U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

A Short History of NRC Nuclear Graphite Research

ORNL/NRC Workshop on Graphite Research

Rockville, MD, U.S.A.

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Graphite R&D Objectives

- Develop scientific information to establish independent technical bases for development of staff regulatory positions and guidance documents to enable safety decisions on graphite and composite materials used in HTGRs; address uncertainty in behavior of graphite under HTGR environments.
- Use research results to confirm materials specifications, codes, and standards and to provide information and data for NRC HTGR EM (graphite dust) and for evaluating HTGR PRAs.

Background - 1

- **The NRC sponsored research at the Franklin Institute Research Laboratories, Philadelphia, PA during mid-1970s.**
  - **V. Svalbonas, T.C. Stilwell and Z. Zudans, "Rules for Design of Nuclear Graphite Core Components – Some Considerations and Approaches", Nucl. Eng. & Design, 46, 313-333 (1978).**

    Identified Research Requirements:

    1. **Oxidation-strength models for graphite;**
    2. **Seismic testing and analysis correlations;**
    3. **Fatigue behavior, and description by fracture mechanics procedures; and**
    4. **Further correlative experiments involving stress categories and associated limits and failure criteria.**

Background - 1

- **The NRC sponsored research at the Brookhaven National Laboratories during mid-1980s.**
  - **D.G. Schweitzer, D.H. Gurinsky, E. Kaplan, and C, Sastre, "A Safety Assessment of the Use of Graphite in Nuclear Reactors Licensed by the U.S. NRC", NUREG/CR-4981 (ML), September 1987.**
    - **Evaluated the potential for graphite fire in U.S. research reactors and Fort. St. Vrain reactor.**
      - **Considered stored energy contributions.**
      - **Established necessary conditions of geometry, temperature, oxygen supply, reaction product removal, and a favorable heat balance for self-sustained rapid graphite oxidation.**
      - **Concluded that no credible potential for a graphite burning accident in reactors analyzed.**

Background - 1

- **The NRC sponsored research at the Brookhaven National Laboratories during mid-1970s.**
  - **H.B. Palmer, M. Sibulkin, R.A. Strehlow, and C.H. Yang, "An Appraisal of Possible Combustion Hazards Associated With A High-Temperature Gas-Cooled Reactor", BNL-NUREG-50764, March 1978.**
    - **Studied combustion hazards resulting from a primary coolant circuit depressurization followed by water or air ingress into the prestressed concrete reactor vessel (PCRV).**
    - **Studied reactions between graphite and steam or air which produce the combustible gases H_2 and/or CO; when mixed with air in the PCRV, flammable mixtures may be formed.**
    - **Possible circumstances leading to these hazards and the physical characteristics related to them were delineated and studied.**

Background - 2

- The NRC held a high-temperature gas-cooled reactor safety and research issues workshop, Rockville, MD, October 10-12, 2001 and during October 22-23 (2002).
- During 2001 – 2002, the NRC conducted a pre-application review of technical papers (pebble bed modular reactor) submitted by Exelon.
- The NRC assigned a staff to U.K.'s Nuclear Installations Inspectorate, Fall, 2002.
- The NRC initiated graphite research (ORNL, FY 2002 – 03) to form committees in ASME and ASTM to enable development of design, inspection, and operation codes and standards for graphite core components.

Background – 2

- The NRC staff has been actively participating in ASME and ASTM meetings and has been participating in International Nuclear Graphite Specialist Meetings.
- The staff participated in developing a NRC-DOE document on licensing strategy (August 2008) on proposed NGNP, as per Energy Policy Act, 2005.
  - The applicant or the industry will generate all required experimental data pertaining to graphite to support the NGNP design development effort.
  - The NRC will have full access to the data to support its development effort for confirmatory tools and for an independent assessment of the safety performance of materials.

Background - 3

- The NRC conducted a graphite phenomenon identification and ranking table (PIRT) exercise, in cooperation with DOE, in 2007 for guidance on prioritization of graphite research.
- The NRC has kept specific research options open, pending DOE HTGR design selection.
- The NRC has sponsored research (FY 2009) at ORNL to conduct a graphite workshop and identify potential research areas that the NRC may conduct in the future, which augments DOE and NGNP applicant's research.

ABBREVIATIONS

ASME	American Society for Mechanical Engineers
ASTM	American Society for Testing Materials
DOE	U.S. Department of Energy
EM	Accident Analysis Evaluation Model
HTGR	High Temperature Gas Cooled Reactor
NGNP	Next Generation Nuclear Plant
ORNL	Oak Ridge National Laboratory
PIRT	Phenomenon Identification and Ranking Table
PRA	Probabilistic Risk Assessment