KEY INPUT VARIABLES FOR RIA SIMULATIONS:

A STUDY BASED ON FRAPCON AND SCANAIR CODES

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INTRODUCTION

•Trends in nuclear industry to reach higher burnup in the nuclear fuel. Safety criteria review.

• CABRI project: Reactivity Initiated Accidents (RIA) tests in CABRI reactor.

•SCANAIR-3.2 code to simulate the thermo-mechanical behaviour of a fuel rod under RIA conditions.

• Input deck of SCANAIR based on the output of an irradiation code (FRAPCON-3) and certain user options

•Transmission of uncertainties from input deck to SCANAIR output results. Identification of key input variables and parameters.

SCOPE

This study is code and version specific; that is, the same conclusions could not be guaranteed for substantially upgraded versions. The scope of the study has been restricted to the experimental scenario provided by the CIP02 test of the CABRI International project.

BASIS FOR THE STUDY

• CIP02 test. November 2002. 74 GWd/tU M5 clad rodlet submitted to 28.2 ms power pulse. 88.7 cal/g deposited.

•SCANAIR 3.2: IRSN rod transient behaviour code.

•FRAPCON-3: PNNL for NRC rod steady state and slow ramps irradiation code.

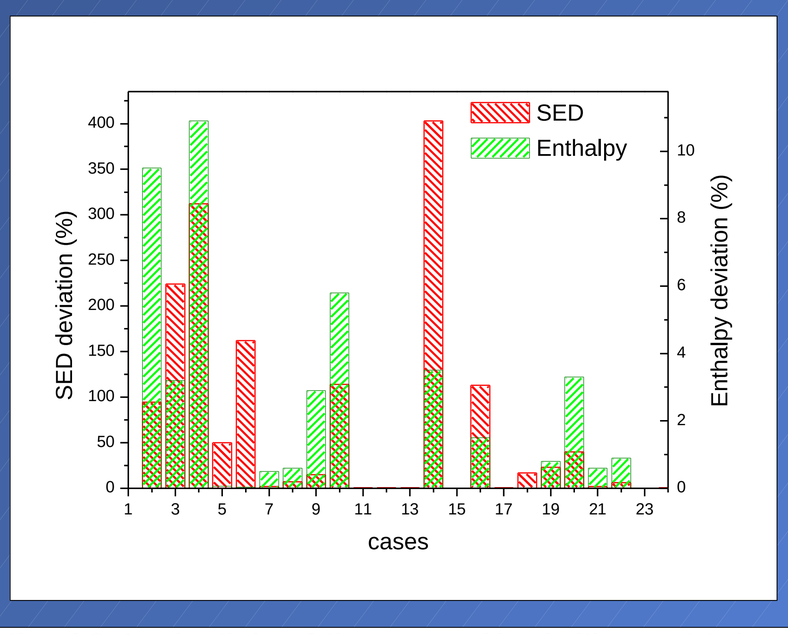
FRAPCON-3 - SCANAIR 3.2 INTERFACE

• FRAPCON-3 provides the main source of information for SCANAIR 3.2 input deck.

• Variables subjected to uncertainties. The range of uncertainty evaluated according to conservative considerations.

• Variables from FRAPCON: Gap width, Oxide thickness, Porosity, Gas concentration, Rim width, End of life temperatures,Power radial profile, Burnup, Plutonium concentration.

• User options: Rim-burst option, fuel and cladding hardness.



