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Lessons Learned During The Procurement of the ITER Steady State Electrical Network Components by the US Domestic Agency

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***Abstract*— The ITER Steady State Electrical Network (SSEN) is an AC distribution system that provides approximately 120MW of power to supply all of the conventional loads of the ITER facility. The US Domestic Agency is responsible for the procurement and in-kind contribution of 75% of the SSEN equipment, all of which consists of standard commercial grade AC power systems components. This paper reports on lessons learned during the SSEN procurement activity that can inform future procurement activities of similar class equipment that will comprise a high fraction of the overall ITER procurements.**

Keywords—AC distribution, AC power systems, transformers, switchgear, circuit breakers, current transformers, potential transformers, surge arresters

I. Introduction

The ITER Steady State Electrical Network (SSEN) is an AC distribution system that provides approximately 120MW of power to supply all of the conventional loads of the ITER facility. The European Domestic Agency (EU DA) is responsible for the design and installation of the SSEN, along with 25% of the components, as well as all cabling and all emergency (diesel generator) power systems. The United States Domestic Agency (US DA) is responsible for providing the remaining 75% of the components.

The Princeton Plasma Physics Laboratory (PPPL), a US ITER Partner Lab, is responsible for the US share of the SSEN in-kind contributions which involves sixteen (16) procurements of various types of AC power systems equipment. Twelve (12) of the sixteen (16) contract awards were awarded by the end of 2014. Delivery of equipment to the ITER site began in 2014 and will be completed in 2017.

All of the SSEN procurements consist of standard commercial AC power equipment. However, the procurement activity itself is a very complex, international, multi-institutional process involving PPPL, its Engineering Support Subcontractor, the US Department of Energy, the US ITER Project Office at Oak Ridge National Lab, the equipment suppliers, and the ITER Organization in France. In addition, the ITER Organization has established a framework contract with a global Logistics Support Provider (LSP) through which all shipments from factories to the ITER site have to be coordinated.

Since the SSEN is needed to provide site power early during ITER construction (when the limit of the existing power source is reached late in 2015) it is the first major ITER system that must be installed and commissioned, and the US SSEN deliveries comprise the first DA equipment deliveries to the ITER site. As such the US SSEN activity has pioneered many of the administrative and logistics procedures that will have to be followed in the years to come as the rest of the ITER deliveries take place.

Many issues and challenges have been encountered and resolved during this activity thanks to a strong, collaborative team effort, and the lessons learned can be applied to future procurements for ITER as well as other similar large scientific projects.

II. SSEN Components

The SSEN procurement groups for which the US DA is responsible are listed in Table 1. Important to note is that none of the SSEN components are deployed in ITER safety systems, nor do they have special seismic requirements. Therefore the items are considered to be standard “commercial grade” items. However none except for some of the substation hardware can be considered “Commercial Off-The-Shelf” (COTS) items since some level of customization is involved. Also important to note is that the EU DA, not the US DA, is responsible for installation and commissioning of the equipment.

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TABLE 1. SSEN PROCUREMENT GROUPS

HV Circuit Breakers	4 x 3-phase units @ 400kV
HV Disconnnect Switches	"
HV Surge Arresters	"
HV Current Transformers	"
HV Potential Transformers	"
HV Substation Hardware	Glass insulators, fittings, fasteners, etc.
HV Substation Transformers	4 units @ 75MVA, 400/22kV
HV Control & Protection	27 cubicles plus UPS and DC distribution
22kV Switchgear	98 cabinets @ 22kV
Earthing Resistors	4 units @ 22kV, 12 @ 6.6kV
MV Power Transformers	8 units @ 35MVA, 22/6.6kV, 4 units @ 7MVA, 22/6.6kV, 6 units @ 2.5MVA , 6.6/0.4kV, 4 units @ 1.6MVA, 6.6/0.4kV
6.6kV Switchgear	186 cabinets @ 6.6kV
Reactive Power Compensators	16 units @ 3.5MVAR, 6.6kV
Uninterruptable Power Supplies	12 units @ 300kVA, 1 hr autonomy
DC Distribution	4 units @ 48VDC, 630A, 1 hr autonomy
LV Distribution & Subdistribution Boards	6 @ 400V/4kA, 4 @ 400V/2.5kV, 15 @ 400V/400A, 7 @ 400V/125A

III. LESSONS LEARNED

A. *Treatment of Standard Commercial Items*

ITER is a complex scientific project that involves many unique high technology first-of-a-kind items, some of which are related to nuclear safety. However, a large fraction, probably a majority, of the equipment to be procured for ITER, including the SSEN components is not of this pedigree. Because of the challenge and criticality of the high technology safety related components the project has focused its attention on the development of procedures and methogologies related thereto. In the future to optimize cost and schedule the procurement of standard commercial items should conform to standard commercial practice whenever possible, with due consideration of their usage on ITER. Requirements for special measures in terms of quality assurance, intellectual property, export control, shipping, etc., should only be imposed when justified. Specific areas for which a graded approach should be applied are as follows.

