Fire safety topics for master thesis TU/e

LIST OF EXAMPLES - 2017

1. **Numerical simulation of local fires with local flames:**
Is a reliable simulation of local flames and/or external flames possible in CFD? If so, is RANS or LES technique more suitable for this simulation and what gridsizes are needed? Compare (and fit) simulation results to empirical flamemodels and empirical models for the local heat flux (radiation and convection). Make a sensitivity analysis on boundary conditions and assumptions.

2. **Numerical simulation of ventilation controlled fires with external flames:**
Is a reliable simulation of a ventilation controlled fire with external flames possible in CFD? If so, is RANS or LES technique more suitable for this simulation and what gridsizes are needed? Is the external flame realistic in heat release rate, temperature and combustion volume? Compare (and fit) simulation results to zone model results for heat release rates. Make a sensitivity analysis on boundary conditions and assumptions.

3. **Physiological aspects in personal safety**
What is the resistance of humans to heat flux, convective heat and toxicity of smoke gases? Is it possible to define the resistance of the human body in a mean value with a standard deviation, related tot different damage levels (1st degree, 2nd degree, lethality) for different ages and physical conditions? Not only the human skin, but also the respiration system is relevant in relation to this research question.

4. **Evacuation safety: probabilistic approach of ASET and RSET**
Safe evacuation of building occupants is possible when the required safe egress time (RSET) doesn't exceed the available safe egress time (ASET): ASET > RSET. The larger the time gap is between ASET and RSET, the higher the safety level is. This can be expressed in a safety factor: ASET = (safety factor) x RSET. What safety factor is needed for a reliable evacuation risk subsytem? Solving this question is possible in a time dependent approach for personal safety, taking into account:
   - The amount of building occupants in time (RSET)
   - The heat and radiation dose on building occupants in time (ASET, stratified situation)
   - Visibility, heat and toxicity dose on building occupants in time (ASET, mixed situation)

5. **Oxygen-controlled fires in zonemodels:**
Most post-flashover fires are oxygen (ventilation) controlled. With oxygen controlled fires there are two different combustion models possible:
   - Extended fire duration: Reduction of the RHR by lack of oxygen means that it will take more time before all fuel has been combusted. In this case, the pyrolysis rate is linked to the RHR and will be reduced in the same way as the RHR. All combustion energy remains in the compartment.
   - External flaming: Reduction of the RHR by lack of oxygen means that combustion partly takes place outside the compartment in the exernal flames. Reduction of RHR doesn't automatically lead to reduction of pyrolysis of the fuel. The gas mass in the compartment contains both combustion products and fuel. Not all combustion energy remains in the compartment.

   In general, the external flaming combustion model is most realistic. However, in case of small openings in the external separation construction of a fire compartment, the RHR of the external flames exceeds the RHR in the compartment. In practice, that is not possible, due to the airflowresistance of the opening. Is it possible to combine the external flaming and extended combustion model to a more realistic combustion model?

6. **Application of the standard fire curve in a natural fire concept:**
The thermal load according to the natural fire concept depends on fuel properties and building properties. Basicly, the thermal load by the gastemperature in the fireroom is a result from the heat release scenario. This project-specific thermal load differs from the standard fire curve. In case of testing the fire resistance of constructions the standard fire curve is used. To value the performance of tested constructions in a

natural fire concept the project-specific fire curve has to be compared to the standard fire curve. What comparison makes sense and in what translation from a project-specific fire curve into the standard fire curve will this comparison result?

7. **Consequences of changing boundary conditions in building and building users:**
   In both new buildings as renovation of existing buildings the boundary conditions by the building envelope will change (e.g. higher thermal insulation, more airtight, etc.). In very well insulated buildings, like passive or active house concepts, the building envelope influences the fire scenario. A local fire may become ogygen controled before the flashover conditions are reached. The probability of a compartment fire decreases. This advantage for loadbearing and separation constructions is a disadvantage for building users or residents. The smothered fire produces a lot of carbon monoxide, while there is hardly any oxygen left in the compartment.
   When we take into account an ageing population, which is less alert and will need more time for escape, the victim risk will increase in the near future. Do we need more stringent fire safety rules and regulations or do we need explicit fire safety objectives?

