MINIMUM IGNITION TEMPERATURE (DUST LAYER) TEST (MIT)

INTRODUCTION

The accumulation of dust in layers is common in industrial facilities handling combustible dusts and can pose fire or explosion hazards. Dust layers that are exposed to hot surfaces can ignite, provoke a fire, and/or initiate a dust explosion. Beyond good housekeeping practices, one method of minimizing the dust layer combustion hazard is the specification of maximum allowable surface temperatures. To specify a maximum allowable surface temperature, the minimum hot surface temperature for ignition of dust layers (MIT) must be known. Tests conducted according to ASTM E2021, "Standard Test Method for Hot Surface Ignition Temperature of Dust Layers" allow for the quantification of MIT.

BACKGROUND

Upon exposure to a hot surface with a temperature high enough to cause combustion of a dust layer, the dust layer temperature will increase above the temperature of the hot surface. In addition, during the exposure:

A. The physical (visual) appearance of the dust may change,
B. The consistency of the dust may change (from dust to an agglomerated or melted mass),
C. Smoke may be generated.

As an example, the behavior of Pittsburgh Pulverized Coal exposed to hot surface temperatures of 230*C and 240*C is shown in Figures 1 and 2. A summary of hot plate experimental results for Pittsburgh Pulverized Coal is given in Table 1. At a hot plate temperature of 230*C, Pittsburgh Pulverized Coal did not ignite. At a hot plate temperature of 240*C, Pittsburgh Pulverized Coal did ignite. The difference between maximum dust layer temperature and the hot plate temperature during the 240*C experiment was 193*C. From these results, the MIT for Pittsburgh Pulverized Coal would be reported as 240*C. This value compares well with reported literature values (230*C - 240*C) [1]. Table 1 gives the maximum temperature of the dust layer during the experiment, the post-test characteristics of the dust, and the amount of smoke generated during the test.

TABLE 1.

MIT TEST SUMMARY
PITTSBURGH PULVERIZED COAL

Hot Plate Temp. (°C)	Dust Layer Max. Temp (°C)	Smoke Generation	Physical Appearance	Discoloration
230	191	Slight	Loose	None
230	202	Slight	Loose	None
240	433	Heavy	Loose	Charred

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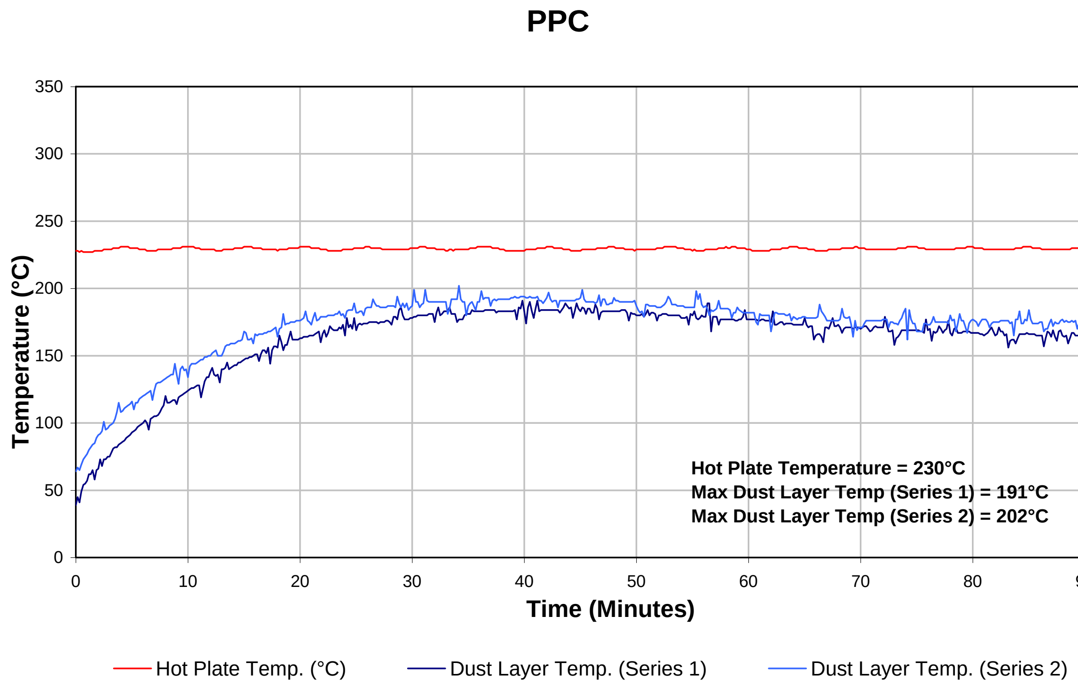

