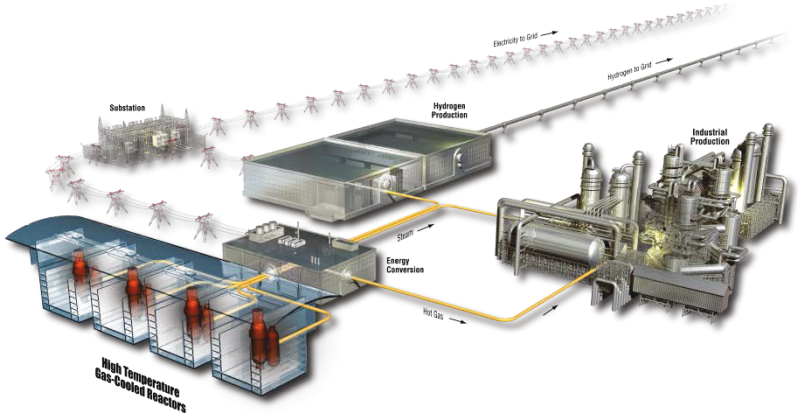
INL/EXT-16-37982
Revision 0

Readiness Review of BWXT for Fabrication of AGR-5/6/7 TRISO Particles

Project # (s) 23841, 29412

D. W. Marshall
M. T. Sharp

February 2016



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Idaho National Laboratory
INL ART Program
Idaho Falls, Idaho 83415

http://www.inl.gov

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INL ART Program

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Authors:

Douglas W. Marshall — Date: 2/23/2016
Fuel Fabrication Technical Lead Engineer

Michelle T. Sharp — Date: 2/23/16
INL Quality Control Services – Quality Engineer

Approved by:

Paul A. Demkowicz — Date: 2/24/16
INL ART TDO AGR Fuel Lead Engineer

Jack Simonds — Date: 02/23/2016
Project Manager, Fuel Development and Qualification

SUMMARY

Battelle Energy Alliance, LLC (BEA) conducted a readiness review at the BWX Technologies (BWXT) facility in Lynchburg, VA on February 9 – 10, 2016 to assess readiness to commence fabrication of tristructural isotropic (TRISO) coated fuel particles for the Advanced Gas Reactor (AGR) irradiation experiments 5, 6, and 7.

The BEA team was welcomed into the BWXT facility and given the opportunity to examine procedures, training documents, and opportunities to interview performers and management.

The review team applied NQA-1-2008/1a-2009 criteria to the following focus areas for the review:

- Process instrumentation and measurement and test equipment calibrations
- Approval, control and accessibility of operating procedures
- Process record control and accessibility
- Configuration design and control
- Operator training, certification, and qualification
- Chemical inventories for fabrication and chemical characterization
- Consumables inventories
- Material Procurements
- Operability of essential TRISO coating furnace and ancillary equipment
- Corrective actions system
- Product acceptance
- Handling and Storage
- Personnel have access to and are familiar with the latest AGR Work scope and requirements documents

With exception of three issues, BWXT is deemed to be ready to fabricate TRISO coated particles for the AGR experiments. The three issues are 1) that recent process equipment failures are still being resolved, so equipment readiness could not be verified, 2) chemical purity specifications were not fully communicated to suppliers in all cases resulting in one spare acetylene cylinder being suspect, and 3) disposition codes had not been recorded on a BWXT Quality Control Deficiency Notice to prevent possible use of the material during production coating runs.

Of these issues, the repair of the equipment is the only issue that will delay TRISO particle fabrication. The other issues are expected to be readily addressed.

ACKNOWLEDGEMENTS

Personnel at the BWX Technologies (BWXT) facility in Lynchburg, VA were very accommodating to the review team and made a concerted effort to provide the objective evidence and requested data in advance of the readiness review. BWXT views customer reviews as a means to identify improvements that can be made in their performances. The friendly and cooperative interaction with the Idaho National Laboratory (INL) review team was appreciated.

CONTENTS

ACRONYMS

AGR	Advanced Gas Reactor
ART	Advanced Reactor Technology
ASME	American Society of Mechanical Engineers
BEA	Battelle Energy Alliance
BWXT	BWX Technologies
INL	Idaho National Laboratory
LEUCO	low-enriched uranium carbide/oxide (kernels)
M&TE	measuring and test equipment
NQA-1	(ASME) Nuclear Quality Assurance standard
PVSS	process variable specification sheet
TRISO	tristructural isotropic
UCO	uranium carbide/oxide

INTRODUCTION

In support of preparations for fabricating tristructural isotropic (TRISO) coated fuel particles for the Advanced Gas Reactor fuel qualification irradiation experiments (AGR-5/6/7), Idaho National Laboratory (INL) conducted a readiness review of the BWX Technology (BWXT) company's procedures, processes, and equipment associated with TRISO coating activities.

The readiness review used quality assurance requirements taken from the American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance Standard (NQA-1-2008/1a-2009) as a basis to assess readiness to start TRISO coated particle fabrication.

