A Comparison of Propane and Kerosene Burners for Cargo Compartment Burnthrough Testing

Timothy Marker

November 1987

DOT/FAA/CT-TN87/45

Document is on file at the Technical Center
Library, Atlantic City International Airport, N.J. 08405

U.S. Department of Transportation
Federal Aviation Administration

Technical Center
Atlantic City International Airport, N.J. 08405

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-TN87/45		

4. Title and Subtitle A COMPARISON OF PROPANE AND KEROSENE BURNERS FOR CARGO COMPARTMENT BURNTHROUGH TESTING	5. Report Date November 1987
	6. Performing Organization Code
7. Author(s) Timothy R. Marker	8. Performing Organization Report No. DOT/FAA/CT-TN87/45
9. Performing Organization Name and Address Federal Aviation Administration Technical Center Atlantic City Airport, NJ 08405	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic Airport, NJ 08405	13. Type of Report and Period Covered Tehnical Note
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report contains the results and evaluation of a propane burner developed by Airbus Industries for burnthrough resistance tests of cargo liner joints, seams, and fasterners, as required by Federal Aviation Regulation (FAR) 25.857, effective June 16, 1986. Measurements of temperature and heat flux were obtained during a typical calibration procedure. These values, along with the results of several test samples utilizing the propane burner, are compared to the results obtained through identical calibration procedures and sample tests using the 2-gallon per hour kerosene burner specified in the final rule.

17. Key Words	18. Distribution Statement
Fire Safety Burnthrough Cargo Compartments Cargo Liners	Document is on file at the Technical Center Library, Atlantic City Inter-National Airport, NJ 08405

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

EXECUTIVE SUMMARY

This report contains the results and evaluation of a propane type burner for cargo liner burnthrough resistance tests as required by Federal Aviation Regulation (FAR) 25.857, effective June 16, 1986. The work was performed in response to a proposal by industry to use this type of burner for fire testing the design features of cargo liners such as joints, seams, fasteners, and lamp assemblies in later generation Airbus aircraft.

Measurements of temperature and heat flux obtained during a calibration procedure are compared to those values obtained using the 2-gallon per hour (GPH) kerosene burner specified in the final rule. The propane burner provides a much less severe flame in terms of both temperature and heat flux and possesses a smaller flame area than the kerosene burner. In addition to the calibration procedure, several specimens were tested using each of the burners to determine the feasibility of using such a burner for this area of testing.

INTRODUCTION

PURPOSE.

This report presents the results obtained during testing of a propane burner as used for cargo liner burnthrough resistance testing.

BACKGROUND.

Cargo liner fire testing, as per Federal Aviation Regulation (FAR) 25.857, effective June 16, 1986, prescribes a 2-gallon per hour (GPH) kerosene burner in which test specimens are subject to flame impingement for five minutes (reference 1). Specimens are required to resist flame penetration and the peak temperature measured at 4 inches above the horizontal test sample may not exceed 400° F. As stated in the final rule, "each specimen tested must simulate the cargo compartment sidewall or ceiling liner panel, including design features such as joints, lamp assemblies, etc., the failure of which would affect the capability of the liner to safely contain a fire." Although a variety of cargo lining materials have been subjected to this test method (reference 2), design features such as joints, seams, and lamp assemblies have not been previously evaluated by the Federal Aviation Administration.

To evaluate the fire resistance and fire containment capabilities of such hardware and assemblies, industry has proposed the use of a propane burner in substitution for the 2-GPH kerosene burner. Testing of the propane burner was performed to measure quantitative characteristics such as temperature and heat flux, and to determine the feasibility of using such a burner for this area of testing.

DISCUSSION

TEST APPARATUS.

The propane burner has a circular "cup-like" shape, 180mm in diameter (figure 1). The propane supply is regulated down to approximately 10 psi, and enters at the bottom of the burner along with the primary air. The secondary air is injected close to the surface of the burner where the base of the flame originates. The pattern and intensity of the flame can easily be controlled using the adjusting valves for each of these three lines. A magnahelic guage measures the differential pressure through expansion chambers located in each of three lines near the burner apparatus. In order to obtain the proposed temperature and heat flux outputs of 1560° F and 4.4 $Btu/ft2^{-sec}$, the differential pressures are set at 50mm of water for primary air, 30mm of water for secondary air, and 41mm of water for the propane.

