NISTIR 6872

Evaluation of Fire Models for Nuclear Power Plant Applications: Cable Tray Fires

International Panel Report

Compiled by Monideep K. Dey, Guest Researcher

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

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Appendix E: Benchmark Analysis with MAGIC, Daniel JOYEUX, and Olivier LECOQ-JAMMES, CTICM, France

REFERENCES CTICM	**INC – 01/222 – OLJ/IM**
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International Collaborative Project to Evaluate Fire Models for Nuclear Power Plant Applications

Benchmark Exercise # 1 - **SUMMARY**

Cable Tray Fires of Redundant Safety Trains

Simulations with MAGIC (V 3.4.7)

(Revised September 11, 2000)

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1. INTRODUCTION

We used for the benchmark (references are given in the following text) the 2-zone model MAGIC version 3.4.7. MAGIC is a classic thermal model of fire in multi-compartment building simulation.

The simulations were made according to the document revised in September 2000.

All results have been given in an additional document and only results of three variables are given in this report :

- gas temperature
- surface temperature of target cable
- centerline temperature of target cable

Reference :

International Collaborative Project to Evaluate Fire Models for Nuclear Power Plant Applications
Benchmark Exercise # 1
Cable Tray Fires of Redundant Safety Trains
(Revised September 11, 2000)
Simulations with MAGIC (V 3.4.7)

2. THE MODEL MAGIC

The software MAGIC (Global Analysis Model for fire into Compartments) is a numerical tool which simulates the behaviour and growth of a fire occurring into adjacent rooms.

It is made of modules accessible from the same front panel : a pre-processor, a computation code called MAGIC_M, a post-processor and an animation module.

The version 3.4.7 proposes physical modelling as : modelling improvement of linear fires, modelling improvement of cable thermal behaviour, mass consumption control, improvement of initial condition and density calculation, improvement of the net radiation flux received by a target placed in a room contiguous to fire room, temperature calculation in the ceiling-jet and in the plume.

3. APPLICATION TO THE BENCHMARK EXERCICE : PART I

3.1 RESULTS PART I

The following table gives the results for these four variables in part I.

Part I	$T_{upper\ layer}$(°C)	$T_{lower\ layer}$(°C)	$T_{surface\ target}$(°C)	$T_{centerline\ target}$(°C)
Base case	63.2	29.4	45.7	27.1
Case 1	62.7	29.4	72.8	27.1
Case 2	63.0	29.4	59.9	27.1
Case 3	63.1	29.4	50.3	27.1
Case 4	63.5	28.9	46.6	27.1
Case 5	60.8	29.3	44.7	27.1

Table 1 : Overview of results Part I

3.2 ANALYSIS OF RESULTS PART I

According to the results part I, we can notice the three following points:

- low temperature of gases
- low temperature of target cable
- non ignition of target cable whatever is the distance from fire centerline

4. APPLICATION TO THE BENCHMARK EXERCICE: PART II

4.1 RESULTS PART II

The following table gives the results for these four variables in part II.

Part II	$T_{upper\ layer}$(°C)	$T_{lower\ layer}$(°C)	$T_{surface\ target}$(°C)	$T_{centerline\ target}$(°C)
Base case LOL=0%	180.2	35.7	134.5	49.4
Base case and case 1 at case 8	169.2	31.5	100.7	37.5
Case 9	168.4	30.7	100	37.5
Case 10	169.1	30	100.6	37.5
Case 11	169.2	31.5	101	37.7
Case 12	169.2	31.5	41.4	29.6
Case 13	169.2	31.5	111.7	78.2

Table 2 : Overview of results Part II

4.2 ANALYSIS OF RESULTS PART II

According to the results part II, we can notice the two following points :

- limitation of heat release between 10 and 15 minutes due to the lack of oxygen
- no damage on target because the centerline target cable temperature is below 100°C.

4.3 ADDITIONAL CASE

We added a case on part II (see the table 3 below) with fire source at 2.1 m ; so ventilation is in the upper layer. According to the results of this additional case, we observe no limitation of rate of heat release.

Part II	Rate of heat release (MW)	D (m)	Door	Vent. Sys.	Target	Elev. (m)
Base Case	1 MW	6.1	Closed	Off	Power	3.4
Additional case	3 MW	3.1	Open	On	Power	2.1

Table 3 : Overview of additional case

- The temperature curves are shown in figures 1, 5 and 8.
- The rate of heat release is shown in figure 3.

- The concentration of O_2 is shown in figure 4.
- The flow rate through vents and door is shown in figure 6.
- The radiative flux on target is shown in figure 7.

The following maximum temperatures are reached :

