technical note

Impact of Improved Materials and Cabin Water Spray on Commuter Aircraft Postcrash Fire Survivability

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16. Abstract

Twelve full-scale tests were conducted in a modified Metroliner fuselage to study the impact of using improved fire retardant materials and a cabin water spray system on postcrash fire survivability. Currently, commuter category aircraft as defined in Part 23 are exempt from meeting the stringent Federal Aviation Regulations (FAR's) requiring seat cushion fire blocking layers and low heat/smoke release panels in large transport aircraft.

A zoned cabin water spray system which allowed for the individual activation of spray zones depending on cabin temperature was designed and installed in the fuselage. The system consisted of four 100 inch long zones, each containing 6 nozzles. Of the twelve tests, five were run with the water spray system and a different combination of cabin materials. These five tests were repeated without the water spray system in order to establish baseline data for each material combination.

Two additional tests were conducted to investigate the impact of a partially obstructed forward t and also to evaluate the effect that the channel-type floor geometry used in the Metroliner aircraft has on flame propagation during a cabin fire. Temperature, smoke levels, and gas concentrations were continuously monitored at a forward cabin location and each test was recorded on video.

17. Key Words

Zoned Cabin Water Spray System
Commuter Aircraft
Fractional Effective Dose

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EXECUTIVE SUMMARY

Currently, commuter category aircraft as defined in Part 23 are exempt from meeting the stringent FAR's requirements for seat cushion fire blocking layers and low heat/smoke release panels in large transport aircraft. To determine the potential improvements in postcrash fire survivability from the usage of these more fire resistant materials in commuter aircraft and also from an onboard water spray system under development for large transport aircraft, a series of twelve full-scale fire tests were conducted in a Metroliner fuselage. Test results demonstrated that improved fire resistant interior materials delayed the onset of "flashover", a condition in which the cabin materials ignite and burn very rapidly, consuming large quantities of oxygen and producing intense heat and copious amounts of toxic gases. The tests also showed the dramatic improvement offered by an onboard cabin water spray system for safeguarding against the effects of an external postcrash fuel fire. By spraying only 5 gallons of water, passengers could gain as much as 3 additional minutes of survival time in this size aircraft.

INTRODUCTION

PURPOSE.

The purpose of this report is to present the results of twelve full-scale fire tests conducted in a commuter type aircraft fuselage. The tests investigated the ability of improved fire resistant cabin materials and an onboard water spray system at providing increased survivability during a postcrash fire scenario.

BACKGROUND.

Historically, fire has been the major cause of fatalities during impact survivable type accidents. The scenario most common to this type of accident involves a ruptured fuel tank and the subsequent spillage of jet fuel adjacent to the aircraft. This fuel can erupt into a pool fire which poses a severe threat to the passengers attempting to escape. The fire can enter the cabin through various paths, including an open escape exit. Once inside, the fire may quickly spread, involving the furnishings such as the seats, sidewall panels, and carpet. During the past decade, the Federal Aviation Administration (FAA) has spearheaded rulemaking that provides passengers a longer duration of time before the cabin conditions become nonsurvivable as well as expedite the evacuation process during this type of accident. In order to accomplish this, the FAA introduced rulemaking which addresses the flammability of the cabin materials. Perhaps the most salient of the rulemaking implemented to date has been the mandatory use of fire blocking material in the seats. By delaying the relatively flammable urethane foam used in the cushions from becoming involved, passengers may be offered an additional 40 to 60 seconds of escape time during a typical postcrash cabin fire. Similarly, the use of low heat release interior panels delay the onset of flashover, a condition in which the cabin materials ignite and burn very rapidly, consuming a large quantity of oxygen and producing intense heat. Flashover is the transition point at which the conditions inside the cabin change from survivable to non-survivable in a very short period of time. The use of fire blocking and low heat release panels significantly delay flashover, thereby improving occupant survivability in transport category aircraft fires.

A safety improvement beyond the fire hardening of cabin interior materials can be achieved by using a low flowrate onboard cabin water spray system (reference 1). Originally developed by Safety Aircraft and Vehicles Equipment (SAVE) Ltd., the system consists of an array of nozzles located throughout the cabin, filling the entire volume with a fine mist. The most recent design is based on a zoned concept which allows for the activation of individual areas based on temperature. By doing so, the water can be applied to the area of greatest fire threat, minimize the amount wasted in the more remote areas, and ultimately reduce the amount of water required. During tests conducted in a narrowbody 707, as much as 159 seconds of additional time available for escape were achieved by using only 8 gallons of water (reference 2).

Currently, commuter category aircraft (as defined in FAR's Part 23) are exempt from meeting the very stringent FAR's requirement for the use of fire blocking and low heat/smoke release panels in large transports (new, small transports which contain 19 seats or less are required to meet the current FAR's as defined in Part 25). In an effort to determine the effectiveness of both the improved fire resistant materials and a cabin water spray system in a commuter sized aircraft fuselage, a series of tests were run using various combinations of interior sidewall panels and seats and a zoned water spray system.

DISCUSSION

TEST DESCRIPTION.

Twelve tests were conducted in a fully fire hardened Metroliner fuselage, representing a typical commuter sized, single aisle aircraft cabin. Of the twelve tests conducted, five utilized the water spray system. An additional five tests were run under identical conditions without the activation of water spray in order to provide baseline data for each material combination. In addition to the five water spray and five nonspray tests, two tests were conducted to investigate the impact of a partially obstructed forward exit and also to evaluate the effect that the channel-type floor geometry used in the Metroliner aircraft has on flame propagation during a typical cabin fire.

As shown in figure 1, the interior fire load consisted of four rows of seats, sidewall/ceiling panels (either honeycomb or thermoplastic depending on the test), and carpet in the fire door area. All tests utilized a 4- by 5-foot pan fire adjacent to the aft cargo door opening which measured 53 inches by 66 inches on the outer surface of the fuselage. This opening was made smaller for all tests by placing a sheet of aluminum over it and cutting a 20- by 26-inch opening in its center (same size opening as the overwing exit). This initial breech, which simulated a fuselage rupture, grew in size as the test progressed; the aluminum sheet quickly melted away, exposing the full 53- by 66-inch opening. The fire was drawn into the fuselage opening by a fan located at the forward exit, exhausting outward.

The water spray system was configured in a "zoned" arrangement consisting of four zones, with six nozzles in each zone (figure 2 top). The zones measure 100 inches in cabin length and include two nozzles mounted at the cabin periphery in each of the two boundary planes with the spray discharge directed towards the center of the zone. Specifically, each nozzle is mounted perpendicular to the supply line, and at a 45 degree angle with the vertical traverse plane (figure 2 bottom). Additionally, two nozzles are mounted in the center of the 100-inch zone at the cabin periphery, also perpendicular to the supply line. A zone temperature of 300 ^{o}F (as measured by a centrally mounted thermocouple at ceiling height) was selected to activate the water spray discharge. The average flowrate for all water spray tests was 0.35 gallons per minute (GPM) per nozzle as this flowrate was determined to yield optimum results in previous tests conducted in both narrow- and wide-body fuselages (references 2 and 3).

After two initial conditioning tests which are omitted from this report, four tests were conducted in which the water spray system was utilized. (The tests were omitted because a different type of aluminum sheet, 2024 T3, was used over the burnthrough area. Subsequent tests revealed that the 5052 aluminum sheet which was used in all remaining tests required a much longer period of time to burn away and allow flame penetration. The tests were also omitted because of the "new" condition of the fire hardening inside the fuselage.

Previous testing has shown that a newly fire hardened test article can produce erratic results, possibly due to the reflective nature of the sheet metal before the finish becomes dulled by the heat and smoke. As a rule of thumb, a few preliminary tests are conducted to "condition" a new test article prior to obtaining satisfactory data). A total of five gallons of water was sprayed during each of these tests. The four tests were then repeated under identical conditions without the introduction of water spray.

Because this particular fuselage had such a small diameter, the forward exit door stretched from essentially a few feet above the bottom to a point very near the crown or top of the fuselage. During tests, the heavy smoke generated was observed emanating from the upper half of the forward exit door which acted as an overhead vent. For this reason, the upper half of the forward exit was covered with sheet metal during one test to determine the impact of the reduction in venting (figure 3). Similarly, it was believed that the channel-type floor employed in the Metroliner had the effect of feeding a cabin fire because it would continually allow air/oxygen to enter a fuselage exit/rupture and progress along this "gully type" passage to the fire. This passage was covered up with fire hardening during all the initial tests but removed for the last test to evaluate the effect of the floor as a channel for feeding fresh air to the cabin fire (figure 3). Table 1 summarizes the various material combinations and the results obtained during the tests.

Figures 4 through 9 display the laboratory (OSU rate of heat release test) results of the three different panels used in the fuselage fire tests. As shown, the improved fire resistant honeycomb panel (designated as TMTP 1) exhibits the lowest peak heat release of approximately 30 kilowatts per meter squared (kW/m^2). The thermoplastic panel (designated TMTP 2) produced the lowest heat release rate of 4.2 kilowatts per meter squared minute ($kW\text{-}min/m^2$) and an average peak heat release of 65.87 kW/m^2.

Although the materials used in newly built aircraft (and aircraft undergoing a substantial refurbishment) are required to have a maximum peak heat release not exceeding 65 kW/m^2, this thermoplastic panel was considered a material which met the new regulation since it only failed marginally. Tests were also conducted using panels similar to those currently in service, which displayed relatively high average peak heat release and high heat release rates (TMTP 3).

The fuselage was outfitted with thermocouple trees, smoke meters, gas sampling stations, and video cameras which monitored the conditions inside the cabin (figure 10). A description of the instrumentation follows.

Thermocouple Trees. Three thermocouple trees continuously measured the temperature throughout the cabin. The trees were located at 50, 200, and 340 inches from the forward bulkhead. Each tree consisted of four thermocouple probes positioned from 1 to 4 feet above the floor.

Smoke Meters. A smoke meter (light transmission) station was located 50 inches from the forward bulkhead. Each station contained two smoke meters positioned at 18 inches and 42 inches from the floor level. The smoke meters consisted of a collimated light source and a photocell 1 foot apart.

Gas Analysis. A continuous gas sampling station used to measure carbon monoxide, carbon dioxide, and oxygen was located 50 inches from the forward bulkhead. The station had an intake positioned at a height of 36 inches.

TEST RESULTS

The following analysis compares the results of the tests based on temperature profiles, gas concentrations, and smoke levels within the cabin. In order to determine the effect the various hazards have on survivability, a fractional effective dose (FED) model was used to calculate the survival time at a forward location within the cabin. The recently developed model utilizes the best available data to determine the incapacitation of humans subjected to heat and toxic combustion gases. It assumes that the effect of heat and each toxic gas on incapacitation is additive. The model also assumes that the increased respiratory rate due to elevated levels of carbon dioxide is manifested by enhanced uptake of other gases (reference 4).

TEMPERATURE PROFILES.

Figure 11 displays the range of temperatures between 3 and 4 feet above floor level at station 50 for three selected tests. As shown, the cabin air temperatures were highest during the test in which in-service materials were used (test 10), slightly lower when using fire blocking and low heat release panels (test 5), and even lower when using a water spray system with in-service materials (test 9). Figures 12 and 13 show the temperatures at 3 feet above floor level for eight of the tests. In all comparisons of like material combinations, the water spray system held the temperatures several hundred degrees lower than the identical non-spray test. The temperature was the highest at this station when the in-service ceiling/sidewall panels (TMTP 3) and non-fire blocked seats were used without water spray. Conversely, the temperatures at this location were the lowest when fire blocking was used along with the improved fire resistant thermoplastic type ceiling/sidewall panel and water spray system (test 8). Although the thermoplastic panel yielded a slightly higher peak heat release than the honeycomb panel in the laboratory tests, the rate of heat release of the thermoplastic was actually much lower than the honeycomb. During full-scale conditions, the thermoplastic may appear to be at an advantage because it simply melts away and falls to the floor area where the amount of burning is reduced and the temperatures are lower. The honeycomb panels have a tendency to stay in place and burn, ultimately yielding higher temperatures under full-scale conditions. Although the thermoplastic may appear to be at an advantage under these full-scale conditions, it is important to note that during an actual aircraft cabin fire the melting and subsequent falling away of sidewall materials exposes other materials such as insulation, wiring, and air ducting, all of which do not meet the low heat/smoke requirements. This in turn could result in a much worse condition.

