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Final Technical Report
IITRI Project J6340
Contract No. 4-36092

UL File USNC-62
Project 74NK6752

DETECTOR SENSITIVITY AND SITING REQUIREMENTS FOR DWELLINGS

Prepared for:
U.S. National Bureau of Standards
Washington, D.C. 20234

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Prepared by

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FOREWORD

This report concerns the siting and sensitivity requirements for fire detectors to protect residential occupancies. The behavior of over 20 detectors of various generic types and nominal sensitivities exposed to 40 fires in actual residences served as the basis for the results and conclusions developed.

The study was a joint effort by IIT Research Institute and Underwriters' Laboratories Inc. on Contract No. 4-36092 (IITRI Project J6340; ULI File USNC-62, Project 74NK6752). The program was sponsored by the U.S. National Bureau of Standards, Washington, D.C. 20234, with Mr. R. Bright as Technical Monitor.

The authors wish to thank Mr. Bright for his cooperation and helpful critiques of the program during its development. Special thanks go to Mr. Carl Foxx (IITRI) and Mr. Robert Pettinger (ULI) for their contributions to the success of the experimental program.

Without the availability of real residential structures in habitable condition, none of this would have been possible. These were provided by the U.S. Department of the Interior, Dunes National Lakeshore and the authors wish to thank Mr. James R. Whitehouse and his staff for use of the structures as well as for many "assists" during the course of the experiments.

Respectfully submitted,
IIT Research Institute

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Approved,

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1.0 INTRODUCTION:

At the present time, standards for fire detector location in dwellings, as well as standards for fire detector sensitivity, are based mostly on laboratory data and engineering judgement without the benefit of extensive full scale data to provide guidance. For example, as new methods of fire detection have developed, laboratory evaluations have been modified in attempts to provide realistic exposure environments; however, this has led to a multiplicity of evaluation techniques. These are only loosely interrelated making comparative judgements most difficult between detectors stimulated by different characteristics of fire. As more and more jurisdictions make dwelling fire detection mandatory, it becomes increasingly important to develop experimental data to back up and improve existing Standards.

The primary purpose of this study was to investigate detector siting and sensitivity as they relate to escape potential in residential fire situations. Although a number of actual detectors were used in the investigation, it was not the intent of this project to judge the merits of the individual detectors used. The detectors were selected to provide a cross section of the several detection principles now available and which represent the current level of technology available in residential type detectors.

2.0 EXPERIMENTAL PROCEDURE:

DESCRIPTION OF TEST BUILDINGS

Two test buildings were used for the program. These homes, made available by the US Department of the Interior (National Park Service), were scheduled for demolition as part of a land clearance program associated with the establishment and expansion of the Indiana Dunes National Lake Shore. Floor plans of the test buildings are included in Appendix G.

The primary test site was a two story brick structure with basement. Interior walls on first and second stories were plaster on wood lathe and floors were wood. The basement walls were wood paneled. The building had a gas forced-air heating system to which a central air conditioning unit was fitted for the summer test conditions. Registers were located in every room with returns in all first floor rooms except the bathroom. There were no returns on the second floor. See Figure 1 for photographs of the building and Appendix G for register locations.

The second test site was selected primary because it employed a hot-water baseboard heating system. This building was a single story brick residence with basement. All walls were wood paneled. The first story had wood floors. See Figure 2 for photographs of the building.

The buildings selected represent major variations in geometry. Since the prime vehicles for moving smoke throughout a residence are the fire itself and the HVAC system, the heating systems in these two buildings should be representative of all types of heating systems, with the possible exception of radiant heat and individual space heaters.

PLAN

It was the plan of the research program to conduct a series of experiments in the primary test site over several seasons, so that the full range of outdoor conditions which significantly affect indoor conditions, e.g. heating, cooling, etc. would be encountered. The secondary test site was utilized only during the winter season since this would provide the maximum "stack effect" and since central air conditioning of a dwelling with hot water baseboard heat is not readily achieved.

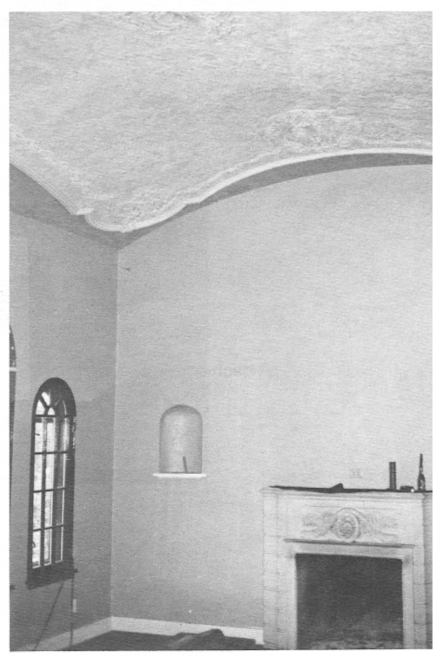
Detector locations were selected in accordance with the four levels for protection defined in the edition of 1974 NFPA/74. Two detectors of each type with two different sensitivities were installed at each required detector location. At one of the detector locations the effect of wall versus ceiling detector mounting was investigated by installing some detectors on the ceiling and some on the wall for several experiments and then reversing the mounting. See Figures 3 and 4 for photographs of the detector test boards.

Instrumentation for the experiments included light beams for measuring smoke obscuration on the ceiling in the room in which the fire was being burned, on the ceiling at each detector location, and at the 5 ft level along the primary escape path and in representative bedrooms.

Individual thermocouples and vertical thermocouple arrays were installed in the burn room and the primary escape path and several representative locations throughout the dwelling. Equipment to monitor carbon monoxide, carbon dioxide, and oxygen levels were installed in the burn room, escape path and representative bedrooms.

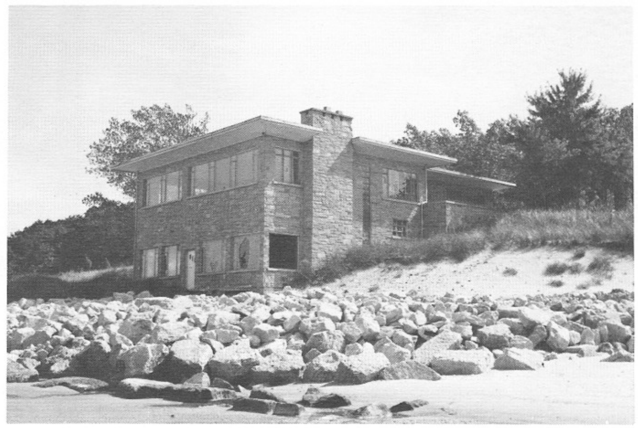
FIGURE 1

J. R. Whitehouse Home



Living Room

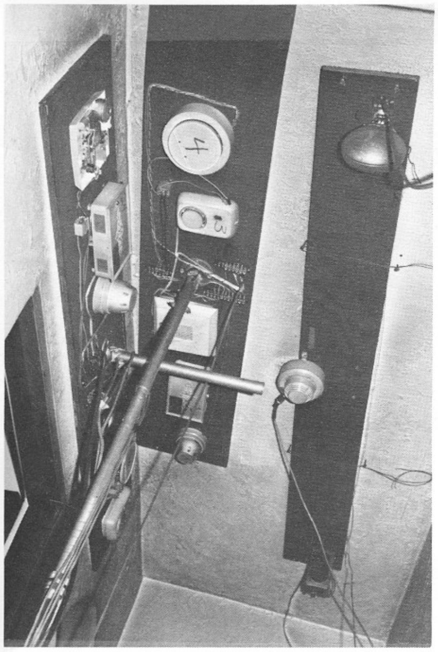
FIGURE 2



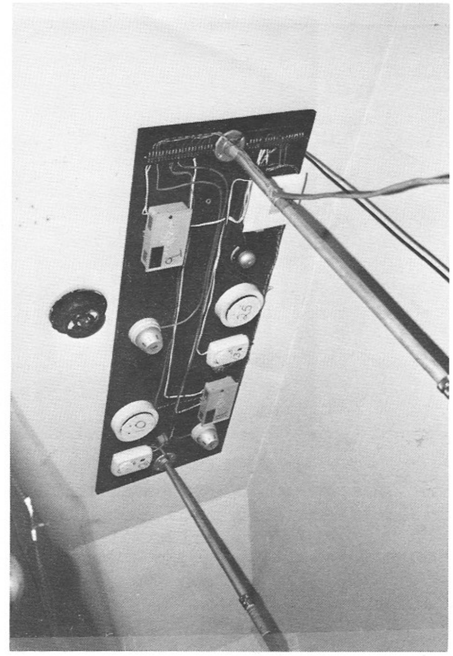
Lakeshore Home

Living Room

Attached Garage



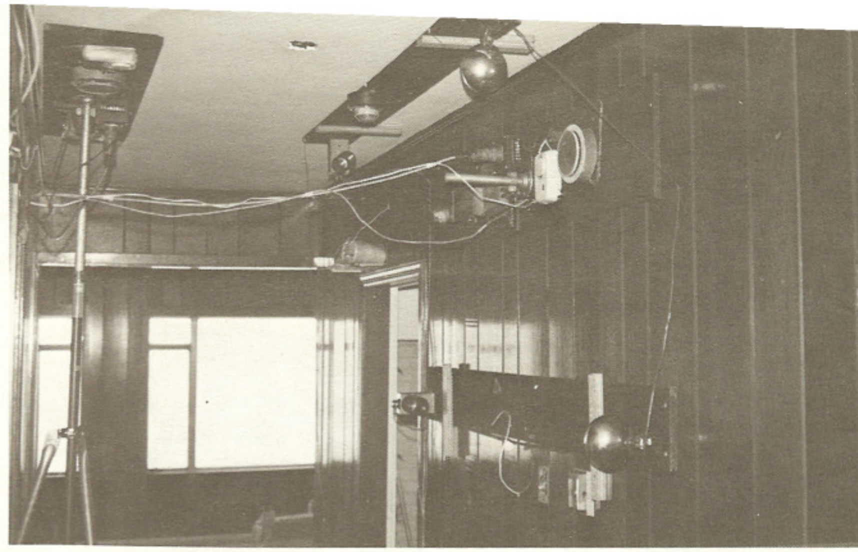
Detector Placement — 1st story Hall
(Whitehouse)



Detector Placement — 2nd story Hall
(Whitehouse)

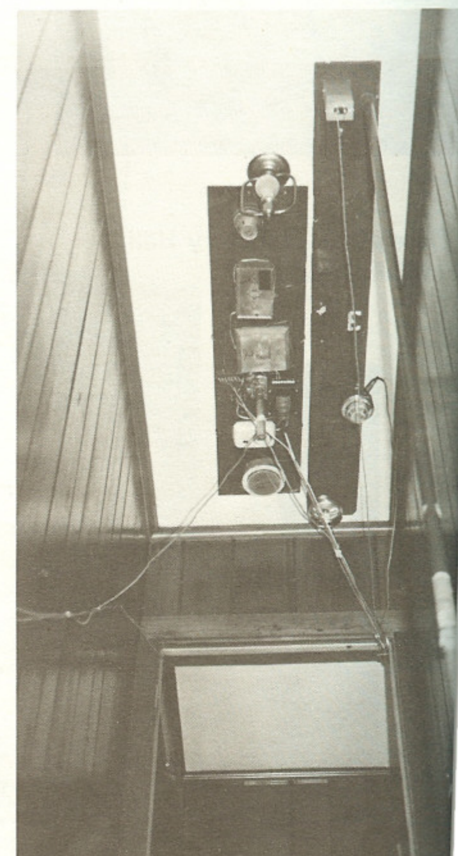
Detector Placement — Head of Basement Stairs
(Whitehouse)

FIGURE 3



Detector Placement — Location B
(Lakeshore)

Detector Placement — Location A
(Lakeshore)



Detector Placement — Basemen
(Lakeshore)

FIGURE 4

Fires were initiated in the various rooms of the dwellings using combustible materials in fire modes (smoldering or flaming) typifing the respective rooms. The data upon which these were selected was from NFPA records.

In conjunction with these experiments, the distribution of sulfur hexafluoride (SF_6) gas as a tracer in the primary test site was measured. These data were collected by NBS representatives. A correlation of the results of the gas tracer analysis and the actual smoke flow pattern data is planned.

DETECTORS

The detectors selected for use in these experiments were typical ionization, photoelectric, dual gate (combination ionization and resistance bridge) and rate of rise of heat detectors. One high sensitivity (1 percent per foot obscuration nominal) and one low sensitivity (2 percent per foot obscuration nominal) detector was used at each detector location. This was done to provide data on the response of various types of detectors to realistic fire conditions, as well as to determine the differences in response time and escape time potential for two different levels of sensitivity of the same detector and type. The detectors selected were considered to be representative of the best detectors of their individual type at this time. All detectors were connected to a 25 clock elasped time indicator panel which indicated detection time to the nearest second after fire ignition.

The sensitivity of each detector employed in the test series was initially determined by Underwriters Laboratories in accordance with the sensitivity test requirements of their applicable standards. The sensitivity of every detector was checked using the same methods after each series of experiments to insure that the detectors had not shifted in sensitivity.

The actual sensitivities of the detectors used are given in Appendix A. Some units vary from the nominal 1 and 2 percent values requested due to variations in the different manufacturer's calibration techniques.

3.0 RESULTS:

In total, 40 experiments were conducted in this program. Twenty-seven experiments at the primary test site, and 13 at the secondary site. Narrative descriptions of all experiments are included in Appendix C.

Identification of the detectors used in the test series by type, sensitivity and clock number is given in Appendix A, Table I. A summary of detector performance for the experiments conducted in the primary test site is given in Appendix A, Table II, and the summary of results of detector performance for the secondary test site is given in Appendix A, Table III.

In Appendix I, curves showing the time histories of various measured quantities throughout the buildings are given. These include temperature, light obscuration, and concentrations of carbon dioxide and carbon monoxide in the fire room, bedrooms, and positions along the escape route. Data from the combustion products meters has not been plotted because there is some doubt about its validity. Laboratory measurements with the three instruments used indicate that extensive calibrations would be necessary before quantitative data could be obtained, and there is no way of knowing whether or not the calibration would be stable.

Figures 5, 6 and 7 are a series of photographs taken during experiment 31 at the lakeshore site. They show the typical progression of a smoldering test fire.

Figure 8 is two photographs taken during experiment 11 in the J. R. Whitehouse building showing a typical smoldering mattress.

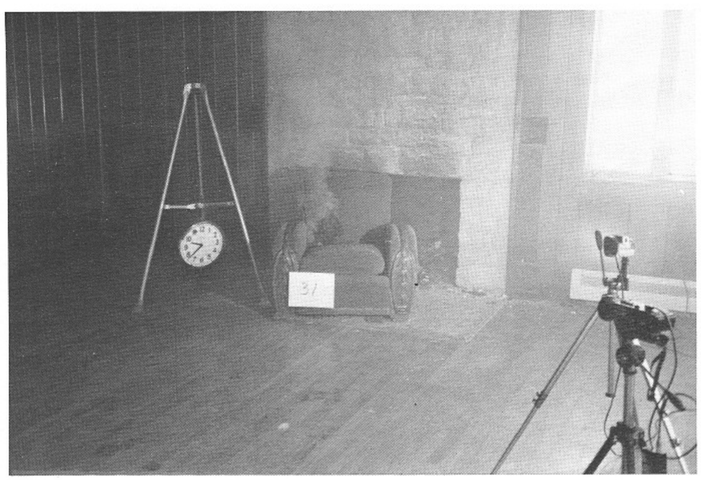
Figure 9 is two photographs taken during experiments 13 and 33, each are typical of the flaming test run.

4.0 DISCUSSION OF RESULTS:

RESPONSE TO FIRES

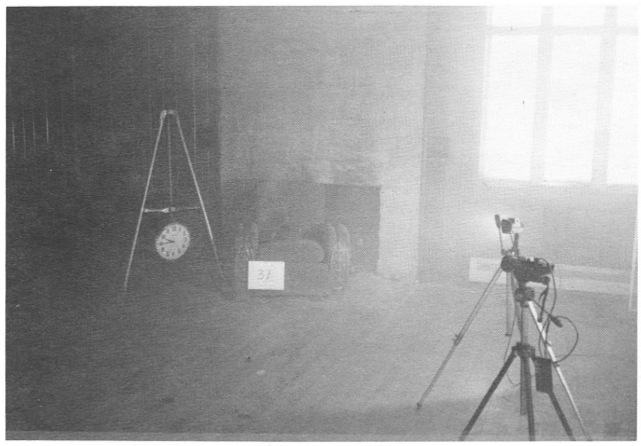
In general, all smoke detectors responded well to all fires. The photoelectric type detectors seem to respond better to the smoldering type fires and the ionization detectors seem to respond slightly better to the flaming fires.

Experiment 31 — 300 seconds

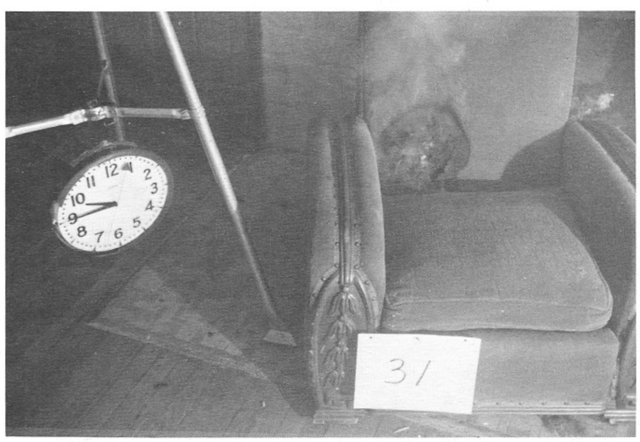


Experiment 31 — 1380 seconds

FIGURE 5

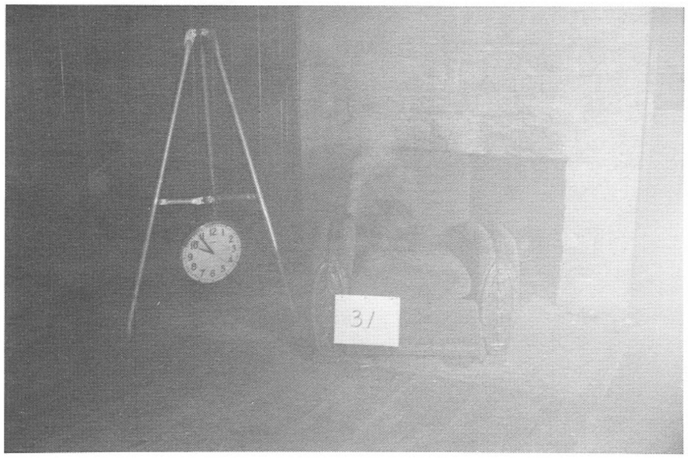


Experiment 31 — 1800 seconds

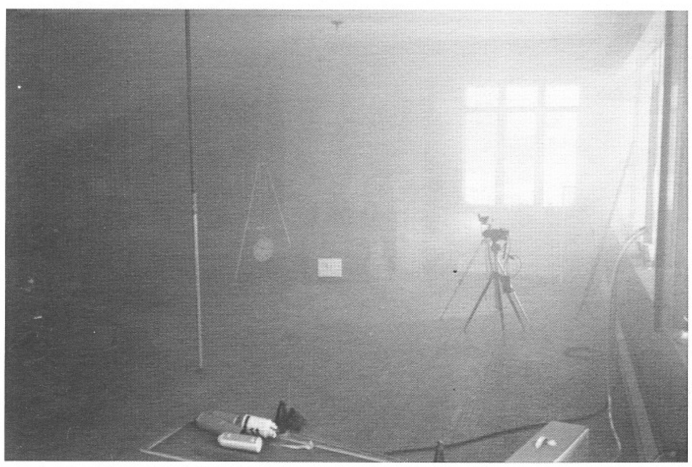


Experiment 31 — 1800 seconds

FIGURE 6



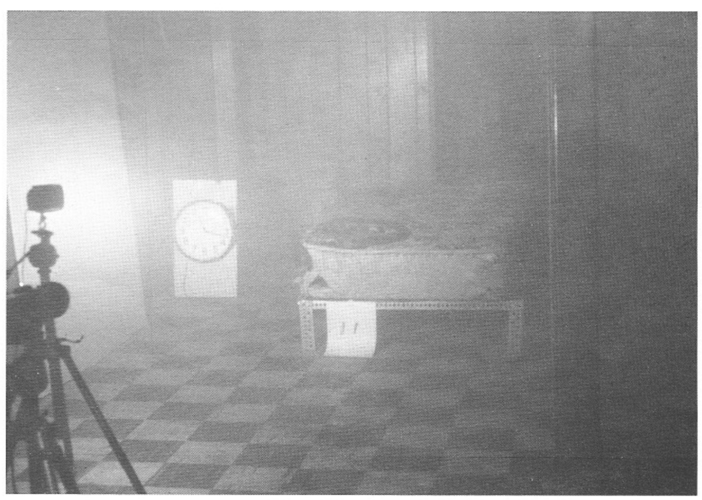
Experiment 31 — 2040 seconds



Experiment 31 — 2100 seconds

FIGURE 7

Experiment 11 — 900 seconds



Experiment 11 — 4380 seconds

FIGURE 8

Experiment 13 — 43 seconds

Experiment 33 — 43 seconds

FIGURE 9

There appeared to be no significant difference observed in the response of detectors mounted on the ceiling or on the wall. Response time and escape time potential was somewhat better for the higher sensitivity units as would be expected.

Appendix H give performance curves for both the theoretical and actual detectors. The theoretical detector results are based on conditions existing at detector locations and assume the detector can sense the condition with no time lag.

The curves indicate the frequency of success (ordinate) that each detector would provide for any required escape time (abscissa). Required escape time may vary considerably depending on size and configuration of the structure, and the age and physical condition of occupants. Times in the range of 2 to 5 minutes seem reasonable, however.

The theoretical smoke detector performance is shown for two escape criteria, 0.03 and 0.070 OD/ft. The choice of escape criteria has a small effect on the theoretical results. The curves show that both the theoretical and actual detectors provide inadequate protection when fires and detectors are on different floors.

In the primary test site, the escape times obtained from detectors installed on the second floor responding to first floor fires seem somewhat marginal. According to NFPA/74 level four for installing the detectors, there would be no detector on the first floor if there were no first floor bedrooms. The results of the experiments seem to indicate that this situation would result in marginal performance under many first floor fire conditions. These results can be seen in Appendix H, Figures 3, 11, 14, 18 and 20.

It should be noted that poor performance of 2nd floor detectors with 1st floor fires was accentuated in the summer, particularly for smoldering ignitions. Since all summer experiments were conducted with the HVAC system operating, summer experiments with no forced circulation may emphasize the effect further.

The lakeshore test building with a 30 ft central hallway had a bedroom configuration which would require a smoke detector near one end of the hallway. An additional detector located at the other end of the hallway significantly increased escape time potential. This is shown in Appendix H, Figures 7, 12, 16 and 20.

The results for detectors H and A seems to indicate that the 2 percent detectors were consistantly operating before the 1 percent detectors. Inspection of the actual sensitivities of detector H as given in Appendix A, Table 1 will show that there is very little difference between units designated 1 percent and 2 percent. Therefore, the differences in operating times are primarily due to the location on the test board and orientation and not to sensitivity. In addition, detector A is intended only for wall mounting due to a large sensitivity to direction of air movement. The units were mounted on the ceiling for most experiments. While this seemed to have only a very small effect, when coupled with the limited difference in sensitivity between units designated 1 percent and 2 percent it could well explain the results.

Detectors from manufacturer B showed poor performance in later experiments in each test series. These were clock numbers 2 and 14 (Dual Gate) and 5. The detectors, especially the dual gate type seemed to be affected by a build-up of dirt on the sensing chambers reducing their sensitivity. It appears to be very important for the homeowner to perform recommended maintenance faithfully on this detector to maintain proper operation.

The response of the heat detectors employed was considerably different from the response of the smoke detectors. Rate-of-rise thermal detectors with a 50 ft space rating were installed on each detector board. In addition, in experiments 13 through 40 a similar rate-of-rise detector was included in the room of fire origin for each experiment. The results of the experiments indicate that these heat detectors, including the one in the room of fire origin, failed to respond to a majority of the fires. Even when they did respond, they were considerably slower than the smoke detectors and provided little or no escape time prior to occurrence of dangerous conditions in the primary escape path. See Appendix H, Figure 21.

Thermocouple readings at the ceiling in the room of fire origin were used to evaluate the escape potential provided by a 135 F fixed-temperature heat detector assuming no thermal lag. These results indicate that fixed-temperature heat detectors with no thermal lag in every room would have little life saving potential in the residential fire situations simulated here. See Appendix H, Figure 22.

The localized convection currents induced by the hot water baseboard heating system in the secondary test site seem to have little or no effect on detector response or smoke flow patterns during any of the experiments. Forced convection from the forced-air heating system in the primary site had some effect on both of these conditions, but did not appear to significantly change escape time potentials.

Experiments carried out in the primary site with the HVAC system operating during winter conditions in the heating mode indicated that the ventilating system was a prime factor in distribution of smoke from the fire throughout the dwelling. Considerable smoke was found in the bedrooms under these conditions even with the bedroom doors closed. Forced flows through doorways and stairwells did not appear to have a noticeable effect on smoke movement to detector sites, however. (See Appendix J)

One very interesting effect noted was that during summer conditions with the HVAC system in a cooling mode, distribution of smoke by the HVAC system was considerably slower. In all cases, it was observed that during these summer conditions there was very little smoke in bedrooms with closed doors as compared to a similar experiment carried out under winter conditions. One possible explanation for this effect could be the scavenging and filtering effect of the wet cooling coil of the air conditioner. It appears that this effect should be studied further as to its implications not only in residential applications but also in the effect it would have on the response of duct-type detectors in commercial applications.

Another explanation of this phenomenon is the difference in smoke stratification observed in summer and winter experiments. During experiments in the heating mode, it appeared that smoke was quite uniformly distributed from floor to ceiling in each room, although there were gradients from room to room. Under those conditions, smoke density and fire gas concentrations rose continuously at ceiling and 5 ft level monitoring points throughout the house.

With the house cooled during the summer experiments, the smoke from most fires stratified in a band 3 to 6 ft above the floor in the fire room and remained there for a long period of time. Under those conditions, very little smoke either entered the return air ducts or flowed along the ceiling to other rooms. Late in the fire, when the smoke layer became very dense, it expanded to fill the fire room and distribution to other rooms and to the return air ducts began. Nevertheless, smoke which was transmitted to other rooms tended to remain stratified at various levels in the lower part of the space.

When the fire was located in a closed bedroom, smoke detectors immediately outside the bedroom did not respond until after dangerous conditions existed in the fire room, even when forced air heating was operating. This phenomenon is evident in the data for Experiments 4 and 5 shown in Appendix I.

Another interesting effect observed during the experiments during the winter at both test sites was that the visibility along the primary escape path changed extremely rapidly immediately following transition from a smoldering to a flaming fire. While the material was smoldering, light gray smoke slowly increased throughout the building in a fairly uniform concentration from floor to ceiling. Generally, it was possible to see very well throughout the primary escape path until transition to flaming occurred. At this point, a very dense dark gray smoke band formed at the ceiling and progressed rapidly downward. What appeared to be happening was that the heat from the flaming fire was causing the evenly distributed smoke to rise to the ceiling. This band reached the 5 ft level and below in a very short time while it appeared that visibility below this dark band was improving slightly. This was noticed in all smoldering fires.

Another unexpected observation during the fires was the slowness of smoke movement throughout the building. All of the experiments, and especially the basement fires, showed that the smoke moving up stairways tended to move in a clearly defined front and at a very slow rate. It was often the case that, when this defined front reached the detectors, a number of the detectors responded almost simultaneously.

CONCLUSIONS:

1. A residential smoke detector of either the ionization or photoelectric types with small lag time would provide more than adequate life saving potential under most real residential fire conditions when properly installed. Even in the case of rapidly building flaming ignition fires the detectors would provide adequate warning before dangerous conditions were reached in the primary escape path.

2. Whereas detectors set at nominal 2 percent per foot obscuration generally provided adequate warning, those detectors whose sensitivities were near 1 percent per foot (actual) provided a considerable increase in escape time for smoldering fires. The effect was much smaller for flaming fires.

3. Fixed temperature (135 F) or rate-of-rise heat detectors in the room of fire origin provided little life saving potential. These detectors failed to respond to a majority of the fires and when they did respond they were considerably slower than smoke detectors located remote from the fire.

4. In the building during forced air heating, there appears to be very little difference in smoke levels obtained in the bedroom with the bedroom doors open or closed. Under central air conditioning, however, greatly reduced smoke levels were obtained in the bedrooms with the doors closed.

Experiments conducted with fires in closed bedrooms resulted in lethal conditions in the bedroom before response of detectors outside the bedroom. Thus, the person in the room of fire origin would not be saved unless the detectors were in the bedroom or the door was open.

5. Response time of detectors on the second floor for first floor fires should be considered inadequate. Thus, it would appear that NFPA/74 should be revised to require at least one detector on each level of a residence.

6. Installation of one smoke detector at each end of a long central hall would significantly increase the escape time potential in comparison with one detector at one end of the hall.

7. It appears that there is no difference in life saving potential between ionization and photoelectric detectors under expected residential fire conditions when taken as a whole. Although some response difference is noticed depending on the type of combustion, (flaming or smoldering) the differences are minimal when compared on an escape time and life saving potential basis. Detectors operating on the dual gate principle appear less advantageous than either the ionization or photoelectric types.

8. Smoke conditions produced by the fires indicate that there should be no significant difference in detection times for ceiling mounting or wall mounting within 12 in. of the ceiling. However, individual detectors with highly directional properties may function quite differently in these two positions.

5.0 RECOMMENDED AREAS FOR FURTHER STUDY:

A number of conclusions which emerge from this series of experiments seem to have great significance to development of requirements for installation of residential fire detection systems. Accordingly it is essential that these be verified in additional experiments. Specifically, the following items need further study.

1. The differences between smoke distribution by the HVAC system under heating and cooling conditions should be investigated in other buildings and for both single and double duct systems. Summer conditions should be further investigated to include fires originating just after the HVAC system shuts off and where air conditioning is not used.

2. Further similar experiments should be carried out in other building geometries to determine if the results of these experiments are specific to these geometries.

3. Some experiments should be carried out in these and other test buildings to determine the effect of open windows on fire conditions and detector response.

4. Experiments should be carried out to determine what affect NFPA/74 protection levels 1, 2 and 3 have on increasing the escape time over those obtained with a level four type installation. This data could be well applied in determining the cost effectiveness of providing these much more expensive detection systems.

5. Consideration should be given to the development of one or more standardized fire which could be used as a correlation test for various building geometries and ambient conditions.

APPENDIX A

DETECTOR IDENTIFICATION
AND
RESPONSE TIME DATA

TABLE 1 - DETECTOR IDENTIFICATION

Manufacturer Code	Type	Preset Sensitivity (Percent/Foot) Theoretical	Preset Sensitivity (Percent/Foot) Measured	Clock Number
A	Photo	1	1.19	1
B	Dual Gate	2	3.89	2
F	ION	2	2.81	3
E	Photo	1	0.96	4
B	ION	2	2.02	5
E	Photo	2	1.98	6
F	ION	1	1.61	7
A	Photo	2	1.4	9
E	Photo	2	1.81	10
A	Photo	1	1.27	11
F	ION	1	1.34	12
F	ION	2	3.04	13
B	Dual Gate	2	2.19	14
ROR	ROR	15F/Min	15F/Min	15
H	ION	1	1.91	16
H	ION	2	2.04	17
H	ION	1	1.81	18
H	ION	2	2.04	19
ROR	ROR	15F/Min	15F/Min	20
ROR	ROR	15F/Min	15F/Min	22
A	Photo	2	2.09	24
E	Photo	1	0.96	25

TABLE 2 - SUMMARY OF DETECTOR
PERFORMANCE - J. R. WHITEHOUSE RESIDENCE

Clock No.	Detector Operating Times For Each Test In Seconds												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1	380	2512	2670	3211	1511	1997	496	91	86	3889	2115	2947	283
2	369	6264	2720	5382	1703	2687	464	31	38	*	*	*	*
3	539	4404	2703	(5706)	1691	1781	122	43	49	4791	3819	4263	126
4	264	1492	1881	1272	499	468	120	33	45	1908	1418	1832	217
5	371	6175	2697	3593	1729	1931	118	30	41	No	6925	No	No
6	279	3050	2678	3832	805	1513	472	62	71	5199	3974	4309	443
7	254	2595	2645	3992	588	473	111	32	48	4813	2488	2763	186
9	1274	*	*	*	*	*	*	*	*	*	*	*	*
10	1045	6385	2807	No	2757	3548	635	199	207	(8661)	7857	8123	1270
11	1293	6458	2787	No	2948	3661	935	204	178	(8998)	6828	7031	1461
12	772	6373	2780	No	2775	3614	579	136	130	(8995)	7862	(8549)	1255
13	917	6421	2824	No	2998	4067	708	136	156	4791	No	(8792)	1291
14	820	6472	2791	No	2980	4039	644	144	146	No	No	(8769)	1266
15	No	No	No	No	No	No	No	No	No	No	No	No	No
16	370	6170	2671	3620	1818	1963	121	30	40	5791	5180	6256	317
17	368	6163	2671	4196	1811	1885	114	32	41	4962	2899	5447	71
18	925	6366	2774	No	2916	3933	573	136	126	No	7871	(8745)	1272
19	823	6365	2773	No	2867	3679	563	131	126	No	7854	(8750)	1265
20	1701	No	2791	No	No	No	No	88	82	No	No	No	No
24	279	2300	*	2100	664	617	215	*	*	2178	2140	2884	*
25	883	6322	2774	No	2747	3268	581	149	154	8185	6775	7041	1251
22	+	+	+	+	+	+	+	+	+	+	+	+	+
Time of Flaming	210	3880	2700	[5670]	3060	-	0	0	0	-	7725	-	0
End of Test	1860	7080	3035	5580	3060	4380	1050	-	-	8520	7890	8210	1500
						Fire out		315	315				

Key -
- No - No operation.
- * - Detector Malfunction.
- [ ] - Opening of windows caused flaming after end of test.
- ( ) - Detector operated during building ventilation after end of test.
- + - Detector 22 added with Test 14 and was always on the ceiling of the burn room.

TABLE 2 - SUMMARY OF DETECTOR (Continued)
PERFORMANCE - J. R. WHITEHOUSE RESIDENCE

Clock No.	Detector Operating Times For Each Test In Seconds													
	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	3525	3064	658	4144	2659	3060	1053	318	1610	278	5938	424	2265	204
2	No	No	488	4156	3127	5538	1627	278	1609	175	6560	113	3284	125
3	3509	3365	362	3623	2703	5681	(2079)	245	1616	139	6009	150	1657	122
4	3094	2043	556	2776	1722	2407	771	349	1609	256	4721	299	1212	165
5	3474	3303	382	3760	2863	No	(2098)	230	(3527)	758	7095	1113	5838	1304
6	3372	2620	718	3420	2504	3299	1118	348	2678	766	6880	1075	3724	996
7	3015	2228	229	2908	1910	2862	562	161	2081	457	6857	694	2617	470
9	3334	3187	540	2554	1907	3055	588	*	2194	*	*	*	*	*
10	3367	2370	438	2659	1468	3101	471	207	2194	410	6489	840	2231	574
11	3044	2098	389	2454	1666	2214	589	198	1982	397	6465	748	1778	451
12	2985	2097	158	2520	1475	3100	285	56	1824	357	6760	509	2314	289
13	3341	3699	357	2869	1965	4064	295	64	2410	365	6761	660	4071	404
14	5654	3827	384	2494	1918	3932	230	57	2440	363	6778	589	5634	445
15	No	No	No	No	No	No	No	245	No	No	No	No	No	No
16	4703	4046	439	4163	2948	No	(2073)	256	(3546)	No	No	1181	No	No
17	3203	2583	319	3232	2157	3305	804	191	1610	98	5786	100	1437	84
18	4758	3702	372	2778	2076	4245	279	84	2983	365	6768	709	5682	1192
19	4209	3305	339	2908	2222	4943	544	68	2761	392	6774	768	5532	1053
20	No	No	No	No	No	No	No	No	No	No	No	No	No	No
24	2898	2103	526	2846	2001	2447	784	280	2321	659	6888	945	2222	732
25	2958	2098	443	1240	1296	2074	370	203	1851	373	5733	655	1629	441
22	No	No	1502	No	No	No	No	233	1597	261	6694	1001	No	158
Time of Flaming	-	-	0	-	-	-	0	0	1650	0	6460	0	5180	0
End of Test	6000	4501	1546	4313	3720	6201	1956	652	3512	900	7215	1350	6510	2030

Key - No - No operation.
* - Detector Malfunction.
[ ] - Opening of windows caused flaming after end of test.
( ) - Detector operated during building ventilation after end of test.
\+ - Detector 22 added with Test 14 and was always on the ceiling of the burn room.

TABLE 3 - SUMMARY OF DETECTOR
PERFORMANCE - LAKESHORE RESIDENCE

	Detector Operating Times For Each Test In Seconds												
Clock No.	28	29	30	31	32	33	34	35	36	37	38	39	40
1	4296	1452	2556	2287	1922	373	3503	753	3950	No	686	714	1759
2	No	No	No	No	2165	No	3503	436	3909	No	No	No	1904
3	4912	1488	1427	2294	1984	177	3546	440	3931	No	793	837	1751
4	3204	786	2122	2018	1802	349	3494	675	3878	447	586	583	1736
5	5309	1701	3378	2267	1954	125	3815	629	4284	No	902	No	1765
6	4023	1221	2577	2266	1849	376	3805	1078	4122	No	794	No	1865
7	3640	799	2564	2125	1822	97	3805	542	4024	488	789	1113	1763
9	4861	1626	1268	2702	2509	354	3837	1201	4333	447	812	730	1692
10	4046	1505	902	2361	2460	385	3836	1196	4270	498	761	751	1680
11	4333	1603	842	2596	2530	331	3834	1199	4191	491	778	657	1613
12	4020	1488	905	2377	2475	160	3837	1168	4236	454	804	748	1208
13	8033	2254	1239	2965	2589	241	3849	1212	4348	516	913	858	1719
14	6152	1506	1321	2340	2243	No	3844	1240	4317	447	925	844	1674
15	No	No	4214	4082	No	No	No	No	No	No	No	No	1811
16	7365	1730	2990	2603	1974	164	3814	615	4220	No	1060	No	1791
17	4327	1411	2537	2194	1824	96	3824	349	3781	583	769	760	1712
18	8005	1882	1635	2752	2503	205	3838	1189	4323	No	950	864	1710
19	7960	1850	1326	2659	2507	206	3835	1185	4324	No	863	867	1715
20	8280	No	(4248)	4068	No	No	No	No	No	No	No	No	No
24	4394	1481	2991	2214	1852	284	3807	731	4158	No	831	No	1762
25	+	+	+	+	+	+	+	+	+	+	+	+	+
22	8264	2521	4193	3986	(2760)	No	No	(1600)	4346	No	No	No	1704
Time of Flaming	7910	2296	3670	3885	2340	0	3765	0	4275	350	-	-	1680
End of Test	8370	2665	4235	4135	2730	1356	4410	1583	4840	614	1210	1200	1915

Key - No - No operation
* - Detector malfunction
[ ] - Opening of windows caused flaming after end of test
( ) - Detector operated during building ventilation after end of test
\+ - Detector out of service due to physical breakage

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING DETECTORS			
TEST NO:						
1-JR	7	F	Ion	1.61	254	1156
	6	E	Photo	1.98	279	1131
FIRE TYPE:	24	A	Photo	2.09	279	1131
S-Chair	16	H	Ion	1.91	370	1040
	5	B	Ion	2.02	371	1039
FIRE LOCATION:	20	-	ROR	15°F/min	1701	-291
Living Room						
			FIRST FLOOR HALL WALL DETECTORS			
SEASON:						
Summer	4	E	Photo	0.96	264	1146
	17	H	Ion	2.04	368	1042
A/C OR HEAT:	2	B	Dual Gate	3.89	369	1041
A/C On	1	A	Photo	1.19	380	1030
	3	F	Ion	2.81	539	871
BEDROOM DOORS CLOSED:						
None						
			SECOND FLOOR HALL CEILING DETECTORS			
BASEMENT DOOR CLOSED:	12	F	Ion	1.34	772	638
No	14	B	Dual Gate	2.19	820	590
	19	H	Ion	2.04	823	587
FLAMES AT:	25	E	Photo	0.96	883	527
210 Secs.	13	F	Ion	3.04	917	493
	18	H	Ion	1.81	925	485
TENABILITY LIMITS:	10	E	Photo	1.81	1045	365
1410 Secs.	9	A	Photo	1.40	1274	136
	11	A	Photo	1.27	1296	117
TEST ENDS:						
1860 Secs.						
			FIRE ROOM DETECTORS			
	T/C	-	FT	150°F	1575	-165
	T/C	-	FT	135°F	1500	-90

TEST NO:
2-JR

FIRE TYPE:
S-Sofa

FIRE LOCATION:
Living Room

SEASON:
Summer

A/C OR HEAT:
A/C On

BEDROOM DOORS CLOSED:
None

BASEMENT DOOR CLOSED:
No

FLAMES AT:
6210 Secs.

TENABILITY LIMITS:
6380 Secs.

TEST ENDS:
7080 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		FIRST FLOOR HALL CEILING DETECTORS			
24	A	Photo	2.09	2300	4080
7	F	Ion	1.61	2595	3785
6	E	Photo	1.98	3050	3330
16	H	Ion	1.91	6170	210
5	B	Ion	2.02	6175	205
20	-	ROR	15°F/min	None	None
		FIRST FLOOR HALL WALL DETECTORS			
4	E	Photo	0.96	1492	4888
1	A	Photo	1.19	2512	3868
3	F	Ion	2.81	4404	1976
17	H	Ion	2.04	6163	217
2	B	Dual Gate	3.89	6264	116
		SECOND FLOOR HALL CEILING DETECTORS			
25	E	Photo	0.96	6322	58
19	H	Ion	2.04	6325	55
18	H	Ion	1.81	6326	54
12	F	Ion	1.34	6373	7
10	E	Photo	1.81	6385	-5
13	F	Ion	3.04	6421	-41
11	A	Photo	1.27	6458	-78
14	B	Dual Gate	2.19	6472	-92
9	A	Photo	-	MALF.	N/A
15	-	ROR	15°F/min	None	None
		FIRE ROOM DETECTORS			
T/C	-	FT	135°F	6420	-40
T/C	-	FT	150°F	6930	-550

TEST NO:
3-JR

FIRE TYPE:
S-Sofa

FIRE LOCATION:
Living Room

SEASON:
Summer

A/C OR HEAT:
A/C On

BEDROOM DOORS CLOSED:
All

BASEMENT DOOR CLOSED:
Yes

FLAMES AT:
2700 Secs.

TENABILITY LIMITS:
2753 Secs.

TEST ENDS:
3035 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-}FT^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
FIRST FLOOR HALL CEILING DETECTORS					
7	F	Ion	1.61	2645	108
16	H	Ion	1.91	2671	82
6	E	Photo	1.98	2678	75
5	B	Ion	2.02	2697	56
20	-	ROR	15°F/min	2791	-38
24	A	Photo	2.09	MALF.	N/A
FIRST FLOOR HALL WALL DETECTORS					
4	E	Photo	0.96	1881	872
1	A	Photo	1.19	2670	83
17	H	Ion	2.04	2671	82
3	F	Ion	2.81	2703	50
2	B	Dual Gate	3.89	2720	33
SECOND FLOOR HALL CEILING DETECTORS					
19	H	Ion	2.04	2773	-20
18	H	Ion	1.81	2774	-21
25	E	Photo	0.96	2774	-21
12	F	Ion	1.34	2780	-27
11	A	Photo	1.27	2787	-34
14	B	Dual Gate	2.19	2791	-38
10	E	Photo	1.81	2807	-54
13	F	Ion	3.04	2824	-71
15	-	ROR	15°F/min	None	None
9	A	Photo	1.40	MALF.	N/A
FIRE ROOM DETECTORS					
T/C	-	FT	135°F	2730	23
T/C	-	FT	150°F	2760	-7

TEST NO: 4-JR

FIRE TYPE: S-Mattress

FIRE LOCATION: 1st Floor Bedroom (A)

SEASON: Summer

A/C OR HEAT: A/C On

BEDROOM DOORS CLOSED: All

BASEMENT DOOR CLOSED: No

FLAMES AT: 5670 Secs.

TENABILITY LIMITS: 4860 Secs.

TEST ENDS: 5580 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		FIRST FLOOR HALL CEILING DETECTORS			
4	E	Photo	0.96	1272	3588
1	A	Photo	1.19	3211	1649
17	H	Ion	2.04	4196	664
2	B	Dual Gate	3.89	5382	-522
3	F	Ion	2.81	(5706)	None
		FIRST FLOOR HALL WALL DETECTORS			
24	A	Photo	2.09	2100	2760
5	B	Ion	2.02	3593	1267
16	H	Ion	1.91	3620	1240
6	E	Photo	1.98	3832	1028
7	F	Ion	1.61	3992	868
20	-	ROR	15°F/min	None	None
		SECOND FLOOR HALL CEILING DETECTORS			
9	A	Photo	1.40	MALF.	N/A
10	E	Photo	1.81	None	None
11	A	Photo	1.27	None	None
12	F	Ion	1.34	None	None
13	F	Ion	3.04	None	None
14	B	Dual Gate	2.19	None	None
15	-	ROR	15°F/min	None	None
18	H	Ion	1.81	None	None
19	H	Ion	2.04	None	None
25	E	Photo	0.96	None	None
		FIRE ROOM DETECTORS			
T/C	-	FT	135°F	None	None
T/C	-	FT	150°F	None	None

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING DETECTORS			
TEST NO:						
5-JR	4	E	Photo	0.96	499	2031
	1	A	Photo	1.19	1511	1019
FIRE TYPE:	3	F	Ion	2.81	1691	839
S-Mattress	2	B	Dual Gate	3.89	1703	827
	17	H	Ion	2.04	1811	719
FIRE LOCATION:						
1st Floor Bedroom (A)			**FIRST FLOOR HALL WALL DETECTORS**			
SEASON:	7	F	Ion	1.61	588	1942
Summer	24	A	Photo	2.09	664	1866
	6	E	Photo	1.98	805	1725
A/C OR HEAT:	5	B	Ion	2.02	1729	801
A/C On	16	H	Ion	1.91	1818	712
	20	-	ROR	15°F/min	None	None
BEDROOM DOORS CLOSED:						
B-E-F			**SECOND FLOOR HALL CEILING DETECTORS**			
BASEMENT DOOR CLOSED:	25	E	Photo	0.96	2747	-217
Yes	10	E	Photo	1.81	2757	-227
	12	F	Ion	1.34	2775	-245
FLAMES AT:	19	H	Ion	2.04	2867	-337
3060 Secs.	18	H	Ion	1.81	2916	-386
	11	A	Photo	1.27	2948	-418
TENABILITY LIMITS:	14	B	Dual Gate	2.19	2980	-450
2530 Secs.	13	F	Ion	3.04	2998	-468
	15	-	ROR	15°F/min	None	None
TEST ENDS:	9	A	Photo	1.40	MALF.	-
3060 Secs.			**FIRE ROOM DETECTORS**			
	T/C	-	FT	135°F	None	None
	T/C	-	FT	150°F	None	None

TEST NO: 6-JR

FIRE TYPE: S-Mattress

FIRE LOCATION: 1st Floor Bedroom (A)

SEASON: Summer

A/C OR HEAT: A/C On

BEDROOM DOORS CLOSED: None

BASEMENT DOOR CLOSED: Yes

FLAMES AT: None

TENABILITY LIMITS: 3470 Secs.

TEST ENDS: 4380 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
FIRST FLOOR HALL CEILING DETECTORS					
4	E	Photo	0.96	468	3002
3	F	Ion	2.81	1781	1689
17	H	Ion	2.04	1885	1585
1	A	Photo	1.19	1997	1473
2	B	Dual Gate	3.89	2687	783
FIRST FLOOR HALL WALL DETECTORS					
7	F	Ion	1.61	473	2997
24	A	Photo	2.09	617	2853
6	E	Photo	1.98	1513	1967
5	B	Ion	2.02	1931	1539
16	H	Ion	1.91	1963	1507
20	-	ROR	15°F/min	None	None
SECOND FLOOR HALL CEILING DETECTORS					
25	E	Photo	0.96	3268	202
10	E	Photo	1.81	3548	-78
12	F	Ion	1.34	3614	-144
11	A	Photo	1.27	3661	-191
19	H	Ion	2.04	3676	-206
18	H	Ion	1.81	3933	-463
14	B	Dual Gate	2.19	4039	-569
13	F	Ion	3.04	4067	-597
15	-	ROR	15°F/min	None	None
9	A	Photo	1.40	MALF.	N/A
FIRE ROOM DETECTORS					
T/C	-	FT	135°F	None	None
T/C	-	FT	150°F	None	None

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING DETECTORS			
TEST NO:						
7-JR	17	H	Ion	2.04	114	571
	4	P	Photo	0.96	120	565
FIRE TYPE:	3	F	Ion	2.81	122	563
F-Mattress	2	B	Dual Gate	3.89	464	221
	1	A	Photo	1.19	496	189
FIRE LOCATION:						
1st Floor Bedroom (A)			**FIRST FLOOR HALL WALL DETECTORS**			
SEASON:	7	F	Ion	1.61	111	574
Summer	5	B	Ion	2.02	118	567
	16	H	Ion	1.91	121	564
A/C OR HEAT:	24	A	Photo	2.09	215	470
A/C On	6	E	Photo	1.98	472	213
	20	-	ROR	15°F/min	None	None
BEDROOM DOORS CLOSED:						
E-F			**SECOND FLOOR HALL CEILING DETECTORS**			
BASEMENT DOOR CLOSED:	19	H	Ion	2.04	563	122
Yes	18	H	Ion	1.81	572	113
	12	F	Ion	1.34	579	106
FLAMES AT:	25	E	Photo	0.96	581	104
0 Secs.	10	E	Photo	1.81	635	50
	14	B	Dual Gate	2.19	644	41
TENABILITY LIMITS:	13	F	Ion	3.04	708	-23
685 Secs.	11	A	Photo	1.27	935	-250
	15	-	ROR	15°F/min	None	None
TEST ENDS:	9	A	Photo	1.40	MALF.	N/A
1050 Secs.						
			FIRE ROOM DETECTORS			
	T/C	-	FT	135°F	899	-214
	T/C	-	FT	150°F	1050	-365

TEST NO:
8-JR

FIRE TYPE:
F-JP-4 on Stove

FIRE LOCATION:
Kitchen

SEASON:
Summer

A/C OR HEAT:
A/C On

BEDROOM DOORS CLOSED:
None

BASEMENT DOOR CLOSED:
Yes

FLAMES AT:
0 Secs.

TENABILITY LIMITS:
220 Secs.

TEST ENDS:
315 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		FIRST FLOOR HALL CEILING DETECTORS			
2	B	Dual Gate	3.89	31	189
17	H	Ion	2.04	32	188
4	E	Photo	0.96	33	187
3	F	Ion	2.81	43	177
1	A	Photo	1.19	91	129
		FIRST FLOOR HALL WALL DETECTORS			
5	B	Ion	2.02	30	190
16	H	Ion	1.91	30	190
7	F	Ion	1.61	32	188
6	E	Photo	1.98	62	158
20	-	ROR	15°F/min	88	132
24	A	Photo	2.09	MALF.	N/A
		SECOND FLOOR HALL CEILING DETECTORS			
19	H	Ion	2.04	131	89
18	H	Ion	1.81	136	84
13	F	Ion	3.04	136	84
12	F	Ion	1.34	136	84
14	B	Dual Gate	2.19	144	76
25	E	Photo	0.96	149	71
10	E	Photo	1.81	199	21
11	A	Photo	1.27	204	16
15	-	ROR	15°F/min	None	None
9	A	Photo	1.40	MALF.	N/A
		FIRE ROOM DETECTORS			
T/C	-	FT	135°F	15	205
T/C	-	FT	150°F	17	203

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING DETECTORS			
TEST NO:						
9-JR	2	B	Dual Gate	3.89	38	93
	17	H	Ion	2.04	41	90
FIRE TYPE:	4	E	Photo	0.96	45	86
F - JP-4 on Stove	3	F	Ion	2.81	49	82
	1	A	Photo	1.19	86	45
FIRE LOCATION:						
Kitchen			**FIRST FLOOR HALL WALL DETECTORS**			
SEASON:	16	H	Ion	1.91	40	91
Summer	5	B	Ion	2.02	41	90
	7	F	Ion	1.61	48	83
A/C OR HEAT:	6	E	Photo	1.98	71	60
A/C On	20	-	ROR	15°F/min	82	49
	24	A	Photo	2.09	MALF.	N/A
BEDROOM DOORS CLOSED:						
All			**SECOND FLOOR HALL CEILING DETECTORS**			
BASEMENT DOOR CLOSED:	18	H	Ion	1.81	126	5
Yes	19	H	Ion	2.04	126	5
	12	F	Ion	1.34	130	1
FLAMES AT:	14	B	Dual Gate	2.19	146	-15
0 Secs.	25	E	Photo	0.96	154	-23
	13	F	Ion	3.04	156	-25
TENABILITY LIMITS:	11	A	Photo	1.27	178	-47
131 Secs.	10	E	Photo	1.81	207	-76
	15	-	ROR	15°F/min	None	None
TEST ENDS:	9	A	Photo	1.40	MALF.	N/A
315 Secs.						
			FIRE ROOM DETECTORS			
	T/C	-	FT	135°F	15	116
	T/C	-	FT	150°F	17	114

TEST NO:
10-JR

FIRE TYPE:
S-Mattress

FIRE LOCATION:
Basement (x)

SEASON:
Summer

A/C OR HEAT:
A/C On

BEDROOM DOORS CLOSED:
All

BASEMENT DOOR CLOSED:
No

FLAMES AT:
None

TENABILITY LIMITS:
5990 Secs.

