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Managing nuclear projects: a Design Agency experience in the design-build of waste management facilities in Canada.

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Abstract

Quality Assurance guarantees the quality of a product; it does not guarantee that it is a quality product. As procedures develop to satisfy QA programs and regulatory needs it is necessary to find ways to ensure that procedural management reinforces project management and does not detract from it. CANATOM NPM's experience in bidding for and executing the design or design and construction of nuclear waste management facilities demonstrates how design excellence and innovation can still be achieved while successfully managing the challenge of technical administration.

The sourcing of expertise, the intricacies of design definition and the coordinating efforts required in the execution of the projects (one fully completed, the other into its engineering phase) will provide a valuable insight into the role and activities of an engineering company engaged in a "Design Agency" (DA) role.

Introduction

Canatom NPM (Canatom), an engineering company created in the late 1960's to provide services to the nuclear industry has been involved extensively in all major CANDU projects outside Ontario and can claim a high degree of confidence in its abilities to meet the design, procurement and project management requirements of an expanding nuclear industry.

In the current Canadian environment where no new plants are under construction the engineering focus is now directed toward the refurbishment, decommissioning and waste management projects of the existing, aging nuclear plants.

Canatom has, once more, successfully confronted the challenge to lead the nuclear consulting industry in the current phase of operational support to the Canadian utilities.

Today's engineering companies are faced with the prospect of successfully operating in a market that imposes the execution of projects requiring a broader technical multi-disciplinarity and characterized by increased complexity in the management of the jurisdictional, regulatory and quality assurance areas.

In addressing the utility (the plant's "Owner") requests for operational support, a conventional 'design-build' company is forced to strengthen its base expertise with specialists traditionally active only within the utility (e.g. specialists in environmental qualification assessments, nuclear waste management, safety analysis, licensing, etc).

In the execution of projects on behalf of the Owner, the engineering company (acting as the "Design Agent") must become thoroughly familiar with the project technical administration (the procedural matrix defined by the Owner Quality Assurance Program) implemented by the various Owners. This task, additional to the implementation of the engineering company 'in-house' QA, is an ever-increasing segment of all design, installation and commissioning activities in nuclear projects.

The BRUCE NGS project

In early 2000, PMMM (acting as the "Owner's Agent for OPG) issued, to pre-qualified bidders, a Request for Proposal for Engineering, Procurement and Construction (EPC) services for the "In-Station Used Fuel Dry Storage Project". The project was planned to be carried out at the Bruce Nuclear Generating Station (BNGS) on two nuclear plants, BNGS A and B, with execution of the design for both stations but erection taking place only at the 'B' station.

The plant Owner needed to modify the Irradiated Fuel Bay of each power plant by adding a small Loading Bay, interconnected with the main bay. This would allow the underwater transfer of batches of fuel from the racks stored in the main bay to a specially designed Dry Storage Container (DSC) immersed in the new loading bay for fuel loading. The 'aged' fuel bundles, stored underwater in the main bay, had to be remotely removed from their storage units and transferred into new modular racks that would then be moved, shielded by water, to the loading bay and loaded in the cavity of the submerged DSC.

The work also required making all the necessary permanent modifications to satisfy the logistics of in-station movement of the 80 Mg DSC, inclusive of the provisions for preventing damage to the loaded DSC and to the station structures

Fig.1 BUFDS project: the Loading Bay.

in case of an accidental drop of the DSC. Accidental drops during DSC handling included a ~10m fall on the floor of the truck bay (adjacent to the fuel bay) and a similar fall inside the water-filled Loading Bay.

Furthermore, all the construction activities (from the excavation of floors to the removal and erection of walls and the installation of nuclear and conventional piping/ducting systems connected to existing systems) were to be carried out while the station and the main fuel bay were kept fully operational. Figure 1 shows the erected loading bay and provides a glimpse of the complexity of the task.

Of course, the design of the modifications, the erection/installation of structures and systems, the testing, commissioning and placement into service of the Bruce "In-Station Used Fuel Dry Storage Project" (referred to as BUFDS) were to be carried out in accordance with the existing Owner's licensing and procedural protocols. That implied the winning bidder needed to assume, in the project, the role of Design Agent, a task so complex that the Owner deferred the technical administration of the project to a third party: the Owner's Agent.