GAS ANALYSIS.

Figures 14 and 15 present the toxic gas levels of carbon monoxide (CO) at station 50. As was the case with temperature, the highest level of CO occurred when in-service materials were used (test 10), slightly lower when seat fire blocking and improved fire resistant panels were used (test 5), and even lower when the materials currently in use were employed in conjunction with a water spray system (test 9). Overall, the lowest level of CO was produced when seat fire blocking and improved fire resistant panels (both honeycomb and thermoplastic) were used in conjunction with water spray (tests 7 and 8).

In figure 16, the production of CO_2 at station 50 (3 foot level) is displayed for eight of the tests. As shown, the levels are highest during tests 4, 5, 6, and 10, (non-water spray tests) and lowest during tests 3, 7, 8, and 9, (water spray tests). Not surprisingly, the highest level of CO_2 occurred when current materials were used and lowest when seat fire blocking and low heat release thermoplastic panels were used in conjunction with a water spray system.

The depletion of oxygen within the cabin parallels the production of CO and CO_2 for all tests in a nearly identical manner (figure 17). As indicated in figure 17, the lowest amount of oxygen depletion occurred during tests 7 and 8, both of which utilized water spray and improved fire resistant materials, including seat fire blocking.

<u>SMOKE LEVELS.</u>

Figure 18 shows a comparison of the smoke level at station 50 at a height of 3 feet 6 inches for four tests: two with advanced materials and no water spray (tests 4 and 5) and two with water spray (tests 8 and 9). As shown, the least amount of light transmission (poorest visibility) occurred during the two tests in which no water was sprayed, even though fire blocking and low heat/smoke release panels were used. The greatest amount of light transmission occurred during the test in which advanced materials were used in conjunction with a water spray system. Even with materials similar to those currently in service, the light transmission was greater than during either of the two non-spray tests with improved fire resistant materials.

<u>FRACTIONAL EFFECTIVE DOSE</u>.

Figures 19 and 20 show the survivability in the forward cabin (station 50) as calculated by the fractional effective dose (FED) model. In figure 19, a comparison is made between tests which used materials currently in-service (test 10), improved fire resistant materials (test 5), and the use of water spray with currently in-service materials (test 9). As shown, nonsurvivable conditions were reached during test 10 in 99 seconds. The use of seat fire blocking and improved fire resistant panels provided an additional 74 seconds (totalling 173 seconds) before nonsurvivable conditions were reached, and the use of water spray (with currently in-service materials) provided 274 seconds of survivability, an additional 175 seconds compared to the test utilizing in-service materials. This comparison illustrates the superiority of a cabin water spray system at providing the greatest increase in survivability in comparison to material fire hardening.

The greatest survivability was achieved by using material fire hardening (low heat release panels and seat fire blocking) combined with a cabin water spray system to yield 358 seconds of survivable conditions.

It is also interesting to note the relatively short duration of survivability in this size fuselage under baseline conditions (99 seconds). During this test, a 4- by 5-foot external fuel fire was required to burn through aluminum skin in which a small (20- by 26-inch) initial breach was cut. In contrast, 213 seconds were required to reach nonsurvivable conditions during a baseline test in a wide-body fuselage in which an 8- by 10-foot fuel pan was used adjacent to a 40- by 80-inch fuselage opening (reference 3). This indicates that the cabin of a small commuter or small transport becomes nonsurvivable much more quickly than the cabin of a large transport.

SUMMARY OF RESULTS

In summary, the air temperatures throughout the cabin were the lowest when using the water spray system. In fact, the temperatures sustained during tests in which in-service type materials and water spray were used were much lower than during tests with improved materials alone (i.e. low heat release panels and seat fire blocking). As shown in previous tests, the water spray lowers the cabin temperatures by controlling the burning rate of materials and by cooling the layer of smoke and gases. The water spray was also most effective at reducing the levels of CO and CO_2 and decreasing the amount of oxygen depletion within the cabin. As was the case with temperature, the production of CO and CO_2 during water spray tests was lower than during any of the nonspray tests, regardless of the materials used.

The same held true for the level of light transmission, and hence visibility, within the cabin. Visibility was improved by the water spray system and lowest during nonspray tests. The water spray also provided greater visibility during the test in which in-service materials were used than with either of the nonspray tests with advanced materials.

In general, there were measurable increases in survivability by using the low heat release panels and seat fire blocking. There was also a marked increase in survivability when the thermoplastic panels were used versus the honeycomb type panels. As mentioned previously, the thermoplastic panels have a tendency to melt and fall to the cabin floor while the honeycomb panels stay in place and burn resulting in more gas production, higher cabin temperatures, and ultimately less survival time.

CONCLUSIONS

As shown during this series of tests run in the commuter type fuselage, the use of a cabin water spray system has the ability to yield the largest increase in survival time, surpassing the performance of any of the material fire hardening improvements.

By using the fractional effective dose model to calculate survivability, it was determined that the conditions within the Metroliner fuselage became non-survivable in 99 seconds when using materials similar to those which are currently in service. By using an identical material combination in conjunction with a water spray system, an additional 175 seconds of survival time was achieved for a total of 274 seconds of protection. A comparison of the other three combinations of materials with and without water spray yielded similar results: an average improvement of 175 seconds of escape time (table 2). Since the zoned spray system required only 5 gallons of water, this calculated to 35 additional seconds of escape time gained per gallon of water sprayed. The survival increase achieved by using improved fire resistant materials such as low heat/smoke release panels and seat fire blocking was not as significant; an additional 74 seconds of survival time was realized, totaling 173 seconds of protection.

The results indicate that it is quite feasible to develop a lightweight and simplistic zoned water spray system to extend occupant survivability in commuter sized aircraft. This type of system could be used in lieu of the use of improved fire resistant cabin materials (such as those currently required on transports) or in conjunction with these materials for maximum safety.

REFERENCES

1. Hill, R. G., Sarkos, C.P., and Marker, T. R., Development and Evaluation of an Onboard Aircraft Cabin Water Spray System for Postcrash Fire Protection, SAE Technical Paper No. 912224, presented at Aerotech '91, September 24-26, 1991.

2. Marker, T., Narrow-Body Aircraft Water Spray Optimization Study, DOT/FAA/CT-TN93/3, February 1993.

3. Marker, T., Wide-Body Cabin Water Spray Optimization Tests, DOT/FAA/CT-TN93/29, August 1993.

4. Speitel, L. C., Toxicity Assessment of Combustion Gases and Development of a Survival Model, DOT/FAA/CT-91/26, to be published.