TEST ENDS:
8520 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		BASEMENT CEILING DETECTORS			
4	E	Photo	0.96	1908	4082
1	A	Photo	1.19	3889	2101
3	F	Ion	2.81	4791	1199
17	H	Ion	2.04	4962	1028
2	B	Dual Gate	3.89	MALF.	N/A
		FIRST FLOOR HALL WALL DETECTORS			
24	A	Photo	2.09	2178	3812
7	F	Ion	1.61	4813	1177
6	E	Photo	1.98	5199	791
16	H	Ion	1.91	5791	199
5	B	Ion	2.02	None	None
20	-	ROR	15°F/min	None	None
		SECOND FLOOR HALL CEILING DETECTORS			
13	F	Ion	3.04	4791	1199
25	E	Photo	0.96	8185	-2195
10	E	Photo	1.81	(8661)	None
12	F	Ion	1.34	(8995)	None
11	A	Photo	1.27	(8998)	None
18	H	Ion	1.81	None	None
19	H	Ion	2.04	None	None
14	B	Dual Gate	2.19	None	None
15	-	ROR	15°F/min	None	None
9	A	Photo	1.40	MALF.	N/A
		FIRE ROOM DETECTORS			
T/C	-	FT	135°F	None	None
T/C	-	FT	150°F	None	None

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			BASEMENT CEILING DETECTORS			
TEST NO: 11-JR	4	E	Photo	0.96	1418	5122
	1	A	Photo	1.19	2115	4425
FIRE TYPE: S-Box Spring	17	H	Ion	2.04	2889	3651
	3	F	Ion	2.81	3819	2721
	2	B	Dual Gate	3.89	MALF.	N/A
FIRE LOCATION: Basement (X)						
			FIRST FLOOR HALL WALL DETECTORS			
SEASON: Summer	24	A	Photo	2.09	2140	4400
	7	F	Ion	1.61	2488	4052
	6	E	Photo	1.98	3974	2566
A/C OR HEAT: A/C On	16	H	Ion	1.91	5180	1360
	5	B	Ion	2.02	6925	-385
	20	-	ROR	15°F/min	None	None
BEDROOM DOORS CLOSED: All						
			SECOND FLOOR HALL CEILING DETECTORS			
BASEMENT DOOR CLOSED: No	25	E	Photo	0.96	6775	-235
	11	A	Photo	1.27	6828	-288
	19	H	Ion	2.04	7854	-1314
FLAMES AT: 7725 Secs.	10	E	Photo	1.81	7857	-1317
	12	F	Ion	1.34	7862	-1322
	18	H	Ion	1.81	7871	-1331
TENABILITY LIMITS: 6540 Secs.	13	F	Ion	3.04	None	None
	14	B	Dual Gate	2.19	None	None
	15	-	ROR	15°F/min	None	None
TEST ENDS: 7890 Secs.	9	A	Photo	1.40	MALF.	N/A
			FIRE ROOM DETECTORS			
	T/C	-	FT	135°F	7700	-1160
	T/C	-	FT	150°F	7700	-1160

TEST NO: 12-JR

FIRE TYPE: S-Mattress

FIRE LOCATION: Basement (X)

SEASON: Summer

A/C OR HEAT: A/C On

BEDROOM DOORS CLOSED: None

BASEMENT DOOR CLOSED: No

FLAMES AT: None

TENABILITY LIMITS: 7050 Secs.

TEST ENDS: 8210 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		BASEMENT CEILING DETECTORS			
4	E	Photo	0.96	1832	5218
1	A	Photo	1.19	2947	4103
3	F	Ion	2.81	4263	2787
17	H	Ion	2.04	5447	1603
2	B	Dual Gate	3.89	MALF.	N/A
		FIRST FLOOR HALL WALL DETECTORS			
7	F	Ion	1.61	2763	4287
24	A	Photo	2.09	2884	4166
6	E	Photo	1.98	4309	2741
16	H	Ion	1.91	6256	794
5	B	Ion	2.02	None	None
20	-	ROR	15°F/min	None	None
		SECOND FLOOR HALL CEILING DETECTORS			
11	A	Photo	1.27	7031	19
25	E	Photo	0.96	7041	9
10	E	Photo	1.81	8123	-1073
12	F	Ion	1.34	(8549)	None
18	H	Ion	1.81	(8745)	None
19	H	Ion	2.04	(8750)	None
14	B	Dual Gate	2.19	(8769)	None
13	F	Ion	3.04	(8792)	None
15	-	ROR	15°F/min	None	None
9	A	Photo	1.40	MALF.	N/A
		FIRE ROOM DETECTORS			
T/C	-	FT	135°F	None	None
T/C	-	FT	150°F	None	None

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			BASEMENT CEILING DETECTORS			
TEST NO: 13-JR	17	H	Ion	2.04	71	1019
	3	F	Ion	2.81	126	964
FIRE TYPE: F-Chair	4	E	Photo	0.96	217	873
	1	A	Photo	1.19	283	807
	2	B	Dual Gate	3.89	MALF.	N/A
FIRE LOCATION: Basement (X)			**FIRST FLOOR HALL WALL DETECTORS**			
SEASON: Summer	7	F	Ion	1.61	186	904
	16	H	Ion	1.91	317	773
	6	E	Photo	1.98	443	647
A/C OR HEAT: A/C On	5	B	Ion	2.02	None	None
	20	-	ROR	15°F/min	None	None
	24	A	Photo	2.09	MALF.	N/A
BEDROOM DOORS CLOSED: None			**SECOND FLOOR HALL CEILING DETECTORS**			
BASEMENT DOOR CLOSED: No	25	E	Photo	0.96	1251	-161
	12	F	Ion	1.34	1255	-165
	19	H	Ion	2.04	1265	-175
FLAMES AT: 0 Secs.	14	B	Dual Gate	2.19	1266	-176
	10	E	Photo	1.81	1270	-180
	18	H	Ion	1.81	1272	-182
TENABILITY LIMITS: 1090 Secs.	13	F	Ion	3.04	1291	-201
	11	A	Photo	1.27	1461	-371
	15	-	ROR	15°F/min	None	None
TEST ENDS: 1500 Secs.	9	A	Photo	1.40	MALF.	N/A
			FIRE ROOM DETECTORS			
	T/C	-	FT	135°F	1065	25
	T/C	-	FT	150°F	1080	10

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	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING DETECTORS			
TEST NO: 14-JR	25	E	Photo	0.96	2958	2582
	12	F	Ion	1.34	2985	2555
FIRE TYPE: S-Chair	11	A	Photo	1.27	3044	2496
	9	A	Photo	1.40	3334	2206
	13	F	Ion	3.04	3341	2199
FIRE LOCATION: Living Room	10	E	Photo	1.81	3367	2173
	19	H	Ion	2.04	4209	1331
	18	H	Ion	1.81	4758	782
SEASON: Winter	14	B	Dual Gate	2.19	5654	-114
	15	-	ROR	15°F/min	None	None
A/C OR HEAT: Heat On			**SECOND FLOOR HALL CEILING DETECTORS**			
	4	E	Photo	0.96	3094	2446
BEDROOM DOORS CLOSED: A & F	17	H	Ion	2.04	3203	2337
	3	F	Ion	2.81	3509	2031
	1	A	Photo	1.19	3525	2015
BASEMENT DOOR CLOSED: No	2	B	Dual Gate	3.89	None	None
			SECOND FLOOR HALL WALL DETECTORS			
FLAMES AT: None	24	A	Photo	2.09	2898	2642
	7	F	Ion	1.61	3015	2525
TENABILITY LIMITS: 5540 Secs.	6	E	Photo	1.98	3372	2168
	5	B	Ion	2.02	3474	2066
	16	H	Ion	1.91	4703	837
TEST ENDS: 6000 Secs.	20	-	ROR	15°F/min	None	None
			FIRE ROOM DETECTORS			
	22	-	ROR	15°F/min	None	None
	T/C	-	FT	135°F	None	None
	T/C	-	FT	150°F	None	None

TEST NO:
15-JR

FIRE TYPE:
S-Chair

FIRE LOCATION:
Living Room

SEASON:
Winter

A/C OR HEAT:
Heat Off

BEDROOM DOORS CLOSED:
A & F

BASEMENT DOOR CLOSED:
No

FLAMES AT:
None

TENABILITY LIMITS:
3750 Secs.

TEST ENDS:
4501 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		FIRST FLOOR HALL CEILING DETECTORS			
12	F	Ion	1.34	2097	1653
25	E	Photo	0.96	2098	1652
11	A	Photo	1.27	2098	1652
10	E	Photo	1.81	2370	1380
9	A	Photo	1.40	3187	563
19	H	Ion	2.04	3305	445
13	F	Ion	3.04	3699	51
18	H	Ion	1.81	3702	47
14	B	Dual Gate	2.19	3827	-77
15	-	ROR	15°F/min	None	None
		SECOND FLOOR HALL CEILING DETECTORS			
4	E	Photo	0.96	2043	1707
17	H	Ion	2.04	2583	1167
1	A	Photo	1.19	3064	686
3	F	Ion	2.81	3365	385
2	B	Dual Gate	3.89	None	None
		SECOND FLOOR HALL WALL DETECTORS			
24	A	Photo	2.09	2103	1647
7	F	Ion	1.61	2228	1522
6	E	Photo	1.98	2620	1130
5	B	Ion	2.02	3303	447
16	H	Ion	1.91	4046	-296
20	-	ROR	15°F/min	None	None
		FIRE ROOM DETECTORS			
22	-	ROR	15°F/min	None	None
T/C	-	FT	135°F	None	None
T/C	-	FT	150°F	None	None

TEST NO:
16-JR

FIRE TYPE:
F-Chair

FIRE LOCATION:
Living Room

SEASON:
Winter

A/C OR HEAT:
Heat On

BEDROOM DOORS CLOSED:
A & F

BASEMENT DOOR CLOSED:
No

FLAMES AT:
0 Secs.

TENABILITY LIMITS:
1062 Secs.

TEST ENDS:
1546 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		FIRST FLOOR HALL CEILING DETECTORS			
12	F	Ion	1.34	158	904
19	H	Ion	2.04	339	723
13	F	Ion	3.04	357	705
18	H	Ion	1.81	372	690
14	B	Dual Gate	2.19	384	678
11	A	Photo	1.27	389	673
10	E	Photo	1.81	438	624
25	E	Photo	0.96	443	619
9	A	Photo	1.40	540	522
15	-	ROR	15°F/min	None	None
		SECOND FLOOR HALL CEILING DETECTORS			
17	H	Ion	2.04	319	743
3	F	Ion	2.81	362	700
2	B	Dual Gate	3.89	488	574
4	E	Photo	0.96	556	506
1	A	Photo	1.19	658	404
		SECOND FLOOR HALL WALL DETECTORS			
7	F	Ion	1.61	229	833
5	B	Ion	2.02	382	680
16	H	Ion	1.91	439	623
24	A	Photo	2.09	526	536
6	E	Photo	1.98	718	344
20	-	ROR	15°F/min	None	None
		FIRE ROOM DETECTORS			
22	-	ROR	15°F/min	1502	-440
T/C	-	FT	135°F	1370	-308
T/C	-	FT	150°F	1510	-448

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING DETECTORS			
TEST NO:						
17-JR	25	E	Photo	0.96	1240	2760
	11	A	Photo	1.27	2454	1546
FIRE TYPE:	14	B	Dual Gate	2.19	2494	1506
S-Mattress	12	F	Ion	1.34	2520	1480
	9	A	Photo	1.40	2554	1446
FIRE LOCATION:	10	E	Photo	1.81	2659	1341
1st Floor Bedroom (A)	18	H	Ion	1.81	2778	1222
	13	F	Ion	3.04	2869	1131
SEASON:	19	H	Ion	2.04	2908	1092
Winter	15	-	ROR	15°F/min	None	None
A/C OR HEAT:			**SECOND FLOOR HALL CEILING DETECTORS**			
Heat On						
	4	E	Photo	0.96	2776	1224
BEDROOM DOORS CLOSED:	17	H	Ion	2.04	3232	768
None	3	F	Ion	2.81	3623	377
	1	A	Photo	1.19	4144	-144
BASEMENT DOOR CLOSED:	2	B	Dual Gate	3.89	4156	-156
No						
			SECOND FLOOR HALL WALL DETECTORS			
FLAMES AT:						
None	24	A	Photo	2.09	2846	1154
	7	F	Ion	1.61	2908	1092
TENABILITY LIMITS:	6	E	Photo	1.98	3420	580
4000 Secs.	5	B	Ion	2.02	3760	240
	16	H	Ion	1.91	4163	-163
TEST ENDS:	20	-	ROR	15°F/min	None	None
4313 Secs.						
			FIRE ROOM DETECTORS			
	22	-	ROR	15°F/min	None	None
	T/C	-	FT	135°F	None	None
	T/C	-	FT	150°F	None	None

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. %-FT^{-1}	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING DETECTORS			
TEST NO:	25	E	Photo	0.96	1296	1974
18-JR	10	E	Photo	1.81	1468	1802
FIRE TYPE:	12	F	Ion	1.34	1475	1795
S-Mattress	11	A	Photo	1.27	1666	1604
	9	A	Photo	1.40	1907	1363
FIRE LOCATION:	14	B	Dual Gate	2.19	1918	1352
1st Floor Bedroom (A)	13	F	Ion	3.04	1965	1305
	18	H	Ion	1.81	2076	1194
SEASON:	19	H	Ion	2.04	2222	1048
Winter	15	-	ROR	15°F/min	None	None
A/C OR HEAT:			**SECOND FLOOR HALL CEILING DETECTORS**			
Heat Off	7	F	Ion	1.61	1910	1360
BEDROOM DOORS CLOSED:	24	A	Photo	2.09	2001	1269
B - E & F	6	E	Photo	1.98	2504	766
	5	B	Ion	2.02	2863	407
BASEMENT DOOR CLOSED:	16	H	Ion	1.91	2948	322
No	20	-	ROR	15°F/min	None	None
FLAMES AT:			**SECOND FLOOR HALL WALL DETECTORS**			
None	4	E	Photo	0.96	1722	1548
TENABILITY LIMITS:	17	H	Ion	2.04	2157	1113
3270 Secs.	1	A	Photo	1.19	2659	611
	3	F	Ion	2.81	2703	567
TEST ENDS:	2	B	Dual Gate	3.89	3127	143
3720 Secs.			**FIRE ROOM DETECTORS**			
	22	-	ROR	150°F/min	None	None
	T/C	-	FT	135°F	None	None
	T/C	-	FT	150°F	None	None

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	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING DETECTORS			
TEST NO: 19-JR	25	E	Photo	0.96	2074	1406
	11	A	Photo	1.27	2214	1266
FIRE TYPE: S-Mattress	9	A	Photo	1.40	3055	425
	12	F	Ion	1.34	3100	380
	10	E	Photo	1.81	3101	379
FIRE LOCATION: 1st Floor Bedroom (A)	14	B	Dual Gate	2.19	3932	-452
	13	F	Ion	3.04	4064	-584
	18	H	Ion	1.81	4245	-765
SEASON: Winter	19	H	Ion	2.04	4943	-1463
	15	-	ROR	15°F/min	None	None
A/C OR HEAT: Heat On			**SECOND FLOOR HALL CEILING DETECTORS**			
	24	A	Photo	2.09	2447	1033
BEDROOM DOORS CLOSED: All	7	F	Ion	1.61	2862	618
	6	E	Photo	1.98	3299	181
	5	B	Ion	2.02	None	None
BASEMENT DOOR CLOSED: No	16	H	Ion	1.91	None	None
	20	-	ROR	15°F/min	None	None
FLAMES AT: None			**SECOND FLOOR HALL WALL DETECTORS**			
	4	E	Photo	0.96	2407	1073
TENABILITY LIMITS: 3480 Secs.	1	A	Photo	1.19	3060	420
	17	H	Ion	2.04	3305	175
	2	B	Dual Gate	3.89	5538	-2058
TEST ENDS: 6201 Secs.	3	F	Ion	2.81	5681	-2201
			FIRE ROOM DETECTORS			
	22	-	ROR	15°F/min	None	None
	T/C	-	FT	135°F	None	None
	T/C	-	FT	150°F	None	None

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	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING DETECTORS			
TEST NO: 20-JR	14	B	Dual Gate	2.19	230	995
	18	H	Ion	1.81	279	946
FIRE TYPE: F-Mattress	12	F	Ion	1.34	285	940
	13	F	Ion	3.04	295	930
	25	E	Photo	0.96	370	855
FIRE LOCATION: 1st Floor Bedroom (A)	10	E	Photo	1.81	471	754
	19	H	Ion	2.04	544	681
	9	A	Photo	1.40	588	637
SEASON: Winter	11	A	Photo	1.27	589	636
	15	-	ROR	15°F/min	None	None
			SECOND FLOOR HALL CEILING DETECTORS			
A/C OR HEAT: Heat On	7	F	Ion	1.61	561	664
BEDROOM DOORS CLOSED: All	24	A	Photo	2.09	784	441
	6	E	Photo	1.98	1118	107
	16	H	Ion	1.91	(2073)	None
BASEMENT DOOR CLOSED: No	5	B	Ion	2.02	(2098)	None
	20	-	ROR	15°F/min	None	None
			SECOND FLOOR HALL WALL DETECTORS			
FLAMES AT: 0 Secs.	4	E	Photo	0.96	771	454
TENABILITY LIMITS: 1225 Secs.	17	H	Ion	2.04	804	421
	1	A	Photo	1.19	1053	172
	2	B	Dual Gate	3.89	1627	-402
TEST ENDS: 1956 Secs.	3	F	Ion	2.81	(2079)	None
			FIRE ROOM DETECTORS			
	22	-	ROR	15°F/min	None	None
	T/C	-	FT	135°F	None	None
	T/C	-	FT	150°F	None	None

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. %-FT^{-1}	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING DETECTORS			
TEST NO:						
21-JR	12	F	Ion	1.34	56	364
	14	B	Dual Gate	2.19	57	363
FIRE TYPE:	13	F	Ion	3.04	64	356
F-Mattress	19	H	Ion	2.04	68	352
	18	H	Ion	1.81	84	336
FIRE LOCATION:	11	A	Photo	1.27	198	222
1st Floor Bedroom (A)	25	E	Photo	0.96	203	197
	10	E	Photo	1.81	207	193
SEASON:	15	-	ROR	15°F/min	245	175
	9	A	Photo	1.40	MALF.	N/A
Winter						
A/C OR HEAT:			**SECOND FLOOR HALL CEILING DETECTORS**			
Heat On	7	F	Ion	1.61	161	259
BEDROOM DOORS CLOSED:	5	B	Ion	2.02	230	190
	16	H	Ion	1.91	256	164
None	24	A	Photo	2.09	280	140
	6	E	Photo	1.98	348	72
BASEMENT DOOR CLOSED:	20	-	ROR	15°F/min	None	None
No						
FLAMES AT:			**SECOND FLOOR HALL WALL DETECTORS**			
0 Secs.	17	H	Ion	2.04	191	229
TENABILITY LIMITS:	3	F	Ion	2.81	245	175
	2	B	Dual Gate	3.89	278	142
420 Secs.	1	A	Photo	1.19	318	102
TEST ENDS:	4	E	Photo	0.96	349	71
652 Secs.						
			FIRE ROOM DETECTORS			
	22	-	ROR	15°F/min	233	187
	T/C	-	FT	135°F	240	180
	T/C	-	FT	150°F	260	160

TEST NO: 22-JR

FIRE TYPE: S-Chair

FIRE LOCATION: Basement (X)

SEASON: Winter

A/C OR HEAT: Heat On

BEDROOM DOORS CLOSED: None

BASEMENT DOOR CLOSED: No

FLAMES AT: 1650 Secs.

TENABILITY LIMITS: 2880 Secs.

TEST ENDS: 3512 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		BASEMENT STAIRS DETECTORS AT TOP			
4	E	Photo	0.96	1609	1271
2	B	Dual Gate	3.89	1609	1271
1	A	Photo	1.19	1610	1270
17	H	Ion	2.04	1610	1270
3	F	Ion	2.81	1616	1264
		FIRST FLOOR HALL CEILING DETECTORS			
12	F	Ion	1.34	1824	1056
25	E	Photo	0.96	1851	1029
11	A	Photo	1.27	1982	898
10	E	Photo	1.81	2194	686
9	A	Photo	1.40	2194	686
13	F	Ion	3.04	2410	470
14	B	Dual Gate	2.19	2440	440
19	H	Ion	2.04	2761	119
18	H	Ion	1.81	2983	-103
15	-	ROR	15°F/min	None	None
		SECOND FLOOR HALL CEILING DETECTORS			
7	F	Ion	1.61	2081	799
24	A	Photo	2.09	2321	559
6	E	Photo	1.98	2678	202
5	B	Ion	2.02	(3527)	None
16	H	Ion	1.91	(3546)	None
20	-	ROR	15°F/min	None	None
		FIRE ROOM DETECTORS			
22	-	ROR	15°F/min	1597	1283
T/C	-	FT	135°F	1600	1280
T/C	-	FT	150°F	1600	1280

TEST NO: 23-JR

FIRE TYPE: F-Chair

FIRE LOCATION: Basement (X)

SEASON: Winter

A/C OR HEAT: Heat On

BEDROOM DOORS CLOSED: None

BASEMENT DOOR CLOSED: No

FLAMES AT: 0 Secs.

TENABILITY LIMITS: 869 Secs.

TEST ENDS: 900 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		BASEMENT STAIRS DETECTORS AT TOP			
17	H	Ion	2.04	98	771
3	F	Ion	2.81	139	730
2	B	Dual Gate	3.89	175	694
4	E	Photo	0.96	256	613
1	A	Photo	1.19	278	591
		FIRST FLOOR HALL CEILING DETECTORS			
12	F	Ion	1.34	357	512
14	B	Dual Gate	2.19	363	506
13	F	Ion	3.04	365	504
18	H	Ion	1.81	365	504
25	E	Photo	0.96	373	496
19	H	Ion	2.04	392	477
11	A	Photo	1.27	397	472
10	E	Photo	1.81	410	459
15	-	ROR	15°F/min	None	None
9	A	Photo	1.40	MALF.	N/A
		SECOND FLOOR HALL CEILING DETECTORS			
7	F	Ion	1.61	457	412
24	A	Photo	2.09	659	210
5	B	Ion	2.02	758	111
6	E	Photo	1.98	766	103
16	H	Ion	1.91	None	None
20	-	ROR	15°F/min	None	None
		FIRE ROOM DETECTORS			
22	-	ROR	15°F/min	261	608
T/C	-	FT	135°F	276	593
T/C	-	FT	150°F	282	587

<u>TEST NO</u>:
24-JR

<u>FIRE TYPE</u>:
S-Sofa

<u>FIRE LOCATION</u>:
Basement (X)

<u>SEASON</u>:
Winter

<u>A/C OR HEAT</u>:
Heat Off

<u>BEDROOM DOORS CLOSED</u>:
None

<u>BASEMENT DOOR CLOSED</u>:
No

<u>FLAMES AT</u>:
6460 Secs.

<u>TENABILITY LIMITS</u>:
6775 Secs.

<u>TEST ENDS</u>:
7215 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		BASEMENT STAIRS DETECTORS AT TOP			
4	E	Photo	0.96	4721	2054
17	H	Ion	2.04	5786	989
1	A	Photo	1.19	5938	837
3	F	Ion	2.81	6009	766
2	B	Dual Gate	3.89	6560	215
		FIRST FLOOR HALL CEILING DETECTORS			
25	E	Photo	0.96	5733	1042
11	A	Photo	1.27	6465	310
10	E	Photo	1.81	6489	286
12	F	Ion	1.34	6760	15
13	F	Ion	3.04	6761	14
18	H	Ion	1.81	6768	7
19	H	Ion	2.04	6774	1
14	B	Dual Gate	2.19	6778	-3
15	-	ROR	15°F/min	None	None
9	A	Photo	1.40	MALF.	N/A
		SECOND FLOOR HALL CEILING DETECTORS			
7	F	Ion	1.61	6857	-82
6	E	Photo	1.98	6880	-105
24	A	Photo	2.09	6888	-113
5	B	Ion	2.02	7095	-320
16	H	Ion	1.91	None	None
20	-	ROR	15°F/min	None	None
		FIRE ROOM DETECTORS			
22	-	ROR	15°F/min	6694	81
T/C	-	FT	135°F	6720	55
T/C	-	FT	150°F	6720	55

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			BASEMENT STAIRS DETECTORS AT TOP			
TEST NO:						
25-JR	17	H	Ion	2.04	100	1000
	2	B	Dual Gate	3.89	113	987
FIRE TYPE:	3	F	Ion	2.81	150	950
F-Chair	4	E	Photo	0.96	299	801
	1	A	Photo	1.19	424	676
FIRE LOCATION:						
Basement (X)			**FIRST FLOOR HALL CEILING DETECTORS**			
SEASON:	12	F	Ion	1.34	509	591
Winter	14	B	Dual Gate	2.19	589	511
	25	E	Photo	0.96	655	445
A/C OR HEAT:	13	F	Ion	3.04	660	440
Heat Off	18	H	Ion	1.81	709	391
	11	A	Photo	1.27	748	352
BEDROOM DOORS CLOSED:	19	H	Ion	2.04	768	332
None	10	E	Photo	1.81	840	260
	15	-	ROR	15°F/min	None	None
BASEMENT DOOR CLOSED:	9	A	Photo	1.40	MALF.	N/A
No						
			SECOND FLOOR HALL CEILING DETECTORS			
FLAMES AT:	7	F	Ion	1.61	694	406
0 Secs.	24	A	Photo	2.09	945	155
TENABILITY LIMITS:	6	E	Photo	1.98	1075	25
1100 Secs.	5	B	Ion	2.02	1113	-3
	16	H	Ion	1.91	1181	-81
TEST ENDS:	20	-	ROR	15°F/min	None	None
1350 Secs.						
			FIRE ROOM DETECTORS			
	22	-	ROR	15°F/min	1001	99
	T/C	-	FT	135°F	950	150
	T/C	-	FT	150°F	990	110

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			BASEMENT STAIRS DETECTORS AT TOP			
TEST NO:	4	E	Photo	0.96	1212	4893
26-JR	17	H	Ion	2.04	1437	4668
FIRE TYPE:	3	F	Ion	2.81	1657	4448
S-Couch	1	A	Photo	1.19	2265	3840
	2	B	Dual Gate	3.89	3284	2821
FIRE LOCATION:						
Basement (X)			**FIRST FLOOR HALL CEILING DETECTORS**			
SEASON:	25	E	Photo	0.96	1629	4476
Winter	11	A	Photo	1.27	1778	4327
	10	E	Photo	1.81	2231	3874
A/C OR HEAT:	12	F	Ion	1.34	2314	3791
Heat On	13	F	Ion	3.04	4071	2034
	19	H	Ion	2.04	5532	573
BEDROOM DOORS CLOSED:	14	B	Dual Gate	2.19	5634	471
A & F	18	H	Ion	1.81	5682	423
	15	-	ROR	15°F/min	None	None
BASEMENT DOOR CLOSED:	9	A	Photo	1.40	MALF.	N/A
No			**SECOND FLOOR HALL CEILING DETECTORS**			
FLAMES AT:	24	A	Photo	2.09	2222	3883
5180 Secs.	7	F	Ion	1.61	2617	3488
TENABILITY LIMITS:	6	E	Photo	1.98	3724	2381
6105 Secs.	5	B	Ion	2.02	5838	267
	16	H	Ion	1.91	None	None
TEST ENDS:	20	-	ROR	15°F/min	None	None
6510 Secs.			**FIRE ROOM DETECTORS**			
	22	-	ROR	15°F/min	None	None
	T/C	-	FT	135°F	None	None
	T/C	-	FT	150°F	None	None

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TEST NO:
27-JR

FIRE TYPE:
F-Mattress

FIRE LOCATION:
Basement (X)

SEASON:
Winter

A/C OR HEAT:
Heat On

BEDROOM DOORS CLOSED:
A & F

BASEMENT DOOR CLOSED:
No

FLAMES AT:
0 Secs.

TENABILITY LIMITS:
1710 Secs.

TEST ENDS:
2030 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		BASEMENT STAIRS DETECTORS AT TOP			
17	H	Ion	2.04	84	1626
3	F	Ion	2.81	122	1588
2	B	Dual Gate	3.89	125	1585
4	E	Photo	0.96	165	1545
1	A	Photo	1.19	204	1506
		FIRST FLOOR HALL CEILING DETECTORS			
12	F	Ion	1.34	289	1421
13	F	Ion	3.04	404	1306
25	E	Photo	0.96	441	1269
14	B	Dual Gate	2.19	445	1265
11	A	Photo	1.27	451	1259
10	E	Photo	1.81	574	1136
19	H	Ion	2.04	1053	657
18	H	Ion	1.81	1192	518
15	-	ROR	15°F/min	None	None
9	A	Photo	1.40	MALF.	N/A
		SECOND FLOOR HALL CEILING DETECTORS			
7	F	Ion	1.61	470	1240
24	A	Photo	2.09	732	978
6	E	Photo	1.98	996	714
5	B	Ion	2.02	1304	406
16	H	Ion	1.91	None	None
20	-	ROR	15°F/min	None	None
		FIRE ROOM DETECTORS			
22	-	ROR	15°F/min	158	1552
T/C	-	FT	135°F	None	None
T/C	-	FT	150°F	None	None

TEST NO: 28-LS

FIRE TYPE: S-Chair

FIRE LOCATION: Study-First

SEASON: Winter

A/C OR HEAT: Heat On

BEDROOM DOORS CLOSED: Yes

BASEMENT DOOR CLOSED: No

FLAMES AT: 7910 Secs.

TENABILITY LIMITS: 8255 Secs.

TEST ENDS: 8370 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		FIRST FLOOR HALL CEILING LOCATION (A)			
12	F	Ion	1.34	4020	4235
10	E	Photo	1.81	4046	4209
11	A	Photo	1.27	4333	3922
9	A	Photo	1.40	4861	3394
14	B	Dual Gate	2.19	6152	2103
19	H	Ion	2.04	7960	295
18	H	Ion	1.81	8005	250
13	F	Ion	3.04	8033	222
15	-	ROR	15°F/min	None	None
		FIRST FLOOR HALL CEILING LOCATION (B)			
7	F	Ion	1.61	3640	4615
6	E	Photo	1.98	4023	4232
24	A	Photo	2.09	4394	3861
5	B	Ion	2.02	5309	2946
16	H	Ion	1.91	7365	890
20	-	ROR	15°F/min	8280	-25
		FIRST FLOOR HALL WALL LOCATION (B)			
4	E	Photo	0.96	3204	5051
1	A	Photo	1.19	4296	3959
17	H	Ion	2.04	4327	3928
3	F	Ion	2.81	4912	3343
2	B	Dual Gate	3.89	None	None
		FIRE ROOM DETECTORS			
22	-	ROR	15°F/min	8264	-9
T/C	-	FT	135°F	8230	25
T/C	-	FT	150°F	8260	-5

TEST NO:
29-LS

FIRE TYPE:
S-Chair

FIRE LOCATION:
Study-First

SEASON:
Winter

A/C OR HEAT:
Heat On

BEDROOM DOORS CLOSED:
No

BASEMENT DOOR CLOSED:
No

FLAMES AT:
2296 Secs.

TENABILITY LIMITS:
2295 Secs.

TEST ENDS:
2665 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		FIRST FLOOR HALL CEILING LOCATION (A)			
12	F	Ion	1.34	1488	807
10	E	Photo	1.81	1505	790
14	B	Dual Gate	2.19	1506	789
11	A	Photo	1.27	1603	692
9	A	Photo	1.40	1626	669
19	H	Ion	2.04	1850	445
18	H	Ion	1.81	1882	413
13	F	Ion	3.04	2254	41
15	-	ROR	15°F/min	None	None
		FIRST FLOOR HALL CEILING LOCATION (B)			
7	F	Ion	1.61	799	1496
6	E	Photo	1.98	1221	1074
24	A	Photo	2.09	1481	814
5	B	Ion	2.02	1701	594
16	H	Ion	1.91	1730	565
20	-	ROR	15°F/min	None	None
		FIRST FLOOR HALL WALL LOCATION (B)			
4	E	Photo	0.96	786	1509
17	H	Ion	2.04	1411	884
1	A	Photo	1.19	1452	843
3	F	Ion	2.81	1488	807
2	B	Dual Gate	3.89	None	None
		FIRE ROOM DETECTORS			
22	-	ROR	15°F/min	2521	-226
T/C	-	FT	135°F	2490	-194
T/C	-	FT	150°F	2510	-214

TEST NO:
30-LS

FIRE TYPE:
S-Chair

FIRE LOCATION:
Bedroom-First

SEASON:
Winter

A/C OR HEAT:
Heat On

BEDROOM DOORS CLOSED:
No

BASEMENT DOOR CLOSED:
No

FLAMES AT:
3670 Secs.

TENABILITY LIMITS:
2400 Secs.

TEST ENDS:
4235 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		FIRST FLOOR HALL CEILING LOCATION (A)			
11	A	Photo	1.27	842	1558
10	E	Photo	1.81	902	1498
12	F	Ion	1.34	905	1495
13	F	Ion	3.04	1239	1161
9	A	Photo	1.40	1268	1132
14	B	Dual Gate	2.19	1321	1079
19	H	Ion	2.04	1326	1074
18	H	Ion	1.81	1635	765
15	-	ROR	15°F/min	4214	-1814
		FIRST FLOOR HALL CEILING LOCATION (B)			
7	F	Ion	1.61	2564	-164
6	E	Photo	1.98	2577	-177
16	H	Ion	1.91	2990	-590
24	A	Photo	2.09	2991	-591
5	B	Ion	2.02	3378	-978
20	-	ROR	15°F/min	None	None
		FIRST FLOOR HALL WALL LOCATION (B)			
3	F	Ion	2.81	1427	973
4	E	Photo	0.96	2122	278
17	H	Ion	2.04	2537	-137
1	A	Photo	1.19	2556	-156
2	B	Dual Gate	3.89	None	None
		FIRE ROOM DETECTORS			
22	-	ROR	15°F/min	4193	-1793
T/C	-	FT	135°F	4190	-1790
T/C	-	FT	150°F	4190	-1790

TEST NO: 31-LS

FIRE TYPE: S-Chair

FIRE LOCATION: Living Room

SEASON: Winter

A/C OR HEAT: Heat On

BEDROOM DOORS CLOSED: Yes

BASEMENT DOOR CLOSED: No

FLAMES AT: 3885 Secs.

TENABILITY LIMITS: 3345 Secs.

TEST ENDS: 4135 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-}FT^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
FIRST FLOOR HALL CEILING LOCATION (A)					
14	B	Dual Gate	2.19	2340	1005
10	E	Photo	1.81	2361	984
12	F	Ion	1.34	2377	968
11	A	Photo	1.27	2596	749
19	H	Ion	2.04	2659	686
9	A	Photo	1.40	2702	643
18	H	Ion	1.81	2752	593
13	F	Ion	3.04	2965	380
15	-	ROR	15°F/min	4082	-737
FIRST FLOOR HALL CEILING LOCATION (B)					
7	F	Ion	1.61	2125	1220
24	A	Photo	2.09	2214	1131
6	E	Photo	1.98	2266	1079
5	B	Ion	2.02	2267	1078
16	H	Ion	1.91	2603	742
20	-	ROR	15°F/min	4068	-723
FIRST FLOOR HALL WALL LOCATION (B)					
4	E	Photo	0.96	2018	1367
17	H	Ion	2.04	2194	1151
1	A	Photo	1.19	2287	1058
3	F	Ion	2.81	2294	1051
2	B	Dual Gate	3.89	None	None
FIRE ROOM DETECTORS					
22	-	ROR	15°F/min	3986	-641
T/C	-	FT	135°F	3980	-635
T/C	-	FT	150°F	4000	-655

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	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. %-FT^{-1}	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING LOCATION (A)			
TEST NO: 32-LS	14	B	Dual Gate	2.19	2243	-173
	10	E	Photo	1.81	2460	-390
FIRE TYPE: S-Chair	12	F	Ion	1.34	2475	-405
	18	H	Ion	1.81	2503	-433
	19	H	Ion	2.04	2507	-437
FIRE LOCATION: Living Room	9	A	Photo	1.40	2509	-439
	11	A	Photo	1.27	2530	-460
	13	F	Ion	3.04	2589	-519
SEASON: Winter	15	-	ROR	15°F/min	None	None
			FIRST FLOOR HALL CEILING LOCATION (B)			
A/C OR HEAT: Heat On	4	E	Photo	0.96	1802	268
	17	H	Ion	2.04	1824	246
BEDROOM DOORS CLOSED: No	1	A	Photo	1.19	1922	148
	3	F	Ion	2.81	1984	86
	2	B	Dual Gate	3.89	2165	-95
BASEMENT DOOR CLOSED: No			**FIRST FLOOR HALL WALL LOCATION (B)**			
FLAMES AT: 2340 Secs.	7	F	Ion	1.61	1822	248
	6	E	Photo	1.98	1849	221
	24	A	Photo	2.09	1852	208
TENABILITY LIMITS: 2070 Secs.	5	B	Ion	2.02	1954	116
	16	H	Ion	1.91	1974	96
	20	-	ROR	15°F/min	None	None
TEST ENDS: 2730 Secs.			**FIRE ROOM DETECTORS**			
	22	-	ROR	15°F/min	None	None
	T/C	-	FT	135°F	2700	-630
	T/C	-	FT	150°F	None	None

TEST NO: 33-LS

FIRE TYPE: F-Two Chairs

FIRE LOCATION: Living Room

SEASON: Winter

A/C OR HEAT: Heat On

BEDROOM DOORS CLOSED: No

BASEMENT DOOR CLOSED: No

FLAMES AT: 0 Secs.

TENABILITY LIMITS: 597 Secs.

TEST ENDS: 1356 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
FIRST FLOOR HALL CEILING LOCATION (A)					
12	F	Ion	1.34	160	437
18	H	Ion	1.81	205	392
19	H	Ion	2.04	206	391
13	F	Ion	3.04	241	356
11	A	Photo	1.27	331	266
9	A	Photo	1.40	354	243
10	E	Photo	1.81	385	212
14	B	Dual Gate	2.19	None	None
15	-	ROR	15°F/min	None	None
FIRST FLOOR HALL CEILING LOCATION (B)					
17	H	Ion	2.04	96	501
3	F	Ion	2.81	177	420
4	E	Photo	0.96	349	248
1	A	Photo	1.19	373	224
2	B	Dual Gate	3.89	None	None
FIRST FLOOR HALL WALL LOCATION (B)					
7	F	Ion	1.61	97	500
5	B	Ion	2.02	125	472
16	H	Ion	1.91	164	433
24	A	Photo	2.09	284	313
6	E	Photo	1.98	376	221
20	-	ROR	15°F/min	None	None
FIRE ROOM DETECTORS					
22	-	ROR	15°F/min	None	None
T/C	-	FT	135°F	None	None
T/C	-	FT	150°F	None	None

TEST NO: 34-LS

FIRE TYPE: S-Mattress

FIRE LOCATION: Basement-Family

SEASON: Winter

A/C OR HEAT: Heat On

BEDROOM DOORS CLOSED: No

BASEMENT DOOR CLOSED: No

FLAMES AT: 3765 Secs.

TENABILITY LIMITS: 3785 Secs.

TEST ENDS: 4410 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		FIRST FLOOR HALL CEILING LOCATION (A)			
11	A	Photo	1.27	3834	-49
19	H	Ion	2.04	3835	-50
10	E	Photo	1.81	3836	-51
9	A	Photo	1.40	3837	-52
12	F	Ion	1.34	3837	-52
18	H	Ion	1.81	3838	-53
14	B	Dual Gate	2.19	3844	-59
13	F	Ion	3.04	3849	-64
15	-	ROR	15°F/min	None	None
		BASEMENT STAIRS CEILING LOCATION			
4	E	Photo	0.96	3494	291
1	A	Photo	1.19	3503	282
2	B	Dual Gate	3.89	3503	282
3	F	Ion	2.81	3546	239
17	H	Ion	2.04	3824	-39
		FIRST FLOOR HALL WALL LOCATION (B)			
7	F	Ion	1.61	3805	-20
6	E	Photo	1.98	3805	-20
24	A	Photo	2.09	3807	-22
16	H	Ion	1.91	3814	-29
5	B	Ion	2.02	3815	-30
20	-	ROR	15°F/min	None	None
		FIRE ROOM DETECTORS			
22	-	ROR	15°F/min	None	None
T/C	-	FT	135°F	4100	-315
T/C	-	FT	150°F	None	None

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. %-FT^{-1}	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING LOCATION (A)			
TEST NO:	12	F	Ion	1.34	1168	62
35-LS	19	H	Ion	2.04	1185	45
FIRE TYPE:	18	H	Ion	1.81	1189	41
F-Sofa	10	E	Photo	1.81	1196	34
FIRE LOCATION:	11	A	Photo	1.27	1199	31
Basement-Family	9	A	Photo	1.40	1201	29
SEASON:	13	F	Ion	3.04	1212	18
Winter	14	B	Dual Gate	2.19	1240	-10
A/C OR HEAT:	15	-	ROR	15°F/min	None	None
Heat On			**BASEMENT STAIRS CEILING LOCATION**			
BEDROOM DOORS CLOSED:	17	H	Ion	2.04	349	881
No	2	B	Dual Gate	3.89	436	794
BASEMENT DOOR CLOSED:	3	F	Ion	2.81	440	790
No	4	E	Photo	0.96	675	555
FLAMES AT:	1	A	Photo	1.19	753	477
0 Secs.			**FIRST FLOOR HALL WALL LOCATION (B)**			
TENABILITY LIMITS:	7	F	Ion	1.61	542	688
1230 Secs.	16	H	Ion	1.91	615	615
TEST ENDS:	5	B	Ion	2.02	629	601
1583 Secs.	24	A	Photo	2.09	731	499
	6	E	Photo	1.98	1078	152
	20	-	ROR	15°F/min	None	None
			FIRE ROOM DETECTORS			
	22	-	ROR	15°F/min	None	None
	T/C	-	FT	135°F	1560	-330
	T/C	-	FT	150°F	1560	-330

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TEST NO:
36-LS

FIRE TYPE:
S-Mattress

FIRE LOCATION:
Basement-Family

SEASON:
Winter

A/C OR HEAT:
Heat On

BEDROOM DOORS CLOSED:
No

BASEMENT DOOR CLOSED:
No

FLAMES AT:
4275 Secs.

TENABILITY LIMITS:
4110 Secs.

TEST ENDS:
4840 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
FIRST FLOOR HALL CEILING LOCATION (A)					
11	A	Photo	1.27	4191	-81
12	F	Ion	1.34	4236	-126
10	E	Photo	1.81	4270	-160
14	B	Dual Gate	2.19	4317	-207
18	H	Ion	1.81	4323	-213
19	H	Ion	2.04	4324	-214
9	A	Photo	1.40	4333	-223
13	F	Ion	3.04	4348	-238
15	-	ROR	15°F/min	None	None
BASEMENT STAIRS CEILING LOCATION					
17	H	Ion	2.04	3781	329
4	E	Photo	0.96	3878	232
2	B	Dual Gate	3.89	3909	201
3	F	Ion	2.81	3931	179
1	A	Photo	1.19	3950	160
FIRST FLOOR HALL WALL LOCATION (B)					
7	F	Ion	1.61	4024	86
6	E	Photo	1.98	4122	-12
24	A	Photo	2.09	4158	-48
16	H	Ion	1.91	4220	-110
5	B	Ion	2.02	4284	-174
20	-	ROR	15°F/min	None	None
FIRE ROOM DETECTORS					
22	-	ROR	15°F/min	4346	-236
T/C	-	FT	135°F	4400	-290
T/C	-	FT	150°F	4400	-290

TEST NO:
37-LS

FIRE TYPE:
Electric Motor

FIRE LOCATION:
Kitchen

SEASON:
Winter

A/C OR HEAT:
Heat On

BEDROOM DOORS CLOSED:
No

BASEMENT DOOR CLOSED:
No

FLAMES AT:
350 Secs.

TENABILITY LIMITS:
Not Exceeded

TEST ENDS:
614 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		FIRST FLOOR HALL CEILING LOCATION (A)			
9	A	Photo	1.40	447	-
14	B	Dual Gate	2.19	447	-
12	F	Ion	1.34	454	-
11	A	Photo	1.27	491	-
10	E	Photo	1.81	498	-
13	F	Ion	3.04	516	-
18	H	Ion	1.81	None	-
19	H	Ion	2.04	None	-
15	-	ROR	15°F/min	None	-
		BASEMENT STAIRS CEILING LOCATION			
4	E	Photo	0.96	447	-
17	H	Ion	2.04	583	-
1	A	Photo	1.19	None	-
2	B	Dual Gate	3.89	None	-
3	F	Ion	2.81	None	-
		FIRST FLOOR HALL WALL LOCATION (B)			
7	F	Ion	1.61	488	-
5	B	Ion	2.02	None	-
6	E	Photo	1.98	None	-
16	H	Ion	1.91	None	-
24	A	Photo	2.09	None	-
20	-	ROR	15°F/min	None	-
		FIRE ROOM DETECTORS			
22	-	ROR	15°F/min	None	-
T/C	-	FT	135°F	None	-
T/C	-	FT	150°F	None	-

TEST NO:
38-LS

FIRE TYPE:
Extension Cord

FIRE LOCATION:
Kitchen

SEASON:
Winter

A/C OR HEAT:
Heat On

BEDROOM DOORS CLOSED:
No

BASEMENT DOOR CLOSED:
No

FLAMES AT:
None

TENABILITY LIMITS:
Not Exceeded

TEST ENDS:
1210 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
FIRST FLOOR HALL CEILING LOCATION (A)					
10	E	Photo	1.81	761	-
11	A	Photo	1.27	778	-
12	F	Ion	1.34	804	-
9	A	Photo	1.40	812	-
19	H	Ion	2.04	863	-
13	F	Ion	3.04	913	-
14	B	Dual Gate	2.19	925	-
18	H	Ion	1.81	950	-
15	-	ROR	15°F/min	None	-
BASEMENT STAIRS CEILING LOCATION					
4	E	Photo	0.96	586	-
1	A	Photo	1.19	686	-
17	H	Ion	2.04	769	-
3	F	Ion	2.81	793	-
2	B	Dual Gate	3.89	None	-
FIRST FLOOR HALL WALL LOCATION (B)					
7	F	Ion	1.61	789	-
6	E	Photo	1.98	794	-
24	A	Photo	2.09	831	-
5	B	Ion	2.02	902	-
16	H	Ion	1.91	1060	-
20	-	ROR	15°F/min	None	-
FIRE ROOM DETECTORS					
22	-	ROR	15°F/min	None	-
T/C	-	FT	135°F	None	-
T/C	-	FT	150°F	None	-

	CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
			FIRST FLOOR HALL CEILING LOCATION (A)			
TEST NO: **39-LS**	11	A	Photo	1.27	657	-
	9	A	Photo	1.40	730	-
FIRE TYPE: **Cord Under Carpet**	12	F	Ion	1.34	748	-
	10	E	Photo	1.81	751	-
	14	B	Dual Gate	2.19	844	-
FIRE LOCATION: **Kitchen**	13	F	Ion	3.04	858	-
	18	H	Ion	1.81	864	-
	19	H	Ion	2.04	867	-
SEASON: **Winter**	15	-	ROR	15°F/min	None	-
			BASEMENT STAIRS CEILING LOCATION			
A/C OR HEAT: **Heat On**	4	E	Photo	0.96	583	-
	1	A	Photo	1.19	714	-
BEDROOM DOORS CLOSED: **No**	17	H	Ion	2.04	760	-
	3	F	Ion	2.81	837	-
	2	B	Dual Gate	3.89	None	-
BASEMENT DOOR CLOSED: **No**			**FIRST FLOOR HALL WALL LOCATION (B)**			
FLAMES AT: **None**	7	F	Ion	1.61	1113	-
	5	B	Ion	2.02	None	-
	6	E	Photo	1.98	None	-
TENABILITY LIMITS: **Not Exceeded**	16	H	Ion	1.91	None	-
	24	A	Photo	2.09	None	-
	20	-	ROR	15°F/min	None	-
TEST ENDS: **1200 Secs.**			**FIRE ROOM DETECTORS**			
	22	-	ROR	15°F/min	None	-
	T/C	-	FT	135°F	None	-
	T/C	-	FT	150°F	None	-

47

<u>TEST NO</u>:
40-LS

<u>FIRE TYPE</u>:
Grease On Stove

<u>FIRE LOCATION</u>:
Kitchen

<u>SEASON</u>:
Winter

<u>A/C OR HEAT</u>:
Heat On

<u>BEDROOM DOORS CLOSED</u>:
No

<u>BASEMENT DOOR CLOSED</u>:
No

<u>FLAMES AT</u>:
1680 Secs.

<u>TENABILITY LIMITS</u>:
1898 Secs.

<u>TEST ENDS</u>:
1915 Secs.

CLOCK NO.	DETECTOR CODE	DETECTOR TYPE	SENS. $\%\text{-FT}^{-1}$	ALARM (SECS)	ESCAPE TIME (SECS)
		FIRST FLOOR HALL CEILING LOCATION (A)			
12	F	Ion	1.34	1208	690
11	A	Photo	1.27	1613	275
14	B	Dual Gate	2.19	1674	224
10	E	Photo	1.81	1680	218
9	A	Photo	1.40	1692	206
18	H	Ion	1.81	1710	188
19	H	Ion	2.04	1715	183
13	F	Ion	3.04	1719	179
15	-	ROR	15°F/min	1811	87
		BASEMENT STAIRS CEILING LOCATION			
17	H	Ion	2.04	1712	186
4	E	Photo	0.96	1736	162
3	F	Ion	2.81	1751	147
1	A	Photo	1.19	1759	139
2	B	Dual Gate	3.89	1904	-6
		FIRST FLOOR HALL WALL LOCATION (B)			
24	A	Photo	2.09	1762	136
7	F	Ion	1.61	1763	135
5	B	Ion	2.02	1765	133
16	H	Ion	1.91	1791	107
6	E	Photo	1.98	1865	33
20	-	ROR	15°F/min	None	None
		FIRE ROOM DETECTORS			
22	-	ROR	15°F/min	1704	194
T/C	-	FT	135°F	1700	198
T/C	-	FT	150°F	1700	198

APPENDIX B

SUMMARY OF DETECTOR LOCATIONS AND EXPERIMENT CONFIGURATIONS

TABULATION OF WEATHER CONDITIONS

SUMMARY OF DETECTOR LOCATIONS AND EXPERIMENT CONFIGURATIONS
TEST SERIES NO. 1: J.R. WHITEHOUSE RESIDENCE SUMMER SCHEDULE (AIR CONDITIONING ON)

Experiment Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Fire Location	L	L	L	A	A	A	A	K	K	X	X	X	X
Bedroom Doors (Open/Closed)	O	O	C	C	*	O	**	O	C	C	C	O	O
Basement Door	O	O	C	O	C	C	C	C	C	O	O	O	O
Detectors #I (9, 10, 11, 12, 13, 14, 15, 18, 19, & 25)	← Second Story Hall Ceiling →												
Detectors #II (5, 6, 7, 16, 20, & 24)	First Story Hall Ceiling			← First Story Hall Wall →									
Detectors #III (1, 2, 3, 4, & 17)	First Story Hall Wall			← First Story Hall Ceiling →						Ceiling, Head of Bsmt Stairs			

* door to A open, rest closed.

