMP 5: Continuous improvement: Continuous improvement is achieved by frequently reviewing, correcting improvement: and improving processes across a business. This will ensure both a short term and long term legacy for the business.
- QMP 6 - Decision making based on facts evidence: The correct use of factual evidence and data is key to improving a business. This must form the basis for all decision making to and optimise performance.
- QMP 7 - Relationship management: Establishing and maintaining strong relationships with clients and suppliers is key to better business performance.

When broken down, the QMS contains the following key elements:

| | | | |
|---|---|---|---|
| - Quality planning | QP | Also known as PDCA: | Planning |
| - Quality control | QC | | Doing |
| - Quality assurance | QA | | Checking |
| - Quality improvement | QI | | Acting/adjusting |

- **QA establishes production standards and the systematic methods used to meet those standards:**
  Uses audits, charts, benchmarks and cause and effect diagrams. QA establishes the control processes used to avoid defects and ensures product output quality continuously improves.

- **QC ensures compliance with production standards:**
  QC is a process and post-process check ensuring compliance with the QA standards and corrective actions, where necessary. In manufacturing Quality Control ensures production output meets quality guidelines.

- **Testing verifies the quality of the product:**
  Testing is, effectively, part of the QC process but may use external standards to verify the product. Information on product quality forms the basis for performance data and overall company competence.

Figure 1, overleaf, provides a functional relationship overview of a Quality Management System.

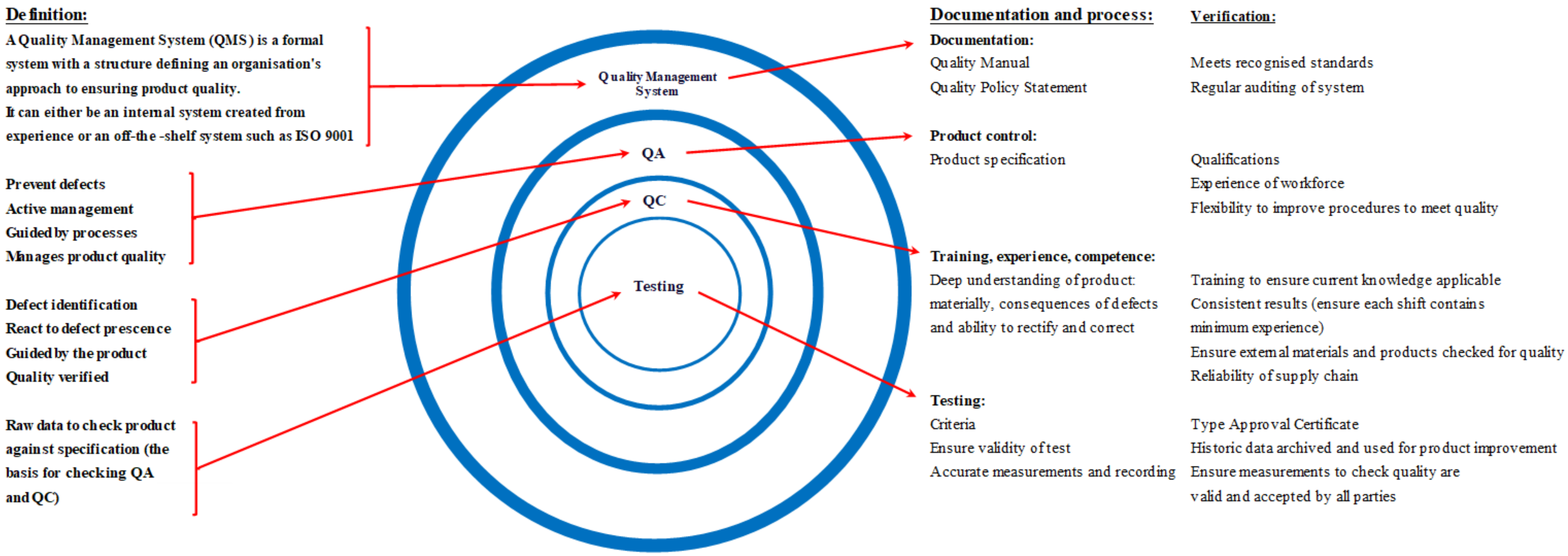


**Figure 1: A schematic showing the principle relationships within a quality system and its key elements**

### 7.2 QA/QC audit duration

The duration of the QA/QC audit is dependent on the size and complexity of the facility, time available by the facility, time allowed for the survey and suitable access being available. It can, therefore, take between 1 day and a week, more or less, as required. Less would be very superficial and more would probably be too extensive and may justify assistance to keep the audit to less than a week.