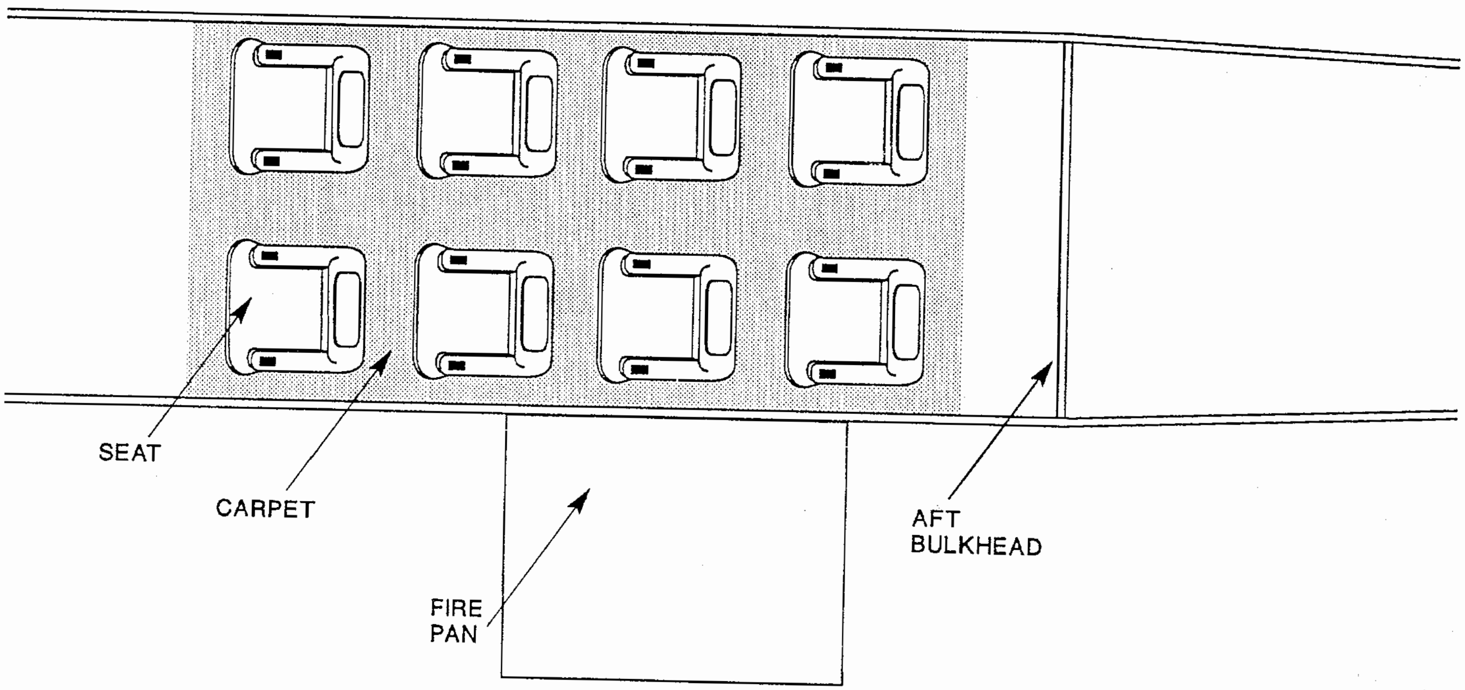


FIGURE 1. METROLINER TEST CONFIGURATION

COMMUTER FUSELAGE WATER SPRAY TESTS

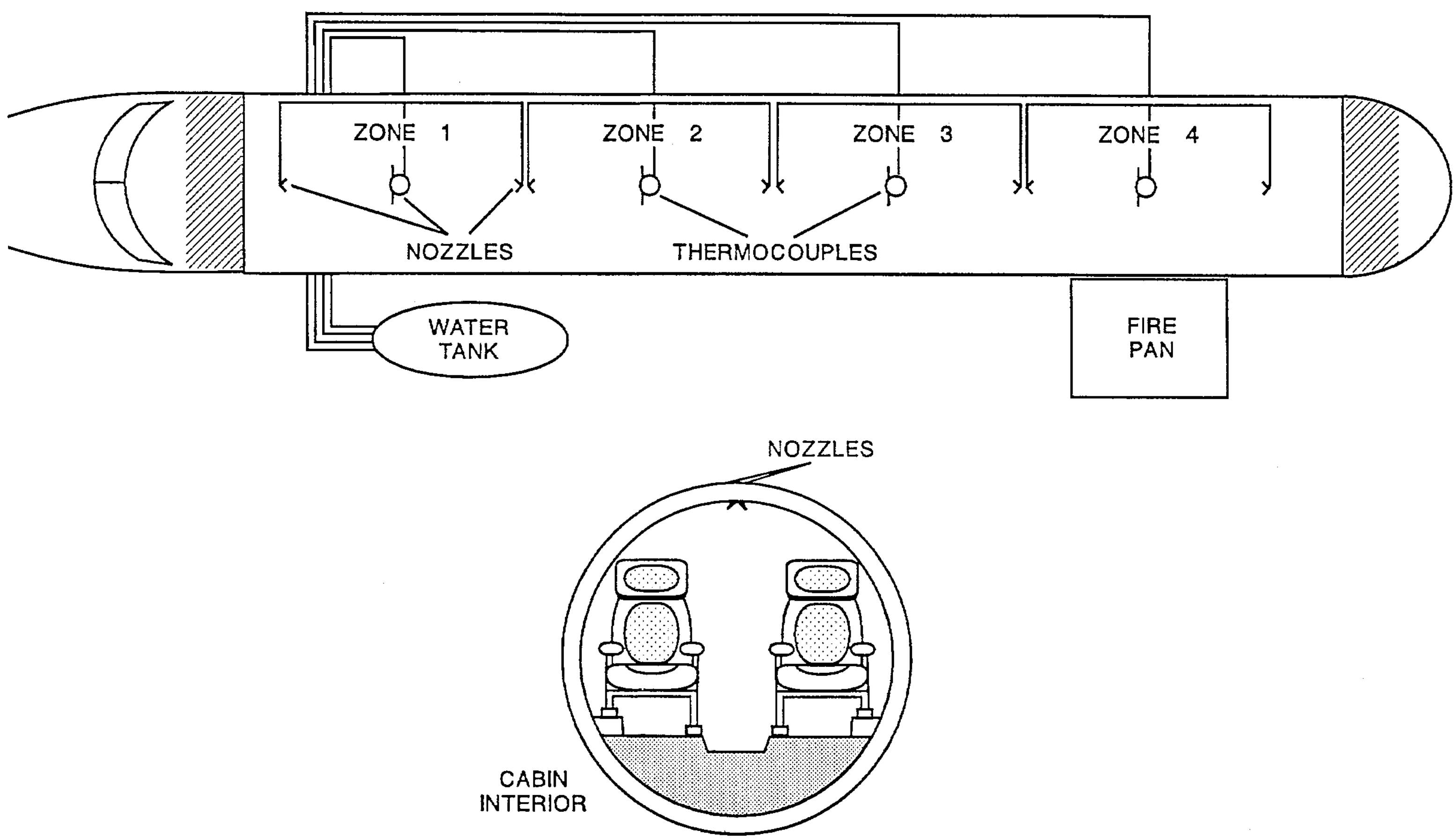


FIGURE 2. WATER SPRAY SYSTEM

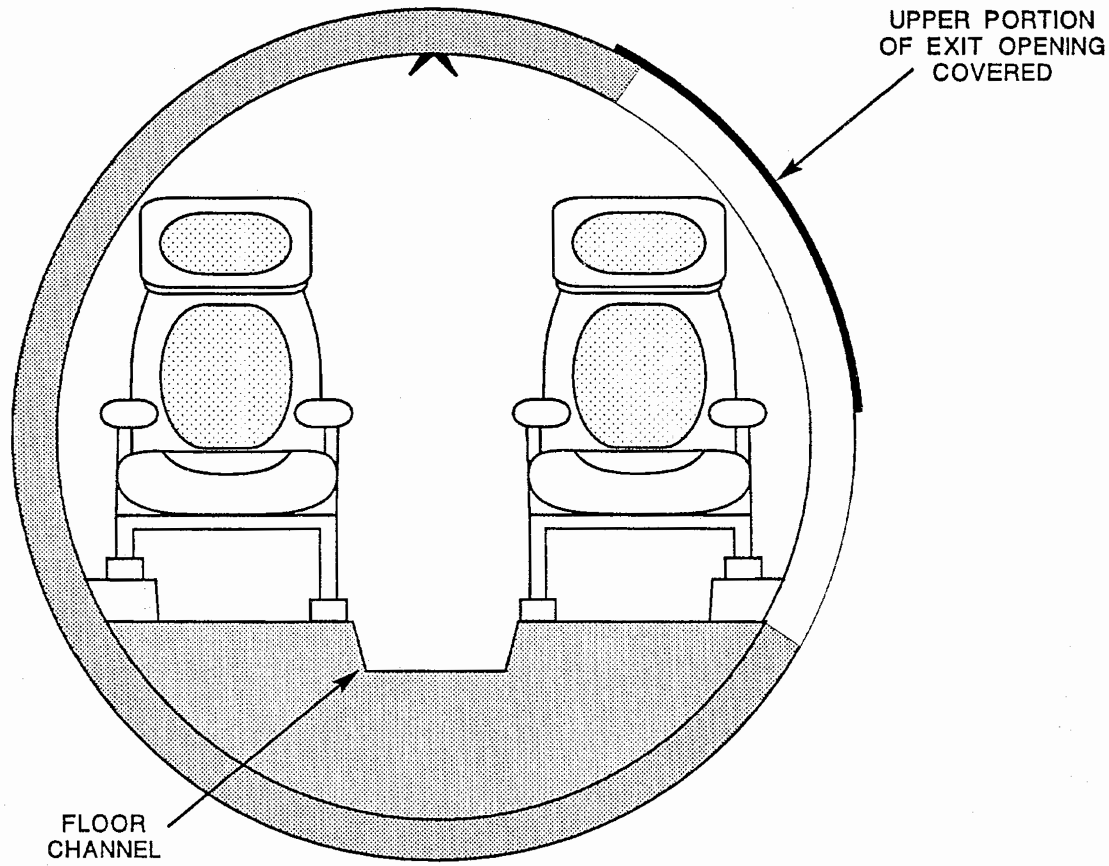
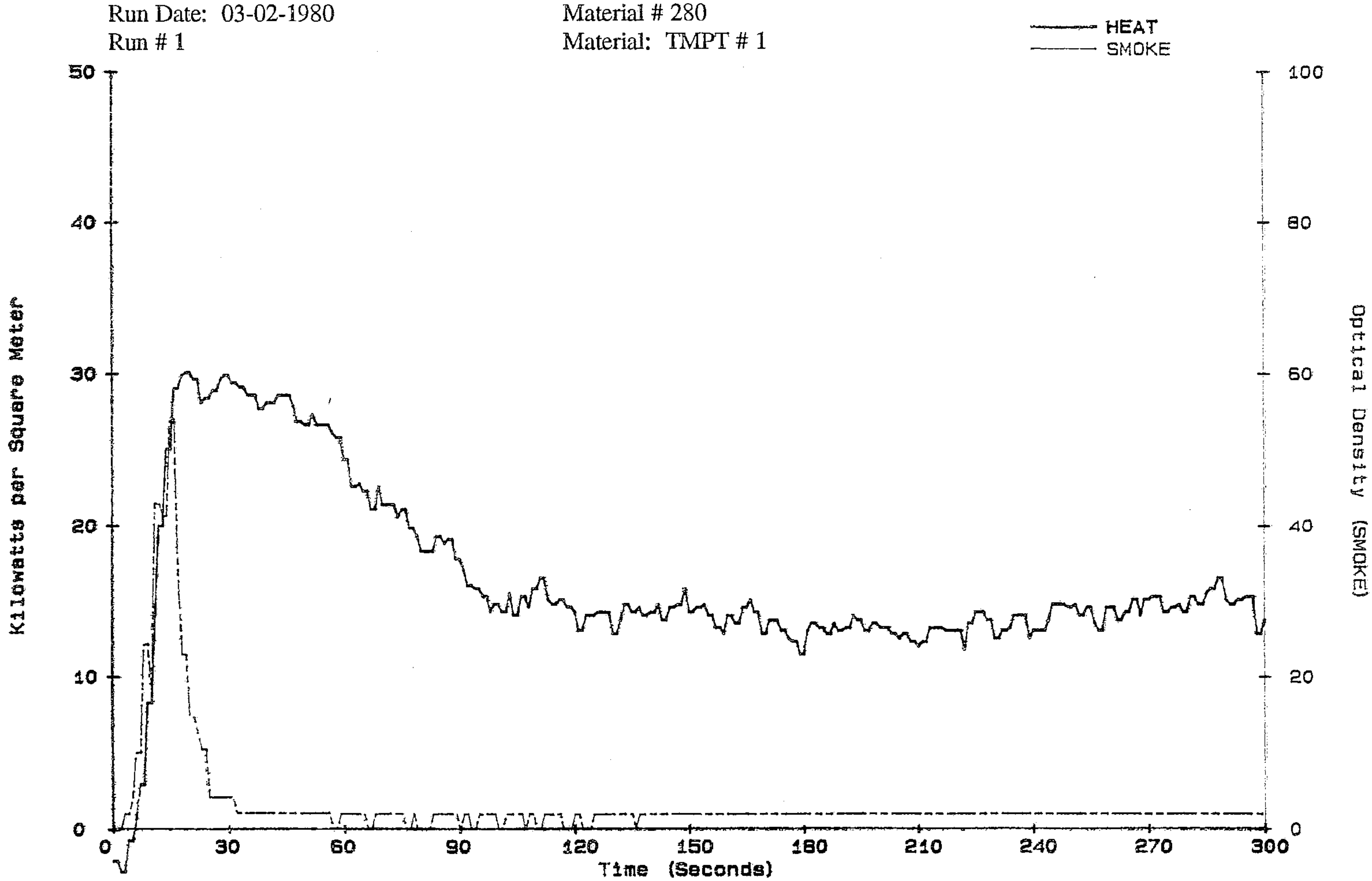


FIGURE 3. FUSELAGE ARRANGEMENT FOR ADDITIONAL TESTS

FIGURE 4. OSU RATE OF HEAT RELEASE RESULTS (TMTP #1)

Run Date: 03-02-1980
Run # 1

Material # 280
Material: TMPT # 1



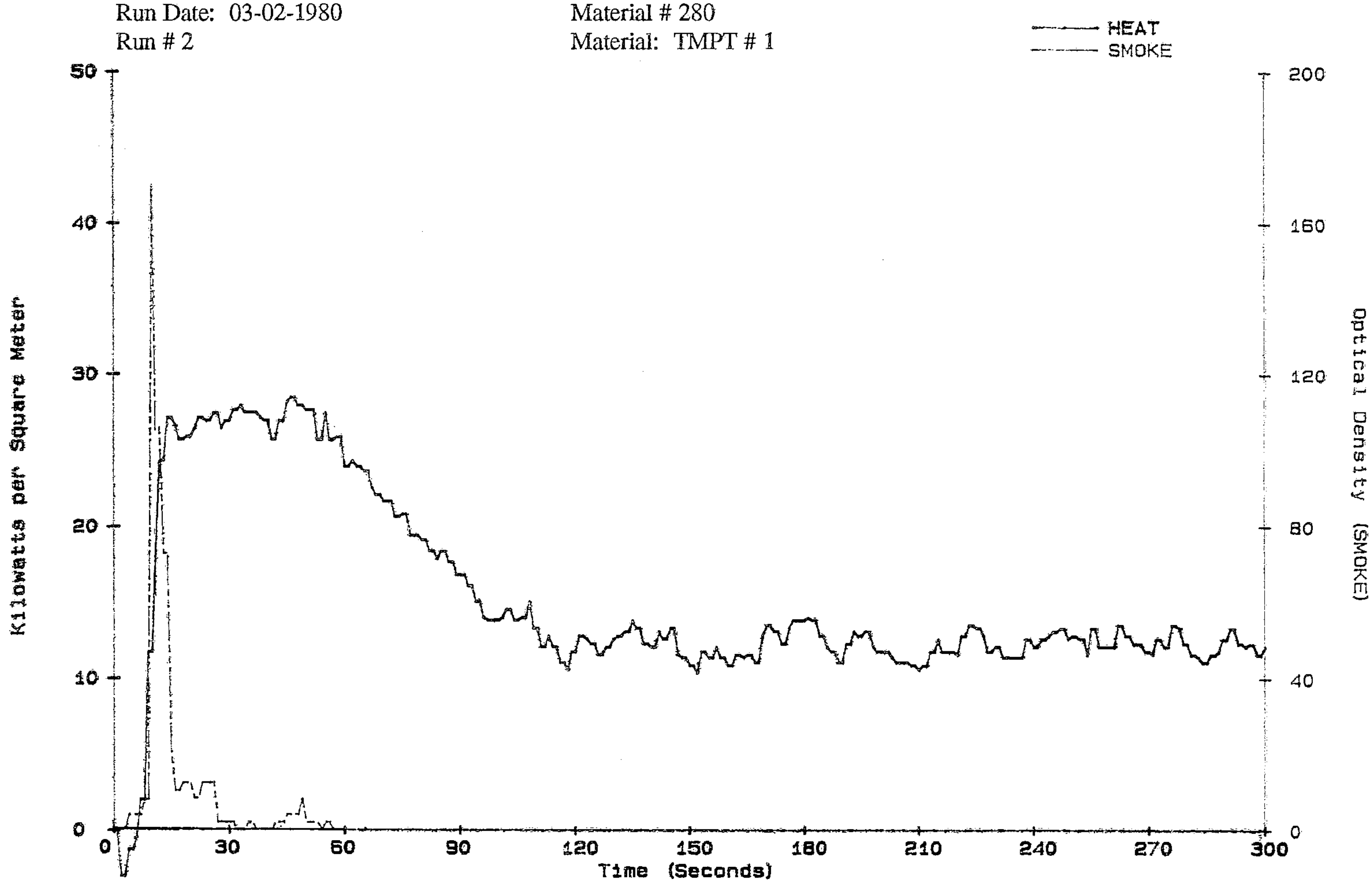
Heat Release Rate is 40.93 (kW-min/m²)
Heat Release Peak is 30.13 (kW/m²)
Heat Release Factor is 10.29

