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(DRAFT 4)

TEST METHOD FOR HEAT AND VISIBLE SMOKE RELEASE RATES OF MATERIALS, PRODUCTS AND SYSTEMS USING AN INTERMEDIATE SCALE APPARATUS

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1. Scope

1.1 This fire test response standard provides for measuring the response of materials, products and assemblies exposed to controlled levels of radiant heating with or without an external ignitor.

1.2 This test method is used to determine the ignitability, heat release rates, mass loss rates, effective heat of combustion, flame travel rate, thermal conduction properties (i.e. effective thermal conductivity and specific heat), and visible smoke development of materials, products and assemblies.

1.3 The rate of heat release is determined by measurement of the oxygen consumption as determined by the oxygen concentration and flow rate in the exhaust product stream as specified in the ASTM Proposed Room Fire Test, 5/86 Draft, and the ISO Standard Room Fire Test Method 9705 .

1.4 Specimens may be exposed to heating fluxes ranging from 0 to 50 kW/m^2 in a vertical orientation. External ignition, when used, is by a pilot flame which can be applied to the top or bottom of specimen (or both if desired).

1.5 This test method has been developed for use for material, product or assembly evaluations, mathematical modeling, design purposes, or development and research. The specimen may be tested in thicknesses representative of actual end product or system uses.

1.7 The values stated in SI units are to be regarded as the standard.

1.8 *This standard should be used to measure and describe the properties of materials, products or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.*

1.9 *This standard does not purport to address all of the safety problems associated with its use. Its is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see Section 7.

2. Referenced Documents

3. Terminology

3.1 *Definitions* -- For definitions of terms used in this test method, refer to Terminology E 176

3.2 *Description of Terms Specific to this Standard:*

4. Summary of Test Method

4.1 This test method is based on the observation that, generally, the net heat of combustion is directly related to the amount of oxygen required for combustion (**1, 2**). Burning may be either with or without a pilot ignition applied either at the top or the bottom of the specimen. The primary measurements of oxygen concentrations and exhaust flow rate are made as specified in (**2**). Additional measurements include the mass-loss rate of the specimen, the time to sustained flaming, lateral flame travel rate across the specimen's surface and the specimen's interior temperature.

5. Significance and Use

5.1 This test method is used primarily to determine the heat ~~evolved in, or contributed to, a fire~~ involving products of the test material. Also determined is the effective heat of combustion, mass loss rate, the time to sustained flaming, smoke production , lateral flame travel rate and temperature transmission through the specimen. These properties are determined on a specimen which may be an assembly of materials or products that are tested in their end-use thickness. Therefore, the heat release rate of a wall assembly, for instance, can be determined.

5.2 This test method is applicable to various categories of products and is not limited to representing a single fire scenario. Additional guidance for testing is given in Appendix X____.

5.3 This test method is applicable to end-use products that may not have an ideally planar external surface. The radiant flux field shall be adjusted to be that which is desired at the average distance of the surface from the radiant panel.

6. Apparatus

6.1 General

6.1.1 Where explicitly stated in the following dimensions, dimensions are mandatory and shall be followed within nominal tolerance of ± 5 mm on the radiant panel and specimen holder assemblies. The tolerances permitted in (2) for the proposed room fire test method are permissible.

6.1.2 The apparatus shall consist essentially of the following components: a radiant panel assembly comprised of two elements as shown in Fig. 1. capable of vertical orientation only; a specimen holder (Fig. 2) and the exhaust collection hood of room fire test method along with its associated data collection system. A detailed view of the interaction between the radiant panels and the specimen holder is depicted in Fig. 3. and a general overview of the whole test method is shown in Fig. 4. A top view of the apparatus identifying measurement parameters critical to heater, sample and triangle mask relational geometry is illustrated in Figure 5.

6.2 *Radiant Panels:*

6.2.1 The two radiant panels are mirror images of each other so the following discussion will be applicable to both panels as if there were no difference between them.

GNM 6.2.2 Each panel consists of a hollow 50 x 50 mm square steel tubing, ___ mm thick frame (Fig. 1) which supports three ceramic-faced natural gas burners (designated as upper, middle and lower burners). The tubing has typical residential water hose connections provided at the bottom of the tubing to facilitate water cooling.

6.2.3 Each of the gas burners[1] measures 858 mm in length, 309 mm in height and 127 mm in width (Fig. 6). They are comprised of a plenum space in which the natural gas is injected at a controlled rate by the heater's control system. The heater's face consists of a grid of 16 ceramic elements 12.7 mm thick with a height of 95 mm and a width of 158 mm. The ceramic operating temperature shall be 1029 °C ± 10 °C as measured by the average of two thermocouples. Each of the thermocouples shall be placed in direct contact with the burner's ceramic face at the geometrical center of each of the middle burners and the temperature shall be monitored throughout a test at a frequency rate of not less that one reading per every 5 seconds. The face is covered with stainless 330 floating screen for higher surface temperature and safety. Each burner surface shall have 0.24 square meters of radiating surface. The three gas burners on each panel shall be separated by a distance of 123 mm from each other and shall be attached to the support tubing at the locations indicated in Fig. 1.

Footnote 1 -- A modified RAY-TEC burner unit, RT 132, from Sun Technology Corp., 14329 23 Mile Road, Mr. Celmens, Michigan 48044 has been found suitable for this application.