1) *Quality Assurance (QA)*

ITER has established three quality classifications along with four sub-classifications that take into account the criticality of a particular component in terms of its role in nuclear safety, personnel safety, machine availability, and "investment protection", with Class 1 the highest and Class 3 the lowest. The extent of QA actions to be exercised is most for Class 1 and least for Class 3. Most of the SSEN equipment procured by the US is assigned QA Class 3 but some is assigned QA Class 2. In several procurement groups there is a mixture of Class 2 and 3 such that the full procurement has to be elevated to Class 2 since it is impractical to have two quality levels within a single procurement. To be conservative it was decided at the outset to try to include for the most part the Class 2 QA measures in each purchasing specification and contract. This decision led to the inclusion of two requirements that proved very difficult to implement and did not materially improve the quality of the end product.

- A "dedicated Quality Plan" (QP) was required of the supplier to describe quality assurance measures *specific to the contract in question* being imposed not only by the main supplier but also sub-suppliers, including organization charts and names of key personnel
- A "Manufacturing Inspection Plan (MIP) was required to describe the main steps in the manufacturing and inspection process with elaboration on procedures used and test records generated, along with sign-off by various parties on a form to be maintained and used in real time by the supplier

Both of these measures are very unusual in the world of mass-production commercial equipment and were very difficult to implement. The type of equipment involved is typically assembled from a large number of parts that come from a variety of sources outside of the factory where the assembly takes place. Often times the parts that are used for a particular production run are taken from inventories of general stock that is held in the factory. And in some cases the actual production run for a particular order may only take a matter of days. Under these circumstances it is very difficult to develop QPs and MIPs that factor in the complex supply chain and mass-production scenario. One noteworthy exception was the production of the large HV substation transformers and MV power transformers that are manufactured in a more traditional way, with raw materials and parts coming into a factor and a finished product coming out may weeks later.

The lesson learned is that QA measures, even for high quality class items, should be tailored to the actual manufacturing process, and that for high volume production commercial grade equipment it is a practical necessity to rely on the suppliers QA/QC program, as well as the highly standardized routine and factory acceptance tests established by the IEC, to ensure a suitable end product. Methods adopted in the nuclear industry for "commercial grade dedication" may be appropriate and should be considered for ITER systems that are safety related.

2) *Intellectual Property*

As a scientific project that will lead to a rich array of discoveries and technical innovations, it is very important that the ITER Project identify any background intellectual property (BIP) that suppliers bring to the table at the outset of contractual work. However, for standard commercial equipment that is mass-produced and available in the public marketplace it is not customary or practical to require that suppliers declare the numerous patents and copyrights that they may hold with regard to their product line, or that sub-suppliers may hold for the numerous items that are included with the final integrated product. Moreover, for items that are part of the conventional infrastructure of the ITER facility and are not unique to the ITER mission, that will never be construed as part of the intellectual property created by ITER, BIP declarations should not be required. The exact manner of classification and exemption of standard commercial equipment is a matter of legal determination, but it seems clear that the large fraction of ITER components in this category should be exempt from BIP declaration.

On all US DA procurements, to ensure in advance that no prospective suppliers would make unacceptable BIP declarations, all offerors were required to fill out a BIP declaration form as part of their proposal package. Owing to the unusual nature of the request and the complex legal terminology most offerors became confused.

The lesson learned is that a clear and simply written option for BIP declaration needs to be available to suppliers of standard commercial equipment so that the process is straightforward and unambiguous.

3) Export Control

As a nuclear device that involves the use of tritium, and employs numerous advanced diagnostics and detectors, the individual governments participating in ITER may wish to limit the dissemination of certain information to individuals within the ITER Organization who have a valid need to know. For the US DA such restrictions are needed for sensitive information related to items that might have weapons-related applications. However for the SSEN equipment that has no weapons-related applications, is available on the open market and is produced by factories located worldwide there is clearly no justification or need for export control. Moreover, for items that are sourced from companies and factories outside the US, no export from the US in fact takes place.