Smoke Release Rate is 11.36 SMOKE/min
Smoke Release Peak is 54.00 SMOKE

FIGURE 5. OSU RATE OF HEAT RELEASE RESULTS (TMTP #1)

Run Date: 03-02-1980
Run # 2

Material # 280
Material: TMPT # 1



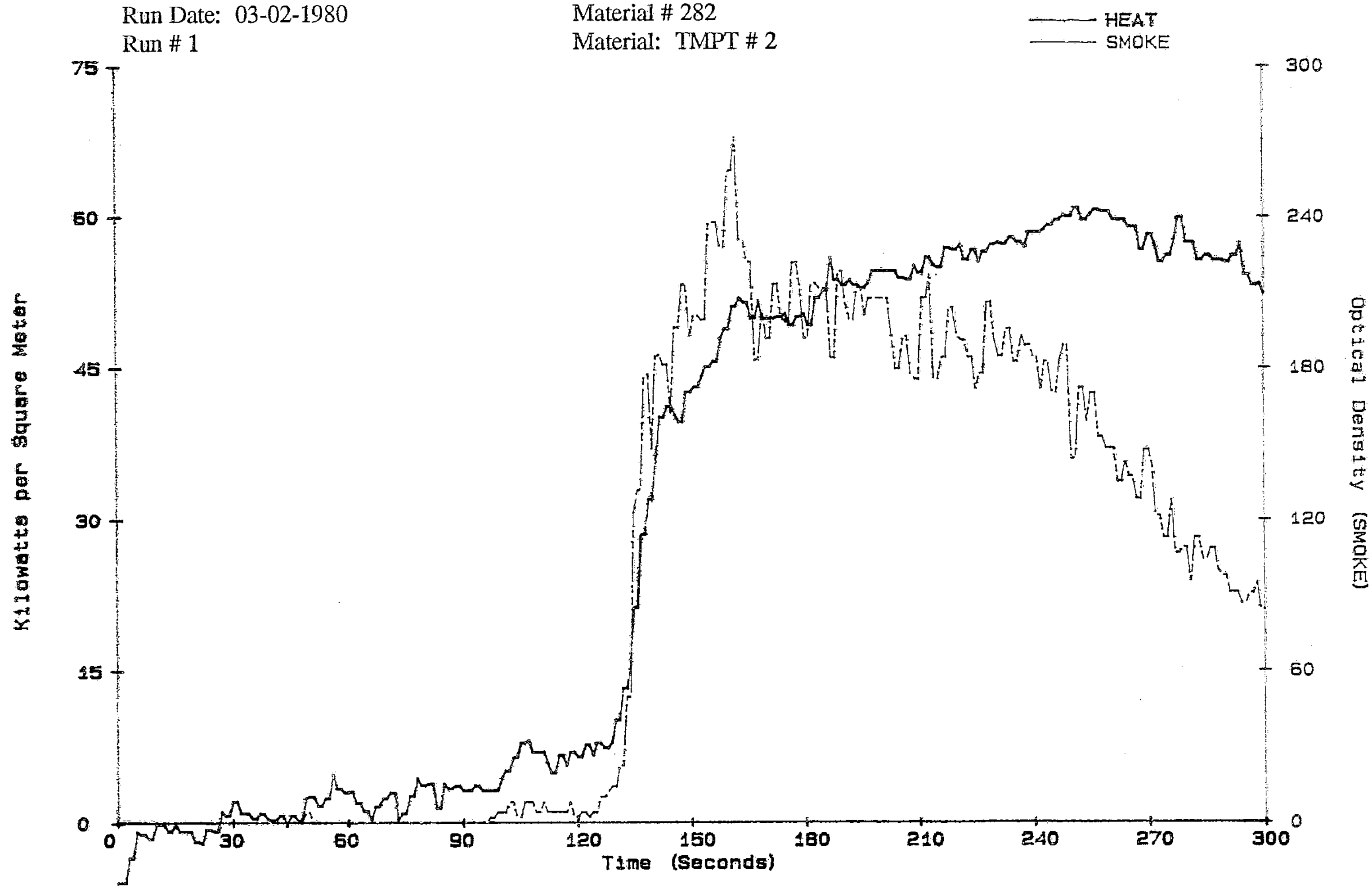
Heat Release Rate is 39.51 (kW-min/m²)
Heat Release Peak is 28.47 (kW/m²)
Heat Release Factor is 10.29

Smoke Release Rate is 12.71 SMOKE/min
Smoke Release Peak is 169.81 SMOKE

FIGURE 6. OSU RATE OF HEAT RELEASE RESULTS (TMTP #2)

Run Date: 03-02-1980
Run # 1

Material # 282
Material: TMPT # 2



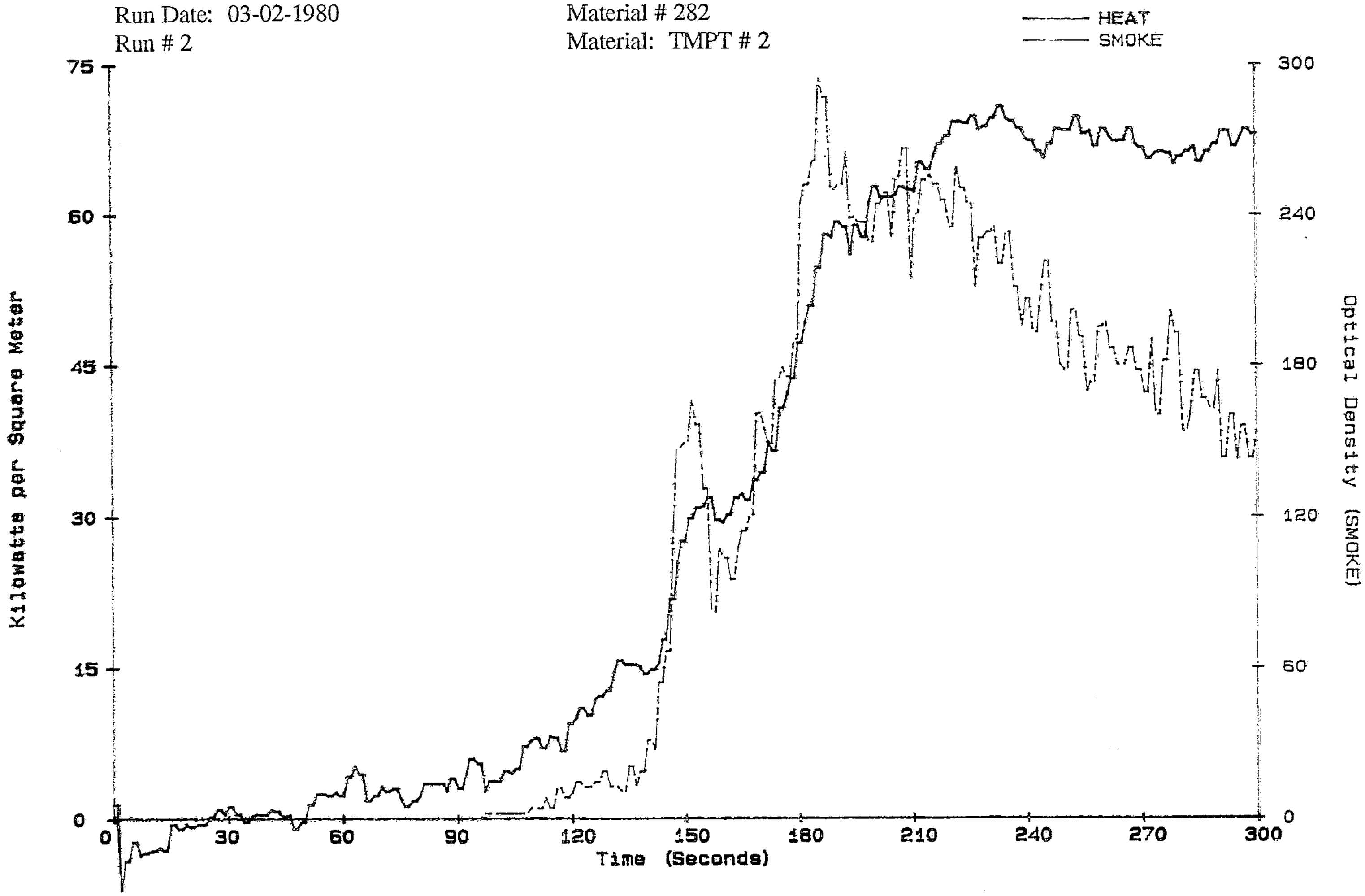
Heat Release Rate is 4.21 (kW-min/m²)
Heat Release Peak is 60.92 (kW/m²)
Heat Release Factor is 10.29

Smoke Release Rate is 2.05 SMOKE/min
Smoke Release Peak is 271.55 SMOKE

FIGURE 7. OSU RATE OF HEAT RELEASE RESULTS (TMTP #2)

Run Date: 03-02-1980
Run # 2

Material # 282
Material: TMPT # 2



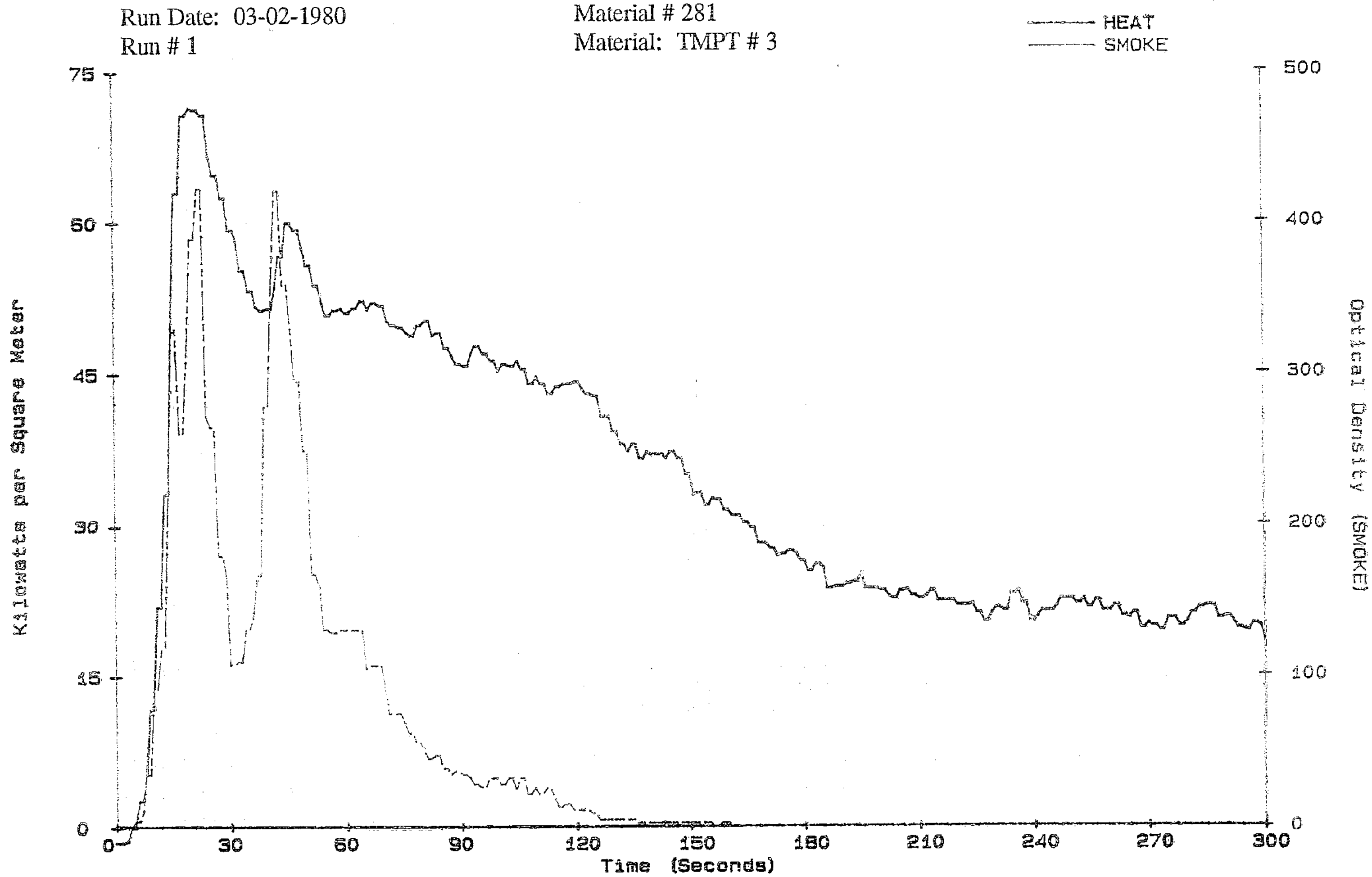
Heat Release Rate is 4.22 (kW-min/m²)
Heat Release Peak is 70.81 (kW/m²)
Heat Release Factor is 10.29