Figure 1: Non-Ignition Temperature Time Records

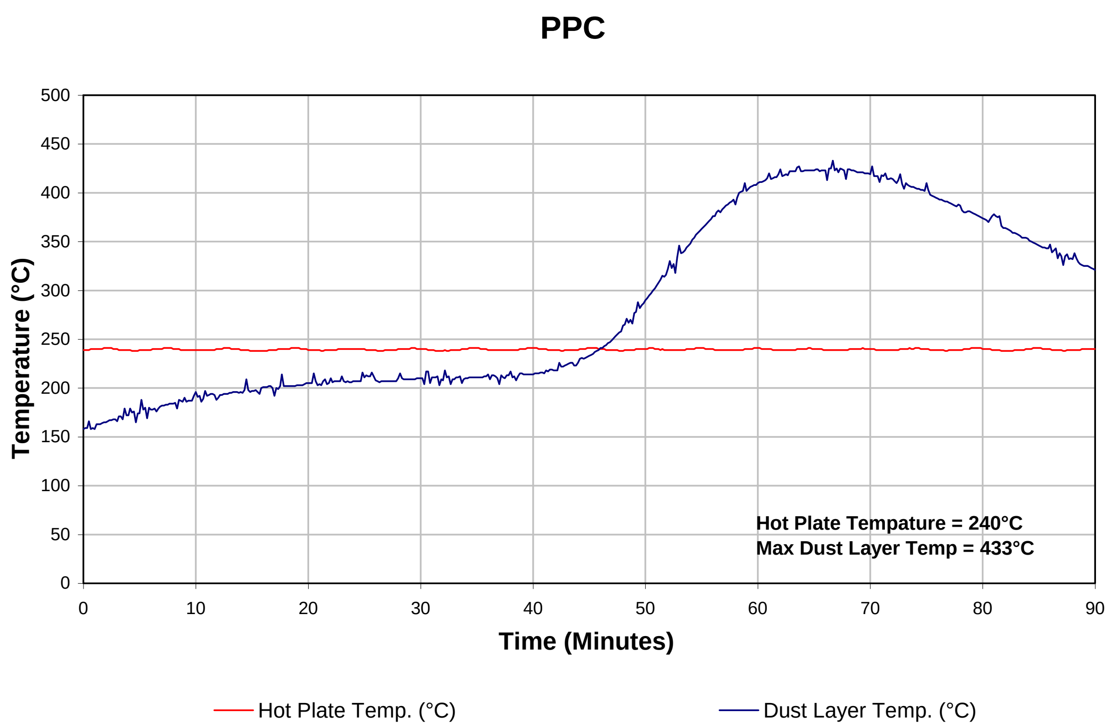

Figure 2: Ignition Temperature Time Records

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MIT is synonymous with the term “smolder temperature”. Some results are reported using the same terms (MIT, smolder temperature) but with different experimental procedures. The MIT of a dust is influenced by the following dust characteristics:

A. physical and chemical properties of the dust (particle size distribution and chemical composition);
B. dust layer thickness;
C. air flow across the dust layer;

In order to conduct a standardized test, all of these parameters must be controlled or kept constant from test to test. A single layer thickness of 12.7 mm and zero air flow are generally accepted for standardized tests. ASTM E2021, “Standard Test Method for Hot Surface Ignition Temperature of Dust Layers” defines ignition as a temperature increase of ≥ 50°C above the hot plate surface temperature in the dust layer center or visible evidence of combustion (i.e. red glow, embers or flame). Often, the temperature within the dust layer can exceed the hot plate temperature as a result of self-heating that does not lead to propagation of combustion. The International Electrotechnical Commission recommends a 20°C increase above the hot plate surface temperature. This lower value of a 20°C increase can also be used to provide more conservative results to the reported MIT value.

EXPERIMENTAL

The heating element used in the tests is a Fisher Scientific infrared hot plate. An 8" diameter, 1" thick aluminum plate is placed on top of the heating element. The surface temperature of the aluminum plate is manually controlled. A type K thermocouple is mounted just below the surface of the plate. The junction of the thermocouple is located within 1 mm ± .05 mm of the center of the upper surface. A stainless steel ring with a 4" inner diameter and a 1/2" depth is placed on the plate. The ring has slots on opposite sides to allow placement of a fine gauge (0.005” or 0.010”) type K thermocouple across the test volume. The thermocouple is located above the surface of the aluminum plate such that the junction will be at the center of the dust layer. The thermocouple outputs are recorded using a personal computer with a data acquisition board installed. A schematic of the MIT apparatus assembly is shown in Figure 3.

