



MARVEL Fuel

Winter Program Review – March 8-9th, 2023

- Overview/Background
- Recent Progress (Technical/Project)
- Next Steps

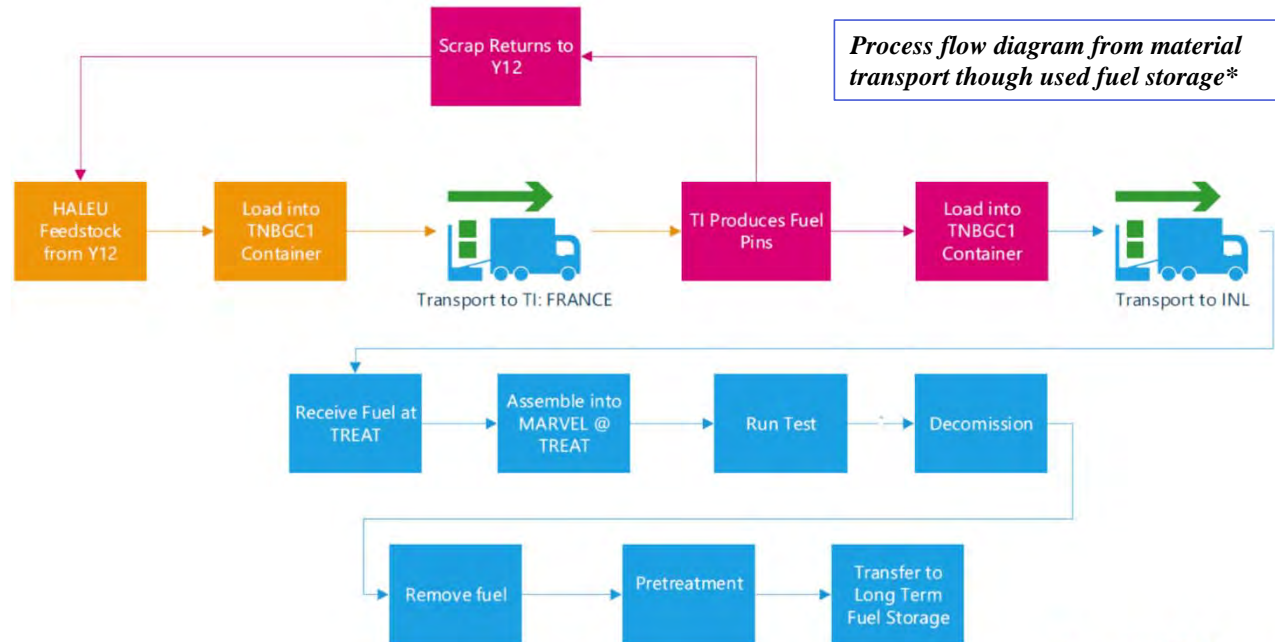
M.W. Patterson

MARVEL Project Manager

Collaborators: DOE RRI Program, Triga International, Los Alamos National Laboratory

Overview: Fuel Fabrication and Transport

- Fuel fabrication - critical path for MARVEL fuel load & start-up
- INL: NQA-1-qualified designer
- TRIGA International (TI): NQA-1-qualified manufacturer
- Production and shipping integrated with University Fuel Services (UFS)

