Nuclear Supply Chain: Perspective of a Component and Sub-system Fabricator - 14474

James C. Stouch, P.E., Vice President Business Development,
Precision Custom Components, LLC

ABSTRACT

Today's nuclear industry supply chain environment is characterized by distinct differences and challenges when compared with the "pre-renaissance" period of ten or more years ago. Examples include: the sometimes conflicting requirements placed on a supplier of fabricated components or sub-systems to NSSS suppliers; the stresses inherent in meeting the cost, schedule, and quality goals of the customer (and customer's customer); and keeping positive customer-supplier relationships intact over extended contract execution periods.

Lessons learned come from over 50 years of company history in the nuclear supply chain. As an original "Rickover Supplier" in the 1950's, the company, Precision Custom Components (PCC) and its predecessors supplied reactor components for Shippingport 1 and has produced Reactor Vessels (RV); RV Heads; RV Internals; Integrated Head Packages; Primary Coolant Pump Components; Pressurizers; Steam Generators; nuclear waste processing equipment; and spent nuclear fuel casks, canisters, and baskets. Today, the company is manufacturing AP1000 and other Generation III and III+ equipment.

Most of the equipment the company has delivered has been "build to print" from our customers' designs. That is, while the company manufactures code stamped equipment (e.g., N-stamped) it has not offered its own proprietary product. That said, the regulatory and code requirements mandated in the US and internationally are numerous and come with measurable demands on time, effort and cost. Given that the nuclear industry today is competitive and the supply chain is global, these demands require finding an optimum balance in order to be successful. Maintaining positive supplier-customer relationships in this environment can also be challenging but must be sustained since manufacturing and construction contracts for nuclear power plants take years to complete.

INTRODUCTION

Today's nuclear industry supply chain environment is characterized by distinct differences and challenges when compared with the nuclear supply chain environment of ten years ago and before. The inherent costs of participating in the business continue to increase and the experience and training on both sides of the customer-supplier relationship continue to change. In an environment of firm fixed price contracts, these and other factors stress the contract relationship. That said, there are numerous new nuclear power plants being designed and built worldwide and as such, these contractual challenges must be dealt with productively.

THE PERSPECTIVE

The perspective of this presentation is from a supplier of components and sub-systems to a Nuclear Steam Supply System (NSSS) vendor. The company in this case, Precision Custom Components, LLC (PCC) (and its predecessors), has been continuously manufacturing large power generation equipment since the late 1800's. In the 1950's, Admiral Hyman Rickover, looking for a manufacturing base to make components for both Navy and civilian nuclear power plant equipment, selected PCC's predecessor company, S. Morgan Smith Co. (soon after acquired by Allis Chalmers Mfg. Co.), to make reactor vessels, closure heads, steam generators, reactor vessel internals, and other primary NSSS equipment. The company machined the reactor vessel head and reactor vessel internals for Shippingport 1, the first

commercial nuclear power plant in the US. Today, PCC still manufactures nuclear equipment for commercial and military applications as well as pressure vessels for the chemical and petrochemical industries; specialized hardware for the US Department of Defense, US Department of Energy, National Laboratories, and NASA; and other specialized industrial equipment characterized as heavy fabrications and large close tolerance machined hardware. The company holds American Society of Mechanical Engineers (ASME) certifications in both Section III (N, NS, and NPT) and Section VIII (U, U2, and U3) of the Boiler and Pressure Vessel Code. One common theme is that PCC has no proprietary product offering. All manufactured product is based on its customers' functional or detailed designs.