On all US DA procurements, to ensure in advance that no prospective suppliers were offering equipment that could require export control according to US regulations, all offerors were required to review arcane US export control information and to fill out an export control declaration form as part of their proposal package whether exporting from the US or not. Since the majority of SSEN suppliers are not US companies they were unduly required to make declarations about their non-US export products with respect to complex US classification procedures that they were unprepared to make.

The lesson learned is that a clear and simply written option for export control declaration needs to be available to suppliers of standard commercial equipment that factors in the nature of the SSEN equipment and the fact (when applicable) that it is not being from the US so that the process is straightforward and unambiguous.

4) Shipping

For a variety of reasons the ITER Project has established a framework contract with a "Logistics Support Provider" (LSP) that has the capability to ship all types of items from all locations worldwide to the ITER site. Although strictly required only for "Highly Exceptional Loads" (HEL) that cannot be transported over classic French roads, the use of the LSP has become the de facto shipping mode for all US DA components. There are certainly some advantages to this arrangement, in particular for the HEL, for the management of special ITER tax and duty exemptions, and for the flow of information into ITER's site material tracking system. However this practice is very unusual for the standard commercial items typical of the SSEN. In normal practice the delivery of items to the job site is included as part of the scope of supply in which case the supplier makes all arrangements and assumes all risk of damage during shipment. For the ITER SSEN components all shipments must be executed by the LSP and the contractual shipping arrangement is based on Incoterms 2010 FCA (Free Carrier (named place of delivery)), often referred to as ex-works. As a result the logistics coordination task falls upon the DAs and the risk of damage during shipment is assumed by the DA. In principle the suppliers reduce their prices since, shipping is not required. It is not clear, however, that they do in fact reduce prices, and if so, that a net savings is passed on to the DAs or the ITER project.

An unintended consequence of the ITER shipping arrangements is that small off-the-shelf catalog-type items cannot be shipped directly to the ITER site. Instead, they need to be shipped to an interim site for consolidation and inspection and then turned over to the LSP for shipment to ITER.

The lesson learned is that conventional shipping arrangements should be allowable for standard commercial items, including small off-the-shelf catalog-type items, whereby shipments are arranged by the suppliers and appropriately received at the ITER site from non-LSP shippers.

5) Site Acceptance and Transfer of Ownership

Under normal circumstances involving AC power systems equipment the final customer acceptance and transfer of ownership might take place as soon as delivery to site, or much later after installation and commissioning, depending on the type and complexity of the equipment in question. For some components such as large power transformers the installation and commissioning is usually included in the scope of supply. Normal warranty terms and conditions are 12 months after energization or 18 months after delivery, whichever comes first.

On the ITER project, due to the distributed responsibilities of the US DA, the EU DA, and the ITER Organization, and because of the use of the LSP with Incoterms FCA shipping, the transfer of ownership from the supplier to the purchaser (PPPL) has to occur when the LSP takes physical possession at the factory. In order to manage this situation for the more complex SSEN components it was necessary to purchase an appropriate (conservatively estimated) amount of site support services as part of the contractual scope of supply to provide the necessary expertise during installation and commissioning and also to validate the warranty. Once items are delivered to the ITER site and inspected, a formal transfer of ownership procedure is executed that conveys ownership of the physical equipment from PPPL to ITER. After this takes place PPPL provides instructions in writing to the supplier to effect the transfer of ownership of the warranty and site support from PPPL to ITER. Provision for this type of transfer is written into each contract and the warranty duration after delivery is extended to 24 months instead of the normal 18 months to account for the relatively early acceptance at the factory rather than the ultimate delivery site.

The lesson learned is that, although the process of acceptance and transfer of ownership is highly unusual, it is manageable using the methods that were adopted for SSEN ITER components.

B. Range of Cost Proposals

Considering that the SSEN components are all quite standard and available from the global competitive marketplace one might expect that the cost proposals from the various suppliers would fall into a tight range. In fact as shown in Fig. 1, this was not the case.

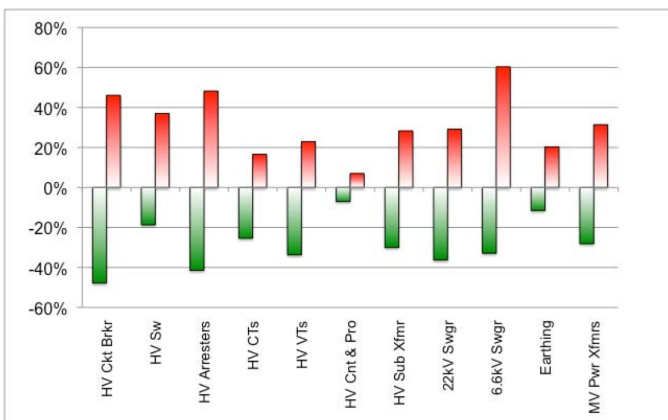

Fig. 1. Cost Proposal Variation Around Average

Although one would assume that the suppliers should understand the marketplace and know how to offer a competitive price, the above result suggests that there is in fact considerable uncertainty.

