Development of Standard Reference Data of Nuclear Fuels and Materials

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1. Introduction

Nuclear energy is categorized as the most economic and sustainable energy by IAEA. However, demand and needs for safety and reliability of nuclear industry are increasing after FUKUSHIMA. Especially, reliable data on the stability of nuclear fuel in a reactor and spent fuel is necessary for safety analysis of nuclear reactor and spent fuel.

In this study standard reference data were developed and uploaded to the database of national standard reference center.

2. Nuclear Fuel and Materials Data Center

NFDC (Nuclear Fuel and materials Data Center) is designated as a one of the data center of National Standard Reference Center from Ministry of Trade Industry and Energy at Dec. 30 2018. The fields of designation were nuclear fuel and energy materials. Target materials that we aim to produce standard reference data include the nuclear fuels such as uranium metal, uranium oxide, and spent fuel and the nuclear cladding materials, such as Zircaloy-4, Zirlo, and HANA. Specifically, we plan to generate the reference thermal properties such as thermal expansion, density, thermal conductivity, and specific heat to analysis the thermal stress of cladding materials, the temperature profile of nuclear fuel, and the heat transfer through the fuel and cladding materials. We also plan to produce the mechanical properties to analysis the PCMI (pellet cladding mechanical interaction). Finally, we plan to produce the chemical properties to analysis the PCCI (pellet cladding chemical interaction). Table 1 shows the yearly-basis road map for incorporating standard reference to nuclear fuel and materials data center.

Table 1. Road map of nuclear fuel and materials data center

	2009	2010	2012	2013	2014	2018	2019	2020
Direct Measurement		UO_2 Thermal expansion	Zicaloy Thermal expansion	Zirlo Thermal expansion	Zircaloy Thermal Diffusivity	Zircaloy Oxidation	Zircaloy strength	Zircaloy Creep
		UO_2 Density	Zicaloy Density	Zirle Density	Zirlo Thermal Diffusivity	Zirlo Oxidation	Zirle strength	Zirlo Creep
		Simulated fuel thermal expansion	Zircaloy Specific heat	Zirle Specific heat				
		Simulated fuel Density						
Indirect collection	UO_2 Creep							
	U Creep							
	UO_2 Specific heat							
	U Specific heat							

3. Produce Standard Reference Data

Data collection follows the data collection procedure [1] established by NFDC. There are two kinds of method in data collection. In direct method, the data is collected through the direct measurements, and in indirect method, the data is obtained from published papers, database, reports and books. Uncertainty of collected data should be evaluated following the guide to expression of uncertainty in measurements. [2] The result of measurement informs the magnitude of a quantity, obtained experimentally. The standard reference data present an estimate ± uncertainty.

Table 2 shows the standard reference data, which were produced from nuclear fuel and materials data center.

Table 2. The standard reference data produced from nuclear fuel and materials data center

Standard Reference Data	Condition	Grade	Resistration	Year
UO_2 Specific heat	293~3000 K	Certificated	56	2009
U Specific heat	293~900 K	Validated	14	2009
UO_2 Creep	1473~2073 K	Validated	133	2009
U Creep	1473~2073 K	Validated	19	2009
UO_2 Thermal expansion	300~3100 K	Certificated	57	2010
UO_2 Density	300~3100 K	Certificated	57	2010
Simulated fuel thermal expansion	300~1500 K	Certificated	87	2010
Simulated fuel Density	300~1500 K	Certificated	87	2010
Zircaloy Thermal expansion	323~1473 K	Certificated	44	2012
Zircaloy Specific heat	298~673 K	Reference data	16	2012
Zirlo Thermal expansion	340~780 K	Certificated	12	2013
Zirlo Density	340~780 K	Certificated	12	2013
Zircaloy Thermal Diffusivit	400~800K	Validated	17	2014
Zirlo Thermal Diffusivity	400~775 K	Validated	16	2014
Total			627	

4. Uncertainty Evaluation

To ensure reliability of experimental data uncertainty should be estimated. There are two kinds of uncertainty: A-type uncertainty from tester and B-type uncertainty from experimental equipment. To reduce the former, the measurement should be repeated for sufficient amount of times, and to reduce the latter type uncertainty all equipment have to be calibrated.

Fig. 1 shows the procedure of uncertainty evaluation; establishing the measurement model, analysis factors affected to uncertainty, uncertainty evaluation of each factor using sensitivity coefficient, calculation of combined uncertainty, and calculation of expanded uncertainty using coverage factor.

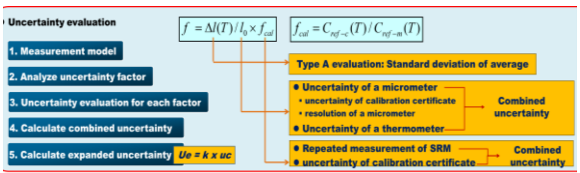

Fig. 1. Procedure of uncertainty evaluation.

5. Database of Nuclear Fuel and Materials Data Center

To supply and service the standard reference data produced from NFDC the database based on website were constructed. The address of URL is www.numat.re.kr. Graph and model as well as standard reference data are serviced in the database. Fig. 2 shows the website of NFDC, which contains the specification of materials, standard reference data, graph and model representing the data, and the reference.

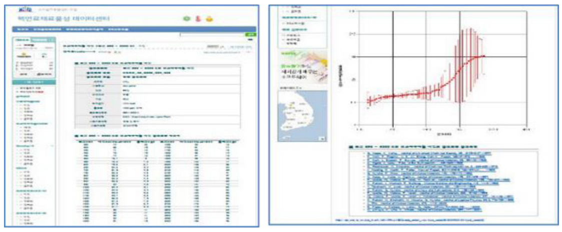

Fig. 2. Website of NFDC.

6. Conclusion

The standard reference data produced in NFDC will be helpful for increasing reliability and stability evaluation of nuclear fuel and spent fuel.

ACKNOWLEDGEMENT

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REFERENCES

[1] Korea Reference Standard Center, Nuclear Fuel and Material Data Center, "The Procedure of Collection/Production for Nuclear Fuels and Materials Properties" LOP-NFDC-CG-01, (2018).

[2] Korea Research Institute of Standard Science, "KRISS Guide to the Expression of Uncertainty in Measurement, KRISS-98-096-SP (1998).