# CHALLENGES FOR SERIAL DEPLOYMENT OF SMRs: A CERTIFICATION BODY’s POINT OF VIEW

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**Abstract**

Certification bodies and independent inspection agencies play a key role in demonstrating the safety of nuclear projects. They provide Testing, Inspection, Certification (TIC) services on a regulatory (mandatory) or voluntary basis, acting as “Third” or “Second” Party. They are accredited by “Accreditation Bodies” and approved by nuclear regulators who constantly audit their effective independence, their knowledge of regulations and their operational conformity assessment procedures (including the technical qualification of inspectors). Their roles and responsibilities are strictly defined by regulators who may chose to involve them at various stages of the project development, and for various technical scopes.

In response to the anticipated strong development of nuclear projects worldwide, certification bodies and inspection agencies have to deal with numerous challenges. These challenges concern the number of projects but also the variety of technologies and the industrial organization specific to the serial construction of SMRs. Uncertainties about the regulatory environment remain the most significant risk factor.

The paper describes how certification bodies and inspection agencies are now preparing to adapt their service offerings and processes for the success of SMRs deployment worldwide.

## Certification bodies and independent inspection agencies

In its Principle 1 (Responsibility for safety), the IAEA’s Fundamental safety principles [1] establish that “The prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks.”

“The licensee retains the prime responsibility for safety throughout the lifetime of facilities and activities, and this responsibility cannot be delegated. Other groups, such as designers, manufacturers and constructors, employers, contractors, and consignors and carriers, also have legal, professional or functional responsibilities with regard to safety.”

One of the missions of nuclear regulators is to develop effective and efficient approaches for their regulatory activities, including assessments and inspections. Determining these effective and efficient approaches is a challenging undertaking, as it depends on the specific national regulatory framework. For instance, regulators need to establish a clear delineation between their own responsibilities for safety and those of the license holder or applicant. When selecting their approaches, regulators must consider not only the direct impact on safety, but also potential indirect effects. These indirect effects may include impacts on the regulator's own resources or changes to the safety culture of the licensee. Furthermore, regulators must continually reassess and adjust their approaches to adapt to evolving legal, economic, and technological circumstances. This continuous evaluation and refinement is necessary to ensure the regulatory framework remains effective and efficient.

When it comes to systems, structures, and components (SSCs), particularly pressurized components, many countries involve independent inspection organizations (IOs) and other conformity assessment bodies. These bodies are tasked with reviewing, assessing, and overseeing various activities during the design, manufacture, construction, and commissioning of SSCs. The regulator may prescribe the use of such conformity assessment bodies, and either the regulator or the licensee/vendor can contract them to perform this work. In other countries, the regulator does not mandate the use of independent conformity assessment bodies, but instead expresses the expectation that the licensee will engage these bodies to review, assess, or supervise critical aspects during the design, manufacture, construction, and commissioning stages.

Regulatory bodies can choose to emphasize either a prescriptive approach or a goal-setting (outcome-based) approach for the inspection of SSCs. Alternatively, they can combine these approaches to varying degrees and incorporate the use of independent conformity assessment bodies as part of their oversight process.

## How Certification bodies and independent inspection agencies work

Conformity assessment is the demonstration that specified requirements are fulfilled. It can be applied to products, processes, installations, organizations, and to those bodies that perform conformity assessment activities [2]. When the conformity assessment is performed by an organization that is independent of the provider of the object of conformity assessment, with no user interest in the object, it is a called a “third-party conformity assessment activity”. “Certification” is the third-party attestation related to an object of conformity assessment (“accreditation” is the equivalent term used for the assessment of conformity assessment bodies).

Certification bodies and independent inspection agencies play a key role in demonstrating the safety of nuclear projects. They can provide testing, inspection and certification services of products, systems, processes, and organizations, working on a regulatory (mandatory) or voluntary basis, and acting either as “Third” or “Second” Party (second party conformity assessment, unlike third party assessment, is performed by a person or organization that has a user interest in the object of conformity assessment [2]). They are accredited by “accreditation bodies” and approved by nuclear regulators who constantly audit their effective independence, their knowledge of regulations and their operational conformity assessment procedures (including the technical qualification of inspectors).

