OFFICE WORK STATION HEAT RELEASE RATE STUDY: FULL SCALE vs. BENCH SCALE

by

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SUMMARY

The National Institute of Standards and Technology (NIST) has conducted a study with office work stations to examine their heat release rates and to determine if the peak heat release rate for a work station can be predicted accurately from cone calorimeter results. Fifteen full scale fire experiments were conducted. Three types of work station panel construction and three work station configurations were examined. Preliminary results for the most common panel construction, fabric over fiberglass batting with a 6 mm thick hardboard core, are presented here. A method utilizing the peak heat release rate from the cone calorimeter experiments has been used successfully to predict peak heat release rates for the most common construction work station. This study is part of the Office Building Fire Research Program being conducted at NIST's Building and Fire Research Laboratory under the sponsorship of the U.S. General Services Administration.

INTRODUCTION

The National Institute of Standards and Technology has completed development of a sprinkler fire suppression algorithm[1] for the U.S. General Services Administration (GSA) Engineering Fire Assessment System. As part of that study, fuel packages consisting of office furnishings and equipment were selected and burned to determine their heat release rate characteristics. All of the furniture fuel packages were ignited with a 50 kW natural gas burner, which simulated a small trash can fire.

To determine what "typical" fuel packages should be composed of, a physical survey was taken of furnishings at GSA's Central Office in Washington D.C. Several categories of furnishings or fuel packages were identified. The primary categories were; 1) reception area furnishings, 2) office furnishings, 3) work stations and 4) maintenance carts.

Of the four fuel package categories tested, the work station fuel package category produced the largest range of heat release rates and had the highest heat release rates. The work stations were composed of partitions and laminated wood composite work surfaces with metal support structures. An ABS plastic "tub chair", a computer terminal, and 98 kg of paper products were added to the work station to represent an "in use" configuration based on the survey of typical GSA office conditions.

From this previous study, a work station composed of 2 partitions, forming a corner around the work surface, reached a peak heat release rate of 1.7 MW at approximately 300 seconds after ignition. A work station enclosed by partitions on three sides produced a peak heat release rate of 6.7 MW at approximately 540 seconds after ignition. The fire in the three-sided work station developed slowly until it reached a plateau at approximately 1 MW. Shortly thereafter, the fire rapidly filled the confines of the work station in a manner similar to that of a flashover[1].

Because of the wide spread use of work stations this study was undertaken to examine the potential fire hazard of work stations in an open plan office environment. This study will investigate whether materials or geometry are the major factor effecting the fire performance of work stations. A combination of laboratory scale and full scale tests were used to determine the predominant cause (i.e. the composition of the panels or the geometry of the panels) of the rapid fire growth within a work station.

EXPERIMENTAL APPROACH

Single office work station fuel packages were assembled and "free burned" under a large oxygen consumption calorimetry hood as shown in Figure 1. For a given panel material, three configurations were examined; two-sided, three-sided and four-sided (Figure 2). The fuel packages were composed of wall panels with a shelf assembly, a desk, a chair, a computer terminal and keyboard, and paper and notebooks. A description of the items for a two-sided fuel package is given in Table 1. For the most common panel construction, fabric over a 25 mm thick fiberglass batting with a 6 mm thick hardboard core and an aluminum frame, three replicate tests were conducted for each configuration. The two other types of panel construction, which were used in this study were hollow core and perforated steel. The hollow core type of construction had fabric over a thin fiberglass material (scrim) on 6 mm thick particle board. This formed one face of the panel. Cardboard inserts were used between the two faces to maintain the spacing between the faces. A wooden frame was used around the perimeter of the panel. The perforated steel type of panel construction had fabric over 6 mm thick fiberglass batting over a steel perforated panel with 25 mm thick fiberglass batting in the core. A wooden frame was used around the perimeter of the panel. The results from these panels will be presented in a future report.