READINESS REVIEW DESCRIPTION

A readiness review was held at the facilities of BWX Technology Lynchburg, Virginia facility from February 9 through February 10, 2016. The purpose of the readiness review was to evaluate and determine readiness status of their TRISO particle coating processes. The readiness review was accomplished primarily through review of procedures and documents to NQA-1-2008/1a-2009 requirements. The scope of the review included:

- Process instrumentation and measurement and test equipment calibrations
- Approval, control and accessibility of operating procedures
- Process record control and accessibility
- Configuration design and control
- Operator training, certification, and qualification
- Chemical inventories for fabrication and chemical characterization
- Consumables inventories
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RESULTS

General

BWXT was prepared for the readiness review with compiled binders of objective evidence for the reviewers and had arranged a tour of the facility and equipment. BWXT personnel were interviewed, as needed, to obtain answers to reviewer questions and to provide additional data and information. The BWXT personnel believe that readiness reviews help them strengthen their processes and helps ensure delivery of quality products to their customers.

A recent attempted "test" run, conducted in January to verify that the coating furnace and ancillary equipment were functioning as intended, found that the desired hydrogen flow rate could not be achieved. Subsequent functional and calibration checks found that a hydrogen flow control valve had failed since the last functional check. The valve is being replaced with a calibrated spare. The existence of a failed flow control valve was self-identified by BWXT prior to the readiness review.

BWXT discovered a material deficiency in furnace while unloading the bed media from the interrupted test run. The insulation and insulators, supplied by the furnace manufacturer to protect electrical lead-ins, showed an unacceptable level of degradation. BWXT was already working with the furnace manufacturer to resolve the material deficiencies at the time of the readiness review. It is important to note that previous successful operation of the coating furnace through multiple sequential coating runs was accomplished using insulating components recently superseded by the present design and configuration, which showed degradation.

The review team cannot deem the TRISO coating furnace and ancillary equipment to be ready until multiple coating runs have been successfully completed and data collected showing that layer properties (especially density and anisotropy) are expected to meet fuel specifications during production runs.

Two findings were identified during the review (see below). These issues are not expected to delay execution of the TRISO coating runs of particles for the AGR-5/6/7 qualification fuel. BWXT corrective actions are to be documented and objective evidence submitted to INL to demonstrate readiness.

Notable Practices

NP-1. Job Order numbers are written and bar coded on cover sheets, which allows easy tracking and record retrieval.

NP-2. Storage of essential chemicals for TRISO layer density analyses are light sensitive. The BWXT analytical laboratory stores bottles of light sensitive chemicals in the original containers and over-packing sleeves inside a darkened cabinet to keep exposure to UV light as low as practical and exceeding manufacturer recommended storage practices.

NP-3. The BWXT team inspected electrical lead-in penetrations while unloading bed from an interrupted "test" run and identified significant degradation of the refractory insulation had occurred. This discovery has resulted in a much shorter delay to the program than would have occurred if the system had been operated to failure. Thanks to the BWXT team, potential causes for previous arcing events at these lead-ins have been identified and are in process of being corrected with input from the furnace manufacturer.

Findings

F-1. A review of purchase orders and certificates of analysis for acetylene showed that the minimum acetylene concentration (i.e., grade) was specified to the gas supplier, but the acceptable levels of impurities for phosphine (PH_3) and hydrogen sulfide (H_2S) were not communicated to the supplier (SPC-1363, "AGR-5/6/7 Fuel Fabrication Feedstock Chemical Pority Specifications," Rev. 2). All customer (INL) specifications applicable to a purchase must be passed down to the supplier. During the review of the certificates of analysis, it was noted that the supplier noted "Requested Purity" limits that were non-compliant with INL impurity specifications on three certificates, of which the delivered acetylene was compliant in two cases and indeterminate in a third (analysis indicated PH_3 was ≤ 25 ppm whereas the specification is for ≤ 15 ppm). The review team only identified one acetylene bottle that was suspect. This bottle is a reserve bottle that has not been put into service.

F-2. A review of Quality Control Deficiency Notices (QCDNs) showed two instances of the documents signed as completed prior to the disposition codes being recorded. QCDN J52F-0075 AGR Chalice diameter size and J52F-0074 – AGR Nozzle were signed without disposition codes assigned. A suggested disposition pending customer (BEA) approval was written on the forms but Form Q11-127 was signed prior to the customer's approval of this disposition on 10/31/13 (recorded on Form N-74). These instances had no negative impact due to the customer's approved disposition of "use as is". However, approval prior to assigning disposition could inadvertently allow the use of nonconforming items if the final disposition were to "reject" or "rework".

REVIEW DETAILS

I. Process Instrumentation & Measurement and Test Equipment Calibrations

BWXT provided a list of calibrated instruments used in the TRISO coating process and dates when the instruments are due for recalibration. Of these, a few will expire prior to executing the AGR TRISO coated particle production runs and four were presently being recalibrated. Some of the instruments, that are readily visible from the processing floor without breaching radiological control barriers, were verified by the review team. The BWXT calibration tracking process appears to be functioning as intended and no shortcomings were identified.

Objective Evidence		
1.	QWI-11.1	Control of Measuring and Test Equipment (Calibrations)
2.	---	Calibrated equipment list
3.	---	Field inspection
4.	---	Interviews with engineering staff and management

II. Approval, Control, and Accessibility of Operating Procedures

Managers and engineering staff review proposed changes to operating procedures and process plan outlines. Changes that could impact quality or safety are submitted to a change review board prior to issuance. Approved revisions are submitted to document control personnel who upload an electronic copy onto the SOLUMINA computer system. Only the latest revision of documents is available to plant personnel via SOLUMINA.

Instructions that are not incorporated into procedures, such as the "recipe" sheets, are prepared, independently reviewed, and signed by engineering staff. These are uploaded onto SOLUMINA on a Process Variable Specification Sheet (PVSS) for access by operating personnel. Operating procedures on SOLUMINA have 'check points' instructing the operating personnel to refer to the PVSS. PVSS instructions are run specific to a particular run.