The lessons learned are that budgetary estimates should be obtained from multiple suppliers and that, even for standard commercial AC power equipment, the precision of cost estimates made during the budgeting process should assume an uncertainty of at least +/- 20%.

C. Activity Durations

At the outset of the planning process, assumptions were made concerning the duration of various activities starting with the preparation of specifications, issuing Request for Proposal (RFP), issuing Release for Manufacturing (RFM), and ending with the delivery of the equipment. Actual experience was different (longer) than the original assumptions and was quite variable amongst the procurements as shown in Table 2.

The time between RFP issuance and contract award was much longer than planned due to difficulties encountered in the negotiation of terms and conditions. On several contracts progress was very slow when interactions were limited to e-mail, phone calls and videoconferencs. Face-to-face meetings were eventually held which proved extremely effective and led to rapid closure.

The time between contract award and RFM also exceeded initial plans. The process of document submittal and review was initially expected to begin just after contract award and to be resolved in ~ 8 weeks but in fact it took much longer. In some cases for items that have a very short production time the suppliers were not motiviated to complete the process early. In all cases the extent of documentation required was unusual by commercial standards and took longer than expected to obtain. To improve the communication a weekly "document submittal status" update was communicated to each supplier that provided a list of all submittal items with an indication of status "not submitted", "pending review", "needs revision", "conditionally approved" and "approved".

TABLE 2. ACTIVITY DURATIONS (WEEKS)

	Prepare Spec and RFP	**RFP to Contract Award**	**Contract Award to RFM**	**RFM to Delivery of 1st Lot**	**Total Start to Finish**
HV Circuit Breakers	12	33	43	9	98
HV Switches	13	31	40	11	95
HV Surge Arresters	16	29	38	6	89
HV Current Transformers	16	29	44	2	91
HV Potential Transformers	16	29	44	2	91
HV Control & Protection	14	23	45	7	88
HV Substation Hardware	6	45	5	30	86
HV Substation Transformers	10	24	39	33	107
Earthing Resistors	37	29	23	11	100
Average	16	30	36	12	94

The lessons learned are that task durations need to allow a large contingency and that effective pro-active communication with suppliers is essential to making progress.

D. Role of Engineering Support Subcontractor (ESS)

PPPL awarded a contract to the URS Corporation (now AECOM) to assist with the preparation of purchasing specifications, to participate in the supplier selection process, to provide liaison with suppliers, and to provide Quality Control (QC) services at the factories.

Purchasing specifications were prepared by the ESS in draft form following a PPPL template along with technical information provided by PPPL that was developed by a EU DA subcontractor as part of the "tender design" activity. PPPL then refined those specifications and interacted with the ITER Organization to obtain final review and approval. PPPL signed and took responsibility for the final versions. A key aspect of this work was that the ESS was not required to access information from the ITER database or to interact directly with the ITER Organization. PPPL served as an intermediary and only assigned the ESS to very specific tasks with well-defined requirements.

After contracts were signed the ESS provided liaison with the suppliers during the process leading up to RFM, during fabrication, and during Factory Acceptance Testing (FAT).

SSEN equipment, under contracts placed thus far, is produced at 16 different factories located in Europe, North America and Asia. Providing cost effective and rapidly deployable QC services around the world required access to a global network of inspectors. Since companies such as URS are involved in major projects all around the world they have extensive experience in this aspect of the work. For each contract an inspector was chosen from a list of candidates based on resume an in some cases telephone interview. The ESS effectivly handled all QC arrangements including inspection orders, final reports, and payments.

The lesson learned is that ESS can provide efficient, cost effective services in areas where their experience and expertise can be directly applied. However it is important that they do not become involved before requirements are stable and they are not required to interact directy with the ITER project and its complicated processes and procedures.

E. Supplier Performance

A complex "Source Selection Procedure" was used to evaluate proposals and select suppliers for contract award. This included feedback from a list of prior customers supplied by the prospective awardees who were contacted by e-mail and telephone interview in some cases. Despite the rigor of this process the performance of suppliers was highly variable. We are confident that the final product being delivered to ITER is of high quality and meets all of the requirements but the process of arriving at that result was sometimes easy and sometimes very difficult. The US DA SSEN team was asked to score the performance of the suppliers of the 12 contracts thus far with 1 = poor and 10 = excellent. The results are given in Fig. 2.