** doors to A and B open, E and F closed.

SUMMARY OF DETECTOR LOCATIONS AND EXPERIMENT CONFIGURATIONS
TEST SERIES NO. 2: J.R. WHITEHOUSE RESIDENCE WINTER SCHEDULE

<table>
<tr><th>Experiment Number</th><th>14</th><th>15</th><th>16</th><th>17</th><th>18</th><th>19</th><th>20</th><th>21</th><th>22</th><th>23</th><th>24</th><th>25</th><th>26</th><th>27</th></tr>
<tr><td>Fire Location</td><td>L+</td><td>L</td><td>L</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Bedroom Doors Open</td><td colspan="3">B and E</td><td colspan="2">All A</td><td colspan="2">None</td><td colspan="5">All</td><td colspan="2">B and E</td></tr>
<tr><td>(Smolder/Flame) Ignition</td><td>s</td><td>s</td><td>f</td><td>s</td><td>s</td><td>s</td><td>f</td><td>f</td><td>s</td><td>f</td><td>s</td><td>f</td><td>s</td><td>f</td></tr>
<tr><td>Furnace* (On/Off)</td><td>on</td><td>off</td><td>on</td><td>on</td><td>off</td><td>on</td><td>on</td><td>on</td><td>on</td><td>on</td><td>off</td><td>off</td><td>on</td><td>on</td></tr>
<tr><td>Detectors #I (9, 10, 11, 12, 13, 14, 15, 18, 19, 25)</td><td colspan="14">1st Hall Ceiling</td></tr>
<tr><td>Detectors #II (5, 6, 7, 16, 20, 24)</td><td colspan="4">2nd Hall Wall</td><td colspan="10">2nd Hall Ceiling</td></tr>
<tr><td>Detectors #III (1, 2, 3, 4, 17)</td><td colspan="4">2nd Hall Ceiling</td><td colspan="4">2nd Hall Wall</td><td colspan="6">Ceiling, Top Bsmt. Stairwell</td></tr>
<tr><td>Basement Door</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td></tr>
</table>

* Furnace on meant blower continuous, burner controlled by thermostat.

\+ L:living room, A&B:1st floor bedrooms, E&F:2nd floor bedrooms, X:basement.

++ When basement door closed for these tests, a return air register on side of plenum was opened.

SUMMARY OF DETECTOR LOCATIONS AND EXPERIMENT CONFIGURATIONS
TEST SERIES NO. 3: LAKESHORE HOME WINTER SCHEDULE

<table>
<tr><th>Experiment Number</th><th>28</th><th>29</th><th>30</th><th>31</th><th>32</th><th>33</th><th>34</th><th>35</th><th>36</th><th>37</th><th>38</th><th>39</th><th>40</th></tr>
<tr><td>Fire Location</td><td colspan="2">Study</td><td>Bedr</td><td colspan="3">Living Room</td><td colspan="3">Basement</td><td colspan="4">Kitchen</td></tr>
<tr><td>(Smolder/Flame) Ignition</td><td>s</td><td>s</td><td>s</td><td>s</td><td>s</td><td>f</td><td>s</td><td>f</td><td>s</td><td>*</td><td>**</td><td>+</td><td>++</td></tr>
<tr><td>Bedroom Door (Open/Closed)</td><td>c</td><td>o</td><td>o</td><td>c</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td></tr>
<tr><td>Detector #I (9,10,11,12,13, 14,15,18,19,25)</td><td colspan="13">A Ceiling</td></tr>
<tr><td>Detector #II (5,6,7,16,20,24)</td><td colspan="4">B Ceiling</td><td colspan="9">B Wall</td></tr>
<tr><td>Detector #III (1,2,3,4,17)</td><td colspan="4">B Wall</td><td colspan="2">B Ceiling</td><td colspan="7">Ceiling, Top of Bsmt. Stairs</td></tr>
<tr><td>Utility Room Door (Open/Closed)</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td><td>o</td></tr>
</table>

* Overloaded electric motor

** Overloaded extension cord (50 ft)

\+ Overloaded extension cord under carpet (50 ft)

++ Overheated grease on stove

WEATHER CONDITIONS

Experiment	Wind Direction	Wind Nominal Speed (FPS)	Wind Gusts	Outdoor Temperature (^{o}C)	Outdoor Relative Humidity (Percent)	Comments
1	-	Calm	-	NA	NA	
2	SW	4-6	-	28	75	
3	SW	4-6	-	28	75	
4	NA	3-5	14.5	24	79	
5	NA	3-5	14.5	24	70	At 2100 sec wind, 5-7 Gusts 11
6	NA	5-6.6	9.2	21	78	
7	NA	2-2.5	-	18	89	
8	SW	3.3-5	-	13	75	
9	N	3	-	9	80	
10	N	3	-	13	100	Thunderstorm
11	WNW	4.4-6	9.5	20	79	
12	WNW	4-6	9	20	75	
13	WNW	4-6	9	20	75	
14	WSW	3.5-6	-	2	83	
15	W-SW	6-8	19	3	83	
16	W-SW	3-6	15	0	84	
17	W	2.4-4	9.5	0	90	
18	W-SW	2-3	6	1.1	72	
19	W-SW	1-3	10	1.2	91	
20	E-SE	0.7-2.5	5	0	100	Light Snow
21	SW	0.2-1.5	-	0	98	Snow
22	NE	0.7-1.5	5	2.5	72	Sunny and Clear
23	N-NE	1.5-3	-	2.3	72	
24	E-SE	1-3	9	-8	66	
25	S	2.5-4	14	-8	76	
26	-	Calm	-	0	71	
27	-	Calm	-	0	85	
28	W-SW	4.1	9	0	99	

(Weather Conditions Continued)

Experiment	Wind Direction	Wind Nominal Speed (FPS)	Wind Gusts	Outdoor Temperature (^{o}C)	Outdoor Relative Humidity (Percent)	Comments
29	W	5	12	-1	97.5	Snow
30	W	4.1	8	-3	99	Snow
31	W	2-2.5	3.2	0	99	Snow
32	W-NW	2.5	4.2	0	95	
33	NW	2.5-3	4	0	91	
34	W-NW	2.5-3	4	3	85	Sunny
35	W-NW	3	4.7	0	92	Snow Flurries
36	W-NW	2.5-3.2	4.5	0	90	
37	W	4.4	-	0	87	Clear
38	W	4.4	-	1	85	
39	W-NW	4.4	8.7	1	79	
40	W	3	-	1	80	

NA - Data Not Available

APPENDIX C

NARRATIVE DESCRIPTIONS OF FIRES

The first week of full scale tests of the Indiana Dunes Research project were conducted at the J. R. Whitehouse test site on East Lake Park Avenue on September 9 through 13, 1974.

This first series was intended to represent summer conditions and all tests were conducted with a central air conditioning system in the residence operating. We attempted to maintain a temperature inside the building of approximately 10 F below the outside ambient temperature.

The original instrumentation for the first tests conducted were as follows:

The main detector board containing detectors No. 19, 11, 13, 25, 14, 9, 18, 10, and 12 was located in the second floor hall outside the bedrooms. The split boards were mounted in the first floor hallway outside of the first floor bedrooms and near the base of the stairs to the second floor. These boards were mounted such that the board containing detectors No. 5, 24, 16, 6, and 7 were on the ceiling and the board containing detectors No. 4, 3, 2, 1, and 17 were on the wall approximately 6 to 8 in. down from the ceiling.

Five foot light beams were mounted at the ceiling in the living room and at the 8 ft level, at the ceiling and the 5 ft level in the first floor hall and the ceiling and the 5 ft level in the second floor hall. In addition, Pyrotronics Model CPM-2 combustion products meters were included in the second floor hall, first floor hall, and in the burn room.

Thermocouples and vertical arrays were arranged in various locations and gas sampling tubes were located in all major rooms and halls.

LIVING ROOM SERIES

The first test in the living room series was an attempted smoldering ignition of an upholstered chair. Since this chair went to full flames in 3 min and 30 sec the results of this test will be considered as the flaming test for the living room series. For this test all bedroom doors and the basement door was open. Observations noted during this test are as follows:

Time After Ignition, Sec	Test No. 1 - Observations
60	First smoke observed from chair
210	Open flaming observed on the chair - 1/2 of the cushion and arm crevice area
600	2 ft flames over most of cushion and arm crevice
1260	Bottom of the chair burned through

The ignition source for this and subsequent fires was a 500 w charcoal igniter with approximately 20 in. of exposed cal-rod and energized from 120 v ac. This method was used to start all smoldering fires and was used in this case as it was an attempted smoldering fire, although flaming did take place rapidly.

The second test of the living room series was another attempted smoldering chair, again using a sectional sofa piece consisting of cotton upholstery material over cotton stuffing and springs on a wooden frame. The charcoal igniter was again used as an ignition source for this test. Bedroom and basement doors were again open.

The test was started at 1:21:18 p.m. on September 10. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 2 - Observations
60	First smoke noted
120	Ignition source removed from chair
560	Light smoke - no readings on the combustion products meters, cold air returns pulling in much of the smoke generated by the chair
1040	Test discontinued due to power failure. Lost power at 1:33:03 p.m.
	Restarting tests with same chair at 01:46:03 p.m.
60	First smoke noticed
120	Ignition source removed from chair

900	No reading at this time on the combustion products meters. Moderate smoke level stratifying at approximately 4 ft in the living room
1800	Moderate-heavy smoke in the living room
5520	Cloth was placed over the original char area to induce flaming
6210	Open flaming on the chair
7080	Test terminated

The third and final test of the living room series was a repeat of the second test except that all bedroom doors and the door to the basement were closed for test No. 3.

The ignition source was again a sectional sofa piece except that no seat cushion was used in this case as a separate cushion was provided containing a polyurethane foam material. The test was started at 4:43:35 p.m. on September 10. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 3 - Observations
60	First smoke noted with heat application on a vertical section of the seat back
120	Ignition source removed
180	Self sustaining smoldering was not achieved so an additional 1 min of heat was applied. During this application a rather dense small cloud of smoke was generated which immediately stratified in an area between 3 and 6 ft from the floor near the chair
630	Small amount of smoke in the first floor light beam and combustion products meter
1800	Additional heat applied for 1 min at the original char
2520	Additional heat applied just above the original char
2700	Open flaming on the chair back

BEDROOM SERIES

Test No. 4 was the first test of the bedroom series conducted in the first floor rear bedroom of the house. Prior to beginning Test No. 4 the split boards in the first floor hall were reversed resulting in the board containing detectors No. 1, 2, 3, 4, and 17 now being on the ceiling and the board containing detectors No. 5, 6, 7, 16, and 24 now on the wall at the same level as the previous board had been. The light beam that was on the ceiling in the living room was placed at the 5 ft level in the front first floor bedroom and the light beam with CPM which was on the wall at the 8 ft level in the living room was moved to the rear bedroom in which the fire was started. The fire source was a single mattress ignited by the charcoal igniter.

For this test, all bedroom doors were closed and the door to the basement was open. The test was begun at 11:06 a.m. on September 11. During the fire, the following observations were recorded:

Time After Ignition, Sec	Test No. 4 - Observations
75	First smoke noted
180	Heat removed The char is approximately 10 in. in diameter and providing moderate smoke generation which is heavier toward the edge of the mattress
2580	The smoke level in the bedroom is getting dense. Charred area approximately 15 in. in diameter with steady smoke production
3600	The char is now 18 to 20 in. in diameter with very heavy smoke generation. It is impossible to see across the fire room
4200	The char is now obliterated by the smoke level in the bedroom. The carbon monoxide level in the bedroom is greater than 0.2 percent. Levels in the bedroom are approximately 0.3 percent carbon monoxide, 1 percent carbon dioxide. First floor hall is at 40 percent transmission, bedroom is at 0 percent transmission and second floor at 95 percent transmission

5460	Windows to the fire room opened
5670	Open flame on the mattress

In the upstairs bedroom, the smoke had stratified approximately 3 ft from the floor. From that level upward there was very little smoke noticed in these bedrooms.

Test No. 5 was a repeat of Test No. 4 with all bedroom doors except the door to the burn room closed, door to the burn room open, and basement door closed. The ignition source was again a cotton mattress in a smoldering configuration ignited by a charcoal igniter.

The test was begun at 2:30 p.m. on September 11. During the fire the following observations were recorded:

Time After Ignition, Sec	Test No. 5 - Observations
60	First smoke observed
120	Heat source removed, outside of the house we have a 2 to 3 mile an hour wind gusting to 10 miles an hour from the south southwest
1800	The fire room smoke is moderate - char is now approximately 12 in. in diameter generating heavy smoke off the transition region between pyrolized and unburned areas
2400	Char diameter now 20 to 22 in., smoke generation rate very heavy
2460	Smoldering has broken through the bottom of the mattress
2700	Heavy smoke generation - obscuration in bedroom very dense, 24 in. char diameter, smoke issuing from all around the base of the mattress
2880	Carbon monoxide level in the bedroom now 0.1 percent, 0 percent transmission. Charred diameter approximately 28 in.
3000	Cannot see the char through the dense smoke
3060	Open flame on the mattress

The upstairs bedrooms had small patches of smoke but the escape path was completely blocked. Escape would only be possible through the upstairs bedroom windows.

Test No. 6 is a repeat of Test No. 4 except that all doors to the bedrooms are open and the basement door is closed. Previous tests have seemed to indicate that there is no difference between having the basement door open or closed so for the remainder of the tests in the bedroom series it will be closed.

For this test we are going to use 1/2 of a full size mattress with the cut end covered with cloth. In the previous two tests less than 1/2 of the mattress was consumed so it is felt that 1/2 mattress would be sufficient for conducting this test.

Ignition in this test was at 4:41:00 p.m. on September 11. During the fire, the following observations were recorded:

Time After Ignition, Sec	Test No. 6 - Observations
60	First smoke observed
120	Heat removed
900	8 in. diameter char, moderate smoke generation
1800	12 in. diameter char, moderate smoke
2100	Mattress has begun to emit smoke through the cut end, producing moderate smoke levels. Original char approximately 14 in. in diameter
2700	Generation rate increasing, can barely see light beam, 24 in. diameter char
3060	Smoldering char has reached corner of the mattress. Char is approximately 22 in. in diameter, smoke generation getting heavy, stratified layer at the 5 ft level
3600	Original char has reached corner of the mattress up to a 24 in. radius from that point. Smoke level is very dense in the fire room with carbon monoxide levels greater than 0.05 percent with some glowing embers and sparks noted

3720	Very heavy smoke generation from char with the cut end producing about the same amount as previously
4200	25 percent transmission on the second floor, 0 percent transmission on the first floor, approximately 28 in. diameter char
4380	Test terminated

Test No. 7 was a repeated Test No. 6 with a flaming ignition of a mattress in the bedroom. The upstairs bedroom doors were closed and the downstairs bedroom doors were open with the basement door closed. A 1/2 mattress was again used but the cut end was not covered this time. A cloth was draped over the end opposite the cut end and a match was applied to the vertical portion of this cloth.

Ignition was at 6:47 on September 11. During this fire the following observations were recorded:

Time After Ignition, Sec	Test No. 7 - Observations
10	Considerable smoke and flames 3 in. high
60	Flames curling up over edges
120	Start of detector responses
570	First ignition has gone out, another match applied
720	Smoke issuing from the cut end
810	Small flames at this cut end
855	Match applied to exposed excelsior at cut end
880	Flames over 3/4 of cut end
900	Flames over entire width of cut end approximately 10 to 12 in. high. Smoke issuing from the cut end
1005	Cannot see the light beam. Area at the floor still clear
1050	Steady burning - Covering material burning better than fill, excelsior burned out
1065	Some amount of stratification in the room noted

1125	Flames dying down, 1/2 of the width of the cut end burning with approximately 4 in. high flames, smoke coming from the side vents
1140	Smoke stratifying from the ceiling down to about 3 ft from the floor level, flames about 18 in. high, majority of flames coming from an 8 to 12 in. section of the cut end near cut edge
1230	Flames spreading along surface of mattress about 4 to 6 in. high
1290	6 in. flames on the surface. 36 in. flames from a 12 in. area of the cut end
1350	Ceiling temperature approaching 135 to 140 F, same flame conditions as previous observation. Smoke is moving down to the floor
1380	Flames approximately 36 in. high from the cut end
1440	Same conditions exist as previous observation - Test terminated

KITCHEN SERIES

Test No. 8 is the first in the kitchen series in which two grease fires on a stove are going to be simulated by burning about 1 in. of JP4 in an 8 in. diameter pan set in a 9 by 13 in. pan about 4 ft from the floor. For this series the light beam and combustion products meter from the previous fire room were moved to the kitchen ceiling.

For this first test in the kitchen series, the basement door will be closed and all other bedroom doors open. Ignition was at 10:27 a.m. on September 12. During the fire, the following observations were recorded:

Time After Ignition, Sec	Test No. 8 - Observations
30	Flames about 36 in. high - additional 30 percent surface area burning in basepan, heavy smoke
105	Smoke is coming down to the level of the ceiling tile which is about 5 ft from the floor

135	Smoke is reaching the ceiling tile area about 5 ft from the floor. The smoke is heavy and black and the floor area is relatively clear of smoke
240	Some cracking starting in the kitchen window
285	Smoke is still at the same level but increasing in density from 5 ft up
315	Fire out

Within 1 min after the fire went out the smoke began to sink in the room probably due to the lack of thermal lift. Upon entering the building we found very dense smoke from the ceiling down to the 5 ft level on the first floor and light smoke from the ceiling down to the 3 ft level on the second floor. It was possible to see the ceiling on the second floor but not on the first floor.

All exit ways were passable and escape through them would be possible by crouching on the first floor. Walking on the second floor presented no problem.

Test No. 9 was a repeat of test No. 8 except that all bedroom and basement doors were closed. Ignition was at 12:46:14 on September 12. During the fire, the following observations were recorded:

Time After Ignition, Sec	Test No. 9 - Observations
105	3/4 of the large pan is burning and additional cracking of the kitchen window noted
120	Black smoke down to the level of the ceiling tile, approximately 5 ft from the floor
130	Flames almost to ceiling - entire large pan surface area burning
150	Smoke getting denser down to the 5 ft level
180	Entire surface burning - same level of smoke
210	Surface still burning - heavy stratification
255	Entire surface burning - more cracks in window - light smoke at floor
285	1/2 large pan and small pan surface area burning
295	Small pan area burning
305	Only small flames left
315	Fire out

Upon entering the house the same conditions were noted as in Test No. 8. Second floor hall had zero visibility. First floor stratification less defined than in No. 8. Upstairs bedroom had no smoke, light smoke in downstairs bedrooms.

BASEMENT SERIES

Test No. 10 is the first test of the basement series. For this test, a smoldering mattress was used with the ignition source being, again, the electric charcoal igniter. The mattress was placed in a corner by the furnace with the light beam and combustion products meter from the fire room on the ceiling near the mattress. For this series, the board from the ceiling in the hall on the first floor was moved to the head of the basement stairs. This is board with detectors No. 1, 2, 3, 4, and 17. The other board was left on the wall.

The test will use a full mattress and all bedroom doors will be closed. The door to the basement will be open.

A thermocouple was placed between the charcoal igniter and the surface of the mattress so that a time-temperature curve could be obtained for the heater.

The test was started at 3:36 p.m. on September 12.

During the test, the following observations were recorded.

Time After Ignition, Sec	Test No. 10 - Observations
60	First smoke noted
120	Heat removed
840	Charred area is oblong about 6 by 12 in. - light smoke in the basement, no stratification noticeable
1800	Char about 18 to 20 in. in diameter. Moderate smoke generation from charred area, moderate smoke in basement. The air movement during this test appears to be extremely slow and very little stratification is noticeable

2700	Char is about 24 in. in diameter, fairly heavy smoke generation appears that char is gone through bottom-transmission about 90 percent in basement
3540	Char covers about 10 percent of the bed - heavy smoke generation, heavy smoke in basement but still passable, can still see across the room
4500	Smoke level in basement now very heavy - smoldering area breaking through the front of the mattress rather than the bottom
4800	Char now 10 in. long by 2 to 3 in. high on the side and covers about 20 percent of the horizontal surface of the mattress. Smoke generation is very heavy but the char is not coming through the bottom. The smoldering has broken through about 1/2 of the total length of left side of the mattress
5040	Char on the left side has come around the left corner with heavy smoke generation and high levels are appearing at the ceiling
5220	The side char and front char have met and the top char area is about 25 percent of the total mattress. The side charred area is now from the center of the left side, around the corner and halfway down the rear side
5520	More heat applied for 2 min in the area of the original char to try to simulate flame. It was found out later that somewhere around this time a heavy storm blew the front doors in the living room and the windows in the upstairs bedroom open
5700	Smoke levels such that you cannot see across the room. Additional heat added to places for 1 min each, 1 and 2 ft from the charred end
6000	Smoke is issuing from the main charred area and all around the edges. About 25 percent of the horizontal surface is charred
6300	Visibility is less than 10 ft, carbon monoxide levels beginning to approach hazardous levels, smoke level very heavy
6540	Carbon monoxide level in first floor hall approximately 0.1 percent

6600	Visibility zero in the basement
6720	Carbon monoxide level in basement reaching 0.15 percent
7200	Carbon monoxide levels in basement and first floor lethal, upstairs hall level low, 85 percent transmission
7500	Carbon monoxide levels in basement are 0.2 percent
7800	Ceiling temperature jumping, may be flaming
8100	Carbon monoxide on second floor level 0.06 percent
8520	Test terminated. Doors open

As the doors had blown open during the storm Test No. 11 was a complete repeat of Test No. 10 except that a heavily padded box spring was used instead of a mattress. Ignition was at 10:09 a.m. on September 13. During the test the following observations were recorded.

Time After Ignition, Sec	Test No. 11 - Observations
67	First smoke observed
120	Heat source removed
900	Char approximately 8 in. in diameter, light smoke observed from the char
1800	Char is about 15 in. in diameter with some smoke issuing from small holes around the wooden base frame
2700	Char is approximately 24 in. in diameter, steady smoke production from the charred area. There is a 15 to 18 in. long char on the side of the box spring 2 to 3 in. high. Basement has light smoke and is passable
3120	Char has reached the corner of the top surface of the mattress
3600	Top surface char is about 28 in. in diameter and extends 3 in. down the side and about 32 in. up the left side. Smoke level is still at passable levels in the basement

3810	Additional heat applied to the back left corner for 1 min and the back right corner for 1 min
4500	Basement is still passable but starting to get bad. Small amounts of carbon monoxide noted in the upstairs hall and bedrooms. Charred area is producing moderate smoke. The char on the left side of the mattress is coming around the front corner
5400	Smoke level in the basement is now heavy, the corner of the mattress is starting to crumble
6000	A cloth was draped over the char to induce flaming
6300	The smoke level in the basement is very heavy
7200	Visibility in the basement is approximately 15 ft
7500	The mattress is about 1/2 to 2/3 gone
7725	Mattress is flaming
7800	Carbon monoxide level in the first floor hall reaching 0.07 percent
7890	Test concluded

Upon entering the building after the test the smoke levels throughout the house were heavy except in the bedrooms where the smoke level was fairly light and the bedrooms would be considered tolerable.

Test No. 12 was the same as Test No. 11 except that the bedroom and basement doors were open. Ignition was at 3:18 p.m. on September 13. Heat was applied at the center of a double size mattress using the charcoal igniter. During the test the following observations were recorded.

Time After Ignition, Sec	Test No. 12 - Observations
67	First smoke observed
120	Heat removed
900	Char is about 8 in. in diameter, light smoke observed
1800	Char is about 15 in. in diameter, still light smoke

2700	Test seems to be progressing slower than previous test. Smoke is now issuing from under the mattress. Additional heat was applied for 1 min to the back corners
3600	Smoke issuing from top and underside of the mattress. Smoke is now at a moderate level in the basement
4275	Cloth was placed over the main charred area
4500	Heavy smoke generation from the central char
5400	Smoke level in the basement is now quite heavy
6000	Smoke level in the basement now extremely heavy. Additional heat applied for 1 min at the top edge of the back left corner to induce flaming
6300	Extremely heavy smoke level in basement, very slow char progression
7200	Visibility in the basement is now roughly zero
8220	Basement door open, test concluded

Upon entering the house the smoke levels in all rooms was quite heavy. It appeared that the house was not passable at the time of conclusion of the test.

Test No. 13 was the final test conducted in the series. This test was a flaming upholstered chair ignited by wastebasket full of newspaper and scrap paper beside the right arm of the chair. Some scrap paper was piled on the seat which was without a cushion, a section of newspaper was draped over the left arm and another was placed halfway under the left front edge of the chair. Ignition was at 7:10 p.m. on September 13. During the test the following observations were recorded.

Time After Ignition, Sec	Test No. 13 - Observations
30	Flames on the arm and over a small area of the right side of the back
60	The right arm and newspaper are burning
90	Flames dying down slightly in the wastebasket, flames on the arm are small
120	Flames are dying down
150	Right arm is burning slowly

180	The top of the right arm and the paper on the seat are burning. Flames are about 4 ft high
210	Wastebasket flames are very low, the back is starting in flames, flames about 6 ft high
240	About 1/2 of the vertical surface of the back is burning, smoke is stratifying about 3 ft down from the ceiling
270	About 1/2 of the seat area is burning very slowly
300	Flames are again dying down, spreading slowly across the front and right arm
360	Right arm on the bottom and the fringe along the bottom of the right side of the chair are burning. Flames are about 3 ft high
390	The smoke coming from the flaming portions of the chair appears to be somewhat darker than the smoke coming from the charred areas. The flames in the burning sections now about 2 ft high
450	Smoke in the basement appears to be stratifying at about the 4 ft level to the ceiling. The seat of the chair is burning and about 3/4 of the back is burning
510	Flames on the lower half of the back are very small
600	Flames are still fairly small, the lower fringe around the front of the seat and the back is burning almost over to the left arm
660	The fire in the wastebasket is going out, the front fringe is burning almost to the newspaper under the left front corner
690	The smoke level in the basement down to the 4 ft level is very heavy but below the 4 ft level is still passable
720	The lower third of the back is in flames to the left arm, flames are very small
810	The seat area and the back area is almost out. The fringe is burning about 1/2 of the way across the front from the right side

840	The flames in the front area in the fringe are about 12 in. high
870	Flames are now noticeable in the underside of the chair
930	Smoke level in the basement is very heavy down to about the 3 ft level above the floor. Smoke generation from the chair is very heavy
960	The left front leg is burning with flames about 12 in. high
1020	The newspaper placed under the front left corner is now burning. The back is burning quite heavily
1050	The flames on the back are about 2 to 3 ft high
1080	About 1/2 the total chair area is now burning
1110	The back left side and front section of the chair are now burning quite well
1140	The smoke level in the basement is very heavy down to about 3 ft off the floor. Definite stratification levels are visible about every foot up from the 3 ft level
1170	Flames now appear to be reaching the ceiling
1260	Flames are beginning to die down, more than 1/2 the chair consumed
1290	Still some flame visible, extremely heavy smoke level in the basement
1320	Smoke level would now be considered impassable all the way to the floor
1350	Chair still flaming although no flames visible from outside the room
1500	Test terminated, chair removed

Upon entering the building there were heavy smoke levels noted in the basement and the first floor with the second floor having moderate smoke levels.

Detector operating times are given in the chart attached. Where a dash is entered the lack of response is attributed to an equipment malfunction. Nonoperation in a test is indicated by NO where the equipment was functioning properly.

The second week of full scale tests of the Indiana Dunes Research Project was conducted at the J. R. Whitehouse Test Site on East Lake Park Avenue on January 28 through 31st and February 10 and 11, 1975.

The second series was intended to represent winter conditions, with tests being conducted under both furnace on and furnace off conditions. For the furnace on conditions, the burner was allowed to cycle normally from the thermostat, but the blower was switched from automatic to a continuous run mode. For the furnace off conditions, the room thermostat was turned to its lowest setting, and the fuse to the furnace blower was removed to prevent its operation. For all tests, we attempted to maintain a minimum temperature differential of 40 F between the inside and outside ambient temperatures.

The original instrumentation for the second test series conducted were as follows:

> Detector Board No. 1 was mounted on the ceiling in the hallway outside of the first floor bedrooms and near the base of the stairs to the second floor. This board contained Detectors No. 9, 10, 11, 12, 13, 14, 15, 18, 19, and 25. Detector Board No. 2 was mounted on the wall in the second floor hall outside the bedrooms. This board contained Detectors No. 5, 6, 7, 16, 20, and 24. Detector Board No. 3 was mounted on the ceiling in the second floor hall outside the bedrooms near Detector Board No. 2. This board contained Detectors No. 1, 2, 3, 4, and 17. The board mounted on the wall was mounted such that the detectors were approximately 6 to 8 in. down from the ceiling.

Five foot beams were mounted on the ceiling and the 5 ft level in the first floor hall near the detectors, on the wall at the 8 ft level, and on the ceiling in the living room, and at the 5 ft level and the ceiling in the second floor hall near the detectors. Beams were also placed at the 5 ft level in the first floor front bedroom, and second floor front bedroom. Starting with the first test in this series (Test No. 14), a heat detector (Clock No. 22) was mounted on the light beam on the ceiling in the living room, which is the light beam which is moved to the ceiling in the burn room for each series. In addition, Pyrotronics Model CPM-2 combustion products meters were included on the ceiling in the first floor hall, second floor hall, and in the burn room.

Thermocouples and vertical thermocouple arrays were arranged in various locations and gas sampling tubes were located in all major rooms and halls.

LIVING ROOM SERIES

Test No. 14 was a smoldering ignition of a chair (cotton/rayon back, acetate loop pile) in the living room. For this test, bedroom doors A and F were closed and Doors B and E were opened. The furnace was on.

As in the first week of experiments, the ignition source for all smoldering fires was a 500 w charcoal igniter with approximately 20 in. of exposed cal-rod, and energized from a 120 v ac source. At the time of ignition, the cold igniter was energized and placed in good physical contact with the combustible. The charcoal igniter was left in contact with the combustible for exactly 120 sec.

The time of ignition for the first test was 3:24 p.m. on January 28, 1975. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 14 - Observations
90	First smoke observed
120	Heater removed
300	Small amount of smoke being generated from vertical back portion of chair
900	Moderate smoke generation from chair - smoke slightly irritating to eyes with distinct scorched cotton odor
1080	Heavy smoke issuing from rip in back of the chair. Steadily increasing rate of smoke generation - no stratification evident in living room
1260	Smoke becoming increasingly irritating to eyes and nose - heavy generation from back of chair being drawn into cold air return in living room under front windows
1500	Steadily accelerating generation rate - smoke still moderately irritating - no stratification

1800	Char dimensions approximately 6 by 8 in., most of smoke being developed from back of chair - smoke now very irritating to eyes and nose, moving outside
2400	Char dimensions approximately 8 by 12 in., with 6 by 8 in. burned out section in center approximately 1 in. deep. Heavy smoke being generated from chair and back - thermal energy from chair pulling smoke up approximately 6 ft before breaking up into room. Still no stratification evident
2880	Many small and moderate sized glowing sections noted
3300	Approximate char dimensions, 12 by 14 in., can still see across room
3600	Approximate char dimensions, 14 by 18 in., becoming difficult to see across the room
3900	Smoke level in living room now very dense, considered impassable. Charred area now 3 in. from top on chair back and all along seat cushion area
4500	Smoke in living room, very heavy - no stratification noticed. Strong column of smoke coming from left arm
5400	Room visibility less than 6 ft, right arm of chair now giving heavy smoke, 2/3 of back and seat consumed
6000	Test terminated

Upon entering the building after the test termination, moderately heavy smoke was found in all bedrooms, including those with closed doors. There was no evidence of stratification of the smoke in any of the rooms, including the bedrooms. This condition was the exact opposite of the conditions noted during similar tests in the summer conditions. In those tests, the bedrooms with the doors closed had very little smoke in them, and what was present was highly stratified.

Test No. 15 was the second test in the living room series. This was identical to Test No. 14 except that the furnace was off for this test. The upholstery material of the chair was rayon/cotton.

Ignition time for Test No. 15 was 10:52 a.m. on January 29, 1975. The observations noted during Test No. 15 are as follows:

Time After Ignition, Sec	Test No. 15 - Observations
70	First smoke observed
120	Heat removed, initial cloud of smoke drifting slowly toward cold air return near windows
300	Smoke is evenly distributing throughout the room, no stratification
900	Smoke generation rate moderate, room filling slowly. Not as irritating to eyes and nose as Test No. 14
1200	Char approximately 6 by 8 in., but not filled in. Smoke beginning to be irritating to eyes and nose - there visually appears to be as much smoke on the second floor hall as there is in the first floor hall
1800	Smoke now too irritating to eyes and nose to stay inside building. Very little smoke currently in basement - smoke appears to be moving down the stairway very slowly. Char approximately 8 by 12 in.
2700	Smoke generation from chair very heavy from charred area. No stratification evident
3600	Smoke density very high in living room, very heavy smoke generation rate. There appears to be a distinct odor of burning rubber which can be detected near the windows. Suspect there is foam rubber inside the seat cushion of the chair
4500	Test terminated

Upon entering the building after the test, the smoke in the house was evenly distributed everywhere but in the basement. The basement had light smoke, stratified in several layers.

Test No. 16 was a repeat of Test No. 14, except a flaming ignition of a chair (cotton back, wool/cotton loop pile) in the living room. The furnace was on, and Doors A and F were closed, Doors B and E open.

A wastebasket was placed next to the left side of the armchair, filled with paper trash and a folded section of newspaper was draped over the chair arm near the wastebasket. The wastebasket was ignited by a burning tissue thrown into it at ignition. Ignition was at 3:15 p.m. on January 29. The observations noted during the tests are as follows:

Time After Ignition, Sec	Test No. 16 - Observations
120	Wastebasket and paper on arm of chair burning - light smoke from chair arm
240	Chair catching on side by wastebasket - 14 in. flames
270	Flames approximately 18 in. high - wastebasket still burning
300	Flames progressing down left side of chair approximately 24 in. high
360	Left side of chair flaming approximately 24 in. high flames
420	Left side and inside of left arm flaming - 28 to 36 in. high flames
480	Flames dying down to 6 to 8 in. high, burning inside left arm
540	Wastebasket almost out - flames on wood frame of left arm 6 in. high
600	Smoke forced us outside - flames small except on rear of chair

690	Chair burning underneath - small flames, very heavy smoke in living room
780	Small flames under front of chair - very heavy smoke generated off charred area, back of chair burning
870	Very heavy smoke in living room, visibility poor
930	No visible flames
1080	Very heavy smoke generation - small flames visible
1175	Large flames appeared on seat area approximately 2 ft high
1260	One-half of seat area in flames approximately 2 ft high
1380	Entire back and seat flaming approximately 2 ft high
1546	Test terminated

Upon entering the house after the test, smoke was heavy and evenly distributed throughout all rooms except the basement. The basement only contained moderate smoke, stratified in multiple layers. The basement would be considered passable.

BEDROOM SERIES

Test No. 17 was the first test in the winter bedroom series. The ignition source was a smoldering cotton mattress located in the first floor rear bedroom. For this test, all doors were open, detector locations the same, furnace on. The light beam from the wall in the living room was moved to the ceiling in the bedroom, along with the combustion products meter and the heat detector No. 22.

Ignition time for Test No. 17 was 5:20 p.m. on January 29. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 17 - Observations
77	First smoke observed
120	Heater removed

300	The smoldering mattress is producing a very light, but highly irritating smoke which does not quite reach the ceiling before curling down. There is no evidence of stratification
600	Charred area is roughly 4 by 7 in., has not yet filled in. No stratification at this point
1800	Charred area approximately 11 in. in diameter, moderate to heavy smoke generation
3000	Smoke coming from under the mattress
3600	Charred area approximately 16 in. in diameter, char has gone through bottom of mattress. Smoke obscuration in the bedroom very heavy
7200	Termination of test - no flaming

Test No. 18 was another smoldering cotton mattress in Bedroom A. For this test, the door to Bedroom A was open and the remaining bedroom doors, (B, E, and F) were closed. The furnace was off for this test. Prior to beginning Test No. 18, detector boards No. 2 and 3 were reversed such that detector board No. 2 was now on the ceiling in the second floor hall, and detector board No. 3 was on the wall in the second floor hall. Ignition time for Test No. 18 was 10:05 a.m. on January 30. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 18 - Observations
67	First smoke observed
120	Heat removed
900	Charred area approximately 6 by 8 in. with moderate smoke production. There is almost no air movement visible in the room. During the first few minutes of the test, the smoke stratified in the multiple layers in the bedroom. These stratified layers were then broken up into a continuous homogeneous mixture in the bedroom
1800	Charred area approximately 10 in. in diameter, smoke coming from vents inside of mattress near char

2700	Charred area approximately 14 in. in diameter, moderate to heavy smoke production from top and underside of mattress
3600	Charred area approximately 18 in. in diameter, with approximately 10 in. diameter center portion burned out. Char also progressing alongside panel of mattress
3720	Test terminated - no flaming

Test No. 19 was another smoldering cotton mattress in Bedroom A with all bedroom doors closed and the furnace on.

Ignition time for Test No. 19 was at 12:05 p.m. on January 30. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 19 - Observations
70	First smoke observed
120	Heat removed
900	Charred area approximately 5 by 7 in.
1500	Charred area approximately 8 to 9 in. in diameter with a 4 in. diameter center hole burned through. Light smoke in the kitchen, light to moderate smoke in the first floor hall. The only room having heavy smoke was Bedroom A
2700	Charred area approximately 16 in. in diameter, smoke level in Bedroom A very heavy - visibility less than 4 ft
6201	Test terminated - no flames

Test No. 20 was a flaming ignition of a cotton mattress and box spring combination in Bedroom A. A cloth was draped over the top of the mattress to simulate a sheet and a wastebasket full of scrap paper was placed next to the mattress. All bedroom doors were closed and the furnace was on for Test No. 20.

Ignition time for Test No. 20 was 4:15 p.m. on January 30. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 20 - Observations
60	Wastebasket burning with approximately 10 in. flames
90	Cloth over mattress beginning to burn
120	Cloth burning near wastebasket with 12 in. flames
150	Flames approximately 4 to 5 in. high along a 2 ft horizontal edge of cloth. There is very dense smoke coming from under the cloth
240	Small flames observed along the entire 3 ft length of the cloth
300	Flames have died down to a very small size
420	Smoke level in the bedroom getting quite heavy, 2 to 3 in. flames noted in several locations on the surface of the mattress
540	Visibility less than 5 ft, all flames noted small in height
600	8 in. flames observed over approximately 10 percent of the surface of the mattress
900	Visibility in the bedroom less than 1 ft. Small flames noted in various locations on the cloth, more than one-half the cloth blackened
1956	Test terminated - flames went out

Test No. 21 was a repeat of Test No. 20, with all bedroom doors open and the furnace on. The mattress and cloth were cotton.

Ignition time for Test No. 21 was 5:45 p.m. on January 30. The observations noted during this test are as follows:

Time After Ignition, Sec	Test No. 21 - Observations
120	Flames approximately 6 in. high along 2 ft section of cloth over the mattress. The flames on the cloth appear to be a purple color at the base and yellow at the top

180	Flames approximately 14 to 16 in. high near the head of the bed and 6 to 8 in. high over the rest of the mattress. Heavy white smoke being generated from the mattress near the foot
210	Flames observed the full length of the mattress along one side approximately 5 in. high
240	Flames observed along full length of one side of the mattress approximately 8 in. high
300	Approximately 25 percent of the surface of the mattress now burning
360	Flames observed inside the box spring and across half of the top of the mattress
390	Flames observed over 1/3 to 1/2 of the underside of the box spring and approximately half of the surface of the mattress
450	Flaming over approximately 1/2 of the underside of the box spring and 1/2 of the surface of the mattress. Smoke level in the bedroom getting very heavy. Flames approximately 6 in. high
540	Flames now observed over 2/3 of the box spring and 2/3 of the top of the mattress. Flames about 8 in. high
600	Visibility less than 2 ft in the bedroom. Flames beginning to come out from under the box spring in the corner of the room, approximately 18 in. high
630	Flames from under the box spring flared up in the corner of the room to the ceiling and approximately 4 ft out across the ceiling from the corner. Had there been other furniture in the room at this time, flashover would have occurred
652	Test terminated

BASEMENT SERIES

Test No. 22 was the first test in the basement series. This was a smoldering ignition of a chair in the basement, with the furnace on and all bedroom doors open. Detector Board No. 3 from the wall on the second floor was moved to the head of the basement stairs. Detector Board Nos. 1 and 2 were left in their position. The light beam with heat detector and combustion products meter was moved from the ceiling in Bedroom A to the ceiling in the basement approximately 5 ft across the ceiling from the fire location.

Prior to beginning Test No. 22, the heat detector which was mounted on the movable light beam was changed to another identical unit. This change was made because previous unit had been exposed to ceiling temperatures in excess of 400 F in Test No. 21.

The ignition source for Test No. 22 was a chair (cotton/rayon/metallic) with no seat cushion. Ignition time was 11:25 a.m. on January 31. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 22 - Observations
70	First smoke observed
120	Heat removed. Smoke cloud from initial heater contact stopped approximately 1 ft from the ceiling in the basement and stratified at that level
300	Smoke stratifying to within approximately 4 in. of the ceiling and then falling back to approximately 2 ft down from the ceiling. The smoke appears to be filling the ceiling bay formed by support beams in which the chair sits, but not progressing into other bays. There is very little or no smoke movement observed
900	Charred area approximately 6 by 8 in. - smoke cloud is very dense to within about 3 ft of the ceiling. The smoke is just beginning to reach the ceiling and is drifting very slowly through the basement
1650	Flame observed on back of chair approximately 3 ft high. Immediately after flaming the smoke which had filled the ceiling bay above the chair was pushed into the other bays and up the stairs in a very dense slug

1740	Smoke density so great that flames are barely visible
1800	Smoke is very heavy and drifting slowly. No visible flames
1920	Chair barely visible through smoke in basement. No flames apparent
2700	Visibility less than 1 ft at the 5 ft level
3375	The back of the chair is broken into flames approximately 3 ft high
3512	Test terminated

Test No. 23 was a flaming chair in the basement, all bedroom doors open and furnace on. The usual wastebasket full of scrap paper was placed next to the left arm of the chair with a section of folded newspaper draped over the left arm.

Ignition of Test No. 23 was at 3:00 p.m. on January 31. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 23 - Observations
30	Flames approximately 6 in. high in wastebasket and on folded newspaper over left arm of chair
90	Flames approximately 10 in. high - same locations
210	Flames visible on rear trim of chair
240	Flames visible on underside and back of chair
255	Approximately 1/2 of the total chair is in flame. Flames approximately 18 in. high
270	Entire chair involved, flames approximately 3 ft high
300	Chair still completely involved, moderate smoke in the basement
360	Flames died down to 10 to 12 in. high over entire chair
420	Same observation
480	Same observation

600	Smoke level in basement now heavy, flames approximately 8 to 10 in. high on arm and back. No stratification observed
900	Test terminated

Test No. 24 was another smoldering sectional sofa piece (cotton/nylon/metallic) in the basement with all doors open and the furnace off.

Ignition time for Test No. 24 was 12:10 p.m. on February 10. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 24 - Observations
76	First smoke observed
120	Heat removed - smoke is moving under the ceiling beam into the front bay better than in Test No. 22
900	Smoke stratifying approximately 5 ft level, charred area on the sofa piece irregular
1800	Char area approximately 8 in. square and irregular - multiple levels of stratification in the basement at the 5 and 6 ft levels
2700	Char has filled in to a 9 in. square - smoke in the basement still light
3600	Smoke generation now only moderate with approximately 8 by 10 in. charred area. Heavily stratified smoke layer at the ceiling
3720	Additional heat applied for 2 min
5575	Manually fanning on the chair to increase smoke generation
6460	Flames visible on the chair approximately 1 in. high
7215	Test terminated

Test No. 25 was a flaming ignition of a chair (cotton/rayon/metallic) in the basement with the furnace off and all doors open. We again had a wastebasket full of scrap paper next to the left arm of the chair, and a piece of folded newspaper draped over the left arm.

Ignition time for Test No. 25 was 4:20 p.m. on February 10. The observations noted during the test were as follows:

Time After Ignition, Sec	Test No. 25 - Observations
60	Wastebasket and paper on chair arm burning
120	Flames approximately 2 ft high off chair arm
150	Left side of chair involved near wastebasket
300	Wastebasket on left side of chair still flaming
465	Flames approximately 1 ft high - seat beginning to become involved
570	Flames approximately 2 ft high - seat and left arm involved
600	Flames observed under chair
660	Left side of chair involved and starting up left side of back
780	Left third of chair involved with 8 in. flames
900	Back fully involved, and front underside flaming
937	Chair fully involved, smoke level near the ceiling increasing very rapidly
1350	Test terminated

Test No. 26 was a smoldering ignition of a couch (rayon/cotton/nylon/metallic) in the basement, with bedroom Doors A and F closed and Doors B and E open. The furnace was on and the basement door was closed for this test.

Prior to igniting Test No. 26, a cold air return directly on the furnace was opened. The cal-rod heater was applied to the lower back of the sofa piece with no cushion.

Ignition time for Test No. 26 was 10:15 a.m. on February 11. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 26 - Observations
75	First smoke observed
120	Heat removed
300	Very heavy smoke generation, more than usual for this type of material. Very heavy stratification observed at the 5 ft level - at exactly the level of the cold air return opened on the furnace
900	Heavily stratified dense smoke noted from the 5 ft level to the ceiling and a moderate layer from the 3-1/2 ft level to the floor. Smoke density actually clearer in the middle at approximately the level of the cold air return. Very heavy smoke generation from front and back of the sofa, charred area approximately 8 by 10 in.
1800	Charred area approximately 14 by 18 in., very heavy smoke in basement and very rapid smoke generation from chair. Several stratification levels still observed in the basement
3000	Smoke level in the basement very heavy. Charred area appears to have the shape of a truncated triangle with approximately 2 ft wide base by 2 ft high by 1 ft wide top portion
4480	Smoke level in the basement very heavy, visibility approximately 2 ft
5180	Flame observed on the sofa
6510	Test terminated

Test No. 27 was the final test in the bedroom series and the final test of the winter tests at the Whitehouse site. Test No. 27 was the same as Test No. 26, except that a mattress and box spring were used. The ignition was again flaming using a wastebasket full of scrap paper and a cloth over the mattress simulating a sheet. Doors A and F were closed, Doors B and E were open. Door to the basement was closed and the furnace was on.

Ignition time for Test No. 27 was at 12:55 p.m. on February 11. The observations noted during the test were as follows:

Time After Ignition, Sec	Test No. 27 - Observations
30	Cloth over the mattress and wastebasket are burning - cloth used probably a synthetic material, as it is giving off rather blackish smoke
60	Heavy black smoke approximately 3 ft down from the ceiling
300	Flames approximately 2 ft high in the top and front 1/3 of the mattress and under the box spring
600	Mattress is barely visible through the smoke. Flames approximately 6 to 8 in. high along the left side of the mattress. Small flames noticed under the box spring
2030	Test terminated

The third and final series of full scale tests of the Indiana Dunes Research Project were conducted at the Lake Shore test site on February 24 through 28, 1975.

As in the second test series, these tests were intended to represent winter conditions. We tried to maintain a minimum of 40 F temperature differential between inside and outside.

It was decided to conduct the winter tests in this second site for several reasons. First, conducting the tests during the winter should, theoretically, maximize the "stack effect", resulting in maximum smoke movement and minimum escape times. Second, the Lake Shore test site provided a single story building with basement as opposed to the two story with basement configuration of the J. R. Whitehouse Test Site. Third, the Lake Shore test site used hot water baseboard heating as opposed to the gas forced air heating in the J. R. Whitehouse residence. This would give us test data which would be applicable to most modes of heating except for radiant types.

The original instrumentation for the Lake Shore test series were as follows:

1. The main detector board (Detector Board No. 1) was located in Location A on the ceiling. This was in the first floor hallway, just outside the bedroom door. Detector Board No. 2 was located on the ceiling in Location B, placing it just outside the study and living room doors. Detector Board No. 3 was placed near Detector Board No. 2 on the wall, approximately 6 to 8 in. down from the ceiling.

2. Five foot light beams were placed on the ceiling near each detector location, at the 5 ft level near each detector location, and at the 5 ft level in the front first floor bedroom. In addition, a 5 ft light beam with heat detector No. 22 and a Pyrotronics Model CPM-2 combustion products meter was always placed on the ceiling in the room in which the test was burned. Two additional combustion products meters were placed on the ceiling light beam near each of the detector boards.

3. Thermocouples and vertical thermocouple arrays were arranged in various locations near the detectors and in major areas.

4. Gas sampling tubes were placed in Bedroom No. 1, near each detector location, and one portable tube was moved with each test series to the room in which the combustibles burned.

STUDY SERIES

Test No. 28 was the first of two experiments to run in the first floor study. The test was a smoldering ignition of a chair (cotton/rayon back, nylon loop pile) with the bedroom door closed. In all Lake Shore tests, the furnace was allowed to cycle normally from the thermostat.

Ignition for Test No. 28 was at 10:30 a.m. on February 24, 1975. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 28 Observations
70	First smoke observed
120	Heat removed
300	Char progression very slow - spreading irregularly around horseshoe
600	Same observation

900	Same observation - char still not filled in, chair smoldering much more slowly than other chairs in other experiments
1800	Char almost filled in to about 6 in. diameter. Light smoke in room of origin, very little smoke in hall - little or no air movement. Small pockets of smoke can be observed to be hanging in the air without movement or agitation
4500	Charred area filled in to roughly 7 in. square
6420	Due to extremely slow progression of the experiment, additional heat applied
7020	Additional heat applied
7910	Flaming induced on left arm of chair
8370	Test terminated

Test No. 29 was a repeat of Test No. 28 with the bedroom door open. The upholstery of the chair was cotton. Ignition of Test No. 29 was at 2:40 p.m. on February 24.

Time After Ignition, Sec	Test No. 29 - Observations
67	First smoke observed
120	Heat removed
900	Charred area roughly 6 by 8 in., moderate smoke production - house still passable
2296	Flaming on the chair
2597	Gas sample taken
2665	Test terminated

BEDROOM TEST

Test No. 30 was the only experiment conducted in the front bedroom. Due to the lack of cold air returns, it was felt that one smoldering experiment in the bedroom with the door open would be sufficient. The upholstery material of the chair was cotton/rayon/wool.

Ignition time for Test No. 30 was 4:15 p.m. on February 24. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 30 - Observations
80	First smoke observed
120	Heat removed
2700	Charred area roughly 16 to 18 in. in diameter and a 6 in. semi-circular char on the seat, fairly heavy smoke being generated and moderately heavy smoke in the burn room
3670	Chair flaming
4175	Gas sample taken
4235	Test terminated

LIVING ROOM SERIES

Test No. 31 was a smoldering ignition of a cotton chair in the living room with the door to the bedroom closed. Prior to conducting Test No. 31, the light beam with heat detector and combustion products meter was moved to the ceiling in the living room.

Ignition of Test No. 31 was at 9:15 a.m. on February 25. The observations noted during the test were as follows:

Time After Ignition, Sec	Test No. 31 - Observations
75	First smoke observed
120	Heat removed
900	Char approximately 6 by 8 in. and irregular - moderate smoke production, smoke in the living room light
1800	Char approximately 8 by 8 in. and irregular, moderate smoke in the living room - slightly irritating the eyes and nose. Smoke in the hall light, no smoke in the kitchen or study. No stratification observed
3885	Chair flaming
4135	Test terminated

Test No. 32 was a repeat of Test No. 31, with the bedroom door open. Prior to conducting Test No. 32, Detector Boards No. 2 and 3 were reversed such that Detector Board No. 2 was moved to the wall and Detector Board No. 3 was moved to the ceiling. A cotton/rayon covered chair was used.

Ignition for Test No. 32 was at 12:45 p.m. on February 25. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 32 - Observations
72	First smoke observed
120	Heat removed
900	Smoke generation very heavy - char progressed between back and seat cushion. Smoke in the living room fairly light - mostly in the vicinity of the chair. Charred area approximately 5 by 8 in.
1200	Smoke distributing evenly in the living room - moderately irritating the eyes and nose
1800	Charred area approximately 6 by 18 in. and progressing behind and under cushion. Very heavy smoke generation from the chair, heavy smoke in the living room. Some stratification observed approximately 1-1/2 to 2 ft from the floor. A solid wall of smoke can be observed moving very slowly down the hall
2340	Flame observed coming from front underside of cushion
2520	Entire chair involved - living room and hall impassable, front bedroom passable
2730	Test terminated

Test No. 33 was the final test in the living room series. This test was a flaming ignition of two chairs in the living room with a wastebasket full of paper between the chairs and a section of folded newspaper on the arm of the left (rayon) chair. The right chair (cotton/rayon) had no arms.