Smoke Release Rate is 1.82 SMOKE/min
Smoke Release Peak is 294.37 SMOKE

FIGURE 8. OSU RATE OF HEAT RELEASE RESULTS (TMTP #3)

Run Date: 03-02-1980
Run # 1

Material # 281
Material: TMPT # 3



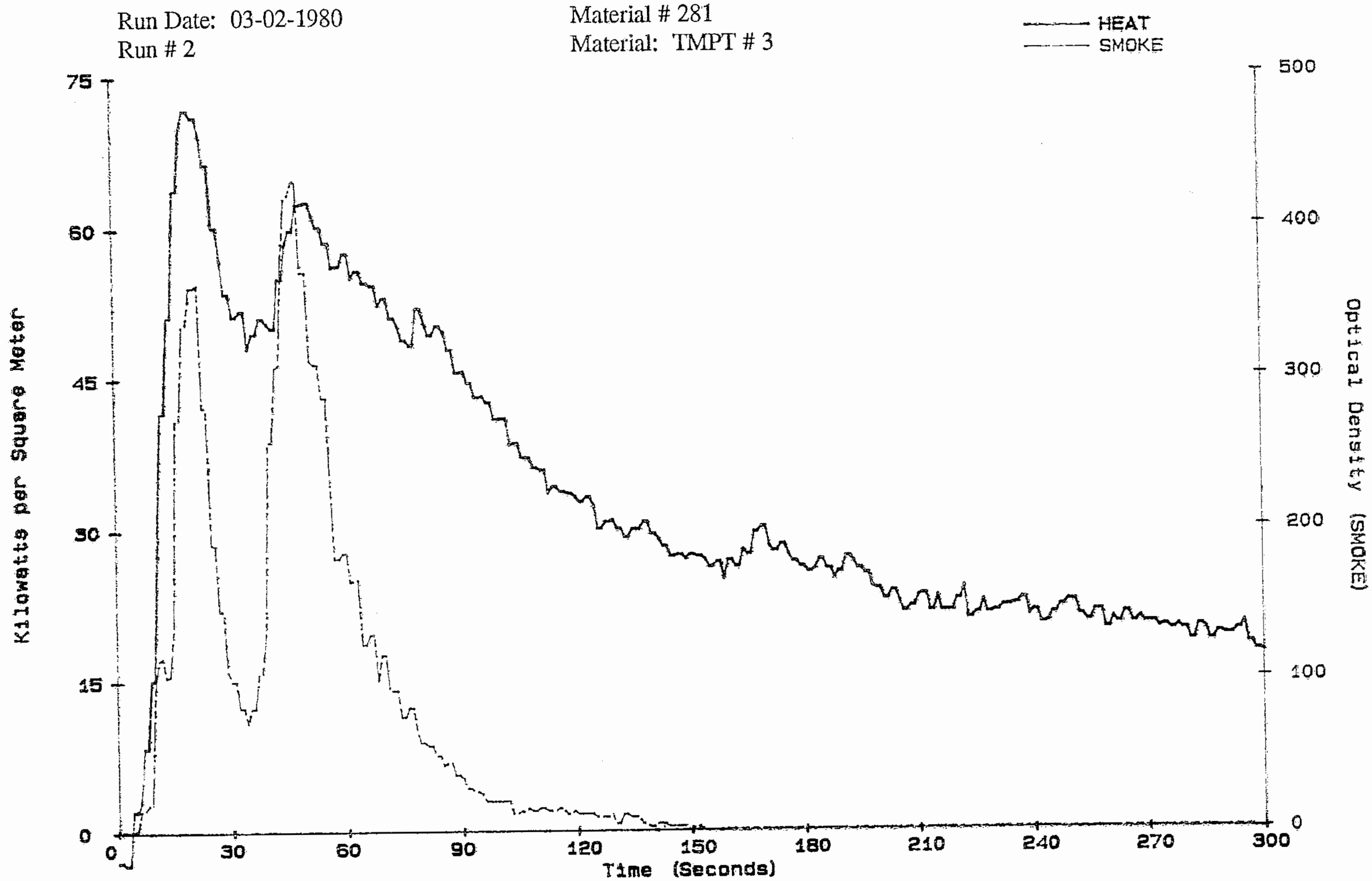
Heat Release Rate is 94.54 (kW-min/m²)
Heat Release Peak is 71.52 (kW/m²)
Heat Release Factor is 10.29

Smoke Release Rate is 242.19 SMOKE/min
Smoke Release Peak is 422.27 SMOKE

FIGURE 9. OSU RATE OF HEAT RELEASE RESULTS (TMTP #3)

Run Date: 03-02-1980
Run # 2

Material # 281
Material: TMPT # 3



Heat Release Rate is 93.11 (kW-min/m^2)
Heat Release Peak is 71.83 (kW/m^2)
Heat Release Factor is 10.29