The traditional engineering and procurement role that Canatom had carried out in the major CANDU projects certainly proved to be its strongest credentials in the preparation for bidding on the Bruce project even though, at the time, the engineering expertise of the company did not include an adequate support in the waste management and fuel handling areas. The full integration of design and building requirements for the project also posed the issue of contracting out the construction segment of the work. Reliability and accreditation of resources was the first concern of the company's management. The solution was multiple Joint Ventures covering the three areas required to form the Design-Build Consultancy necessary to successfully compete in the bid for the Bruce project.

To broaden the engineering expertise to all areas of nuclear waste management Canatom secured the partnership of a UK veteran in the nuclear business, AEA Technology, to form CTECH. This new integrated engineering concern sought the additional partnership of GE Canada, a nuclear and fuel handling design specialist, and of BFC Construction (now Aecon), builder of structures and systems, a most suitable field partner in the project. The resulting Canatom led joint venture (CTECH-BFC) submitted the winning bid for the BUFDS project.

The crucial engineering aspect of the BUFDS was the governance of the CSA N285.0 (General requirements for Pressure-Retaining Systems and Components in CANDU Nuclear Power Plants) throughout the project. The accreditation of the Design Agency for the project was based on meeting the Quality Assurance requirements associated with design, procurement, fabrication and installation and commissioning of pressure retaining systems, all under the jurisdiction of the CAN/CSA-N286.0 (Overall Quality Assurance Program Requirements for Nuclear Power Plants); Canatom had been a long term holder of the Design and of the Procurement QA programs under the CSA-N286.2 and CSA-N286.1.

Fabrication (construction and installation) and commissioning QA programs were contributed to the team by BFC and GE Canada.

Once the project had begun, the elation of the contract award was somewhat dampened by the realization that the Owner's technical administrative protocol, to be adhered to for the whole project, was not only procedurally different from the Canatom in-house QA program, it was substantially more complex and meticulous. On a tightly scheduled project, re-alignment of the work process to new standards and procedures did create an initial sense of anxiety, only later relieved by the benefit provided by the new work structure.

The engineering journey began by getting acquainted with the existing In-Station Used Fuel Dry Storage System operational at Pickering NGS. Although the two designs had conceptual similarities, the substantial structural differences amongst the two stations defined the challenge of solutions based on site specific optimization vs. multi-plant integration (a concern somewhat lifted when Bruce NGS changed ownership from OPG to Bruce Power).

The engineering of DSC movements from the truck bay (adjacent to the fuel bay) to the loading bay imposed the assessment of drop accidents on floors, walls and the bay itself. The modeling of the accidents and the conceptual design of the crush pads needed to attenuate the effect of the falls was led by the UK team members. The integration of the detailed design of the massive crush pads with the station structures (underwater units, bay deck units and truck bay floor and wall units) was carried out by the Canatom design team following an iterative process that slowly finalized the crash pad configurations. The proposed design of the new loading bay required the verification by analysis (performed by Kinectrics as a consultant to Canatom) that the hydrodynamic wave caused by a DSC drop in the loading bay would not upset the status of the thousands of used fuel bundles stored in the main bay (in Fig 2 the DSC is shown being lifted to the loading bay edge for immersion).

The accidental fall assessment also indicated that, although the drop on the crush pad in the truck bay floor would have left the DSC undamaged, a bouncing off effect would have caused the DSC to possibly hit the outer steel framed wall of the truck bay. That unexpected problem required the removal of a steel column (substituting it with a structural steel frame) in the outer perimeter of the station service area. The column replacement problem was further complicated by the fact that a re-analysis of the whole building structure (designed to Codes and Design Basis Earthquakes types in effect at the time of the station construction) showed some changes required under the Codes and DBE cases in effect during the BUFDS project. Reinforcements and modifications to the building wall and roof structures had to be designed for implementation in conformance with the initial project schedule.

The issue of variances of Codes, Standards, regulatory and jurisdictional requirements in effect during the design/construction of the stations from those in effect during the execution of the project proved to be a remarkable stumbling block because many of the requirements (under federal and provincial jurisdiction) were, at that particular time, under substantial revision with provisional issuances that made their interpretation difficult and sometime uncertain. Only a sound knowledge of the historical issues allowed the preparation of position cases submitted for regulatory arbitration. As a result, from system re-classifications to special case waivers, a gambit of unexpected design issues had to be addressed and resolved.