Ignition for Test No. 33 was at 2:30 p.m. of February 25. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 33 - Observations
30	Wastebasket and folded paper burning, flames 8 in. high
60	Side of armchair burning near wastebasket
120	Arm of left chair and seat of right chair burning with 6 in. flames. No smoke visible
180	Arm of left chair and about 1/4 of seat of right chair burning with flames approximately 8 to 10 in. high
195	Back of right chair burning with flames approximately 8 to 10 in. high
240	One-half of back of left chair and right chair seat burning with flames approximately 12 to 14 in. high. Smoke level very light - very little odor
300	Two-thirds to three-quarters of back of left chair burning with flames approximately 12 in. high, two-thirds of seat of right chair burning with smoke, small flames. Right chair burning very slowly
345	Left arm of chair beginning to produce very heavy smoke. Flames approximately 12 to 14 in. high on left chair - right chair burning very slowly
420	Flames approximately 12 to 14 in. high in left chair on left arm and back. Smoke level in living room and hall very heavy in a standing position - could exit with acceptable visibility in crouched position. Smoke beginning to be very irritating to eyes and nose
1356	Test terminated

BASEMENT SERIES

Test No. 34 was the first test in the basement series. Prior to beginning Test No. 34, Detector Board No. 3 was moved to the head of the basement stairs along with a light beam and combustion products meter. Detector Board No. 2 was left on the wall in the hall.

The light beam with heat detector and combustion products meter was mounted on the ceiling in the basement.

Ignition for Test No. 34 was at 10:45 a.m. on February 26. The observations noted during the test were as follows:

Time After Ignition, Sec	Test No. 34 - Observations
67	First smoke observed
120	Heat removed
300	Most of the smoke generated from the smoldering mattress appears to be going up the stairway and into the utility room. Little to no smoke is moving up the stairs towards the detectors
900	Smoke generation from the mattress moderate - still moving into the utility room. Additional heat applied
1800	Smoke from the second ignition spot also moving up the stairway and into the utility room. Still no smoke moving up the stairs. Original ignition charred area roughly 12 by 14 in. with second ignition spot approximately 6 by 8 in. Moderate smoke generation from both spots. Smoke level in the basement beginning to become slightly irritating to the eyes and nose
2700	Initial charred area approximately 24 in. in diameter with 12 to 14 in. char along the edge of the mattress in its vicinity. Second charred area approximately 14 in. in diameter with 10 in. char along edge in its vicinity. Smoke has now filled the utility room and is beginning to come very slowly up the stairs in a large slug. Basement now impassable. Also, we are now beginning to get smoke, which seems to be coming up between the walls from the utility room, into the kitchen
3765	Flames on the mattress
4410	Test terminated

Test No. 35 was a flaming ignition of a sofa in the basement with a wastebasket full of newspaper next to the sofa and folded newspaper on the seat near the wastebasket. For this experiment, a foam rubber filled cushion was used on the sofa piece.

Ignition for Test No. 35 was at 1:00 p.m. on February 26. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 35 - Observations
60	Flames in the wastebasket approximately 12 in. high
180	Flames in the wastebasket died down to approximately 4 in. high - sofa still not beginning to burn
300	Flames from the wastebasket up to 14 to 16 in. high - still no burning on sofa
330	Seat cushion on sofa beginning to scorch in vicinity of wastebasket - 14 in. high flames from wastebasket, heavy smoke beginning to be generated from under the folded newspaper
390	Folded newspaper on top of sofa flaming
450	Flames approximately 14 to 16 in. high on top surface of cushion burning down the side. Smoke given off by the sofa is very dark. Smoke level at the ceiling in the basement now appears to be only moderate and not very irritating
1200	Flames approximately 2 ft high on the sofa, very dark and sooty smoke filling the basement
1583	Test terminated

Test No. 36 was a repeat of Test No. 34 (smoldering mattress in the basement) with the door to the utility room closed.

Ignition for Test No. 36 was at 2:30 p.m. on February 26. The observations noted during the test were as follows:

Test No. 40 was the final test in the test series. This was a grease fire in the kitchen.

Three pounds of solid shortening were placed in 8 in. diameter, 4 qt aluminum pot with lid. At ignition, the 8 in. diameter electric stove burner upon which the pot was placed was turned on high.

Ignition was at 4:00 p.m. on February 27. The observations noted during the test are as follows:

Time After Ignition, Sec	Test No. 40 - Observations
1000	Small amount of grease spilled on the stove heating element, giving off smoke. One detector (ionization) in alarm
1500	Very heavy smoke now being generated from under the pan lid
1680	Lid removed from pot - grease immediately burst into flame approximately 5 ft high, impinging on ceiling
1915	Test terminated when ceiling began to burn

APPENDIX D

ESCAPE CRITERIA

In order to judge adequacy of the warning provided by various detectors used in this study, measurements were made of temperatures, carbon monoxide concentrations, and light obscuration at 5 ft above the floor in bedrooms and along routes of escape to ground level doors. Critical values adopted as the limits beyond which escape would not be possible were optical density of 0.07 per ft, temperature of 150 F, or a time-averaged concentration of CO of 0.04 percent over a 1 hr period. The basis for these choices are given in the following paragraphs. In all of the present experiments, the limiting value of light obscuration was reached first, and thus the escape times cited are based on this criterion of untenability.

CRITICAL SMOKE LEVEL:

Presently, there does not appear to be any completely satisfactory way to specify the tenability limits in terms of optical properties of smoke. The situation would be complicated enough if only light transmission through smoke were important, but the effects of respiratory and eye irritation on behavior and visual accuity are also involved.

Table 1 shows some frequently-cited values of critical smoke level from the literature. Obviously, a wide range of smoke densities is represented there. Among References 1, 4, 6, and 7, at least a rough consensus can be found for a critical optical density of 0.07 per ft over a viewing distance of about 15 ft, when only light obscuration is involved.

References 3 and 5 cite critical smoke densities which are said to take account of eye irritation. The optical density of 0.002 per ft derived from Reference 3 is probably unreasonably low because it represents the unset of apprehension rather than the limit of endurance of the observers. The optical density of 0.07 per ft derived from Reference 5 is said to be based on the results of the Los Angeles School Burns No. 2 (8). Nowhere in those results is a critical value of 20 percent light transmission over a 10 ft path length to be found. As a matter of fact, Reference 8 mentions only that 80 percent obscuration is the critical value for tenability, but identifies neither the location nor the length of the light path. From the information given in Reference 8 and its predecessor study (9), it is possible to surmise that the light beam subject to 80 percent obscuration might have been as short as 11 ft or as long as 60 ft. It appears most probable that the light beam involved a double traverse of a corridor 10-15 ft wide, or a path length of 20-30 ft. The critical optical density for that case would be 0.023 to 0.035 per ft. On this basis, it appears more reasonable to assign a critical optical density of about 0.03 per ft to the results of the Los Angeles School Burns. Rasbash (10) reassessed his earlier work and later work by

Jin (11, 12, 13) and concluded that his original correlation (1) represents a useful worst condition which includes in an approximate way the effects of eye irritation. From a study of behavior of people in fires by Wood (14), he also judged that a minimum visibility for escape from fire is about 30 ft, and that this corresponds to an optical density of 0.08 per meter or 0.025 per ft. Thus, the best estimates now possible suggest limits of 0.03 to 0.07 per ft for the critical optical density.

For the dwelling fire situation, escape routes are not usually long and are familiar to occupants. Thus, it appears reasonable to adopt a critical smoke level of 0.07 per ft along escape routes.

Table 1. Frequently-Cited Critical Smoke Levels

Source	Minimum Light Transmission (Percent)	Viewing Distance (Foot)	Optical Density Per Foot	Criterior Applied
Rasbash (1)	10 10.5 12.6	10 15 20	0.10 0.065 0.045	(Empirical correlation* (of visibility of (illuminated objects)
Kingman, et al (2)	5	2	0.65	Visibility of sign held 4 ft away and illuminated by hand-held lamp in smoke-filled room
Shern (3)	80		0.002	Apprehension in observers without OBA in smoke-filled room
Shern (3)	60		0.0044	Judgement of observers with OBA in smoke-filled room
Gross, et al (4)	16	10	0.079	Assumed value
Los Angeles Fire Dept. (5)	20	10	0.070	Visibility and eye irritation of observers in smoke-filled corridor
Bono and Breed (6)	10	11.3	0.088	Visibility of illuminated exit signs photographed from outside smoke-filled room
Malhotra (7)	11	14.8	0.064	Visibility of illuminated signs observed from outside smoke-filled room

*Correlation: $V = 1.40/D^{.767}$
where D is optical density per meter
V is distance of vision in meters

CRITICAL CARBON MONOXIDE CONCENTRATIONS:

The toxicology of carbon monoxide is probably better understood and more fully reported than that of other constituents of fire gases, nevertheless there are areas of considerable disagreement concerning its effects. This is true particularly for long term exposure to low concentrations of carbon monoxide. Table 1 shows the physiological effects of carbon monoxide as reported by various sources. A reasonable 1 hr limit of 0.04 percent may be inferred from these data.

Since all of the data in Table 1 are for situations wherein carbon monoxide concentration does not vary with time, it is reasonable to expect that the minimum concentration allowable in a fire situation will be greater than 0.04 percent. This is because the carbon monoxide concentration will be near zero at the start of the fire, and will increase with time as fire gases permeate the space. If the carbon monoxide concentration increases linearly with time, the maximum concentration attained will be twice the average concentration.

The treatment due to Minchin (23) suggests that the average carbon monoxide concentration, rather than the maximum, is the appropriate indicator of physiological response. Thus, it appears that a logical 1 hr limit for a fire situation in which carbon monoxide increases linearly with time would be one having a maximum average carbon monoxide concentration of 0.04 percent.

The data indicate that carbon monoxide concentration does in fact increase almost linearly with time during the time periods of interest, and a time-average concentration of 0.04 percent has been chosen as the critical level. In only 2 of the 40 experiments did carbon monoxide concentrations approach this level before the optical density reached 0.07 per ft. Nevertheless, the occurrence of the critical optical density preceded the occurrence of critical carbon monoxide levels in all of the experiments.

TABLE 1

ALLOWABLE CARBON MONOXIDE LEVELS FROM VARIOUS SOURCES

Reference	Carbon Monoxide Percent	Exposure	Physiological Effect
Bowes and Field (15)	0.1	1 hr	Unstated
Pryor, et al (16)	0.04	4 hr	Lethal
	0.04	2 hr	Collapse
	0.04	1 hr	Headache
	0.03	3 hr	Collapse
	0.03	1.5 hr	Headache
	0.02	4-5 hr	Collapse
	0.02	2-3 hr	Headache
Yuill (17)	1.5	5 sec	Lethal
	0.3	5 min	Lethal
	0.15	30 min	Lethal
	0.045	2 hr	Lethal
Gross, et al (18) (Based on Refs. 19, 20, and 21)	0.005	8 hr	None
	1.0	2-5 min	Lethal
Autian (22)	0.01	8 hr	None
Minchin (23)	0.1	45 min	Collapse
	0.05	90 min	Collapse

CRITICAL TEMPERATURE:

The maximum temperatures to which humans may be exposed are not well defined, and thus are subject to considerable controversy. Yuill's (17) data showing a 4 hr limit of 130 F indicates that the appropriate temperature limit for escape from a dwelling must be somewhat higher. The value of 150 F was adopted as the criteria of untenability in Reference 9, and this appears to be the minimum which could be considered applicable to the present experiments. This temperature was never exceeded at the 5 ft level along an escape route before untenable smoke occurred. Hence, adoption of any limiting temperature above 150 F would lead to identical conclusions in this study.

REFERENCES

(1) Rasbash, D. J., "Smoke and Toxic Products Produced at Fires", Trans, J. Plastics Inst., Jan. 1967, p. 55.

(2) Kingman, F. E. T., Coleman, F. H., and Rasbash, D. J., "The Products of Combustion in Burning Buildings", Brit. J. Appl. Chem., Vol. 3, 1953, p. 463-8.

(3) Shern, J. H., "Smoke Contribution Factor in the Fire Hazard Classification of Building Materials", ASTM STP422, 1967.

(4) Gross, D., Loftus, J. J., and Robertson, A. F., "A Method for Measuring Smoke from Burning Materials", ASTM STP422, 1967.

(5) Anonymous, "Fire Detection Systems in Dwellings", Quarterly of NFPA, 65 No. 3, January 1963, p. 201.

(6) Bono, J. A. and Breed, B. K., "Study of Smoke Ratings Developed in Standard Fire Tests in Relation to Visual Observations", Underwriters' Laboratories Bulletin of Research No. 56, 1965.

(7) Malhotra, H. L., "Movement of Smoke on Escape Routes, Part 1 - Instrumentation and Effect of Smoke on Visibility, Joint Fire Research Organization", Fire Research Note 651, January 1967.

(8) Anonymous, "Operation School Burning No. 2", NFPA, Boston, 1961.

(9) Anonymous, "Operation School Burning", NFPA, Boston, 1959.

(10) Rasbash, D. J., "Sensitivity Criteria for Detectors Used to Protect Life", 7th International Seminar on Problems of Automatic Fire Detection, I.E.N.T., Aachen, Germany, March 5 and 6, 1975.

(11) Jin, T., "Visibility Through Fire Smoke I", Fire Research Institute, Japan, July, 1969.

(12) Jin, T., "Visibility Through Fire Smoke II", Report of Fire Research Institute of Japan 33, 1971.

(13) Jin, T., "Visibility through Fire Smoke III", Bull. of Japanese Assoc. Fire Science and Eng., 22 1972.

(14) Wood, P. G., "The Behavior of People in Fires", JFRO, Borehamwood, England, Fire Research Note No. 953.

(15) Bowes, P. C. and Field, P., "The Assessmen of Smoke Production by Building Materials in Fires - 2. Test Method Based on Smoke Accumulation in a Compartment", Joint Fire Research Organiation, Fire Research Note 749, (March 1969).

(16) Pryor, A. J., Johnson, D. E., and Jackson, N. N., "Hazards of Smoke and Toxic Gases Producted in Urban Fires" SWRI Report No. 03-2402, OCD Work Unit 2537B, Contract DAHC 20-70-0212 (September 1969)

(17) Yuill, C. H., "The Life Hazard of Bedding and Upholstery Fires", Journ. Fire and Flammability, Vol. 1 (October, 1970) p. 312.

(18) Gross, D., Loftus, J. J., Lee, T. G., and Gray, V. E., "Smoke and Gases Produced by Burning Aircraft Interior Materials", NBS Building Science Series 18 (February 1969).

(19) Henderson, Y. and Haggard, H. W., "Noxious Gases" (Rheinhold, New York 1943).

(20) Elkins, H. B., "The Chemistry of Industrial Toxicology" (John Wiley and Sons, New York 1959).

(21) American Conference on Government Industrial Hygienists, Document of Threshold Values (1966 Edition), Cincinnati, O.

(22) Tian, J., "Toxicologic Aspects of Flammability and Combustion of Polymeric Materials", Journ. Fire and Flammability, Vol. 1 (July 1970) P. 239.

(23) Minchin, L. T., "Mild Carbon Monoxide Poisoning as an Industrial Hazard", Ind. Chem., Vol. 30 (1954) p. 381.

Heskestad, G., "Escape Potentials From Apartments Protected By Fire Detectors In High-Rise Buildings", FMRC Serial Number 21017. Department of HUD, Contract Number H-2034R, June, 1974.

APPENDIX E

DESCRIPTION OF GAS AND PARTICULATE SAMPLING TAKEN AND DATA OBTAINED

PARTICULATE SAMPLES:

The particulate samples investigated were collected from Experiment 27:

1st Floor, 2nd Filter, 1.75 mg
2nd Floor, 2nd Filter, 1.05 mg

A nucleopore filter was treated exactly like the sample filters to serve as an analysis blank.

The samples were refluxed with CS_2 for 5 hr to extract organic material. The CS_2 extract was then concentrated to 0.1 ml and aliquots were taken for gas chromatographic analysis. The extract concentrate was also analyzed by IR spectroscopy.

To try to survey for as broad a range of species as possible, the samples were analyzed on three columns: Carbowax 20M temperature programmed from 60 C to 200 C; OV-1 temperature programmed from 60 C to 300 C; and Dexsil 300GC from 60 C to 300 C. Chromatograms of the blank on all three columns exhibited a significant amount of material. (Gas chromatographic analysis routinely provides detection sensitivity of 1×10^{-9} g). Comparing the chromatograms from the samples to those from the respective blanks showed no significant amount of additional species detected. Some peaks showed increases in size. To determine whether these instances were actual sample species or merely differences in the concentration of species extracted from the filter material would require identification of the components by gas chromatography-mass spectrometry. However, the concentrations available from these samples were not sufficient for GC-MS analysis. From the data obtained it is estimated that no species amenable to gas chromatographic analysis is present at levels above 0.05 wt percent of the collected particulate sample.

The IR analysis of the sample showed only trace absorption for hydrocarbon species. For the heavier, e.g. polymerized, species that may be present, IR spectroscopy is a means of surveying the sample but again larger concentrations are required.

For any future studies of organic materials present in particulate samples, these preliminary results suggest that:

(1) An inorganic filter (e.g., glass fiber filters) should be used to collect samples for organic analyses. Any organic filter will necessarily contribute background contaminants in the procedures required to extract organic species from the sample.

(2) Much larger samples should be collected, preferably two or three orders of magnitude larger. If the total organic content of the particulates is a low percentage of the amount collected, then identification of individual components becomes a trace analysis problem and to characterize a complete unknown becomes an impossible task. Once initial characterization is accomplished, however trace analytical procedures can be developed to detect particular species of interest.

SMOKE PARTICLE CHARACTERISTICS:

To gain information on the triggering characteristics of various fire alarms, samples of smoke particles were taken at the four fire events on February 10, 1975 and February 11, 1975 (Experiments 24 through 27) at the Whitehouse site. Data were obtained on particle number concentrations, mass concentrations and particle chemistry at selected places within the house at approximately the time of alarm triggering. The results are described below.

PARTICLE NUMBER CONCENTRATION

Number concentrations were determined with a Gardner Type CN small particle counter. This portable manually-operated device has a time resolution of about 15 sec. Each agglomerate is counted as one particle, rather than the number of its constituent particles. The device counts all particles in the size range 0.002 to approximately 2 μm diameter.

Table 1 shows particle concentrations for Experiment 24. It is apparent that the smoke travel in that fire was very slow.

For Experiment 25, events progressed much faster and only a few readings were obtained. Backgrounds in the house were 34,000 to 76,000 particles/cc. Readings were obtained on the first and second floors at the time of the first alarm on the respective floors. These readings were 250,000 and 420,000 for the first and second floors respectively. Considering the difficulties in properly sequencing the measurements, the concentrations cited above should be considered roughly equal.

TABLE 1
PARTICLE CONCENTRATION READINGS
FOR EXPERIMENT 24 PARTICLES/CC

Time	Basement		First Floor				Second Floor	Outside
	A	B	C	D	E	F		
Prior to fire ignition at 11:10 a.m.	90,000				48,000		34,000	24,000
11:10-11:15	190,000	48,000						
1:23 p.m.					40,000	24,000		
1:33					46,000			
1:45			235,000					
2:00				150,000				
2:05						68,000		

A: By outside door
B: By stairs to first floor
C: By basement stairs
D: Kitchen
E: Alcove
F: By stairs to second floor

For Experients 26 and 27, emphasis was placed on obtaining good number concentration histories at one selected point (the alcove area of the first floor). Figs. 1 and 2 show the results. These figures show that the alarm triggering lagged the start of concentration increase by only a few minutes. No appreciable advance warning was obtained from the concentration measurements.

In Experiment 26 one reading was obtained on the second floor at 11 min after the triggering of the first second floor alarm. The concentration was 140,000 particles/cc, identical to the reading obtained on the first floor at 11 min after the first floor alarm. This suggests that the two alarms had approximately the same trigger levels, in terms of particle concentration.

Figs. 1 and 2 show that particle concentration is not the only criterion for alarm triggering: If it were, the alarm would have triggered on the background concentration for Experiment 27. (This background was higher than the trigger level concentration in Experiment 26.)

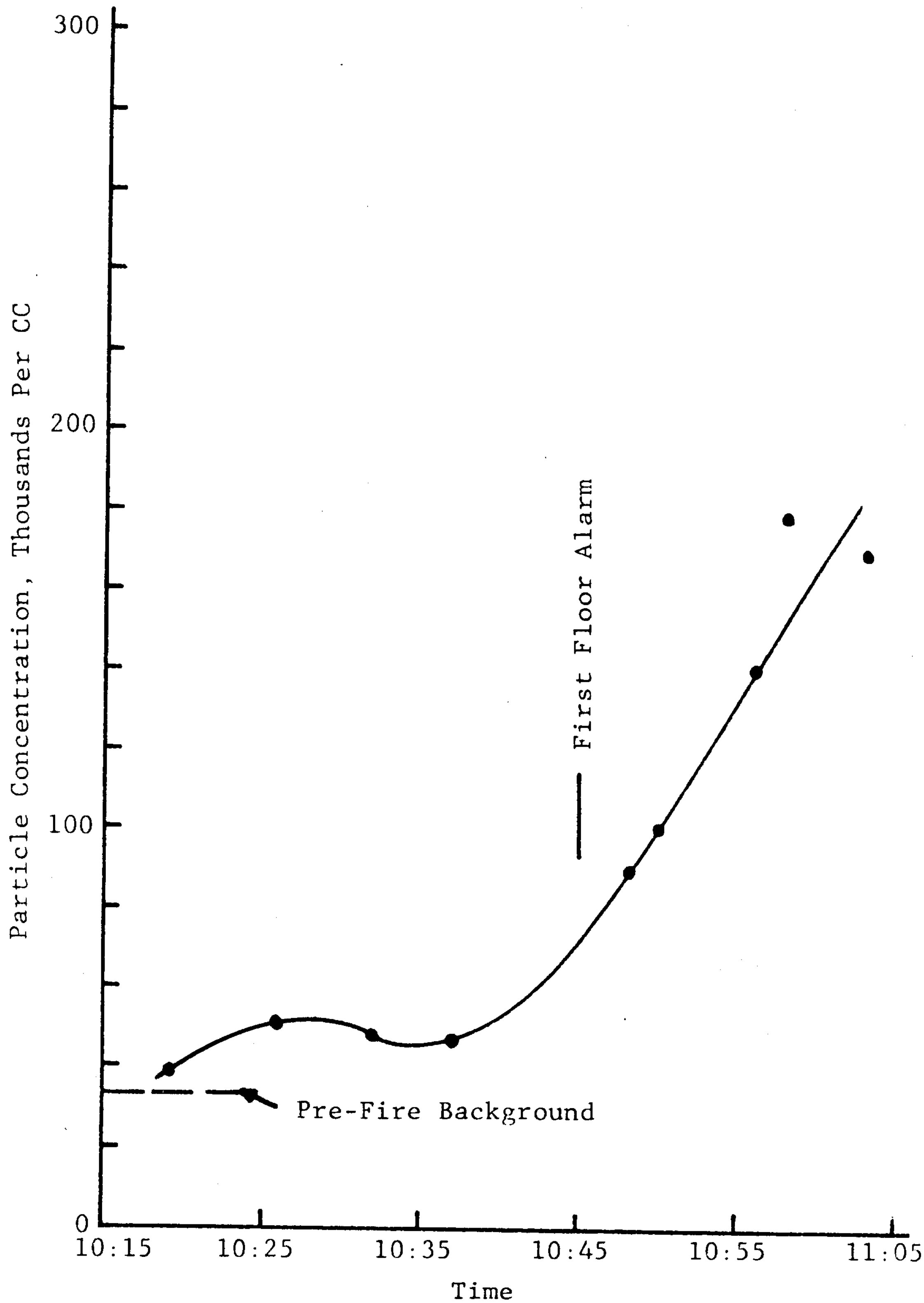


Fig. 1 PARTICLE CONCENTRATION IN FIRST FLOOR ALCOVE SMOULDERING FIRE (EXPERIMENT 26, 2/11/75).

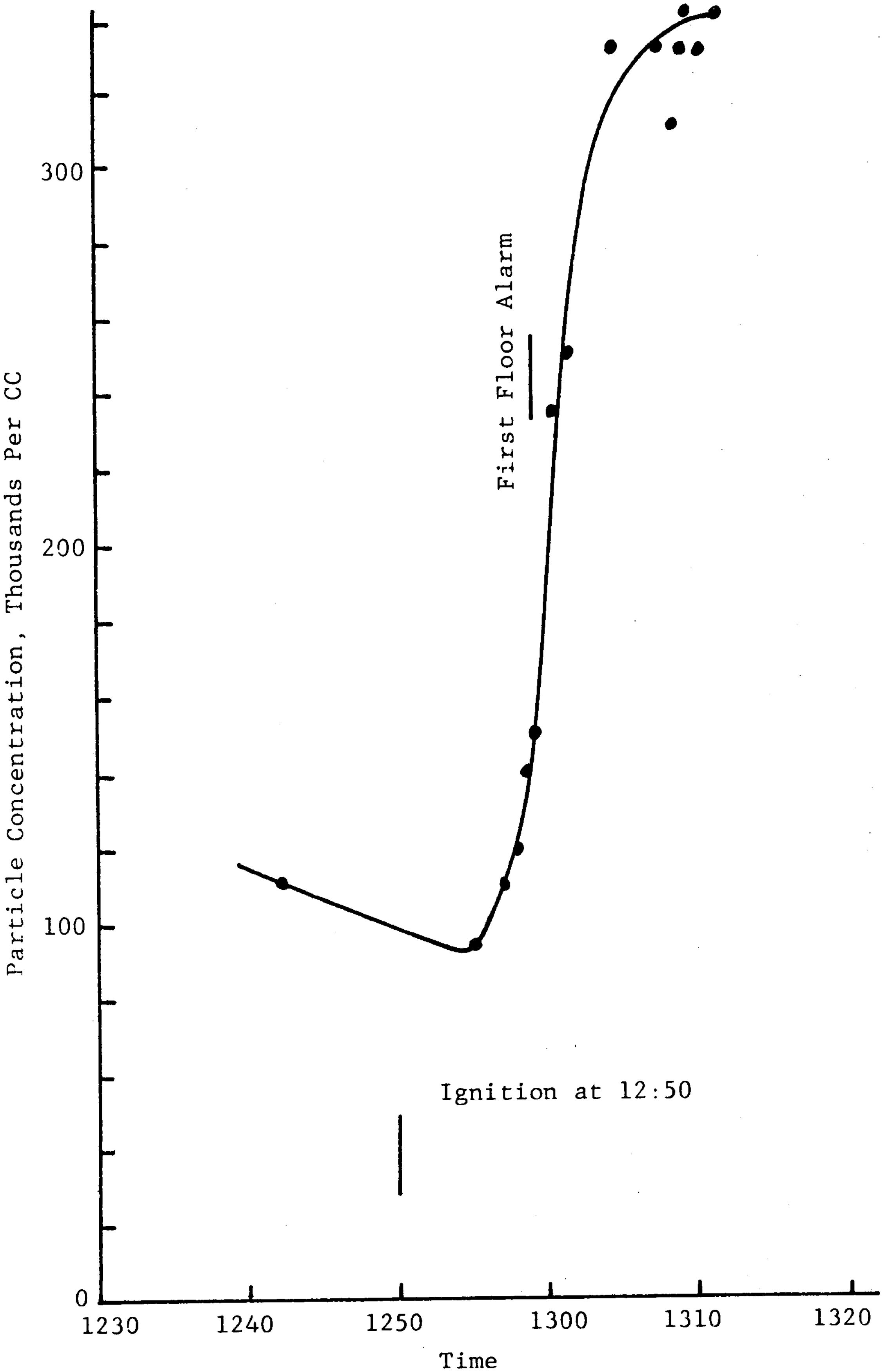


Fig. 2 PARTICLE CONCENTRATION IN FIRST FLOOR ALCOVE FLAMING IGNITION (EXPERIMENT 27, 2/11/75)

MASS CONCENTRATIONS

Particle mass concentrations were determined by before-and-after weighing of filters exposed to Experiments 24 through 27. The samples were drawn at 10 liters per min onto 47 mm diameter nucleopore filters. The results are shown in Table 2.

The time sequencing for the samples was as follows: Samples were drawn simultaneously on the two floors. The first sample was started at the time of the first first floor alarm and the second sample was started at the time of the first second floor alarm. Sampling times ranging from 3 to 15 min were used.

To compare the triggering levels of the first and second floor alarms in terms of mass concentrations, the underlined values in Table 2 should be consulted. These values are for the samples obtained just after the first alarm sounded on the respective floors. It is seen that the trigger levels for the smoldering fires were comparable, from day to day and from floor to floor. For the flaming fires, the results are less meaningful, due to the rapidly changing concentration in these fires. It appears, however, that the second floor alarm required higher mass concentration to trigger.

Comparison of the number and mass concentration data indicates that the average particle mass was approximately 6×10^{-10} g. These values imply an average particle diameter of the order 0.4 μm. Better size information was obtained by scanning electron microscopy; as described next.

TABLE 2
MASS CONCENTRATIONS FOR
EXPERIMENTS 24 THROUGH 27-MG/M^3

	Smoldering Fire		Flaming Fire	
	First Sample	Second Sample	First Sample	Second Sample
Experiments 24 And 25				
First Floor	<u>6.7</u>	30.5	<u>11.6</u>	55.0
Second Floor	4.3	<u>7.0</u>	7.0	<u>29.0</u>
Experiments 26 And 27				
First Floor	<u>6.0</u>	11.6	<u>3.3</u>	17.5
Second Floor	3.3	<u>5.0</u>	0	<u>10.5</u>

Note: Underlined values indicate the samples which were taken just subsequent to the first alarm on the corresponding floor.

PARTICLE SIZE AND COMPOSITION

One of the exposed nucleopore filters was examined in some detail by scanning electron microscopy. The filter was from Experiment 27, first floor, first sample. A section of the filter was mounted on a graphite block and coated with a thin carbon layer to improve imaging. A micrograph taken at 10,000 times is shown in Fig. 3.

The micrograph shows several particle types and sizes. The predominant type is a floc consisting of 10 to 20 particles whose individual size is 0.05 to 0.2 μm. A few larger particles of 0.3 to 1.0 μm also appear.

Several of the larger particles were analyzed by the x-ray fluorescense accessory of the scanning electron microscope. This method detects elements of atomic number 9 or higher. The predominant type was a volatile particle which evaporated when the electron beam was trained upon it. Several particles evaporated before they could be analyzed. The analyses obtained successfully showed that the particles contained silicon and chlorine. No other elements could be detected. Further chemical analysis is required to positively identify these particles.

Several other particle types were found occasionally on the filter. Some were identified as soil particles from the elemental analysis.

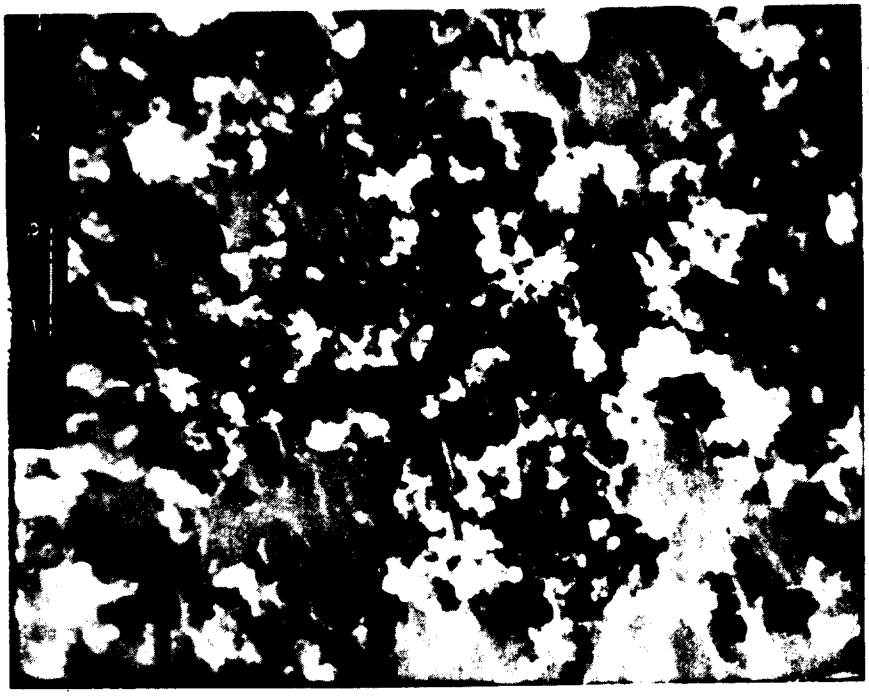


FIGURE 3

SCANNING ELECTRON MICROGRAPH OF SMOKE PARTICLES

Magnification: 10,000 X

The particles are deposited on a nucleopore filter. Filter pores of 0.3 um diameter can be seen in the background.

GAS SAMPLES

Methods Of Analysis

The gas samples were first surveyed using gas chromatographic techniques, taking aliquots with a gas-tight syringe. The instrument used was a Varian Aerograph Model 2860 equipped with both thermal conductivity (TCD) and flame ionization (FID) detectors. The TCD is required to detect inorganic species; the FID will detect any organic species with three orders of magnitude greater sensitivity. Two columns were employed for the survey analyses:

(1) 5A Molecular Sieve (18 ft by 1/8 in. OD stainless steel). This column will separate O_2, N_2, and CO. Column effluent was monitored with the TCD.

(2) Porapak QS (12 ft by 1/8 in. OD stainless steel, 80/100 mesh). All other gases and vapors of moderately volatile liquids can be surveyed with this column. The column effluent was split and monitored simultaneously with both the TCD and FID.

Based on the results of these analyses, the use of additional columns to survey for the presence of higher molecular weight species was not considered necessary.

The combined technique of gas chromatography-mass spectrometry (GC-MS) was also employed for two of the Lakefront House samples. After initial survey analyses, the entire sample was flushed from the sampling container into a liquid nitrogen cold trap (1/8 in. OD stainless steel coil collector) with purified helium. The trap was attached to the gas chromatograph and then rapidly heated with applied voltage while being swept with the carrier gas flow to inject the collected sample. The analyses were conducted on the Porapak QS column. The column effluent from the TCD was directed into the mass spectrometer through a Biemann-Watson separator which selectively removes the carrier gas. Mass spectra are obtained on the separated sample components as they elute from the GC. The mass spectrometer is an Hitachi-Perkin Elmer Model RMU-6D.

The survey analyses on the Whitehouse Residence samples indicated that additional GC-MS analysis was not warranted. The inorganic species detected can be unambiguously identified from GC retention time data. Only a few organic species were detected and these also can be postulated from GC data. All organics were generally below 10 ng/cc in concentration, with most less than 1 ng/cc. Even by concentrating the entire sample for analysis, these levels are insufficient to produce useable mass spectra. The higher concentrations of species in the Lakefront House samples allowed some identification when the entire sample was concentrated for analysis.

Analysis Results

The data from the Whitehouse Residence samples are compiled in Table 1. Samples were taken in two types of containers: Type A, "Vacuum Samples" (Alltech Associates), which are evacuated, and Type B, "Vacu-Samplers" (MDA Scientific, Inc.), which are evacuated and then backfilled with nitrogen to a partial vacuum of 10 in. Hg. The CO content was analyzed only on those samples showing some significant deviations from normal air composition. The CO detection limit is approximately 10 ppm (by volume) for the analysis technique employed. All samples were surveyed for organic species. Components detected above a level of approximately 1×10^{-10} g/cc air were reported. Values for all replicate analyses are listed to provide an indication of precision. The values for H_2O were included, but only as a point of interest. Water content is extremely difficult to analyze accurately using this type of procedure because of absorption problems.

Analysis data from the Lakefront House samples are listed in Table 2 for the inorganic species and Table 3 for organic species. Table 3 lists by chromatographic retention time all the components detected when total samples from LF#33A and B were concentrated for analysis. Concentration estimates are given for all species above a concentration level of 1×10^{-10} g/cc air. The total sample analyses and all survey analyses run under the same conditions produced very similar chromatograms. The differences among the samples were in concentration levels rather than in the types of species present. The species detected in the Whitehouse Residence samples, although relatively lower in concentration, were the same. All the compounds detected are expected products of any incomplete combustion process.

Most of the compounds detected could not be identified because of insufficient concentration. A concentration in the range of 1×10^{-6}-1×10^{-7} is generally required to obtain mass spectral data. The total sample in Type A containers was 280 cc and in Type B only 123 cc. If species in the range of 1×10^{-9} g/cc are of interest, one liter samples should be taken. For the molecular weight range of species detected here, 1×10^{-9} g/cc represents a volume concentration on the order of 1 ppm.

TABLE 1
WHITEHOUSE RESIDENCE

Sample	Type	cc x 10^{-4}/cc air: CO_2	CO	H_2O	10^{-9} g/cc air: CH_4	C_2H_4	C_2H_6	X(12.2)	X(13.8)	X(14.4)
Experiment 24										
Basement Background	B	16,12,14		38,250,133	5,6,3					
1st Floor	B	8,10		34,169	5,3					
2nd Floor	B	31,25,28,30	3,2	230,237,209	17,16,18	7,9,7	4,4,3	2,4,3		7
Experiment 25										
Background	B	13,10		42,200	2,1					
1st Floor	B	10,11,13,10		275,205	7,1,4,4	0.7,0.9,0.7				
2nd Floor	B	8,9		160	2		2			
Experiment 26										
Basement Background	B	5,6		110,89	3,3					
1st Floor Background	B	8		144	2					
2nd Floor Background	B	6,4		213,167	3,2					
1st Floor 10:42	A	15,19	0.3,0.3	24	3,3	0.3,0.4	0.3,0.5			
1st Floor 10:46 Bathroom	B	34,31		76	5,4	0.5,0.1	0.5			
1st Floor 10:57	A	12,12	0.6,0.4	42	5,5	0.8,0.7	0.9,0.9	0.9	0.8	
2nd Floor Alarm	B	13,9,10		118	5,5,4	0.5,0.7,0.5	0.5,0.7,0.5			
2nd Floor 10:45	A	15,14,14	0.3,0.3	87,85	4,4,4	0.4,0.3,0.3	0.4,0.4,0.3			
2nd Floor 10:59	B	14,31,32,12		140	7,13,13,5	2,2,0.7	2,2,0.7	2	2	
2nd Floor 10:59	A	9	0.4	25	4	0.6	0.8			
Experiment 27										
Basement Background	A	10,12,10		28,80	3,4,3					
1st Floor Background	A	9,11		14,25	1,3					
1st Floor Alarm 12:59	A	6,9		110,36	4,4	0.1,0.1	0.1			
2nd Floor Alarm	A	11,11	0.2	32,34	2,3	0.5,0.4	0.2,0.1			
Laboratory Air		5,5,5		28,40,56	5,5,5					

TABLE 2
LAKEFRONT HOUSE - INORGANIC SPECIES

Sample	Type	10^{-4} cc/cc air		
		CO_2	CO	H_2O
LF#29* at 2597 sec Location B at 5 ft	B	28	4.0, 3.5	225
LF#30 at 4175 sec Bedroom at 5 ft	B	20	8.9, 8.2	304, 225
LF#33 hall at 5 ft Location B taken at 18 min	A	62, 58	6.1, 6.0	92, 104
LF#33 hall at B, 5 ft 20 min after ignition	B	59	9.7, 9.3	294
LF#38 kitchen door at 5 ft 14 min, 10 sec to 20 sec PVC "fire"	A	7	<0.1	76
Laboratory air			<0.1	29

* LF#29 - Lakefront Experiment 29

TABLE 3
LAKEFRONT HOUSE - ORGANIC SPECIES

Retention Time[1] (Min)	Identification MS Data	10^{-9} g/cc air					Laboratory Air
		LF#29	LF#30	LF#33-A	LF#33-B	LF#38	
1.0	methane	27	41, 52	29, 31	54	4	6
2.2 sh[2]	acetylene						
2.7	ethylene	10	33, 43	19, 19	30	0.6	
3.8	ethane	6	9, 11	6, 6	10	0.6	
10.9	propylene	5	8, 10	4, 5	8	0.3	
11.6		2	8, 9	1, 1	2	0.3	
12.0		0.2		0.6, 0.6	1		
12.6	methanol	0.6	1, 1	2, 2	5		
14.5	probable acetaldehyde	3	5, 5	3, 3	6	0.1	
17.1		2	5, 7	2, 2	4	0.6	
17.6		0.7	2, 3	0.5, 0.6	0.6	0.5	
17.8 sh[2]					0.1		
18.6			0.7, 0.9				
19.3 sh[2]				0.3, 0.3			
19.9	acetone	4	5, 7	3, 3	6		
20.7							
21.5							
22.0							
22.7							
23.5							
24.3 sh							
24.9		3	7, 7	0.9, 1	5	1	
27.5							
29.9	probable benzene	3	9, 9	1	8		

[1]Porapak QS column, FID response, temperature: isothermal at 60 C for 6 min then programmed to 200 C at 10 C/min and held at 200 C.

[2]Minor shoulder components on larger peaks.

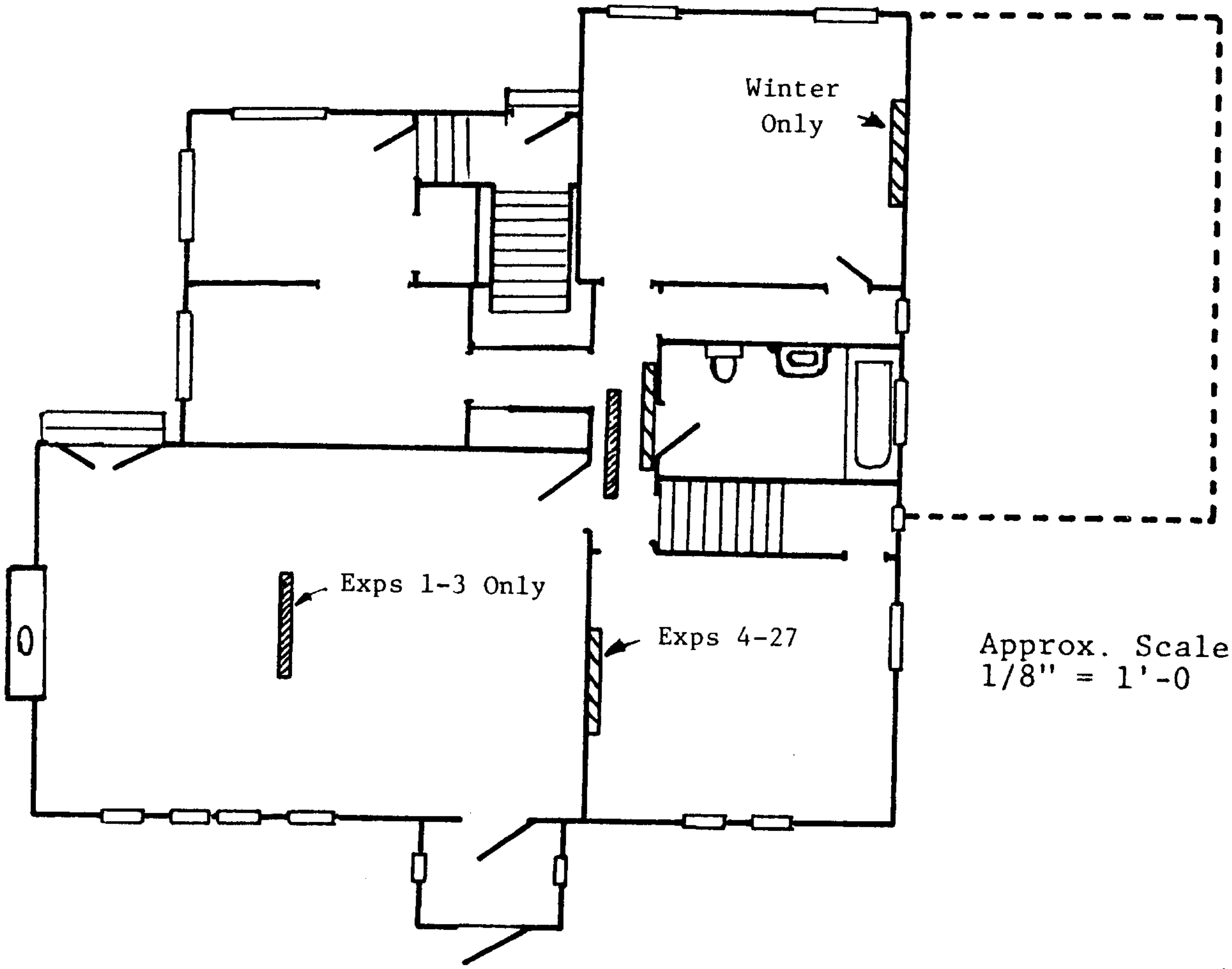
APPENDIX F

FLOOR PLANS OF TEST BUILDINGS SHOWING DETECTOR, FIRE, AND INSTRUMENT LOCATIONS

KEY

Ceiling Mounted

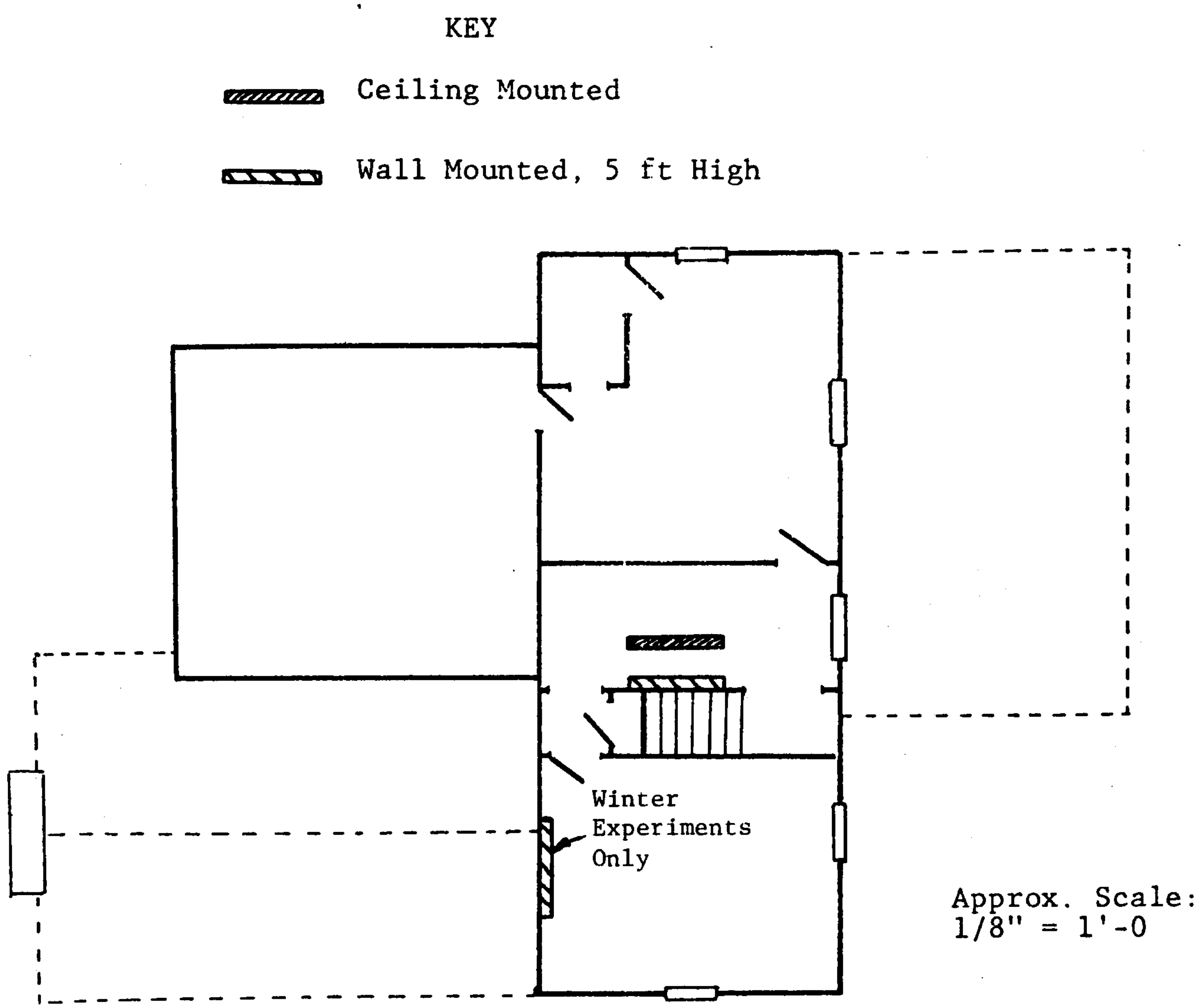
Wall Mounted, 5 ft High



Approx. Scale:
1/8" = 1'-0

1ST FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 1 FIXED LIGHT BEAM LOCATIONS, (SMOKE)



2ND FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 2 FIXED LIGHT BEAM LOCATIONS, (SMOKE)

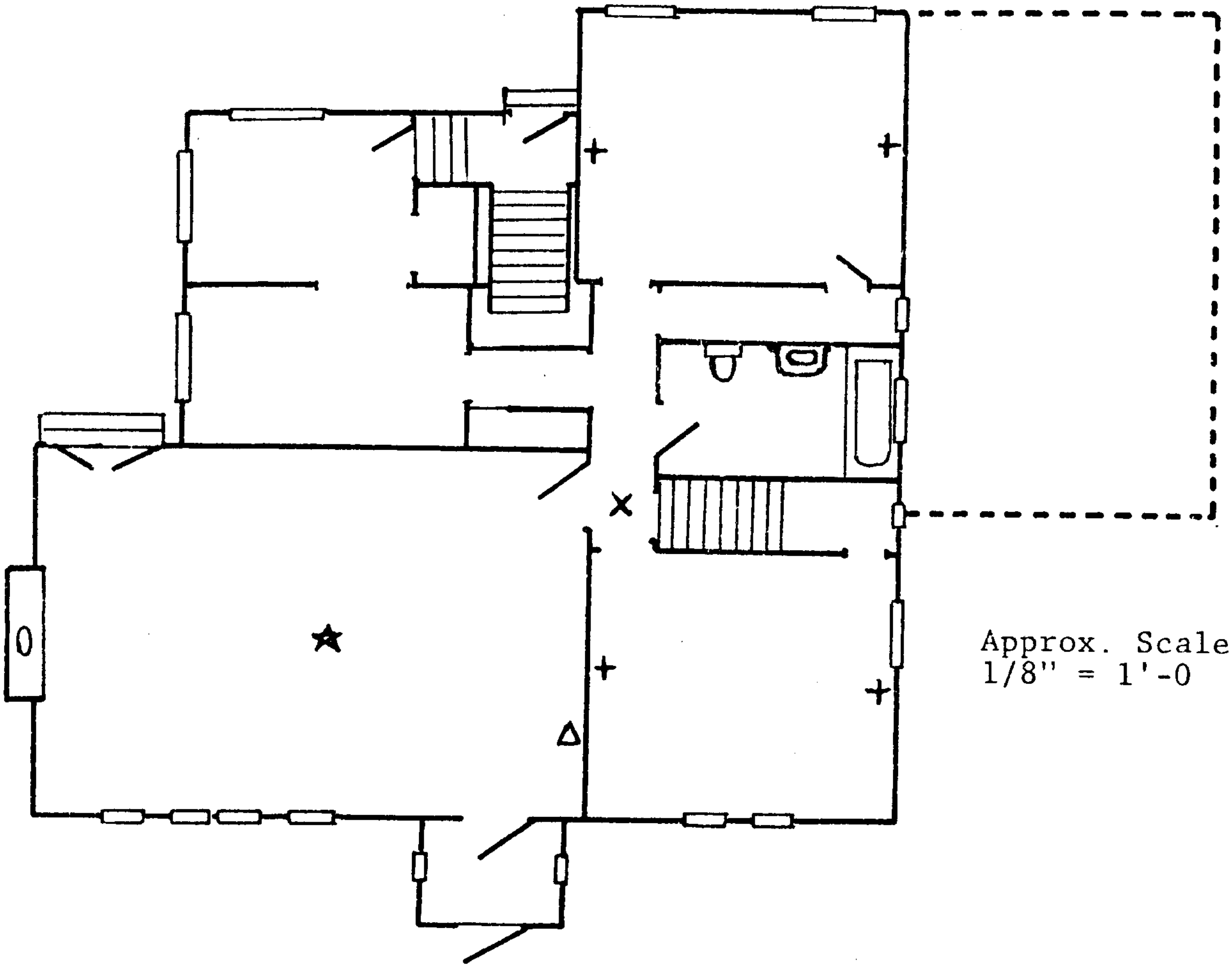
KEY

× Thermocouple Profile

+ Thermocouples 5 ft High

△ Thermocouple 4 in. Above Hot Air Register

★ Ceiling Thermocouple (13 ft High)



