

Return experience to help the success of a cable system project

This contribution focuses on return experience gained from failure investigation and consultant service to help the success of cable projects during the manufacturing, installation and operational phases.

Quality management is a cornerstone of any project's success.

Many activities (e.g., design, manufacturing, installation, testing and operational activities) occur throughout a cable system realisation project. A project realisation shall be conducted in parallel with the quality management process, which includes planning activities, setting requirements for activities, performing activities, checking the results of activities and acting upon the findings.

Quality management recognises that investments in the checking and acting as described above increase the probability of project success.

Very often, engineer intends to treat testing as nearly a whole quality management process. Actually, quality management includes two main aspects: quality assurance (QA) and quality control (QC), and testing is only part of quality control shown in Figure 1.

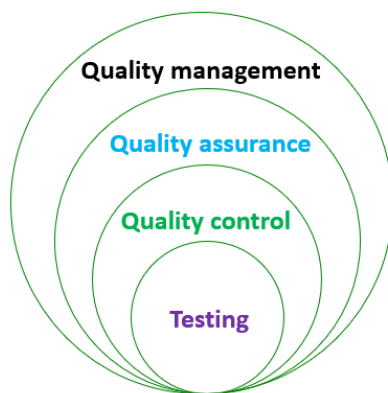


Figure 1 Quality management overview

Quality assurance provides the confidence that quality requirements will be fulfilled within a realisation process, while quality control ensures quality requirements will be fulfilled by a product (e.g., by measuring, testing, detecting deviations or defects). So, if QC discovers and roots out deviations or defects, QA will reevaluate and fine-tune processes to avoid and eliminate deviations or defects in the finished products.

Lessons learned during the manufacturing phase

In the manufacturing phase, it is key to carefully manage the cable system integrity (in particular, insulation material purity and semiconductive material conductivity). To accomplish this, during the production phase, clear, complete and strict requirements and

properties shall be defined in the quality assurance document. Furthermore, a suite of quality control procedures such as tests, measurements or other verifications should be in place to measure and ensure the status of the cable system.

A set of manufacturing plans is listed below as a checklist to help an engineer improve manufacturing quality management:

- Breakdown and identification of all individual manufacturing steps of delivered components and cable systems;
- Manufacturing production line set up, identification and location of manufacturing sites and description of transportation between factories;
- Definition of the equipment that will be used to manufacture the cable system components;
- Definition of all incoming goods, their handling, storage and testing;
- Delivery of incoming goods shall be strictly controlled to avoid unwanted inclusions (e.g., random batch tests, FTIR analysis);
- Review of new raw material to ensure electrical and mechanical properties of this material under required conditions are clearly understood;
- Definition of all required cable system components manufacturing procedures including quality control activities, monitoring activities, machine settings, expected forces and movements, and cleanliness requirements for each handling step;
- Definition of expiry dates of incoming goods / half-products;
- Storage of incoming goods / half-products / finished products shall be detailed;
- Quality control measures applied during the manufacturing phases (e.g., frequency of quality control measures, numbers of samples and requirements of each measurement should be clarified);
- Traceability of materials and documentation of traceability;
- Calibration of relevant manufacturing, measuring and testing equipment;
- Qualification of the people and equipment;
- Internal audits and manufacturer's quality management;
- Position of third-party witnesses;
- Non-conformity handling procedures;
- Production non-conformity should be recorded, and their underlying cause should be analysed and addressed. More important is that identified non-conformity has to be removed, corrected and avoided, and preventive activity shall take place to maintain the required level of quality ;
- Repair handling procedures.

Lessons learned during the installation phase

Developing plans for the cable installation (and all other cable handlings) is recommended. Installation plans can be quite complex as many aspects need to be defined and are very project specific simply because the installation is different for each project.

The installation plan shall describe how the installation will be performed such that the cable system is installed in the intended environment and all cable system limitations (for example, the forces and movements ensured by the cable system design) are respected. Typically, installation plans comprise the following information:

- Breakdown and identification of all individual installation steps;

- The installation procedure includes quality control activities, monitoring activities, machine settings, expected forces and movements for each installation step. Note that the cable jointing / application of accessories and auxiliaries is typically a part of the installation procedure;
- Definition of the equipment that will be used to install the cable system components;
- Protection against (third party) damage and other sources of the potential hazard to the cable system components (UV radiation, water ingress) during installation;
- Quality control measures applied during the installation phases;
- Traceability of materials and documentation of traceability;
- Calibration of relevant installation equipment;
- Qualification of the people and equipment;
- Extreme situation plans include how to define extreme situations and how to handle these situations;
- Internal audits and installer's quality management;
- Position of third-party witnesses;
- Non-conformity handling procedures;
- Repair handling procedures.

Lessons learned during the operational phase

In the operational phase, it should be ensured that the cable system is operated within its design basis. After all, the design will only function well within the design basis boundaries. Special care has to be taken to continue to obey thermal limitations and to keep the cable system protected against damage (third party or from the environment), as it is known that the cable environment may change over time. Monitoring of the cable environment, e.g., by Distributed Temperature Sensing (DTS) or other forms of sensing (strain, vibrations, and more), is therefore interesting to keep control during the operational lifetime of a cable system.

In case of a failure, it is recommended to apply a Root Cause Analysis (RCA), preferably by an independent, knowledgeable party (even during the period of warranty). Results should be documented, filed and shared as mentioned under "Quality Management" to prevent any similar future failures in the industry.