Tests are conducted by placing the stainless steel ring on a clean aluminum plate. The desired power setting is set on the heating element and entered into the software controlling the hot plate temperature to begin heating the aluminum plate. When the aluminum plate has reached the desired temperature and has stabilized, the ring is filled with the dust sample. Care is taken to avoid compaction or overfilling. The temperatures of the aluminum plate and of the dust layer are recorded by the data acquisition system with six samples/second. The duration of the test is dictated by the time required to reach the maximum temperature within the dust layer. Data is collected for a minimum of 30 minutes beyond the time in which the maximum dust layer temperature is reached and the temperature within the layer has stabilized, if no visual signs of combustion are observed. In addition to temperature/time records, visual observations of events such as smoke generation (heavy, light, none), physical appearance (caked, melted, loose), and discoloration (charred, slight, none) are also recorded. Each test is conducted with a “fresh” dust sample. Tests are conducted at different hot plate temperatures until the lowest hot plate temperature in which an ignition of the test sample is achievable has been established. The difference between the lowest hot plate temperature in which an ignition was observed and the highest hot plate temperature in which a non-ignition was observed shall not exceed 10°C. Once this difference has been reached, the non-ignition experiment is replicated to confirm the non-ignition result. Tests can be conducted up to a hot plate temperature of 450°C. In the event no ignitions are observed up to this upper temperature limit of the apparatus, a replicate test is performed at 450°C and the reported MIT value is >450°C. Additionally, samples may melt prior to reaching a temperature capable of producing an ignition. In these cases, replicate tests are performed at a temperature just below the observed melting point. When melting is observed, the report will indicate that no MIT exists below the observed melting point.

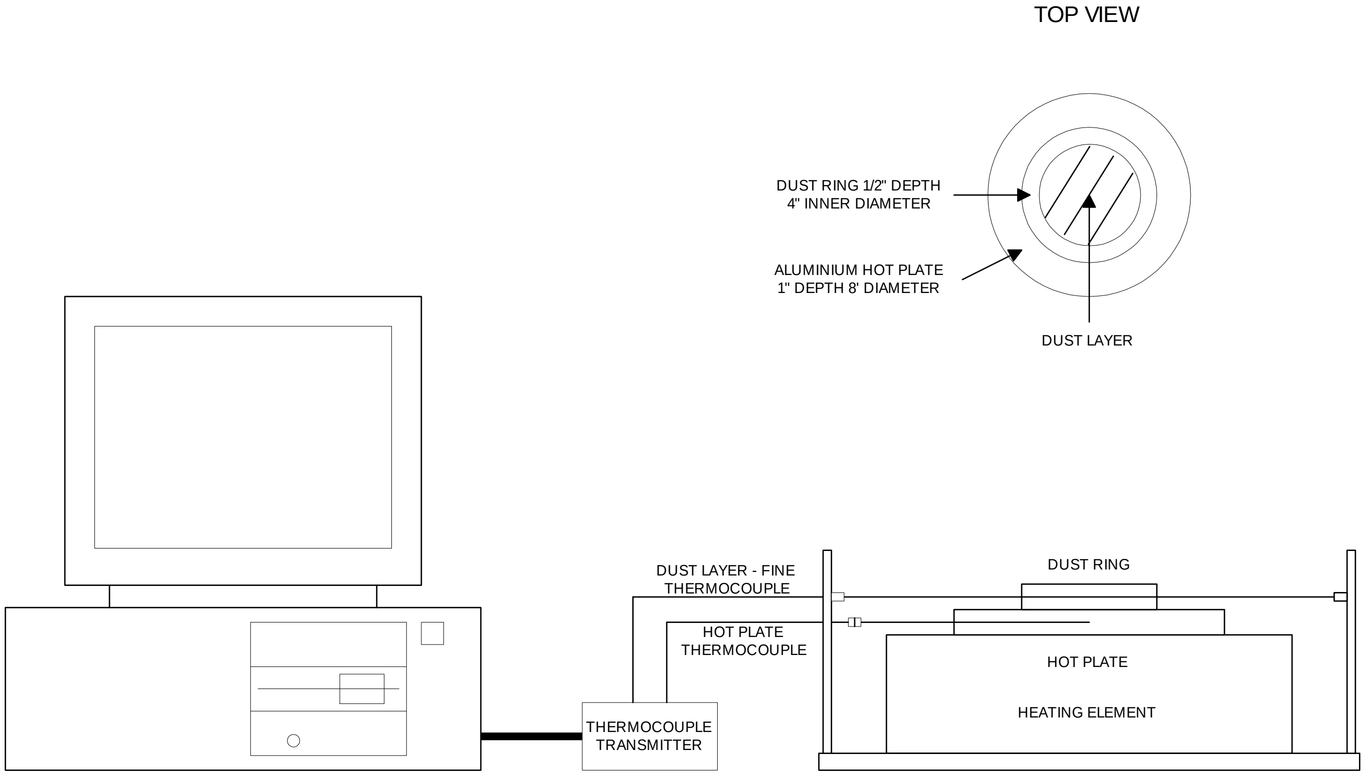

FIGURE 3 MIT APPARATUS

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