Approx. Scale:
1/8" = 1'-0

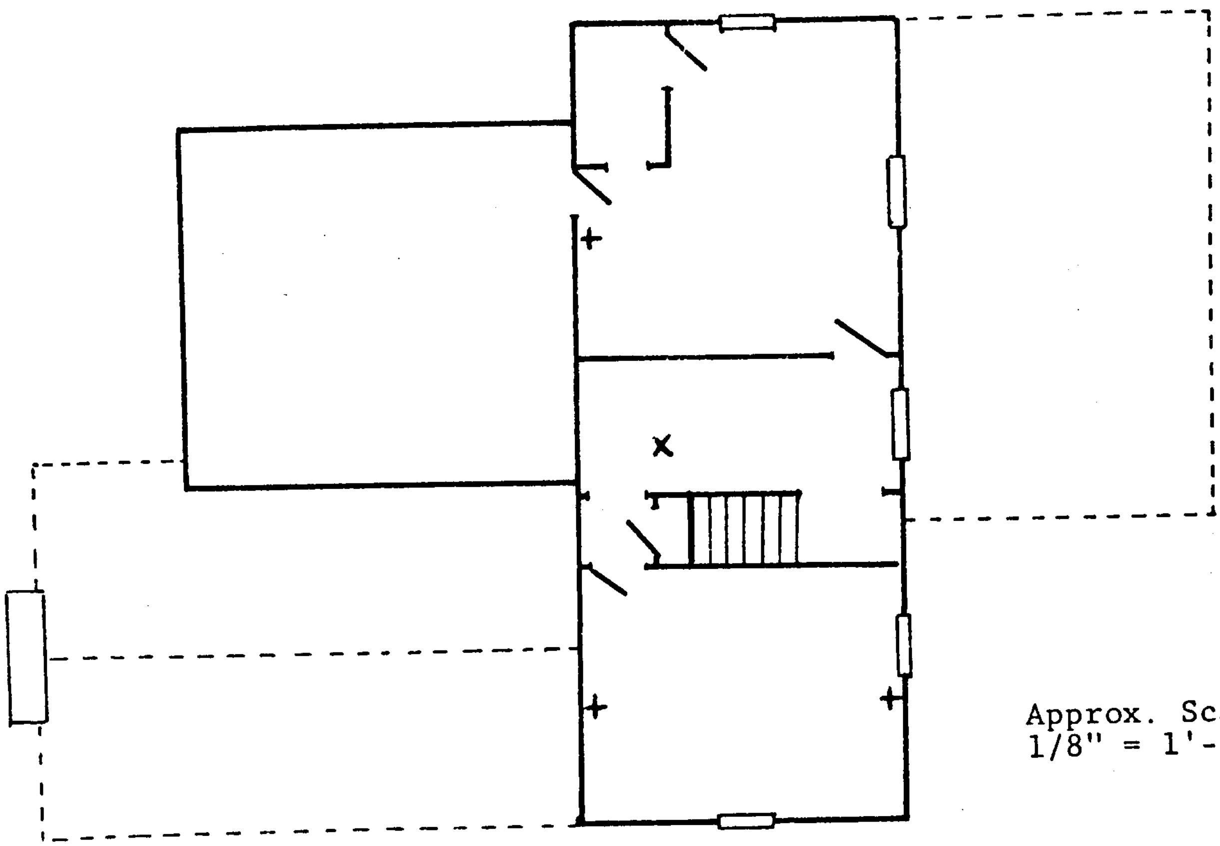
1ST FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 3 FIXED TEMPERATURE MEASUREMENTS

KEY

× Thermocouple Profile

+ Thermocouples 5 ft High



Approx. Scale: 1/8" = 1'-0

2ND FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

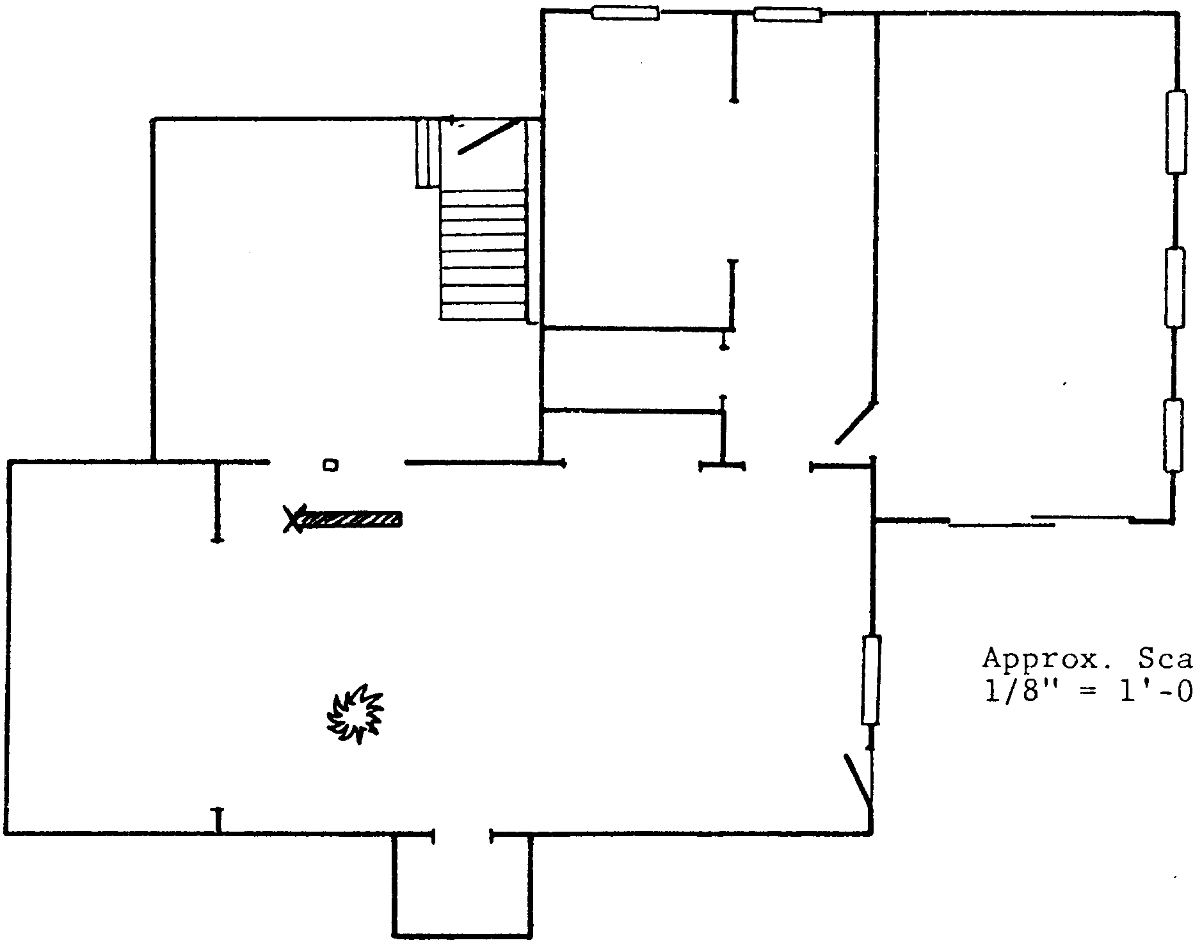
Fig. 4 FIXED TEMPERATURE MEASUREMENTS

KEY

Ceiling Light Beam (Smoke)

Thermocouple Profile

Fire Location



Approx. Scale:
1/8" = 1'-0

BASEMENT FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 5 FIRE LOCATIONS AND PORTABLE IGNITION ROOM INSTRUMENTATION

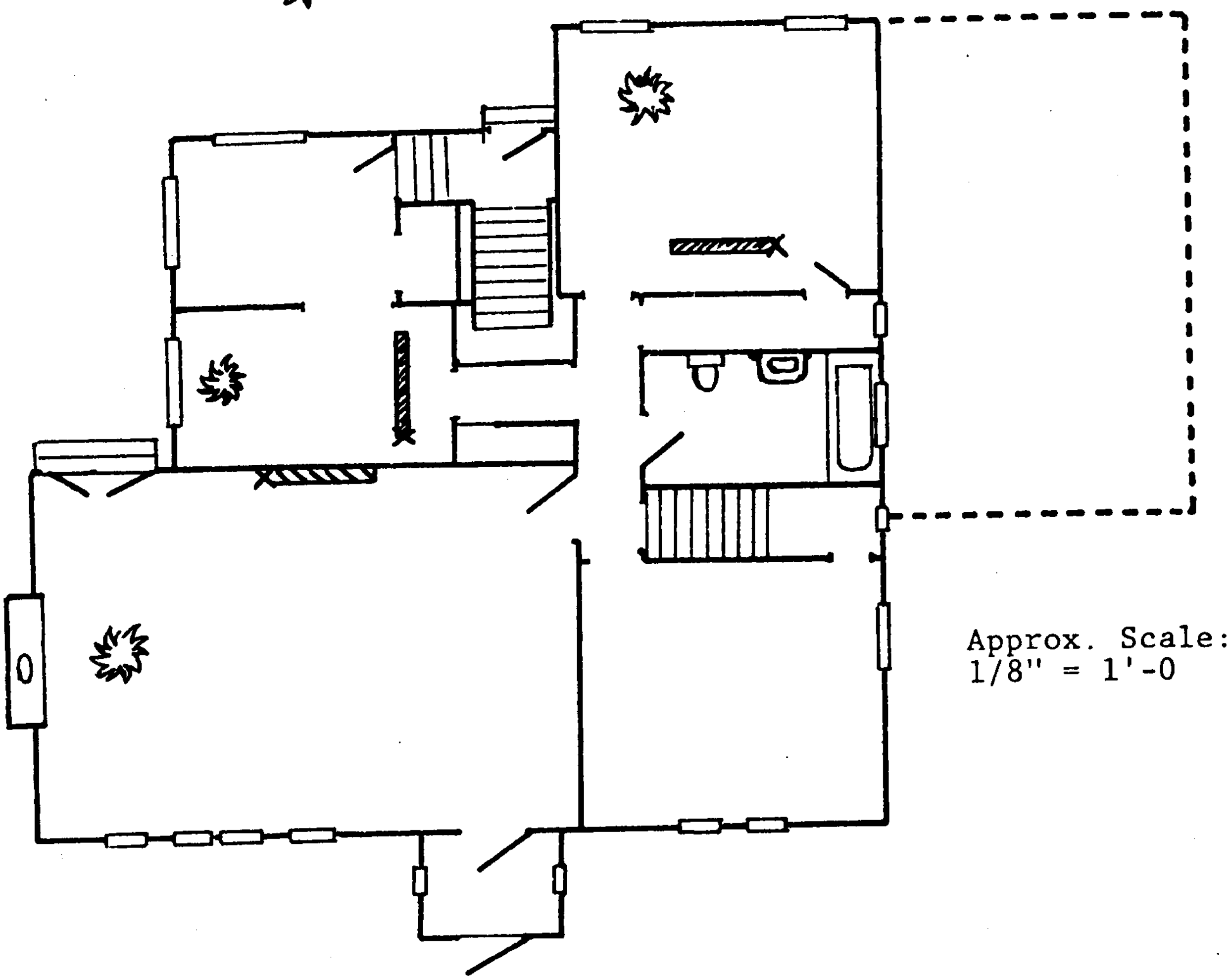
KEY

Ceiling Light Beam (Smoke)

Light Beam (and Temp. Profile) at Wall, 8 ft High

X Thermocouple Profile

Fire Location



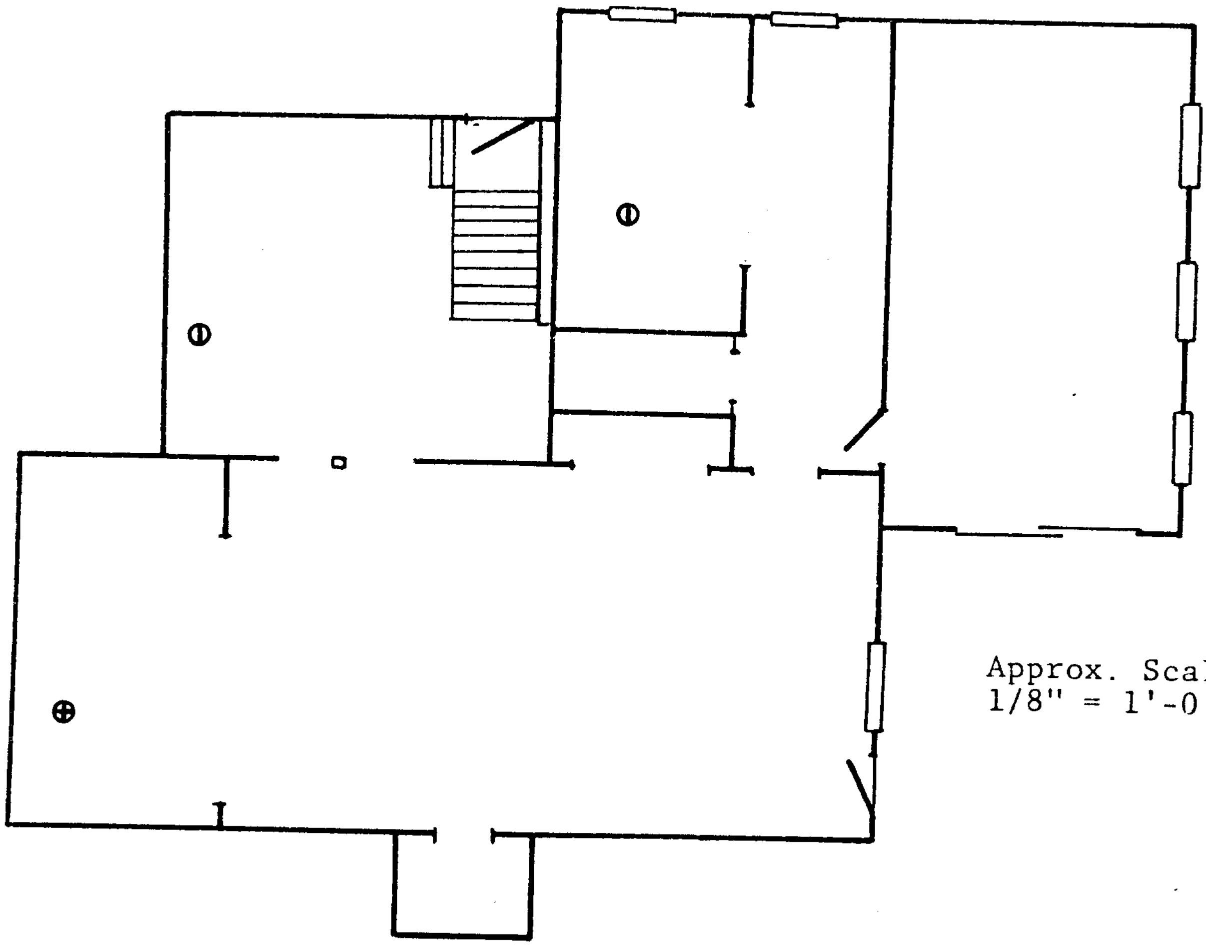
1ST FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 6 FIRE LOCATIONS AND PORTABLE IGNITION ROOM INSTRUMENTATION

KEY

Summer Experiments

Winter Experiments



Approx. Scale:
1/8" = 1'-0

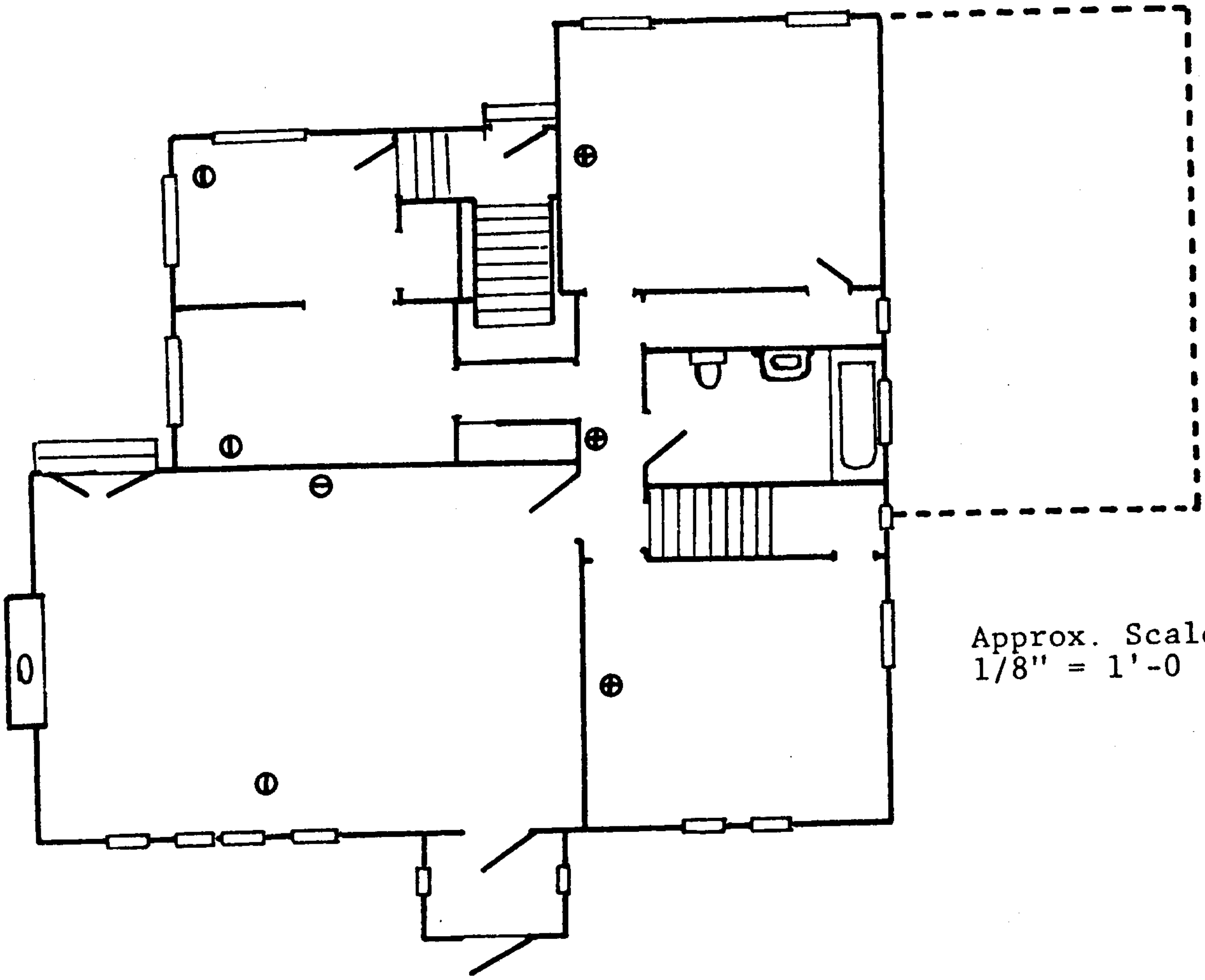
BASEMENT FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 7 GAS SAMPLING LOCATIONS

KEY

⦶ Summer Experiments

⊖ Winter Experiments



Approx. Scale:
1/8" = 1'-0

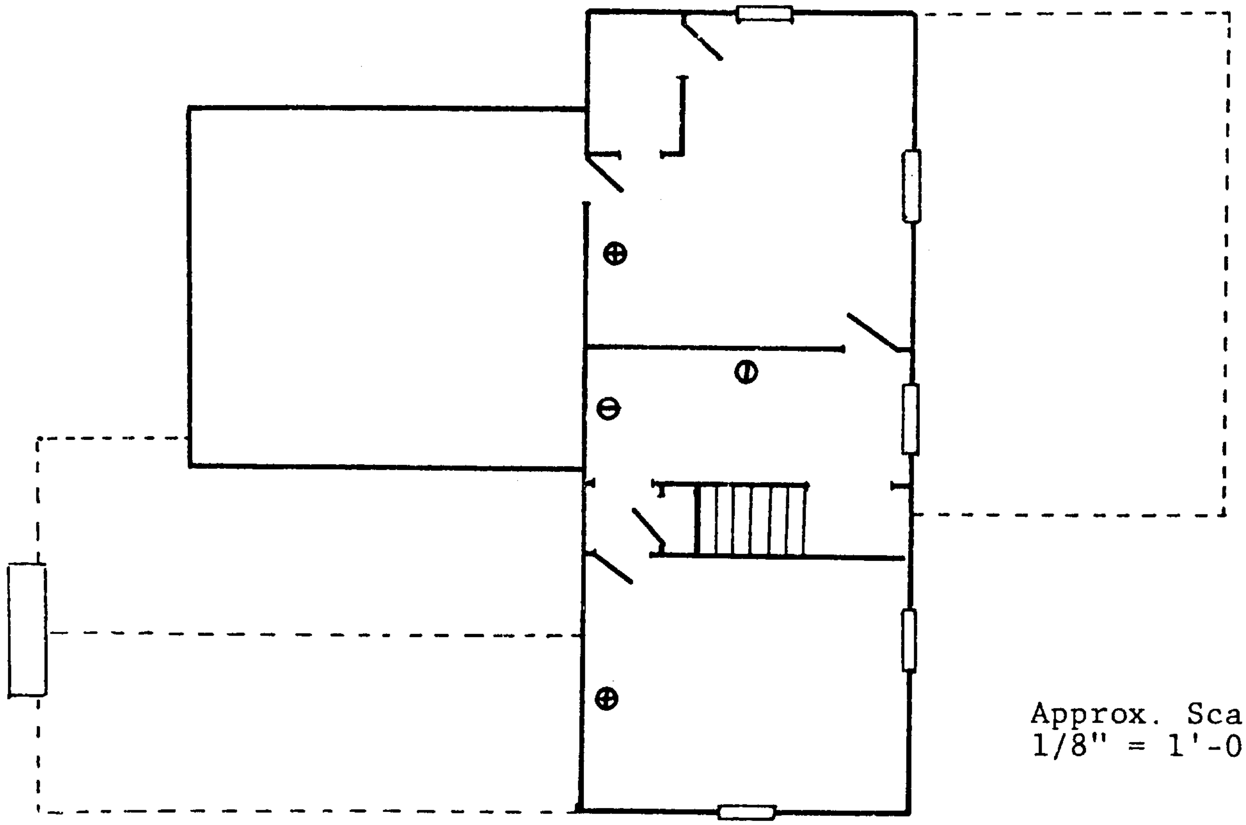
1ST FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 8 GAS SAMPLING LOCATIONS

KEY

⦶ Summer Experiments

⊖ Winter Experiments



Approx. Scale:
1/8" = 1'-0

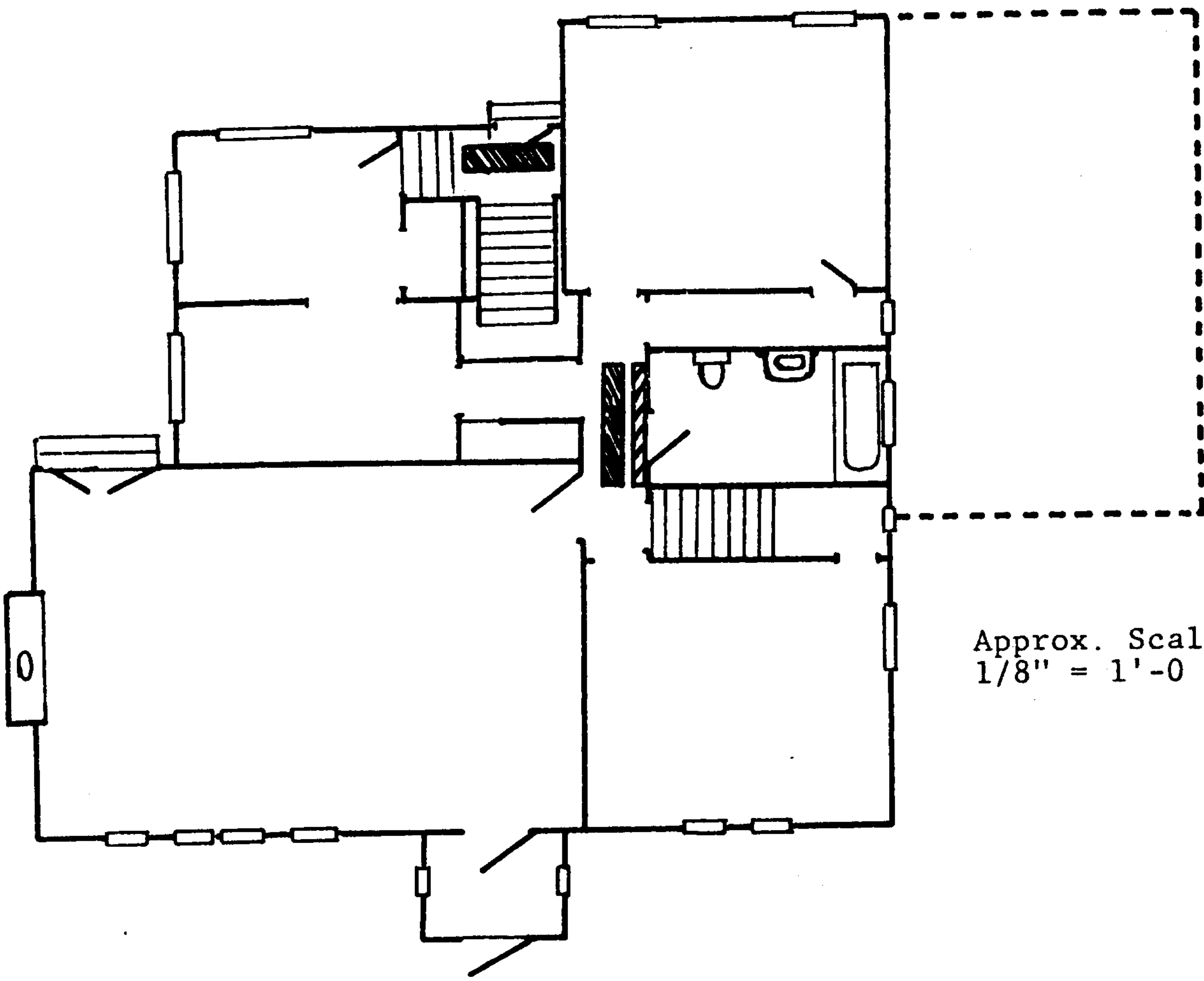
2ND FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 9 GAS SAMPLING LOCATIONS

KEY

Ceiling Mounted

Wall Mounted, 9 In. Below Ceiling



Approx. Scale:
1/8" = 1'-0

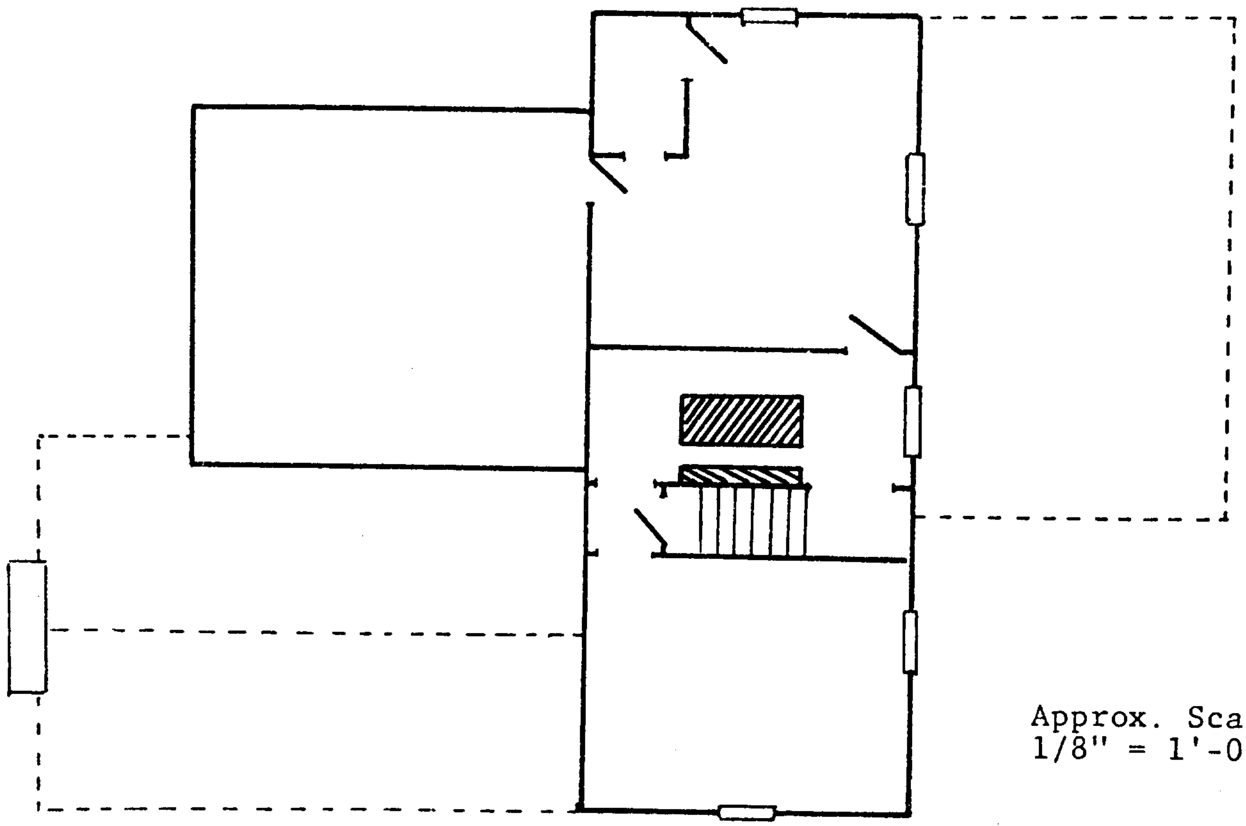
1ST FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 10 DETECTOR LOCATIONS

KEY

Ceiling Mounted

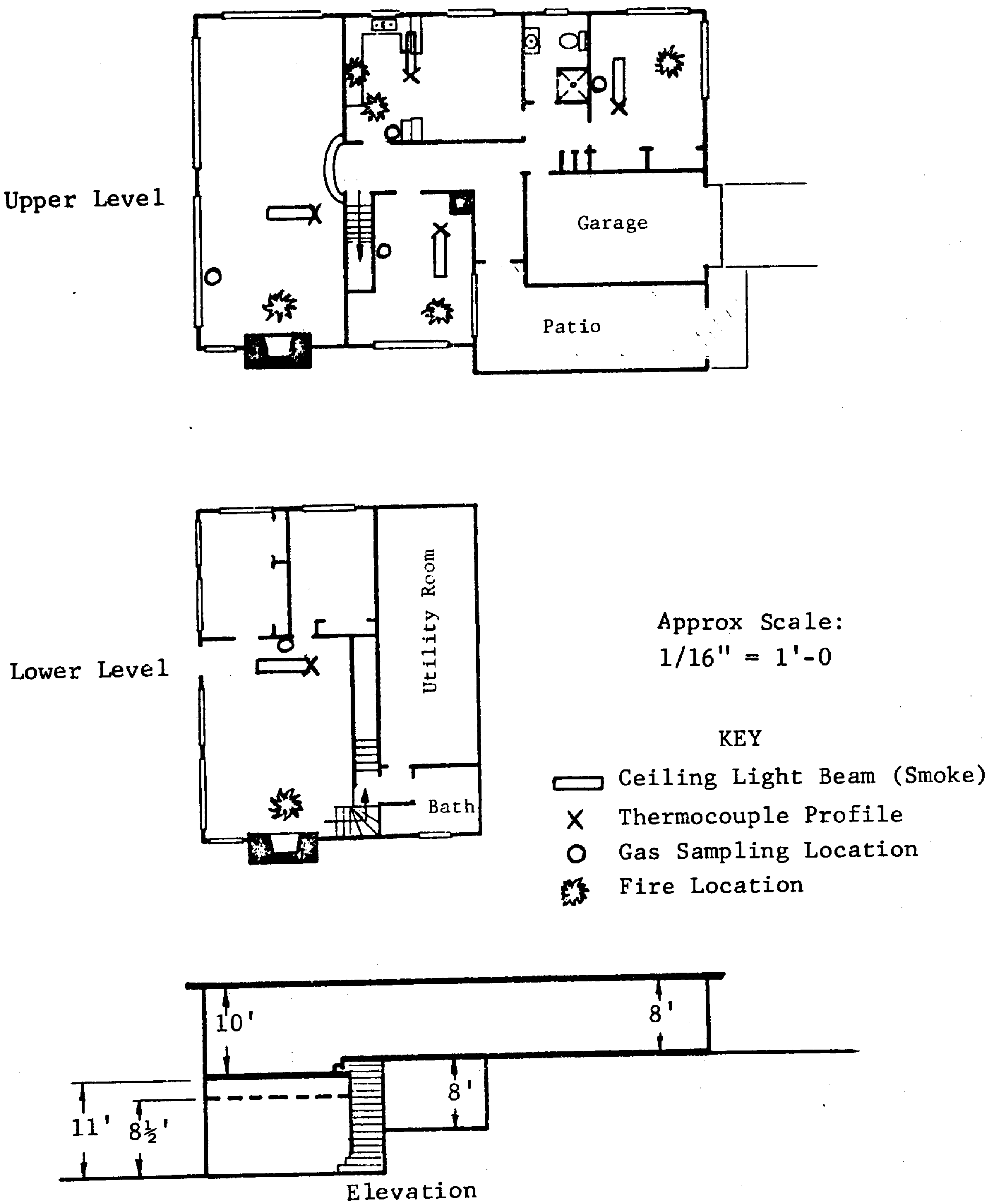
Wall Mounted, 9 In. Below Ceiling



Approx. Scale:
1/8" = 1'-0

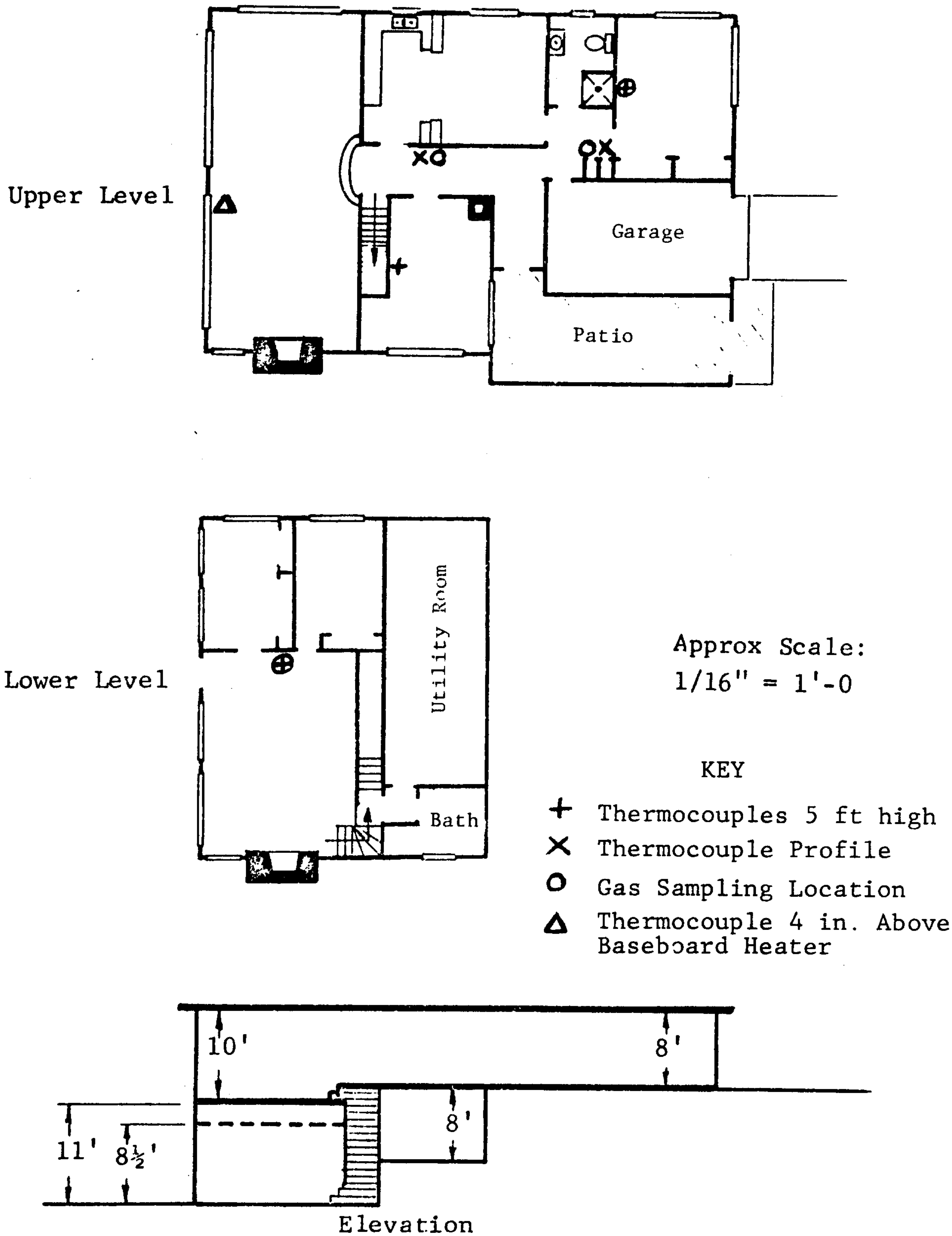
2ND FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 11 DETECTOR LOCATIONS



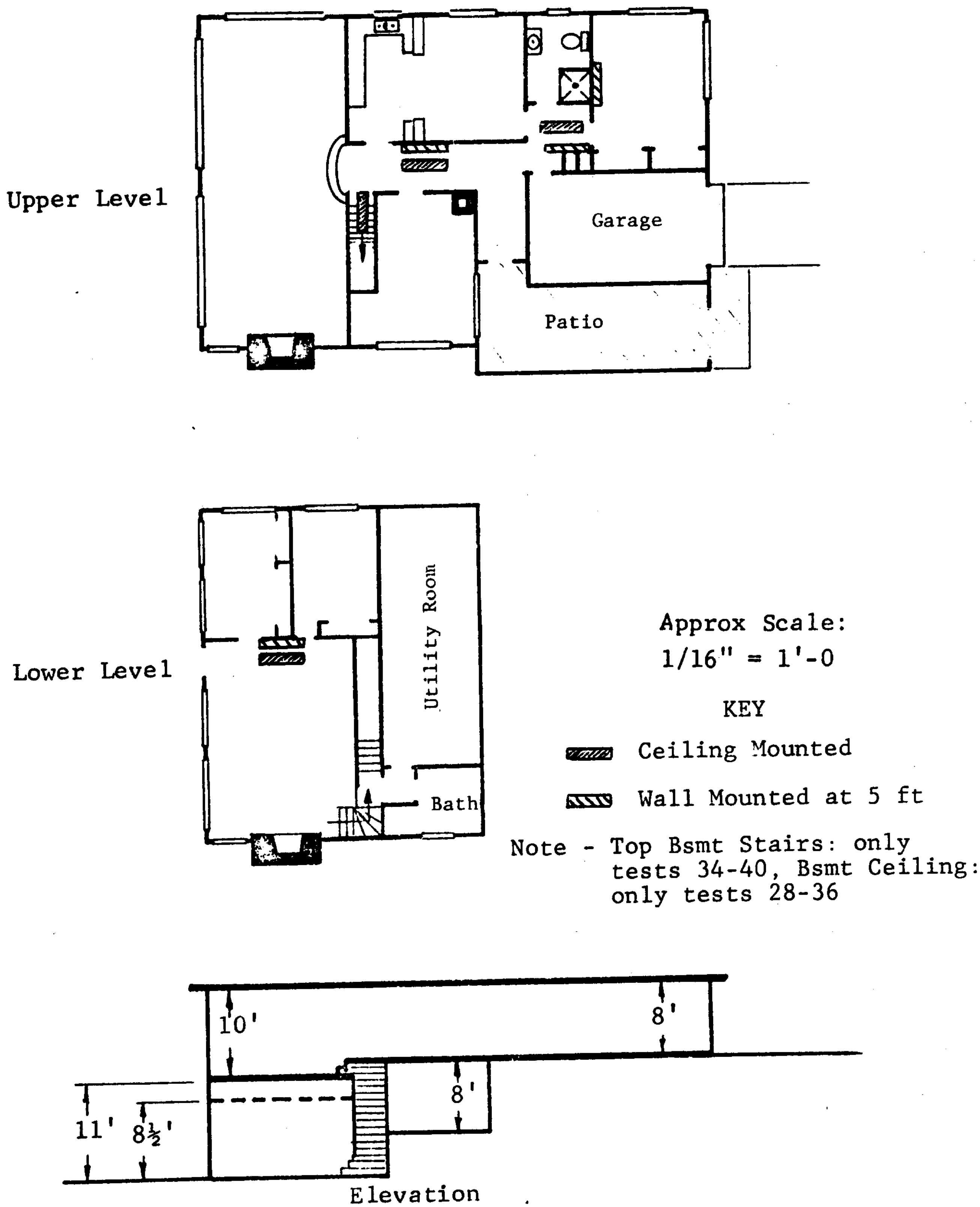
FLOOR PLAN - LAKESHORE RESIDENCE

Fig. 12 FIRE LOCATIONS AND PORTABLE IGNITION ROOM INSTRUMENTATION



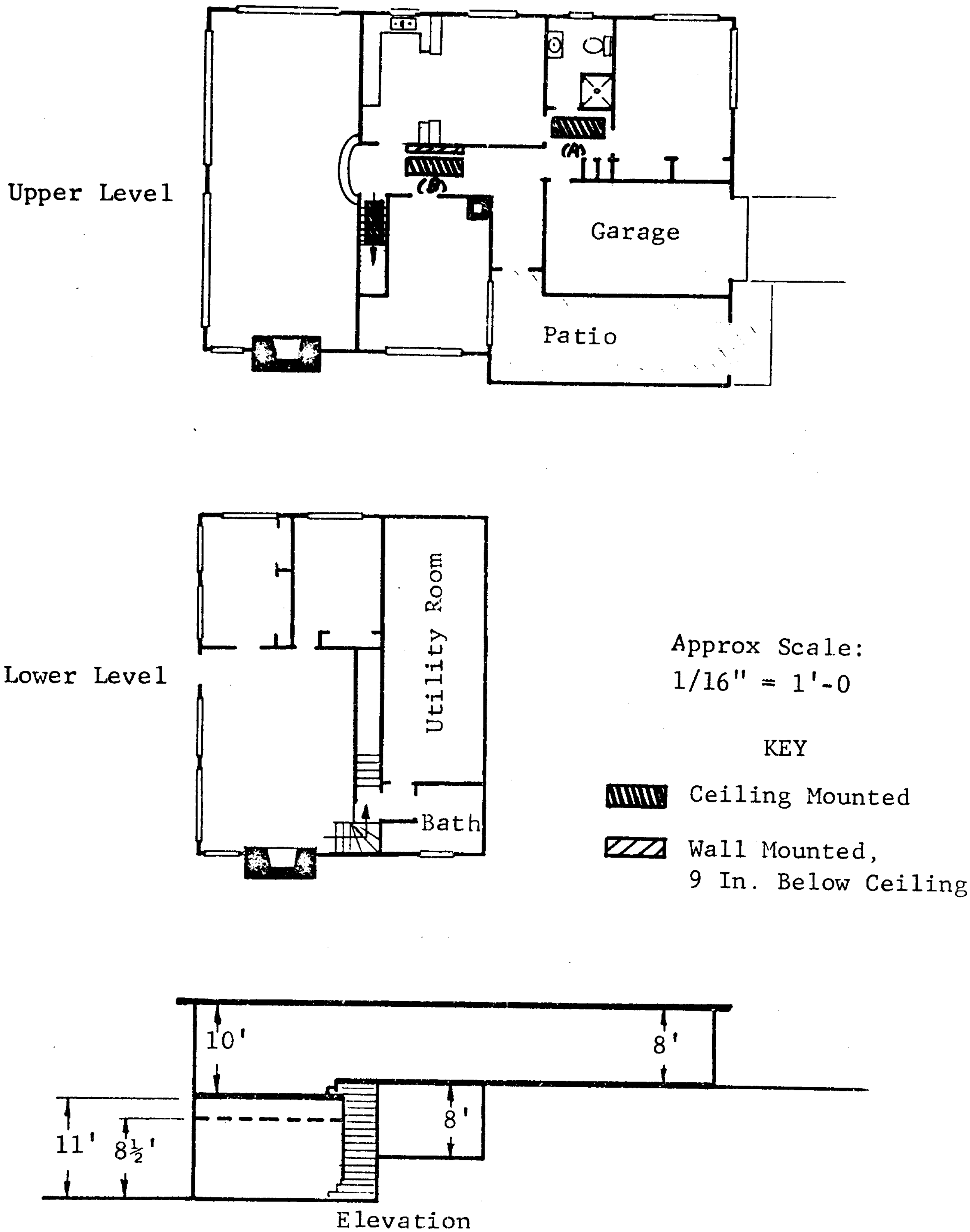
FLOOR PLAN - LAKESHORE RESIDENCE

Fig. 13 FIXED TEMPERATURE MEASUREMENTS AND GAS SAMPLING LOCATIONS



FLOOR PLAN - LAKESHORE RESIDENCE

Fig. 14 LOCATION OF LIGHT BEAMS FOR SMOKE MEASUREMENTS (EXCEPT FOR IGNITION ROOM)



FLOOR PLAN - LAKESHORE RESIDENCE

Fig. 15 DETECTOR LOCATIONS

APPENDIX G

FLOOR PLANS OF TEST BUILDINGS AND REGISTER LOCATIONS FOR WHITEHOUSE TEST SITE

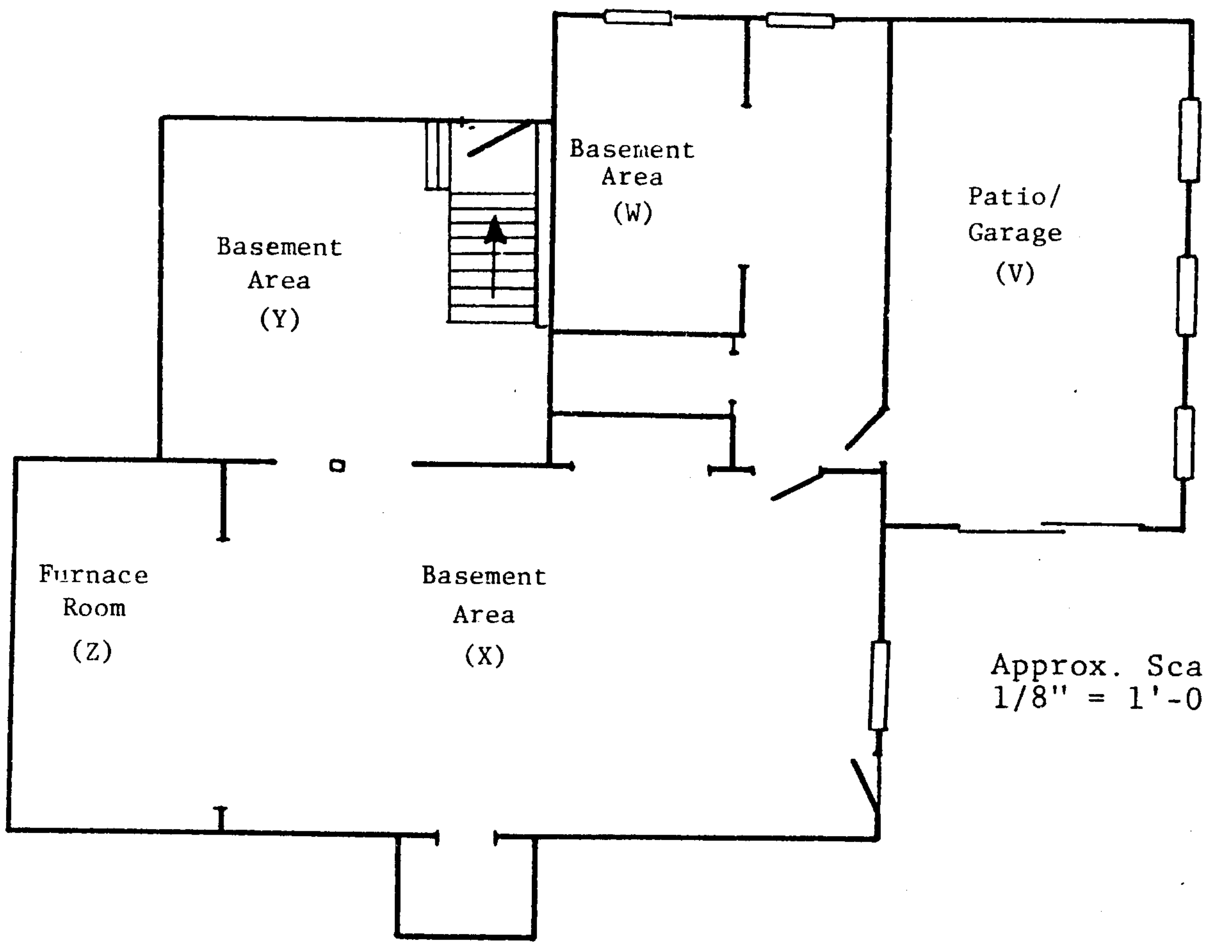
1. Furnace		Williamson Model 1164-12 (Serial No. 1113) Upright basement furnace Input: 119,000 Btu/hr (0.85 gal/hr) Output: 95,000 Btu/hr bonnet capacity
Air Conditioner		Sears Roebuck and Company Model 769816420 (Serial No. 2307238660) Capacity: 28,000 Btu/hr "A" coil Model 769814720

Duct locations are shown in Figs. 4, 5, and 6. Register velocities are Listed in Table 1.

TABLE 1
REGISTER VELOCITIES - RESIDENCE ON EAST LAKE PARK AVENUE

Register Number	Opening Dimensions Inches	Air Velocity, ft/min	
		All Bedroom Doors Open	All Bedroom Doors Closed
1	2 x 11	800	650
2R*	7-3/4 x 13-3/4	600	650
3	2-1/2 x 11	400	450
4	3 x 11	300	340
5R	3-3/4 x 13-3/4	12	35
6	2-1/2 x 11	575	550
7	5 x 11	90	90
8R	3-3/4 x 13-3/4	15.5	70
9R	5 x 11	475	425
10	1-3/4 x 11	750	725
11	3-1/2 x 11-1/2	165	120
12	5 x 10-1/2	145	165
13	4 x 10-1/2	280	280
14	5 x 8-1/2	120	130
15R	7-3/4 x 9-1/2	36	32

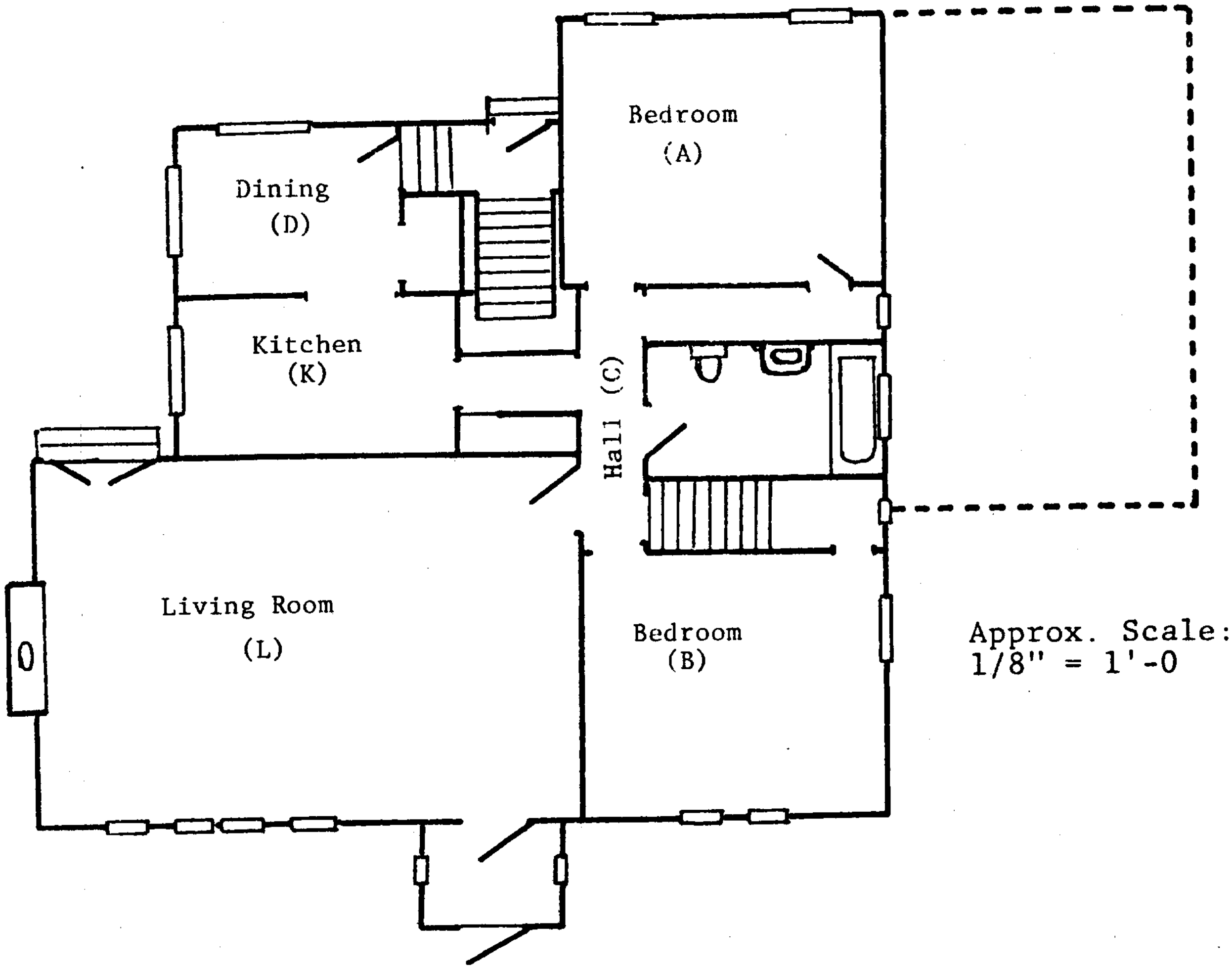
*R = Return Air.