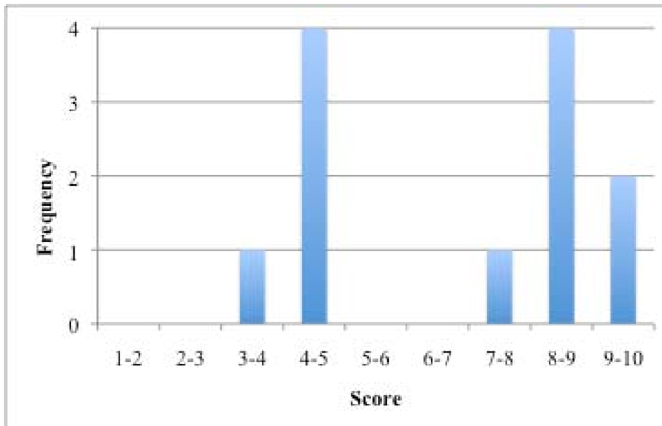

Fig. 2. Scoring of Supplier Performance

The lesson learned is that, even with a diligent selection process it should be anticipated that supplier performance may be very uneven.

F. Other Unanticipated Issues

Two unanticipated issues arose that ended up consuming significant time and resources, namely the CE marking issue and the issue of limited distribution rights on documents.

The CE (Conformité Européenne) mark, is a conformity marking for certain products sold within the European Economic Area. Some of the small components within the control cubicles of SSEN components fall within the scope of the "Low Voltage Directive" and the "EMC Directive". These directives are intended to prevent Original Equipment Manufacturers (OEMs) from mass marketing non-conforming products within the EU community that could have an adverse impact in the public domain. However the ITER Organization has determined that all individual items incorporated into ITER equipment shall conform to CE requirements based on the ITER Agreement Article 14 that requires that ITER "shall observe applicable national laws and regulations of the host site…". Evidently per French law the CE requirement is extended to fixed equipment not in the public domain, as is the case with SSEN equipment. In any case to conform with the requirement before affixing the CE mark an OEM is required to self-certify and issue a Declaration of Conformity (DOC) that the item in question is safe and conforms to applicable EU standards. No testing is required; it is simply a legal declaration.

To conform with this requirement we initially attempted to obtain, from the SSEN supplier, copies of the DOC from the sub-supplier of each of the many small components used in the low voltage control compartments. This proved impossible so we then sought "catalog cuts" indicating CE conformity and/or photographs of each of the individual items showing the CE mark. We did discover that some items were not CE marked and we required that the supplier substitute other items that display the mark. We eventually settled on an approach where we obtained from the supplier a single over-arching Certificate of Conformance (COC) that all items to which the CE mark applies are, in fact, CE marked. We also allow an approach whereby a supplier declares that an entire low voltage assembly, which contains many small components, conforms with the requirement and affixes the CE mark to the assembly itself.

The other issue relates to restrictions that SSEN suppliers, and sub-suppliers, routinely place on document items such as drawings, instruction manuals, etc. that are intended to limit distribution, for example:

"This document is the property of (company name) and contains proprietary and confidential information which must not be duplicated or otherwise disclosed unless authorized in writing by (company name)".

Although it seems that these sort of restrictions are routinely ignored in commercial practice, both the US DA and the ITER Organization have established a high standard and will not accept any documents citing such restrictions. Therefore, suppliers were asked to delete such statements when possible but if not possible to add a statement such as the following.

PPPL, and members of the ITER Organization, are authorized to share this document with all members of the ITER Organization for the express purposes of quality assurance, installation, commissioning, operation, and maintenance of the equipment in accordance with the specification and subcontract.

Suppliers were also required to obtain authorization in writing from sub-suppliers whose instruction manuals, etc., contained similar restrictive language.

IV. Summary and Conclusions

Lessons were learned during the procurement of the ITER SSEN by the US DA in the following five categories:

- Treatment of standard commercial items
- Range of cost proposals
- Activity durations
- Role of Engineering Support Subcontractor
- Supplier Performance
- Other unanticipated issues

Hopefully the information conveyed in this paper about the lessons learned can inform future ITER activities to improve the effectiveness of the procurement process, especially as it applies to standard commercial items that are likely to comprise a large fraction, probably a majority, of the equipment to be procured for ITER.

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