

LVRF Fuel Bundle Manufacture For Bruce – Project Update

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Abstract

In response to the Power Uprate program at Bruce Power, Zircatec has committed to introduce, by Spring 2006 a new manufacturing line for the production of 43 element Bruce LVRF bundles containing Slightly Enriched Uranium (SEU) with a centre pin of blended dysprosia/urania (BDU). This is a new fuel design and is the first change in fuel design since the introduction of the current 37 element fuel over 20 years ago.

Introduction of this new line has involved the introduction of significant changes to an environment that is not used to rapid changes with significant impact. At ZPI we have been able to build on our innovative capabilities in new fuel manufacturing, the strength and experience of our core team, and on our prevailing management philosophy of “support the doer”. The presentation will discuss some of the novel aspects of this fuel introduction and the mix of innovative and classical project management methods that are being used to ensure that project deliverables are being met. Supporting presentations will highlight some of the issues in more detail.

1. Bruce LVRF Bundle Background

The Bruce LVRF bundle requires two sizes of fuel elements; 8 large diameter (13.5 mm nom. dia.) and 35 small diameter (11.5 mm nom. dia.). In extending the traditional 37 element bundle design the Bruce LVRF development has required the manufacturer to combine what are essentially two separate production lines for the two sizes of fuel into one bundle. The two enrichments in the bundle have compounded the complications. The increased number of sheaths and the addition of the mixer tabs (buttons) has presented an added challenge. The majority of the manufacturing issues have been resolved over the years in various test manufacturing campaigns.

Zircatec has been involved with the manufacturing development of Canflex type fuel since 1986. Early work involved the manufacture of enriched fuel pellets and sheath assemblies for test fuel bundles. During the 1989 -1994 period we developed tooling and procedures for the manufacture of several (3 - 6) Canflex design (Mk III) bundles

for irradiation at CRNL. These bundles were manufactured with 2.26% enriched fuel and also with fuel of mixed enrichment. The uniqueness of this bundle design - two fuel element sizes - required considerable innovation in manufacturing process flow control and tooling design. Due to the small scale of the early work these were not serious issues. However, as the scale of the campaigns increased, so did the attention that was paid to future production level manufacturing issues. As is usual with all new product development activities, the initial campaigns were conducted at a small scale. Most of the early campaigns involved the processing of < 200 kg of UO₂ powder (1 - 8 bundle equivalent quantities) and the production of small quantities of tubing. For example, pellet pressing was done in presses which we would consider "laboratory scale"; braze runs were small and brazing was done in a "one off" fashion using a small scale brazing unit; end cap welding was done in a laboratory scale, manually operated welding unit. This early work included development of processes for control of density and microstructure of Canflex UO₂ pellets; small scale manufacture of enriched and natural UO₂ pellets and bundles; 26 Canflex bundles for the Point Lepreau Demonstration Irradiation; NU Bruce style Canflex bundles; and the currently ongoing campaign for Bruce LVRF Demonstration Irradiation. This campaign uses processes that will apply for full core manufacture and the opportunity is being taken to fine tune the processes that will be used during full scale manufacture.

2. Full Scale Production Issues – Bruce LVRF

2.1 New Processes – Quality Built-in

The primary issues with production level scale-up are, the increased number of elements in the fuel as compared with traditional 37/28 element fuel, the fact that the bundle design incorporates two sizes of elements, the fact that the bundle contains both SEU and BDU pellets, the thinner sheath wall, the greatly increased number of appendages on the 43 element design and the increased number of braze planes. The manufacturing concept is to "build in" quality and this has been a major focus of our efforts.

The different enrichments requires the implementation of two distinct manufacturing lines, one for SEU and one for BDU. SEU and BDU lines have to be kept segregated from each other and from the NU lines. Further, two additional processes for each size of tube, pellet and end cap need to be incorporated. In addition, each size of pellet stack requires a set of end pellet sizes appropriately designed to provide the degree of control for stack length. The thinner sheath wall requires the introduction of new production level control techniques. Finally, product flow of appendage

manufacture, is an issue, since with Canflex twelve different appendage types are required rather than the traditional seven and this complicates process flow and leads to an increased number of unit processes.

2.2 Criticality

Ensuring Nuclear Criticality Safety (NCS) during the manufacture of enriched uranium fuel involves designing the process such that a nuclear reactor is NOT created. It is important to realize that LVRF production cannot be conducted in the same manner as natural uranium production. A robust yet manageable system has to be designed and set up via policies, program structure, process design and operational limits and controls and operator and supervisor training such that an inappropriate assembly of material and moderator cannot be created during the manufacture of the fuel. The fact that such concerns are new to CANDU fuel production, makes it imperative that issues of cultural mindset be addressed at the outset through rigorous involvement and training of all operational levels. The Zircatec NCS program is based on various Industry Standard guidelines (ANS) such as those for administrative practices, processes and operations, and training.

