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Continuing Education Course #259
An Introduction to Heat Transfer in Structure Fires

1. What are the three sides of the fire triangle?
- a. fire, thermal radiation, water
- b. oxidizer, hydrogen, electricity
- c. steam, foam, halon
- d. Fuel, heat, oxygen

2. What are the three forms of heat transfer?
- a. thermal, solar, fire
- b. conduction, convection, and radiation
- c. radiation, infrared, thermal
- d. smoke, flame, plume

3. What is the range of heat fluxes where most materials will ignite?
- a. 1-5 kW/m^2
- b. 10-20 kW/m^2
- c. 20-30 kW/m^2
- d. 40-50 kW/m^2

4. What is the one dimensional (1D) steads state conduction through a 0.3m copper rod with a temperature of 373K (boiling point of water at sea-level) at one end and a temperature of 325K at the other end? Assuming the thermal conductivity for copper is 0.387 kW/(m K).
- a. 51.9 kW/m^2
- b. 61.9 kW/m^2
- c. 71.9 kW/m^2
- d. 81.9 kW/m^2

5. What is a representative range of the convective heat transfer coefficient for buoyant flows in air?
- a. 1-2 $kW/(m^2 K)$
- b. 100-500 $kW/(m^2 K)$
- c. 0.0007-0.006 $kW/(m^2 K)$
- d. 0.005-0.01 $kW/(m^2 K)$

6. What is the convective heat flux to a wooden wall with a temperature of 298K (25°C) from the heated buoyant flow from a fire with an average temperature of 500K? Assume a convective heat transfer coefficient of 0.006 $kW/(m^2 K)$.
- a. 1.2 kW/m^2
- b. 2.2 kW/m^2

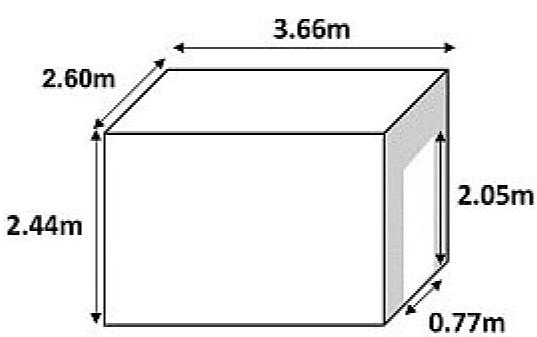
- c. 4.2 kW/m^2
- d. 5.2 kW/m^2

7. What is an example of an open source computer model for doing conduction and convection calculations?
- a. CFAST
- b. ANSYS Fluent
- c. CONTAM
- d. OpenFOAM

8. What is the variable that fire scientists use to combine the effects of conduction and convection in a compartment fire upper layer temperature calculation?
- a. convective heat transfer coefficient (h)
- b. conduction coefficient (h)
- c. effective heat transfer coefficient (h_k)
- d. specific heat (c_p)

9. What is a reasonable initial value for the effective heat transfer coefficient in a compartment fire?
- a. 0.0025 $kW/(m^2K)$
- b. 0.025 $kW/(m^2K)$
- c. 0.25 $kW/(m^2K)$
- d. 2.5 $kW/(m^2K)$

10. If a steady state 250 kW fire occurs in the room shown below, what will the upper layer temperature be? Assume: $T\infty$=298K, and h_k = 0.025 $kW/(m^2K)$.



- a. 293K
- b. 393K
- c. 493K
- d. 593K

11. What is the maximum temperature seen in a compartment fire?
- a. 1473 K
- b. 1373 K
- c. 1273 K
- d. 1173 K

12. What is the heat flux that will cause pain on exposed skin for the average person?
- a. 0.017 kW/m^2
- b. 0.17 kW/m^2

○ c. 1.7 kW/m^2
○ d. 17 kW/m^2

13. What is the maximum heat flux that the US Department of Housing and Urban Development allows for building?
○ a. 25.2 kW/m^2
○ b. 31.5 kW/m^2
○ c. 35.2 kW/m^2
○ d. 41.5 kW/m^2

14. If a steady state stove top fire is creating an incident heat flux to a child sitting in a high chair at the kitchen table of 3.5 kW/m^2, how long will would it take for the child to start feeling pain from thermal radiation exposure?
○ a. 1.7s
○ b. 10.7s
○ c. 107s
○ d. 1070s

