Accident-tolerant Fuel

Game-changing Technology for Safety, Reliability and Lower Operating Cost

Westinghouse

Why Accident-tolerant Fuel (ATF)?

1. Safety
2. Reliability
3. Lower Operating Cost

Westinghouse ATF is being designed to achieve all three. Working with technology partners, Westinghouse plans to conduct long-term testing and licensing, as well as manufacture lead ATF test rods between 2016 and 2022.

While current fuel designs have operated extremely well under normal plant operating conditions, these designs can be challenged under severe-accident scenarios. This can lead to the destruction of the fuel cladding and the release of fission products—in the event of a beyond-design-basis condition, such as that which occurred in both the Three Mile Island and Fukushima accidents.

Westinghouse Electric Company and its partners are developing game-changing ATF that can significantly increase the tolerance to severe accidents. This is expected to improve nuclear plant safety and reliability, while providing financial savings to the utilities that operate the plants.

Westinghouse ATF Program Development

Westinghouse has been an industry leader in ATF development since 2004. The primary program focus areas have been advanced cladding and fuel technologies.

Advanced Cladding Technology

- Coatings on current Zircaloy claddings for providing an intermediate level of improvement in severe accident scenarios
- Silicon carbide composites to increase maximum tolerable cladding temperature (up to 2000°C), fuel cycle cost benefits and corrosion resistance

Advanced Fuel Technology

- Uranium silicide (U_3Si_2) for a 17 percent U235 increase; 5x increase in thermal conductivity
- Waterproofed $U^{15}N$ for up to a 35 percent U235 increase; 10x increase in thermal conductivity
- Improved fuel cycle costs, a strong financial incentive

Research and Development Support from the U.S. Department of Energy (DOE)

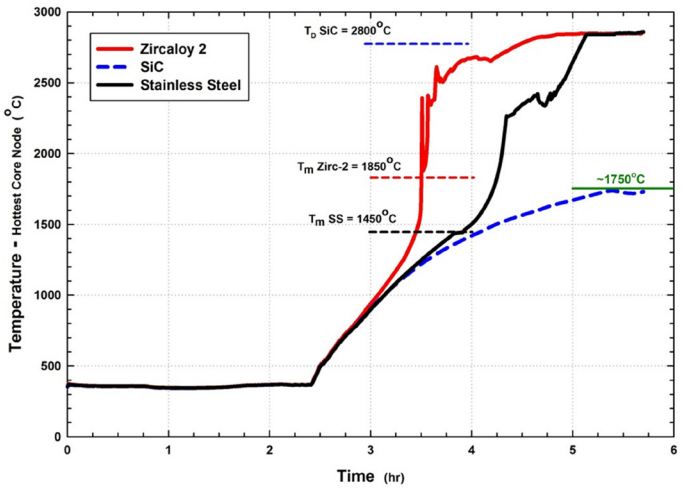
After gaining significant expertise in this area with internal funding between 2004 and 2010, Westinghouse has secured three major DOE funding awards for ATF.

Key Tasks:

- Evaluate options for ATF (2010) – economics, manufacturability and performance
- Technical feasibility evaluations (2012 to 2015)
- Manufacture test items (2014 to 2016)

These tasks will be followed by a joint Westinghouse-DOE program to conduct long-term testing, licensing and the manufacture of lead test rods (2016 to 2022).

Station Blackout Without Hot Leg Creep Rupture MAAP Modeling



(Johnson, Henry and Paick, ICAPP'12. paper 12175,2012)

Silicon Carbide (SiC) Ceramic Matrix Composite (CMC) offers long-term solution for cladding

ON TARGET ON SCHEDULE

Aggressive program targeted at inserting lead test rods into commercial reactors by 2022