2.3 Fuel segregation

One of the major concerns in introducing enriched fuel into a natural uranium environment is that complete segregation of enriched and natural fuel be maintained at all times. The design of the Bruce LVRF bundle introduces the added complication of the central BDU element and the added requirement that segregation of BDU/NU and SEU be maintained. The Zircatec strategy is to divide the plant into three physically separate areas for natural, BDU and SEU manufacture. They are physically separated by block walls and each area has its own air extraction and waste system. The BDU area has separate personnel change/shower rooms and entry/exit areas which are some distance from entry/exit areas for SEU and natural. Personnel change/shower rooms for natural and SEU production are common but have separate entry/exit points for the two lines. The SEU area will have coded access for specific qualified personnel who will be identified by color coded coveralls. This physical segregation and color coding will ensure that personnel are continually cognizant of the differences between the lines.

2.4 Project Mandate

As can be seen, implementation of the new fuel will have a significant impact of our current facility. In addition to the introduction of a culture change related to a new fuel

design, fuel segregation and criticality safety the project involves the relocation of several existing processes as well as the introduction of some new ones. These changes are, of necessity, accompanied by structural changes to the facility and the associated relocation of people.

The Zircatec Project Mandate is to implement full production (~ 125 bundles/day) of the new fuel at our facility by Spring 2006. The project is to be engineered so that any changes to the facility do not interfere with the ongoing delivery of NU fuel to our customers. As can be seen, the changes that we have had to implement to our facility are not trivial and have affected almost everyone at ZPI. It is well known that if changes are introduced without taking account the dynamics of people's often unstated fears and anxieties the enterprise is likely doomed. The balance of this discussion will discuss some of the methods we have used to coalesce people's energies, ensure that this does not happen and meet the project deliverables.

3. Project Structure and Teams

3.1 Language and Culture Change

We recognized that the language that is used in daily practice determines the reality that is created. Einstein made the comment that "you cannot solve a problem using the same language that created it". An extension of this statement is that in order to create sustainable change to an existing order, the language being used needs to change – "if you want a new answer you must use a new language". Cooperidge and Srivastava (1) postulated that since the basis of language is metaphor, it is important to use the correct (appropriately oriented) metaphors in conversations. A "solution" metaphor in contrast to a "problem" metaphor is more likely to result in a synergistic definition of the real issue which, in turn, will lead to an inherently implementable and sustainable solution. Since the primary response to a stimulus of change is fear and anxiety, we recognized that a traditional problem solving approach – one which started with a metaphor of "what is wrong" – would be more likely to generate barriers and would prevent the airing of the real issues that could impede progress. Instead we attempted to recognize the pride and ownership that our co-workers had brought to the company over many years and utilized the metaphor of "what has been right all these years" and "what do you want to contribute" in each of our discussions. It has been our experience that this allowed fears and anxieties to more easily be brought forward and dealt with.

In the context of the introduction of a new fuel line in a traditional framework – where change has been infrequent – it is important to recognize the subtle barriers to change that may pre-exist in the prevailing language. Elliot (2) postulates that an organization may have a "syntax" – the "...rules of construction and word order..." but a very different

“grammar” – “..the larger concept that makes sentences mean what we mean...”. In a traditional organization which is not used to routinely engaging in major changes, the temptation is to “change by edict” in order to “get things done quickly”. In the above analogy this addresses the issues of “syntax”. However, the people who will be implementing and be affected by the change are not used to a “change language” – a language that can easily discuss issues of change without the solution being hampered by the barriers of fear and anxiety - at the daily practice level. Thus, the “grammar” of the language they actually use in daily life remains unchanged and is still rooted in trying to hold on to the security of the old. The end result is that the change can take a lot longer than expected, is full of tensions and anxieties and, worse, is not sustainable.

At ZPI we recognized the need to counter these subtle yet far-reaching potential roadblocks to project implementation and we have attempted to develop an environment where people who would be affected by the changes and the process could easily participate in and contribute their energy to the discussions that defined the change. Significant effort was placed in generating appropriate metaphors that were conducive to participation and an attempt was made to use these in daily language so that conversations leading to successful completion of actions became a habit rather than an effort. We recognized that Team Leaders had to be encouraged to foster such enabling conversations – ones where real issues affecting people could readily be aired and where appropriate actions could be derived and implemented. We recognized the fact that “what you talk about in daily practice will define the reality you get”. One example of this is our introduction of the concept of safety. No organization will deny that safety is important; we introduced an environment where it became routine to start every conversation in the facility with a safety topic. We deliberately avoided putting out a “edict” on the issue – we just talked about it. Every day. Discussions emanating from the safety topic became enabling, and since every conversation generated actions, the result was that people took ownership of safety enabling actions which were then implemented. The end result has been a general increase in the level of awareness on safety issues, an implementing of safe actions in our daily practice and our safety record has dramatically improved.