The burner is mounted to a remote control unit (figure 1) which has the capability of vertical and horizontal movement to allow for the exact positioning of the flame with respect to the test panels.

The propane burner is mounted approximately 5 inches (125mm) from the horizontal ceiling specimens in comparison to the kerosene apparatus in which the specimen is 8 inches from the burner cone (figure 3).

INSTRUMENTATION.

During the calibration procedure, a thermocouple rake identical to the one specified in the final rule was used for measuring the temperature profile. This consisted of seven ceramic sheathed, type K grounded thermocouples of 1/16-inch diameter. The calorimeter rig used to measure the heat flux was identical to the rig specified in the final rule as well. Both the thermocouple rake and the calorimeter rig were mounted at a distance of 125mm above the burner surface (figure 2).

In addition to the calibration procedure, a test apparatus was constructed to determine the intensity of the flame in the corner (figure 4). This set-up measured the heat flux at two points and temperature at six points as shown. These measurements helped determine the feasibility of fire testing a simulated corner assembly with this burner. The same test was run using the 2-GPH burner for comparison (figure 5).

All channels were sent through an analog-to-digital converter and stored on a floppy disk of a Tandy mini-computer. Each run on the computer is a 10-second average.

The flow of propane gas and air into the burner apparatus was monitored by a magnahelic pressure gauge measuring 0 to 15 inches of water.

The testing of several specimens was visually recorded on tape using a color video camera and recorder. The camera was mounted in the upper corner of the test chamber giving a downward view of the test.

TEST RESULTS.

Calibration Procedure: The propane burner was ignited as the primary air, secondary air, and propane valves were adjusted to the values set according to Airbus Industries. The computer began to take data approximately every 30 seconds after the initial warm-up. Figure 2 summarizes several computer runs, giving both the temperature profile and heat flux. The number 4 thermocouple average (figure 2) is close to the value stated in the industry proposal. The two end thermocouples, which are not considered in the proposal, are significantly lower (figure 2) in temperature than number 4. The average heat flux was slightly higher than the value proposed by industry.

Referring to figures 4 and 5, the temperature profile of the 2-GPH kerosene burner is consistenly higher than the propane burner. Thermocouples 8, 9, and 10 in the corner of the test rig show the temperature to be several hundred degrees higher. This also holds true for the heat flux as it is significantly higher; 8.2 $Btu/ft2^{-sec}$ for the kerosene burner, 2.7 $Btu/ft2^{-sec}$ for the propane burner in the corner of the apparatus.

Sample Tests: Several tests involving different material types and thicknesses were conducted using the test specimens in the ceiling position and the sidewall position blocked with kaowool board. A comparison of propane and 2-GPH kerosene burner test results is summarized in table 1. For each liner material, greater damage occurred with the kerosene burner. In the case of the 0.023-inch Kevlar®, burnthrough occurred in 21 seconds with the kerosene burner, but did not burnthrough with the propane burner, reaching a maximum temperature of only 234° F.

TABLE 1. COMPARISON OF PROPANE AND 2-GPH KEROSENE BURNER TEST RESULTS

	MATERIAL	THICKNESS (in.)	BURNER	RESULT		
1.	Kevlar	0.019	Propane	Burnthrough	at	4:40
2.	Kevlar	0.019	Kerosene	Burnthourgh	at	0:13
3.	Kevlar	0.023	Propane	Max Temp 234° F	at	4:59
4.	Kevlar	0.023	Kerosene	Burnthrough	at	0:21
5.	Nomex	0.027	Propane	Burnthrough	at	0:42
6.	Nomex	0.027	Kerosene	Burnthrough	at	0:12
7.	Conolite	0.032	Kerosene	Max Temp 282° F	at	4:59
8.	Conolite	0.032	Propane	Max Temp 210° F	at	5:00
9.	Conolite	0.013	Kerosene	Max Temp 360° F	at	3:38
10.	Conolite	0.013	Propane	Max Temp 266° F	at	4:24
11.	BMS 8-100E	0.023	Kerosene	Max Temp 350° F	at	0:21
12.	BMS 8-100E	0.023	Propane	Max Temp 211° F	at	4:57

REFERENCES

1. Airworthiness Standards; Fire Protection Requirements for Cargo or Baggage Compartments; Federal Register, Volume 5, No. 95, pp, 18236-18247, May 16, 1986.