6.2.4 Natural gas of net heating value at least (790 kJ/mol) shall be supplied to the unit through a control system provided with a safety interlock system. (GNM ----- supply description of voltage potential etc). All gas pipe connections to the heaters must be sealed with a gas pipe compound resistant to liquified petroleum gases. A drip leg shall be installed in the gas supply line going to each heat to minimize the possibility of any loose scale or dirt within the gas supply line from entering the heater's control system.

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6.2.4 The two radiant panels shall be mounted in a stand that will permit their relative ease in adjustment both in separation and angle with respect to their common centerline. Figure 5 shows measurement parameters which have to be adjusted to produce a uniform flux distribution at the location of the sample surface for a desired radiant flux exposure.

6.3 *Sample Holder Assembly:*

The sample holder assembly consists of the Sample Holder, Water-cooled Shield, Weighing Platform and Trolley as discussed in the following four paragraphs:

6.3.1 Sample Holder - The sample holder assembly is shown in Figure 2 and is capable of holding a specimen whose thickness is 152 mm. The top portion of the assembly is removably to facilitate sample insertion. Prior to testing the trolly (6.3.4) shall have positioned the sample holder so that its exposed face shall be no closer than 3048 ± 50 mm from the radiant panel. A drip tray, 100 mm wide x 100 mm deep x 914 mm long, shall be attached to the bottom of the sample holder (the top of drip tray shall be not more than 25 mm below the bottom of the sample) to contain limited amounts of materials that melt and drip.

6.3.2 Water-Cooled Shield - It has been determined that a water-cooled shield (Figure 4) must be provided to absorb the radiant energy from the bottom structural steel elements of the sample holder. If this shield is not in place, radiant energy from the heaters is absorbed by the steel which results in a convective plume of hot gases being formed which travel from the bottom of the sample along its surface. This plume produces "unnaturally" high convective flow rates across the specimen surface and must be eliminated. The shield shall be constructed in a "automobile radiator" fashion or in such a manner that, with a preset water flow sufficiently high enough to keep the exit water temperature below 50°C, the temperature rise of steel elements behind the shield shall not raise more than 12 °C above ambient room conditions.

6.3.3 Weighing Platform - The general arrangement of the sample holder and the weighing platform is indicated in Figure 4. The weighing platform shall be capable of weighing the sample to an accuracy of _____ grams (GEL please fill in with "best" values (i.e. lowest scale). A scale[2] has been found suitable for this application.

GEL

GEL Footnote 2 -- A Fairbanks Scale Model Nr _____ etc. , etc. (GEL please fill in.)

6.3.4 Sample Holder Trolly - A trolly, as shown in Figure 4, shall be provided to hold the Sample Holder, Water-Cooled Shield and Weighing Platform and so that the sample can be moved to a predetermined location in front of the radiant panel at the beginning of a test. The trolly shall be placed or rails or guides to facilitate exact sample placement with respect to the radiant panel. The trolly tracks shall be located perpendicular to the plane of the radiant panel so that the sample is moved directly toward the radiant panel. The trolly tracks shall be long enough to remove the exposed face of the sample holder to a distance of 3048 ± 50 mm from the radiant panel.

6.4 *Sample Shield:*

6.4.1 Prior to testing, the sample shall be protected from the flux of the radiant panel by an aluminum foil faced covered sheet of rigid non-combustible fiber reinforced calcium silicate board having a dry density of 680 ± 50 kg/m^3 and whose size is a minimum of 1220 x 1220 ± 25 mm. A single layer of aluminum foil shall be used to cover the radiation exposed face of the board with the shiny face toward the radiant panel. The aluminum and the board shall be replaced if the aluminum has melted or if the board has obviously been weakened to the point that it can not support the aluminum foil. During insertion of the sample in the sample holder prior to test, the shield shall be in place and located between the sample holder assembly and the radiant panel assembly. It shall be located at a point 914 ± 25 mm on the horizontal sample centerline from the sample toward the radiant panel.

6.5 *Specimen Mounting:*

6.5.1 The specimen shall be placed in the specimen holder by removing the top specimen holder cap section, inserting the specimen and replacing the top cap.

6.5.2 The specimen is to be tested in its end use configuration with no backing materials.

6.6 *Heat Flux Meter:*

6.6.1 The total heat flux meter shall be of the Gardon (foil) or Schmidt-Boelter (thermopile) type, with a design range of about 100 kW/m^2. The target receiving radiation, and possibly to a small extent convection, shall be flat, circular, approximately 12.5 mm in diameter, and coated with a durable matt-black finish. The target shall be water cooled.

Radiation shall not pass through any window before reaching the target. The instrument shall be robust, simple to set up and use, and stable in calibration. The instrument shall have an accuracy of within ± 3% and a repeatability of within 0.5 %.

6.6.2 The calibration of the heat flux meter shall be checked whenever a recalibration of the apparatus is carried out by comparison with an instrument (of the same type as the working heat flux meter and of similar range) held as a reference standard and not used for any other purpose. The reference standard shall be fully calibrated at a standardizing laboratory at yearly intervals.

