# Minimum Auto-Ignition Temperature (Dust Cloud) Test (MAIT)

**INTRODUCTION**

Handling, manufacturing and storing powders and bulk solids requires careful consideration of dust explosion hazards. A part of this consideration must be the ignition characteristics of the dust. Once a dust has been established to be combustible, the natural next step is to quantify the lowest ignition energy necessary to ignite the dust. These considerations apply to dust clouds and dust layers. For dust clouds, the quantification of the lowest ignition energy is typically conducted with an electrical spark ignition source and/or with a thermal ignition source. The lowest spark ignition energy is referred to as the "minimum ignition energy" (MIE). The lowest thermal ignition energy is referred to as the "minimum auto-ignition temperature" (MAIT). In an MAIT determination, a dust cloud is exposed to heated air and an observation is made of the presence of flame. The resulting MAIT can be used in explosion prevention efforts.

**BACKGROUND**

The MAIT of a dust is defined to be the lowest temperature at which the dust cloud can self-ignite (or more specifically, produce a self-sustaining deflagration). This determination must be made over a range of dust concentrations. At a given dust concentration, varying the temperature will result in a temperature above which the dust cloud will self-ignite and below which the cloud will not self-ignite. This "boundary" temperature will vary with the dust cloud concentration. The MAIT is the lowest "boundary" temperature over a range of concentrations. The MAIT 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. concentration of dust in the dust/air mixture;
C. homogeneity and turbulence of the dust/air mixture;
D. geometry of the vessel in which the explosion is occurring;

Literature shows the use of four different test apparatus for the measurement of the MAIT. The Godbert-Greenwald furnace is a 0.27 liter vertical ceramic tube with dust cloud injection at the top. The BAM oven is a 0.35 liter horizontal cylindrical chamber with dust injection at the side. The U.S. Bureau of Mines has used two vertical cylindrical chambers with volumes of 1.2 liters and 6.8 liters. Both chambers have dust injection from the bottom. All of the chambers are operated with a similar procedure and use visual criteria for flame observation. The apparatus used for the testing reported at Fike Corporation is similar to the Bureau of Mines 1.2 liter chamber. The primary difference is the use of a stainless steel chamber instead of a ceramic chamber. A comparison of results from the different chambers is presented below. The non-Fike results were obtained from ASTM E1491, "Standard Test Method for Minimum Autoignition Temperature of Dust Clouds".


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**MAIT'S FROM VARIOUS CHAMBERS (°C)**

| | **G-G** | **BAM** | **1.2 L** | **6.8 L** | **Fike** |
|---|---|---|---|---|---|
| Anthracite Coal | >900 | >600 | 740 | 730 | 699 |
| Anthraquinone | 670 | >600 | 620 | 680 | |
| Pocahontas Coal | 640 | 580 | 610 | 600 | 632 |
| Pittsburgh Coal | 600 | 570 | 540 | 530 | 560 |
| Lycopodium | 460 | 410 | 440 | 380 | 410 |
| Sulfur | 260 | 240 | 290 | 260 | 299 |
| Dried Cornstarch | | | | | 370 |

## EXPERIMENTAL

The apparatus used to conduct the dust cloud ignition temperature tests is schematically shown in Figure 1. The apparatus consists of a furnace, a control box and a dust discharge system. The furnace is a 304 stainless steel 1.2 liter vertical cylinder (length = 9", diameter = 3") with a port at the bottom and a port at the top. The bottom port allows insertion of the dust discharge nozzle into the furnace. The top port allows placement of a high temperature burst diaphragm and allows venting of the deflagration from the furnace. A type K thermocouple is placed on the inside furnace wall. The steel tube is heated with 18 gage ni-chrome wire (resistance = 15 ohms) and the entire furnace assembly is placed inside of an insulated chamber. The control box provides electrical energy to the heater wires, controls the furnace temperature and controls the activation of the solenoid valve in the discharge system. A UDC 3000 Honeywell controller is used to maintain the furnace temperature within approximately 5°F of the set point. A 0.2 liter discharge vessel pressurized to 25 psig is separated from the discharge nozzle by a solenoid valve. The discharge hose and the solenoid valve are 0.5" diameter. The discharge nozzle is a 0.25" diameter tube with a removable nozzle head.

The following procedure is used to conduct a test:

A. The furnace is heated to the required temperature.
B. The discharge vessel is pressurized to 25 psig.
C. An appropriate quantity of dust is placed in discharge nozzle tube.
D. The burst diaphragm is placed on top of the 1.2 liter chamber.
E. The discharge nozzle is placed into the furnace.
F. The discharge solenoid is activated by using the fire switch on the controller.
G. The diaphragm on top of the chamber is observed for 10 seconds.
H. All observations are recorded.