Primary circuit pressure boundary components (such as the reactor vessel and steam generators) represent the highest risk and level of assurance. Design, manufacturing and assembly of nuclear pressure equipment is the area where certification bodies are the most likely to be involved among all nuclear SSCs. The conformity assessment process may deal with new equipment or existing equipment that has been maintained or repaired and for which a requalification is required by regulations or standards.

Depending on local regulatory requirements, inspection organizations may be involved in additional activities such as:

* Destructive Testing of materials (e.g. samples of forged parts) or oversight of such tests;
* Non-destructive testing or oversight of such tests;
* Management System certification;
* Inspection of civil works;
* Environmental monitoring;
* Other types of product certification (e.g. Low Voltage equipment, Electro Magnetic compatibility, construction products in the European Union);
* In service regulatory inspections of conventional equipment such as lifting equipment, electrical equipment, fire protection systems.

A conformity assessment body conducts thorough reviews of the detailed design documentation. The detailed design documentation typically includes the following:

* Standards and criteria that have been adopted;
* Structural and other types of analysis;
* Structural and isometric drawings;
* Material specifications;
* Welding and fabrication/manufacturing processes, along with their qualification;
* Control/examination plans and procedures for destructive and non-destructive testing.

If the conformity assessment body's review, which may involve their own verification analysis, demonstrates that the relevant requirements have been met, the body may issue a design examination certificate or an equivalent document.

The design examination certificate or its equivalent should, in principle, be a prerequisite before the manufacturing process can commence. During the manufacturing stage, conformity assessment bodies perform supervision and testing at different phases, in accordance with the control and examination plans. This includes activities such as visual examination and hydrostatic testing conducted at the manufacturing facilities.

The qualification of welding procedures and welding personnel is supervised and evaluated by a certification body. After the completion of testing, the results are evaluated by the licensee and the conformity assessment bodies, with any outliers being assessed. Deviations and non-conformances are also reviewed, and the results are evaluated. If these reviews and evaluations demonstrate that the relevant requirements have been met, the conformity assessment body may issue a manufacturing examination certificate or an equivalent document.

The manufacturing examination certificate or its equivalent should, in principle, be a prerequisite before the start of the installation process. During the installation stage, independent bodies perform supervision, examinations, and testing in accordance with the control and examination plans.

After the installation of a component or structure within the plant, an inspection body should verify the following:

* The component has been installed in accordance with the controlled drawings and flow charts, and its performance meets the safety requirements.
* Any deviations and non-conformances identified during the installation are reported and evaluated by the licensee and the inspection body, as appropriate.
* The surface finishes and coatings of the installation are completed to the required final state.
* Tests have been conducted to demonstrate that the safety valves and other safety equipment operate properly, and that the component was not exposed to harmful vibrations or other loads that were not accounted for in the design. The inspection body should witness these tests.

If these verifications and tests show that the relevant requirements have been met, the inspection body may issue an installation examination certificate or an equivalent document.

## Challenges faced in the context of the nuclear renaissance

The nuclear industry faces challenges that will significantly impact the inspection and certification business. These challenges include:

* The “human capacity challenge” and competition between projects. The 2023 United Nations Climate Change Conference (COP 28) has set extremely ambitious objectives for the construction of new generation capacities (tripling the existing nuclear generation capacity by 2050), whilst in the coming decades, existing nuclear fleets will have to undergo massive life-time extension programmes. High CO2 emitting industries will amplify their decarbonization effort with nuclear technology solutions to meet the demand for heat, hydrogen, desalination, and electricity.
* The “innovation challenge”, with fourth generation nuclear systems expected to become ready to deploy within the challenging time frame of the early 2030s [3] and with the emergence of advanced manufacturing, use of digital twins, AI, intelligent instrumentation…
* On the industry and supply-chain side, insufficient “intelligent customer” capabilities of new licensees / operators could threaten the procurement of safe and compliant safety class components (in particular long lead items), with an increased risk of counterfeit and fraudulent items (CFIs) [4].