The approval, control, and accessibility of operating procedures and instructions appear to be effective and no shortcomings were identified. It is reasonable to expect operations personnel to have the correct procedure and PVSS information.

Objective Evidence		
1.	QWI-5.1.1 Rev. 10	Control of Plan List for Documents
2.	QWI-5.1.4	Operating Procedures
3.	QWI 5.1.12	Change Control
4.	OP-1015720 Rev. 33	Operating Procedure for: Coating in the CENTORR Furnace for Advanced Gas Reactor Program (U)
5.	OP-1016020 Rev. 10	Operating Procedure for: AGR Coating Furnace Scrubber Operation and Maintenance (U)
6.	OP-1015211 Rev. 5	Operating Procedure for: Sieving for AGR (U)
7.	OP-1015306 Rev. 6	Operating Procedure for: Tabler Operations for Advanced Gas Reactor (U)
8.	OP-1015213 Rev 2.	Operating Procedure for: Split Blend Operation for AGR (U)
9.	OP-0390001	Operating Procedure for: Product Identification Control (U)
10.	PPO-0930001-011	Process Plan Outline for: AGR Coating
11.	---	Interviews with engineering staff and management

III. Process Record Control and Accessibility

QWI -16.1.2, UPRR Quality Assurance Records was reviewed and found compliant with NQA-1-2008/-1a-2009 requirements. Records are validated if stamped and signed by authorized personnel. QWI -16.1.2, Table 1 provides a comprehensive list of the project quality assurance records. Corrections to records are not allowed unless they are approved in the formal change system. A notable practice was identified during this review; the Job Order numbers are written on cover sheets and a matching bar code is also placed on the cover sheets, which allows easy tracking and record retrieval.

Objective Evidence		
1.	QWI -16.1.2	UPRR Quality Assurance Records
2.	PAC- J52F Chg 093 Job Order No 000001115136	AGR Graphite Parts Inspection RTR QA Record # 11416
3.	PAC- J52F Chg 093 Job Order No 000001119871	AGR Graphite Parts Inspection RTR QA Record # 11709
4.	NPN-QC-28	Quality Control Data Sheet – AGR Nozzle Graphite
5.	SMT-5050021-001	SOLUMINA Move Ticket: AGR Graphite Inspection

IV. Configuration Design and Control

Configuration control is maintained by invoking a change review board whenever configuration changes are proposed and by communicating tolerances on fabrication drawings. Non-conforming parts were approved, via a N-74 Data Transmittal Form, for use in non-production runs. Configuration control appears to be effective for consumable parts.

Objective Evidence		
1.	QWI 5.1.12	Change Control
2.	CR-1044974-00	Update Mixing Pot Drawing
3.	Job Order No. 000001115136	AGR Graphite Parts Inspection
4.	Job Order No. 000001119781	AGR Graphite Parts Inspection
5.	Job Order No. 000001133750	AGR Graphite Heating Element Inspection
6.	Job Order No. 000001141679	AGR Graphite Furnace Tube Inspection
7.	Purchase Order 4700034930 8/30/15	Graphite Chalice, Nozzle, and Extension (SAP Req. 20020161)
8.	Purchase Order 4700034933 6/8/15	CENTORR Vacuum Industries Graphite and Other Parts for Work Station 300 (SAP Req. 20020230)
9.	UPRR-1002B	Drawing: INL 2010 AGR Nozzle and Chalice
10.	UPRR-10031	Drawing: AGR Reactor Assembly
11.	UPRR-10032	Drawing: AGR Reactor Tube
12.	UPRR-10033	Drawing: Graphite Extension
13.	UPRR-10035	Drawing: Reactor Tube Extension
14.	SMT-5050021-001	SOLUMINA Move Ticket: AGR Graphite Inspection
15.	QCDN J52F-0074	Quality Control Deficiency Notice on the AGR Nozzle dimensions
16.	QCDN J52F-0075	Quality Control Deficiency Notice on the AGR Chalice dimensions
17.	N-74 J52F-002	Data Transmittal Form: QCDN No. J52F-0074 and QCDN No. J52F-0075
18.	---	Interviews with engineering staff and management

V. Operator Training, Certification, and Qualification

Operators are trained on OJT Checklists as detailed in QWI-18.1.3. These checklists include required plant system training, required reading, written examination, and proficiency of operating the specific equipment being used (under the supervision of Engineer). Operators cannot run the equipment unsupervised until the checklist is complete and signed. At this time, there are no qualified operators for TRISO coating because there have not been sufficient coating runs to satisfy the OJT requirements. The in-process OJT checklists are kept by the Floor Supervisor in a desk drawer for easy access during training and assessments. When completed, the qualification records will be copied and transmitted to Quality Assurance.

Objective Evidence		
1.	QWI-18.1.3	On-the –Job Training
2.	QWI-16.1.2	UPRR Quality Assurance Records
3.	OJT checklists	Individual Operator in-process checklists reviewed: Randy Steele, Tom Markham, Rob Lindsey, Chase Haney, Jason Hall, Stanley Glover, and Monica Culpepper

VI. Chemical Inventories for Fabrication and Chemical Characterization

An inventory sheet was provided that included chemical inventories for the coating operation and consumables such as graphite furnace retort components. The review team assessed the quantity on hand as being sufficient for performing more than the five pre-production and five production coating runs planned. The engineer over TRISO coating operations (Joe Keeley) verbally affirmed that the supplies exceed what is required for the planned runs.

