Pacific Northwest
NATIONAL LABORATORY

# Microreactor Transportation Emergency Planning Challenges


## Steven J. Maheras


**DOE-NE Microreactor Program**
**Winter Review Meeting**
**March 8-9, 2023**

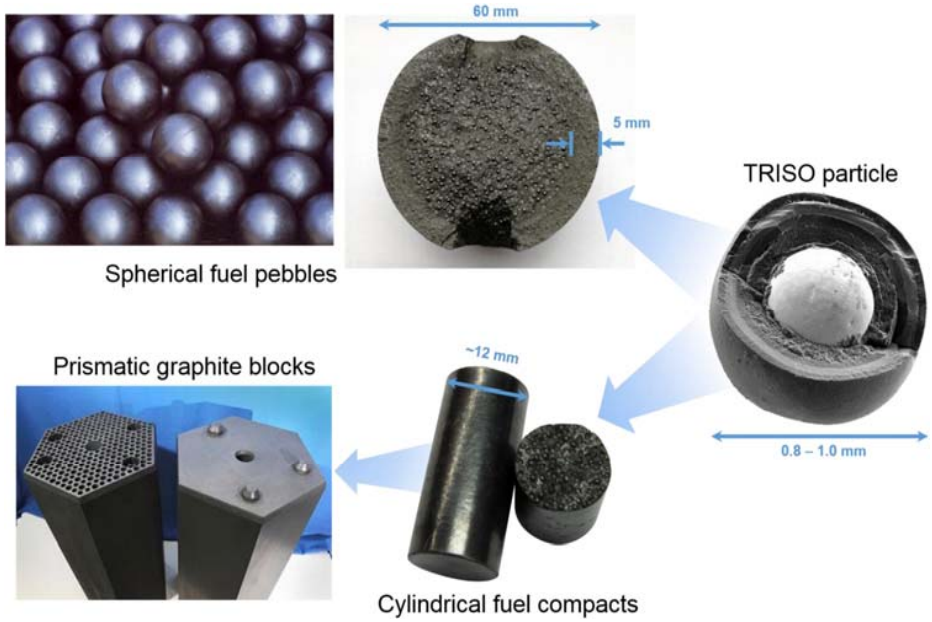
U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

Pacific Northwest
NATIONAL LABORATORY

# Microreactor Properties

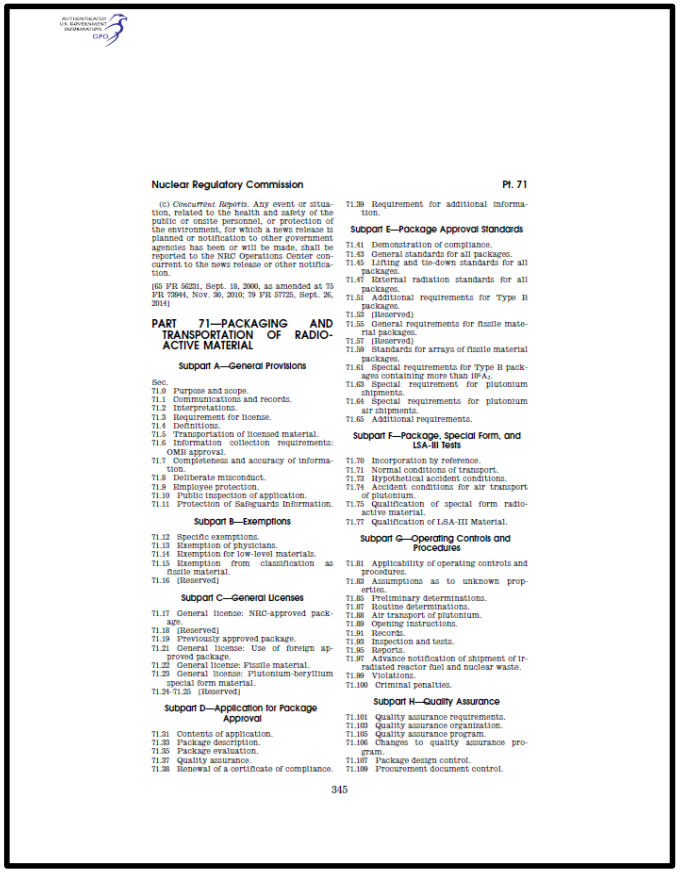
- ≤ 20 MW electrical power
- Factory built and fueled
- Modular
- Highly transportable
- Tristructural isotropic (TRISO) fuel
- Goal is to develop a microreactor that can be shipped containing its unirradiated or irradiated contents
- These microreactors are known as transportable nuclear power plants (TNPPs)



Pacific Northwest NATIONAL LABORATORY

# TNPP Transportation Package Approval Options

- U.S. transportation package approval regulatory requirements are contained in 10 CFR Part 71
- A TNPP with its unirradiated or irradiated contents is unlikely to meet the entire suite of regulatory requirements in 10 CFR Part 71
- If all Fissile Material or Type B package regulatory requirements cannot be met, several options are possible
  - Alternate environmental and test conditions [10 CFR 71.41(c)]
  - Special package authorization [10 CFR 71.41(d)]
  - Exemption [10 CFR 71.12]
    - ✓ Requires Environmental Assessment and DOT Special Permit



Nuclear Regulatory Commission Pt. 71

(c) *Concurrent Reports.* Any event or situation, related to the health and safety of the public or onsite personnel, or protection of the environment, for which a news release is planned or notification to other government agencies has been or will be made, shall be reported to the NRC Operations Center concurrent to the news release or other notification.