15. What is the total radiative heat flux from a table with a surface temperature of 450K in a compartment with uniform wall temperatures of 350K. Assume the table is a blackbody radiator with an emissivity of 1.
○ a. 1.47 kW/m^2
○ b. 2.47 kW/m^2
○ c. 3.47 kW/m^2
○ d. 4.47 kW/m^2

16. A 5m diameter storage tank is burning 10m from a group of people, using the Shokri and Beyler method, what is will the radiative heat flux to the people be? (Do not incorporate the factor of safety.)
○ a. 0.59 kW/m^2
○ b. 1.59 kW/m^2
○ c. 2.59 kW/m^2
○ d. 3.59 kW/m^2

17. Which equation can be used to estimate the radiative fraction of a pool fire?
○ a. $q" = \varepsilon\sigma(T_O^4 - T_\infty^4)$
○ b. $\chi_r = 0.21 - (0.0034)D_p$
○ c. $q''_{rad} = 15.4\left(\frac{d_t + 0.5D_p}{D_p}\right)^{-1.59}$
○ d. $q" = \frac{\chi_r Q}{4\pi(d_t + 0.5D_p)^2}$

18. A 3.048m diameter storage tank is burning 10m from a group of people, if the heat release rate is 8600 kW, and it is assumed 30% of the fire's heat release rate is given off as radiation, using the point source model, what is the radiative heat flux to the people? (Ignore the safety factor of 2.)
○ a. 0.0155 kW/m^2
○ b. 0.155 kW/m^2
○ c. 1.55 kW/m^2
○ d. 10.5 kW/m^2

19. Which equation can be used to estimate the emissive power of the flame of a pool fire?

○ a. $E = 58\left(10^{-0.00823(D_p)}\right)$

○ b. $q''_{rad} = 15.4\left(\frac{d_t + 0.5D_p}{D_p}\right)^{-1.59}$

○ c. $q'' = \frac{\chi_r Q}{4\pi(d_t + 0.5D_p)^2}$

○ d. $\chi_r = 0.21 - (0.0034)D_p$

20. What would be the heat flux to person 4m from a 1.22m (4 ft) diameter kerosene fire with a heat release rate of 1360 kW and the average flame height of 2.97 m and would the person be at risk of pain from thermal radiation? Assuming:
$\chi_c = 0.85, \Delta H_c = 43200[kJ/kg], m''_\infty = 0.039\left[kg/\left(m^2 s\right)\right], k\beta = 3.5[1/m]$

○ a. 1.6 kW/m^2
○ b. 2.6 kW/m^2
○ c. 3.6 kW/m^2
○ d. 4.6 kW/m^2

21. What is the radiative heat flux to a firefighter crawling 2m below a heated upper gas layer with a temperature of 800K? Assume the upper layer has a width of 3m and a length of 4m.

○ a. 12.8 kW/m^2
○ b. 13.8 kW/m^2
○ c. 15.8 kW/m^2
○ d. 17.8 kW/m^2

22. What term represents the minimum heat flux that will ignite a material in an infinite amount of time.

○ a. critical heat flux
○ b. maximum heat flux
○ c. optimum heat flux
○ d. prim heat flux

23. How long would it take for a solid pine wall support member to ignite if it is 1ft thick and the wall is being heated by a bedside radiant heater at a flux of 30kW/m^2? Assume that pine has a critical heat flux of 16 kW/m^2, an ignition temperature of 663K, a conduction coefficient of 1.4x10-4 kW/(m K), a density of 640kg/m^3, and a specific heat of 2.85 kJ/(kg K).

○ a. 20s
○ b. 25s
○ c. 30s
○ d. 35s

24. How long would it take for a sprinkler head with an RTI of 55m$^{1/2}$s$^{1/2}$ and an activation temperature of 348K (75°C) activate in a fire plume with a temperature of 500K and a velocity of 1.5 m/s? Assuming an ambient temperature of 298K (25°C or 77°F).

○ a. 8.8s
○ b. 10.8s
○ c. 12.8s
○ d. 14.8s

25. What is the temperature at a location 4m from the centerline of a fire with a steady state heat release rate of 450 kW in a compartment with a ceiling height of 5m as shown below? (Assume the base of the fire is on the floor.)

- ◯ a. 300K
- ◯ b. 325K
- ◯ c. 350K
- ◯ d. 375K