THRESHOLD REQUIREMENTS FOR PARTICIPATION IN THE NUCLEAR SUPPLY CHAIN

There are a myriad of industry and regulatory requirements demanding strict adherence in order to participate in the supply of primary NSSS components. Among these can be:

ASME Boiler and Pressure Vessel Code: Sections II, III, VIII, IX, etc.
Pressure Equipment Directive (PED) - Europe
ESPN / ASN (Europe, France)
American Welding Society (AWS) standards
American Society of Testing for Metals (ASTM)
HAF 601, 604 (China)
JIS (Japan)
Customer-specific specifications
Others

All of these standards require some measure of training and implementation of internal procedures in order to obtain and maintain associated certifications and/or to assure conformance with applicable requirements. Adherence to these specifications and standards is the minimum threshold. This effort carries with it significant costs of getting into and staying in the business. These costs include the time and effort to support third party and internal audits as well as the documentation required to meet contract requirements. For example, audits required of third party certification bodies and/or customer and industry groups include:

ASME - certification renewal audits required every three years
NIAC member audits
NUPIC
US Navy - NAVSEA Technical Representative
Customers (e.g., immediate NSSS customer, EPC's, customer's customer)

The effort needed to support these audits can range from one to three full time equivalent (FTE) technical staff. In addition the documentation required to support the applicable contract requirements is extensive. A long time industry adage is that "the paperwork that ships with the equipment weighs more than the hardware".

The predominant contractual mode in this business is use of firm fixed price (FFP) contracts. That means the utility/owner holds a FFP contract with the NSSS vendor who in turn holds FFP contracts with its suppliers. As the supply chain tiers move further away from the plant owner, there is generally less flexibility to deal with cost and schedule impacts from design revisions

and other project variables that are inherent in large complex projects such as design and construction of nuclear power plants. In light of that and the threshold costs of participating in the industry, one NSSS supply chain executive noted at a meeting of its key suppliers that "there can be no nuclear premium" in its business. If that view holds true, there can be little room to learn on the job by new suppliers and very little margin to remain profitable for mature suppliers.

CHARACTERISTICS OF TODAY'S NUCLEAR MARKETPLACE

There are many changes in today's nuclear marketplace as compared to the "pre-renaissance" period of ten or more years ago. Many of today's Generation III+ light water reactors currently under construction can be characterized as first-of-a-kind (FOAK) even though they rely on many aspects of earlier generation designs. As such, there are many revisions that are inherent in FOAK designs such as manufacturability issues that are encountered during the course of the contract.

The experience of the designer in some cases is limited to training based on codes and standards, in-house procedures or on the job training rather than many years of repeated design and construction of operating plants and their components and sub-systems. The universal adaptation of CADD has also instituted an unlimited ability to add significant digits. When applied to dimensional tolerances, this "freedom" to specify tighter requirements can and has introduced significant cost drivers, especially with FOAK hardware. Just because tighter tolerances are within the capability of the designer does not mean they add to the performance or functionality of the equipment. In some cases they can add cost and impact schedule due to delays required to incorporate drawings revisions to make the equipment more manufacturable.

Front end design reviews that should filter out these issues and serve to train new design engineers in the industry appear to fall short either due to short supply of experienced reviewers or restrictive availability of time and/or budget resources to support such reviews. One specific example is the case of a piece of Gen III+ equipment manufactured from 400+ drawings. The first units of this equipment experienced a minimum of one revision to each drawing and in some cases three or more. In addition, some of the specifications were revised seven times from P.O. award until the equipment shipped. This quantity of revisions requires significant time and effort for the customer and supplier to evaluate cost and schedule impacts. Further, this is all performed in an environment of a tiered supply chain with tight budget expectations.

MAINTAINING THE CUSTOMER-SUPPLIER RELATIONSHIP

The quantity of changes and the resultant cost and schedule pressure inherent in these first projects of the nuclear renaissance can stress the customer-supplier relationship. Manufacture of nuclear power plant equipment and construction of these plants take years. Therefore, deterioration of the customer-supplier relationship must be avoided whenever possible. Some ways to avoid this situation include:

- Communicate, communicate, communicate. Good news should be shared as soon as possible (as long as it is true). The information should be validated. Walking good news back can do more damage than having withheld it in the first place.