The Testing, Inspection and Certification (TIC) industry is currently organized and sized to support the industry and regulators in a well-known context of regulations, codes and standards, dealing mostly with mature technologies such as light water reactors. The development of SMRs brings additional industry transformations with substantial impact due to:

* Standardization of systems and components, resulting in fewer product references, higher volumes, serial production, transforming manufacturing organizations and quality assurance/quality control processes. For example, higher production volumes of components allow statistical process control (SPC) as an efficient and cost effective quality control method;
* Modularity, resulting in increased fabrication in workshops, less construction and assembly work on site;
* New technologies, i.e. new reactor designs, new applications (such as the production of process heat, hydrogen, desalination) with potential increased needs for energy storage close to the client;
* New safety issues specific to the operation of multiple modules and proximity with industrial facilities;
* New materials not yet considered by design and construction codes;
* New suppliers;
* New fuels;
* New lifecycle phases, such as the transportation of nuclear modules from manufacturing facilities to sites, with or without fresh/used fuel.

One of the most critical issues for conformity assessment bodies is certainly the lack of visibility over the emergence of new licensing frameworks. Countries considering the construction of SMRs or AMRs are still developing or adapting their licensing regulations. An objective based regulatory approach (vs. a prescriptive approach) will require conformity assessment bodies to develop new conformity assessment strategies and will change the way inspectors are internally trained and qualified. Regulatory harmonization initiatives are also welcome to facilitate internationally accepted certification and lower its cost. The possibility to have equipment certified before they are assigned to a specific customer would be a major competitive advantage for SMR technology developers.

## Adapting service offering and processes for the success of SMRs deployment worldwide: a paradigm shift

In this changing context, conformity assessment bodies need to proactively adapt their assessment procedures, adopting conservatory approaches before regulations and licensing requirements are fully developed. Developing and offering a risk-based approach for the qualification of new technologies (in the case of technologies which are not covered by existing recognized requirements (e.g. rules, standards, codes of practice) is an essential asset as it allows to take the necessary measures to later prepare an acceptable level of confidence in safety demonstrations (especially with respects to design and manufacturing quality).

Such a methodology for qualification of technologies may be used to qualify, for example:

* unproven equipment or system, or unproven integration of equipment into a system;
* system with unproven components;
* technology not covered by recognized requirements;
* technology without relevant operating experience.

Other use of technology qualification may typically be:

* to confirm feasibility and absence of barriers that may prevent the technology from being developed to maturity;
* to confirm readiness of the technology to go to the next stage of development;
* to confirm readiness of the technology for specific application
* to support testing phases of a technology.

A qualification plan will be established upfront to provide evidence that risks identified during the technology assessment are adequately addressed. Typical qualification activities include a selection or a combination of the following:

* Design review;
* Testing of materials or equipment, performance tests;
* Inspections during manufacturing;
* Review of certificates and manufacturing records;
* Quality system audit audits.

## Conclusion

This paper has examined the critical role that certification bodies and independent inspection agencies play in ensuring the safety of nuclear facilities and components. As the nuclear renaissance drives increased construction of new plants and deployment of innovative small modular reactors, these third-party conformity assessment bodies will face significant challenges.

Key challenges include the human capacity shortages across the industry, the need to assess and qualify emerging innovations like advanced manufacturing and fourth generation reactor designs, and adapting to new modularized SMR supply chains and delivery models. Conformity assessment bodies must proactively transform their processes, and develop risk-based technology assessment methodologies to meet these future demands.

Developing robust qualification schemes for new unproven technologies not yet covered by codes and standards will be essential. So too will be efforts to harmonize regulatory approaches internationally to facilitate efficient certification across borders. Overcoming these challenges will require close collaboration between regulators, licensees, technology developers and the TIC industry. By anticipating and adapting to change, certification bodies and inspection agencies can continue to play their vital third-party oversight role in nuclear safety as the industry undergoes its renaissance in the coming decades. Their rigorous independent assessments will remain a critical element in maintaining public trust and confidence in the safe deployment of nuclear power.

References

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