Approx. Scale:
1/8" = 1'-0

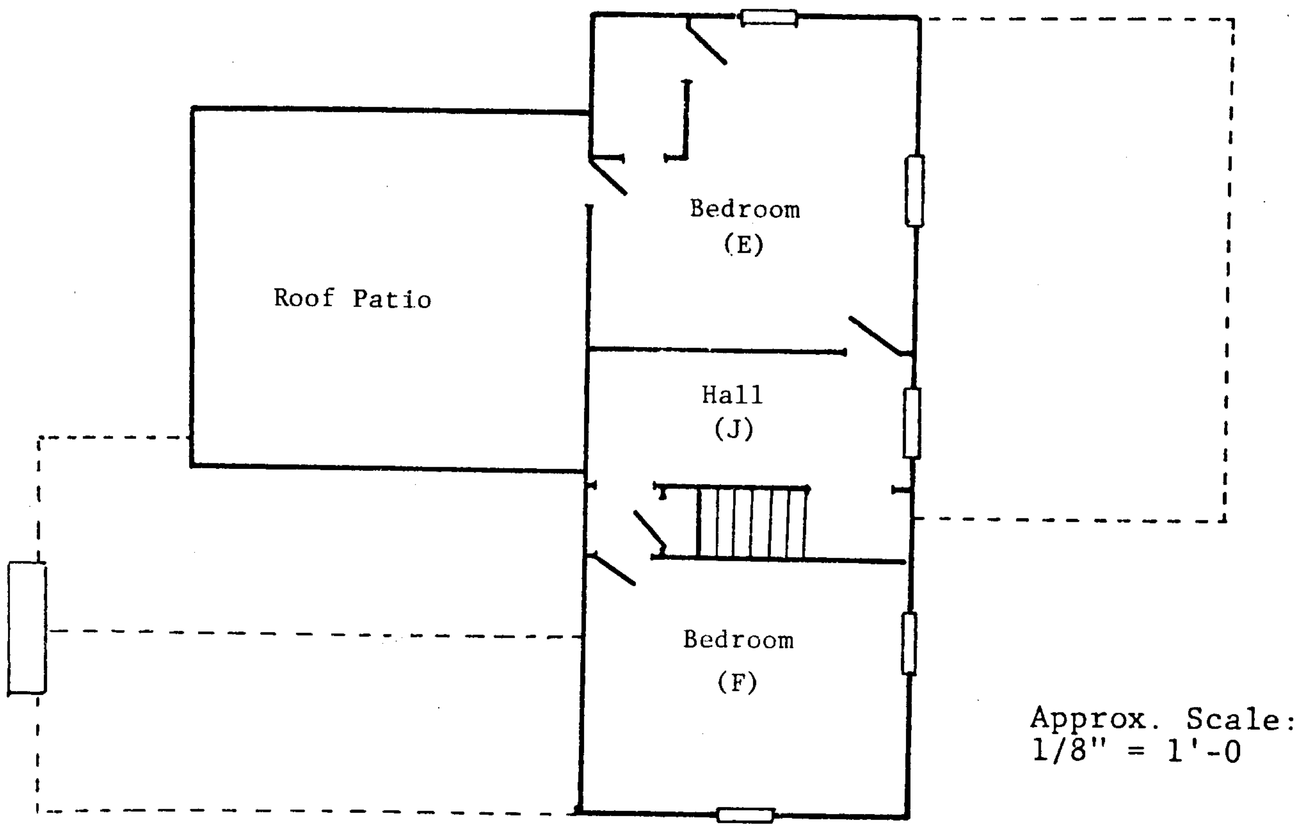
BASEMENT FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 1 ROOM IDENTIFICATION



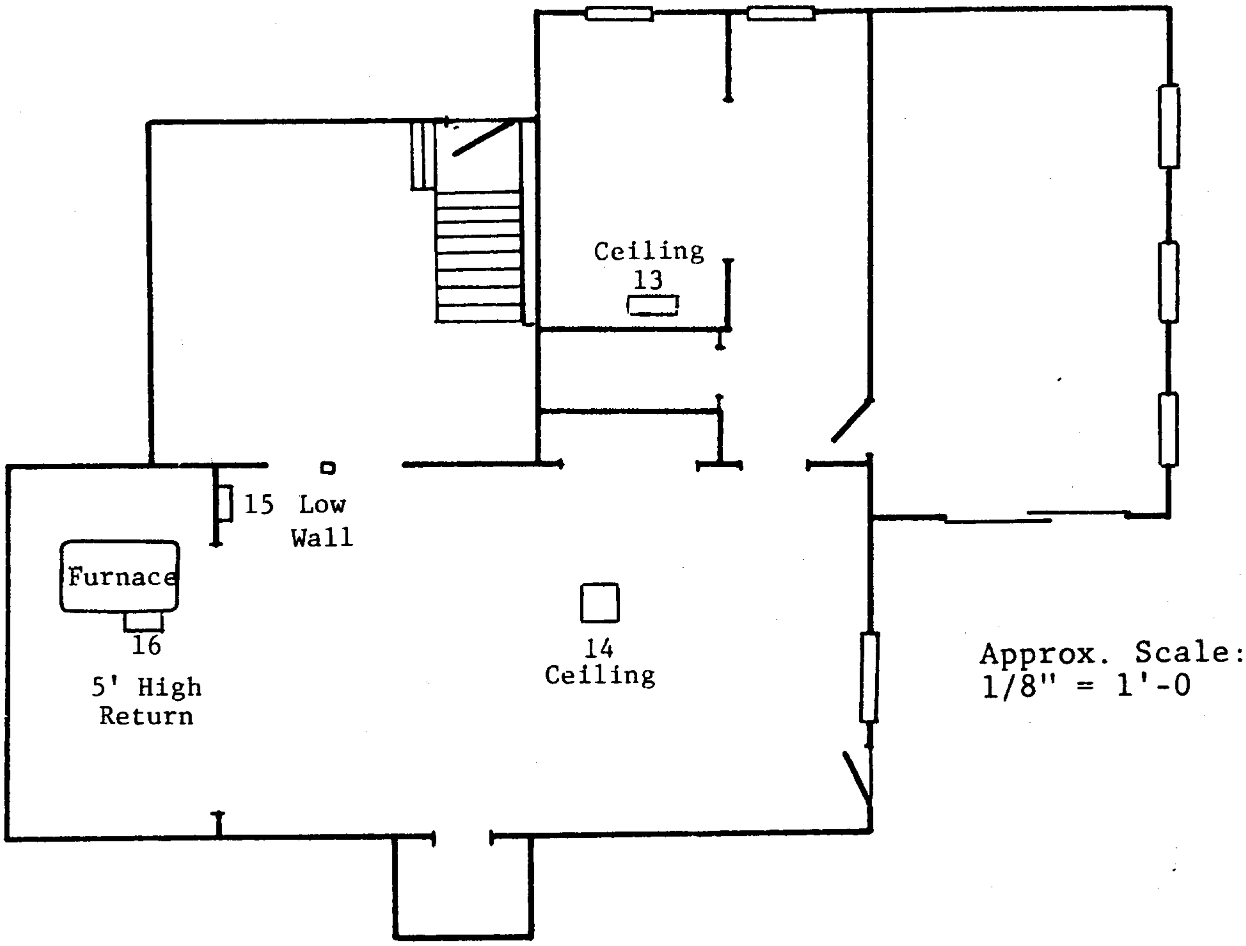
1ST FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 2 ROOM IDENTIFICATION



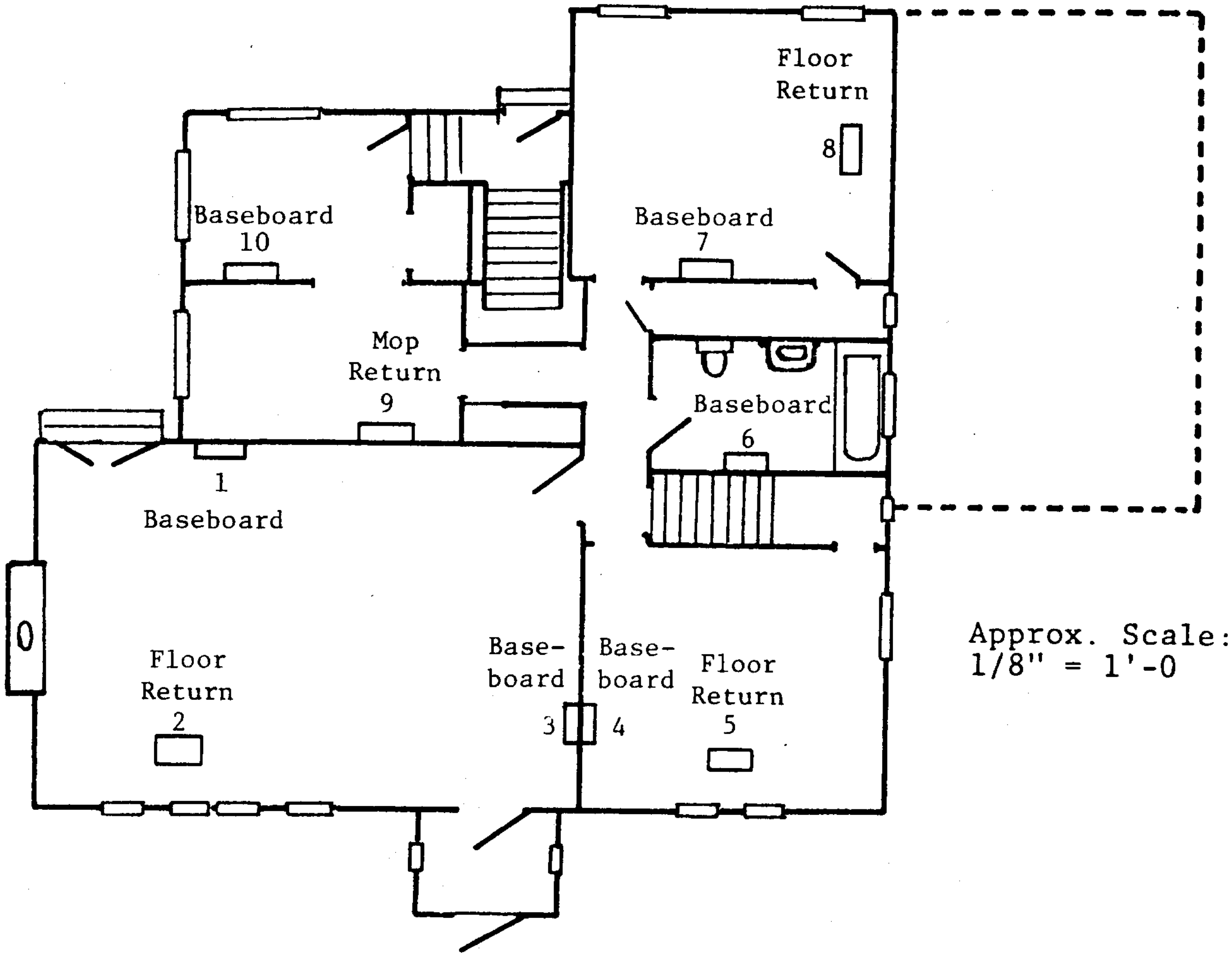
2ND FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 3 ROOM IDENTIFICATION



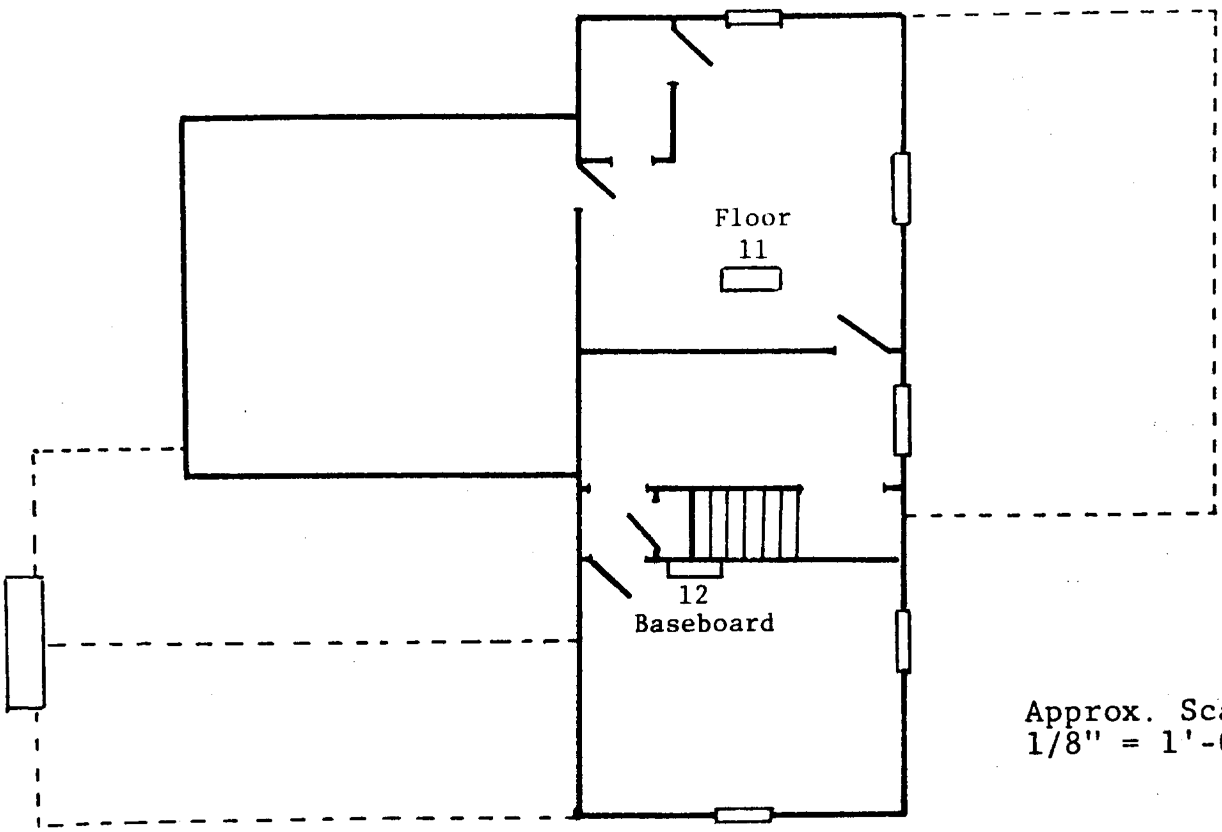
BASEMENT FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 4 REGISTER LOCATIONS



1ST FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 5 REGISTER LOCATIONS

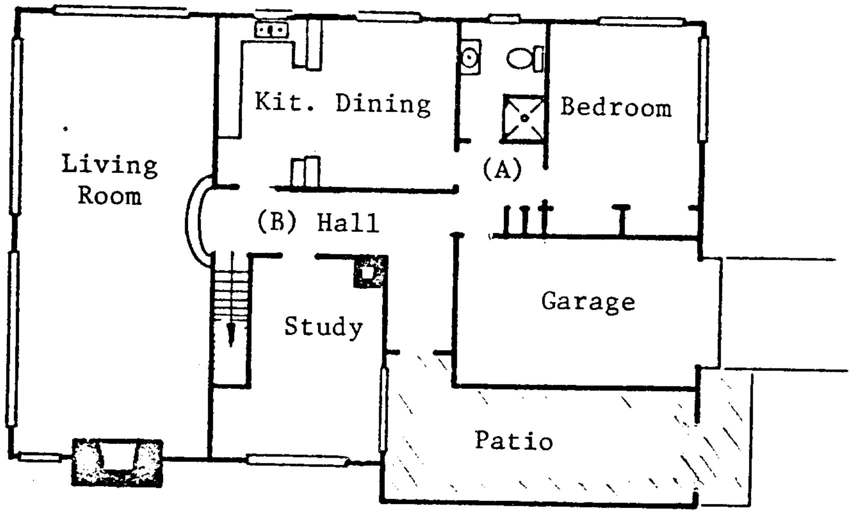


Approx. Scale:
1/8" = 1'-0

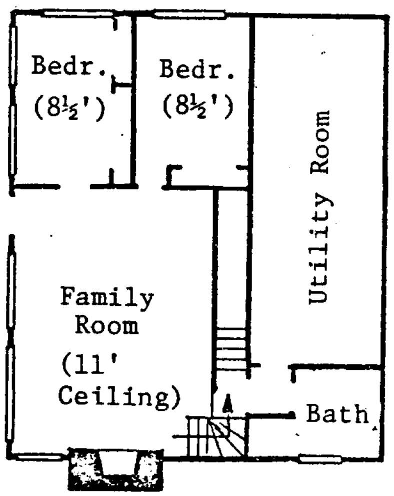
2ND FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 6 REGISTER LOCATIONS

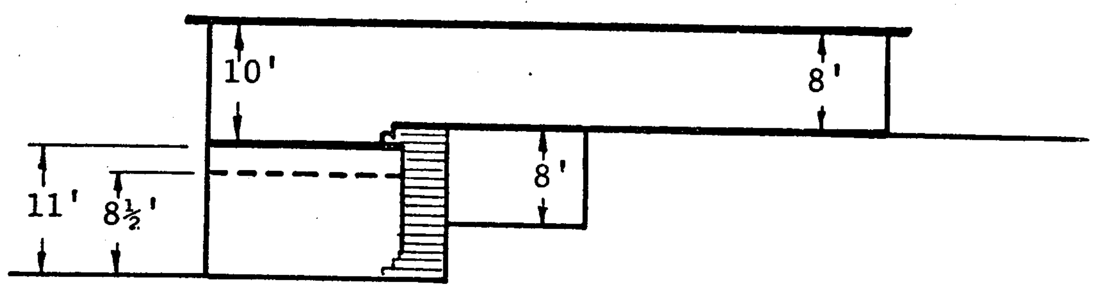
Upper Level



Lower Level



Approx Scale:
1/16" = 1'-0



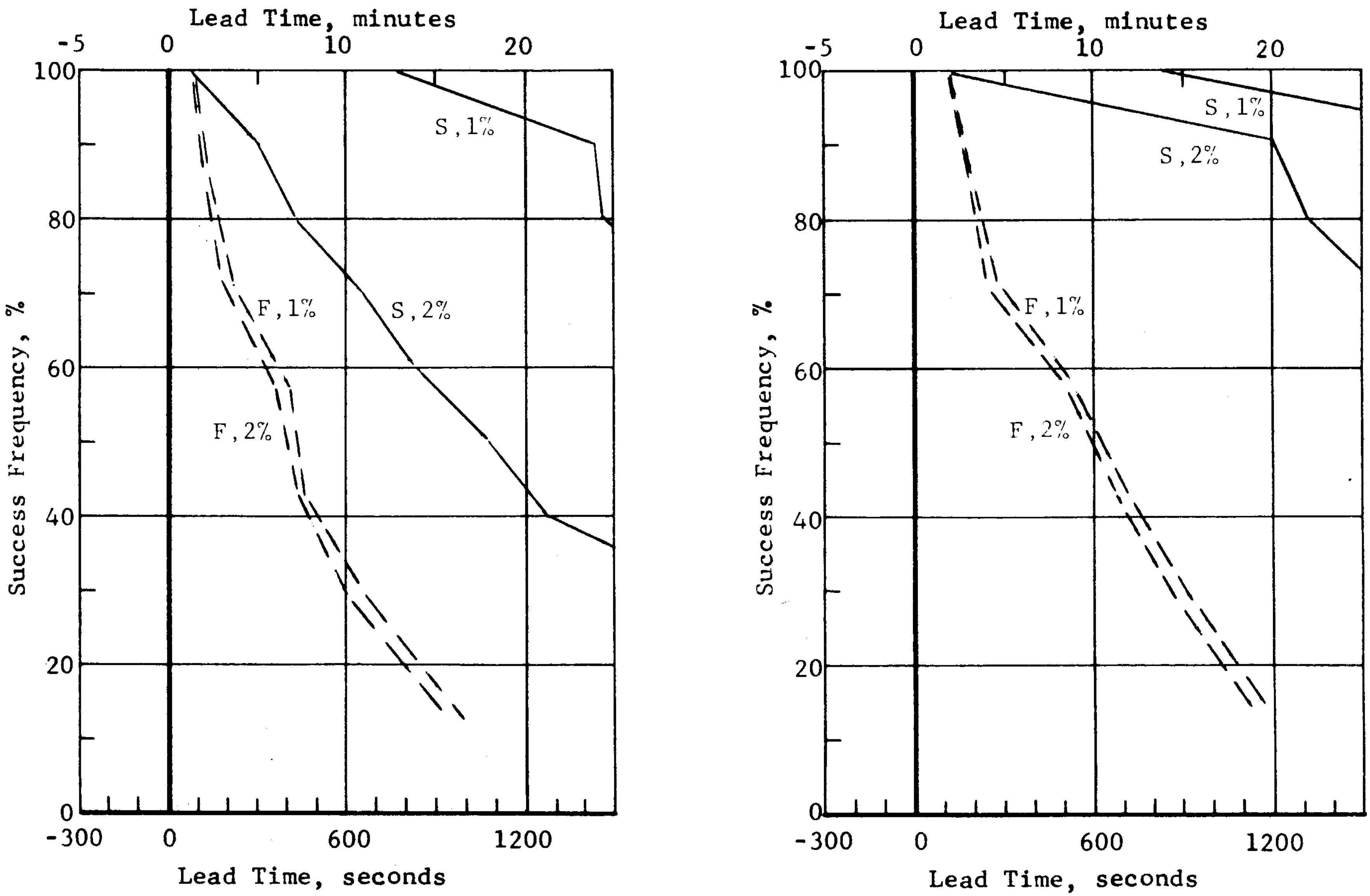
Elevation

FLOOR PLAN - LAKESHORE RESIDENCE

Fig. 7 ROOM IDENTIFICATION

APPENDIX H

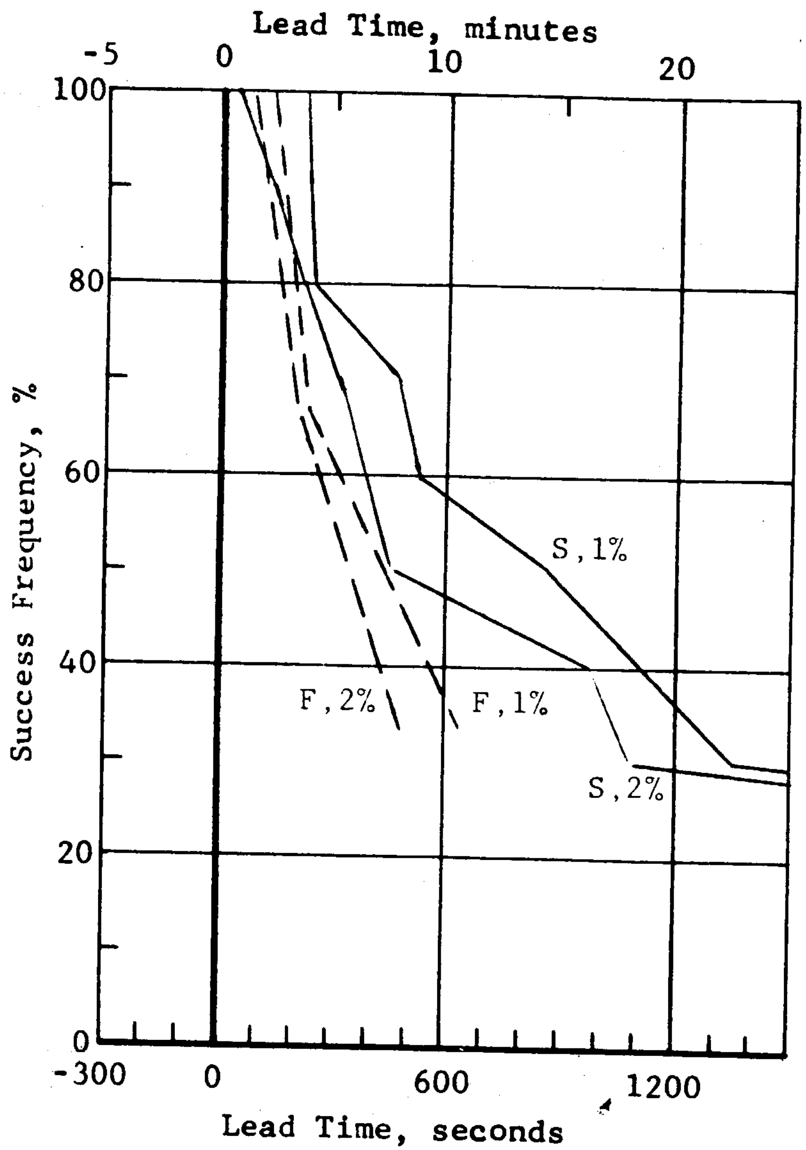
ESCAPE POTENTIAL CURVES



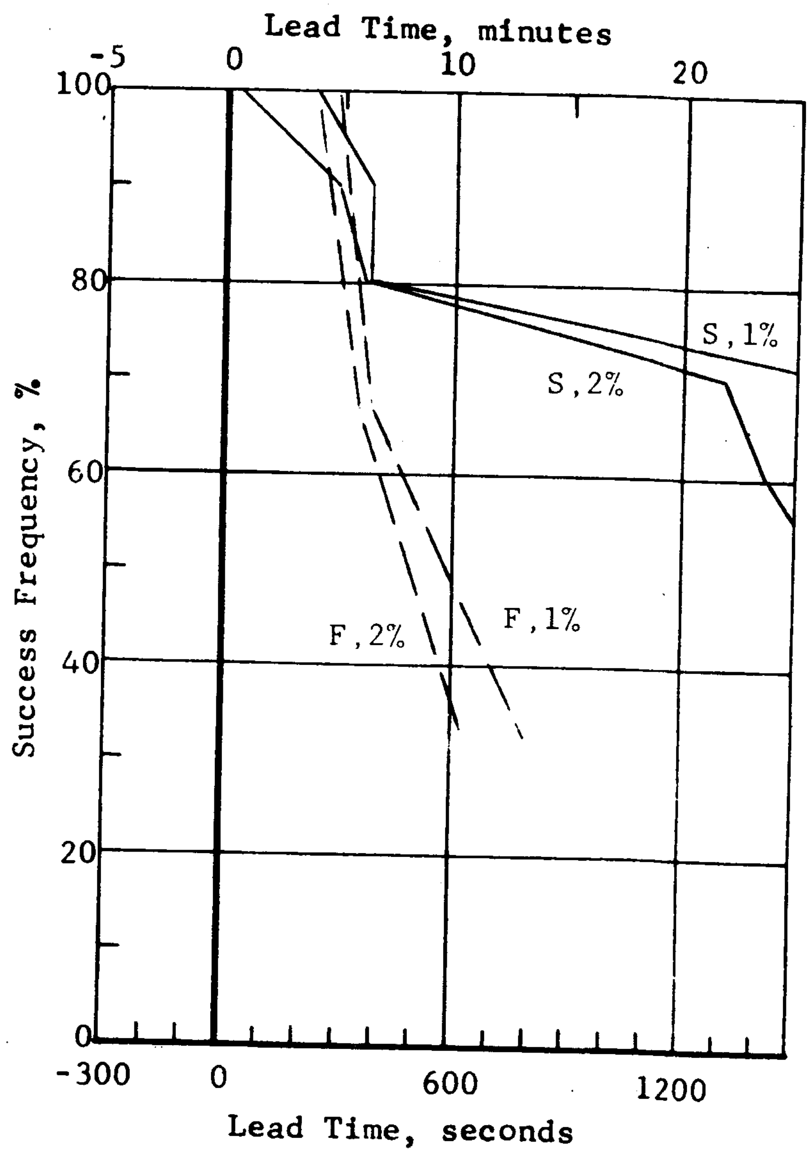
Escape Criteria: OD/ft=0.03

Escape Criteria: OD/ft=0.07

Fig. 1 THEORETICAL ABILITY TO SENSE 1ST FLOOR FIRES, DETECTORS ON 1ST AND 2ND FLOOR, (J.R. WHITEHOUSE RESIDENCE)

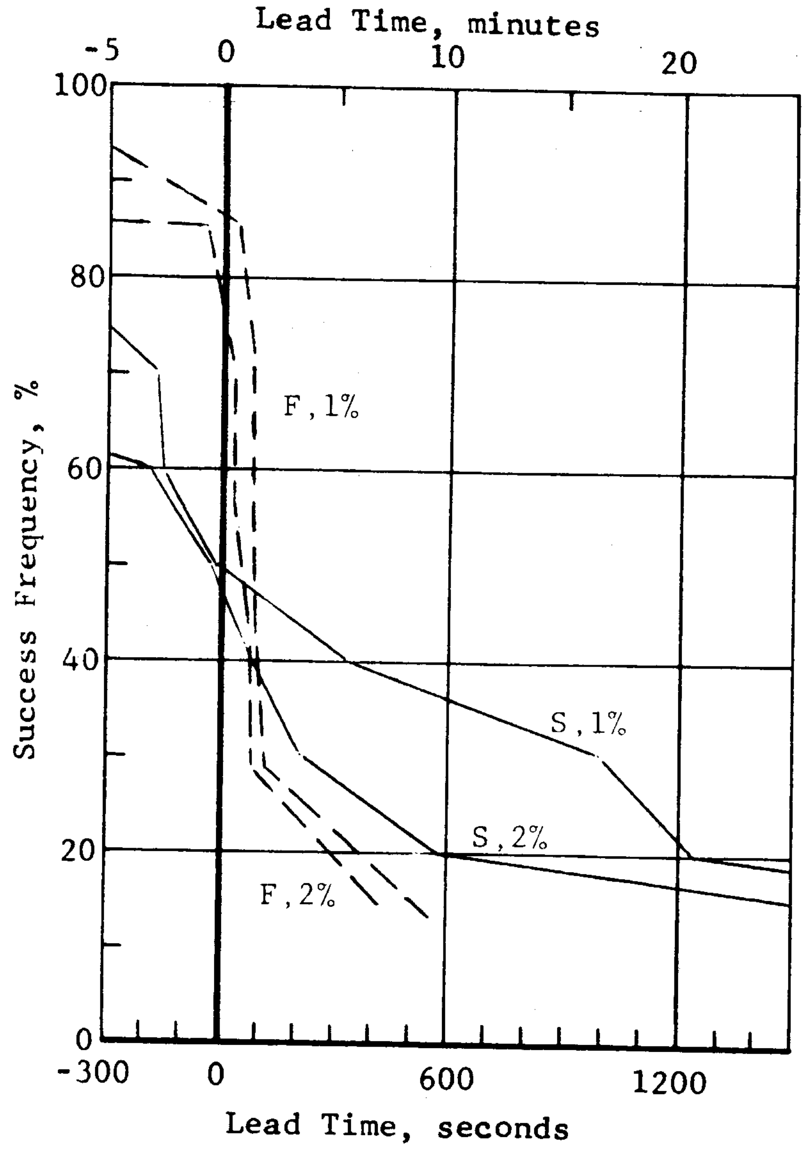


Escape Criteria: OD/ft=0.03

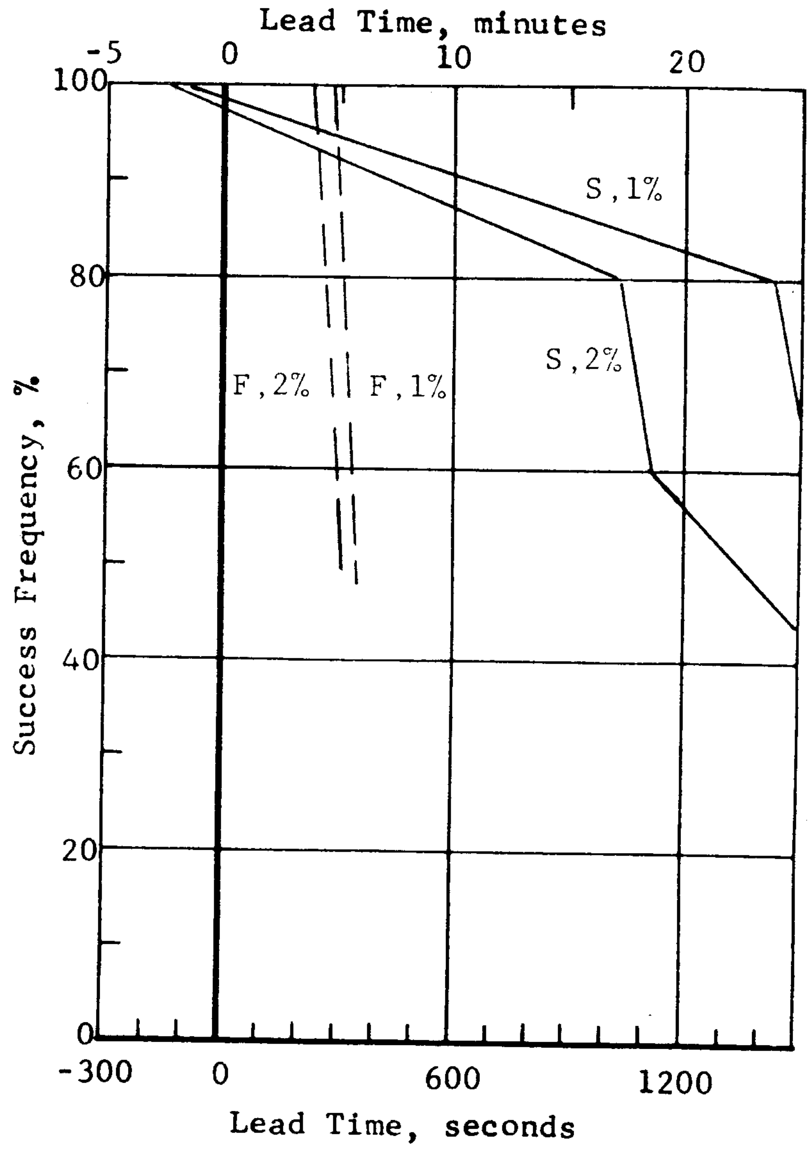


Escape Criteria: OD/ft=0.07

Fig. 2 THEORETICAL ABILITY TO SENSE ALL FIRES, DETECTORS AT EACH END OF HALL, TOP OF BASEMENT STAIRS (LAKESHORE RESIDENCE)

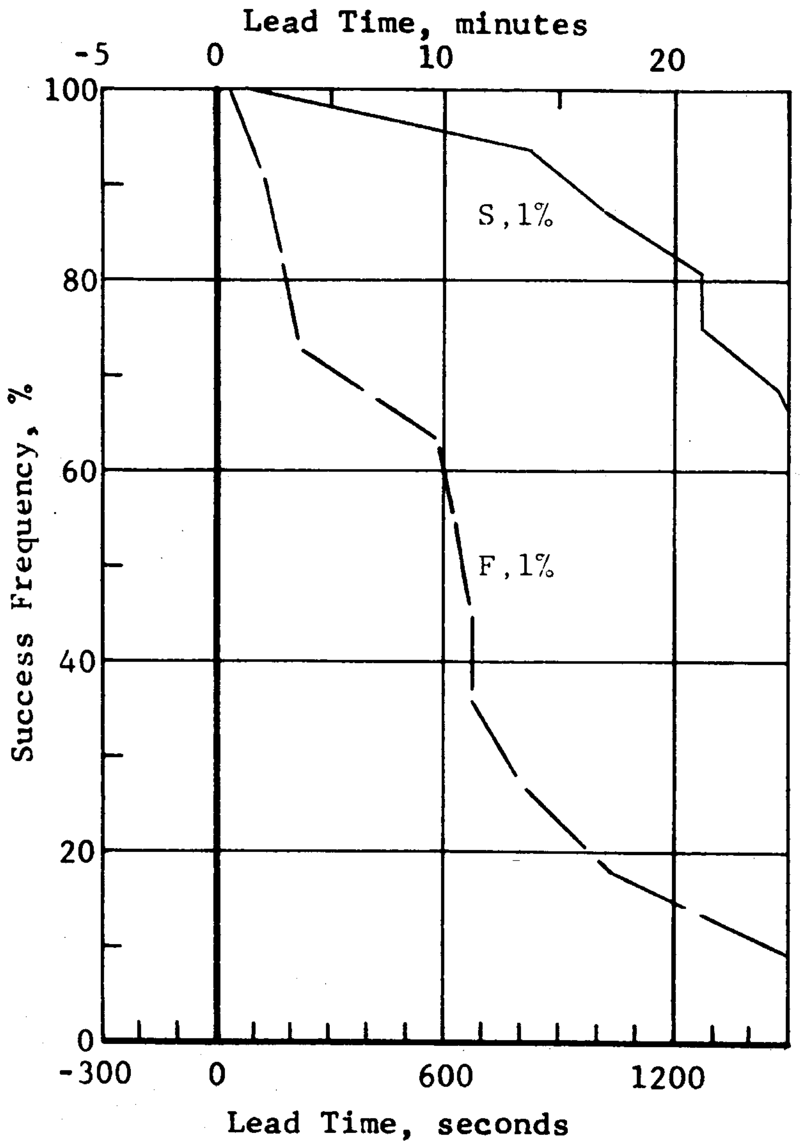


Detectors on 2nd Story
(J. R. Whitehouse Residence)

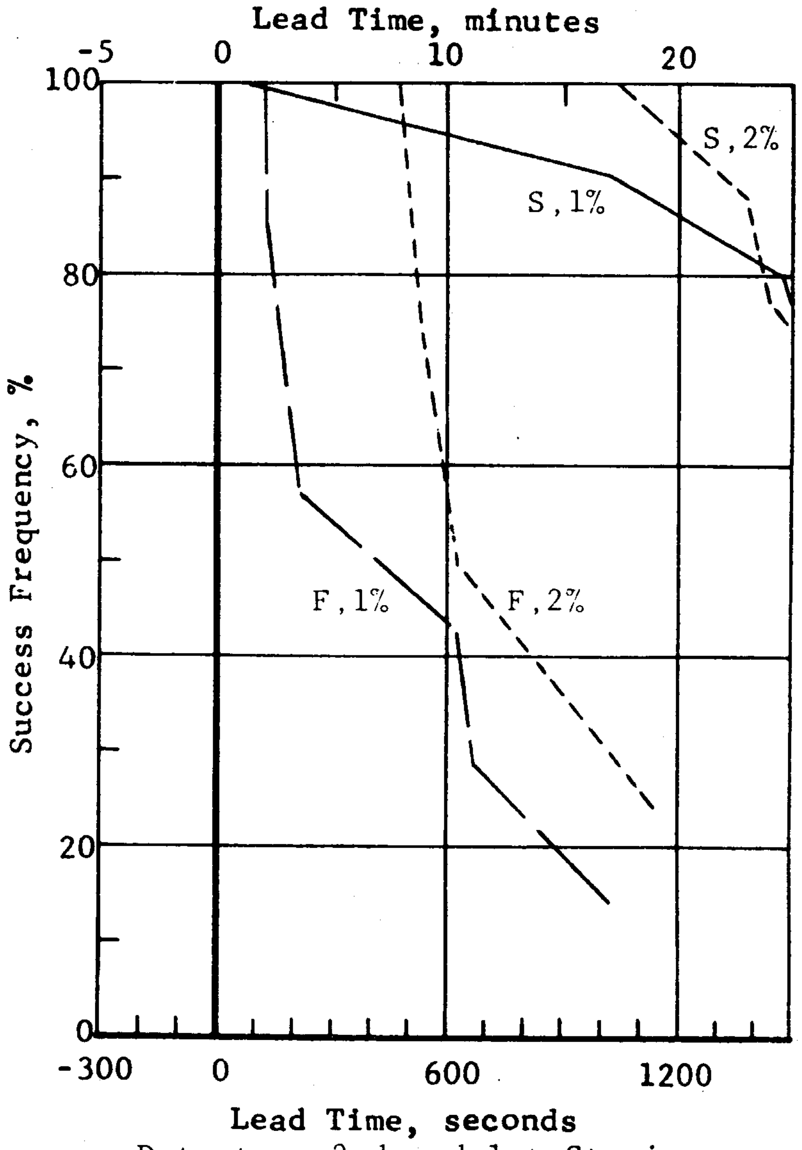


Detectors at Hall "A"
(Lakeshore Residence)

Fig. 3 THEORETICAL ABILITY TO SENSE 1ST STORY FIRES,
ESCAPE CRITERIA: 0.07 OD/FT



Detectors 2nd, 1st and Top Bsmt. Stairs
Fires on 1st and in Bsmt.



Detectors 2nd and 1st Stories
Fires on 1st Story

Fig. 4 ABILITY OF DETECTOR "A" TO SENSE FIRES
(J.R. WHITEHOUSE RESIDENCE)

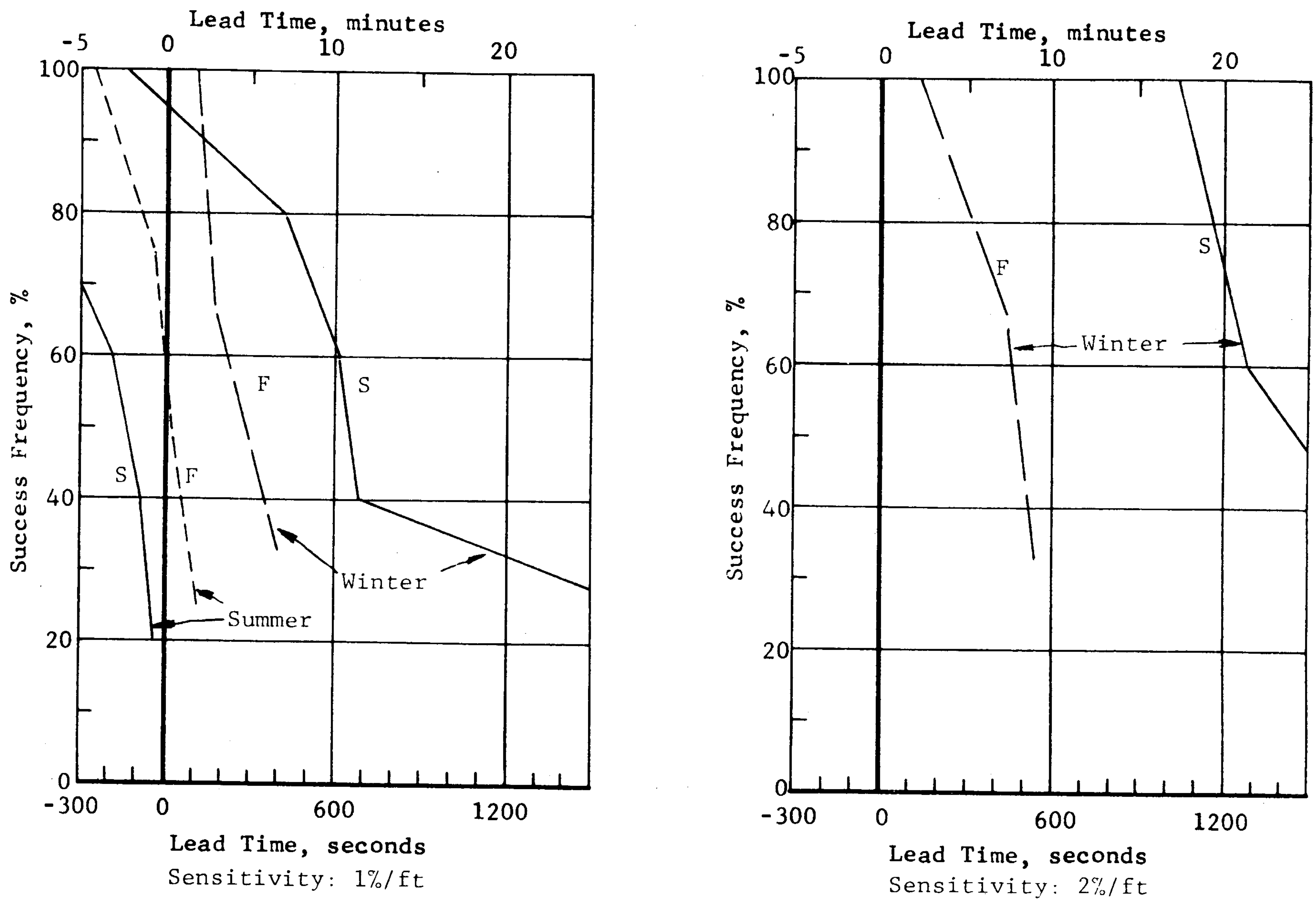
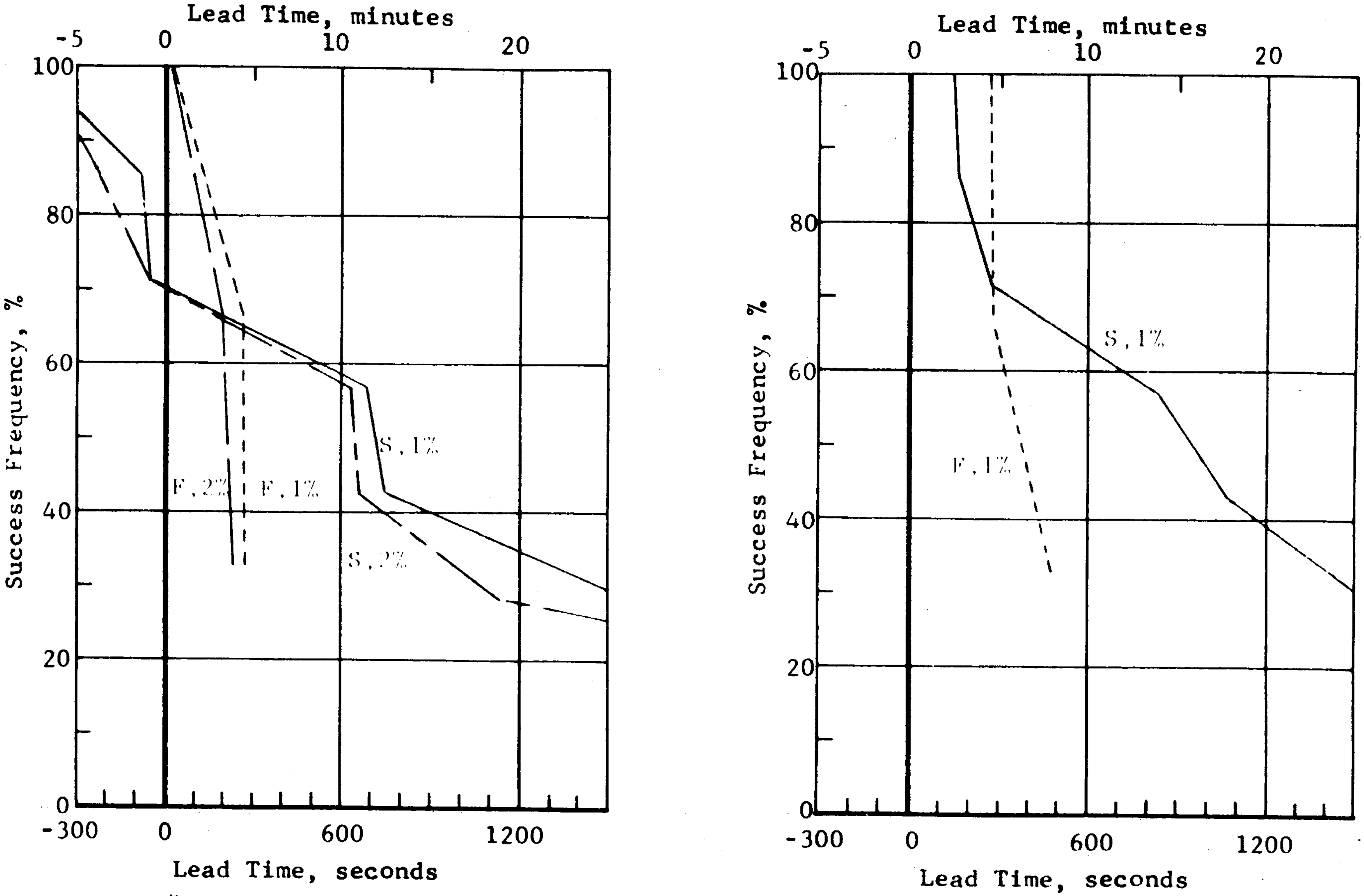


Fig. 5 ABILITY OF DETECTOR "A" ON 2ND STORY TO SENSE FIRES ON 1ST STORY (J.R. WHITEHOUSE RESIDENCE)



Detector at A Only

Detectors at A, B, Top Bsmt. Stairs

Fig. 6 ABILITY OF DETECTOR "A" TO SENSE FIRES IN BASEMENT AND 1ST STORY (LAKESHORE RESIDENCE)