- Bad news rarely gets better with time. Validate the bad news as well, but do so expeditiously. It is better to get it out and work constructively toward a solution rather than to withhold bad news for an extended period.
- Whenever possible, especially when communicating a problem, propose a solution or alternative solutions. This sets the tone for promoting a productive outcome and strengthens the customer-supplier relationship under what are stressful circumstances.

Keep in mind that it is not personal, it is strictly business.

BEST PRACTICES, LESSONS LEARNED

Regardless of the challenges mentioned above, improving the nuclear new build process can and must be done. Following are a number of lessons learned that can contribute to that outcome.

Manufacturability Reviews And Prototyping

First, manufacturability reviews should be completed, especially on FOAK equipment. Competing requirements and priorities must be balanced. These include code and regulatory requirements, equipment performance and operating efficiency, ease of in-service inspection, cost effective manufacturing processes, dimensional tolerance stack-up, in process material handling, and transportation of equipment to the project site. Manufacturability reviews can address these factors. Design for Manufacturability (DfM) can add real value.

Prototyping and building mock ups can also avoid unintended costs from FOAK designs. The 1:3:8 rule applies to manufacturing equipment for and constructing new nuclear power plants. That is, if resolving a problem at the design stage costs one dollar, resolving it during manufacturing will cost three dollars, and resolving it during or after installation will cost eight dollars. Resolving design issues prior to start of manufacture is therefore critical.

International Marketplace

Supplying today's nuclear industry is conducted internationally. Conference calls scheduled for 8:00 pm Eastern time are typical, whether you are a sub-supplier, the customer, or the customer's customer. The supplier must be aware of cultural differences ranging from other countries' national holidays, to terminology (does "yes" mean "yes", or merely, "I hear you"), to the relative importance of full disclosure of non-conformances with specifications. Cost and quality differences must be monitored whether emanating from local standards differences to outright fraud. Finally, maintaining an international approved suppliers list (ASL) is more costly as driven by the time and effort needed to audit and manage a geographically dispersed supply chain.

Teamwork Is A Must

As stated earlier, manufacturing nuclear components and constructing nuclear power plants are a complex business. Complex projects must be worked from both sides of the customer-supplier relationship (sometimes three sides, when it also involves the customer's customer). When this

many parties are involved, turnaround times for document or change order review become extremely critical when trying to maintain schedule performance. This is especially critical when delay liquidated damages are at stake in the contract. For example, if the contract calls for three day turnaround time for document reviews and it takes 15 working days, not maintaining schedule is almost guaranteed. Also, when resolving a non-conformance, always propose on or more solutions along with corresponding cost and/or schedule impact. It helps move the process forward and sustains the customer-supplier relationship in a more constructive manner.

CONCLUSIONS

Today's nuclear supply chain is more tightly wound that in the past due to technologically enabled communication. In a firm fixed price contract environment that makes for less margin for non-conformances when trying to make a profit. The complexity of both technical and contract requirements has added cost to getting into and staying in the nuclear supply chain.

Newer generation reactor designs have been developed by staff with less experience in the industry than in the past. While the body of regulations, codes, and standards provide the setting for a safe industry, manufacturability has at times taken a secondary position thereby adding more cost burden to the supplier. The volume of changes that must be dealt with in this environment can stress the relationship between supplier and customer. Keeping a solution-oriented philosophy while working through these changes and complexities helps sustain the relationship over the years it takes to manufacture nuclear equipment and construct power plants.

Manufacturability reviews and prototyping can help balance competing priorities of design, manufacturing, construction, and operation. The international nature of today's nuclear industry requires an awareness of different cultures, interpretation of requirements, work habits, and the geographic reach of the supply chain.

Complex nuclear power projects must be worked productively from all sides. Turnaround time for reviewing and approving documents is a key concern when involving multiple parties as is typical in these projects.

In the 1950's we had a very limited knowledge base on which to create a nuclear power industry, including the supply chain. However, US industry figured it out and led the world. In addition, it was done with slide rules and drafting tables. Today, nuclear power generation technology offers the only carbon free way to meet base load electricity demand. To the extent the nuclear renaissance continues, the free market supply chain will respond.