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## Technical Evaluation Study

Project # 23747, 29412, 23841

# Technical Evaluation of Graphite Acquisition for NGNP Characterization Studies


The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance.

**Idaho National Laboratory**

| **TECHNICAL EVALUATION OF GRAPHITE ACQUISITION FOR NGNP CHARACTERIZATION STUDIES** | Identifier: TEV-235<br>Revision: 0<br>Effective Date: 07/25/08 | Page: 1 of **10** |
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## REVISION LOG

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# 1. INTRODUCTION

To prepare for future Advanced Test Reactor (ATR) Graphite Capsule experiments and baseline graphite characterization activities, additional graphite material must be purchased. To meet anticipated American Society of Mechanical Engineers (ASME) and Nuclear Regulatory Commission (NRC) requirements for the resulting test data, the initial program required that the graphite manufacturers be placed on the Idaho National Laboratory (INL) approved supplier list. For that, suppliers needed to have an ASME Nuclear Quality Assurance (NQA)-1 2000 quality program verified by an INL audit. Currently, no graphite manufacturing companies have an approved NQA-1-based quality assurance (QA) program. Two graphite vendors supplying three of the major grades being tested in the Next-Generation Nuclear Plant (NGNP) program were selected for additional graphite purchases and subsequent Quality Assurance (QA) audits.

While performing the audits, several issues were identified that prompted reevaluation of graphite acquisition strategy. Simply put, nuclear graphite grades available for purchase are in different states of development. Some are purely experimental (no full-size production yet); some are at pilot scale development (limited full-size production); and only one could be considered a full-scale production graphite. (NBG-18 has been selected as the preferred graphite for the pebble bed modular reactor in South Africa.) Various levels of quality have been applied to the different grades, resulting in differences in the amount of QA data needed to satisfy the NGNP program. In addition, ASTM standards used to specify and provide characterization guidance are still evolving and are not always practical to implement on experimental grade nuclear graphite. In some cases, graphite companies are making incorrect assumptions on how to implement ASTM guidance, which could result in incorrect data. To address these concerns, a graded QA approach has been implemented to allow testing of the entire range of available graphite types for the NGNP program. Specific issues encountered while purchasing these initial graphite materials are outlined below, as well as details on the recommended approach to purchasing future graphite grades.

# 2. AUDIT LOCATIONS

The PCEA graphite has been selected as a major graphite grade in the AGC-1 experiment and is undergoing baseline material characterization this fiscal year. PCEA was manufactured at the GrafTech International Notre Dame Facility in France. GrafTech has ceased PCEA production at the Notre Dame facility and started producing it at the Clarksburg, West Virginia, facility, which has not manufactured PCEA before. An audit of GrafTech facilities was held April 1-4, 2008, at the Parma, Ohio, and Clarksburg, West Virginia, facilities. The Parma facility, corporate headquarters and location for graphite research and development, contains laboratories for graphite characterization and selected source material acceptance. The Clarksburg facility is where PCEA billets are manufactured. Q programs at the two facilities are implemented separately. Figure 1 shows graphite billets at the Clarksburg facility similar in size to the anticipated NGNP order.

The audit of SGL Carbon took place May 12-16, 2008, at SGL facilities in Mitiengen, Germany, and Chedde France. SGL Carbon is organized under separate business units, with each business unit having its own distinct QA program. The INL auditor reviewed appropriate portions of the QA documentation and procedures for each of the business units involved with the manufacture of NBG-18 graphite. The manufacturing flow diagram in Appendix A shows the different manufacturing steps between Chedde and Meitingen facilities used to make NBG-18.

## 3. SUMMARY OF AUDIT ISSUES

Both audits found that the two graphite companies did not have elements of NQA-1 in their QA plans and did not implement procedures that conform to selected portions of NQA-1 requirements. Both companies admitted their QA programs and implementing procedures needed further attention. Graphite manufacturers are using company internal procedures developed from production history rather than current ASTM standards for nuclear grade graphite, because ASTM standards for nuclear grade graphite are still undergoing development and acceptance in some areas. Figure 2 shows the audit team inspecting NBG-18 billets in Meitingen, Germany.

## 4. RECOMMENDATION FOR FUTURE GRAPHITE ACQUISITIONS

Currently, most of the graphite being considered as major grades in the NGNP program have not been in full production and are still considered experimental, except for historical graphite grades IG-110 and H-451. Grade H-451 is no longer produced because of depletion of raw materials. Grade IG-110 is only produced for the research helium gas reactors HTTR in Japan and HTR in China. Both countries have decided not to use IG-110 in future gas reactors. China is developing its own graphite industry to supply its future helium gas reactors, and Japan is planning to use IG-430 in its next evolution reactor GTHTR300.