Certificates of Analysis for reactive coating gases and hydrogen were reviewed. The requested purities and the as-received purities were compliant with SPC-1363 “AGR-5/6/7 Fuel Fabrication Feedstock Chemical Purity Specifications,” Rev.2 except for acetylene. Most of the acetylene certificates did report purity and impurities analyses in compliance with the specification. Three certificates indicated an incorrect “Requested Purity” for the impurities and one certificate reported impurities as possibly exceeding the SPC-1363 limits. Only one acetylene cylinder is suspect. This was communicated to BWXT during the review. The suspect cylinder is one of several loose spare cylinders and not part of the inventory installed in the primary and reserve cylinder banks for AGR-5/6/7.

The analytical laboratory was toured and a chemist and analyst interviewed. Both have affirmed that the present inventory of chemicals exceed quantities needed for the anticipated number of analyses to be performed. The lead time to order additional chemicals is short enough that additional supplies could be ordered if more analyses became necessary.

The inventory of the gases to be used in applying the TRISO coatings on fuel kernels for the AGR-5/6/7 is calculated to be sufficient and purities compliant with SPC-1363, except for the single acetylene cylinder that will not be authorized for use.

Objective Evidence		
1.	---	Inventory spreadsheet (process chemicals and graphite parts)
2.	---	Interviews with engineering staff, analysts, and management with verbal statement that inventory was deemed to be in excess of what will be needed for pre-production and production coating runs.
3.	---	Field inspection of analytical laboratory
4.	Job Order No. 000001115136	AGR Graphite Parts Inspection
5.	Job Order No. 000001119781	AGR Graphite Parts Inspection
6.	Job Order No. 000001133750	AGR Graphite Heating Element Inspection
7.	Job Order No. 000001141679	AGR Graphite Furnace Tube Inspection
8.	Purchase Order 4700034930 8/30/15	Graphite Chalice, Nozzle, and Extension (SAP Req. 20020161)
9.	Purchase Order 4700034933 6/8/15	CENTORR Vacuum Industries Graphite and Other Parts for Work Station 300 (SAP Req. 20020230)
10.	Purchase Order 4700035386 10/2/15	Acetylene, Atomic Absorption Grade, Minimum Purity 99.6%, 323 Cu Ft Cylinder (Size 5 Cylinder) (SAP Req. 20020241)
11.	ACE-8 ACE-9 ACE-10 ACE-11 ACE-13 ACE-14 ACE-15 ACE-16	Certificates of analysis for acetylene shipped from Airgas and AirProducts.
12.	Release H-010	Bulk Hydrogen
13.	Releases PROP-02	Propylene

Objective Evidence		
	PROP-03 PROP-06 PROP-07	
14.	Release MTS-015	Methyltrichlorosilane

VII. Consumables Inventory

The inventory of consumable graphite parts (chalices, gas distributor nozzles, etc.) was inspected and assessed as being adequate to meet the needs for AGR pre-production and AGR production runs. The engineer verbally confirmed that he expects the inventory to be more than adequate. Parts are inspected for compliance with the tolerances specified in the BWXT fabrication drawings, non-conforming parts are dispositioned such that they will not be used for AGR production runs.

Objective Evidence		
1.	---	Inventory spreadsheet (process chemicals and graphite parts)
2.	---	Interviews with engineering staff
3.	Job Order No. 000001115136	AGR Graphite Parts Inspection
4.	Job Order No. 000001119781	AGR Graphite Parts Inspection
5.	Job Order No. 000001141679	AGR Graphite Furnace Tube Inspection
6.	Purchase Order 4700034930 8/30/15	Graphite Chalice, Nozzle, and Extension (SAP Req. 20020161)
7.	QCDN J52F-0074	Quality Control Deficiency Notice on the AGR Nozzle dimensions
	QCDN J52F-0075	Quality Control Deficiency Notice on the AGR Chalice dimensions
8.	N-74 J52F-002	Data Transmittal Form: QCDN No. J52F-0074 and QCDN No. J52F-0075

VIII. Material Procurements

The material procurement process is generally compliant. Level I and Level II items are procured from suppliers listed on the Approved Suppliers List (ASL). Suppliers are audited and the approval level and approved criteria are listed on the ASL. Certificates of Compliance are received as applicable and required inspections are completed and documented.

Contrary to NQA-1-2008/-1a-2009 Section 4, technical requirements were not communicated to the supplier via the purchase requisition/purchase order system. Acetylene was ordered from Air Gas with a purity level of $\geq$ 99.6%, but $\leq$ 25 ppmv H_2S and $\leq$ 15 ppmv PH_3 requirements specified in the SPC-1363

"AGR-5/6/7 Fuel Fabrication Feedstock Chemical Purity Specifications," Rev. 2 were not communicated to the supplier. Three certificates of analysis for acetylene indicated incorrect "Purity Requested" values and one indicated an analytical value for PH_3 of ≤ 25 ppmv and therefore suspect. All other gases and consumables were purchased to the required specifications and certificates of analyses showed compliance with the specification.