All of the work station fuel packages were ignited with a natural gas diffusion flame burner 250 mm long, 185 mm wide and 70 mm deep. The top of the burner was located 380 mm above the floor to represent the height of a trash can. The burner was positioned next to a panel and in front of the desk. The burner was operated at 50 kW for 200 seconds to simulate a small trash can fire as defined by Babrauskas[2,3]. In addition to measuring the heat release rate, radiometers were positioned in the panels opposite the ignition area to measure the radiative heat flux inside the work station.

Cone calorimeter tests were conducted on all of the materials used in an office work station fuel package including the panel assembly, work surface material, chair materials, computer shell material, and paper. The tests were conducted at 35 kW/m^2 and 70 kW/m^2. While 35 kW/m^2 is the heat flux that is recommended in NFPA 264A, Standard Method of Test for Heat Release Rates For Upholstered Furniture Components or Composites and Mattresses Using an Oxygen Consumption Calorimeter [4], the heat flux that the material might actually be exposed to under fire conditions could be significantly higher. Therefore, tests were also performed at double the "standard" heat flux.

The peak rates of heat release from the cone calorimeter experiments were examined for each item. Since most of the samples were composed of layers of different materials, many of the samples had more than one peak. For example, a panel sample could be composed of a top layer of fabric over a fiberglass bat on top of hardboard. As the heat penetrates the sample and the layers burn, a distinct heat release rate peak may be produced for each layer. The highest heat release rate peak of each sample was chosen for use in the prediction calculation.

In previous work station fire experiments, at the time of the peak heat release rate, it appeared that all of the exposed surface areas were burning. Therefore, to predict the peak heat release rate of a fuel package, the heat release rate data from the cone calorimeter, given in heat release rate per unit area (kW/m^2), was multiplied by the exposed surface area of the fuel in full scale. The data from the cone calorimeter was used to predict the full scale peak heat release rate by two methods. A previous study had shown good agreement between full scale fire experiment results for upholstered furnishings and the predicted peak heat release rate using the 180 second average rate of heat release from the cone calorimeter[5]. This was the first method used for this study. The second method used the peak heat release rate from the cone calorimeter tests, regardless of time to occurrence, to predict the full scale, peak heat release rate. The peak heat release rates per unit area from the cone calorimeter experiments for a sample material were multiplied by the exposed surface area of the object made of that material in the full scale office module fuel package. This was done for all of the materials in the fuel package and the heat release rates were added, providing a prediction of the peak heat release rate for the full scale fire test.

RESULTS

Heat release rate data was collected for each work station burn. The work stations had peak heat release rates ranging from 2.8 MW to 6.9 MW. Figures 3 and 4 are representative of the data being compiled for each work station. Figure 3 contains six photographs which provide an illustrative and quantitative time history of the fire growth of a three-sided work station. Figure 4 shows the heat release rate curve compared to T-squared fire curves from NFPA 72[6]. Notice how the fire begins as a "slow"-"medium" growth rate fire and then the slope increases to be representative of an "fast"-"ultra-fast" fire. For the most common panel construction, Figure 5 shows a comparison of the heat release rate curves for two, three and four sided configurations. The fire in the four- sided configuration clearly develops faster and has a peak heat release that is 70% greater than the three-sided case. The peak radiation measured at the panel face inside the work station provides some insight to this phenomomena. The peak radiation, prior to structural collapse of the work station, never exceeded 35 kW/m^2 for the 2 and 3 sided configurations. However, for the four sided configuration the radiation peaked at 90 kW/m^2.

Figures 6 and 7 compare the heat release rate predictions using the cone calorimeter results with the full-scale peak heat release rate data. For all cases, the 180 second average rate of heat release calculation method under predicts the full-scale peak heat release rate data. Utilizing the peak heat release rates from the cone calorimeter at 35 kW/m^2 for the two-sided and three-sided configurations and at 70 kW/m^2 for the four-sided configuration yields reasonable agreement with the full scale results. This is consistent with the heat fluxes realized within the work station, in the full scale fire experiments.