The NGNP graphite irradiation and characterization program wants to obtain qualified data for use in design and NRC licensing of the NGNP. This requires having graphite manufacturers with QA plans that implement necessary portions of the NQA-1 code and who have established full-scale production lines of graphite using mature ASTM standards for acceptance.

Audits of the two large graphite manufacturers, who are representative of all the graphite vendors, show neither has a defined, documented, and implemented NQA-1 quality program. Current evaluations verified that both manufacturers have a quality program in place that will ensure product reproducibility, but lacked the necessary elements for a fully verified NQA-1 2000 quality program. Both companies expressed interest in developing an NQA-1 based QA program to support future procurement of graphite used in a licensed reactor. However, developing an NQA-1 program requires considerable expenditure of resources that a company may not choose to commit on an experimental grade of nuclear graphite.

The NGNP graphite program had to address this legitimate issue and still allow testing of the maximum types of nuclear graphite available from vendors. It is recommended that future graphite procurements supporting graphite characterization come from companies with a verified quality program in place to ensure product reproducibility. At present, programs need not be NQA-1 based. The QA program evaluation will focus on individual quality requirements to ensure that future products will exhibit similar mechanical characteristics and irradiation performances. One quality requirement will be achieved by ensuring proper quality controls on raw materials such as coke and binder. In addition, the recipe for the graphite grade must be followed and documented. Additional verification of graphite reproducibility will be accomplished through extensive pre-use graphite characterization at INL and/or ORNL. As the graphite down selection process takes place, the NGNP project will assist participating companies in developing NQA-1-based quality programs with visits aimed at identifying gaps in program documentation and implementation.

This will allow the NGNP graphite program to test as many nuclear graphite types as are available while still meeting appropriate QA standards. As the graphite choices are down selected, the remaining graphite types will be subjected to more stringent QA standards aimed at eventually producing a fully qualified NQA-1 2000 program. This will provide full NQA-1 2000 quality programs for only those graphite types that are viable candidates for future reactor use.

Finally, it was evident from the two audits that the current ASTM test standards used for graphite acceptance testing have not matured to where repeatable or accurate acceptance testing can be relied on. In fact, many of the graphite manufacturers are using company internal procedures developed from production history rather than current ASTM standards for nuclear graphite. Without mature ASTM graphite test standards for guidance, acceptance test data between lots, billets, and other graphite grades would provide inconsistent data quality.

Statement of Works (SOWs) will be used for future graphite purchases with appropriate QA clauses as necessary to ensure repeatability of the graphite grade irradiated performance and the variance in the lot-to-lot and billet-to-billet nonirradiated thermo-physical properties. These future purchases will assume the graphite grades to be off-the-shelf grade material. After a reactor technology has been selected for the NGNP, the SOW for future graphite purchase will include requirements of a fully implemented NQA-1 program, an appropriate ASTM acceptance testing program, and a mutually developed graphite manufacturing specification

# 5. GRAPHITE PURCHASED

To purchase the graphite grade PCEA, a detailed manufacturing specification was written that instructed GrafTech what quality assurance tests to perform on the raw materials, the intermediate stages of manufacture, and the final graphitized billets. The specification also described the testing and process data capture that would be sent to the INL and the

process data that would be recorded and kept at the plant. The specification requires delivery of 19 billets to the INL nine months after award of contract. Teleconferences with GrafTech furthered understanding of the manufacturing process and key process parameters. The key process parameters for PCEA were put in the specification to ensure repeatability for future purchases. Because these process parameters describe the proprietary manufacturing process for PCEA, the discussions between GrafTech and BEA and the manufacturing specifications are covered under a prior NDA signed between Battelle Energy Alliance and GrafTech. Therefore, the manufacturing specification is considered as a proprietary document

A SOW was written for purchasing six NBG-18 billets from SGL Carbon. The billets, made to PBMR specification but owned by SGL, were completed in September, 2007, during a test run for PBMR. The NGNP cannot purchase small lots of NBG-18 billets independent of PBMR production because the PBMR specifications have an impact on the overall SGL production line, making small lots uneconomical to manufacture. Therefore, future purchases of newly manufactured NBG-18 billets must be included in the PBMR production runs. This has been discussed with PBMR, because PBMR will also have to order additional billets for testing in excess of the original contract. INL has an nondisclosure agreement (NDA) with PBMR to cover discussions on graphite testing and qualification. INL has examined the proprietary PBMR NBG-18 manufacturing specification. INL has specified some of the mandatory data reporting requirements from the proprietary NBG-18 manufacturer specifications in the INL SOW. Therefore, the SOW for purchasing NBG-18 is treated as a proprietary document. PBMR funded the development of NBG-18 and owns the recipe for NBG-18. NBG-18 cannot be sold to other customers without PBMR's approval.