Fig. 2 The DSC lifted to the Loading Bay edge

With the design slowly proceeding to its definition and in preparation for component procurement, the field station was set up in trailers adjacent to the construction zone. In fact, one trailer was communicating with the truck bay (a zoned area of the station) and required the installation of personnel radiation monitoring equipment to allow the workers and their green man escorts to move in and out of the soon-to-be work area in the truck bay.

If the design activities had met with some challenges, the construction and system installation showed that even bigger challenges were to be overcome. The irradiated fuel bay is a pristine pool of demineralized and constantly purified water open to an atmosphere of equally controlled air. That environment had to be tampered with by the demolition of concrete and steel (internal and perimetric) of walls and ceiling, of concrete floors and by the erection of substantial concrete structures. All those activities had to be carried out without risking contamination of the bay water and by minimizing the exposure of the bay environment to the outside. Fig 3 shows the main spent fuel bay before the modification s (see Fig.1 in relation).

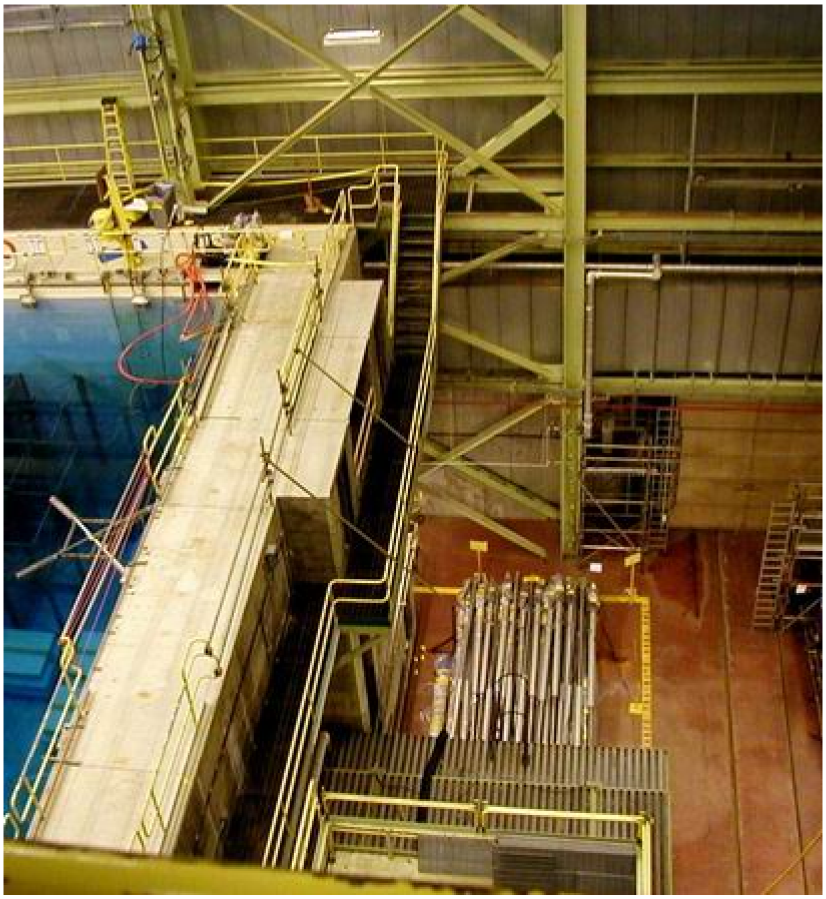

Fig 3. The Bruce SiFB, before modifications had begun.

The demolition of a large portion of reinforced concrete floor structures required the set up of provisional superstructures that created small controlled environments where cutting, hammering and debris removal could be carried out without contaminating the adjacent operational fuel bay (see Figures . 4 and 5). Even the highly monitored Cobalt transfers in the fuel bay were required to maintain their scheduled program during the project duration.

The design of the logistic elements of DSC movements revolved around two main pieces of equipment: a new bridge crane, that had to replace an underrated unit in service in the building; and the DSC lifting beam, a massive steel frame that engaged the 80 Mg DSC and its lid/clamp assembly.

The custom designed crane, spanning the width of the bay, required a sophisticated control system that enabled the DSC movements within narrow, three-dimensional corridors. Its installation necessitated the removal of a portion of the ceiling in the fuel bay building (also needed to remove the existing crane) and installation of an engineered roof hatch to permit removal and installation even during inclement weather.

Fig. 4 The temporary environmental enclosure for concrete cutting/pouring.