6.7 *Calibration Heat Flux Meter Holder:*

6.7.1 A holder to facilitate calibration of the heat flux meter shall be constructed from nominal 12.7 mm thick calcium silicate board. The holder shall be the same size as a sample (1000 x 1000 mm) and shall have holes drilled in the locations indicated in Figure 6. (GEL -- please provide drawing -- Fig 6 -- with hole locations).

GEL

6.8 *Calibration Burner :*

6.8.1 The burner specified in Paragraph 5, Ignition Source of (2) or the burner outlined in Annex A, A.1 of (3) shall be used.

6.9 *Thermocouples:*

6.9.1 All thermocouples shall be Type K, Chromel-Alumel.

6.9.2 Thermocouples used for measurement of burner ceramic face temperatures shall be Type K, 0.7 mm or smaller and those monitoring temperature flow through a sample shall be 0.25 mm or smaller.

6.9.3 The location of the minimum number of thermocouples for measurement of homogenous sample temperature shall be at the geometric center of the sample and on the centerline through the sample as follows: Surface, 1/4 depth, 1/2 depth, 3/4 depth and unexposed surface. Other temperatures may be taken as needed to gain specific information such as interface temperatures between assemblies of materials.

6.9.4 The interior thermocouples shall be inserted in holes which have been pre-drilled from the unexposed face of the sample toward the face to the desired depth. These thermocouples shall be sheathed with ceramic insulation. (GEL -- insert the specs on the twin lead, small ceramic insulators). The two wires leading up to the junctions of exterior thermocouples shall be bared for a distance of at least 50 mm on both sides of the junction. Each lead shall be pulled tight so that the bead is contacting the surface and stapled at a point on each wire 25 mm away from the junction. The bead shall be pushed by thumb with moderate force into surface if it will penetrate.

GEL

- Joe's approach with R hands
Optical Pyrometer

6.10 *Pilot burners:*

6.10.1 A top and/or bottom pilot burner may be employed. (Check with JRS, JOE, MARK re: describing a straight methane vs a premixed air/acetylene similar to the LIFT -- They should be gas because we want a bottom flame impingement).

6.11 *Digital Data Collection:*

6.11.1 The data collection system shall be equal to or better than that required in Ref (2). Readings shall be made at intervals not exceeding 6 seconds.

7. Hazards

7.1 The test procedures involve high temperatures and combustion processes. Therefor hazards may exist for burns, ignition of extraneous objects or clothing and for inhalation of combustion products. The operator must use protective gloves and clothes while removing the Sample Shield and while moving the Sample Trolley toward or away

from the radiant panels. The construction of a viewing wall with windows is recommended for laboratories with small spaces where the operator and viewers cannot move far enough away from the area of the radiant panel.

8. Test Specimens

8.1 *Size and Preparation:*

8.1.1 Test specimens shall be 1000 by 1000 mm in area, up to 152 mm in thickness. They shall be representative of the construction of the end-use product. The specimen's shall fit snugly in the sample holder at the beginning of a test.

8.1.2 If a product is designed to normally have joints in a field application, then that specimen shall incorporate the joint detail. The joint shall be centered in the specimen's vertical centerline. The specimen shall also be tested without a joint detail.

8.1.3 Composite and intumescing materials may require special mounting and retaining techniques to retain them adequately within the specimen holder during combustion. Such mounting techniques include the use of a wire grid. The exact mounting and retaining method used shall be specified in the test report.

8.1.4 For samples that melt or drip, a melt trough shall be attached to the specimen holder at the bottom of the specimen.

8.2 *Conditioning:*

8.2.1 Specimens shall be conditioned to moisture equilibrium (constant weight) at an ambient temperature of 23 ± 3°C and a relative humidity of 50 ± 5%.

9. Calibration of Apparatus

9.1 *Heat Flux Calibration:*

9.1.1 Ignite the radiant panel and allow face temperature to come to equilibrium as indicated by each of the two thermocouples measuring the ceramic element temperature (6.2.3) reaching the operating temperature of 1029 °C ± 10 °C and maintaining it for a period of ten minutes.

9.1.2 The holder shall be placed in the same position as a sample and the radiometer inserted from behind through the holes. The target face of the radiometer shall extend 25 mm toward the radiant panel from the exposed surface of the calibration holder to minimize the convective heat transfer.

9.1.3 Adjust the distances d1, d2, d3, d4 and d5 (Fig 5 and Annex Table 1) of the sample holder apparatus and the geometry of the radiant panel sections so that the desired sample flux exposure level is obtained.

9.1.4 The flux uniformity shall be adjusted so that average of all the readings (Fig 6) shall be within ± 5% of the desired flux exposure (e.g., for a desired exposure of 20 kW/m^2 a permissible average of all the readings would lie between 19.0 - 21.0 kW/m^2). No individual readings shall deviate from the average by more than 10%.

9.2 *Heat Release Rate Calibration:*

9.2.1 The calibration shall be performed with the burner (Paragraph 6.8) positioned directly under the hood described in (3) or (4). Measurements shall be taken at least every 6 seconds and shall be started 1 minute prior to ignition of the burner. At steady

state conditions, the time average value taken over 1 minute of the HRR calculated from the measured oxygen consumption and the metered gas input shall agree to within 5% for each level of heat input.

9.2.2 For calibration purposes, HRR determinations shall be made with metered gas flow rates at 20, 40 and 160 kW^2 and with the duct flow set at 0.25 m^3/s.