2. Blake, D., An Evaluation of the Burnthrough Resistance of Cargo Lining Materials, FAA/CT-TN85/11, May 1985.

TEST SETUP

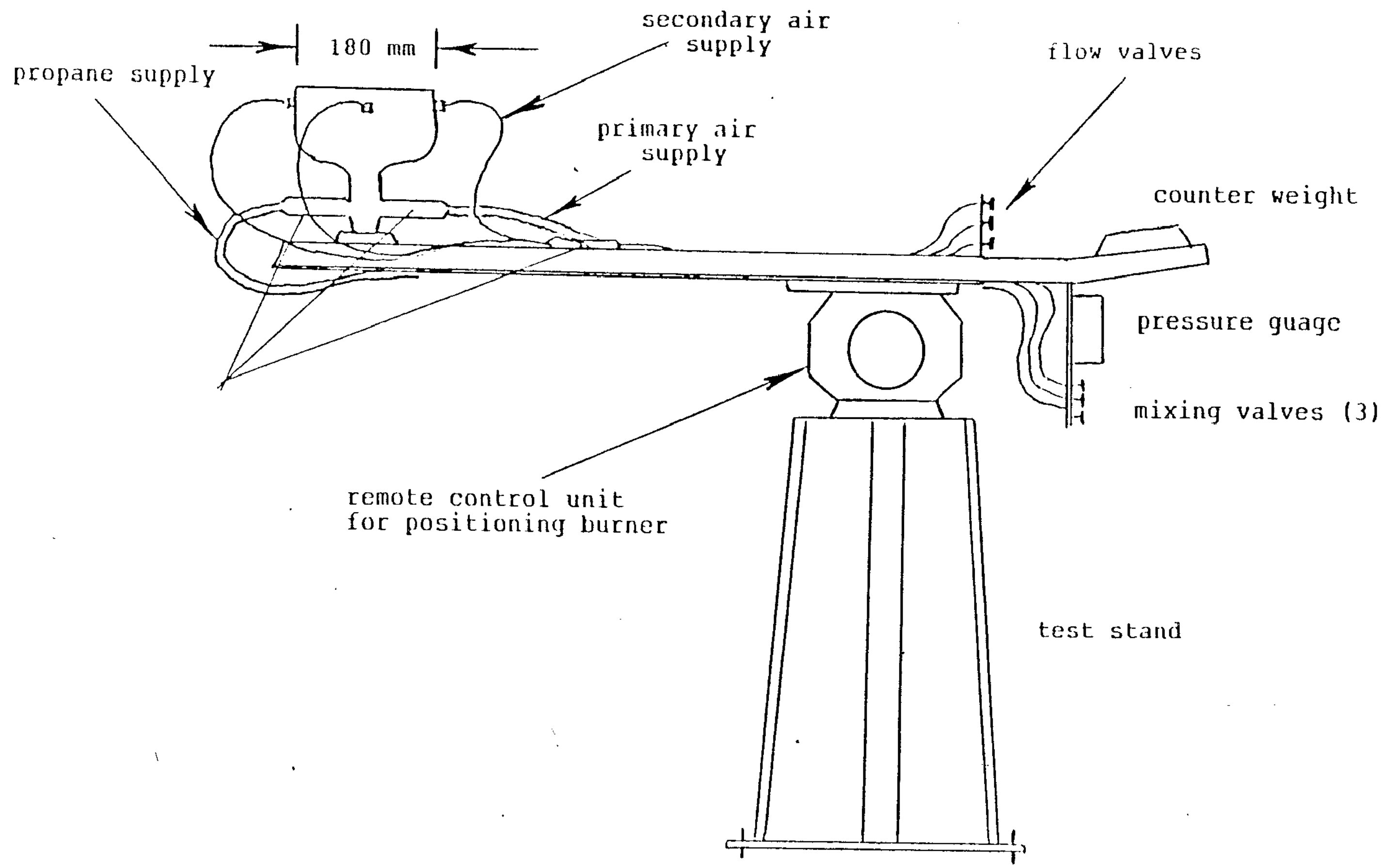
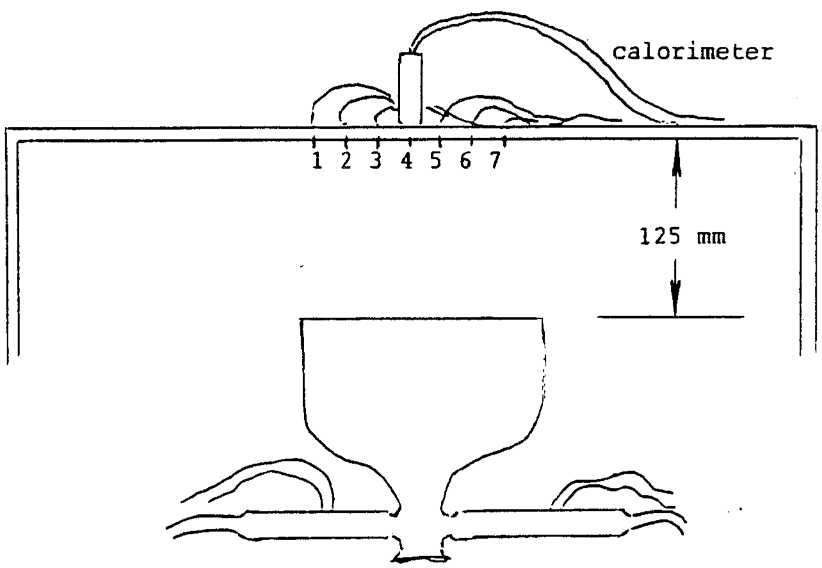