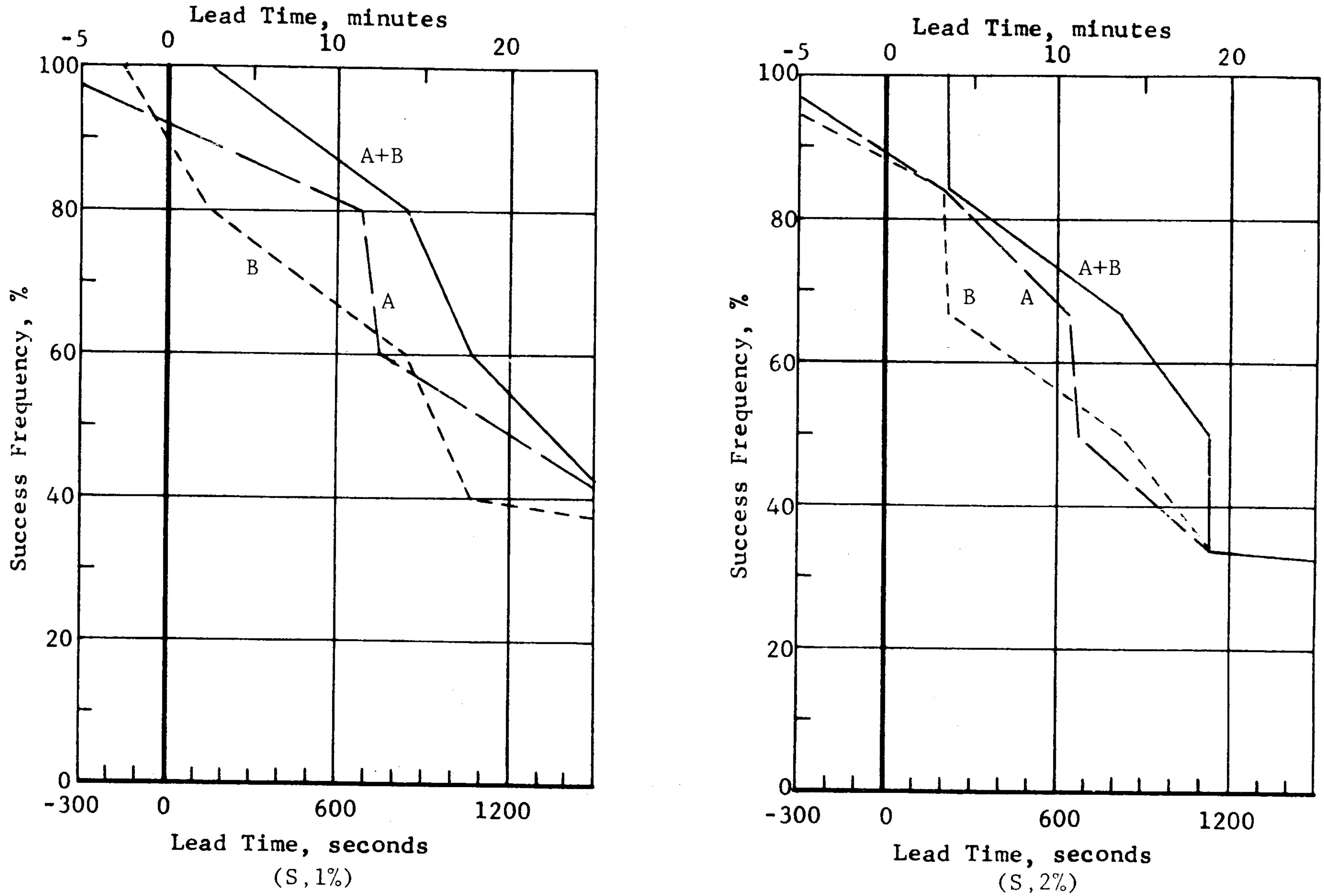
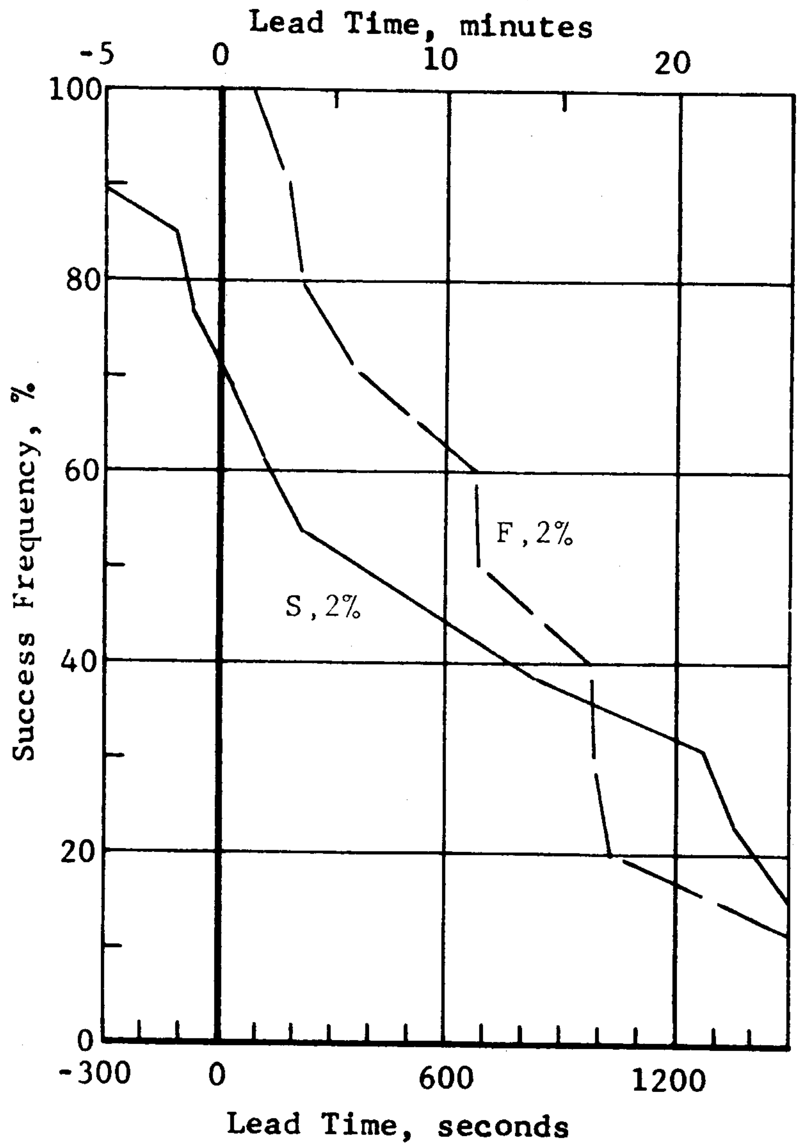
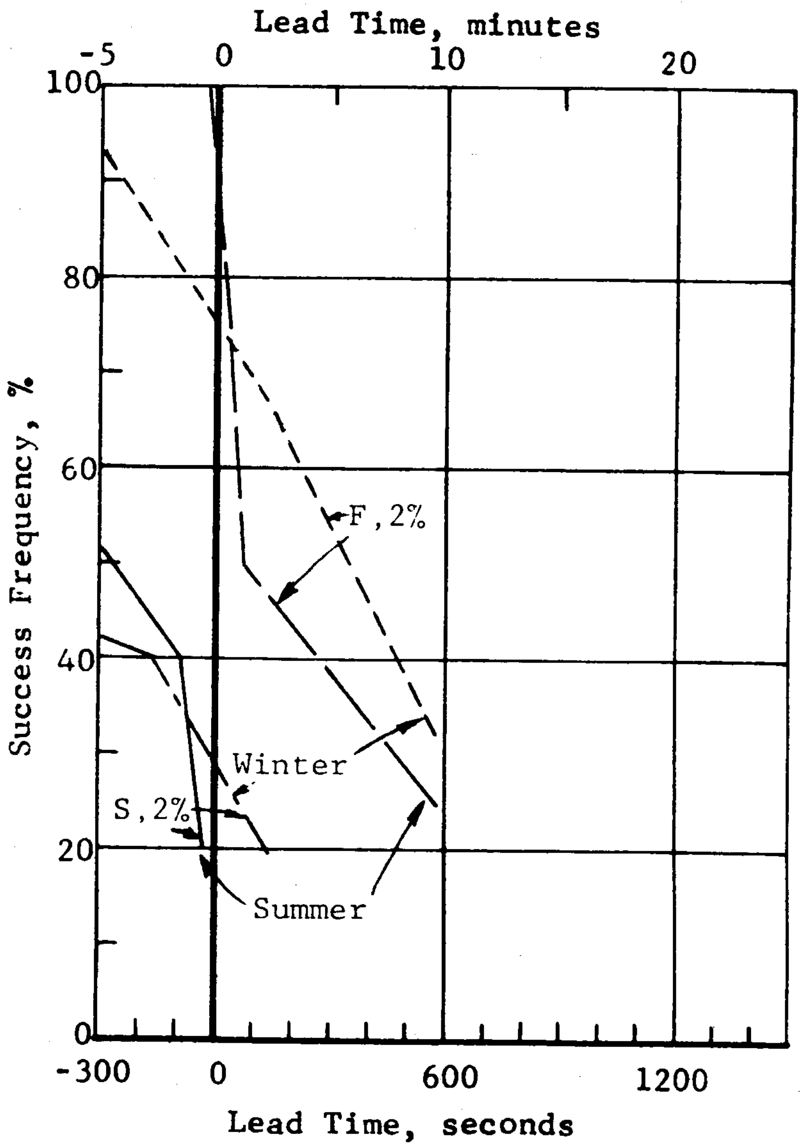


Fig. 7 EFFECT OF LOCATION ON ABILITY OF DETECTOR "A" TO SENSE 1ST STORY FIRES (LAKESHORE RESIDENCE)

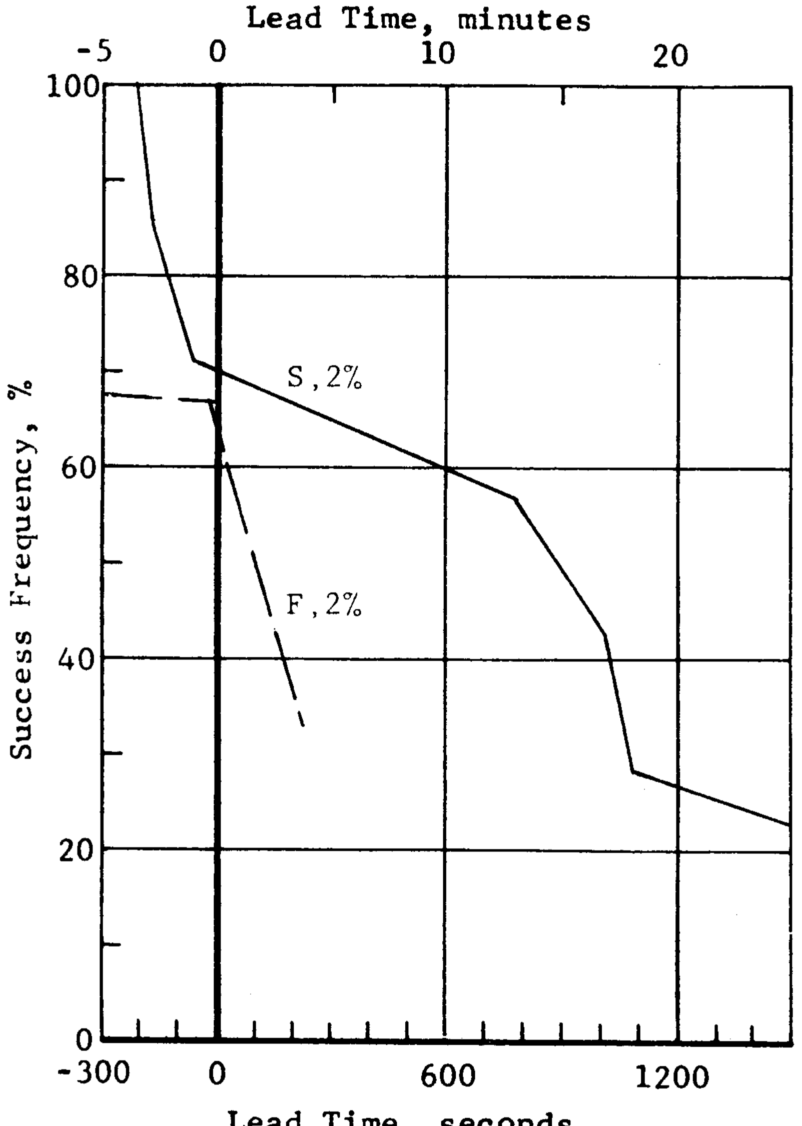


Detectors 2nd, 1st and Top Bsmt. Stairs
Fires on 1st and in Bsmt.

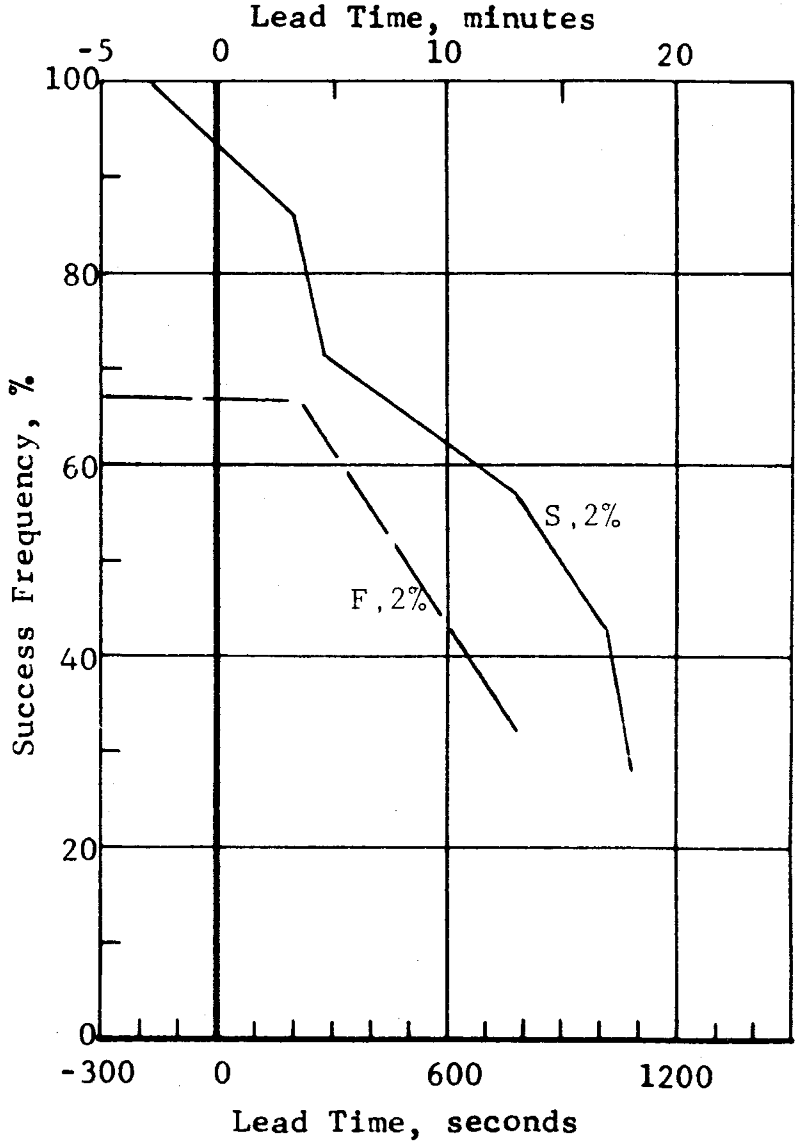


Detector on 2nd Story
Fires on 1st Story

Fig. 8 ABILITY OF DETECTOR "B" TO SENSE FIRES
(J.R. WHITEHOUSE RESIDENCE)

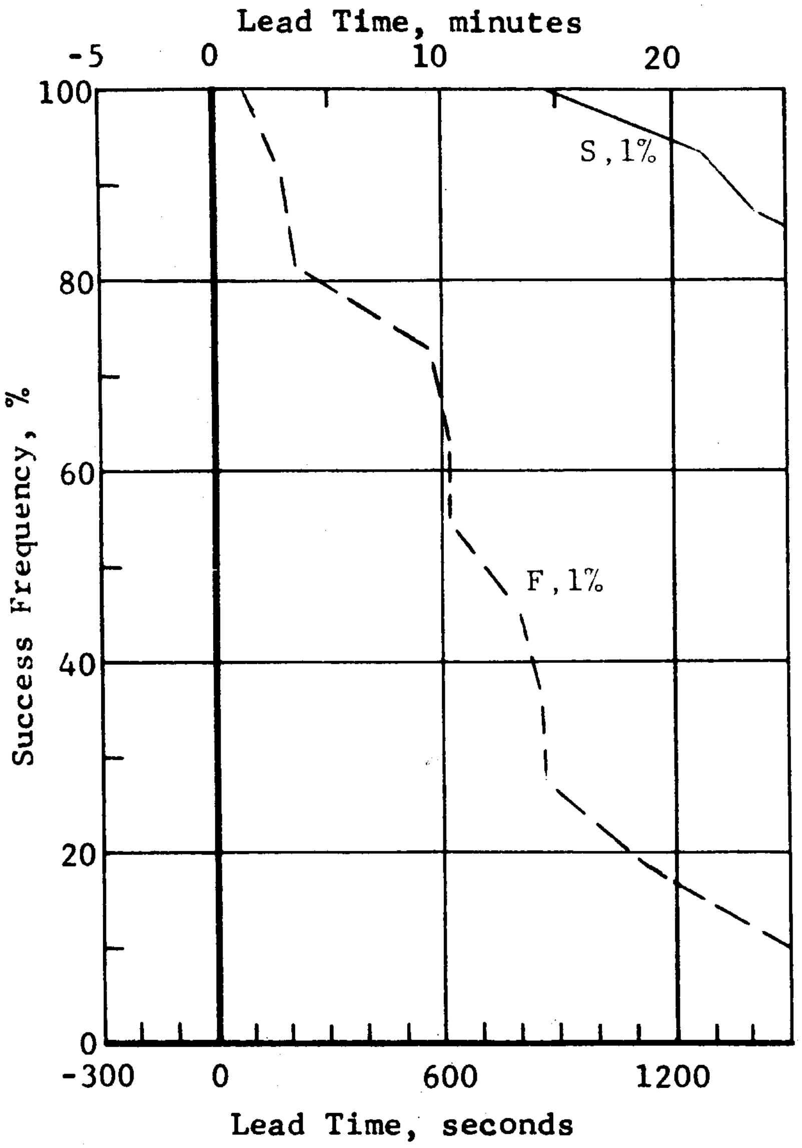


Detector at A Only

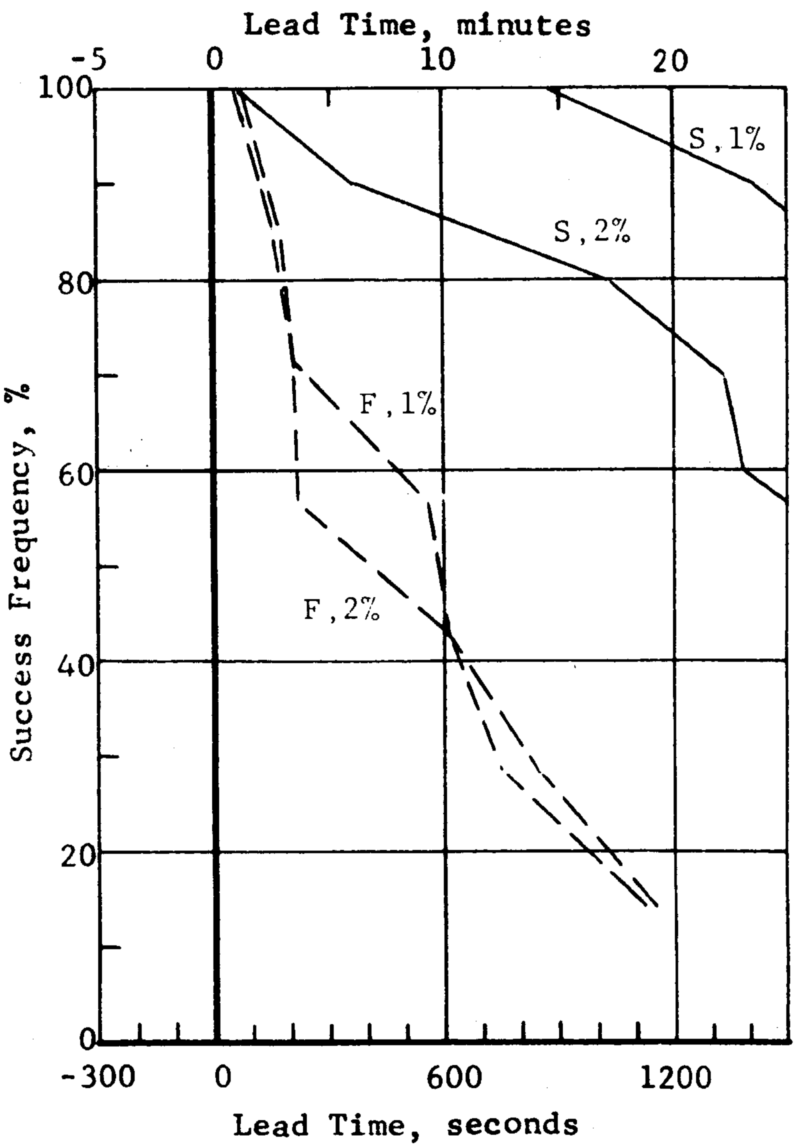


Detectors at A, B, Top Bsmt. Stairs

Fig. 9 ABILITY OF DETECTOR "B" TO SENSE FIRES IN BASEMENT AND 1ST STORY (LAKESHORE RESIDENCE) (DETECTOR AT B ALARMED ONLY ONCE IN SIX FIRES AND THEN AT -95 SECONDS)

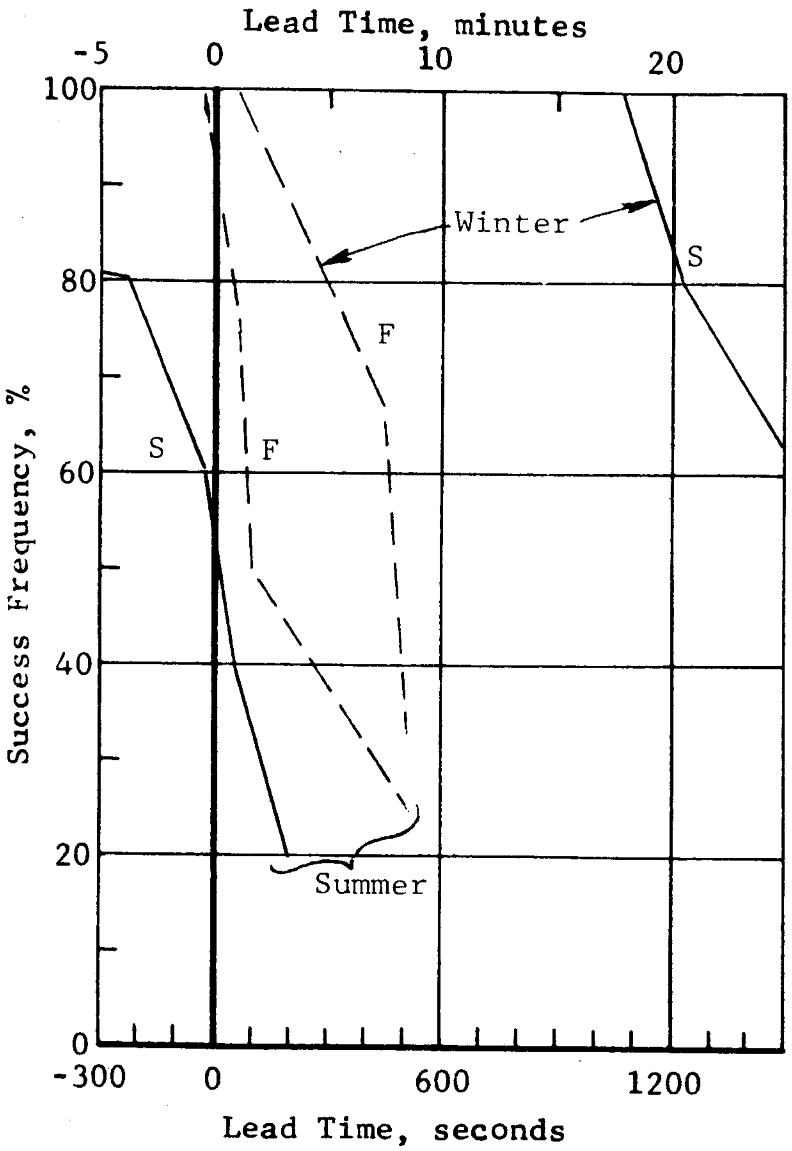


Detectors 2nd, 1st and Top Bsmt. Stairs
Fires on 1st and in Bsmt.

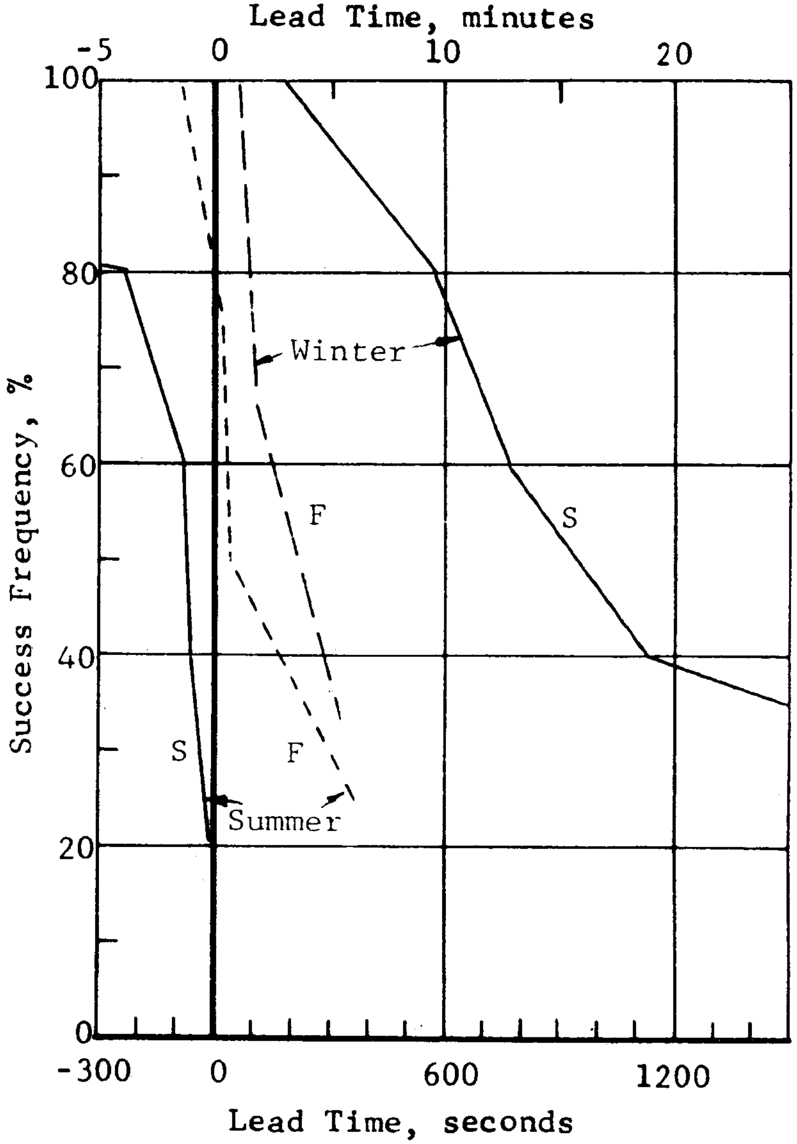


Detectors 2nd and 1st Stories
Fires on 1st Story

Fig. 10 ABILITY OF DETECTOR "E" TO SENSE FIRES
(J.R. WHITEHOUSE RESIDENCE)

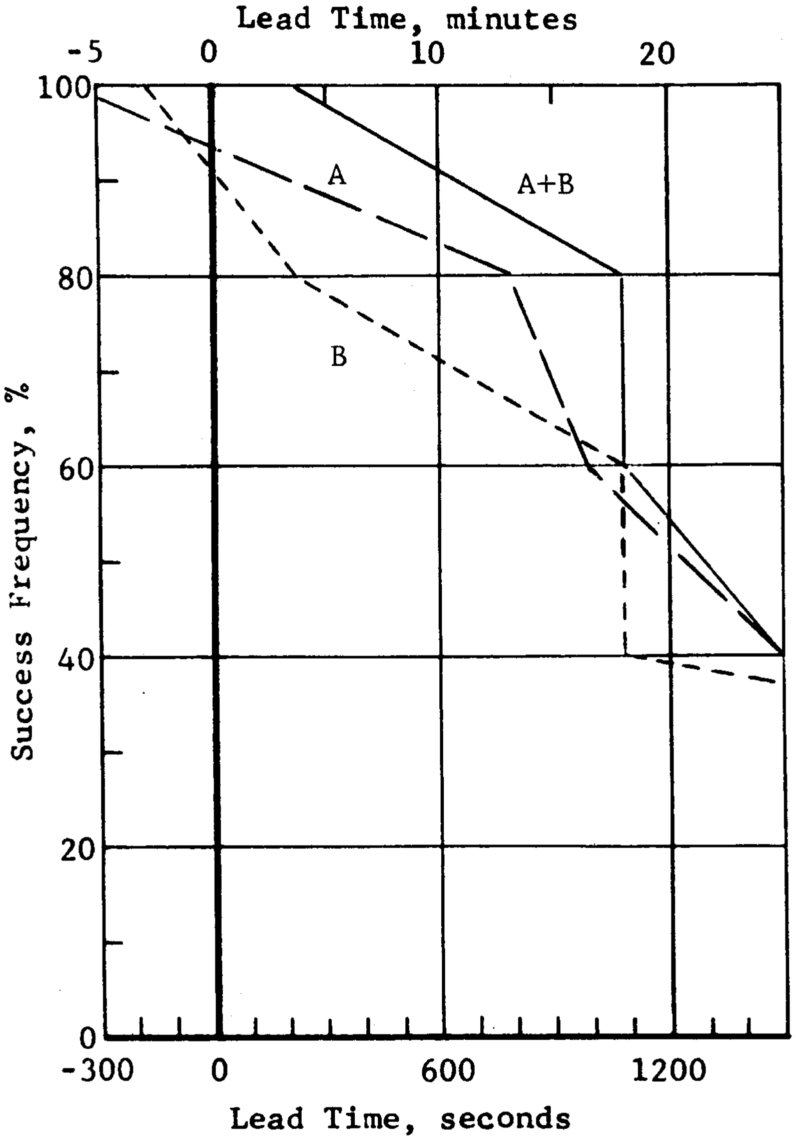


Sensitivity: 1%/ft

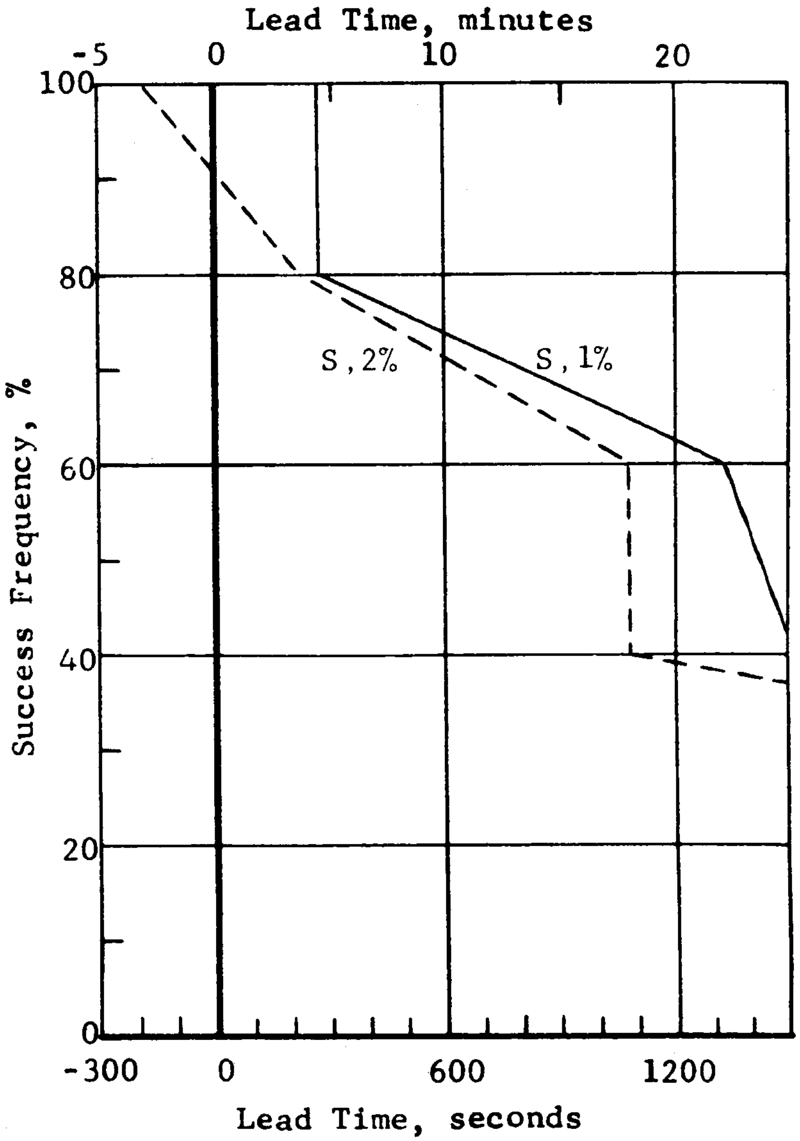


Sensitivity: 2%/ft

Fig. 11 ABILITY OF DETECTOR "E" ON 2ND STORY TO SENSE FIRES ON 1ST STORY (J.R. WHITEHOUSE RESIDENCE)

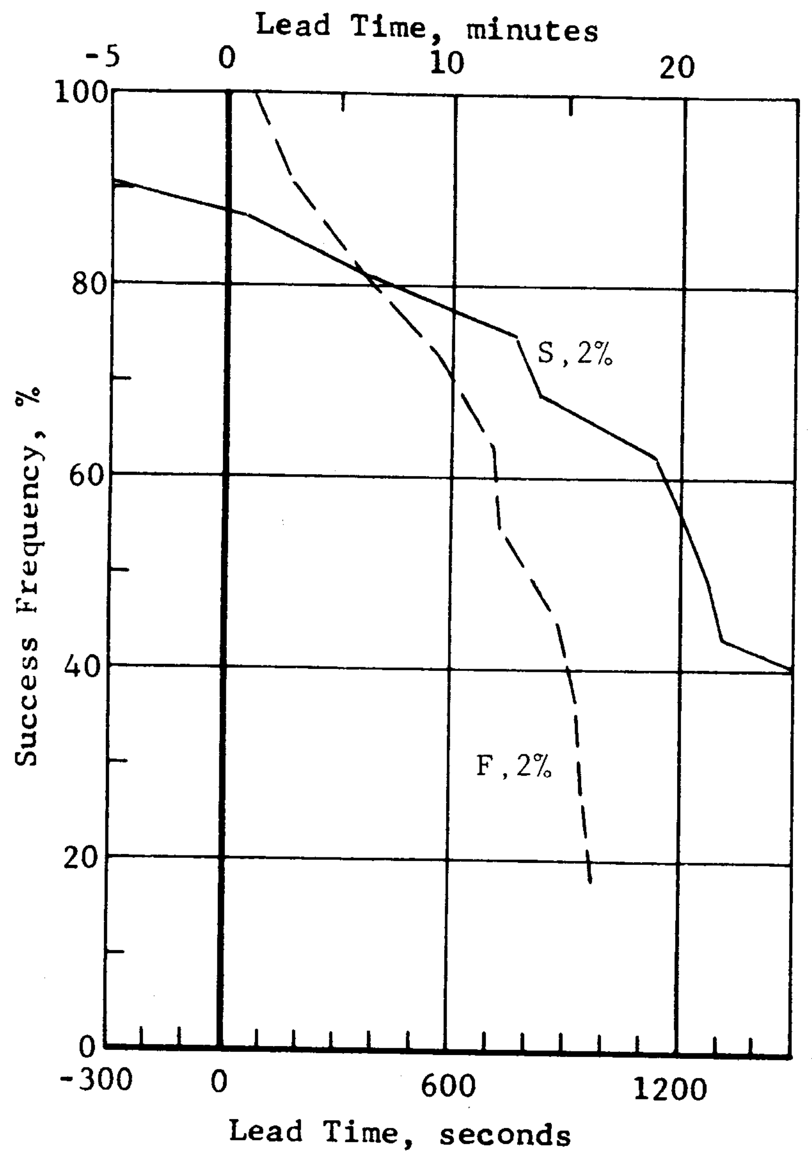


Effect of Location, S,2%

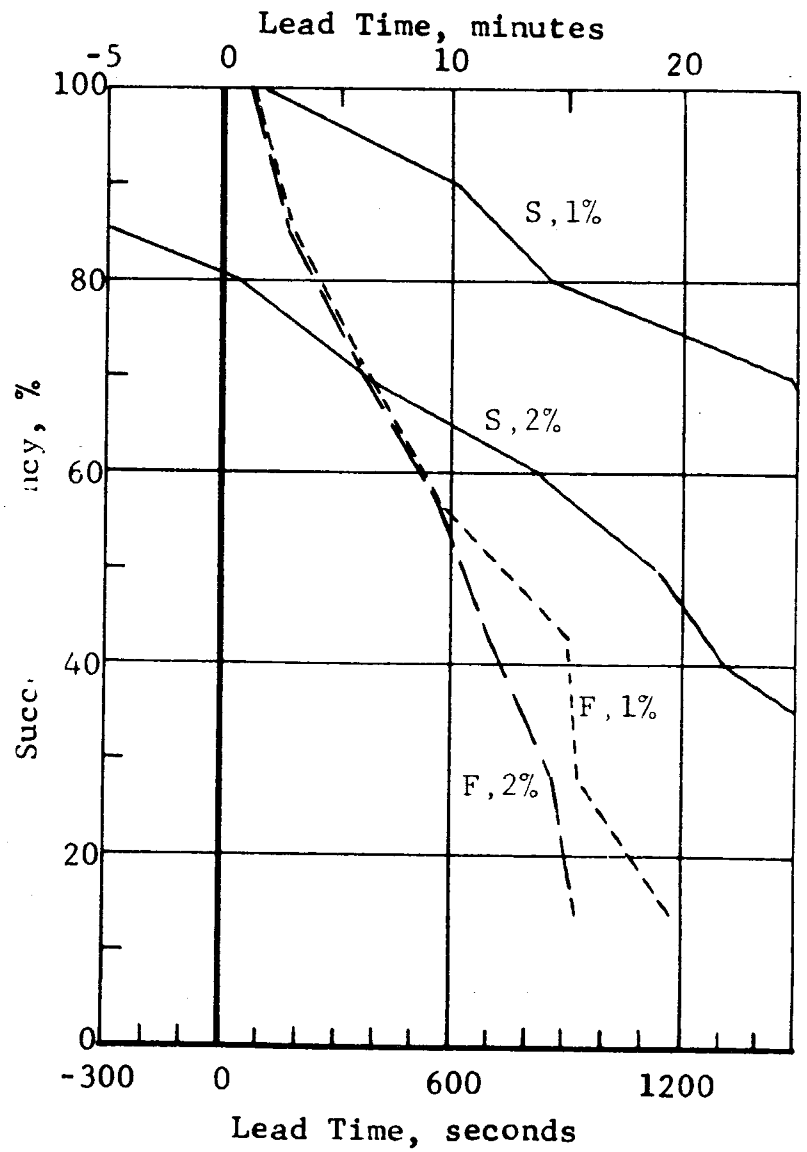


Effect of Sensitivity at Location "B"

Fig. 12 ABILITY OF DETECTOR "E" TO SENSE 1ST STORY FIRES
(LAKESHORE RESIDENCE)



Detectors 2nd, 1st and Top Bsmt Stairs
Fires on 1st and in Bsmt.



Detectors 2nd and 1st Stories
Fires on 1st Story

Fig. 13 ABILITY OF DETECTOR "F" TO SENSE FIRES
(J.R. WHITEHOUSE RESIDENCE)

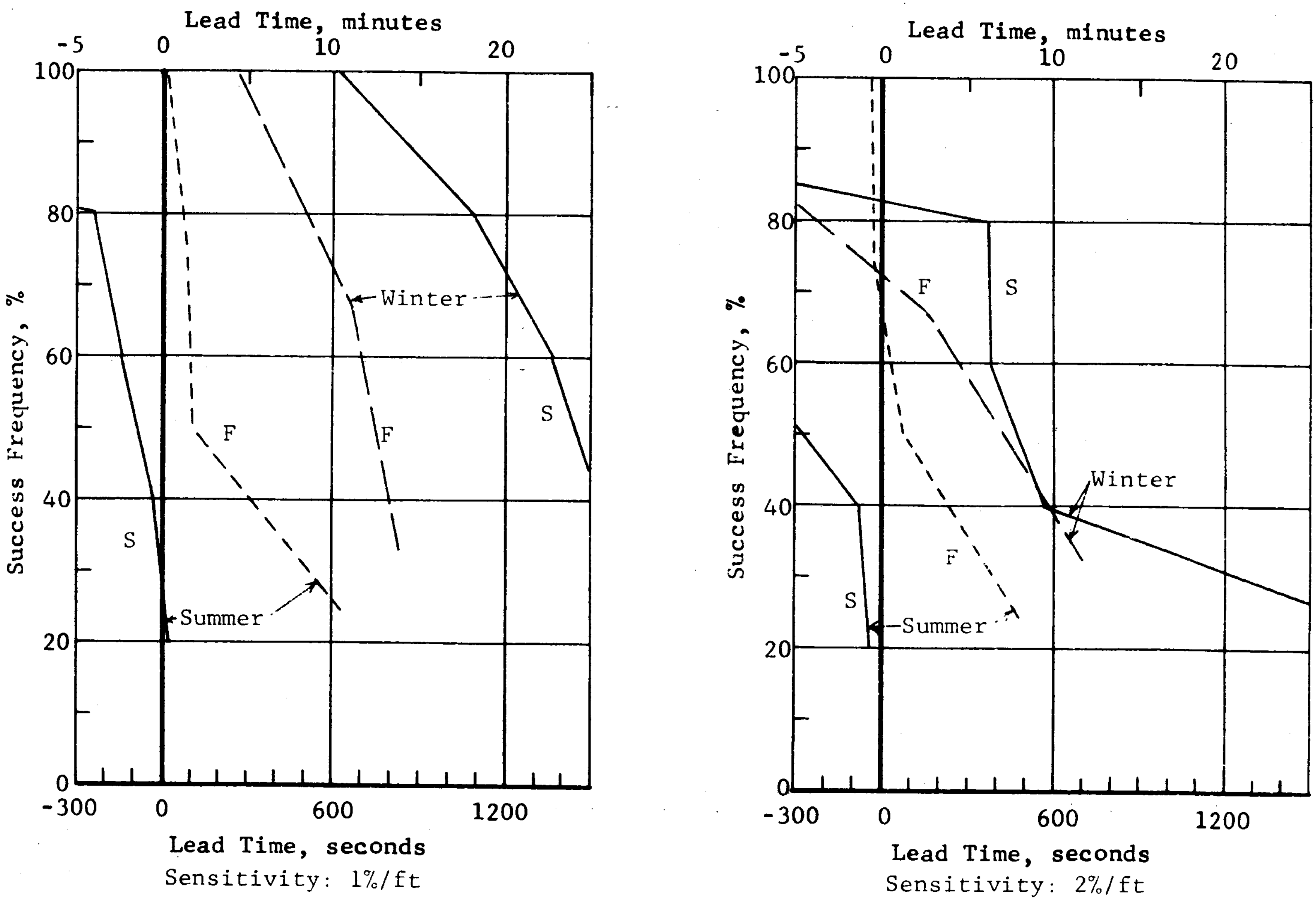
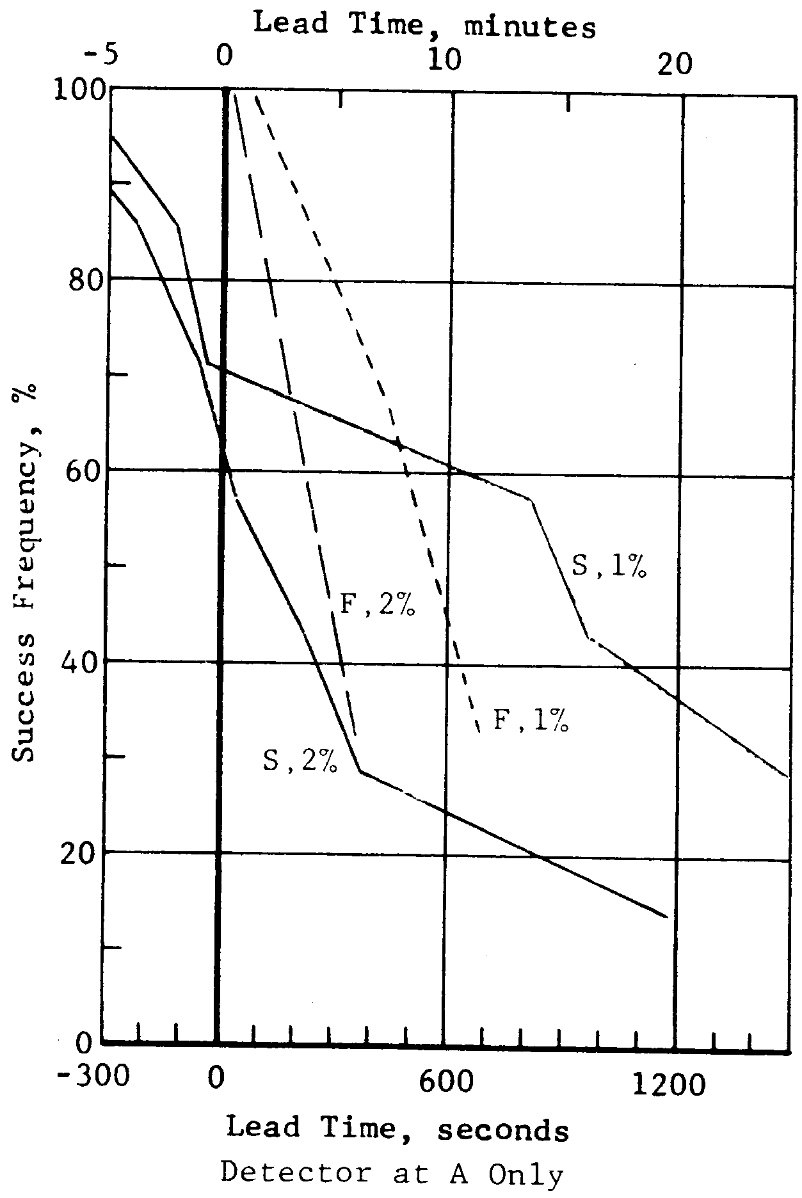


Fig. 14 ABILITY OF DETECTOR "F" ON 2ND STORY TO SENSE FIRES ON 1ST STORY (J.R. WHITEHOUSE RESIDENCE)



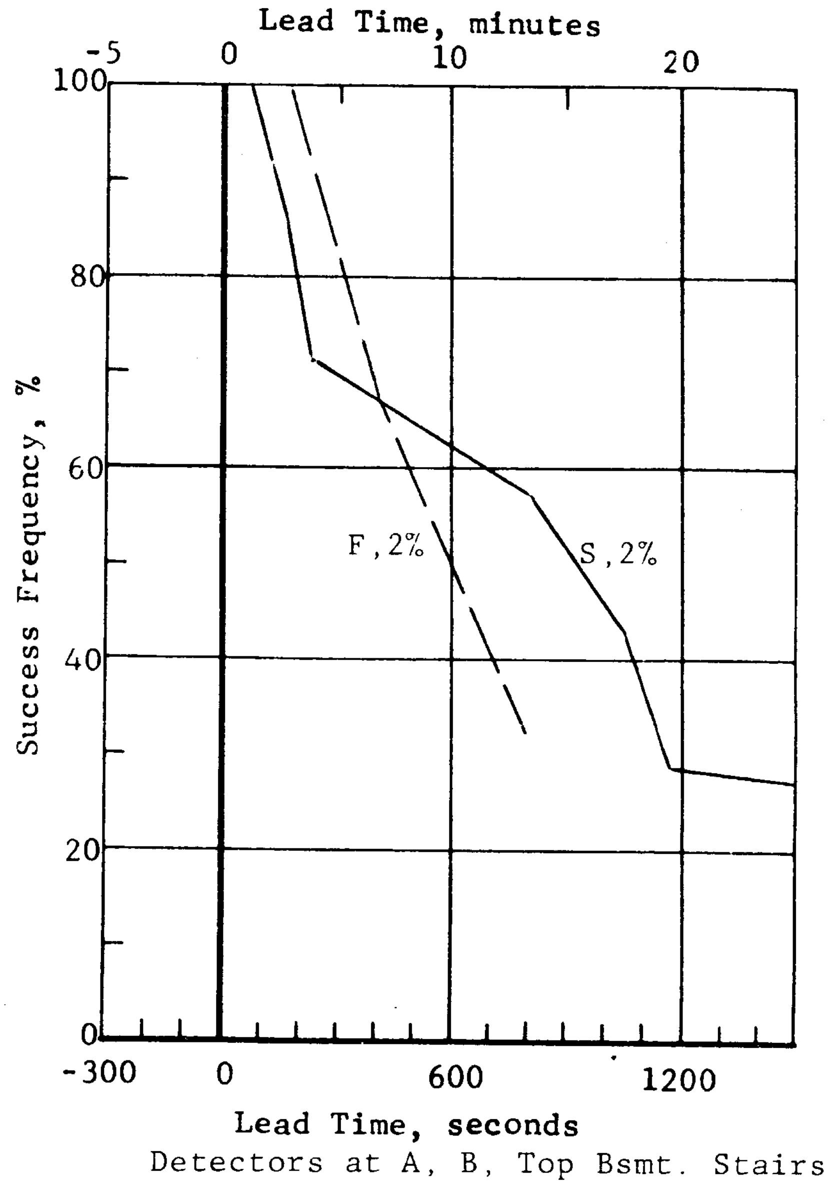
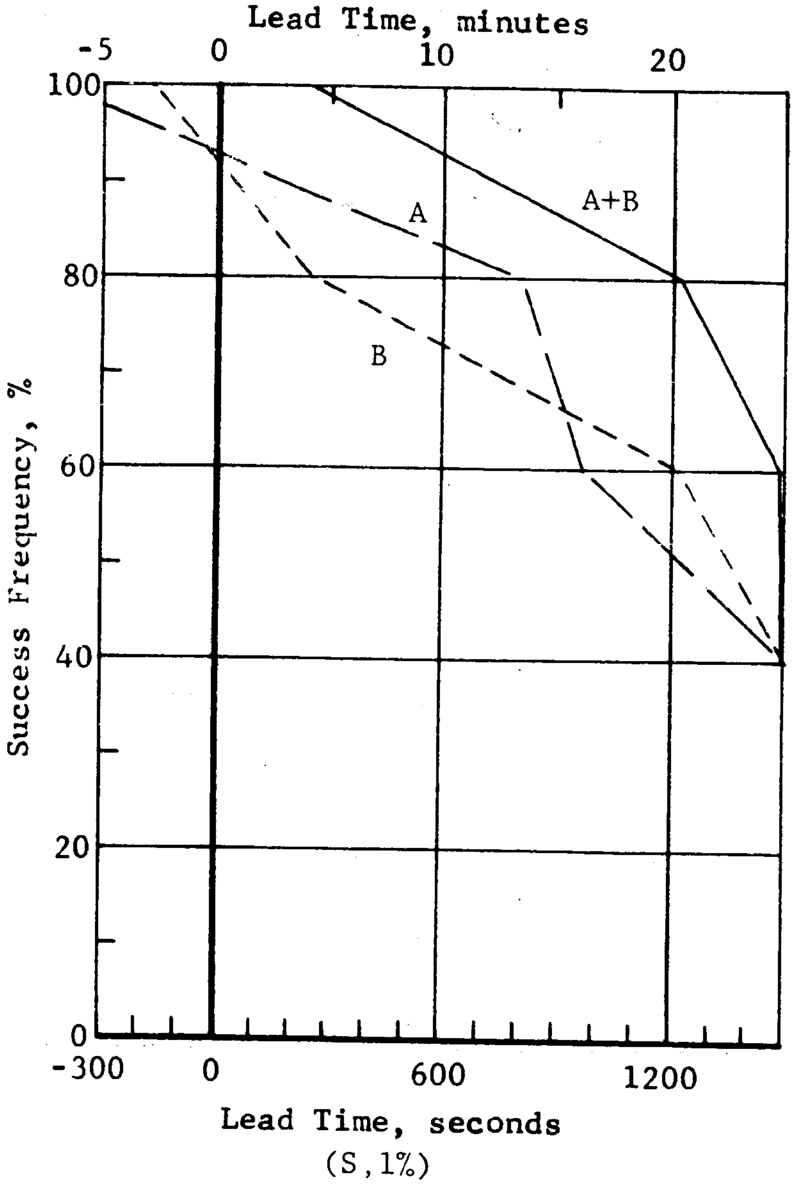


Fig. 15 ABILITY OF DETECTOR "F" TO SENSE FIRES IN BASEMENT AND 1ST STORY (LAKESHORE RESIDENCE)