Smoke Release Rate is 246.42 SMOKE/min
Smoke Release Peak is 431.63 SMOKE

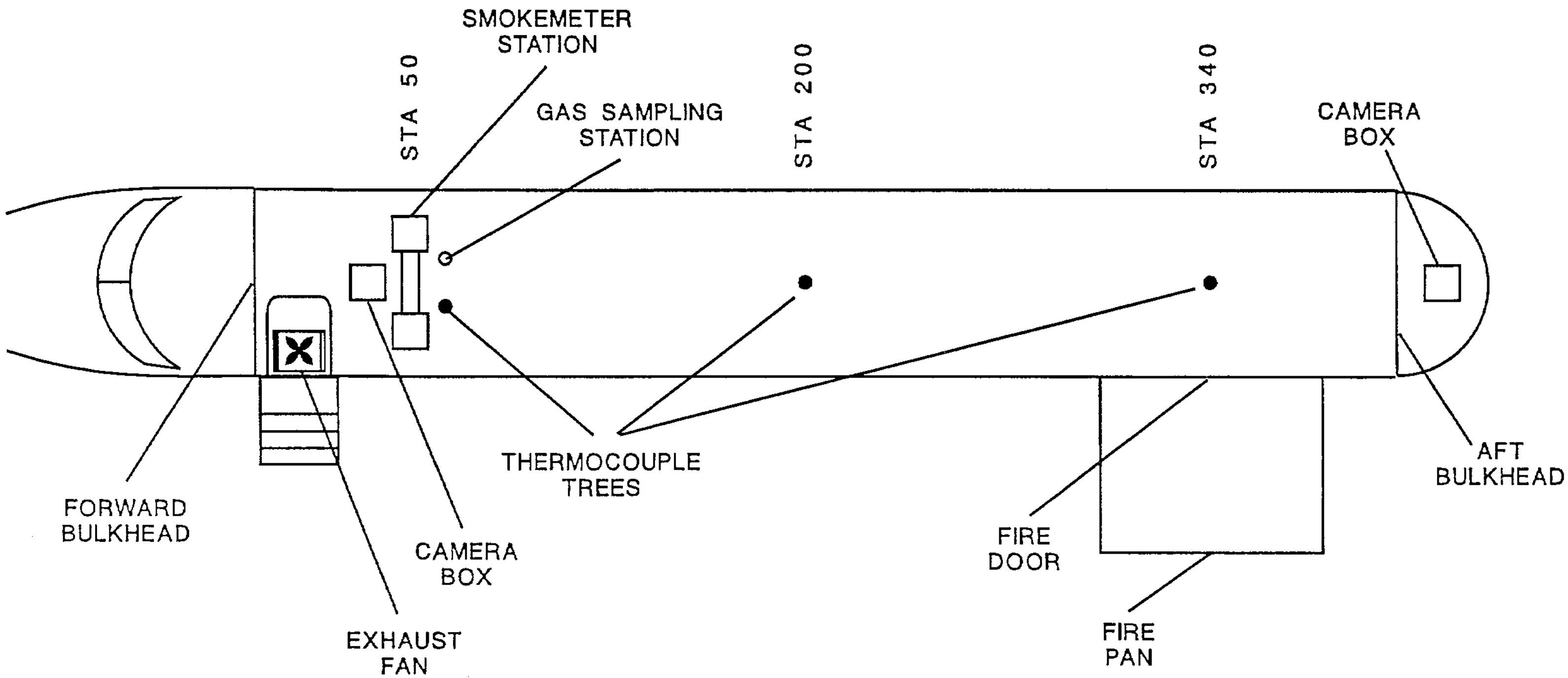


FIGURE 10. FUSELAGE INSTRUMENTATION

FIGURE 11. TEMP @ STA 50, 3 TO 4 FEET

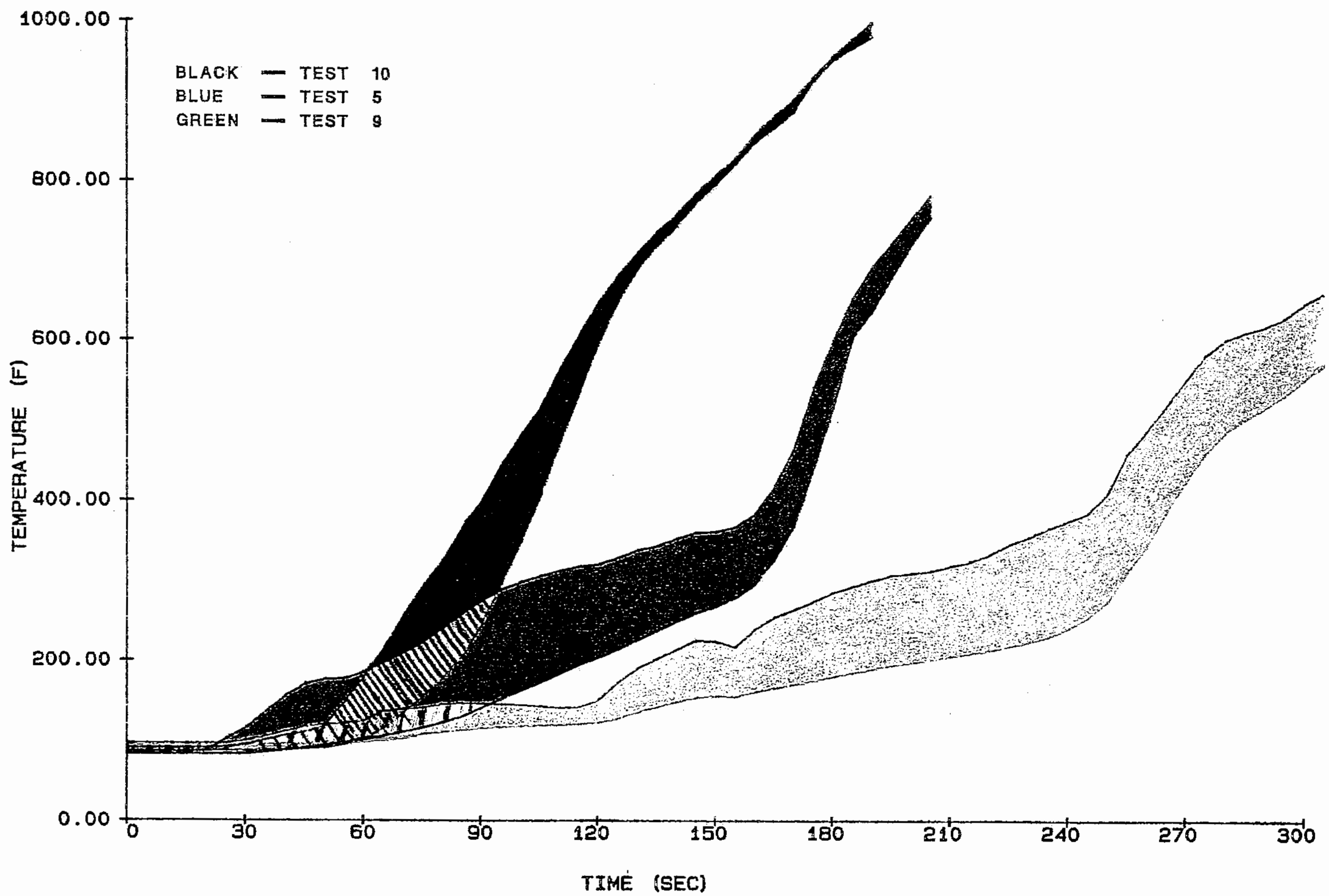


FIGURE 12. TEMP COMPARISON @ STA 50, 3 FEET

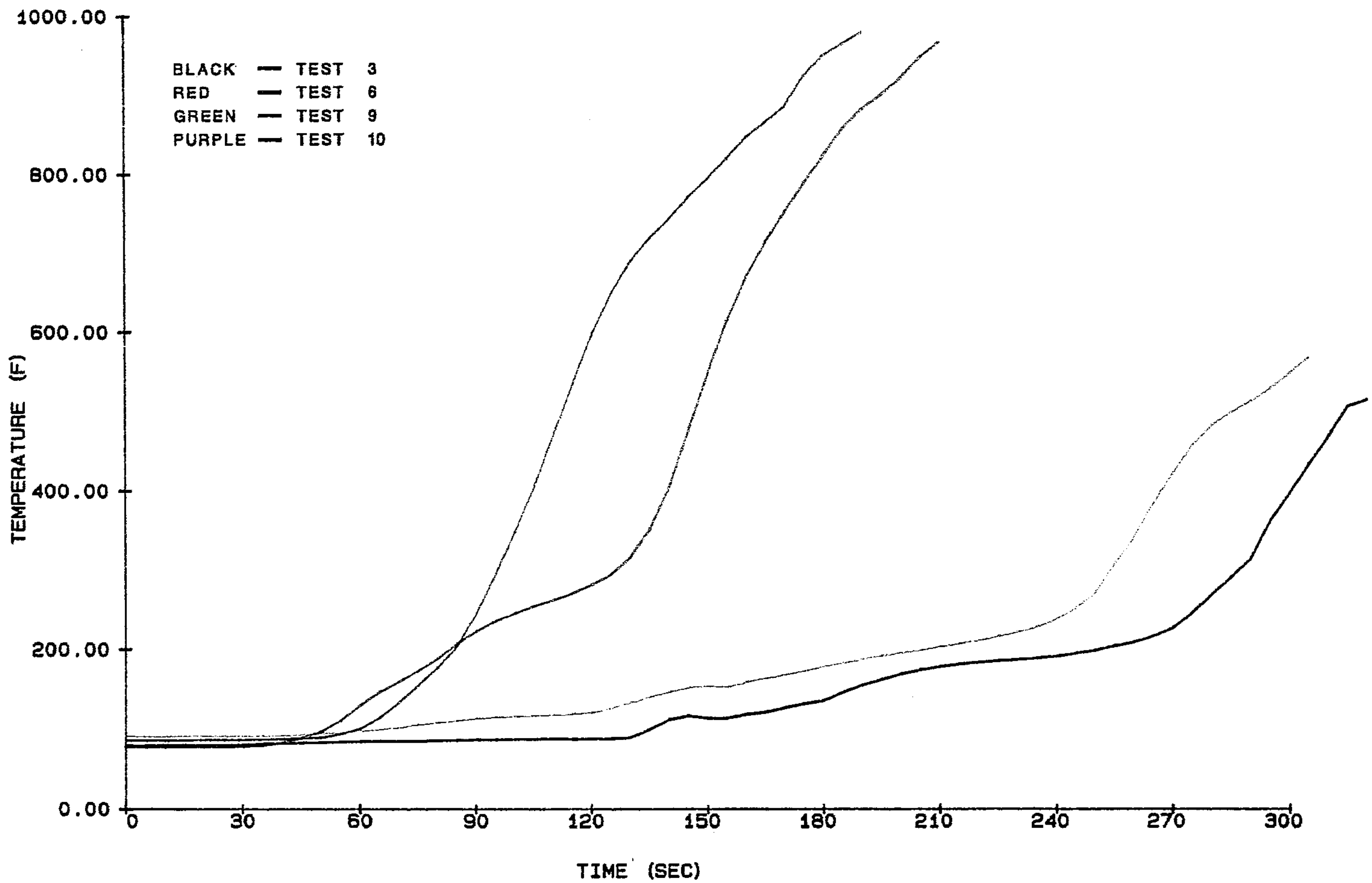


FIGURE 13. TEMP COMPARISON @ STA 50, 3 FEET

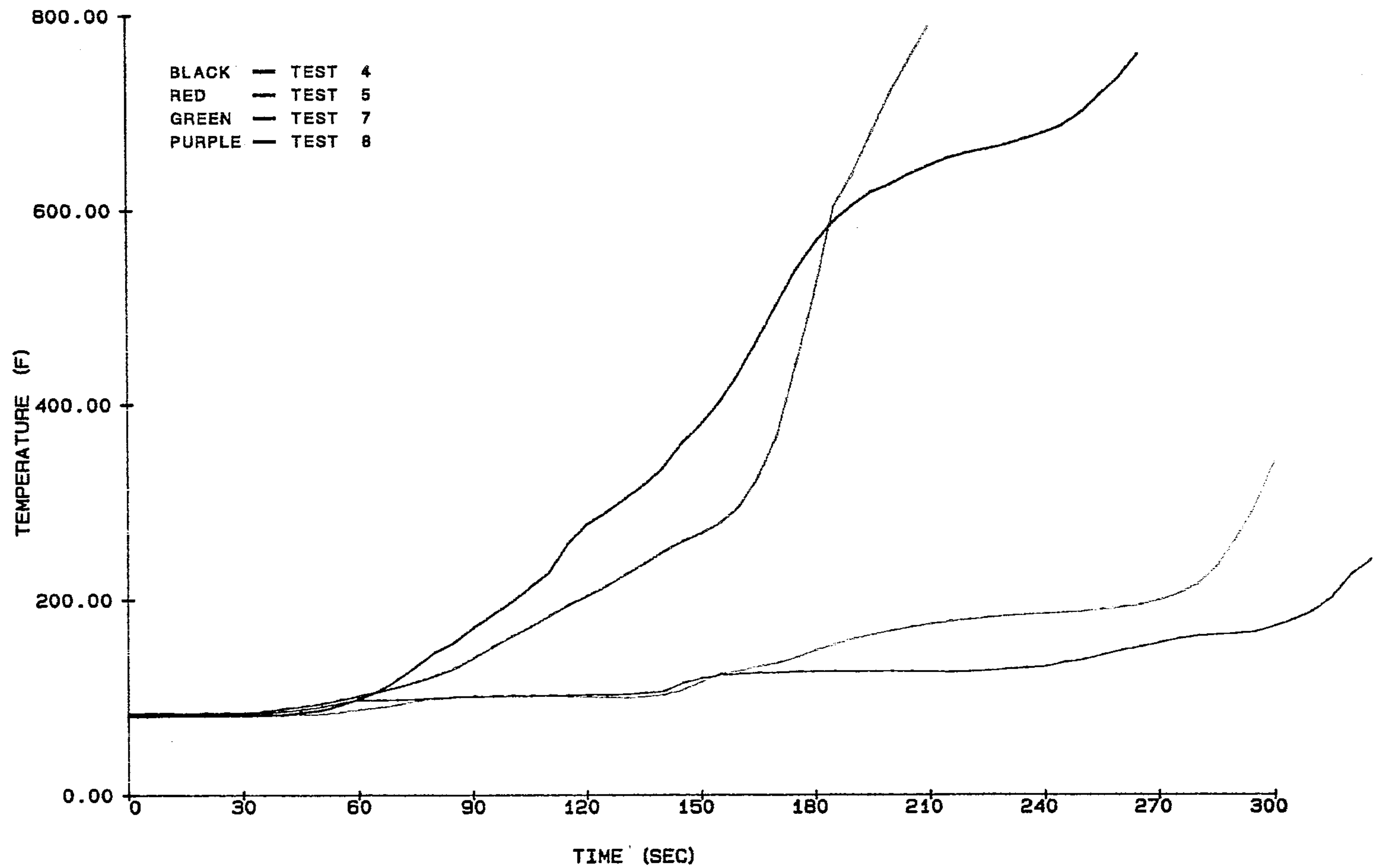


FIGURE 14. CO COMPARISON @ STA 50, 3 FEET

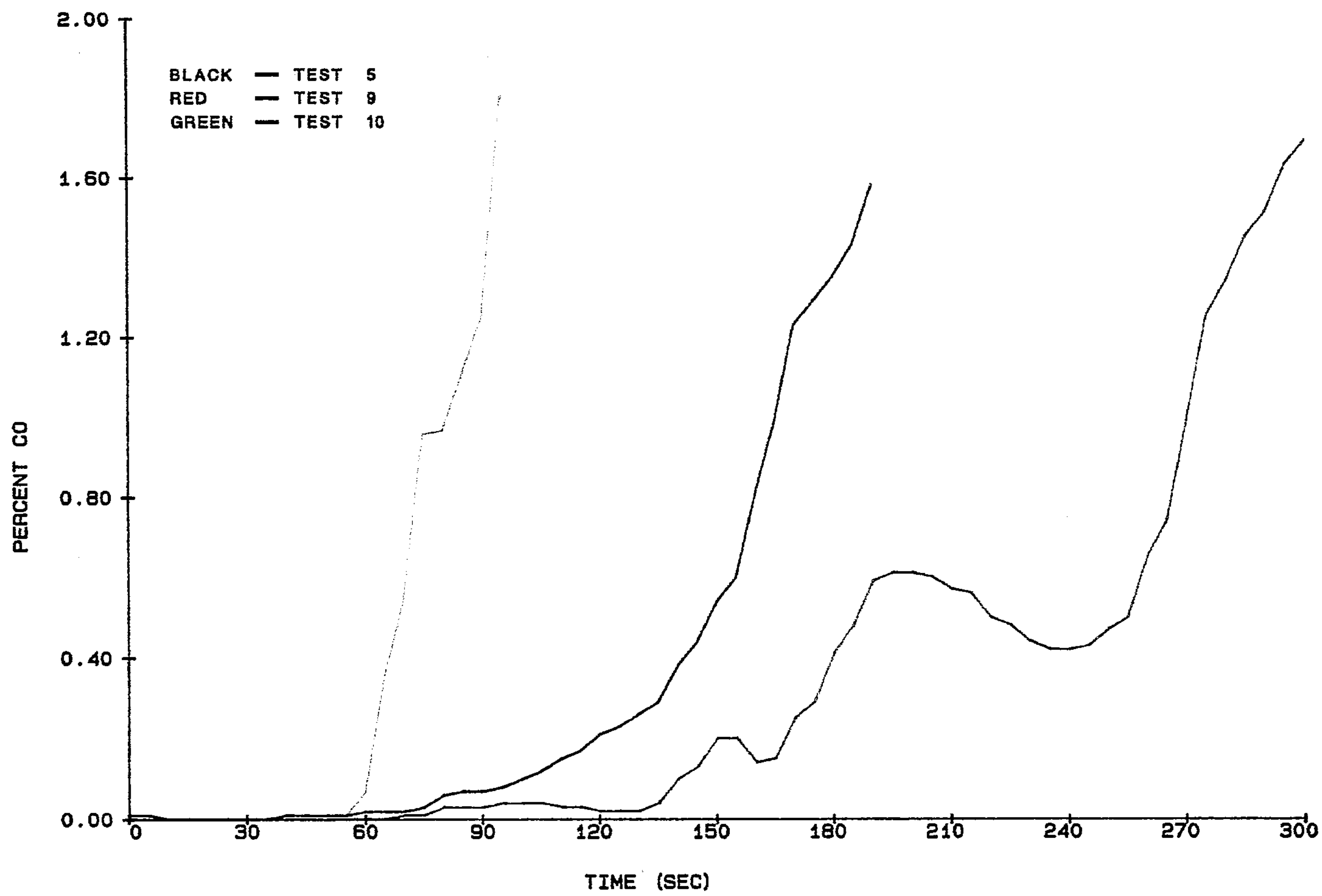


FIGURE 15. CO COMPARISON @ STA 50, 3 FEET

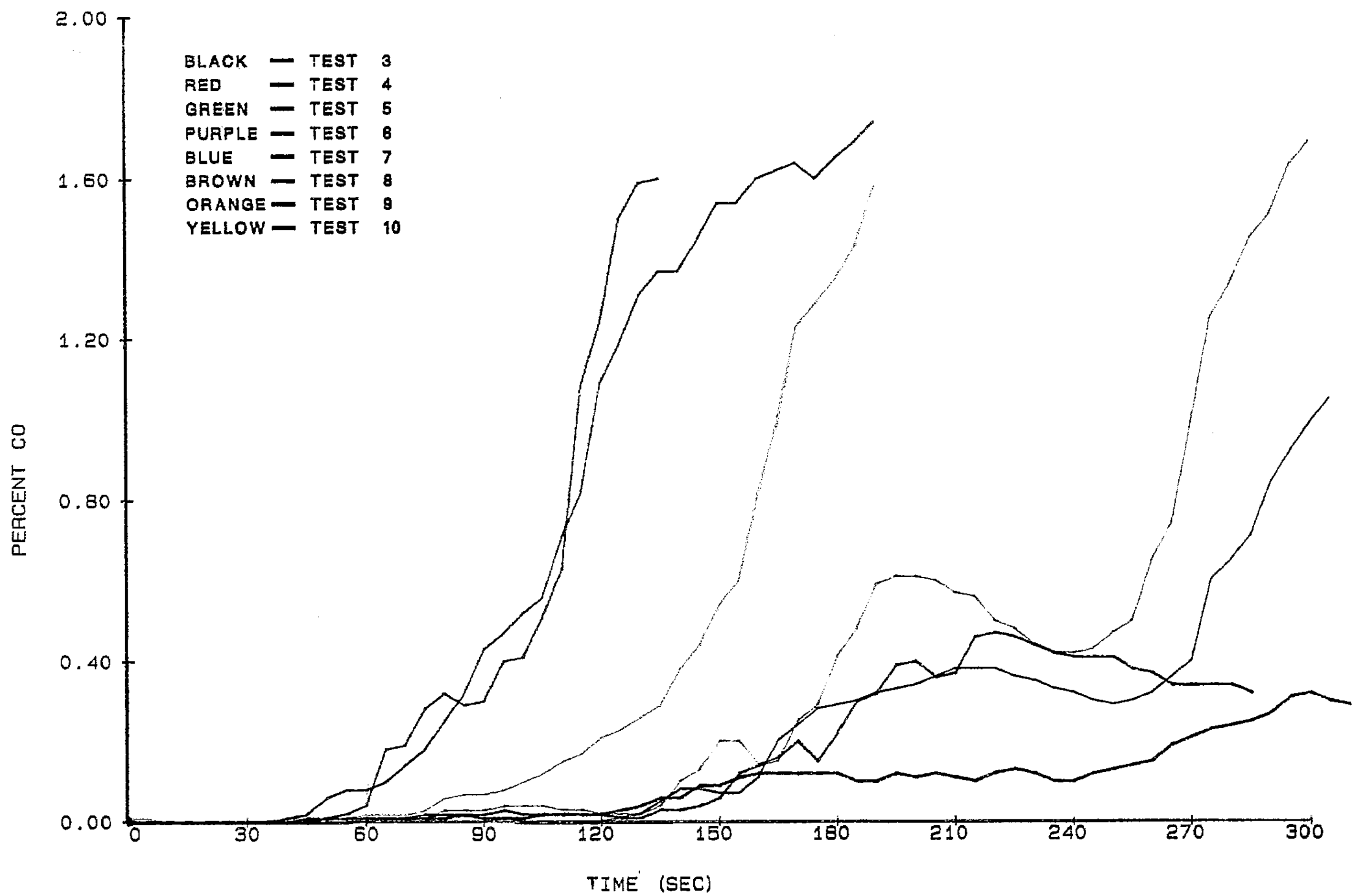


FIGURE 16. CO_2 COMPARISON @ STA 50, 3 FEET

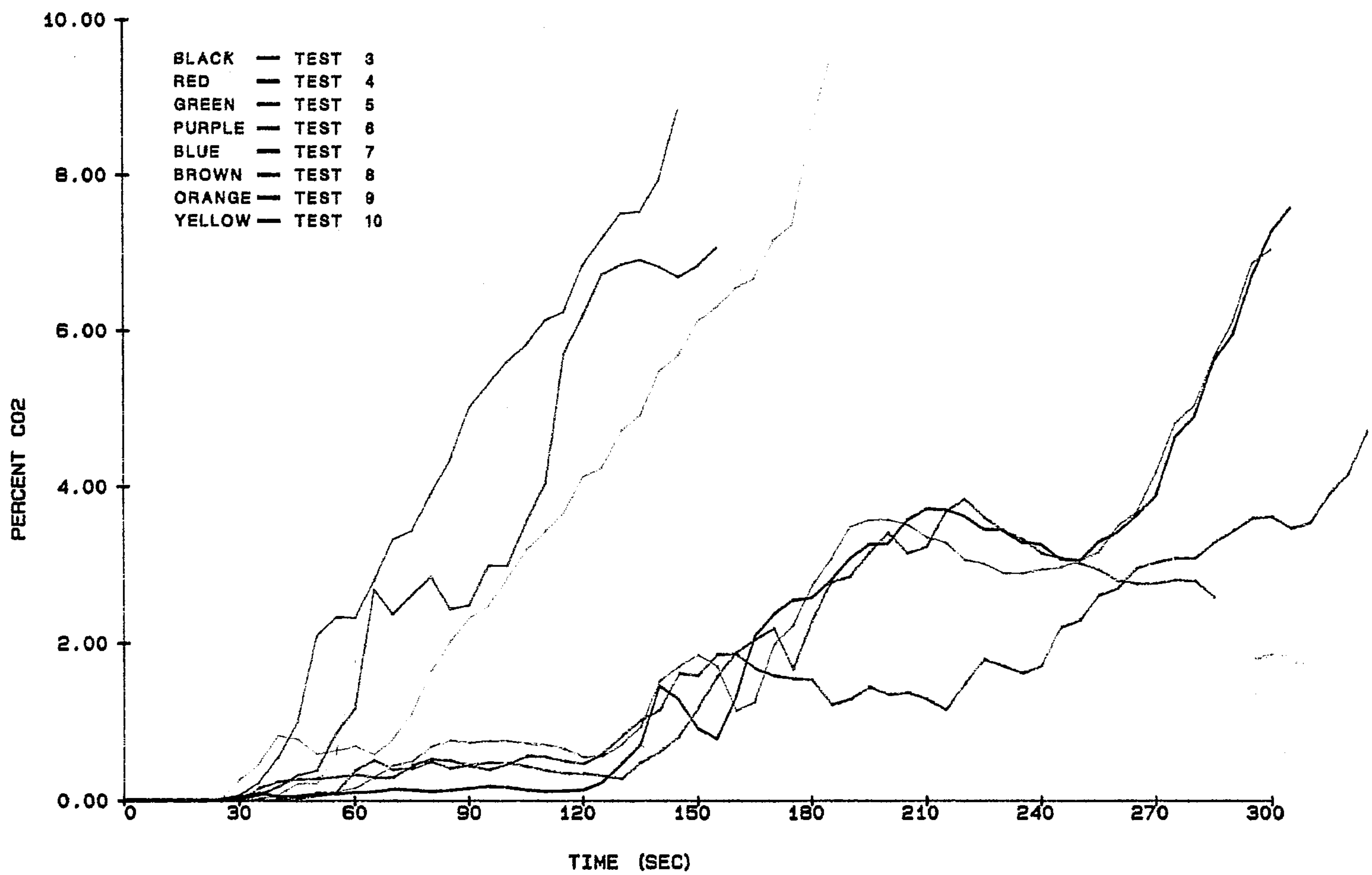


FIGURE 17. O_2 COMPARISON @ STA 50, 3 FEET

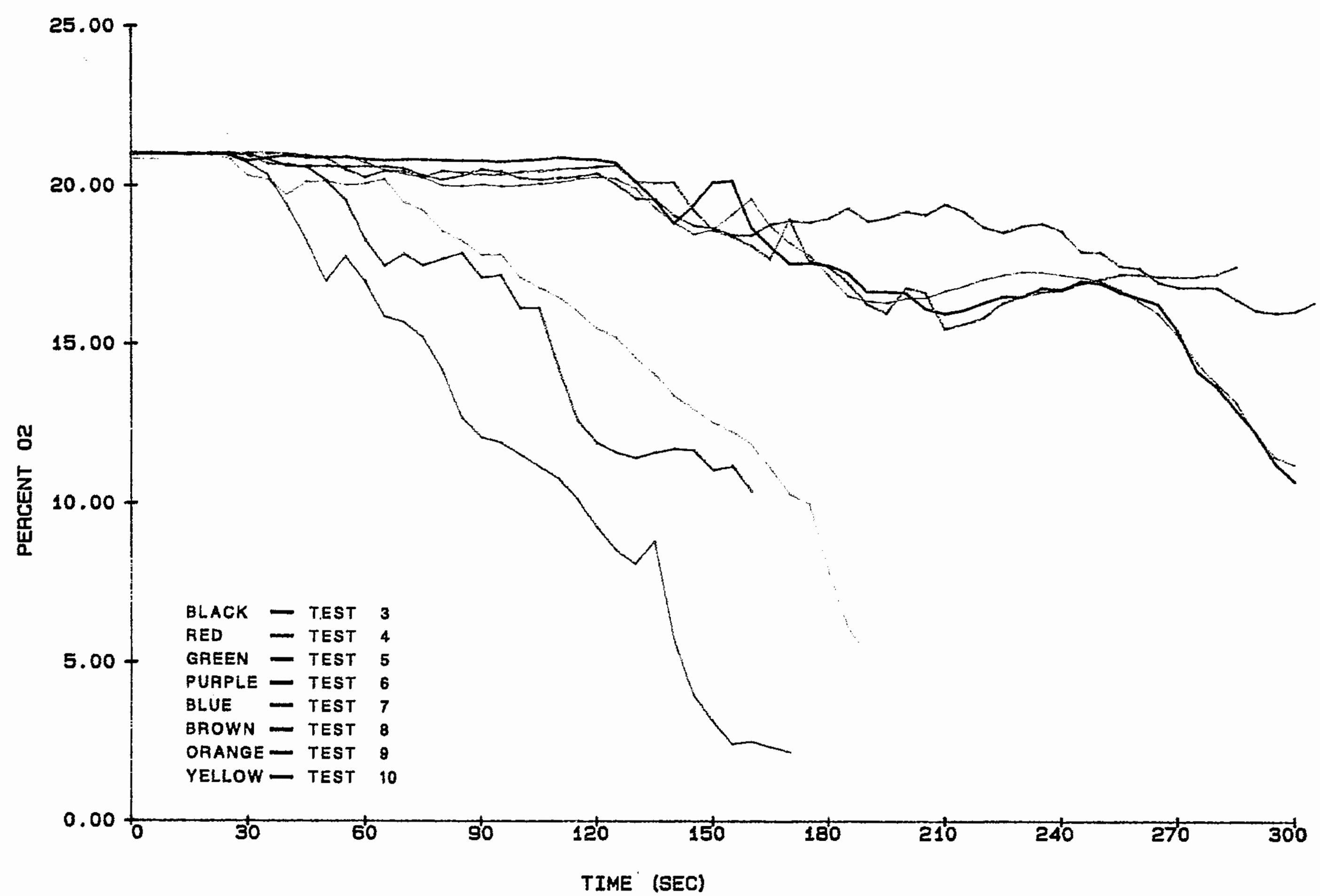


FIGURE 19. FED COMPARISON @ STA 50, 3 FEET

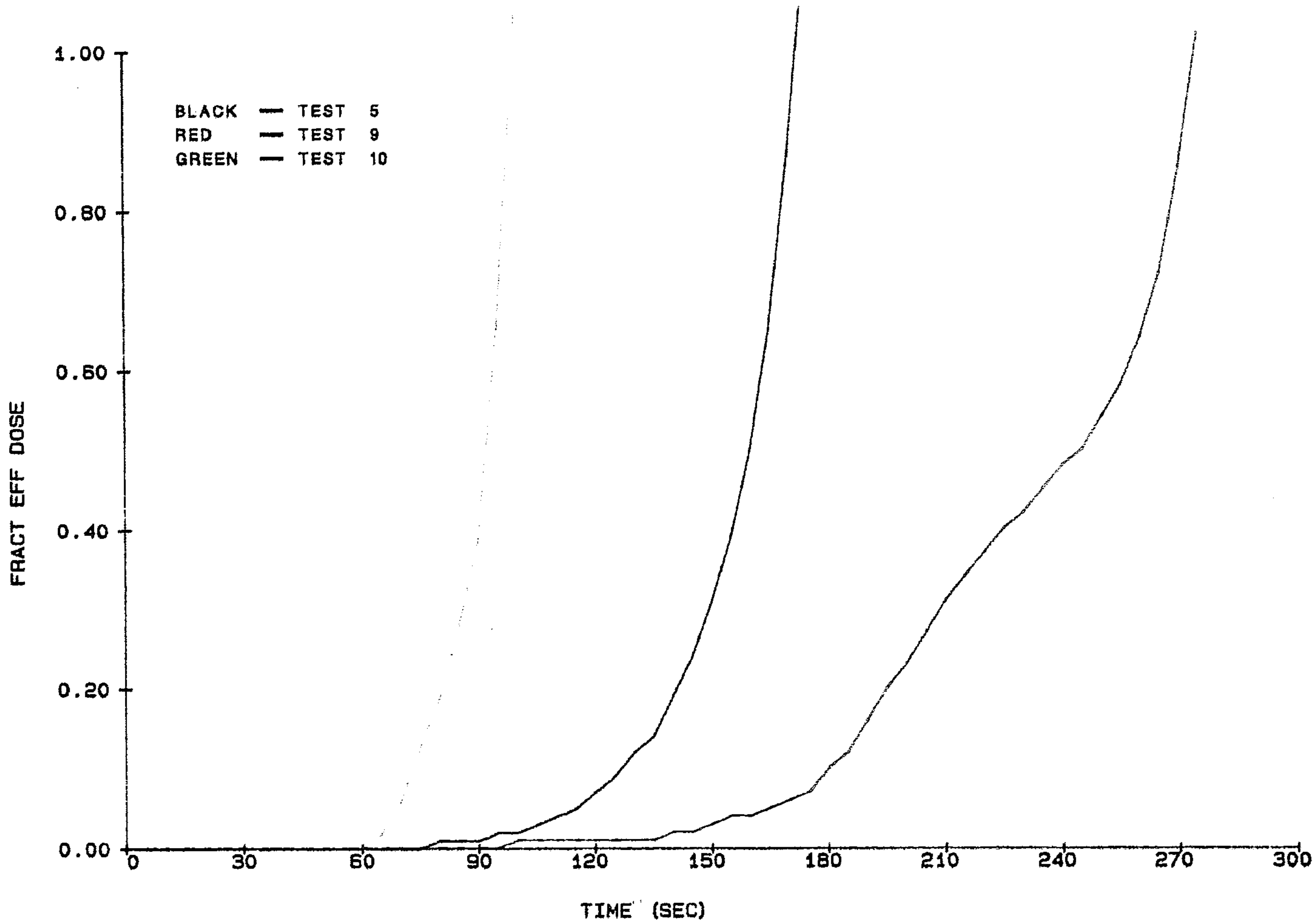