FIGURE 1. BURNER APPARATUS

CALIBRATION



TEMPERATURE PROFILE

1	2	3	4	5	6	7	
1004	1388	1585	1557	1598	1250	923	1st
900	1280	1566	1529	1574	1219	817	2nd
919	1303	1548	1505	1577	1283	835	3rd
864	1218	1533	1491	1581	1176	773	4th
922	1297	1558	1520	1582	1232	837	AVE

HEAT FLUX (BTU/FT^2 SEC)

4.69	1st
4.89	2nd
4.59	3rd
4.14	4th
4.58	AVE

FIGURE 2. POSITION OF CALIBRATION EQUIPMENT

COMPARISON OF BURNER POSITION

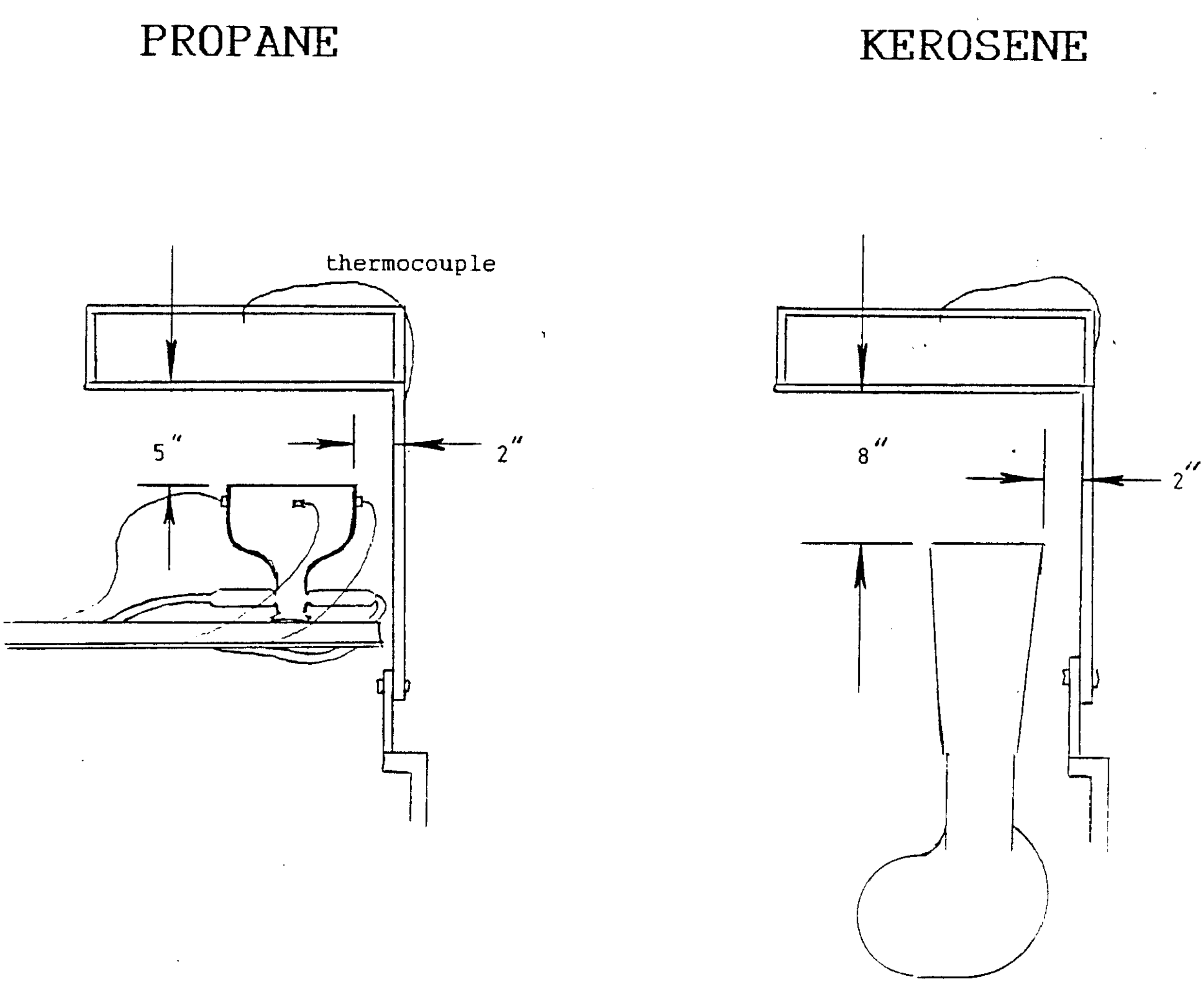
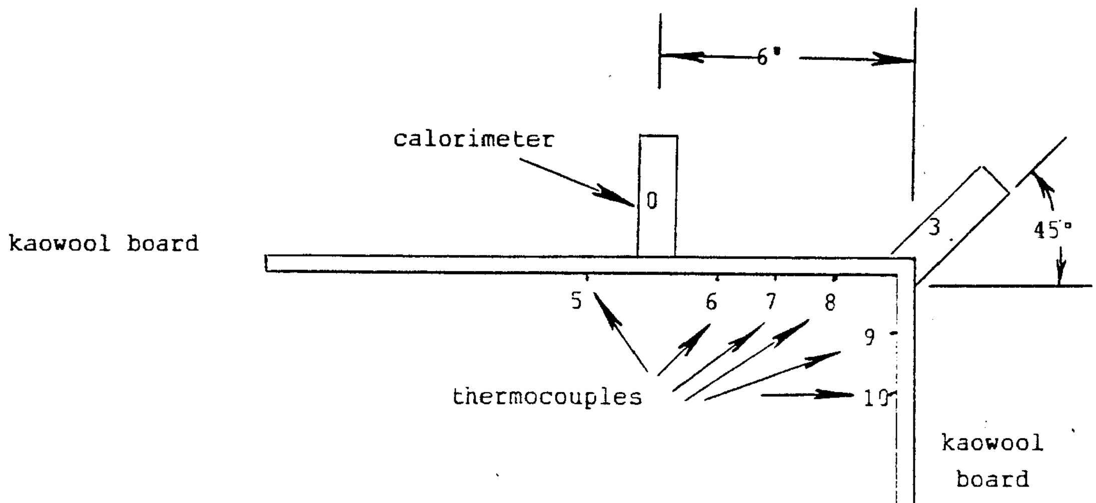