- upper layer temperature = 350°C
- target surface temperature = 330°C

MAGIC V 3.4.7 / BENCHMARK CTICM / PART II additional case

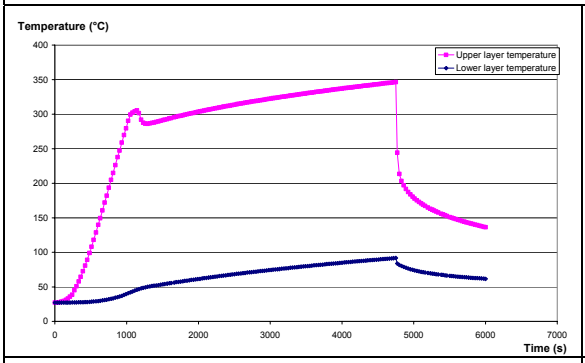

Figure 1 : Upper and lower layer temperature

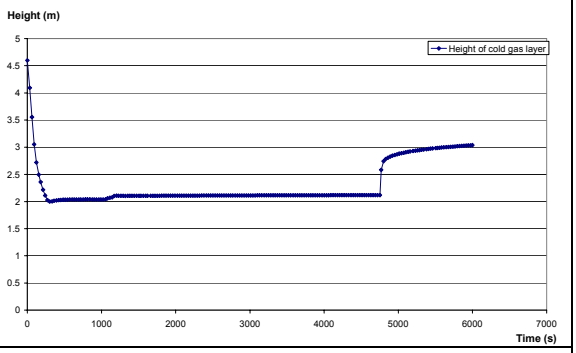

Figure 2 : Height of cold gas layer

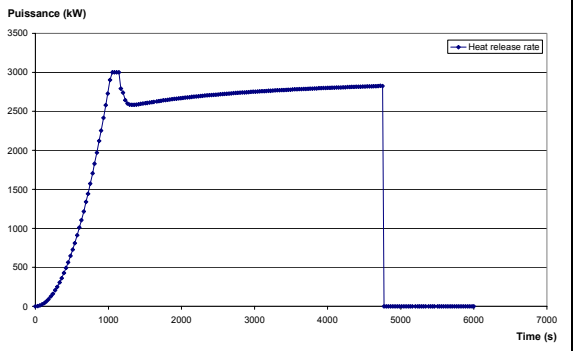

Figure 3 : Heat release rate

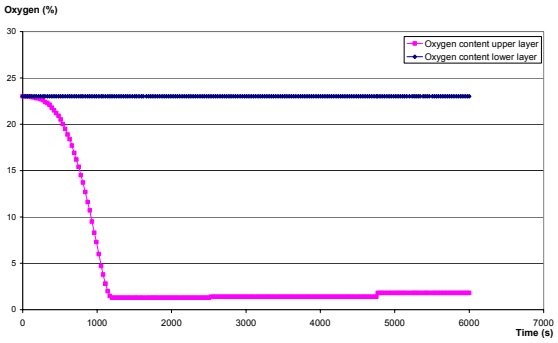

Figure 4 : Oxygen concentration

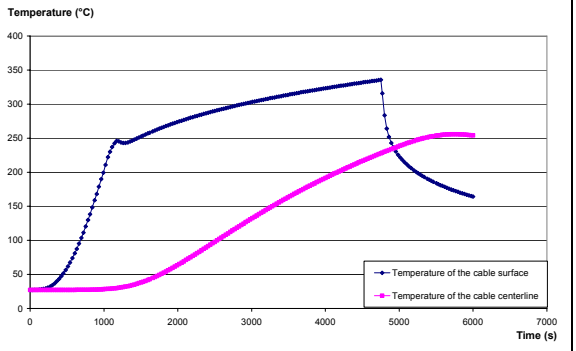

Figure 5 : Cable temperature

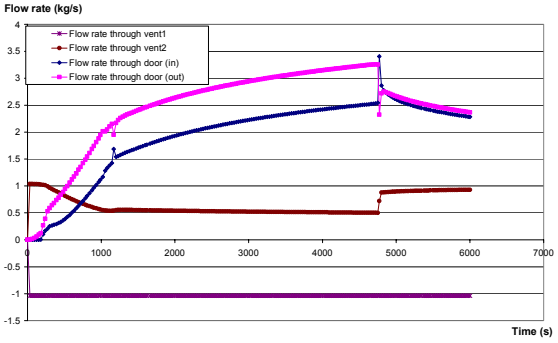

Figure 6 : Flow rate through vents and door

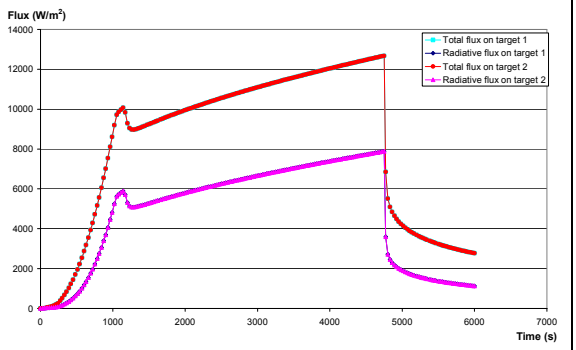

Figure 7 : Radiative flux on target

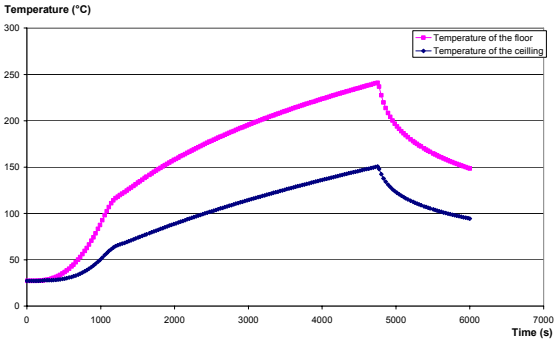

Figure 8 : Floor and ceiling temperature

5. CONCLUSION

According to the simulations, the following comments about the code MAGIC can be given :

- If the target is into the plume, we have a simplified prediction of the target temperature.
- The use of cable target gives better information than the use of a simple target.
- The mechanical ventilation model is an important parameter in this benchmark because it controls the rate of heat release.
- Target centerline temperature = 260°C

According to the criteria for cable damage given by the benchmark (centerline temperature of 200°C), cable damage is observed in this additional case.

According to the different cases of the benchmark, it should be interesting to define more sensitive case for models.

In part I, a higher rate of heat release should be used with a parameter study leading to the ignition or non-ignition of the cable.

In part II, lower source height and ventilation in the hot layer should be used for occurrence of damage criteria.