QUALIFICATIONS NEEDED TO DESIGN, CONSTRUCT AND MANUFACTURE NUCLEAR SYSTEMS AND EQUIPMENT

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Abstract

This paper divides a nuclear plant into 4 zones, in terms of the qualifications that will be needed to construct or manufacture components, equipment and systems to nuclear standards. Alberta companies that have performed similar work for the oil industry could qualify within 3 to 4 months to do similar types of work for nuclear zones 3 or 4. Should they want to perform work for zone 2, their qualification period becomes 6 to 12 months. For zone 1 work, the qualification period becomes 18+ months.

A manufacturer or contractor willing to go through the qualification process will not only receive a good return on his investment, but will also place his company ahead of the competition for additional nuclear contracts. In addition, he will increase the quality and reliability of his services or products, and thereby, will become more competitive for contracts in the oil business.

1. Introduction

As nuclear power emerges in Alberta, it is imperative that developers of nuclear systems ensure appropriate levels of safety and quality.

Many local manufacturers and construction companies contemplating an entry into this new business arena have questions like, “Does the nuclear industry needs locally produced products and services?” and “What kind of qualifications and approvals are required?”.

Because 80% of a nuclear reactor’s life time costs are upfront costs, keeping down time to a minimum is essential. Whenever the plant is not operating it costs about $4 million/day (for 1000MW reactor) in lost revenues and interest on its up-front capital costs. Consequently, most reactor operators need infrastructure around the reactor, capable and qualified to quickly assist in bringing the reactor back on power. Such an infrastructure is usually made up of local companies. As a result, nuclear operators tend to favor as much as possible the use of local companies for the original construction.

Alberta based companies aspiring to become involved in the infrastructure described above, will have to realize that even the most minute failure of equipment or components in such an environment, can cause the plant to shut down with serious cost and even safety implications. Each type of system in a nuclear plant is designed to perform under certain operating

conditions. Therefore, all systems will undergo testing of each component and the overall assembly at those conditions.

There are numerous nuclear plant technology stakeholders interested in the regulatory approvals system.

- Project owners or their designated installers
- Investors and Insurers
- Designers such as engineers and architects
- Construction specialists
- Authorities having jurisdiction

Most of the nuclear safety permits are obtained by the project owners or Architect/Engineers, and they formulate their requirements for the manufacturers and constructors based on the requirements of these permits.

A Request for Tender from an Architect/Engineer for a nuclear project, clearly specifies all the applicable conformance requirements, including those of the regulatory authorities.

Interested suppliers, manufacturers or construction companies need first to prequalify for the work they want to do and then have the Architect/Engineer verify their ability to conform prior to being included in the "Tenders List". Consequently, a company must commence the pre-qualification process before expressing their interest to the Architect/Engineer. Together they can evaluate the timing of the qualification process. A consultant may be able to accelerate this process.

This paper breaks down the complete nuclear power plant into zones of approximately similar conformance requirements. If a company, for example, manufactures pressure vessels for the oil industry, they should be able to know what extra qualifications they need in order to fabricate a certain pressure vessel for a nuclear power plant.

The codes and requirements frequently change as new developments occurs. This paper is intended to provide only a general idea on what to expect, should your company want to participate in a nuclear project.

2. The Zones

For the purpose of Qualification Requirements the power station is divided into four zones. They are as follows:

ZONE 1*:* Includes the reactor core, its control systems and anything in contact with the Primary Heat Transport System.

ZONE 2 Includes The Reactor Core Moderator Cooling System, the Containment System, and most systems and equipment inside the containment area.

ZONE 3 Includes the Turbine Steam System, the turbine building and all the systems inside the turbine building except for Emergency Core Cooling System pumps and piping.

ZONE 4 Includes all Non Nuclear systems in the station

3. Applicable Codes in general

The governing codes for nuclear installations include:

- ASME Section III Classes 1,2,and 3 nuclear systems
- CSA N285 nuclear components
- CSA B51 pressure vessels and pressure piping
- ANSI B31 pressure piping
- CSA C22.1, 2 & 3 Electrical systems code
- IEEE for Electrical systems code
- National/Alberta building code
- National/Alberta Fire Code
- ASME Section IX Welding and Brazing qualifications
- ASME Section NF Supports
- ISO Quality assurance 9000 or 10000 series
- CSA Z-299 Quality assurance

The ASME Section III is the defining code of nuclear systems in terms of their importance and hence requirements. The ASME Section III makes references to other applicable codes and standards.

ASME Section III Class 1 - applies to all equipment in Zone 1

ASME Section III Class 2 - applies to all equipment in Zone 2

ASME Section III Class 3 - applies to all equipment in Zone 3

ASME Section III Class 4 - applies to all equipment in Zone 4

4. Construction and Manufacturing systems for the various zones

As the nuclear industry is an evolving industry, the code requirements as well the code contents may change from project to project. Nevertheless, the following guidelines can form the basis for Prairie companies to decide what general level of qualification they want to achieve.

4.1 Zone 4 Construction and Manufacturing Components, Equipment and Systems

This zone includes mostly auxiliary systems and equipment. Most of them do not affect directly the operation of the plant. In addition, any failures can be repaired while the plant is running.