In addition, the SOW requires SGL to supply a shipping requirements report to the INL for concurrence. This report outlines construction of the shipping containers and procedures to protect the billets from damage during transatlantic shipment. The INL has requested that SGL use the Port of Atlanta to off-load the standard shipping container. The DOE policy to forgo insuring transatlantic shipments should be reviewed because of cost and availability of replacement billets if billets were damaged in shipment. Figure 3 and Figure 4 show potential shipping packaging and moisture isolation barriers used to keep the billets from absorbing moisture.

# 6. CONCLUSIONS

Best and finals request for quote went to SGL on June 3, 2008. On June 25, 2008, INL awarded SGL Carbon a contract for the purchase of six billets of NBG-18. The SOW states the billets will be shipped 5 months from award of contract. Receipt of the billets from Europe is expected in Idaho Falls at the end of November, 2008. The data package providing QA acceptance documentation is due two weeks before shipment from Europe.

Best and finals request for quote went to GrafTech International on June 3, 2008. On July 15, 2008, INL awarded GrafTech International a contract to manufacture nineteen billets of PCEA. The contract states that receipt of the graphite billets is due nine months after award of contract, thus the billets are expected in late March, 2009. Portions of the data package will be sent to the INL during the different stages of manufacture with a complete data package detailing the entire manufacturing process two weeks before the shipment of the billets from West Virginia.

# 7. APPENDIXES

Appendix A, Figures

## Appendix A

## Figures

Figure 1. Graphite billets of similar size as PCEA.

Figure 2. Review of the NBG-18 graphite by INL auditors.

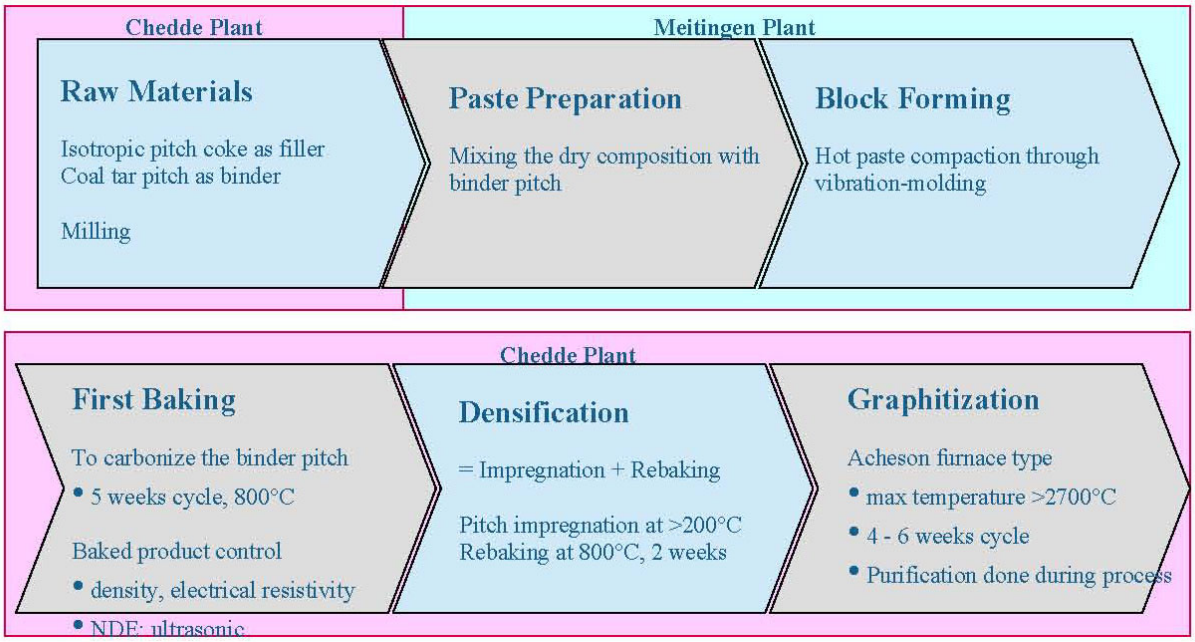


Figure 3. Flow sheet outlining NBG-18 manufacture and at which facility.


Figure 4. Photos of prospective packaging for NBG-18 transatlantic shipment. The blue nozzle allows backfilling of the vapor barrier with an inert gas.


Figure 5. Photos of prospective packaging for NBG-18 transatlantic shipment. The blue nozzle allows backfilling of the vapor barrier with an inert gas.