The Nuclear Regulatory Commission’s Role in the Conversion of Research and Test Reactors from High-Enriched to Low-Enriched Uranium Fuel

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Historical Challenges on the Road to Success

Raise licensee awareness of the need for conversion

Develop regulatory requirements for conversion

Approve new low enriched uranium (LEU) fuels

Develop licensing guidance

Lessons learned from conversion reviews
NRC History of Conversion - 1

1982 – Commission Policy Statement on conversion

1984 – Conversion of University of Michigan as RERTR Program demonstration

1986 – Commission issues 10 CFR 50.64 conversion rule

1987 – TRIGA LEU generic fuel safety evaluation report (NUREG- 1282) and requalification evaluation of SPERT fuel (NUREG- 1281) issued

1988 – LEU uranium silicide-aluminum dispersion fuel report (NUREG- 1313 ) issued
NRC History of Conversion - 2

1988 – First conversions under 10 CFR 50.64

1996 – Licensee format and content guide and NRC staff standard review plan (NUREG-1537) issued which includes chapter on reactor conversion

2000 – First group of conversions completed (10 facilities)

2006 – second group of conversions start

2007 – NRC staff starts attending high performance working group meetings – continues today

2009 – Second group of conversions complete (6 facilities)
Status of Conversion

26 Reactors with high-enriched uranium (HEU)

- 16 Converted
  - 5 Subsequently shut down
- 4 Terminated license before conversion
- 2 Decommissioning approved before conversion
- 1 No suitable fuel
- 2 Unique purpose applications
- 1 No funding
Raise Licensee Awareness

Commission Policy Statement

- Outlined issue and gave full support to RERTR

NRC outreach

- Commission briefings and meetings
- Meetings and discussions with licensees
- LEU study group prepared assessment of conversion
- Develop conversion rule
Conversion Regulation 1

Basic requirements (10 CFR 50.64)

• No new construction permits for HEU fueled reactors unless reactor has a unique purpose

• Not initiate acquisition of additional HEU fuel if LEU “fuel acceptable to the Commission” is available unless the reactor has a unique purpose

• Replace HEU fuel with LEU fuel acceptable to the Commission in accordance with approved schedule
Conversion Regulation 2

Fuel Acceptable to the Commission

- Meets operating requirements of the existing license, or
- Through NRC safety review and approval, can be used in a manner that protects public health and safety and promotes the common defense and security, and
- Limits to the maximum extent possible, the use of HEU fuel
Conversion Regulation 3

Unique Purpose

• Project, program, or commercial activity that cannot be reasonably accomplished without HEU
  
  – Such as -

  • Specific project, program or commercial activity that significantly serves the U.S. national interest

  • Reactor physics or reactor development

  • Research based on HEU flux levels or spectra

  • Reactor core of special design

• NRC has not taken action on 2 unique purpose requests still active
• NRC waiting to understand impact of conversion to LEU
Conversion Regulation 4

Timing of conversion is dependent upon:

- Government funding
- Availability of fuel acceptable to the Commission
- Availability of shipping casks
- Reactor usage
Conversion Regulation 5

Conversion proposal contains:

• Necessary changes to the license, facility and procedures
• Supporting safety analyses
• Limited to conversion

NRC will, after review, issue an enforcement order directing the conversion and any necessary changes to the license, facility, and procedures
Approval of LEU Fuels

DOE responsible for fuel development

- Submits qualification reports to NRC
- Presents results of fuel development and testing
- Presents information on fuel fabrication

NRC must conclude that fuels are suitable and acceptable for use

- NRC approval allows licensees to reference NRC evaluation in safety analysis reports
- Licensees do not need to justify approved generic aspects of the fuel
- Licensees need to address any facility-specific fuel issues
Approval of Uranium Silicide Fuel

Power, heat flux and temperature of testing

Material Properties – fuel porosity, heat capacity, thermal conductivity, material compatibility, corrosion behavior

Irradiation Behavior – swelling, blister resistance, fission product release (safety limit), burnup

Development of acceptance specifications for fabrication
Approval of TRIGA Fuel

Reactor Physics – power peaking, prompt negative temperature coefficient, reactivity worth, prompt neutron lifetime and effective delayed neutron fraction

Material Properties – thermal conductivity, heat capacity, thermal expansion, hydrogen dissociation pressure, water quench response, thermal cycling for dimensional changes, and fuel/cladding compatibility formation of eutectics

Irradiation Performance – fuel swelling, fission product release, pulse heating, safety limit
In the 1990s, the NRC staff started development of application guidance for licensees and a standard review plan for the NRC staff.

The guidance contains a chapter on HEU-LEU conversion.

The conversion application updates the safety analysis report (SAR) in those areas impacted by the conversion to LEU.

Depth of NRC review takes graded approach - for safety significant areas (e.g., accident analysis), review could be equal to that of initial licensing.

Reactor design and accident analysis are areas of the SAR most impacted by conversion.
Conversion Application – Reactor

Areas of focus are neutronics and thermal-hydraulics

Codes and calculations are benchmarked against the measured HEU reactor then used to analyze the LEU reactor

Show that margins of safety are maintained/sufficient in LEU reactor

NRC is looking for good agreement between calculations and measurements or an explanation of differences

NRC performs environmental evaluation
Conversion Application – Accidents

Licensee analyzes HEU SAR accidents with LEU fuel to determine impact from conversion.

Consideration is given to changes in power per fuel element, fission product inventory, and reactivity additions.

A review is also performed to determine if conversion introduces new accidents.

Conversion should not have a significant impact on accident analyses results.

Conversion normally should not introduce new accidents.
Next Steps

- Maintain close communications with DOE/NNSA
- Review high performance facilities partial analyses to capture results
- Maintain awareness of fuel development
Future Technical Considerations

Blister temperature results

Fuel irradiation history (numbers)

Lead test assemblies behavior

Power increases

Accuracy of core design

Transition core safety
Lessons From Conversion

Updating analyses takes licensees effort and time.

Make sure what is analyzed can be built.

There may be technical surprises.

Licensee technical expertise may be limited.

Conversion has safety benefits beyond the elimination of HEU (e.g., updated licensing basis).
Conclusions

Regulatory challenges have been met

NRC provides:

- Regulatory policy
- Regulations
- Licensing guidance
- Independent safety review
Resources

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Regulations (10 CFR 50.64)
NUREG-1537 (search NRC website)
Oregon State conversion (ML082390775,
ML080420546, ML080730057,
ML082350345)
Silicide fuel review (ML080950428)