### 7.3 Basic auditing principles

- **Audit objectives and purpose:**
  Clearly define the audit objectives. Determine whether it aims to improve existing operations or address specific quality issues within the manufacturing process.
- **Supplier Qualification:**
  Establish that the paper qualifications of a supplier are supported by evidence of production and quality. Most companies have supplier onboarding processes. A manufacturing process audit is essential to assess a supplier's capabilities before employing, ensuring they meet specific production requirements.
- **Preproduction Validation:**
  Prior to mass production, conducting a thorough initial inspection of production facilities is essential to identify potential flaws, improve efficiency by streamlining operations and upholds regulatory compliance.
- **Efficiency Gains:**
  Process audits can identify inefficiencies and bottlenecks, allowing specific improvements.
- **Post-production defects:**
  Repetitive, frequent product defects, customer complaints or returns require a specific audit to recognize the cause and identify rectification.
- **Select the Audit Team:**
  The audit team must be suitably qualified ensuring the assessment is unbiased.
- **Audit Frequency:**
  Decide whether the audit will be a one-time evaluation or a regular, ongoing process. Regular audits contribute to continuous improvement and sustained improvements.
- **Timetable Specification:**
  Clearly outline the audit timetable with detailed schedules. Include the coverage of different shifts and random observations.
- **Schedule:**
  Stick to the schedule in its entirety. All involved must be given sufficient notice of the audit.
- **Record keeping:**
  Thorough records must be kept of all aspects of the audit. These records must then be used for future improvements.
- **Reporting results:**
  All audit results must be conveyed to the auditee with feedback and acceptance of the results verified before departure from site.
- **Feedback from auditees:**
  All auditees must be allowed to respond to the findings to ensure they are fair, accurate and transparent with suggestions for improvement being recorded as part of the audit.
- **Corrective Actions:**
  Corrective actions are an integral part of the audit process and must be included in any reporting.
- **Root Cause Analysis:**
  When failures or defects occur, an audit is required to investigate the root cause of the problem. This analysis is intended to identify where the faults occurred, what caused them and how to rectify future problems.

The 7 steps of root cause analysis are:

- Define the Problem (this may not necessarily be obvious).
- Gather Data.
- Establish the cause.
- Find solutions.
- Develop a strategy to correct or prevent future problems.
- Report the cause, nature, effective and resolution to the problem.
- Periodically monitor the problem.

Another mnemonic for RCA is PREAD: PReserving Evidence and Acquiring Data

Below are just five of the methods that could be used around which to structure an RCA:

a. The Pareto chart (a chart containing bars to represent discrete values and the line to show the cumulative total).
b. The Ishikawa or Fishbone chart (a cause and effect chart in the shape of a fishbone; the cause being the bones feeding into the spine depicting the effect).
c. The five whys method (repeating Why? Five times or until a conclusion is reached regarding the root cause).
d. Scatter diagrams (graphical presentation of raw data which is dependent on two or more Variables). Best fit curves can be fitted to this data.
e. Failure Modes and Effect Analysis (FMEA). A method of systematically identifying all the elements of a process and assessing ways in which they can fail allowing causes and effects to be systematically analysed and rectified.

## 8.0 Characteristics of facilities with good QA/QC

More specifically, measures of good quality in the facilities covered in this document are as follows:

### 8.1 General

The following are general characteristics expected to be seen in a company with good QA/QC practices :

- No strikes.
- Minimal sick days and unauthorized absences.
- Adequate manpower with neither overmanned or undermanned facilities.
- Workforce of varied and mixed experience, with old and young, to ensure continuity of experience and a broad outlook.
- Good inventory keeping to ensure equipment is routinely maintained, spares are adequate, replacements or machinery and spares can be ordered in a timely manner and facilities to house new equipment and processes can be planned in good time.
- Everyone in the company (with the exception, initially, of trainees, apprentices and interns) having an intimate knowledge of their sphere of responsibility, their interactions with other department and are constantly critical of performance with the aim of improvement.
- Cordial personal and inter departmental relationships. Internal disagreements, poor individual behaviour or politics should not influence product quality or customer relations.
- Fairness in the treatment of customer complaints, internal discipline and remuneration.
- Customer facilities are good ensuring they have an office, furniture, computer access, regular access to the area where their product is being fabricated and they have good access to management, the canteen and PPE.
- The company produces products within budget and at a profit.

### 8.2 Factories

Factories, although massively varied in products, sizes and objectives should follow some or all of the following principles:

- Equipment, whether old or modern, should be well maintained, is completely adequate at producing the product(s) and is run by competent operators.
- Working conditions are well kept with good housekeeping, orderly workstations and minimal workforce idleness.