The installation and commissioning of the bridge/trolley of the 100 Mg crane required a lengthy series of adjustments caused by the need to position the crane hook with an accuracy, in some cases, of a few centimeters (e.g. during the lifting beam engagement of the out of line-of-sight submerged DSC).

The lifting beam design, based on the Pickering NGS unit, underwent a series of design modifications dictated in part by the structural differences between stations and in part by the operational requirements set by the, by then different, Owner of the Bruce station. The dimensionally much longer Bruce lifting beam did warrant the minor design changes although, unwittingly, they led to further DSC handling changes that further differentiate the DSC operations between the two stations.

The need to rotate and tilt the DSC in the truck bay (to allow the draining, vacuuming of its cavity and its repositioning for removal from the bay building) was ultimately accomplished at the Bruce NGS, unlike at Pickering, by the design and supply of a sophisticated piece of equipment that enabled all the required movements.

While the design process proceeded, in part iteratively, toward its finalization, the construction activities remained on schedule by advancing through the major concrete floor excavation and the erection of the loading bay.

Fig. 5 Working inside the enclosed environment (Fig.4) after concrete removal.

The loading bay, literally ‘attached’ to the main bay, faced an existing fuel bay gate and bulkhead assembly. Removal of the gate and bulkhead would have enabled the loading bay to open up to the main bay for fuel transfer.

Since the bay construction method was steel lined concrete, the loading bay had to match such design. While the loading bay concrete work was joined to the main bay structure relatively easily, the welding of the two liners proved to be a remarkable challenge. The welding of the two liners could only be accomplished by removing the steel bulkhead (placed “downstream” of the main bay steel gate, facing the loading bay), a simple task if the steel gate could have ensured the hydraulic isolation of the main bay. Unfortunately, the gate seal, with time, had deteriorated and the gate/bulkhead gap was flooded. The seal replacement, carried out by the construction crew, reduced the leak to a flow that could be pumped out but could not prevent water seepage in the gate/bulkhead gap. To enable bulkhead removal an engineered solution was devised: the installation of a provisional, secondary dam between the gate and the bulkhead to collect the gate water seepage and allow its pump-out. The shorter, temporary dam successfully allowed the removal of the main bulkhead and the welding of the liners (although one night, before the liner welding NDE had been completed, the main sump pump and its back up failed to operate with the resulting call in of the intervention crew on a Sunday morning, rather early). No loss of time or material resulted from the pump malfunction, upon restart of the pumps the liner testing was quickly completed and the loading bay was finally placed in a flooded condition.

The design and fabrication of the equipment to transfer, underwater, the used fuel from storage rack modules (bundle spacing for water cooling) to DSC stacking modules (tight bundle pitch for air cooling) was carried out by GE Canada. Following functional testing at the GEC facility, the sophisticated equipment was shipped to the station for installation at the bottom of the main bay. Commissioning of the remotely controlled equipment with fuel bundles posed several challenges to the fuel handling crew and the GEC technicians. Some electrical and hydraulic malfunctions required the large unit to be removed from the bay (and then decontaminated) for the final adjustments. To carry out a minor equipment tune-up while many other project field activities were still at various stages of completion in the area, required a major organizational effort.

Of course, our engineering, construction and installation crews joined by the Owner’s maintenance and operation crews met the final challenge when the new systems we had installed had to be physically connected with the station operational piping and ducting systems. Piping segments in pressurized nuclear and class 6 systems had to be isolated, cut, joined, tested and re-set under special station control. In some instances the whole process was required to be carried out in a matter of hours because of the essential nature of the affected systems.

In order to meet the Owner’s unwavering project in-service schedule, the coordination of all the technical and administrative functions stretched, at times, the Design Agency, the Owner’s Agent and the Owner resources to the limit. The meeting of that target was, nevertheless, accomplished to the satisfaction of all parties.

The Darlington NGS project

Following the completion of the Bruce project, Canatom decided to dissolve the multiple ventures that made it possible because the teaming-up had specifically targeted the requirements of one project. The possibility of being asked to bid on another project structured similarly to the BUFDS was deemed unlikely considering the constantly evolving structure of the Canadian Nuclear industry.

Canatom's assessment indeed proved correct when another major nuclear project was tendered out by OPG.

In 2003, PMM (acting as the "Owner's Agent for OPG) issued, to pre-qualified bidders, a Request for Proposal for engineering services for the design (and support during construction) of the "Darlington NGS In-Station Used Fuel Dry Storage Project" (DUFDS).