It is these concepts that we have used in developing our team and in implementing the new fuel line.

3.2 Project Team and Team Philosophy

The project structure made use of existing available highly skilled and experienced people supplemented by contract personnel. Hiring the right people was an important issue and we used our method of involving affected people in critical hiring decisions – thus, peers and direct reports were part of the hiring teams. Recognizing the fact that the project involved many changes in quality methods, facility, engineering, licensing, human issues and operations we engaged a team with leaders from each of these

disciplines to lead the project. The oversight of team activities was at the company senior executive level. “Forming” of the Project Team involved various (minimal) structured training as required including traditional project management methods. An attempt was made to use the Project Management Book of Knowledge (PMBok) (3) methods but these were found to be excessively planning/reporting/measuring oriented and were either abandoned or modified in favour of what project execution really required which were methods such as “The Last Planner” (4) which are implementation/decision making/consensus generating methods; more in line with the internal “grammar” we had developed.

We also built on our background in new fuel manufacturing development and our process improvement skills. Since this is a major endeavour, we have attempted to retain existing processes and methods for manufacture where possible and develop new processes only where such development was unavoidable due to the complexity of the new fuel design.

The Team Leaders each developed a team Mandate for their area by engaging appropriate team members in the discussions. As the project progressed, particular cross functional teams were struck to deal with particular issues. In all cases the teams had shop floor people at the discussion table.

This project structure, which involved all the affected in a meaningful fashion and inherently encouraged open discussion at all levels resulted in definition of the right actions and encouraged reliable promises from the people who were responsible for executing the actions. The role of the oversight team rapidly devolved to one of removing roadblocks and staying out of the way.

Project coordination was via weekly structured meetings where traditional methods were used to track actions and develop forward plans. These were supplemented by equally important discussions about potential anxieties among our co-workers that may be emerging from the rapidly changing environment. In this manner we attempted to reveal any hidden issues which could delay the project. Each of these very detailed discussions generated specific actions and in the main we were able to either prevent or minimize any detrimental impact on the project and on the normal production that continued unabated. Potential roadblocks requiring either senior management intervention or customer input were discussed at these meetings and were dealt with as the need arose. The team sense was one of agility; issues were dealt with quickly and with care and respect for all co-workers. The overall language was one of consensus and action and individuals challenged themselves to bring forward all relevant information in a timely fashion so that roadblocks could be easily removed.

4. Project Status

4.1 Achievements

Considerable changes have occurred in the ZPI plant since late 2002 when the project was started. The list below describes some of the actions that have been completed.

It should be noted that these milestones were accomplished during a period when the NU productions reached some of the highest levels in ZPI history – we consider this a major achievement from our team and a direct result of the spadework that was done in addressing issues of culture.

- Developed bundle design related manufacturing documentation and obtained approvals
- Prepared supporting Quality, Manufacturing and Criticality documentation and obtained approvals
- Developed, tested and scaled-up new processing methodology for BDU
- Tested and scaled up processing methodology for SEU
- Designed/built, procured and tested LVRF production equipment
- Designed/built, procured and tested LVRF inspection equipment
- Developed, tested, scaled up and made production ready all processes for the subassembly and bundle manufacture of the new 43 element design.
- Moved five non-uranium unit processes off-site
- Restructured plant to accommodate new lines and personnel moves
- Relocated ~ 30% of people to new work areas
- Deployed rigorous criticality safety training for all supervisors and support staff
- Deployed criticality training to specific operators
- Developed cross-functional teams to do the process designs and Criticality Safety Evaluations ~70% of unit process Criticality Safety Evaluations ongoing or completed
- Started DI bundle manufacture

4.2 Current Status

The project is on target. Plant structural work is complete except for two areas where complete definition is still outstanding due to unresolved issues outside of ZPI. All process designs and equipment procurement is substantially complete. Licensing issues are on track.

5. Summary:

The implementation of the LVRF fuel line at ZPI is on track. A Considerable amount of work has been completed. The success of the effort is attributed to a dedicated effort being applied to addressing issues of culture change within the organization.

6. References

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3. “A Guide to the Project Management Book of Knowledge”.; Project Management Institute, 2000
4. HOWELL, G. L., and Macomber, H., “A Guide for the Users of the Last Planner System – Nine Steps for Success”, Lean Project Consulting Inc.