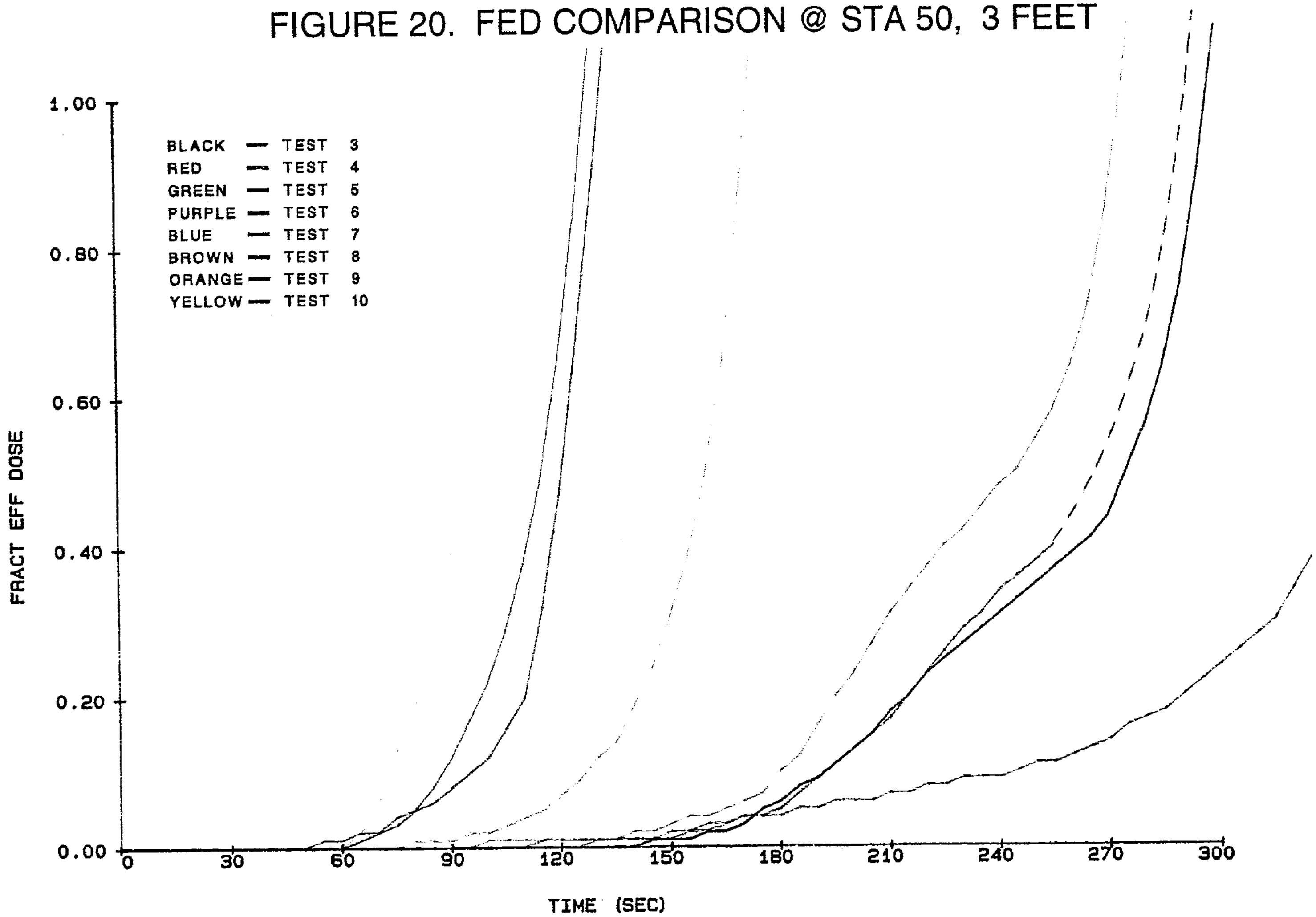


FIGURE 20. FED COMPARISON @ STA 50, 3 FEET



TEST #	SEATS	CEILING/ SIDEWALL PANELS	WATER SPRAY	FED CALCULATION @ STA 50, 3' (SEC)	COMMENTS
1	FB	TMTP1	YES	----------TEST OMITTED FROM ANALYSIS----------	
2	FB	TMTP2	YES	----------TEST OMITTED FROM ANALYSIS----------	
3	NFB	TMTP2	YES	296.4	DETERMINE IMPROVEMENT WHEN USING UPGRADED PANELS AND WATER SPRAY SYSTEM
4	FB	TMTP1	NO	132.1	DETERMINE PERFORMANCE OF UPGRADED MATERIALS
5	FB	TMTP2	NO	172.9	
6	NFB	TMTP2	NO	127.9	DETERMINE PERFORMANCE IMPROVEMENT WHEN USING UPGRADED PANELS
7	FB	TMTP1	YES	303.6	DETERMINE PERFORMANCE OF UPGRADED MATERIALS AND CABIN WATER SPRAY
8	FB	TMTP2	YES	358.1	
9	NFB	TMTP3	YES	274.3	DETERMINE PERFORMANCE OF MATERIALS CURRENTLY IN SERVICE AND CABIN WATER SPRAY SYSTEM
10	NFB	TMTP3	NO	99.3	DETERMINE PERFORMANCE OF MATERIALS CURRENTLY IN SERVICE