CONCLUSIONS

Based on the results from this experimental series, a data base of heat release rates for office work stations is being developed. This study also demonstrated the effect of work station geometry on the peak heat release rate and the feasibility of predicting the peak heat release rate with cone calorimeter data. Similar analyses will be conducted for the other work stations in the study.

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Table 1. Two-sided work station fuel package components.

Item Description (cm)	Mass (kg)
Desk, high pressure laminate over particle board, 178 X 76 X 76h	101.8
Office chair, plastic outer shell, padded seat, and steel pedestal base	15.9
Partitions: 91.4 X 2.5 X 152.4h (3) 121.9 X 2.5 X 152.4h (1) Fabric over fiberglass batting with 6 mm hardboard core, metal frame, and support poles	69.1
Book shelf with "flipper door" and work light	32
Computer terminal with keyboard	15.9
File boxes with paper, 10 kg (4)	40
Paper, notebooks, file holders, and newspaper	60
Total Load	**334.7**

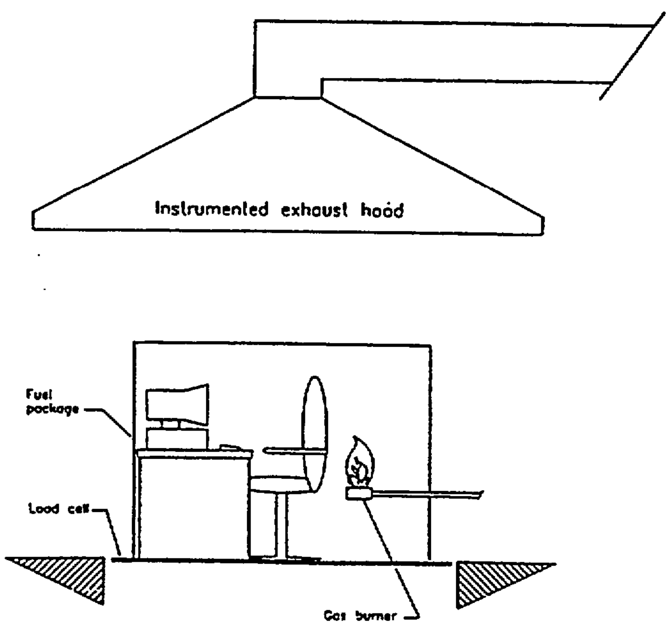


Figure 1. Schematic of experimental configuration.

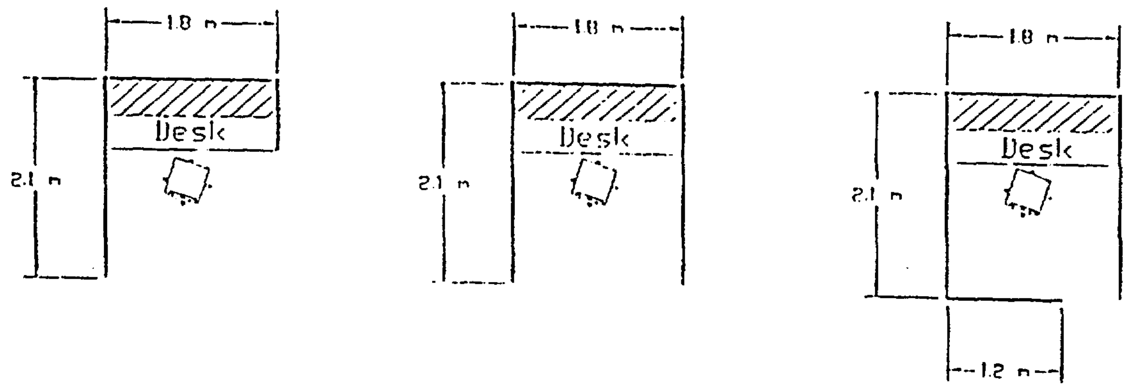


Figure 2. Work station configurations.