Deviation of SED and Enthalpy of the cases considered with respect to base case

Modified variable			Observa-tions	Enthalpy J/g	Coolant Temp. °C	Fuel max. Temp. °C	Cladding Hoop stra. %	Clad elong. cm	SED J/cm³
Experimental results					383		0.31	0.25	
BASE CASE	1		Hard=0 Rim=NO	342.9	387.6	1263	0.37	0.32	1.65
Hardness	2	∞		**375.6 9.5%**	**353.3 -8.8%**	**1365 8%**	**0.44 18.9%**	0.32 0%	**3.21 94.5%**
Rim-burst	3	YES	Hard=0	353.8 3.2%	377.3 -2.6%	1286 1.8%	**1.12 202%**	0.32 0%	**5.36 224%**
	4		Hard=∞	**380.4 10.9%**	**348.8 -10%**	**1370 8.4%**	**1.11 200%**	**0.33 3.1%**	**6.81 312%**
Gap width	5	+50%		343.1 0.06%	387.6 0%	1264 0%	**0.2 -45.9%**	**0.22 -31.2%**	**0.82 -50%**
	6	-50%		342.8 -0.03%	387.5 -0.03%	1263 0%	**0.51 37.8%**	**0.38 18.7%**	**2.67 162%**
Oxide thickness	7	+50%		344.7 0.5%	384.1 -0.9%	1265 0.2%	0.42 13.5%	0.33 3%	1.62 -1.8%
	8	-50%		340.9 -0.6%	391.1 0.9%	1262 0%	0.34 -8%	0.3 -6%	1.77 7%
Porosity	9	up to 25% in the rim zone	Rim=NO	352.9 2.9%	376.4 -2.8%	1278 1.2%	0.35 -5.4%	0.32 0%	1.9 15%
	10		Rim=YES	**362.8 5.8%**	**367.5 -5.1%**	**1321 4.6%**	**0.63 70%**	0.32 0%	**3.54 114%**
Gas conc.	11	+50%		342.9 0%	387.6 0%	1263 0%	0.38 2.7%	0.32 0%	1.66 0.6%
	12	-50%		342.9 0%	387.6 0%	1263 0%	0.36 -2.7%	0.32 0%	1.64 -0.6%
Rim width	13	+90%	Rim=NO	342.9 0%	387.6 0%	1263 0%	0.39 5.4%	0.32 0%	1.64 -0.6%
	14		Rim=YES	355.1 3.5%	376.2 -2.9%	1291 2.2%	**1.72 364%**	0.33 3.1%	**8.31 403%**
	15	-90%	Rim=NO	342.9 0%	387.6 0%	1263 0%	0.36 -2.7%	0.32 0%	1.65 0%
	16		Rim=YES	348.3 1.5%	382 -1.4%	1270 0.5%	**0.73 97%**	0.33 3.1%	**3.52 113%**
EOL Temp.	17	+20%		342.9 0%	387.6 0%	1263 0%	0.35 -5.4%	0.32 0%	1.64 -0.6%
	18	-20%		343.1 0%	387.5 0%	1264 0%	0.36 -2.7%	0.32 0%	1.37 -16.9%
Power radial profile	19	+30%	Rim zone	339.9 -0.8%	397.3 2.5%	1380 9%	0.39 5.4%	0.29 -9%	1.26 -23%
	20	-30%		354.4 3.3%	375.6 -3%	1322 4.6%	0.36 -2.7%	0.34 6.2%	2.31 40%
Burnup	21	+30%		345.2 0.6%	384.9 -0.7%	1266 0.2%	0.37 0%	0.31 -3%	1.68 1.8%
	22	-30%		339.7 -0.9%	391.2 0.9%	1259 -0.3%	0.38 2.7%	0.32 0%	1.55 -6%
Pu Conc.	23	+30%		342.9 0%	387.6 0%	1263 0%	0.37 0%	0.32 0%	1.65 0%
	24	-30%		342.9 0%	387.6 0%	1263 0%	0.36 -2.7%	0.32 0%	1.64 -0.6%

SCANAIR input deck sensitivity assessment

RESULTS

•The base case fits reasonably well to the experimental results.

•There are variables or parameters whose effect in the results is quite huge, while others have much less influence.

•Hardness, Rim-burst option and Gap width have strong influence in the results.

•Gap width and rim-burst affect mainly mechanical response, hardness affects both thermal and mechanical response.

•Comparison with available experimental results shows that in CIP02 simulation the input with the parameter hardness set to zero and rim-burst non-activated produces a closer result.

•The rest of the variables do not have so high influence.

•User options can make some variables become important. For example, porosity or rim width have a strong influence when including the rim-burst option activated.

CONCLUSIONS

SCANAIR input variables may be grouped in two sets:

- HARD: with large effect in the SCANAIR simulation (Hardness, Rim-burst, Gap width) .
- SOFT: without so large effect (Porosity, EOL Temperature, Rim width, Burnup, Pu content…).

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