[65 FR 56221, Sept. 18, 2000, as amended at 75 FR 73944, Nov. 30, 2010; 79 FR 57725, Sept. 26, 2014]

PART 71—PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIAL

Subpart A—General Provisions

Sec.
71.0 Purpose and scope.
71.1 Communications and records.
71.2 Interpretations.
71.3 Requirement for license.
71.4 Definitions.
71.5 Transportation of licensed material.
71.6 Information collection requirements: OMB approval.
71.7 Completeness and accuracy of information.
71.8 Deliberate misconduct.
71.9 Employee protection.
71.10 Public inspection of application.
71.11 Protection of Safeguards Information.

Subpart B—Exemptions

71.12 Specific exemptions.
71.13 Exemption of physicians.
71.14 Exemption for low-level materials.
71.15 Exemption from classification as fissile material.
71.16 [Reserved]

Subpart C—General Licenses

71.17 General license: NRC-approved package.
71.18 [Reserved]
71.19 Previously approved package.
71.21 General license: Use of foreign approved package.
71.22 General license: Fissile material.
71.23 General license: Plutonium-beryllium special form material.
71.24-71.25 [Reserved]

Subpart D—Application for Package Approval

71.31 Contents of application.
71.33 Package description.
71.35 Package evaluation.
71.37 Quality assurance.
71.38 Renewal of a certificate of compliance.
71.39 Requirement for additional information.

Subpart E—Package Approval Standards

71.41 Demonstration of compliance.
71.43 General standards for all packages.
71.45 Lifting and tie-down standards for all packages.
71.47 External radiation standards for all packages.
71.51 Additional requirements for Type B packages.
71.53 [Reserved]
71.55 General requirements for fissile material packages.
71.57 [Reserved]
71.59 Standards for arrays of fissile material packages.
71.61 Special requirements for Type B packages containing more than $10^5$ $A_2$.
71.63 Special requirement for plutonium shipments.
71.64 Special requirements for plutonium air shipments.
71.65 Additional requirements.

Subpart F—Package, Special Form, and LSA-III Tests

71.70 Incorporation by reference.
71.71 Normal conditions of transport.
71.73 Hypothetical accident conditions.
71.74 Accident conditions for air transport of plutonium.
71.75 Qualification of special form radioactive material.
71.77 Qualification of LSA-III Material.

Subpart G—Operating Controls and Procedures

71.81 Applicability of operating controls and procedures.
71.83 Assumptions as to unknown properties.
71.85 Preliminary determinations.
71.87 Routine determinations.
71.88 Air transport of plutonium.
71.89 Opening instructions.
71.91 Records.
71.93 Inspection and tests.
71.95 Reports.
71.97 Advance notification of shipment of irradiated reactor fuel and nuclear waste.
71.99 Violations.
71.100 Criminal penalties.

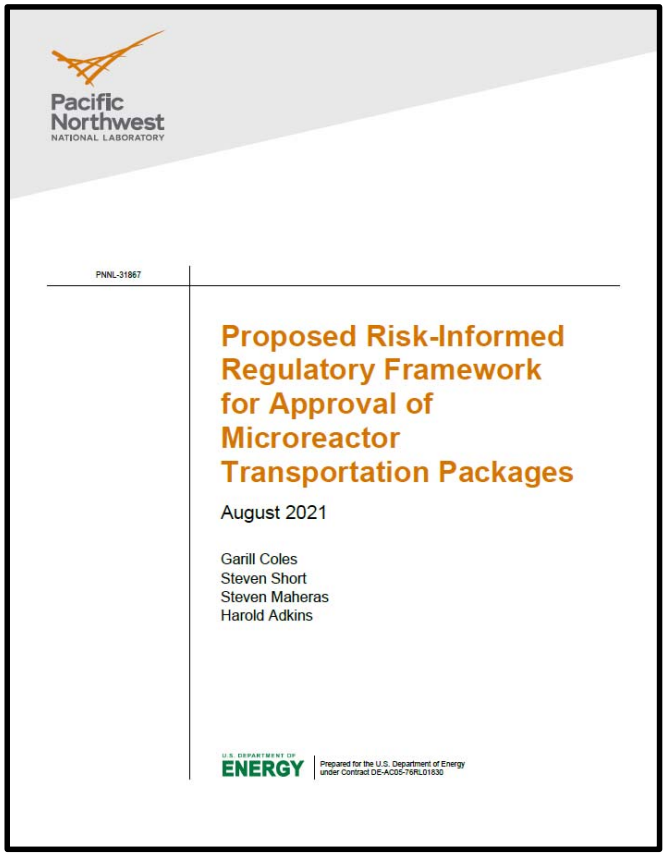
Subpart H—Quality Assurance

71.101 Quality assurance requirements.
71.103 Quality assurance organization.
71.105 Quality assurance program.
71.106 Changes to quality assurance program.
71.107 Package design control.
71.109 Procurement document control.