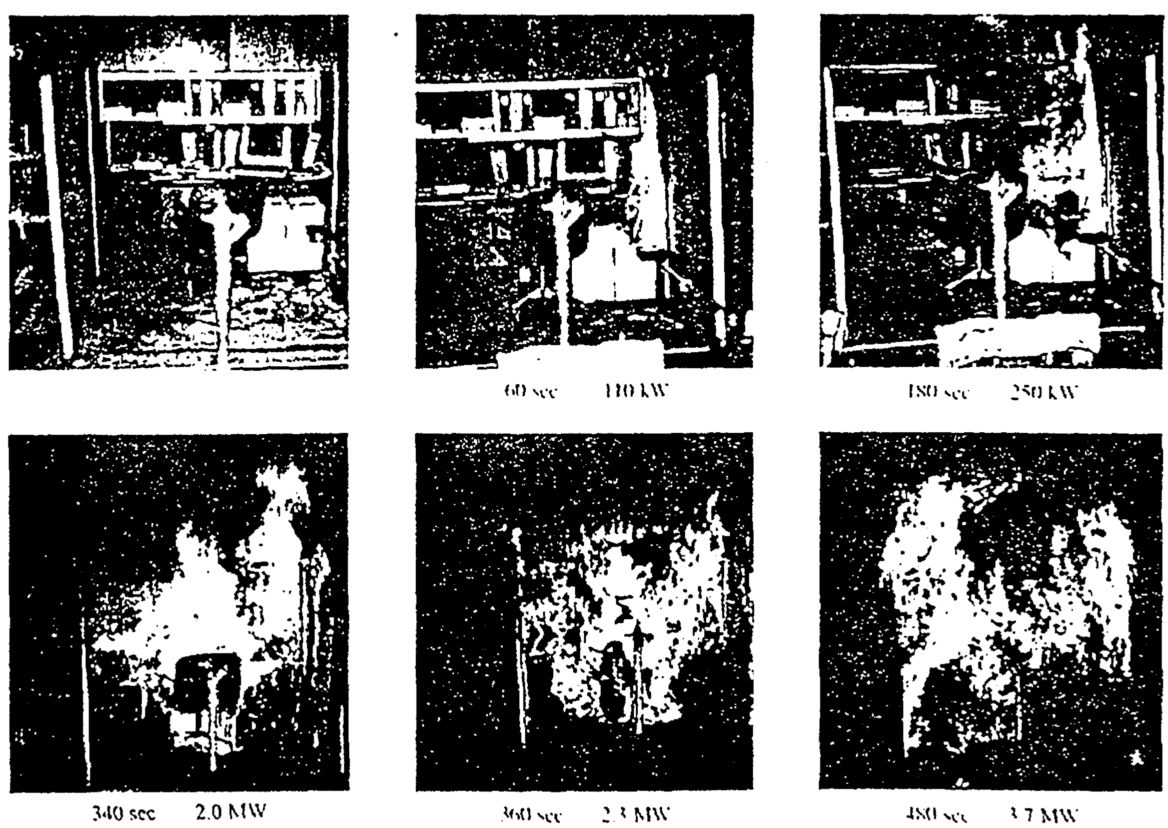


Figure 3. Three-sided work station fire development photographs.