The codes and standards used by the oil industry for small, low pressure systems roughly correspond to Zone 4, i.e. non nuclear, non process systems and equipment. Manufacturing and Construction would be expected to be governed by ASME Section III Class 4. The requirements of a class 4 system are similar with the "Best Practice" codes and standards with which the local industry is already familiar (building codes, fire codes, electrical codes etc). As usual meeting a Quality Assurance Standard, ISO or CSA, will be required.

Small and low pressure vessels, piping and systems (less than 103.4 kPa) do not normally require a Canadian Registration Certificate (CRN) from the provincial boiler and pressure vessel safety authority (ABSA).

4.2 Zone 3 Construction and Manufacturing Components, Equipment and Systems

This zone includes the conventional (non nuclear) portion of a nuclear plant's process systems. It includes the turbine building, which houses the turbine/generator, and associated systems of feed-water heaters, re-heaters, condensers, pumps, storage tanks and cooling systems for the condensers as well as for the generator.

The controlling code for zone 3 equipment and systems is ASME Section III Class 3. Codes and standards applicable to high pressure systems (greater than 103.4 kPa), for the oil industry, roughly correspond to ASME Section III Class 3 nuclear systems. Class 3 includes all the codes and standards included in Zone 4. As in the oil industry, the Boiler/Pressure Vessel code CSA B51 controls the design and registration of pressure vessels and piping systems.

The designated provincial/territorial government department (in Alberta ABSA), approves a new pressure vessel or component design and allocates an individual "CRN" number. Note that the CRN allocation is coordinated through a decimal point system with a unique identifier for the different provinces and territories.

Caution is required when the system includes pressure fittings. Manufacturing companies need to provide clear specifications to their suppliers ahead of time. Even so, it will happen often that special imported fittings are not registered in Canada. In this case, the original manufacturer must sign a notarized declaration of conformance and the design must go through an evaluation process before a CRN is issued for the fittings. As usual a quality Assurance code, ISO or CSA Z299.3, is required.

4.3 Zone 2 Construction and Manufacturing Components, Equipment and Systems

This zone contains all the systems inside the containment of the reactor building, and inside the containment of the Spent Fuel Bay. Excluded are the reactor core, its controls as well as the Primary Heat Transport System.

This zone contains the majority of the non process nuclear reactor systems. It is controlled by the ASME Section III Class 2 code. The requirements of ASME Section III Class 3 systems and CSA B51 are included here and apply. In addition, depending on the system, the following may be required:

a) Material traceability and control to the ingot for material used in all products
b) Quality Assurance system ISO 9001 or CSA Z299.2
c) The design and submission of Manufacturing Procedures
d) The design and submission of Testing Procedures
e) The development of Testing Rigs
f) Witnessed testing of components and systems in their operating conditions
g) The development and maintenance of a complete "History Docket"
h) CRN is required for all pressure boundary systems that may compromise the containment system even if they are low pressure*

(*A typical example is control tubing with valves, going through the containment of the reactor building. ASME Section III Class 2 considers the Reactor Building to be a containment that could be compromised. As a result, all tubing and valves must have material traceability (above certain sizes) and must be registered with the provincial boilers and pressure vessels jurisdictional authority. This may seem like overkill, but it concerns nuclear safety.)

4.4 Zone 1 Construction and Manufacturing Components, Equipment and Systems

This zone includes the Reactor Core, and its supports, primary containment, controls and cooling system called the Primary Heat Transport System (PHT).

In Canada, the controlling codes are ASME Section III Class 1, and CSA N285. These codes define the requirements for the materials, design, fabrication, examination, testing, inspection, installation, certification, stamping and overpressure protection of nuclear power plant components and their supports. The pumps, valves, metal vessels, systems, piping and core support structures are intended to function within the overall safety requirements of the nuclear power system.

ASME Section III, provides the requirements for new construction and includes considerations of mechanical and thermal stresses due to cyclic operation. It also provides the requirements for concrete reactor vessels and containments. In addition, it provides the requirements for the transportation and containment of high level radioactive wastes.

The CSA N285 Component Fabrication, provides the requirements, in addition to those of ASME Section III Class 1, for the preparation of prototype components or batches which are subjected first to extensive Non Destructive Testing and finally to destructive testing. This is required before approval is given for the final manufacturing procedures, test procedures, test rigs, manufacturing tools, personnel training and quality control.

5. Conclusions

5.1 Designing and constructing a nuclear power plant requires an extension of the requirements used to construct an oil refinery or a bitumen upgrading facility.

5.2 The requirements for zone 3 and zone 4 components are very similar to those used today by the oil industry.

5.3 The requirements for zone 2 components include the requirements of the oil industry for similar components plus material traceability and the development and execution of witnessed testing.

5.4 The requirements for zone 1 components include all requirements for zone 2 equipment plus the manufacturing and testing of prototypes and sample batches of components.

5.5 Time considerations If a local manufacturer or contractor has executed contracts for the oil industry and decides to do nuclear work, he could qualify within 3-4 months to do

work in zone 3 or zone 4 of a nuclear station. If he decides to do work in zone 2 he will need a qualification period of approximately 6-12 months. If he decides to do work in zone 1, the qualification time would be 18 + months.

All this testing, time and effort may sound like too much. However, the manufacturer or contractor willing to go through the qualification process will find an excellent return on his investment. Not only will he place himself ahead of future competition for nuclear contracts, but will also increase his ability to provide high quality products or services, more competitively, with in the oil industry.