9.2.3 A HRR calibration test shall have been performed prior to and within 30 days of any testing.

9.3 *Weighing Platform Calibration:*

9.3.1 The calibration of the weighing platform outlined in paragraph 6.3.3 shall be made by placing standard masses on the platform. The masses shall cover the range of expected loads on the platform. (GEL -- please comment on accuracy here..

9.3.2 A calibration test shall have been performed on the weighing platform prior to and within 30 days of any testing.

9.4 *Smoke Meter Calibration:*

9.4.1 The smoke meter shall be that described in Para 9.9 of Ref (2).

9.4.2 The smoke meter is initially calibrated to read correctly for two different value neutral density filters, and also at 100%. Once this calibration is set, only the zero value of extinction coefficient (100% transmission) normally needs to be verified prior to each test.

9.4.3 A calibration test shall have been performed on the smoke meter using the two neutral density filters prior to and within 30 days of any testing.

10. Procedure

10.1 *Preparation:*

10.1.1 Remove the Sample Holder Assembly to its furthermost retracted position.

10.1.2 Turn on the flow of gas to each of the radiant panel assemblies and ignite the radiant panels.

10.1.3 Establish a duct flow of 0.25 m^3/s.

10.1.4 Turn on all sampling and recording devices and establish steady-state baseline readings for at least 1 minute.

10.1.5 For a standard test where gas phase ignition is desired, ignite the top ignition burner. If the flamespread rate across the sample is desired, ignite the bottom burner.

10.1.4 Perform all the required calibration procedures specified in Section 9.

10.1.5 Make sure all gas analyzers are baseline "zeroed".

10.1.6 If temperature flow through the sample is to be monitored, attach the thermocouples as described in Section 6.9.

10.2 *Procedure:*

10.2.1 With the Sample Shield in place, insert the sample into the Sample Holder.

10.2.2 Collect baseline data for 1 minute after the signal from the Weighing Platform settles down to equilibrium.

10.2.3 Remove the Sample Shield and quickly move the Sample Trolly to the location necessary for the desired flux exposure. No more than 5 seconds shall elapse between the time the shield is removed and the sample is in place.

10.2.4 Collect data until 2 min after any flaming or other signs of combustion cease, the average mass loss over a 1 min period has dropped below _____ g/m^2, or until 60 min have elapsed.

11. Test Limitations

11.1 The test data may have limited validity if any of the following occur:

11.1.1 The specimen melts sufficiently to overflow the melt trough,

11.1.2 Explosive spalling occurs.

11.1.3 The specimen swells sufficiently prior to ignition so that it contacts the radiant heater or if, a bottom pilot ignition is being used, it puts out the pilot flame.

11.1.4 HRR is below _____ baseline noise level -- defined ___.

12. Calculations

12.1 General -- Same as 12.1 of Ref (1)

12.2 Calibration Constant Using Methane -- Same as 12.2 of Ref (1)

12.3 Calculations for Test Specimen -- Same as 12.3 of Ref (1)

12.3.1 Heat Release Rate -- Same as A1 of the Annex of Ref (2)

12.3.2 Mass Loss Rate and Effective Heat of Combustion -- Same as 12.3.2 of Ref(1) -- note -- meld the room burn with the cone procedures. Stress cone procedures where possible.

12.3.3 Smoke Obscuration -- Same as 12.3.3 of Ref(1)

(Discuss following with JRS, JOE and MARK -- discuss at meeting..)

12.5 *Lateral Flame Travel Rate: -- phi nr??*

12.6 *Temperature Conduction: Radiative and Convective Heat Transfer*

12.7 *EffectiveThermal Conductivity*

12.8 *Effective Specific Heat:*

13. Report -- Same as 13 of Ref (1) -- note modifications for difference between cone and ISHRR.

14. Precision and Bias

12.1 *Precision:* The task group is actively pursuing the development of data regarding the precision and bias of this test method. Results from the Weyerhaeuser ISHRR are are attached to this Draft.

15. Keywords

15.1 Intermediate Scale Heat Release Rate Apparatus
etc.

ANNEXES

put in the sections regarding calculation of hrr and table for adjusting flux distribution to sample.

APPENDIX
(Nonmandatory Information)

Write up section illustrating need for test method and shortcomings of bench-scale methods.

References

(1) ASTM E1354, Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products using an Oxygen Consumption Calorimeter.

(2) ASTM Proposed Room Fire Test Method, Draft 5/86

(3) ISO/DIS 9705, Fire tests - Full scale room test for surface products

Intermediate Scale Heat Release Rate
240 kW
Propane Gas-Fired
Radiant Panel Assembly

(Assembly is composed of 6 units with each unit having a 40 kW Output)