11	FB	TMTP1	NO	132.1	UPPER HALF OF FORWARD EXIT DOOR COVERED
12	FB	TMTP1	NO	140.7	CHANNEL TYPE FLOOR USED

FB .... Fire Blocking Used
NFB .... No Fire Blocking
TMTP1 .... Phenolic Fiberglass Honeycomb Panel
TMTP2 .... Thermoplastic Panel
TMTP3 .... Phenolic Kevlar Honeycomb Panel

TABLE 1. SUMMARY OF TESTS

MATERIAL COMBINATION	TIME @ FED = 1 (SEC) WITHOUT WATER	WITH WATER	INCREASE
TEST 3 VS. 6 IMPROVED FIRE RESISTANT THERMOPLASTIC PANEL (TMTP 2), NON FIRE BLOCKED SEATS	127.9	296.4	168.5
TEST 4 VS. 7 IMPROVED FIRE RESISTANT HONEYCOMB PANEL (TMTP1), FIRE BLOCKED SEATS	132.1	303.6	171.5
TEST 5 VS. 8 IMPROVED FIRE RESISTANT THERMOPLASTIC PANEL (TMTP 2), FIRE BLOCKED SEATS	172.9	358.1	185.2
TEST 9 VS. 10 CURRENTLY IN SERVICE HONEYCOMB PANEL (TMTP3), NON FIRE BLOCKED SEATS	99.3	274.3	175.0
AVERAGE	133.1	308.1	175.0

TABLE 2. WATER SPRAY VS. NON WATER SPRAY TEST COMPARISON