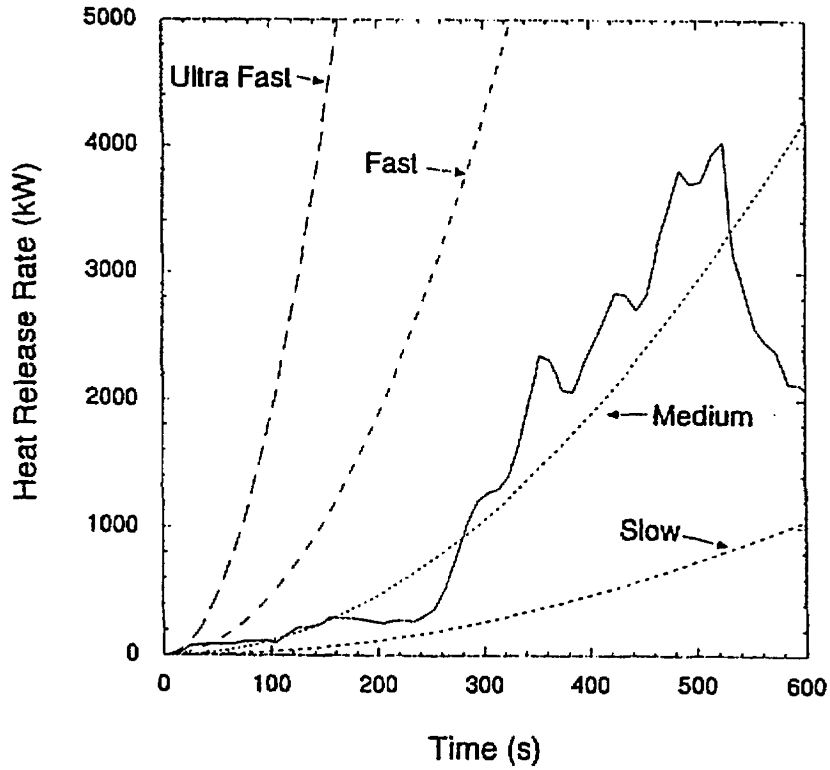


Figure 4. Three-sided work station heat release rate curve compared with "T-squared" curves.

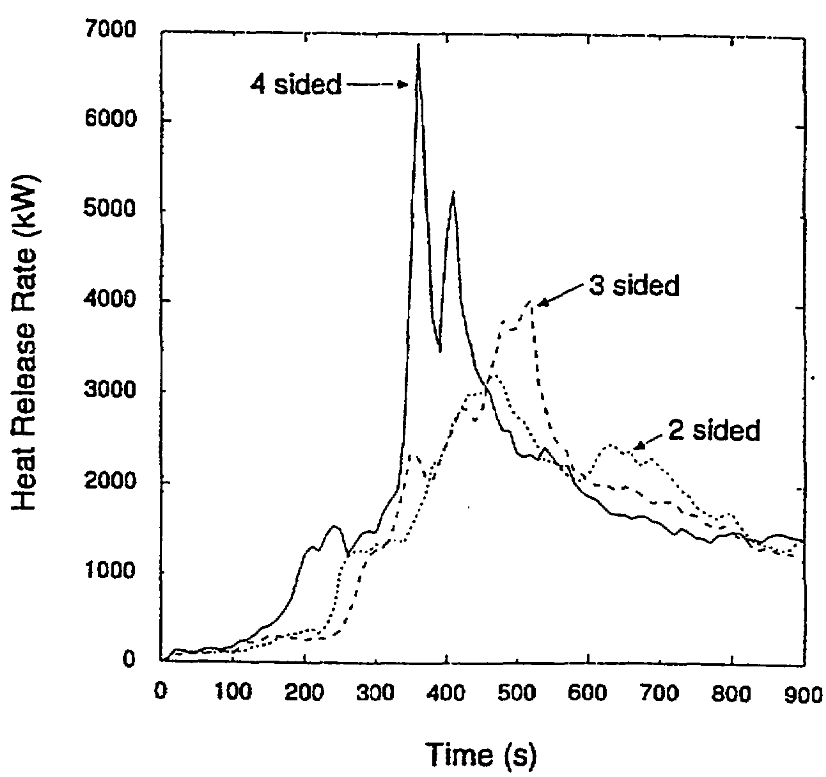


Figure 5. Heat release rate curves for two, three and four-sided work station configurations.