- Product quality is verified through:
  - Testing
  - Trials
  - Reliability
  - Meets specifications
  - Customer experience fed back to the factory management
  - Good record keeping of performance

### 8.3 Fabrication yards

Fabrication yards, of the three facilities types considered in this document are probably the least permanent, and sometimes being used for the fabrication of single large contracts. They have the ability to close quickly if contracts are sparse and contain more subcontractors than either of the other facilities.

- Standards may be based on good industry practice and structure codes as well as ISO 9001 and similar, relevant, ISO standards.

- Good control of sub-contractors with retention for extended periods if sub-contractors are good.
- Good security. Although this applies to factories and shipyards, the size of fabrication yards, their openness and the value of equipment together with fewer security patrols and cameras, means theft is more prevalent.
- Regular shop floor meetings (toolbox talks) for ensuring that everyone is working to correct standards and are all briefed in a similar manner.
- Communications are sound with isolated areas of the yard having good contact with supervisors.
- Areas of flooding and poor drainage are repaired or avoided for the fabrication of high value structures.
- Thorough NDT of structure, meeting the minimum requirements and rapid and formal rectification of defects together with feedback to improve future quality and minimise repairs.

- Product quality is verified through:
  - Dimensional accuracy of fabrication
  - Minimal repair work - *at least, rapidly decreasing number of repairs as the project progresses.*
  - Codes used for the product are closely followed.
  - Smooth transition to the transportation state with seafastenings, testing and closures all complete.

### 8.4 Shipyards

Shipyards are, perhaps, the most complex are all the facilities covered. They include all the elements of a factory and fabrication yard with a product designed to be a totally self-contained, independent unit, apart from the supply of fuel and stores. As a result nearly all the previous factors apply but with the following additional characteristics which identify the facility as having good QA/QC procedures:

- Efficient production flow through the yard. There should be a logical sequence between production stages with minimal distance and time spent transferring from one stage to another.
- Maximum number of work faces are being used for fabrication.
- Greatest number of trades are involved in production as early as possible.
- A variety of good quality and efficient cranage in sufficient numbers and with sufficient spares to ensure production is continuous with an excess of capacity to cover for breakdowns.
- Continuity of orders.
- Yard produces and updates standard designs.
- The yard either has or has access to research and development facilities such as a testing tank, CFD software and other facilities where improvements can be made and optimized to existing designs.

- Product quality is verified through:
  - Ship quality and fitting out meets detailed specification
  - Product produced on time and to budget
  - Sea trials satisfying performance criteria

While there are many more factors involved the above are general considerations for each facility showing the characteristics of a good facility. There are almost an unlimited number of permutations for the above but it is intended that this is used as initial guidance on facilities with good QA/QC procedures.

## Appendix

**Abbreviations:**

| | |
|---|---|
| BI | Business Interruption |
| CBI | Contingent Business Interruption |
| CFD | Computational Fluid Dynamics |
| DSU | Delayed Start-Up |
| FAT | Factory Acceptance Test |
| FDS | Functional Design Specification |
| FLNG | Floating Liquified Natural Gas |
| FMEA | Failure Modes and Effect Analysis |
| IFAT | Integrated Factory Acceptance Test |
| ISAT | Integrated Site Acceptance Test |
| JNRC | Joint Natural Resources Committee |
| KPI | Key Performance Indicator |
| IACS | International Association of Classification Societies |
| IEA | International Energy Agency |
| IVB | Independent Verification Body |
| ISAT | Integrated Site Acceptance Test |
| ISO | International Standards Organisation |
| JNRC | Joint Natural Resources Committee |
| JSA | Job Safety Analysis |
| MoC | Management of Change |
| MPI | Magnetic Particle Inspection |
| NCR | Non Conformance Report |
| NDT | Non Destructive Testing |
| OEM | Original Equipment Manufacturer |
| PD | Property Damage |
| PDCA | Planning, Doing, Checking, Acting/adjusting |
| PMT | Project Management Team |
| PPE | Personal Protective Equipment |
| PREAD | PReserving Evidence and Acquiring Data |
| QA | Quality Assurance. The procedures for assuring a product or services quality. |
| QC | Quality Control. The process for assuring a product or services quality. |
| QI | Quality Improvement |
| QMP's | Quality Management Principles/Quality Management Plan |
| QMS | Quality Management System |
| QP | Quality Planning |
| RCA | Root Cause Analysis |
| SAT | Site Acceptance Test |
| SIT | Systems Integration Testing |
| SPMT | Self Propelled Modular Transporter |
| TRL | Technology Readiness Level |
| UAT | User Acceptance Test |
| URS | User Requirements Specification |
| USR | User System Requirement |
| UT | Ultrasonic Testing |