Baseline Graphite Characterization
Baseline Graphite Characterization Purpose and Results

Establish the physical and mechanical properties of nuclear grade graphite and their variability…

- Intra Billet
- Billet to Billet
- Batch to Batch
- Grade to Grade

Method and procedure for obtaining data

- NQA-1 Qualified Data Set
- Manufacturing process improvement
- Initial selection of graphite
- Qualify graphite as a structural material (ASME)

Development of measurement techniques, standards and design code

- Split disc tensile strength
- ASME BPVC.III.5
- ASTM D02.F0

Baseline of un-irradiated properties for comparison to AGC irradiated properties

- Statistically valid
- Scalar value
- Distribution
Baseline Graphite Characterization Method

- Select necessary material properties
- Apply sampling plan
- Perform standardized testing
- Evaluate/compare properties
- Build NQA-1 qualified database
- Apply the “system” and database to the evaluation and qualification of future grades of graphite

Current Grades
- NBG-18
- PCEA
- IG-110
- 2114
- NBG-17

Additional Grades
- IG-430
Baseline Property Measurements

Compressive Strength
Flexural Strength
Tensile Strength
Brazilian Disc

Physical Properties Testing
- Density
- Coefficient of Thermal Expansion
- Thermal Diffusivity
- Electrical Resistivity
- Elastic Modulus
  - Young’s
  - Shear

ASTM C695
ASTM C651
ASTM C749
Baseline Progress

- Second and third billets of 2114 in progress.
- Second billet of NBG-17 currently being machined.
- A billet of IG-430 and a third billet of IG-110 to be initiated in FY-22.
- Over 18,000 NQA-1 qualified measurements taken so far.

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<tr>
<th>Graphite</th>
<th>Laboratory</th>
<th>Billet #</th>
<th>Percent Complete</th>
<th>Data Report</th>
<th>Analysis Reports</th>
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By compressively loading a disc-shaped specimen on edge the resulting tensile stresses, transverse to the loading axis, result in the specimen failing in tension transverse to the load. The load at failure, P, and geometry of the specimen provide an indication of the tensile strength.

\[ \sigma_{sts} \approx \frac{P}{\pi LR} \left[ 1 - \left( \frac{b}{R} \right)^2 \right] \]
One to One Comparison of Breaking Strength
Re-machined Baseline Specimens

- Split disc specimens machined from broken ends of full-size tensile specimens.
- 12.7 mm dia. X 6.3 mm thk.
- One to one material correspondence between the Split disc specimen and the ASTM C749 full size uniaxial tensile specimen.
Identification of Proper Split Disk Fracture

• This measurement technique originated in rock and concrete where the ratio of compressive to tensile strength is ~10. (Graphite ~3-4)

• Calculation of tensile stress in a compressed disc requires the fracture to initiate from the center of the disc.

• This occurs when the compressive strength is much higher than the tensile strength.

• Proper crack/fracture initiation is easily identifiable.
Identification of Proper Split Disk Fracture

- Instron DIC camera used to further verify proper split disc fracture.
- Measurement of actual stress/strain curve.
Irradiated Split Disc Testing

- Contamination control for testing of irradiated samples.
- The only method for comparing irradiated tensile strength.
- Future plans for oxidized testing.
Thank you