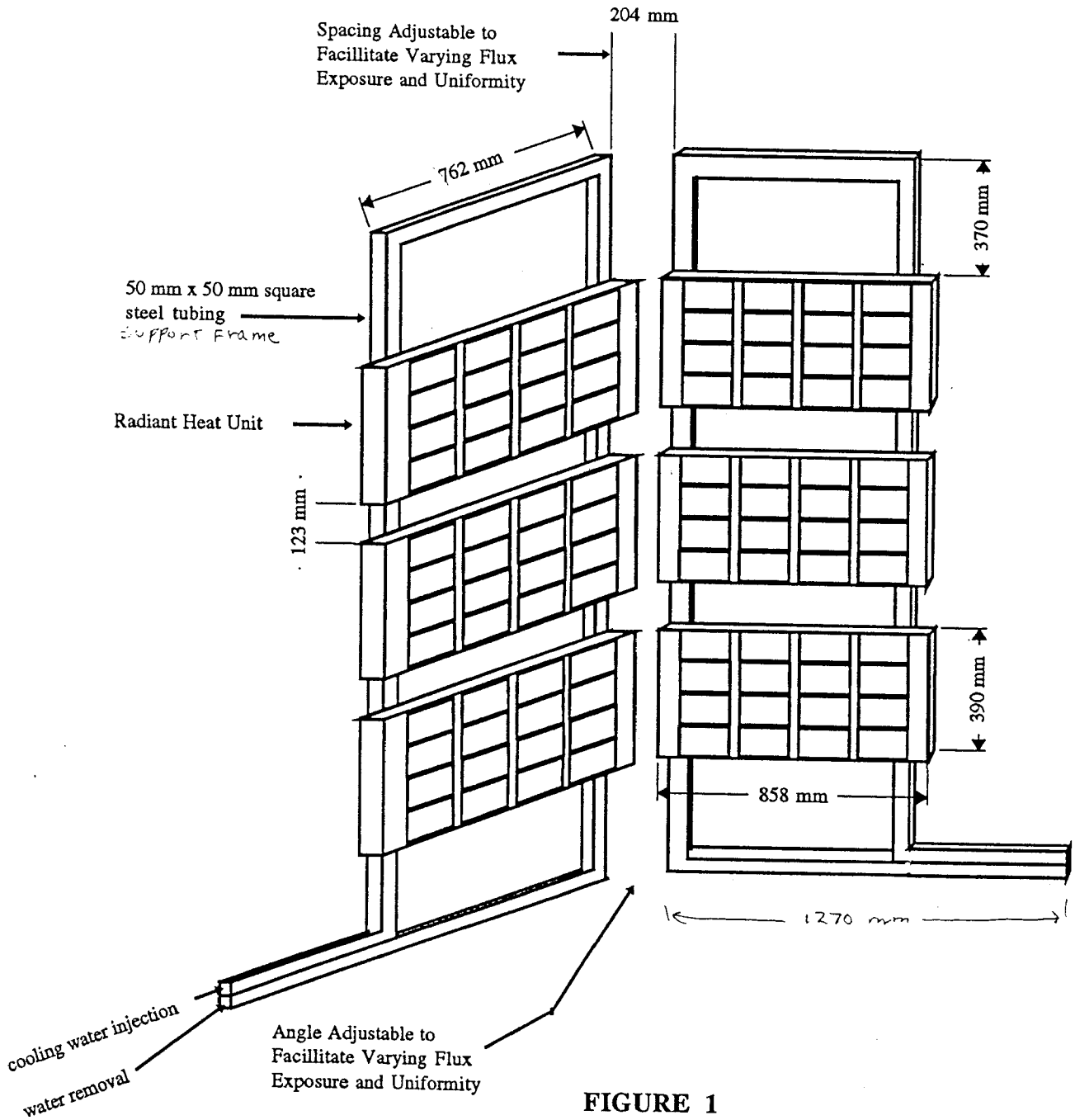

FIGURE 1

Intermediate Scale Heat Release Rate

SAMPLE HOLDER AND WEIGHING PLATFORM ASSEMBLY

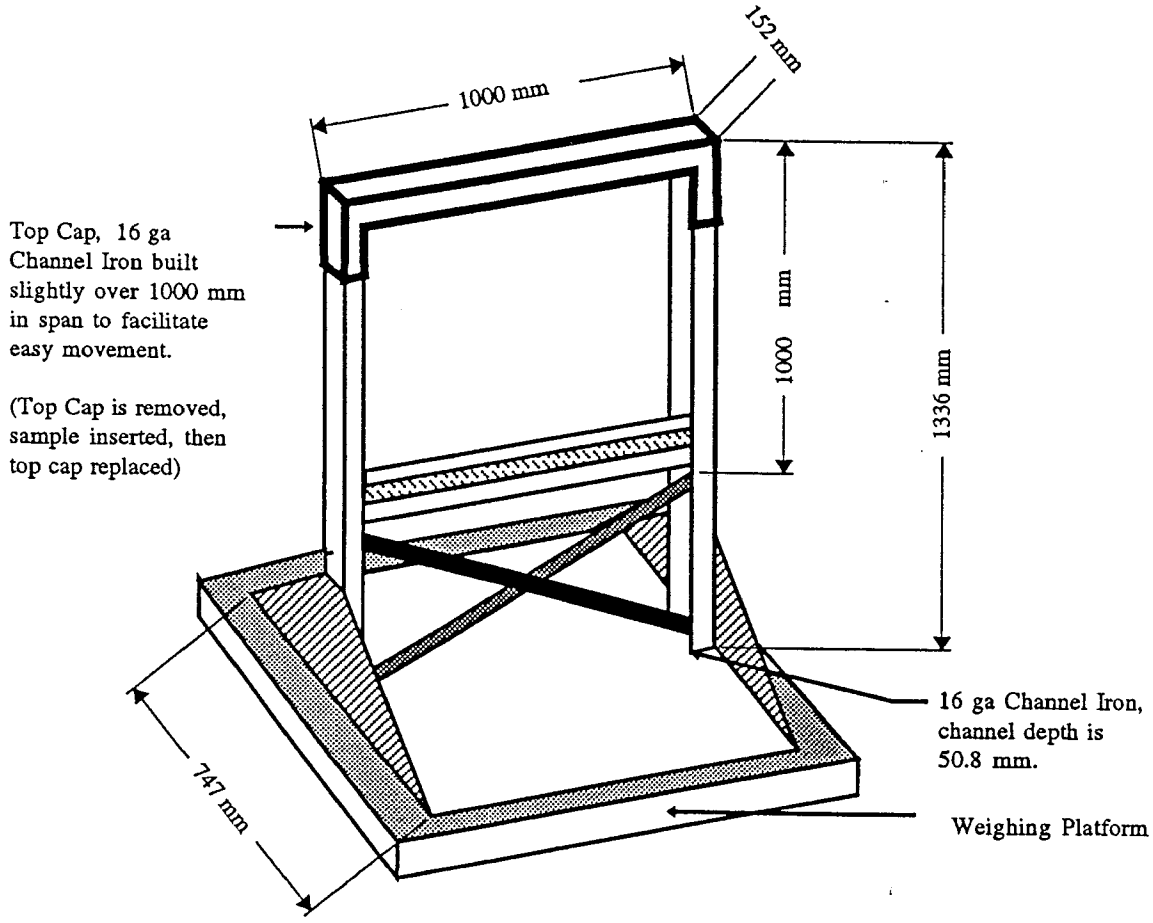

Figure 2

Intermediate Scale Heat Release

Sample Holder in test position

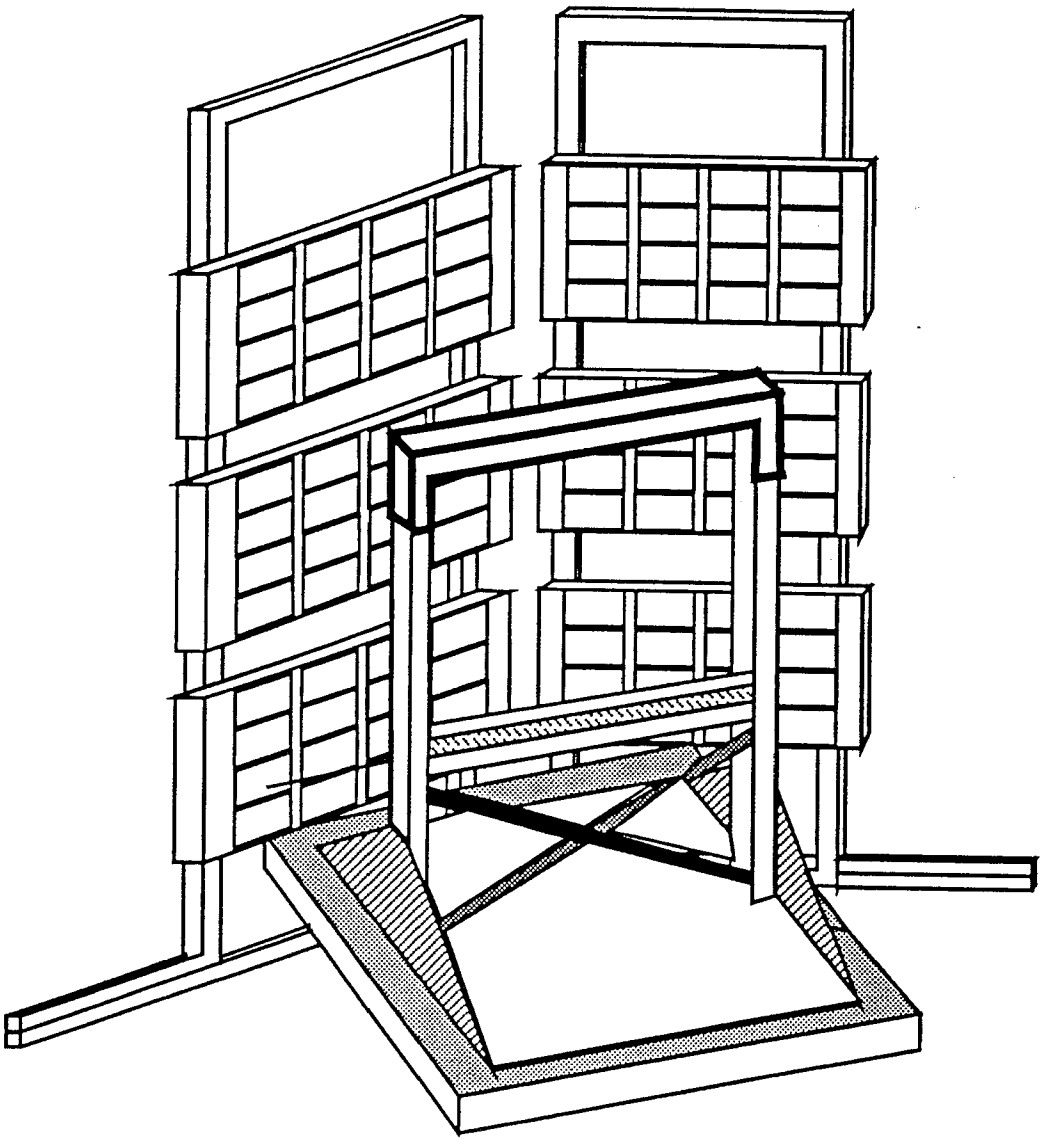

Figure 3

