

FIRE DYNAMICS AND MODELLING
Monday 11 - Friday 15 October 2010

PROVISIONAL PROGRAMME

Fundamental Processes

MONDAY 11 OCTOBER 2010

08.30 *Registration and coffee*

09.00 **Physical concepts**

Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds

Matter, density, specific gravity; gases & vapours; convective (or buoyant) flows; vapour pressures of liquids; heat and temperature; heat capacity; specific heat capacity; latent heat; the transmission of heat. Example calculations: densities of gases at various temperatures and pressures, density of fire gases; vapour pressures of liquids – relevance to flammability limits.

10.10 Coffee

10.30 **Fuel and combustion processes and fundamentals**

Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds

Polymers; synthetic polymers; thermal decomposition and stability of polymers; modes of fuel vapour generation from a solid; mechanisms of decomposition; thermal stability; importance of volatiles; the physical chemistry of combustion in fires; regimes of burning (flame types); rate of burning; energy release in a fire; the heat of combustion, DH_c ; the mechanism of gas phase combustion.

Example calculations: calculation of heat combustion of material from knowledge of chemical formula.

12.00 **Limits of flammability**

Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds

Determination; quenching diameter; upward v's downward flame propagation; minimum ignition energy (MIE); limitations/alternatives; influence of pressure on FL; influence of temperature; critical adiabatic temperature at the lower limit; predicting LFLs of mixtures of flammable gases (Le Chateliers rule); flammability diagrams; addition of suppressants. Example calculations: calculation of flammability limits of mixtures, use of flammability diagrams.

13.00 Lunch

14.00 **Heat transfer: conduction and convection**

Dr John Staggs, Energy and Resources Research Institute, University of Leeds

Background; Conduction: Fouriers law; thermal conductivity; thermal diffusivity; steady state conduction; thermally thin; thermally thick; thermal resistance; composite slab.

15.10 Tea

15.30 **Heat transfer: conduction and convection (continued)**

Dr John Staggs, Energy and Resources Research Institute, University of Leeds

Convection: convective heat transfer coefficient; thermal boundary layer; Navier Stokes equations; Prandtl number; Reynolds number; Stanton number; friction coefficient; Reynolds analogy; empirical method.

Approximate integral method for transient conduction

Example calculations: heat transfer through an over door, temperature difference across a fire door (steady), estimation of critical heat flux, temperature difference across a fire door (unsteady).

17.00 End of day one

19.00 Course Dinner

Radiation, Ignition and Flame Spread

TUESDAY 12 OCTOBER 2010

08.45 *Registration and coffee*

09.00 **Radiation from fires**

Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds

Nature of Radiation: Absorptivity, reflectivity and transmissivity; black body; emissive power (black body); emissive power (grey body); the inverse square law; effects of radiation.

Radiative heat exchange: Simplified situations; view factors and exchange areas.

10.20 Coffee

10.40 **Radiation from fires (continued)**

Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds

Representation of flames in fire calculations. Thermal radiation in participating media: Mean beam length; emissivity of hot gases (no-soot i.e. non luminous flames); emissivity of gas-soot mixtures; applications. **Representation of flames in fire calculations**

Example calculations: true thermocouple temperature; view factors in an enclosure; minimum separation distance between school building and mobile classrooms.

12.30 Lunch

TUESDAY 12 OCTOBER 2010 cont ...

- 13.30 **Ignition**
Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds
General: The elements of ignition; ignition sources and fire causes; physical and chemical characteristics of fuels. **Ignition of gaseous fuels:** Minimum ignition energy (MIE). **Ignition of liquid fuels:** Experimental ignitability data; relationship between flash point and lower flammability limit (LFL). **Ignition of solids:** Critical heat fluxes, self heating and spontaneous combustion.
Example calculations: liquid vapour concentration at flash point. Time to ignition for thin and thick solids.
- 15.00 Tea
- 15.15 **Spread of flame**
Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds
Factors influencing rate of spread; relative flame spread rates; liquid fuels; solid fuels: orientation and direction of propagation; density, thermal capacity and thermal conductivity; sample geometry; environmental effects. Example calculations: determining the point of origin.
- 16.30 End of day two