The plant Owner wanted to provide the station with the capability to load spent fuel stored in two Irradiated Fuel Bays (East and West FFAA) in DSCs to be immersed in existing 'cask' bays (ancillary to the main fuel bays). The underwater fuel transfer replicated the Pickering and the Bruce process. The Request for Proposal solicited the design of the modifications to the station required to execute the DSC loading.

Darlington NGS had some design provisions for the transfer of fuel from wet to dry storage based on a 'cask' (designed for loading of fuel in air) that never achieved implementation. The use of the DSC (designed for loading of fuel in water) replaced the 'cask' concept and imposed modifications of some of the station structures previously designed and erected for the fuel cask.

Unlike the BUFDS project RFP, the Owner wished to secure a Design Agency's engineering services for the design of the building/systems modifications and, following the Owner procurement of equipment and placement of a construction contract to a Builder, further engineering services of support during construction and system installation/commissioning were to be provided until the work 'close-out' phase would have reached completion.

The structure of the work under contract was substantially different from the BUFDS, somewhat reduced in scope but at the same time requiring a more complex method of project management.

On this occasion Canatom was very pleased to form a team with AECL in which Canatom would project manage and undertake all the design and AECL would provide specialist expertise in the analysis of the DSC drop scenario (the Kinectrics analysis team had transferred to AECL). Canatom's proposal was selected by OPG and the engineering activities for the DUFDS project started in September 2004 and are currently underway.

An insight into the engineering process that the Design Agency has to manage in this project would reveal the astounding intricacy of technical administration that characterizes it. Although the 'Client' is OPG, its corporate structure is, in this project, jurisdictionally represented as two "Owners" (the Station itself as the licensee of the FFAA and the Waste Management Division as the licensee of the DSC operation of the “In-station” and the “Out-of-station” facilities, and as well the ‘Owner’ of the ‘Out-of-Station’ facility)). The presence of the “Owner’s Agent (PMMM), intended to ease the DA interaction with the Owners, does, at the end, also bring into this arena another organizational entity.

Conclusions

The procedural challenges created by multiple levels of contractual responsibility and conflicting Quality requirements between partners, agents and owners can be overcome. Process management when handled clearly and concisely can reinforce Project Management and support design excellence and innovation.

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CANATOM NPM Inc (Canatom) is based in Mississauga, Ontario and has offices in Montreal, Quebec and onsite at various locations around the world.

Canatom is the largest private sector nuclear engineering company in Canada. It offers the following services in accordance with recognized national and international quality and nuclear standards:

- Project Management
- Design Engineering
- Supply Management (Procurement) Services
- Construction Management
- Operating Plant Support
- Radioactive Materials Management & Decommissioning

Formed in 1967 as a wholly owned subsidiary of 3 large Canadian engineering companies; namely Montreal Engineering, Shawinigan Engineering and Surveyer, Nenniger & Chenevert (SNC), it is now a wholly owned subsidiary of SNC-Lavalin Inc. The company was formed to provide services exclusively to the nuclear industry and this continues to be the primary focus.

SNC-Lavalin (TSX: SNC) is one of the leading groups of engineering and construction companies in the world, and a key player in facilities and operations management, and in the ownership, operation and maintenance of infrastructures. The SNC-Lavalin companies employ nearly 15,000 people in offices across Canada and in 30 other countries around the world and are currently working in some 100 countries.

Traditionally, outside Ontario, CANDU nuclear power plant engineering scope has been split between Atomic Energy Canada Ltd (AECL), the supplier of the Nuclear Steam Plant (NSP), and CANATOM NPM, the nuclear engineering consultant for the Balance of Nuclear Steam Plant (BNSP). The Balance of Plant (BOP) engineering has been performed by CANATOM NPM when BOP equipment is procured in a supply contract or by the turnkey supplier of the turbine-generator.

Major nuclear projects with key Canatom NPM contribution:

<u>Nuclear Power Plants</u>: Gentilly NGS 1 & 2 (QB); Point Lepreau NGS (NB); Qinshan NGS (China); Wolsong NGS 1 to 4 (S. Korea): Cernavoda NGS (Romania); Embalse NGS (Argentina): KANUPP NGS (Pakistan); RAPP NGS (India);

<u>other nuclear related plants</u> : La Prade (heavy water) (QB); Glace Bay (heavy water) (NS); Tokamak de Varennes (research) (QB); Taiwan (research).