Objective Evidence		
1.	QWI 6.1.15	Technical Requirements for UPRR Purchased Items
2.	Q8-9909	Supplier Corrective Action Request (in process)
3.	Q8-9930	Acetylene - Certificate of Batch Analysis– Air Gas 8/14/13
4.	Q8-9930	Bulk Hydrogen - Certificate of Batch Analysis– Air Gas 4/15/15
5.	Q8-9930	Propylene - Certificate of Batch Analysis– Air Gas 6/10/13
6.	Approved Supplier List (ASL)	NOG-L Composite Subcontractor Database (Approved Supplier)
7.	Audit	Supplier audit of DuBose in September 2015 to qualify to NQA-1-2008/-1a-2009, 10 CFR 50 QA Criteria for Nuclear Power Plants and Fuel Processing Plants, NCA-3800 ASME Boiler and Vessel Code, and 10 CFR 21 Reporting of Defects and Noncompliances
8.	PR 20020161	PO 470034930 including associated drawings
9.	PR20020230	Level 3 – not safety significant
10.	PR 20019917	Level 2 – Hydril cylinders ≥ 99.95%
11.	PR 20019917	Level 2 – Acetylene - ≥ 99.6% ≤ 25 ppmv H_2S ≤ 15 ppmv PH_3
12	PO 4700035386-0	Air Gas - 12/9/2015 Acetylene - ≥ 99.6%
13	Job Order No. 000001115136	AGR Graphite Parts Inspection - Quality Control Data Sheet
14	Job Order No. 000001133750	AGR Graphite Heating Element Inspection- Quality Control Data Sheet
15	Job Order No. 000001141679	AGR Graphite Furnace Tube Inspection- Quality Control Data Sheet

IX. Operability of Essential TRISO Coating Furnace and Ancillary Equipment

An examination by BWXT of the coating furnace following an interrupted coating "test" run, to verify equipment functionality, revealed an unacceptable degradation of insulation and ceramic insulators surrounding the electrical lead-ins for the heating elements. The furnace manufacturer, CENTORR, had made recent changes in these materials. BWXT is working with CENTORR to resolve the issue and to obtain insulation and insulators known to have worked well in the past.

The coating test run was interrupted because the desired hydrogen flow rate could not be established. A post run inspection identified that a flow control valve had failed. BWXT is in the process of checking calibration on a spare flow control valve.

The coating furnace, work station WS-300, is not presently ready for operation. The scrubber system and off-gas filtration systems performed as designed.

Objective Evidence		
1.	---	Interviews with engineering staff and management

X. Corrective Actions System Effectiveness to Capture "Lessons Learned"

BWXT has a defined corrective action process that is compliant with NQA-1-2008/-1a-2009 requirements that have three paths of investigation depending on the level of severity. Lessons learned reports are sent to all employees in a Quality Advisory. The corrective actions listed below were reviewed and found to be adequately documented and compliant.

Objective Evidence		
1.	QWI-14.1.1	Preventative/Corrective Action System
2.	QWI-14.1.1 Attachment 1	Preventative/Corrective Action System Severity Level
3.	QWI-14.1.3	Lessons Learned Report
4.	Form Q8-9909	Supplier Corrective Action Report
5.	CA 201501878	Sample Calculation incorrect – wrong valve used
6.	CA 201501400	AGR coating run acetylene flow incorrect due to Windows 7 update
7.	CA 20150188	Chemical near miss- chemical tipped over
8.	Quality Advisory	Incompatible Valve Material in Systems Containing Acid

XI. Product acceptance

BWXT has processes for the receipt inspection of materials to drawings and has the analytical methods to ensure that TRISO coated particles are compliant with fuel specifications, with two exceptions. High resolution X-ray imaging technology for IPyC defect fraction analysis is not available at BWXT and the ellipsometer used for pyrocarbon anisotropy measurements is out-of-service for upgrades. Arrangements have been made by INL with Oak Ridge National Laboratory (ORNL) to perform analyses for IPyC defect fraction and temporarily for the pyrocarbon anisotropy until the BWXT ellipsometer is back in service.

BWXT analytical personnel are running analyses on archived TRISO coated particles to re-familiarize themselves with the methods and the equipment.

The review team is confident in the ability of BWXT, with support from ORNL, to ensure that the AGR-5/6/7 TRISO coated particles are fabricated with equipment meeting dimension tolerances, that gases used will meet purity specifications, and that only TRISO coated particles meeting fuel specifications will be accepted for AGR-5/6/7.

Objective Evidence		
1.	---	J52O-16-93160 kernel density and wt/count analyses
2.	---	J52O-16-93161 buffer density, wt/count, and envelope density
3.	---	J52O-16-93161 isotopic analyses
4.	Job Order No. 000001115136	AGR Graphite Parts Inspection - Quality Control Data Sheet
5.	Job Order No. 000001133750	AGR Graphite Heating Element Inspection- Quality Control Data Sheet
6.	Job Order No. 000001141679	AGR Graphite Furnace Tube Inspection- Quality Control Data Sheet
7.	---	Interviews with the analytical chemist and technician

XII. Handling and Storage

An electronic system MAP issues maintenance plans to the floor on a weekly basis. QCDNs are issued for nonconforming items and those items are appropriately marked and/or removed from service.

A review of Quality Control Deficiency Notices (QCDNs) showed two instances of the documents signed as completed prior to the disposition codes being recorded. QCDN J52F-0075 AGR Chalice diameter size and J52F-0074 – AGR Nozzle were signed without disposition codes assigned. A suggested disposition pending customer (BEA) approval was written on the forms but Form Q11-127 was signed prior to the customer's approval of this disposition on 10/31/13 (recorded on Form N-74). These instances had no negative impact due to the customer's approved disposition of "use as is". However, approval prior to final disposition does not preclude use of nonconforming items if the final disposition were to "reject" or "rework".