Pool Fires, Jet Fires and Cloud Fires

WEDNESDAY 13 OCTOBER 2010

- 08.45 *Registration and coffee*
- 09.00 **Steady burning diffusion fires**
Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds
Diffusion flames: Buoyant fire; jet fire; knowledge required for determination of hazard consequences: Jet fires; buoyant fires; fire plume regions: The buoyant plume; plume from a point source; air entrainment; virtual source; scaling laws; the "flame" plume; intermittency; flame length; velocities and temperatures (Centreline); effects of wind. Example calculations: length of turbulent diffusion flame.
- 10.15 Coffee
- 10.30 **Pool and jet fires in the open**
Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds
Ignition and flame spread, mass burning rate, **flame extent and geometry**, flame length, flame tilt, flame drag. Case studies. Example calculations; rate of heat release from a pool fire, flame length.
- 11.40 **Radiation from flames**
Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds
Radiation from flames (calculations): Representation of flames in fire calculations; point source models; surface emitter models.
- 12.20 Lunch
- 13.05 **Example calculations: radiation flux from flare on escape route**
Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds
- 13.35 **Pool and jet fires, large scale tests**
Phil Cleaver, Germanischer Lloyd
This talk summarises the large-scale experimental work that has been carried out by Germanischer Lloyd to study jet and pool fires. The type and range of fires of interest are noted, by reference to the different situations of industrial relevance. It is noted that many of the features of these fires are scale dependent. The type of data that can be collected in such experiments is discussed and the uses for this data are mentioned.
Videos and pictures are used to illustrate the different fires and, in passing, to mention some of the key points that have been learnt as a result of carrying out this work.
- 14.20 **Pool fires in fuel storage areas**
Vania De Stefani, Major Hazard and Fire, BP International Limited
A real case scenario will be used to demonstrate how the available consequence models can predict the thermal radiation observed during accidents.
- 15.05 Tea
- 15.20 **Cloud fires**
Peter Rew, ATKINS
Definitions, key modelling issues, prediction of burn area, flame speed, fatalities, heat fluxes.
- 16.15 **Pool and jet fires in compartments**
Professor Geoff Chamberlain, Consultant, Waverton Consultancy Ltd, previously Shell Global Solutions (UK)
Heat fluxes, mass burning rates, heat release rates, fire product compositions.
- 17.00 End of day three

Compartment Fires

THURSDAY 14 OCTOBER 2010

08.15 *Registration and coffee*

08.30 **The growth period**

Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds

Comparison to open fires. The Growth period: Fire plumes in compartments (during the early stages), effects of walls and ceiling. **Applications:** Response of ceiling mounted detectors; interaction between sprinkler sprays and fire plume; experimental modeling; Froude modelling; Grashof modelling; **design fire growth rates.** Example calculations: Gas temperatures in plume and near ceiling; minimum size fire for detector activation; response time of heat detectors; rate of heat release at time x after ignition.

10.00 Coffee

10.20 **Flashover**

Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds

Definitions; conditions necessary for flashover; sources of radiative flux; flashover as a thermal instability; burning regimes; fuel and ventilation conditions necessary for flashover; critical heat releases; effects of lining material; Thomas' flashover correlation; compartment temperatures prior to flashover. Example calculations: Maximum burning rate in a room of certain dimensions; size of fire necessary for flashover for different lining and construction materials; time to flashover.

12.00 Lunch

12.45 **The post-flashover period and backdraughts**

Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds

The post-flashover period: Air entrainment and burning rate; fire resistance (introductory comments), correlation between fire resistance and fire severity; A note on flame temperatures; glass breakage in fires. **Backdraught:** Definition; circumstances leading to backdraught; scenarios; warning signs.

14.15 **Fire performance of structures**

Dr Florian Block, BURO Happold

Prediction of the performance of steel and concrete structures. An integrated fire safety design approach considering evacuation, structural performance, fire fighting and fire safety management. Project example.

15.15 Tea

15.30 **Smoke movement**

Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds

Definition of smoke; optical density of smoke visibility through smoke; **Smoke movement:** Forces responsible; stack effect; fire buoyancy; External wind; air handling systems; smoke control systems: Smoke vents; smoke curtains; protected escape routes; **toxicity:** Definitions; tenability limits; carbon monoxide; hydrogen cyanide; carbon dioxide; low oxygen hypoxia; irritants.

16.15 **Fire combustion products and toxicity as a function of ventilation conditions**

Professor Gordon Andrews, Energy and Resources Research Institute, University of Leeds

17.15 End of day four

Compartment Fire Modelling

FRIDAY 15 OCTOBER 2010

08.45 *Registration and coffee*

09.00 **Overview of fire models**

Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds

What is a model? What do we need fire models for? What do fire models do? Computer fire modelling; zone models in some detail; field models.

09.40 **A zone model in detail – CFAST**

Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds

10.30 Coffee

10.45 **A CFD model in detail – JASMINE**

Richard Chitty, BRE Global

Practical use of a CFD fire model (JASMINE) to examine smoke movement in a large complex building.

12.00 *Buffet Lunch*

FRIDAY 15 OCTOBER 2010 cont ...

**THE AFTERNOON 'HANDS ON' SESSION WILL BE HELD IN THE COMPUTER CLUSTER
AT THE UNIVERSITY OF LEEDS**

12.40 Transport to the University of Leeds

13.00 **Hands on experience with a zone model**

Peter Riley, Energy and Resources Research Institute, University of Leeds

Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds

CFAST/CFASTlite model for multi-compartment fire simulations. Tutorial 1: Workshop fire: single compartment simulation. Tutorial 2: Workshop and office fire: multi-compartment simulation with one of the compartments fitted with sprinklers.

Tutorial 3: Backdraught simulation (real incident): Multi-compartment fire in which fire burned under severely vitiated conditions, until door opened by fire fighters, resulting in backdraught.

15.30 Return transport to Weetwood Hall Hotel

15.45 Tea / coffee and issue of attendance certificates

16.00 End of day five and course