thermal hazard technology

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Technical Information Sheet No 24

Tests at ϕ = 1 with the Accelerating Rate Calorimeter

Tests at $\phi = 1$? Yes it is impossible to do this in the Accelerating Rate Calorimeter as it is impossible to do this in other adiabatic calorimeters.

The desire to carry out testing at low ϕ and the idea of using $\phi = 1.01$ seems desirable but in many cases is not necessary. Lowϕ testing is important. A fully adiabatic experiment is what is desired. Phi is just one part of error in adiabatic calorimetry. Low ϕ instruments may minimise the heat lost into the sample container but what about heat loss from the sample/container system, a loss that is very difficult quantify ?

In the Accelerating Rate Calorimeter the aim was to make heat loss from the sample/container negligible and in successfully doing this, the thermal inertia of the system, ϕ, must be somewhat higher. But not very much higher – and low ϕ test cells are available for the Thermal Hazard Technology Accelerating Rate Calorimeter, which will give a ϕ of 1.1 or below.

When a test needs to be carried out in a fully adiabatic state to simulate the worst case scenario, it may be noted initially that in a fire, heat would be added to the system, the so-called over adiabatic scenario and thus, what is the worst case scenario?

But to do a test under fully adiabatic conditions in the Accelerating Rate Calorimeter since losses are negligible, testing at $\phi = 1$ is appropriate since other heat losses are negligible.

But how can this be done? Use a very large bomb, use a very light bomb, put a heater outside or inside the bomb, construct a fiendishly inventive device? But this can be accomplished very simply!

Consider a sample A which is to be used as a 20% solution in solvent Y. If both have a similar specific heat, and a 6 gram sample is tested in a 6 gram sample container of specific heat

$$\phi = 1 + \frac{6 \times 0.1}{6 \times 0.5}$$

$$\phi = 1.2$$

But the test ought to be carried out at $\phi = 1$. **To do this simply substitute the heat capacity or eliminate the heat capacity of the bomb by reducing an amount of solvent Y used.** The solvent after all only absorbs heat.

To calculate the reduction in solvent required and thus the higher concentration of sample X in solution is simple.

Firstly it must be understood that there are two ϕ's to consider. The ϕ of the solution (X in Y) and the ϕ of the active ingredient, X. If there was no container ϕ solution = 1, but ϕ of the active ingredient = 5, since it is a 20% solution and the specific heats of sample and solvent are the same, this is shown in the equation below.

$$\phi_{activeingredient} = 1 + \frac{M_{tY} . c_{pY}}{M_X . c_{pX}}$$

$$\phi_{activeingredient} = 1 + \frac{80\% x 0.5}{20\% x 0.5}$$

Therefore a sample of higher concentration of X is required which, when the heat capacity of the bomb is considered, will still give $\phi = 5$.

$$\phi_{activeingredient} = 1 + \frac{M_b.c_{pb} + M_{tY}.c_{pY}}{M_X.c_{pX}}$$

So to give a ϕ = 5 with a container, what percentage of X is required. If 'A' is the percentage of X required:

$$\phi_{activeingredient} = 1 + \frac{6x0.1 + (1 - A)0.5}{Ax0.5} = 5$$

Therefore if a test is carried out with a 23% X solution in Y solvent in the 6 gram container, the data obtained will be equivalent to a test carried out in the fully adiabatic state, ϕ = 1. The contribution of heat lost into the bomb has been compensated for by a reduction in solvent.

But a word of caution, there may be a mechanism change. Whilst this is very unlikely a test in the Accelerating Rate Calorimeter with a 25% solution may be prudent to check this.

Clearly in this way tests with a phi values below 1 could also be carried out or tests at any ϕ value could be carried out.