Objective Evidence		
1.	QCDN J52F-0074	Quality Control Deficiency Notice on the AGR Nozzle dimensions
2.	QCDN J52F-0075	Quality Control Deficiency Notice on the AGR Chalice dimensions
3.	N-74 J52F-002	Data Transmittal Form: QCDN No. J52F-0074 and QCDN No. J52F-0075
4.	OP-1016020 Rev. 10	Operating Procedure for: AGR Coating Furnace Scrubber Operation and Maintenance (U)
5.	OP-1015211 Rev. 5	Operating Procedure for: Sieving for AGR (U)
6.	---	Inventory spreadsheet (process chemicals and graphite parts)
7.	---	Interviews with engineering staff, analysts, and management
8.	---	Field inspection of analytical laboratory

XIII. Personnel Access and Familiarity with Latest AGR Work Scope and Requirements Documents

The AGR work scope and specification documents are controlled at the INL and formally transmitted to BWXT management through procurement and contract management. These documents are reviewed and approved by BWXT. The Lead Engineer distributes the applicable requirements to the production floor via OJT checklists and briefings.

Objective Evidence		
1.	SMT-5050021-001	SOLUMINA Move Ticket: AGR Graphite Inspection
2.	Process OJT Checklists	Randy Steele, Tom Markham, Rob Lindsey, Chase Haney, Jason Hall, Stanley Glover, and Monica Culpepper
3.	---	Interviews with engineering staff and management

XIV. Considerations from Previous Reviews and Incidents

Shortcomings from previous readiness reviews were revisited to ensure that corrective actions were effective. In a previous review, multiple calibrated check weight sets were found in the gloveboxes used for handling fuel kernels and TRISO coated fuel particles without the performer noting which check weight set had been used. BWXT resolved this by removing redundant check weight sets. This corrective action is effective for both kernel and TRISO particle fabrication.

A previous review found that training records were not signed by an authorized individual (manager or lead engineer) and one case was found that a qualification exam had not been graded. The review team inspected training records and found that all required signatures were in place. Many of the documents are still working documents and not yet finalized as records, but the review team finds the BWXT process to be effective.

A previous review for TRISO particle coating identified a lack of receipt inspection for graphite parts to ensure that the parts were compliant with the dimensional tolerances specified in fabrication drawings. This review found evidence that graphite parts are receipt inspected to verify conformance to drawing dimensional tolerances and that non-conforming parts approved only for non-production coating trials. The review team is confident that corrective actions taken previously by BWXT have been effective.

Objective Evidence		
1.	OP-0390001	Operating Procedure for: Product Identification Control (U)
2.	---	Interviews with , SFF Frontline Manager, engineering staff, and management
3.	QCDN J52F-0074	Quality Control Deficiency Notice on the AGR Nozzle dimensions
4.	QCDN J52F-0075	Quality Control Deficiency Notice on the AGR Chalice dimensions
5.	N-74 J52F-002	Data Transmittal Form: QCDN No. J52F-0074 and QCDN No. J52F-0075
6.	Job Order No. 000001115136	AGR Graphite Parts Inspection - Quality Control Data Sheet

Objective Evidence		
7.	Job Order No. 000001133750	AGR Graphite Heating Element Inspection- Quality Control Data Sheet
8.	Job Order No. 000001141679	AGR Graphite Furnace Tube Inspection- Quality Control Data Sheet
9.	QWI-18.1.3	On-the –Job Training
10.	QWI-16.1.2	UPRR Quality Assurance Records
11.	OJT checklists	Individual Operator in-process checklists reviewed: Randy Steele, Tom Markham, Rob Lindsey, Chase Haney, Jason Hall, Stanley Glover, and Monica Culpepper

CONCLUSIONS

The readiness review team was cordially received and provided with examples of objective evidence, which had been compiled in advance of the review by BWXT. Additional information was provided when requested. The review was productive and professionally facilitated by BWXT. Arrangements were made in a timely manner by BWXT for the team to meet with key individuals and to conduct spot checks in the field.

The readiness review team finds that BWXT will be ready to fabricate TRISO coated fuel particles once the coating furnace operability has been successfully demonstrated and the two findings have been addressed. Functionality of the coating furnace will be adequately demonstrated when the test run, check run, and at least one pre-production run have been successfully completed without major equipment failures. Both findings are related to awareness of processes to preclude suspect and off-spec materials and chemicals from being used in the fabrication of the AGR-5/6/7 TRISO coated fuel; one being communication of all purity specifications to suppliers during procurement of chemicals and the other is ensuring appropriate disposition codes are given when Quality Control Deficiency Notices (QCDN) are signed. BWXT is expected provide information on corrective actions taken to address these findings.