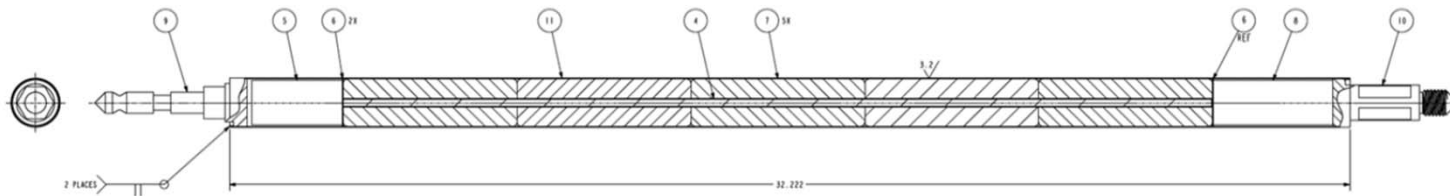


* INL/RPT-22-66550, MARVEL Fuel Fabrication Strategy, Mar. 2022

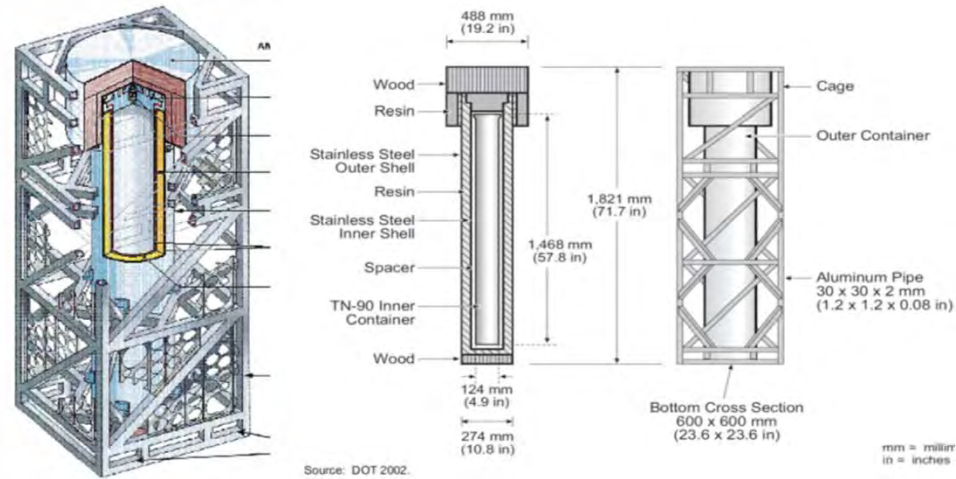
MARVEL Fuel – Technical Background

- Fuel purchased from external supplier - TRIGA International (TI): Romans, France
- Modified “off the shelf” - Catalog item 419 (5 fuel pellets instead of 3, longer cladding)

MARVEL Fuel Element



TN-BGC-1 container schematic



HALEU Source Material (Y12)



MARVEL Fuel – Technical Background - continued

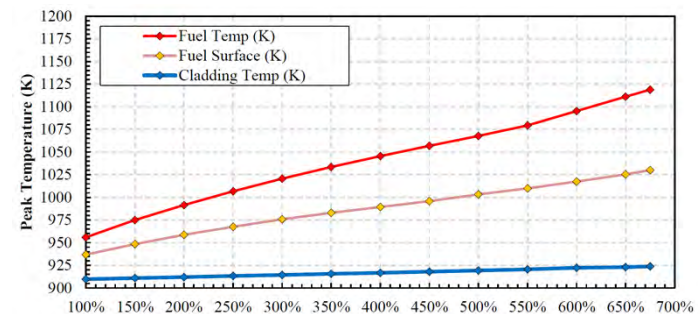
MARVEL Fuel Performance Report

(INL/RPT-22-68555, Rev. 2, Nov. 2022:

J. Evans, R. Sweet, & D. Kaiser)

- Qualification case for MARVEL fuel system
- Survey of thermophysical properties, performance, and quantitative relationships
- “Hand calculations” to demonstrate TRIGA design bounds MARVEL fuel in MARVEL operating conditions
- Determines mechanical integrity during the most extreme accident scenario
- Known failure mechanisms evaluated in transients and accident scenarios
- BISON analyses for additional confidence and quantification, but use of BISON results limited to scoping and sensitivity evaluations

Fuel Element Design Data	Specification
Number of fuel elements	36
Fuel type	U-ZrH _{1.6}
Zirconium rod diameter, in.	0.225
Fuel meat outer diameter, in.	1.370
Fuel meat length, in.	25.0
Clad thickness, in.	0.020
Clad material	304 SS
Total uranium, wt%	30.0
Uranium density, g/cm ³	2.14
Weight of U-235 per rod, g	246.85
Uranium enrichment, %	19.75
Nominal hydrogen/zirconium ratio	1.6



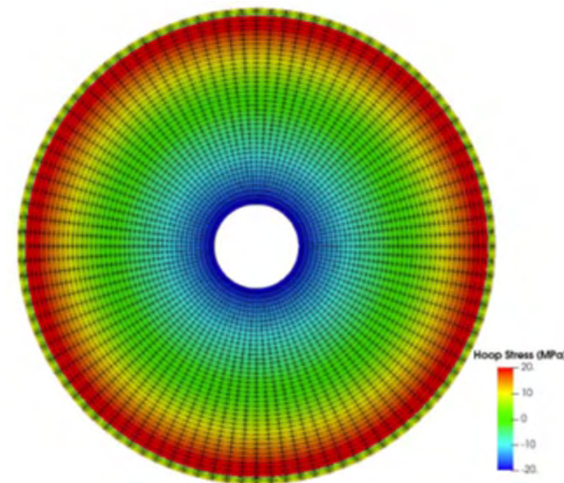
Fuel rod temperatures vs. fission rate, calculated using BISON for design limit scoping study