FIGURE 3. RELATIVE POSITIONS OF BURNERS

PROPANE

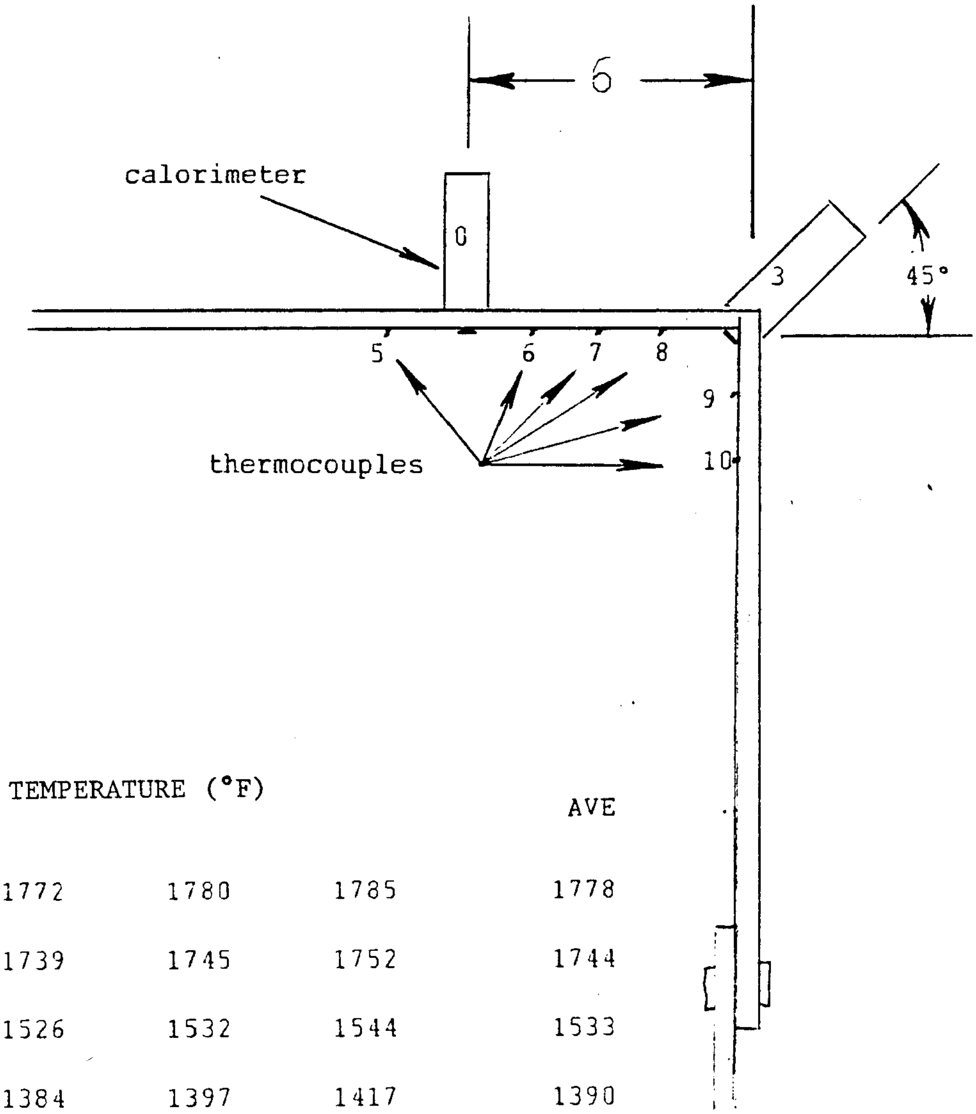


	TEMPERATURE (°F)				AVE
#5	1245	1265	1289	1300	1275
#6	1295	1313	1334	1354	1324
#7	1177	1202	1250	1266	1224
#8	1055	1093	1199	1235	1145
#9	1267	1266	1296	1326	1289
#10	676	686	773	969	761

	HEAT FLUX (BTU/FT^{2}SEC)				AVE
#0	4.11	4.28	4.34	4.79	4.38
#3	3.63	3.09	2.00	2.03	2.69

FIGURE 4. CORNER FLAME INTENSITY MEASURING APPARATUS (PROPANE)

2 GPH KEROSENE



TEMPERATURE (°F)

					AVE
#5	1775	1772	1780	1785	1778
#6	1739	1739	1745	1752	1744
#7	1529	1526	1532	1544	1533
#8	1363	1384	1397	1417	1390
#9	1551	1555	1557	1577	1560
#10	1592	1588	1586	1603	1592

HEAT FLUX (BTU/FT^{2}SEC)

					AVE
#0	10.46	10.56	10.32	10.54	10.47
#3	8.33	8.07	8.29	8.08	8.19

FIGURE 5. CORNER FLAME INTENSITY MEASURING APPARATUS (KEROSENE)