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Investigation for Ensuring the Reliability of the MELCOR Analysis Results

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1. Introduction

In Spent Fuel Pool (SFP) severe accident, especially in case of boil-off, partial loss of coolant accident, and complete loss of coolant accident; heat source and flow rate could be main points to analyze the MELCOR results.

Heat source might be composed as decay heat and oxidation heat. Because heat source makes it possible to lead a zirconium fire situation if it is satisfied that heat accumulates in spent fuel rod and then cladding temperature could be raised continuously to be generated an oxidation heat, this might be a main factor to be confirmed. Flow rate could be also main factor to be proven because it is in charge of a role which takes thermal balance through heat transfer in inner side of fuel assembly.

Some problems about a reliability of MELCOR results could be posed in the 2nd technical report of NSRC project. In order to confirm whether MELCOR results are dependable, experimental data of Sandia Fuel Project 1 phase [1-3] were used to be compared to be a reference.

2. Methods

To analyze SFP severe accident scenario, main parameters of MELCOR input composition are commonly set as following to compare OECD-SFP project [4] easily unless something noted otherwise.

- ΣK: Sum of loss coefficient = 24.8
- Laminar loss coefficient (S_{lam}): 146
- Decay heat: 5 kW
- Heating time: 46537 sec.
- Running time: 20 hours.
- Type of severe accident scenario: Complete LOCA

2.1 Flow Loss Coefficient

Since there are no clear standards to choose flow loss coefficients, it was just tried to choose values in order to correspond for experimental data [1-3] although the values cannot describe physical phenomena. Also, to confirm the sensitivity of MELCOR results according to varying with flow loss coefficients, simulations were executed with eight cases as following table.

Table I: Input value about flow loss coefficient in Complete LOCA

SFP MELCOR Number	Laminar Loss Coefficient (S_{lam}) Value	Sum of loss coefficients (ΣK)
SFP Complete LOCA-1	*Part of the nuclear fuel: S_{lam} = 36.5	27.7 3.15+3.35x7+1.10=27.7
SFP Complete LOCA-2	*Part of the nuclear fuel: S_{lam} = 36.5	24.8 2.75+3.05x7+0.70=24.8
SFP Complete LOCA-3	*Part of the nuclear fuel:S_{lam} = 27.475	27.7 3.15+3.35x7+1.10=27.7
SFP Complete LOCA-4	*Part of the nuclear fuel:S_{lam} = 27.475	24.8 2.75+3.05x7+0.70=24.8
SFP Complete LOCA-5	*Part of the nuclear fuel:S_{lam} = 32.5	24.8 2.75+3.05x7+0.70=24.8
SFP Complete LOCA-6	*Part of the nuclear fuel: S_{lam} = 32.5	27.7 3.15+3.35x7+1.10=27.7
SFP Complete LOCA-7	*Part of the nuclear fuel: S_{lam} = 32.5	30.0 3.25+3.65x7+1.20=30.0
SFP Complete LOCA-8	*Part of the nuclear fuel: S_{lam} = 30.0	27.7 3.15+3.35x7+1.10=27.7

* Remainder (except for part of the nuclear fuel): S_{lam}=16

2.2 Oxidation Coefficient

Despite it makes clear for nitrogen to have a significant role related with cladding oxidation, new model for explaining oxidation realistic have not been applied to MELCOR analysis model until now.

Equations of oxidation reaction are following Arrhenius equation which is used in MELCOR.

$$\frac{d(W^2)}{dt} = K(T) \quad (1)$$

$$k_i = A_i e^{-E_{ai}/(RT)} \quad (2)$$

- *W*: mass gain due to oxidation reaction per cladding unit area
- k: Proportional constant
- A_i & E_{ai}: Coefficient of Arrhenius

Stated oxidation coefficients from each institute are not in coincidence neither. Referring to following table, therefore, MELCOR results were derived.

Table II: Oxidation Coefficient used in MELCOR Input

Correlation	$A_i(kg_{zr}^n/m^{2n}/s)$	$Ea_i(K)$	Range of Temp (K).
NUREG	10.50 25.11 104 50.40	15630 28485 14634	T<1333 1333< T< 1550 T>1550
AEKI	$21.72\ 10^4$	29054	T
IRSN	$2.27\ 10^4$	23442	T
ANL pre-breakaway *(pre-oxidized cladding)*	26.82	17490	T
ANL post-breakaway *(pre-oxidized cladding)*	2982.27	19680	T
KIT	$9.691\ 10^2$ 7.741	20890 9687	973<T<1173 1373<T<1673

3. Results

3.2 MELCOR results depending on Flow Loss Coefficient

Despite of minute change in flow loss coefficients, it could be confirmed that MELCOR results varied sensitively.

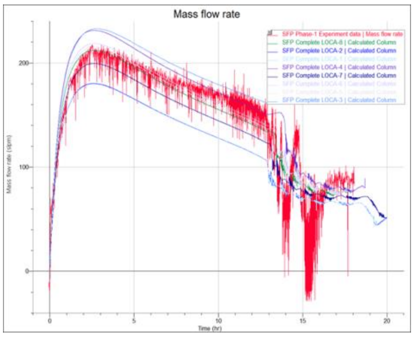

Fig. 1. Mass flow rate depending on variation about flow loss coefficients [1-3]

3.1 MELCOR results depending on Oxidation Coefficient

All of input condition was identical except for oxidation coefficient. As confirmed following figure, it might be shown that zirconium fire, which increases its temperature sharply, calculated each oxidation coefficient did not correspond to the occurring time.

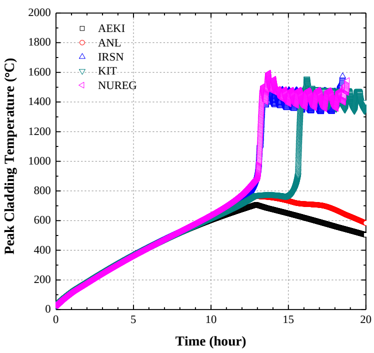

Fig. 2. Zirconium fire in condition at 5kW decay heat

4. Conclusion

This work was proposed to investigate reliability of MELCOR results in order to confirm physical phenomena if SFP severe accident is occurred. Almost results showed that MELCOR results were significantly different by minute change of main parameter in identical condition.

Therefore it could be necessary that oxidation coefficients have to be chosen as value to delineate real phenomena as possible. Also more reasonable flow loss coefficients have to be determined in based on theory and experiment. Finally, in case of exposure of source term, it has to be checked about influence of CV.

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