The furnace is cleaned of any residual dust prior to every test and left open to the atmosphere during the heating period. This assures that the furnace chamber is filled with ambient air. Toggle clamps are used to secure the diaphragm holder and discharge nozzle in place during the experiment. Typically,


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during a deflagration, the burst diaphragm will rupture within the first second after activation of the solenoid valve. To assure that the marginal deflagrations are appropriately recorded as explosions, a ten second observation period is chosen. The quantity of dust placed in the nozzle is varied from test to test to obtain the necessary dust concentrations. Dust concentrations usually vary from 200 g/m3 to 1000 g/m3 in 200 g/m3 increments. In the determination of the MAIT value, the difference in temperature between the lowest auto-ignition temperature and the highest non-auto-ignition temperature is no greater than 20°F.

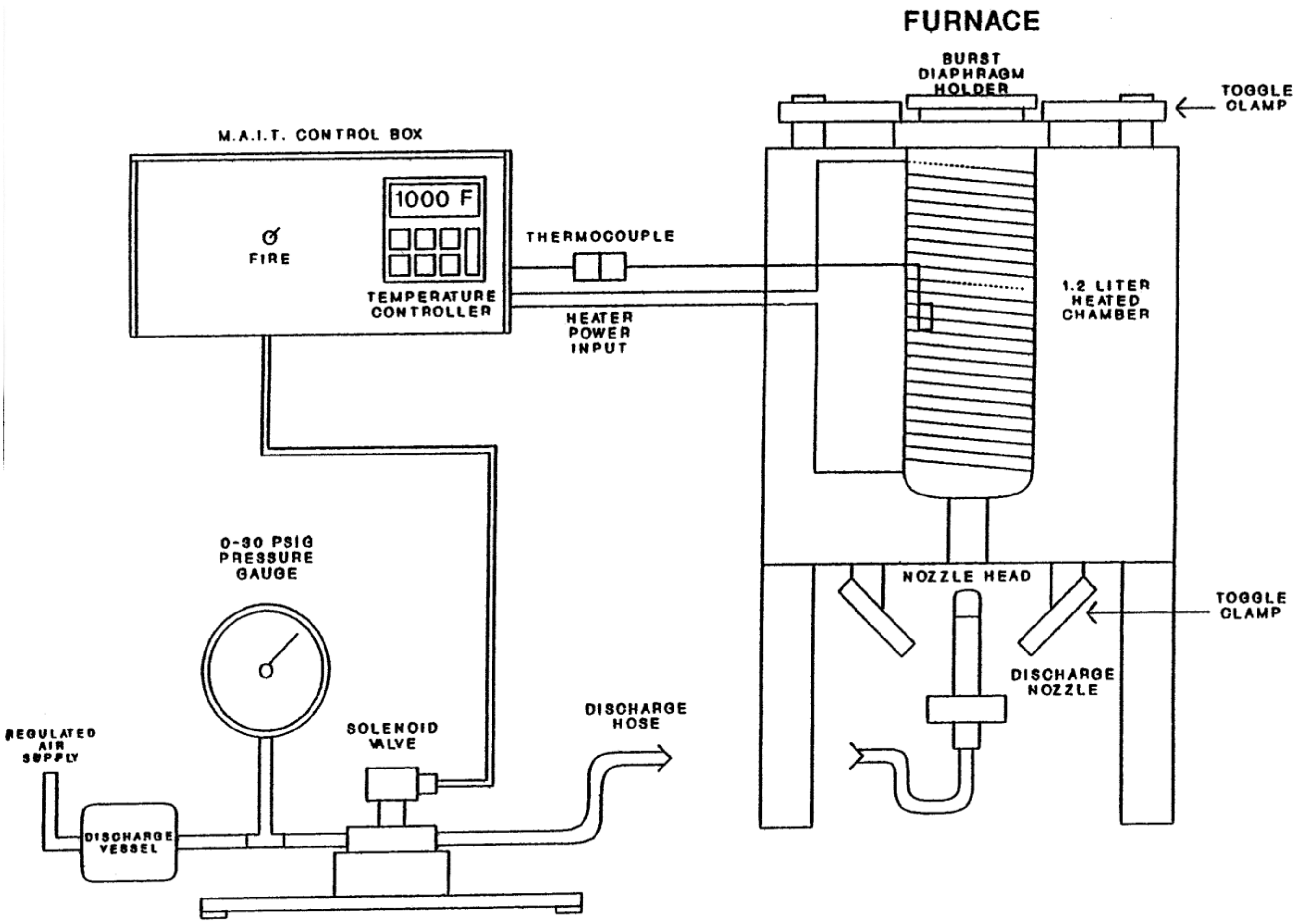


FIGURE 1 M.A.I.T. APPARATUS SCHEMATIC


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