MARVEL Fuel – Technical Background - continued

MARVEL Fuel Performance Report - Summary of Key Results

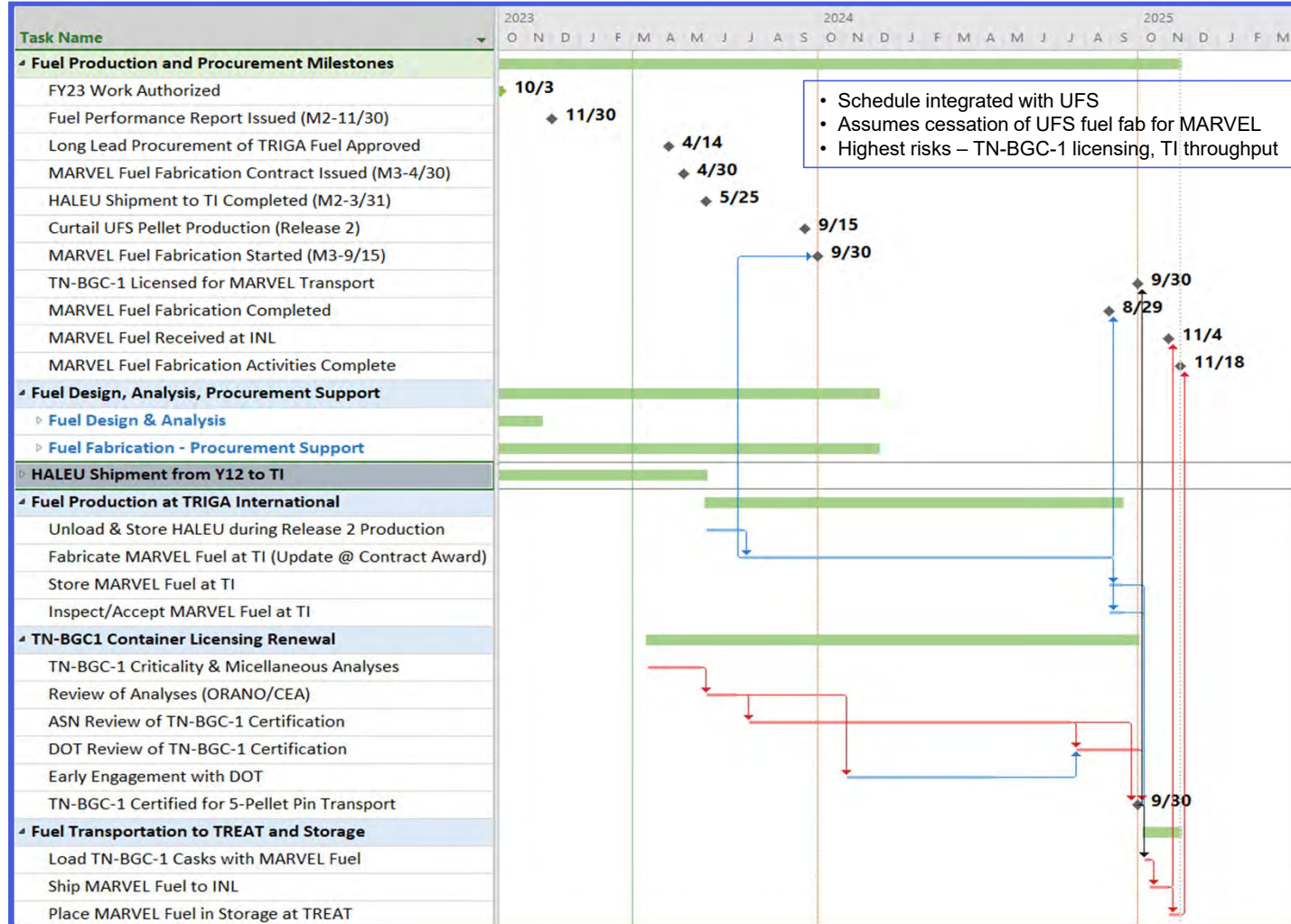
- MARVEL fuel maintains structural integrity during most extreme accident
 - Max hoop stress developed 12.28 MPa
 - Allowable unirradiated: ~130 MPa
 - Allowable at end of operational cycle: ~189 MPa
- Considerable margin for fuel meat temperature during most extreme accident
 - Recommended fuel meat temperature limit: 875°C
 - Recommended limit ~200°C higher than predicted peak fuel temperature in beyond design basis accident (BDBA)

BISON simulation of MARVEL fuel element hoop stress during the extended BDBA



Conclusion: MARVEL fuel elements meet design & safety functions; qualified for use in MARVEL per NUREG-1537 guidance

Fuel Production and Procurement Schedule



- Schedule integrated with UFS
- Assumes cessation of UFS fuel fab for MARVEL
- Highest risks – TN-BGC-1 licensing, TI throughput

Status & Path Forward

- Contracts for TN-BGC-1 certification, HALEU transport, and fuel fabrication are being negotiated
- Fuel drawings/specifications are in the final process of review and issue
 - Issue of drawings/specifications (with fuel performance report) represent final design
 - Issue of drawings/specifications support issue of fuel fabrication contract
- Visit to fuel fabrication facilities in Romans, France scheduled for week of March 13, 2023
 - Review of fabrication process and recent modifications
 - Identification of quality assurance steps in fabrication process to finalize sub-tier documents in the fuel fab contract
- Additional BISON modeling and evaluations as recommended in the Fuel Performance report add definition and provide defense in depth but don't change the conclusion that the fuel is acceptable for use
- Equivalent of fuel qualification comes with DOE approval Preliminary Documented Safety Analysis (PDSA)

Questions??