APPENDIX A
CONTENTS OF THE BWXT OBJECTIVE EVIDENCE BINDER

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APPENDIX B
READINESS REVIEW ATTENDANCE SHEET

AGR-5/6/7 TRISO PARTICLE FABRICATION READINESS REVIEW ATTENDANCE SHEET

Vendor BWXT

Dates 2/9/2016 – 2/10/2016 Location Lynchburg, VA

Technical Lead Douglas Marshall Quality Engineer Michelle Sharp

Attendees:

NAME (Print)	POSITION	Entrance Meeting (Y/N)	Exit Meeting (Y/N)	Interviewed (Y/N)
DAVID NAVOLIO	UPRR Dev. Eng Manager	✓	✓	
CLAY RICHARDSON	P. Manager SFF Uranium Recovery	✓	✓	
Chip Shaffer	UPRR Dept. Mgr.	✓	✓	
Scott Niedzielski	UPRR Eng/QC Mgr	✓	✓	
DeWayne L Hosser	UPRR Eng.		✓	✓
Jeff Daniel	UPRR Quality Unit Manager			✓
Karen Crosby	Chemist			✓
Grant Ward	Lab Technician			✓
Norman Coles	SFF FLM			✓
Kelly Hartless	UPRR Engineer			✓
Joe ~~Keff~~ Keeley	UPRR Engineer			✓
Brandon Treadway	UPRR QA Engineer			✓
Nat N. Neigle	UPRR QA Engineer			✓
Tim Johnson	UPRR QA Engineer			✓

Comments:

APPENDIX C
READINESS REVIEW PLAN

READINESS REVIEW CRITERIA

AGR-5/6/7 TRISO PARTICLE FABRICATION

The following focus areas are subject to scrutiny by the readiness review team as each applies to LEU TRISO particle fabrication activities (e.g., coating, upgrading, etc.) described in SOW-11518 (Rev.7) "AGR-5/6/7 Fuel Fabrication." INL will focus the areas below as they apply to TRISO coated particle fabrication, but INL will respond to the information and objective evidence obtained and follow leads as necessary to assess readiness.

A visit to the processing area is requested to allow reviewers to see the equipment and make limited inspections of calibration stickers and equipment condition.

References to NQA-1 mean ASME-NQA-1-2008/1a-2009. The outline below may not quote the entire text of each referenced paragraph within a NQA-1 requirement. Nevertheless, objective evidence may be requested by the review team to demonstrate compliance with all requirements within the referenced paragraph.

Documents and objective evidence presented by BWXT to INL should be associated with activities related to the AGR fuel fabrication. It is understood that BWXT has the prerogative to either refuse presentation of evidence that may contain classified or sensitive information or to present redacted documents as evidence of compliance.

Focus Area	Suggested Objective Evidence
I. Process instrumentation and M&TE calibrations a. Tools, gages, instruments, etc. are controlled, calibrated, adjusted, and maintained to required accuracy limits (NQA-1 Req't 12 ¶100) b. Calibrations performed at prescribed intervals against traceable or certified equipment/standards (NQA-1 Req't 12 ¶301) c. M&TE consistently found out of calibration is repaired or replaced (NQA-1 Req't 12 ¶303) d. When M&TE is found out of calibration or damaged, data collected since the last known acceptable calibration shall be evaluated for acceptability (NQA-1 Req't 12 ¶303.2) e. M&TE calibration status can be readily determined by inspection and documented (NQA-1 Req't 12 ¶303.6, 401 - 402)	• List of calibrated process instruments with calibration intervals • List of tools, gages, weights, etc. that require calibration and calibration intervals • Evidence that the calibrations are traceable to certified equipment or standards • Evidence that the calibrations are current • Acceptability evaluations for M&TE out of calibration

Focus Area	Suggested Objective Evidence
II. Approval, control, and accessibility of operating procedures a. Activities affecting quality prescribed by and performed in accordance with documented instructions, procedures, etc. (NQA-1 Req't 5 ¶100) b. Operating procedures and instructions are controlled to ensure the latest revision is used (NQA-1 Req't 6 ¶100) c. Operating procedures and instructions are reviewed and approved prior to releasing them for use (NQA-1 Req't 6 ¶100) d. Documents and changes to documents are controlled (NQA-1 Req't 6 ¶200) e. Test (process) requirements and acceptance criteria based upon documented specifications [NQA-1 Req't 11 ¶200(b); 300(a-b)] f. Review, authorization, and control of operator instructions (e.g., recipe sheets)	• Binder containing copies of current operating procedures applicable to activities associated with applying TRISO coatings and analytical methods for characterization • Evidence that only the current procedures and instructions are available to those performing the work • Evidence that changes to controlled instructions, methods, or procedures are authorized by management • Evidence of operating instructions or recipe sheets being authorized • Records showing how performers know that they have the latest recipe sheet/instruction version
III. Process record control and accessibility a. Records are validated or authenticated by authorized personnel [NQA-1 Req't 17 ¶300(a)]	• Records management procedure • Examples of validated/authenticated AGR records – inspection reports, training records, etc.
IV. Configuration design and control a. Procedures established to implement configuration management and responsibilities/authorities are identified (NQA-1 Req't 3 ¶601) b. Configuration changes affecting quality are (NQA-1 Req't 3 ¶601.1 – 601.9): i. Recognized before implementation ii. Analyzed against design bases and requirements iii. Approved by responsible persons iv. Documented (incl. basis) c. Controls are established to ensure that only correct and accepted items (e.g., materials of construction) are used or installed (NQA-1 Req't 8 ¶100 - 303)	• Documentation associated with recent maintenance or configuration changes demonstrating the focus points to the right.