Global ATF Project Partners and Roles

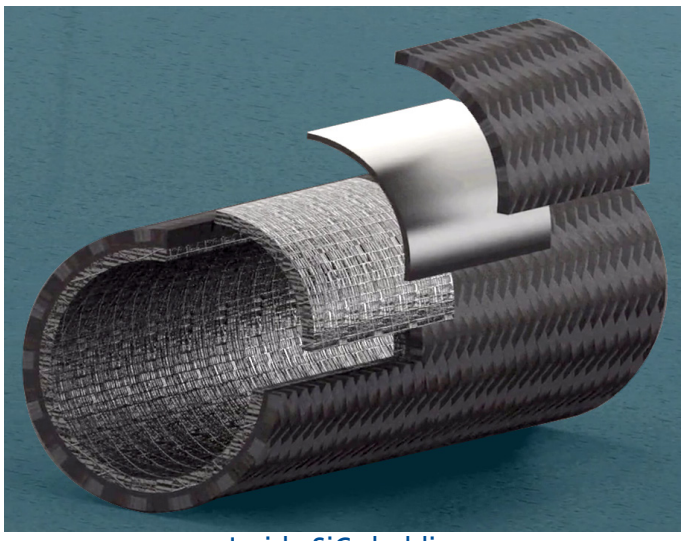
To accomplish key tasks, Westinghouse has assembled a world-class team including:

Advanced Test Reactor at Idaho National Laboratory—*Irradiation and testing*
Argonne National Laboratory—*Coatings for zirconium cladding (atomic layer deposition)*
Ceramic Tubular Products—*SiC wrapping of coated tubes*
EWI—*Coatings for zirconium cladding (thermal spray coating)*
EXELON—*Utility perspective for economics and licensing*
General Atomics—*SiC/SiC composite cladding development and manufacture*
Halden Reactor Project (Norway)—*Irradiation and testing*
Idaho National Laboratory—*High-density fuels (U_3Si_2)*
Los Alamos National Laboratory—*High-density fuels (waterproofed UN)*
Massachusetts Institute of Technology—*Irradiation and oxidation testing*
National Nuclear Laboratory (United Kingdom)—*High-density fuels manufacture*
Paul Scherrer Institute (Switzerland)—*SiC cladding behavior under irradiation*
Southern Nuclear Operating Company—*Utility perspective for economics and licensing*
Texas A&M University—*High-density fuels (waterproofed UN)*
University of Wisconsin—*Coatings for zirconium cladding (cold spray coating)*
Westinghouse Electric Company LLC—*ATF design, engineering and licensing*

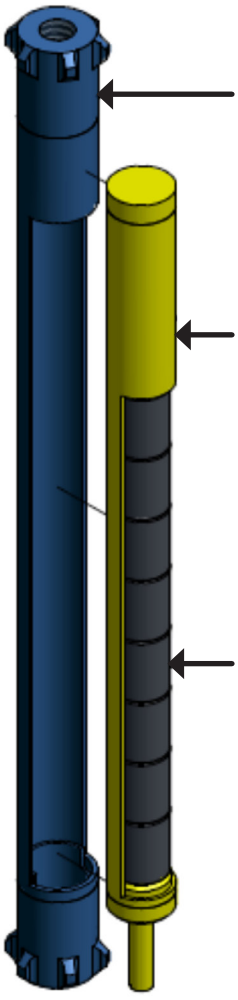
CARAT – Collaboration for Advanced Research on Accident-tolerant Fuel

- 30 self-funded organizational members from research institutes, universities, national labs and industrial companies worldwide
- Focused on fundamental research
- Generating technical data to support ATF design and technology innovation

The above partners comprise a world-class team developing the next evolution of LWR fuel.



Inside SiC cladding



Westinghouse – Advanced Technology Leader

- Westinghouse is collaboratively developing ATF with a world-class team (including the CARAT working group, providing global cooperation on fundamental research)
- State-of-the-art fuel and cladding concepts are being developed (SiC/SiC Ceramic Matrix Composite and coated Zr with and without SiC wrapping; U_3Si_2 and waterproofed UN)
- Irradiation testing of the advanced fuel and cladding is underway

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