INTERMEDIATE SCALE HEAT RELEASE RATE
GENERAL OVERVIEW

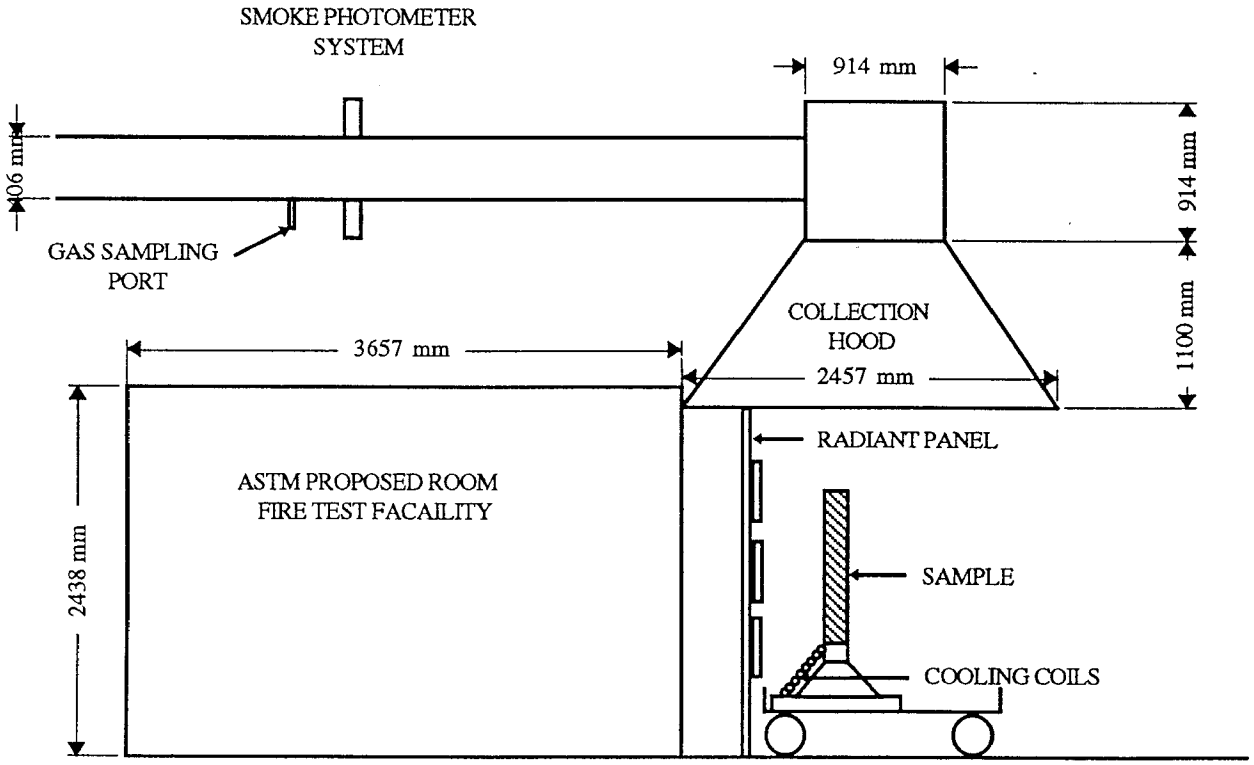

FIGURE 4

Intermediate Scale Heat Release Rate

Top View

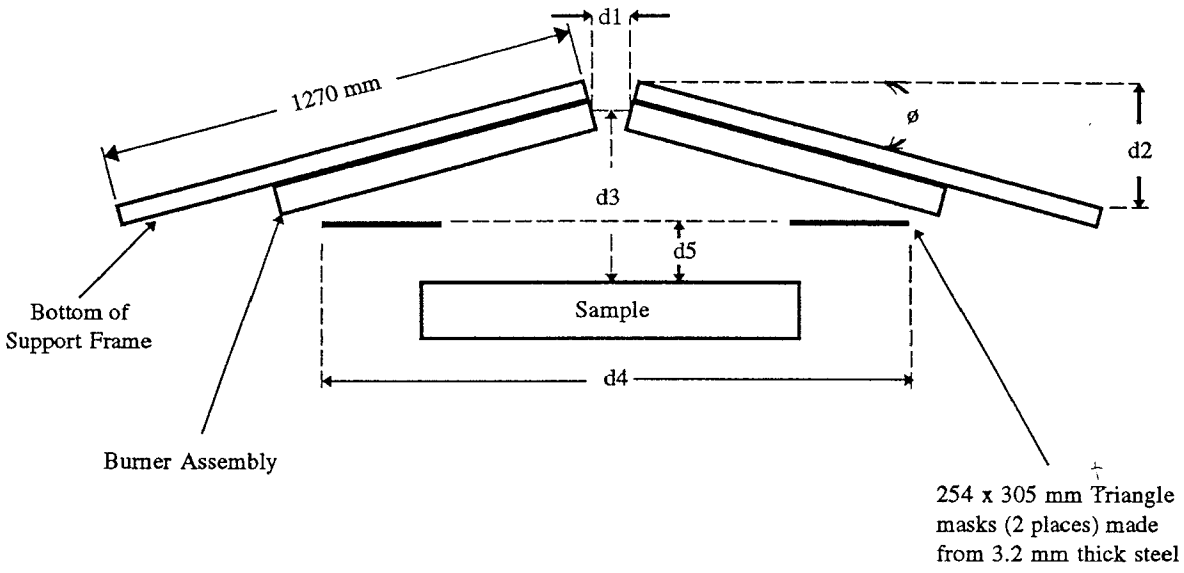

Figure 5

J. White

GNM

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GNM