Focus Area	Suggested Objective Evidence
V. Operator training, certification and qualification a. Indoctrination and training (NQA-1 Req't 2 ¶200) b. Performers indoctrinated and trained (NQA-1 Req't 2 ¶201) c. Formal training program (NQA-1 Req't 2 ¶202)	• Training plans, training rosters, etc. • Management concurrence that training was completed and effective
VI. Chemical inventories for fabrication and chemical characterization a. Chemical inventories are sufficient for expected needs or a plan is in place to acquire chemicals before the inventory is depleted. b. Chemical shelf-lives will not be exceeded during the period of TRISO particle fabrication (NQA-1 Req't 8 ¶302) c. Chemicals comply with SPC-1363, "AGR-5/6/7 Fuel Fabrication Feedstock Chemical Purity Specifications," Rev. 2	• Chemical certificates of conformance and expiration dates (as applicable) • Spreadsheet of process and analytical chemicals with: o Quantities on hand o Quantities needed for remaining pre-production runs and at least six (5 + 1) production runs o Plans to acquire any deficient inventories
VII. Consumables inventory (e.g., graphite furnace parts) is adequate for expected needs and spares	• Quantities of graphite parts (chalice, nozzles, etc.) needed to complete pre-production and production runs • Quantities in inventory • Plans to acquire any needed parts
VIII. Material procurements a. Procured from qualified suppliers (or with commercial grade dedication) (NQA-1 Req't 4 ¶100; NQA-1 Req't 7 ¶100, 700) b. Technical & functional requirements and non-conformance reporting requirements are communicated to suppliers (NQA-1 Req't 4 ¶202, 206; NQA-1 Req't 7 ¶501 - 503) c. Receiving inspection is performed to verify conformance with technical and functional requirements (NQA-1 Req't 7 ¶505)	• Sample procurement documents • Qualified supplier list (as applicable to TRISO fabrication) • Evidence that technical and functional requirements were communicated to the vendor • Evidence of receipt inspections being completed and conformance of items to the technical and functional requirements (e.g., dimensions on nozzles and chalices, etc.)
IX. Operability of essential TRISO coating furnace and ancillary equipment	• Equipment walk-down to inspect equipment and instrumentation for cleanliness, material compatibility, out-of-service tags, current calibrations, general condition, etc.

Focus Area	Suggested Objective Evidence
X. Corrective action system effectiveness to capture "lessons learned" a. Conditions adverse to quality identified and corrected ASAP (NQA-1 Req't 16 ¶100) b. Significant conditions adverse to quality investigated to determine the cause and actions taken to prevent recurrence (NQA-1 Req't 16 ¶100) c. Significant conditions and corrective actions are documented and reported to appropriate management (NQA-1 Req't 16 ¶100) d. Completion of corrective actions is verified (NQA-1 Req't 16 ¶100)	• Documentation of a recent incident where conditions adverse to quality were identified, investigated, corrected, reported, and documented • Evidence that other processes were reviewed for similar conditions • Evidence demonstrating that the corrective actions are durable (lessons learned are not forgotten)
XI. Product acceptance a. Inspection for acceptance by an independent, qualified person (NQA-1 Req't 10 ¶100) b. Inspection requirements and acceptance criteria are specified and documented (NQA-1 Req't 10 ¶200) c. Sampling procedures based on standard statistical methods with engineering approval (NQA-1 Req't 10 ¶402) [INL sampling plan, PLN-4352 Rev. 4 is used] d. Performance of the analytical laboratory in product characterization i. ASTM or other standards used ii. Internal standards are documented and traceable to national standards e. Acceptance is approved by authorized personnel (NQA-1 Req't 10 ¶604)	• Documentation showing acceptance or rejection of product to documented criteria/specifications • Documentation that sampling procedures provide representative samples in quantities sufficient to satisfy the sampling plan • Walk-down of the analytical laboratory to verify that chemicals are current, that the inventory is sufficient to support characterization, instruments are calibrated, and that standards are traceable to national standards • Evidence that analytical results are reviewed for quality and approved prior to official release

Focus Area	Suggested Objective Evidence
XII. Handling and Storage a. Product stored to prevent loss, damage, and minimize deterioration (NQA-1 Req't 13 ¶100, 200, 300) b. Product containers are marked or labeled with special handling/storage requirements (NQA-1 Req't 13 ¶600) c. Controls are in place to prevent inadvertent use of non-conforming product [NQA-1 Req't 15 ¶100, 300(a-b)] d. Non-conforming product shall be evaluated for alternative use or disposition (NQA-1 Req't 15 ¶401) e. The disposition of non-conforming product shall be documented (NQA-1 Req't 15 ¶404)	• Procedures and documents showing how product is segregated from non-conforming material and controlled to prevent loss of identity
XIII. Personnel have access to and are familiar with the latest AGR work scope and requirements documents a. SOW-11518, "AGR-5/6/7 Fuel Fabrication," Rev. 6 b. SPC-1352, "AGR-5/6/7 Fuel Specification," Rev. 5 c. SPC-1363, "AGR-5/6/7 Fuel Fabrication Feedstock Chemical Purity Specifications," Rev. 2 d. PLN-4352, "Statistical Sampling Plan for AGR-5/6/7 Fuel Materials," Rev. 4	• Show how superceded AGR documents are controlled • Show how current AGR documents are controlled

Focus Area	Suggested Objective Evidence
XIV. Considerations from previous reviews and incidents a. Check weight ID's are recorded when used to verify balance functionality b. Training records are signed by management c. Internal audits reflect assessments of process effectiveness (if an audit has been performed for unclassified systems associated with AGR fuel fabrication) d. Computerized process control functions have been verified following programming changes or updates to operating systems e. Coating furnace graphite components are inspected upon receipt to verify that parts comply with dimensional tolerance limits f. Materials of construction are compatible with service conditions	

Prepared by

Quality Engineer _____ 1/15/16

Technical Lead _____ 1/15/16