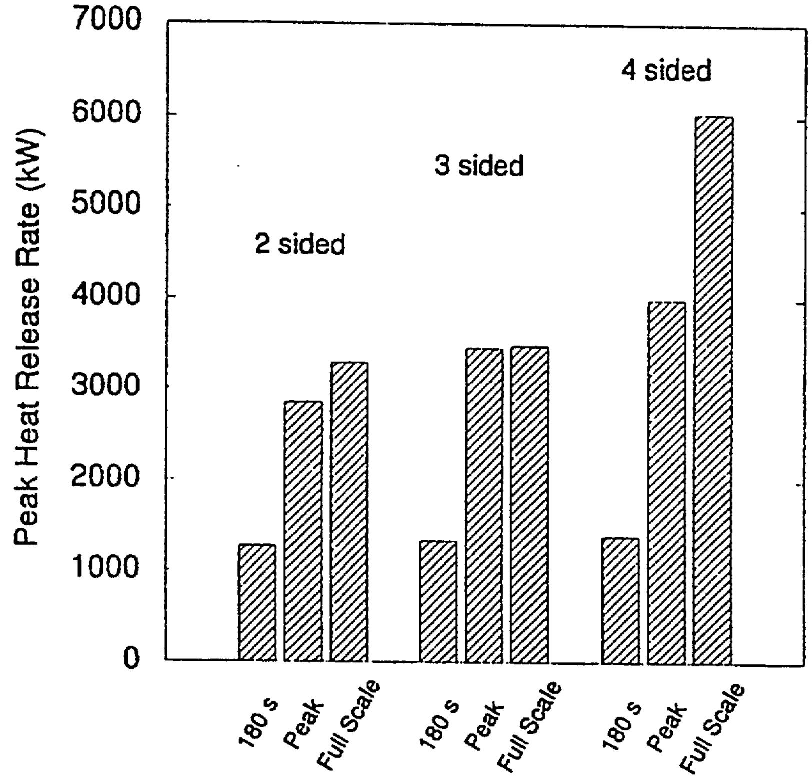


Figure 6. Work station peak heat release rate predictions using the 180 second average and peak from the cone calorimeter at 35 kW/m^2 compared with measured full scale peak heat release rate.