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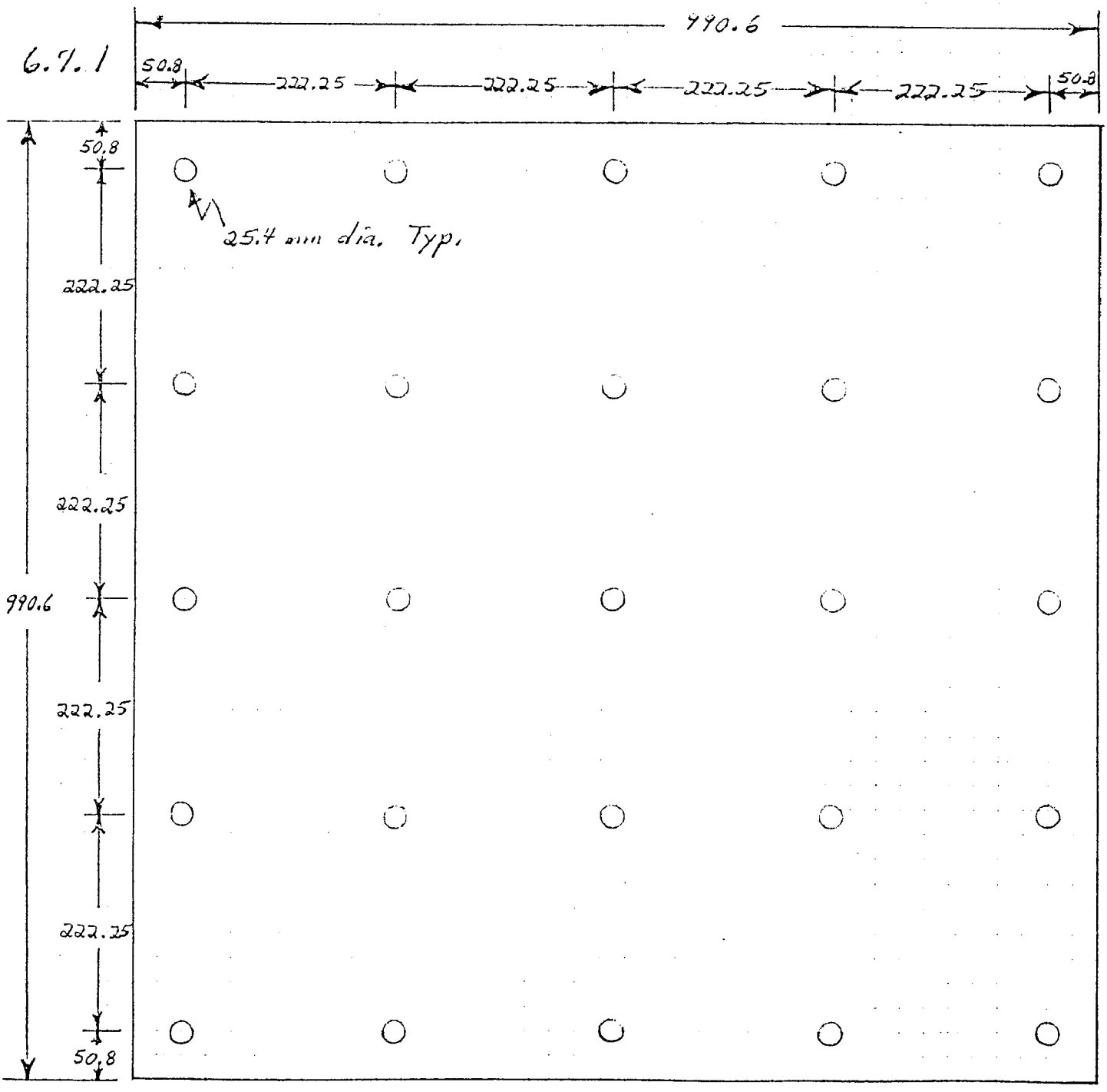
If has been found satisfactory to use the NBSF control system which operates on 110 VAC and features a cycling spark reignited pilot. The pilot turns off when the unit is turned off. All gas is shut off when power is lost or turned off.

6.3.3 Accuracy of 20 grams

Footnote 2 -- A Fairbanks Series 7 Scale with a Model Nr H70-4100A platform and a Model Nr H90-167-1 indicator calibrated for a maximum capacity of 227 kg. Fairbanks Weighing Div., Colt Industries, 711 E. St. Johnsbury Rd., St. Johnsbury, VT 05819

6.7.1



All dimensions in mm