8. **Multizone evacuationmodel:**
   In huge and complex buildings building evacuation simulations are difficult to interprete. They offer a resolution which is much too detailed for assessing the egress safety of the building as a whole. Multizone evacuation models are more suitable for this type of buildings. There are some examples (Evacnet, ca. 1985) that may be useful to set up a calculation algorithm for multizone evacuation models. A study to boundary conditions, related to building users and building escape routes is necessary.

9. **Design of pressurized stairwells:**
   Strategies, positive and negative pressure zones and the role of any bufferzone. Justification of the safety level of a pressurized stairwell, compared to a safety escaperoute, containing at least one outdoor zone. Consequences of the european standard method for the design of pressurized escaperoutes.

10. **Fire safety of car parks:**
    In large car parks fire ventilation (smoke ventilation) is applied to prevent fire compartmentation in the car park. Is it possible to create a firesafe car park using fire ventilation or is a sprinklered car park a more robust solution? Is it also possible to accept a large carpark without compartmentation and without smoke ventilation or sprinkler system? The robustness of these concepts can be determined from a sensitivity analysis on boundary conditions. For construction elements near the fire scenario it is necessary to take into account local flames. Are local flames also important for the flashover risk from a cark park fire to adjacent compartments or buildings?

11. **Prevention and suppression – Linking fire suppression strategy to Lines of defense**
    Fire suppression tactics are divided in 4 main strategies: defensive outdoor attack, offensive outdoor attack, defensive indoor attack and offensive indoor attack. Fire suppression is only effective when suppression stratgy fits with the preventive lines of defense in the building. Preventive lines of defense are commonly represented in a 'cascade riskmodel'. Is it possible to link fire suppression also to this cascade riskmodel?

12. **Natural fire concept for fire suppression:**
    Monitoring the temperature distribution in a building during a fire can give insight in the fire development. It may even be possible to predict the fire development within certain boundaries. This information is very useful for the fire brigade during suppression. What requirements to the (predicitve) fire model are needed to process the temperature data and optimize fire suppression tactics?

13. **Fire safety concept without building evacuation:**
    Is it possible to create a fire safety concept for a building, without evacuating the building? Then escape routes are no longer necessary. But are there consequences to building constructions (separation constructions and load bearing elements), fire safety installations and emergency assistance?

14. **Prescriptive rules and performance based objectives for fire safety:**
    Most building codes use prescriptive requirements for fire safety of buildings. In a project-specific approach prescriptive requirements don't make sense. A project specific approach requires a risk assessment to risk objectives. What are the objectives, related to the prescriptive requirements of the Dutch building code. Is it possible to quantify these risk objectives?

15. **Heat release rate and fire development in residential functions:**
    In residential functions the fire load depends on furniture, furnishings and decor. This fire load is very sensitive to trends. The fire development also depends on furniture, furnishings and decor, but also on the building envelope and internal separation constructions. In september 2014 the heat release rate and fire development in residential functions will be measured by real-scale experiments. These real-scale experiments have to be translated into new boundary conditions for zone- and CFD-modelling.

16. **Reliability of fire safety objectives**
    In fire (safety) engineering we follow a project-specific approach to realize the required fire safety objectives. In a generic rule based approach the assessment is very simple, you only have to a check if all requirements are fulfilled. In an objective based approach the objectives are quantified in an acceptable failure probability (or failure risk). To determine the failure probability, uncertainties in boundary conditions (building and fuel characteristics) have to be taken into account. Is it possible to quantify the safety objectives of the Building Code and how do you set up a sensitivity analysis for assessment to these acceptable failure probabilities?

17. **Underventilated fires**
    Normally, a localized fire is fuel controlled. In some cases, localized fires become oxygen controlled. In case of an airtight building envelope without any openings that's nog very surprising. But even with open windows a localized fire becomes sometimes oxygen controlled. What is the explanation for this and what boundary conditions are significant fot this type of localized fire?
    Is it possible to simulate underventilated fires in zonemodels or CFD-models? Is it possible to set up an experimental model for simulation?

18. **Plume in zonemodels**
    In most cases, several empirical plumes can be used in zonemodels. All empirical plume models assume a free plume, a plume that is not influenced by walls and obstructions. However, for a local fire near to the compartment envelope, the entrainment of air in the plume is far different from the entrainment of air in a free plume. Is it possible to adjust the plume in zonemodels taking into account the influence of walls and obstructions on air entrainment in the plume? And is it also possible to adjust the plume for sprinklerd fires? Use empirical models and compare them witch CFD-models.

<u>More info:</u>

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