345

# Preferred Regulatory Pathway

- 10 CFR 71.41(c) process used for the 10-160B and 8-120B transportation casks
- 10 CFR 71.41(d) process used for the West Valley Melter Package
- 10 CFR 71.12 process used for the Trojan Reactor Vessel
- Preferred regulatory pathway identified by PNNL is the 10 CFR 71.12 exemption process for initial or first-of-a-kind TNPP transport
  - Use compensatory measures to provide the basis for the exemption
  - Demonstrate that the risk to the public is low
- For fleet of TNPPs, an NRC transportation Certificate of Compliance (CoC) will likely be pursued


Pacific Northwest NATIONAL LABORATORY

PNNL-31867

Proposed Risk-Informed Regulatory Framework for Approval of Microreactor Transportation Packages

August 2021

Garill Coles
Steven Short
Steven Maheras
Harold Adkins

U.S. DEPARTMENT OF ENERGY | Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830

Pacific Northwest
NATIONAL LABORATORY

# Purpose

- In general, the transportation emergency response community is not familiar with microreactors or the concept of transporting a microreactor containing its irradiated fuel
- The purpose of this work is to describe the emergency planning challenges associated with the transportation of a microreactor containing its irradiated fuel
- The challenges are not likely to be the same as for shipments of spent nuclear fuel in transportation casks (the current paradigm)
- Some challenges are likely to be mode-specific (i.e., different for shipment by truck, rail, air, and vessel)
- Some challenges will be design-specific, e.g., presence of other hazardous materials

Pacific Northwest NATIONAL LABORATORY

# Assumptions

- The microreactor shipment would be a commercial shipment and would receive transportation package approval from the NRC
- Truck and rail transport modes are being evaluated. Transport by air and vessel are not being evaluated at this time.
- The microreactor containing its irradiated fuel will contain a highway route controlled quantity of radioactive material (i.e., 3000 $A_2$)
  - For truck shipments this means that a CVSA Level VI inspection and safety permit would be required (see 49 CFR 385 and 49 CFR 397)
  - For rail shipments this means that the transportation planning requirements in 49 CFR 172.820 would apply
- The analysis will assume that the microreactor is fueled by LEU or HALEU. To the extent that information is available, the report will identify the potential for unique challenges associated with different fuel forms.
- For rail shipments, transport will be via Association of American Railroads (AAR) Standard S-2043 railcars

Pacific Northwest
NATIONAL LABORATORY

# Areas To Be Examined In Identifying TNPP Transportation Emergency Planning Challenges

| | |
|---|---|
| • Assignment of Responsibility | • Accident Assessment |
| • Emergency Response Organization | • Protective Response |
| • Emergency Response Support and Resources | • Radiological Exposure Control |
| • Emergency Classification System | • Medical and Public Health Support |
| • Notification Methods and Procedures | • Recovery, Reentry, and Post-Accident Operations |
| • Emergency Communications | • Exercises and Drills |
| • Public Education and Information | • Radiological Emergency Response Training |
| • Emergency Facilities and Equipment | • Responsibility for the Planning Effort: Development, Periodic Review, and Distribution of Emergency Plans |

Pacific Northwest NATIONAL LABORATORY

# Potential Compensatory Measures (I)

- This section will discuss potential compensatory measures that may be required to obtain NRC transportation package approval, and for a DOT special permit, if required.
- TNPPs containing irradiated fuel shipped by highway will be highway route-controlled quantities (HRCQ) (> 3000 $A_2$) and will need to meet the routing requirements in 49 CFR Part 397
  - Interstates, beltways around cities, state identified preferred routes
- TNPPs will likely be overweight/overdimension and will require state permitting when transported by highway
  - Specific heavy haul truck or superload permit requirements could be considered as compensatory measures

Pacific Northwest
NATIONAL LABORATORY

# Potential Compensatory Measures (II)

- Other potential compensatory measures that may be credited in the transportation PRA or identified as a defense-in-depth measure such as:
  - Increased exclusion zone around TNPP because of radiation dose rate
  - Real time health/fitness onboard monitoring/diagnostics of reactor package
  - Escorting of the reactor forward and aft for the entire route
  - Travel at reduced speeds
  - Choosing a route that avoids bodies of water (balanced by quality of road)
  - Controls for bridges over bodies of water (bridge inspection, speed reduction, close bridge to other traffic)
  - Judicious use of time-of-day and day-of-week restrictions
  - Avoid shipping during severe weather
  - Conduct training for emergency responders along the route

Pacific Northwest
NATIONAL LABORATORY

# Cross-Cutting Issues Also Being Identified

- For transportation, there is no process equivalent to the 10 CFR 50.59 or 10 CFR 72.48 processes for reactors or storage systems
- Implication– change to microreactor design could mean resubmittal of microreactor transportation safety analysis

Pacific Northwest
NATIONAL LABORATORY

# Thank you