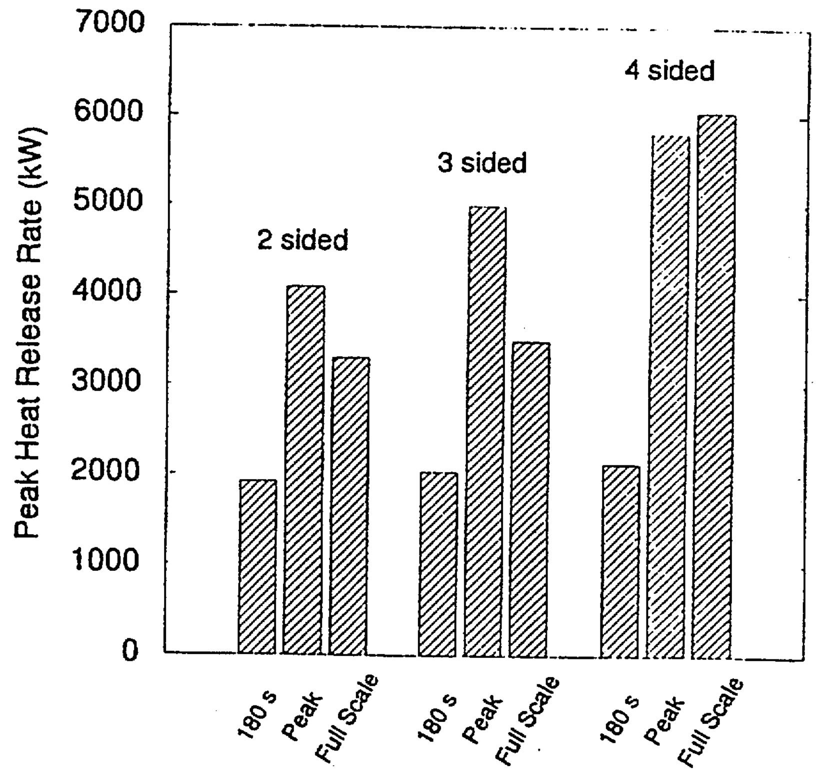
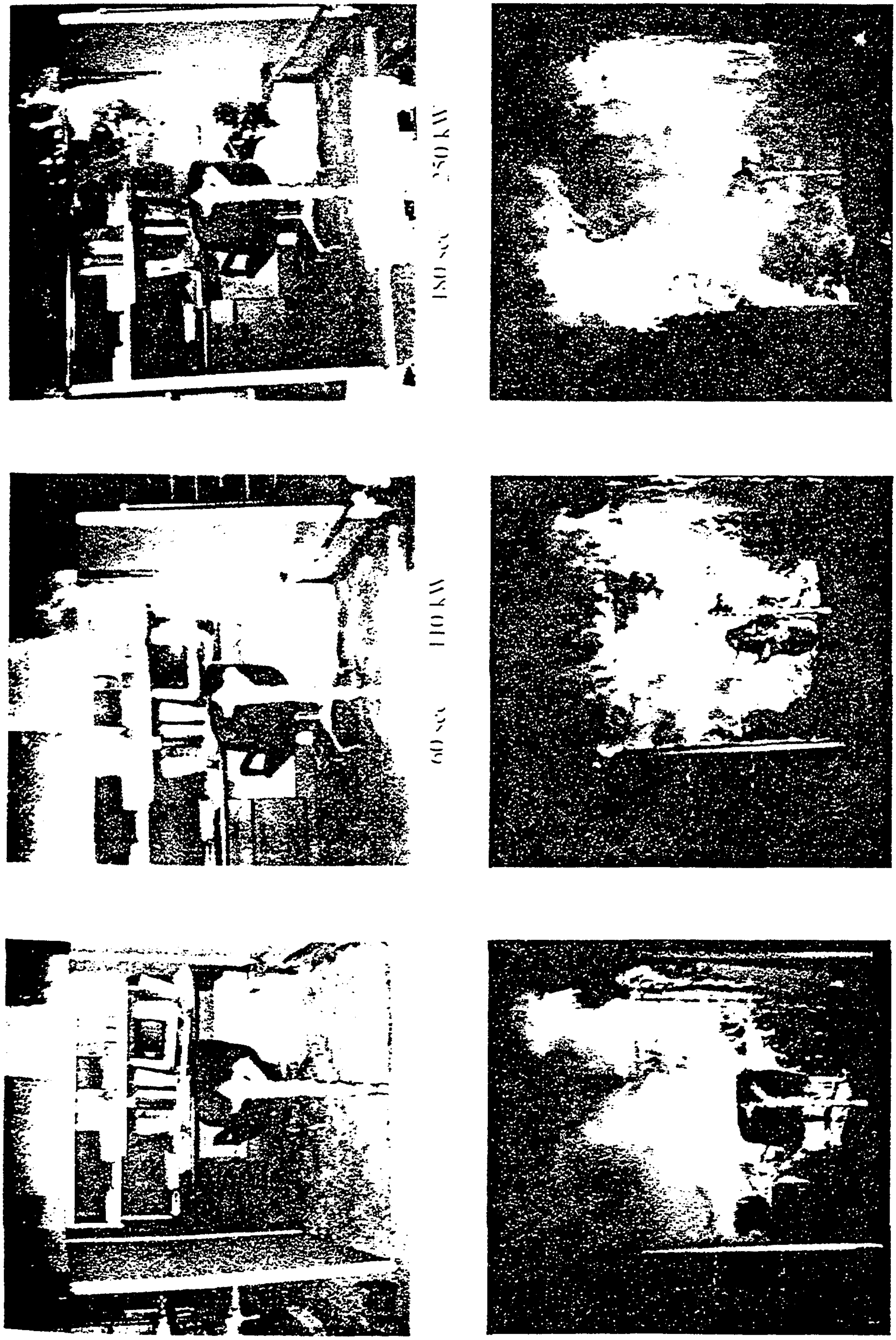


Figure 7. Work station peak heat release rate predictions using the 180 second average and peak from the cone calorimeter at 70 kW/m^2 compared with measured full scale peak heat release rate.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