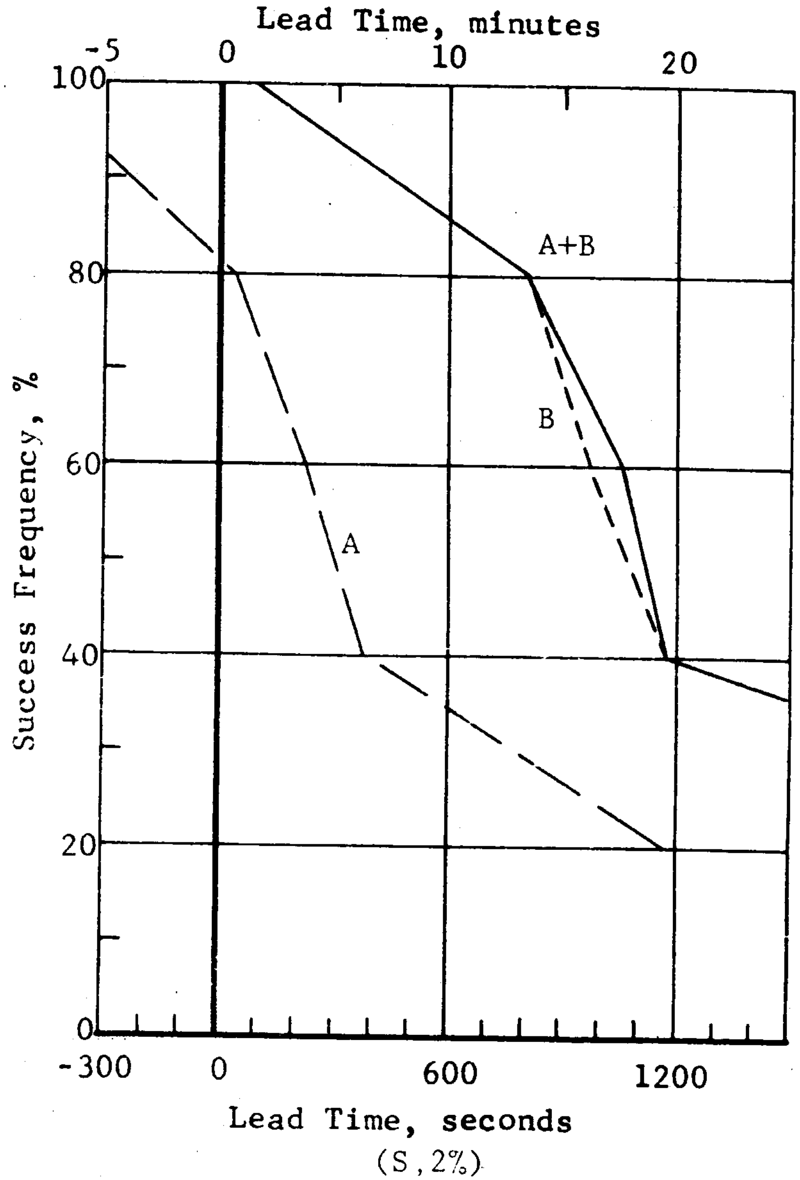
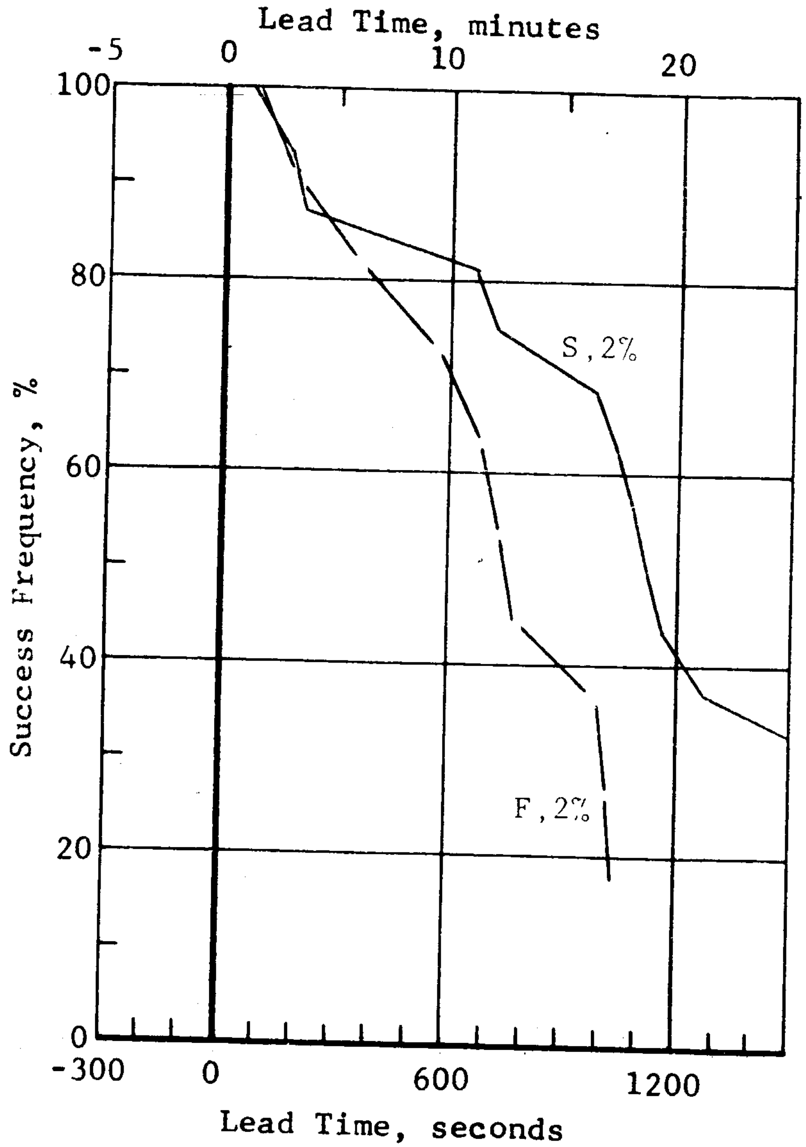
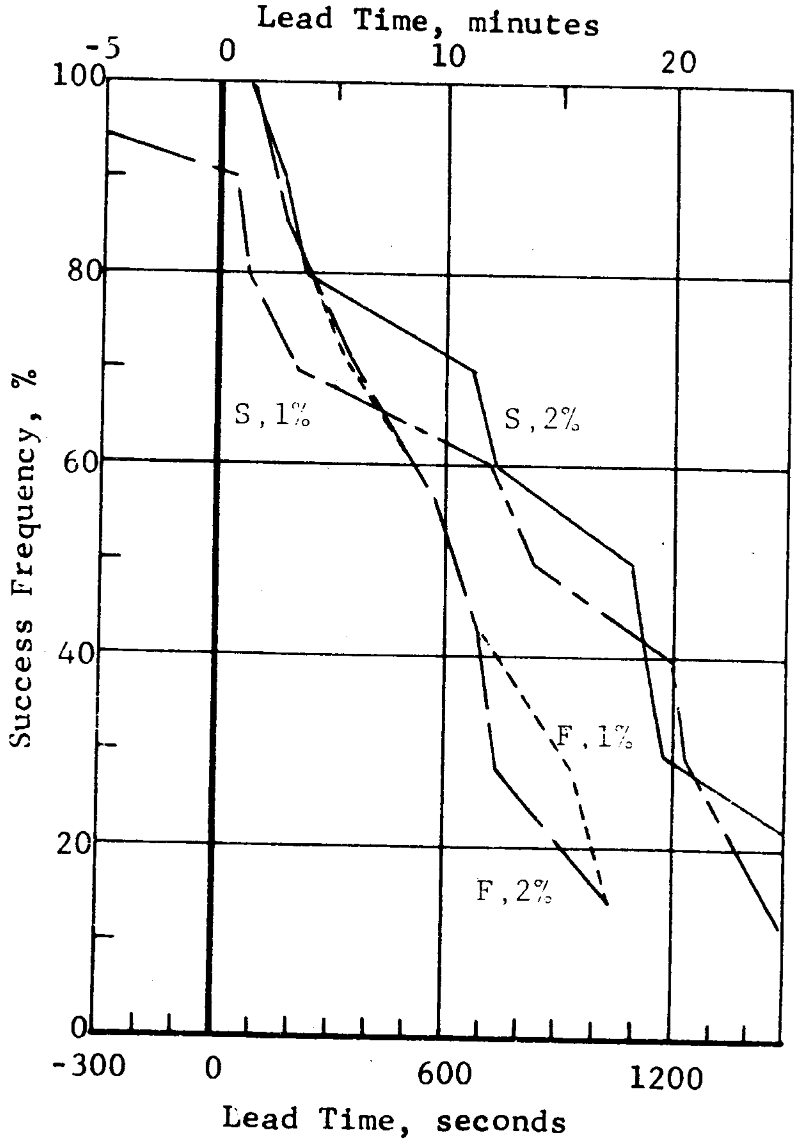


Fig. 16 EFFECT OF LOCATION ON ABILITY OF DETECTOR "F" TO SENSE 1ST STORY FIRES (LAKESHORE RESIDENCE)

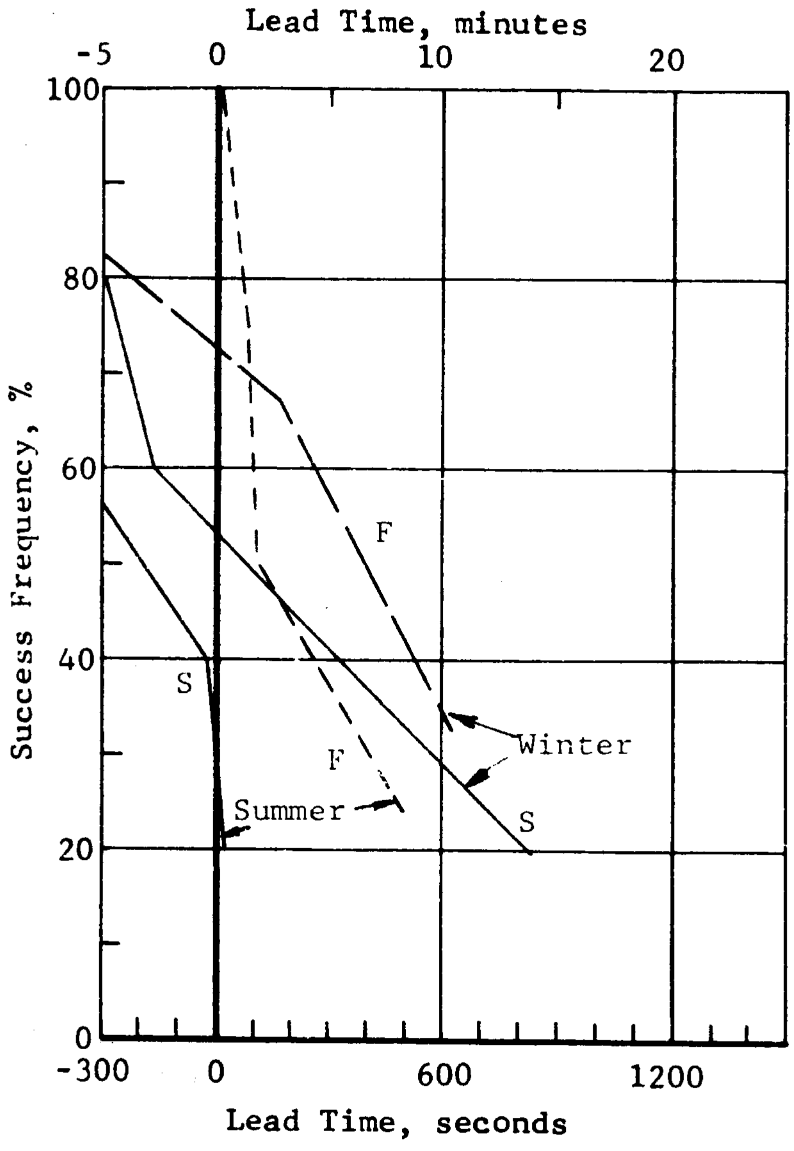


Detectors 2nd, 1st and Top Bsmt. Stairs
Fires on 1st and in Bsmt.

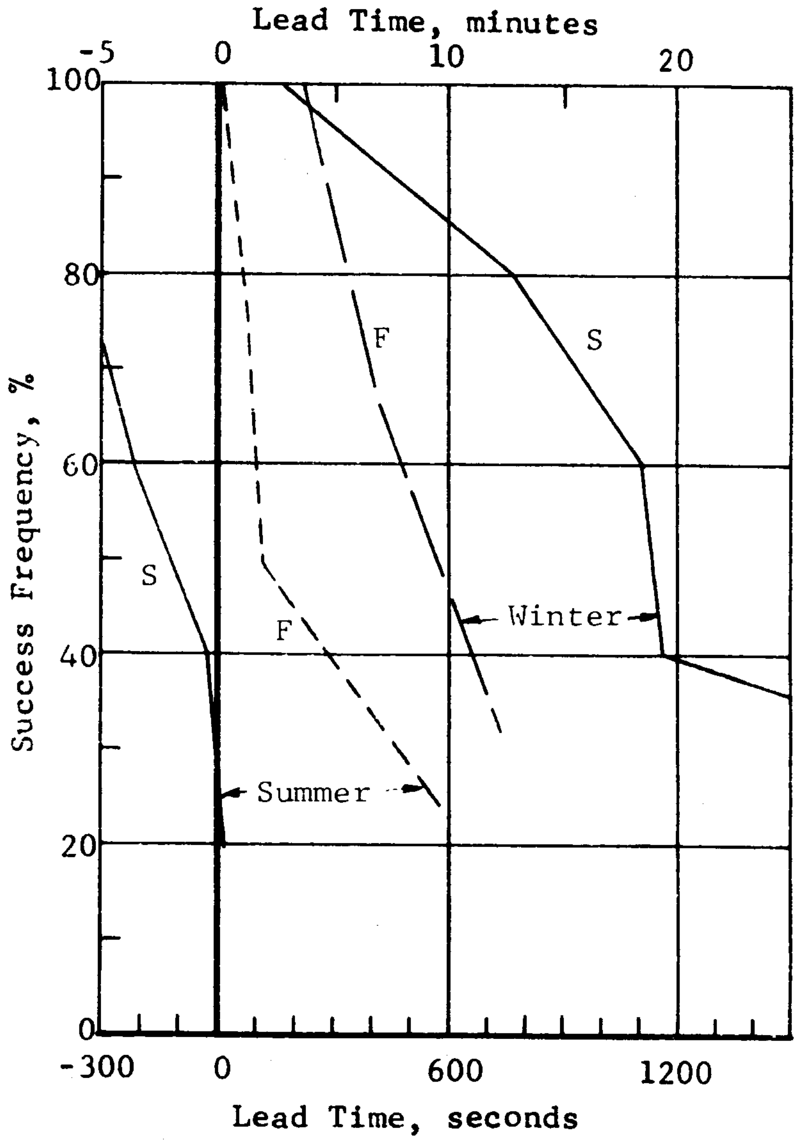


Detectors 2nd and 1st Stories
Fires on 1st Story

Fig. 17 ABILITY OF DETECTOR "H" TO SENSE FIRES
(J.R. WHITEHOUSE RESIDENCE)

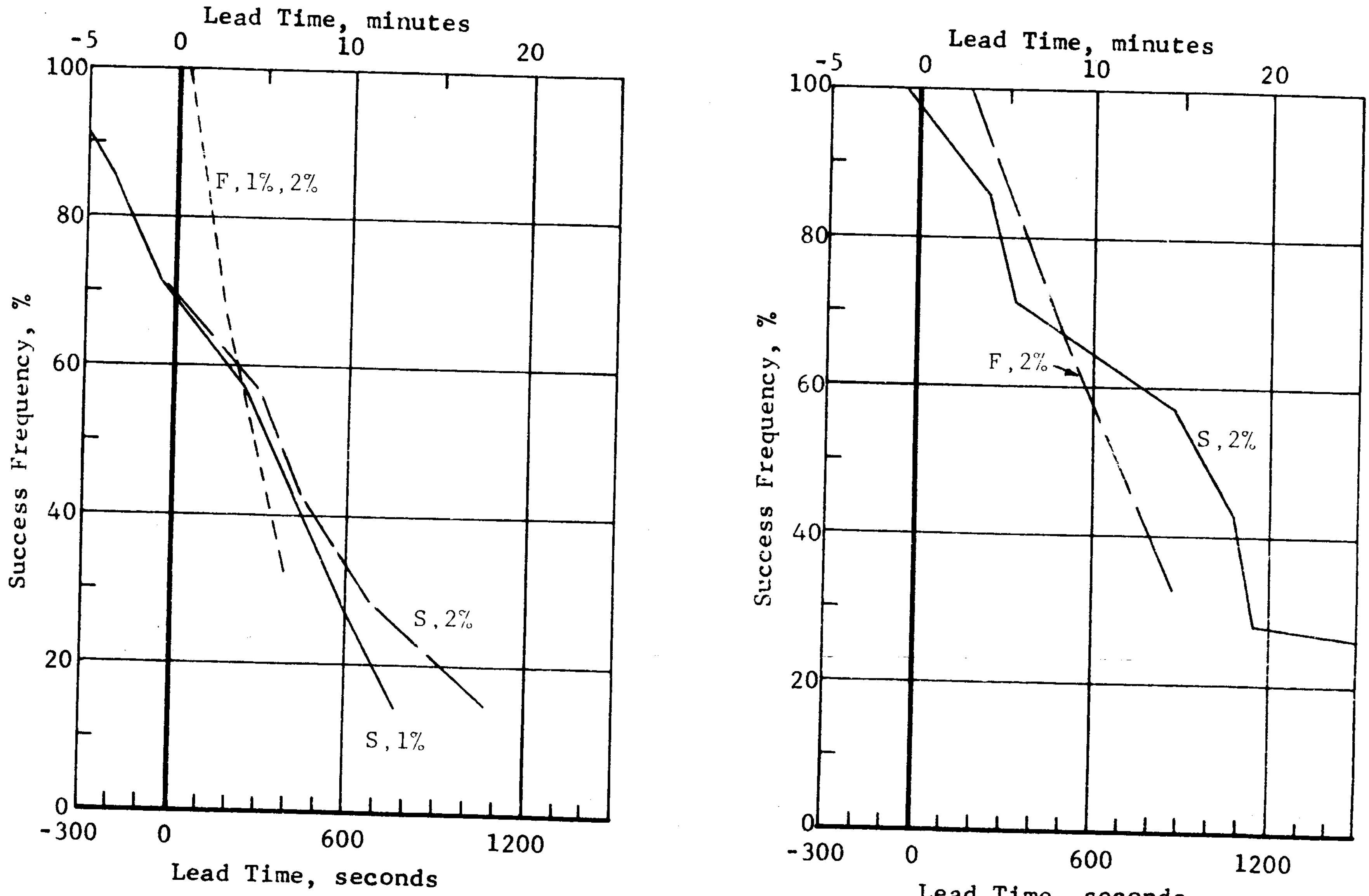


Sensitivity: 1%/ft



Sensitivity: 2%/ft

Fig. 18 ABILITY OF DETECTOR "H" ON 2ND STORY TO SENSE FIRES ON 1ST STORY (J.R. WHITEHOUSE RESIDENCE)



Detector at A Only

Detectors at A, B, Top Bsmt. Stairs

Fig. 19 ABILITY OF DETECTOR "H" TO SENSE FIRES IN BASEMENT AND 1ST STORY (LAKESHORE RESIDENCE)

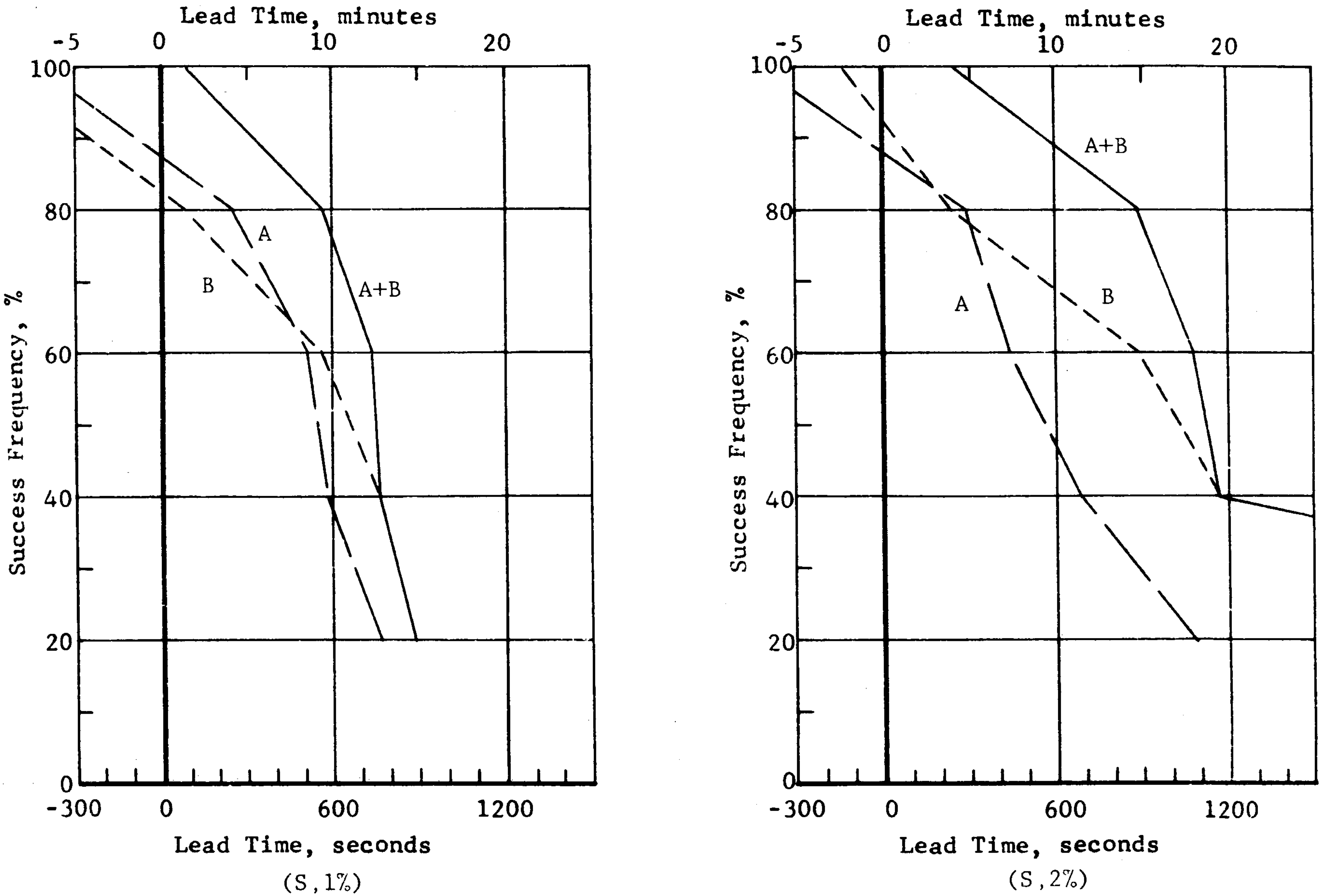
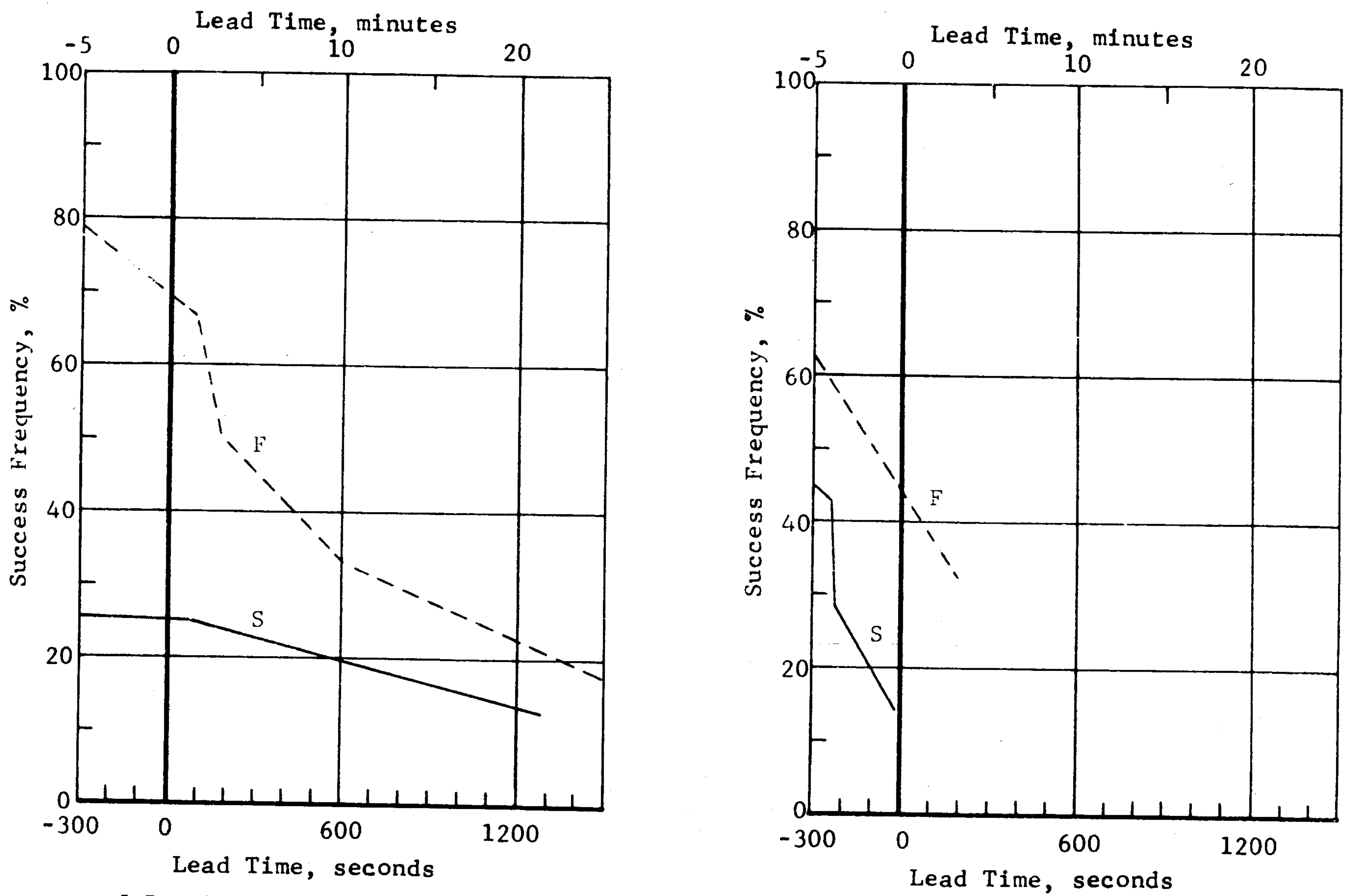


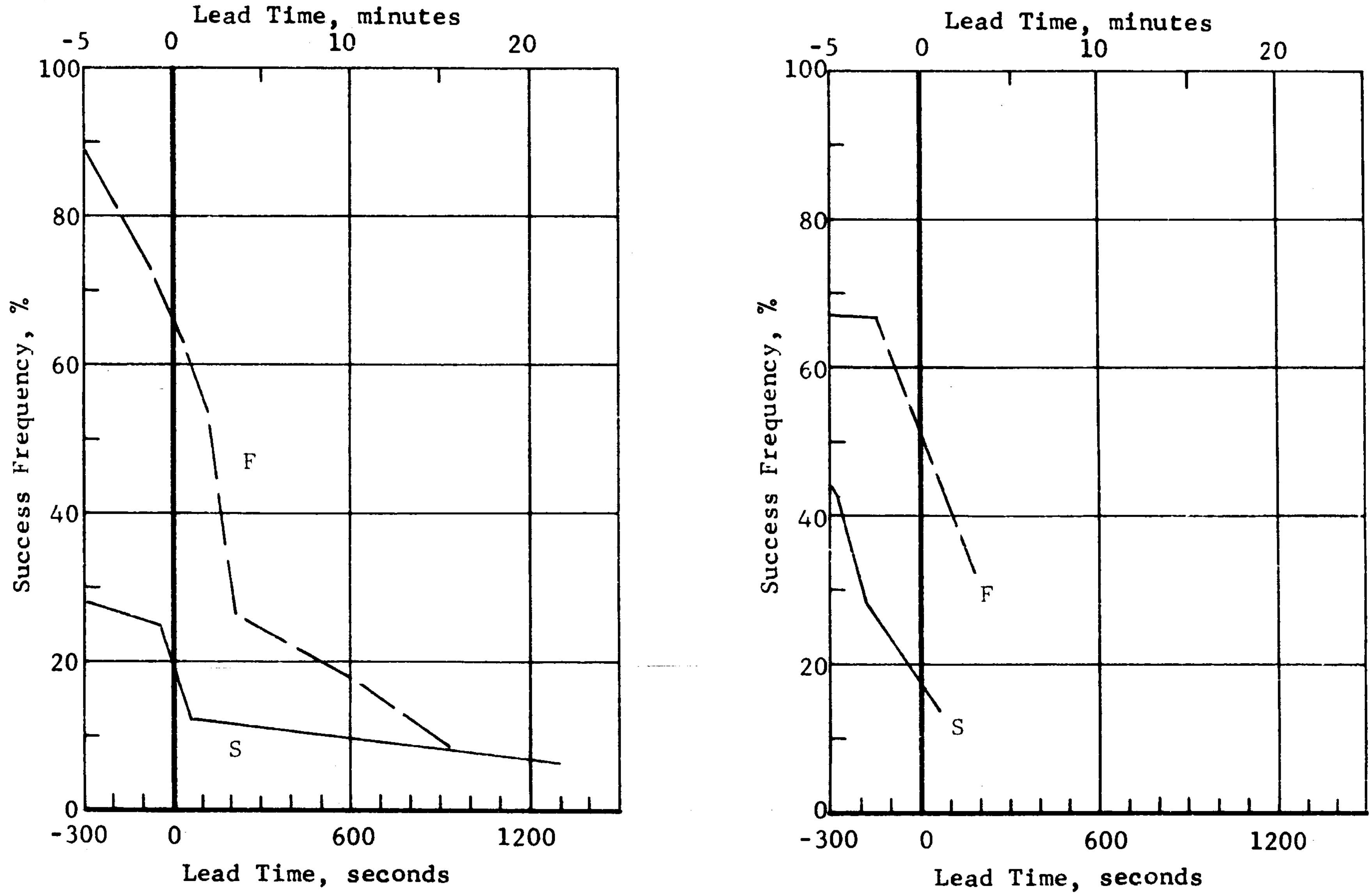
Fig. 20 EFFECT OF LOCATION ON ABILITY OF DETECTOR "H" TO SENSE 1ST STORY FIRES (LAKESHORE RESIDENCE)



J.R. Whitehouse Residence

Lakeshore Residence

Fig. 21 ABILITY OF "RATE-OF-RISE" DETECTOR IN ROOM OF IGNITION TO SENSE FIRES (WINTER EXPERIMENTS)



J.R. Whitehouse Residence

Lakeshore Residence

Fig. 22 ABILITY OF "NO-LAG" 135°F HEAT DETECTOR IN ROOM OF IGNITION TO SENSE FIRES

APPENDIX I

OBSERVATIONS OF EFFECTS OF THE HVAC SYSTEM IN THE PRIMARY TEST SITE (WHITEHOUSE RESIDENCE)

AIRFLOW PATTERNS:

The airflow patterns developed by the heating and air conditioning system might be expected to have significant effects on distribution of fire products within a dwelling, especially when slowly-developing fires with little heat release are involved. Interpretation of data obtained in the Whitehouse residence must therefore take account of these patterns insofar as possible.

Complete description of air condition within the building is not feasible, however a simplified representation can provide useful general observations. Table I-1 shows air velocities measured at the various supply and return registers, along with corresponding flow areas and volumetric flow rates. Data are given for two configurations, namely: all interior doors open, and all bedroom doors closed with other interior doors open. Because of fluctions in the various velocities and nonuniform distributions over the outlet and inlet areas, the flow rates are probably accurate to only about 25 percent. For all practical purposes, flow rates were the same in both heating and cooling modes.

If it is assumed that there is no exchange of air between the interior and exterior of the building, and that air enters and leaves the various rooms only through the air ducts and doorways, then the gross air movements in the building can be estimated. This has been done neglecting the effect of temperature on air density, and the results are shown in Figures I1 through I6.

Of particular interest in these figures are the net flows through the various doorways, which may act to either aid or impede the flow of smoke and combustion products from a fire. Buoyancy from natural or fire-induced temperature gradients will produce flows through the doorways also, and in combination with the forced flows will often generate opposing flows in upper and lower parts of a doorway. Thus, the air movements may not always have been exclusively in the directions shown in Figures I1 through I6, although the net flow rates are probably estimated reasonably well.

EFFECTS ON DETECTION TIMES:

It is not possible to make direct comparisons of detection times for the various experiments in order to judge possible effects of the air movements, since no attempt was made to exactly reproduce the fires. However, a number of useful observations can be made.

It may be noted in Figures I2 through I5 that Hallway C experienced considerable air exchange with the surrounding rooms and with the stairway when the furnace was operating. The directions of the air movements were such as to oppose smoke movement from the living room to Hallway C and from Hallway C to the stairway, and to aid smoke movement from Bedroom A to Hallway C. Data from Experiments 14, 15, 17 and 18 are useful for estimating the magnitude of these effects for winter conditions.

Table I-2 shows the times at which smoke densities of 2 percent per foot were observed at the ceilings in Bedroom A, Hallway C, and Hallway J, and at the 8 ft level in the living room. Shown also are the time delays between the occurrence of 2 percent smoke in the fire rooms and in the hallways.

If the forced flow from Hallway C to the living room and from the stairway to Hallway C were controlling the smoke movement, it would be expected that the time delays for Hallways C and J would be greater for Experiment 14 than for Experiment 15. In fact, the opposite is true and this can only be attributed to the higher temperatures produced in Experiment 14, and the greater rate of smoke development in the living room in Experiment 15. Thus, the large forced airflows in Experiment 14 did not overcome the effects of the living room fire insofar as detection times in Hallways C and J were concerned.

In Experiment 17, forced air flow would be expected to aid smoke transfer from Bedroom A to Hallway C. This, along with the slightly greater rate of smoke development in the bedroom in Experiment 18, and the higher temperatures produced in the bedroom in Experiment 17, would tend to make the delay time greater in Experiment 18. Here, the delay times in Hallway C are approximately equal for the two experiments, indicating that none of these effects significantly altered detection times in Hallway C.

Also, in Experiment 17, the forced air flow would be expected to oppose smoke movement up the stairway into Hallway J, causing delay time to be greater than in Experiment 18. Since the delay time for Experiment 18 is in fact the greater, it seems that the effects of high temperature in Experiment 17 and faster smoke development in Experiment 18 were overriding any effects of forced flow down the stairway.

Comparative experiments with blower on and off were not made for the cooling mode in this series, so similar judgements of possible effects of the forced air movements during air conditioning are not possible. However, it may be observed that in Experiments 2 and 3 (smoldering living room fires) and Experiments 5 and 6 (smoldering Bedroom A fires), the smoke densities at the ceiling of Hallway C corresponded rather closely to the smoke densities at comparable elevations in the fire rooms. Thus the large differences in magnitude and direction of the forced flow through open living room and bedroom doorways did not have any appreciable effect on detection times in Hallway C. Flaming fires in the living room, bedroom, and kitchen produced similar behaviors (Experiments 1, 7, 8, and 9).

These observations tend to support the thesis that smoke movement along ceilings from room to room and up stairways in a heated building is not greatly influenced by gross air movements through doorways. It would appear that the major effect of the forced air heating system in this building was in distributing smoke throughout the building through the ductwork, and diluting the smoke in the fire room. The slower rates of smoke development observed in Experiments 14 and 17 may well have been the result of such dilution.

SMOKE DISTRIBUTION THROUGH DUCT SYSTEM:

While the airflow patterns involving superimposed effects of forced convection and free convection from natural and fire-induced density gradients are too complex for detailed analysis, useful qualitative observations may be made using a simplified representation of the air distribution system. In this simplified approach, uniform mixing within each room or hallway is assumed, and only the gross air movements shown in Figures I1 to I6 are considered. Mass balances can be made for any constituent of the air in each room of the building to yield a first order differential equation for the concentration in the room. For example, this procedure yields the following for Bedroom A:

$$V_A \frac{dc_A}{dt} = I_A C_T - L_{AC} C_A - O_A C_A + F_A(t) \qquad (1)$$

where

$$O_T = O_A + O_B + O_K + O_L + O_X$$

$$C_T = \frac{O_A C_A + O_B C_B + O_K C_K + O_L C_L + O_X C_X}{O_T}$$

and C_n = Concentration of any constituent in room n.

t = Time

V_n = Volume of room n

I_n = Flow rate into room n from supply register.

O_n = Flow rate out of room n through return register.

$L_{n,m}$ = Net flow through the doorway from room n to room m.

$F_n(t)$ = Rate of addition of the constituent by a fire in room n.

Subscripts A, B, K, L, and X refer to similarly lettered rooms in Figures I-1 to I-6. Rearrangement yields the equation for Room A:

$$\frac{dc_A}{dt} = \frac{I_A}{V_A} \left[(f_A - 1)C_A + f_B C_B + f_K C_K + f_L C_L + f_X C_X \right] \frac{F_A(t)}{V_A} \quad (2)$$

where $f_m = O_m / O_T$

Similar equations arise for each room and the final result is a series of 14 simultaneous, first order equations of the general form:

$$\frac{dc_m}{dt} = \sum_{j=A}^{X} A_{m,j}\, C_j + \frac{F_m(t)}{V_m}$$

where $F_n(t)$ = 0 everywhere except the room of fire origin. For this derivation, the volumes of basement rooms, X, Y and Z have been taken together as one room of volume 4875 cu ft and designated Room X.

As discussed previously, smoke distribution appeared to be fairly uniform from floor to ceiling in each room during winter experiments with the furnace operating, but stratification of smoke was marked during summer experiments. For this reason, the following discussion is limited to fires during winter conditions.

While the series of equations is easily soluble by standard methods, it is not clear as yet that any useful quantitative information would be obtained in view of the approximate nature of the mathematical model. Nevertheless, the relative magnitudes of the coefficients $A_{n,j}$ can be used for some qualitative observations.

Table I-3 and I-4 show the values of $A_{n,j}$ for the flows measured with all bedroom doors open and closed, respectively, with all other interior doors open. The magnitude of any particular coefficient $A_{n,j}$ is a measure of the influence that the concentration of a constituent in room j has on the rate of increase of that constituents concentration in room n, when only the air handling system is responsible for air movement. Thus, comparisons of values of $A_{n,j}$ provide means to judge relative effects of fires in various rooms.

For example, inspection of the first column in Table I-3 indicates that a fire in Bedroom A would have the greatest effect on Hallway C ($A_{C,A}$ = 0.0781) and least effect on the basement X ($Z_{X,A}$ = 0.0000589) if only the air handling system caused air movement. It may also be observed that the effect on Bedroom F on the second floor ($A_{F,A}$ = 0.000429) would be about the same as the effect on Bedroom B on the first floor ($A_{B,A}$ = 0.000425); and the effect on Bedroom E would be somewhat less ($A_{E,A}$ = 0.000260). Also, it may be observed that Hallway J would receive products from a fire in room A either by flows out of Bedrooms E and F by forced flow or by natural convection up Stairway H. But, CO concentrations measured in Experiment 17 (smoldering fire in Bedroom A - all doors open, furnace on) at the 5 ft level on the second floor show more CO in Hallway J than in Bedrooms E and F, indicating that there was substantial free convection up the stairway from Hallway C. For the same experiment, it may be observed that the CO concentration in Bedroom B is not greatly different than in Hallway C, even though $A_{C,A}$ is much greater than $A_{B,A}$. This is a clear indication that free convection is predominant there. Also, concentrations of CO in bedrooms E and F are only slightly less than in Bedroom B, which shows that the predominant mechanism of movement is by convection up the stairway. Obviously, a good deal of stratification was occurring because CO concentration at the 5 ft level in the 2nd floor hallway exceeded that at the 5 ft level in the first floor hallway toward the end of the experiment. This stratification is apparently much greater when the furnace is off, as shown by the data for Experiment 18 (smoldering fire - Bedroom A -furnace off). In that experiment, CO concentration in Hallway J was much greater than in Hallway C at the 5 ft levels.

Comparisons between Tables I-3 and I-4 indicate that the effect of closed bedroom doors may not always be beneficial when forced air heating is involved. It may be seen, for example, that the effect on Bedroom E of a fire in Bedroom A is three times as great with closed doors as with open doors if only forced convection is occurring. Similarly the effect on Bedroom F is five times as great with the doors closed. In the Whitehouse residence, it happened that free convection was an important mechanism of smoke movement, so that the transfer through air ducts was of secondary importance when doors were open. Thus, the increased transfer through the air handling system when doors were closed was not sufficient to exceed the effects of free convection with open doors. It is not clear however that this would always be the case.

Inspection of Tables I-3 and I-4 show that fires in the living room would have the greatest potential for smoke transfer through the air system, with fires in the kitchen a close second. This is indicative of the fact that air return rates to the system are greatest for these rooms, amounting to about one air change every 8 min for the living room and every 7 min for the kitchen. In view of the results discussed above for fires in Bedroom A, these effects probably have significance only for transfer of fire gases into closed rooms.

SUMMARY:

Forced air movement caused by the HVAC blower produced substantial flows through various doorways, some of which were in opposition to the flow of fire gases from the room of origin to the remainder of the house. For the experiments examined, these flows appeared to have no significant effect on detection times for either summer or winter conditions with either flaming or smoldering fires.

The most significant effect of the HVAC system appears to be in distributing fire products in the building through the duct system. The smoke is distributed fairly uniformly from floor to ceiling during operation in the heating mode, but severe stratification occurs in the cooling mode. Indications are that transfer of smoke through the HVAC system is secondary in importance to free convection through open doors, but is the prime transfer mechanism of smoke transfer to closed rooms.

The characteristics of the building and HVAC system were such that smoke travel through the HVAC system was more rapid for fires in the living room and kitchen than for fires in any other room, but this would be of importance only for transfer to closed rooms. Differences in the airflow patterns established with bedroom doors open and bedroom doors closed suggest that closed bedroom doors may not always be beneficial in preventing transfer of smoke and gases into the bedrooms. This arises from the particular characteristics of the heating system in this building, and would apparently apply only when transfer through open doorways by free convection is negligible.

TABLE I-1
AIRFLOWS MEASURED IN WHITEHOUSE RESIDENCE - HEATING AND COOLING MODES

Location (See Figs. I-1 Through I-6)	Airflow In CFM	
	All Doors Open	Bedroom Doors Closed
1	116	98.1
2	470	487
3	72.5	84.9
4	65.3	77.0
5	4.6	12.7
6	104	104
7	32.6	34.0
8	5.9	25.3
9	192	164
10	95	95.9
11	43.8	33.1
12	50.2	59.4
13	77.5	80.7
14	33.6	37.2
15	19.5	16.6

TABLE I-2
DELAY TIMES FOR TRANSFER OF SMOKE FROM FIRE ROOMS
TO DETECTORS WITH FORCED AIR HEATING

Experiment	Fire Room	Furnace	Time Of Occurrance Of 2 Percent Per Ft Smoke - Min*		
			Fire Room	Hall C	Hall J
14	L	On	33	46 (13)**	54 (19)
15	L	Off	20	36 (16)	>75 (55)
17	A	On	11	25 (14)	58 (47)
18	A	Off	9	23 (14)	>62 (53)

*Measured at 8 ft level in living room, and ceiling level elsewhere.

**Number in parentheses are time delays between occurrance of 2 percent per ft smoke in fire room and in the respective hallways.

TABLE I-3

COEFFICIENTS $A_{n,j}$ IN EQUATION 3 FOR ALL INTERIOR DOORS OPEN IN WHITEHOUSE RESIDENCE

(Note: Numbers in parenthesis are powers of 10 for values above.)

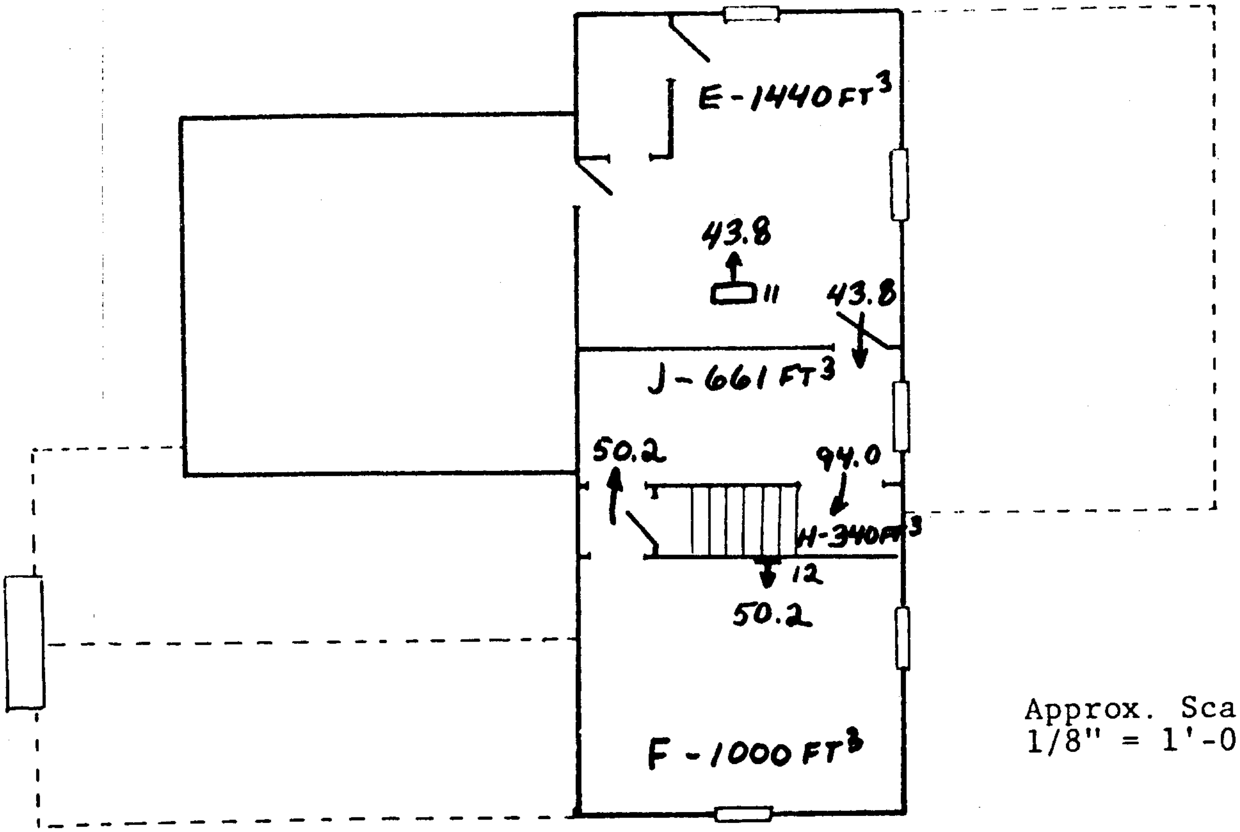
n↓ \ j→	A	B	C	D	E	F	h	H	J	K	L	P	W	X
A	-2.45 (-2)	1.66 (-4)	0	0	0	0	0	0	0	6.92 (-3)	1.69 (-2)	0	0	6.85 (-4)
B	4.25 (-4)	-4.94 (-2)	0	0	0	0	0	0	0	1.38 (-2)	3.39 (-2)	0	0	1.37 (-3)
C	7.81 (-2)	1.80 (-1)	-8.39 (-1)	0	0	0	0	2.74 (-1)	0	0	0	3.04 (-1)	0	0
D	7.05 (-4)	5.50 (-4)	0	-1.77 (-1)	0	0	7.97 (-2)	0	0	2.30 (-2)	5.61 (-2)	0	0	2.27 (-3)
E	2.60 (-4)	2.20 (-4)	0	0	-3.04 (-2)	0	0	0	0	8.35 (-3)	2.06 (-2)	0	0	8.36 (-4)
F	4.29 (-4)	3.35 (-4)	0	0	0	-5.02 (-2)	0	0	0	1.39 (-2)	3.41 (-2)	0	0	1.38 (-3)
h	0	0	0	0	0	0	-3.98 (-1)	0	0	0	0	0	0	3.98 (-1)
H	0	0	0	0	0	0	0	-2.76 (-1)	2.76 (-1)	0	0	0	0	0
J	0	0	0	0	6.64 (-2)	7.60 (-2)	0	0	-1.42 (-1)	0	0	0	0	0
K	0	0	3.92 (-3)	1.35 (-1)	0	0	0	0	0	-1.39 (-1)	0	0	0	0
L	3.82 (-4)	2.98 (-4)	6.69 (-2)	0	0	0	0	0	0	1.24 (-2)	-8.11 (-2)	0	0	1.23 (-3)
P	1.90 (-3)	1.48 (-3)	0	0	0	0	0	0	0	6.14 (-2)	1.51 (-1)	-2.23 (-1)	0	6.14 (-3)
W	3.83 (-4)	2.99 (-4)	0	0	0	0	0	0	0	1.25 (-2)	3.03 (-2)	0	-4.49 (-2)	1.24 (-3)
X	5.89 (-5)	4.60 (-5)	0	0	0	0	0	0	0	1.92 (-3)	4.69 (-3)	0	1.59 (-2)	-2.27 (-2)

TABLE I-4

COEFFICIENTS $A_{n,j}$ IN EQUATION 3 FOR BEDROOM DOORS CLOSED AND ALL OTHER INTERIOR DOORS OPEN IN WHITEHOUSE RESIDENCE

(Note: Numbers in parenthesis are powers of 10 for values above.)

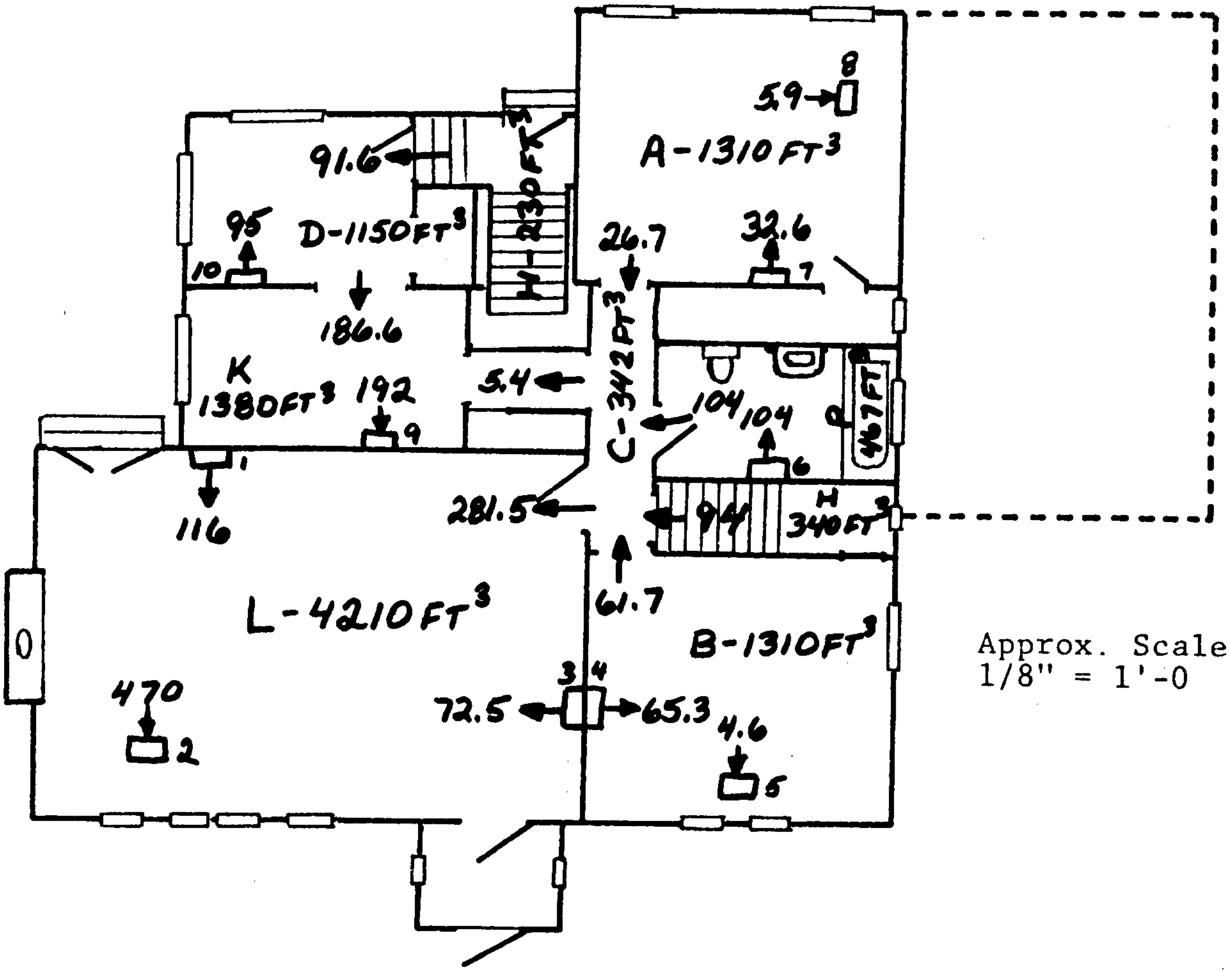
n ↓ \ j →	A	B	C	D	E	F	h	H	J	K	L	P	W	X
A	-2.50 (-2)	4.66 (-4)	0	0	0	0	0	0	0	6.03 (-3)	1.79 (-2)	0	0	6.09 (-4)
B	2.11 (-3)	-5.77 (-2)	0	0	0	0	0	0	0	1.37 (-2)	4.06 (-2)	0	0	1.38 (-3)
C	2.54 (-2)	1.88 (-1)	-8.99 (-1)	0	0	0	0	2.70 (-1)	0	9.71 (-2)	0	3.04 (-1)	0	0
D	2.99 (-3)	1.50 (-3)	0	-1.71 (-1)	0	0	8.81 (-2)	0	0	1.94 (-2)	5.76 (-2)	0	0	1.96 (-3)
E	8.26 (-4)	4.14 (-4)	0	0	-2.30 (-2)	0	0	0	0	5.36 (-3)	1.59 (-2)	0	0	5.41 (-4)
F	2.13 (-3)	1.07 (-3)	0	0	0	-5.94 (-2)	0	0	0	1.38 (-2)	4.10 (-2)	0	0	1.40 (-3)
h	0	0	0	0	0	0	-4.40 (-1)	0	0	0	0	0	0	4.40 (-1)
H	0	0	0	0	0	0	0	-2.72 (-1)	2.72 (-1)	0	0	0	0	0
J	0	0	0	0	5.01 (-2)	8.99 (-2)	0	0	-1.40 (-1)	0	0	0	0	0
K	0	0	0	1.43 (-1)	0	0	0	0	0	-1.43 (-1)	0	0	0	0
L	1.56 (-3)	7.83 (-4)	7.22 (-2)	0	0	0	0	0	0	1.01 (-2)	-8.57 (-2)	0	0	1.02 (-3)
P	8.01 (-3)	4.01 (-3)	0	0	0	0	0	0	0	5.19 (-2)	1.54 (-1)	-2.23 (-1)	0	5.24 (-3)
W	2.00 (-3)	1.00 (-3)	0	0	0	0	0	0	0	1.30 (-2)	3.85 (-2)	0	-5.57 (-2)	1.31 (-3)
X	2.74 (-4)	1.37 (-4)	0	0	0	0	0	0	0	1.78 (-3)	5.27 (-3)	0	1.66 (-2)	-2.40 (-2)



Approx. Scale:
1/8" = 1'-0

2ND FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

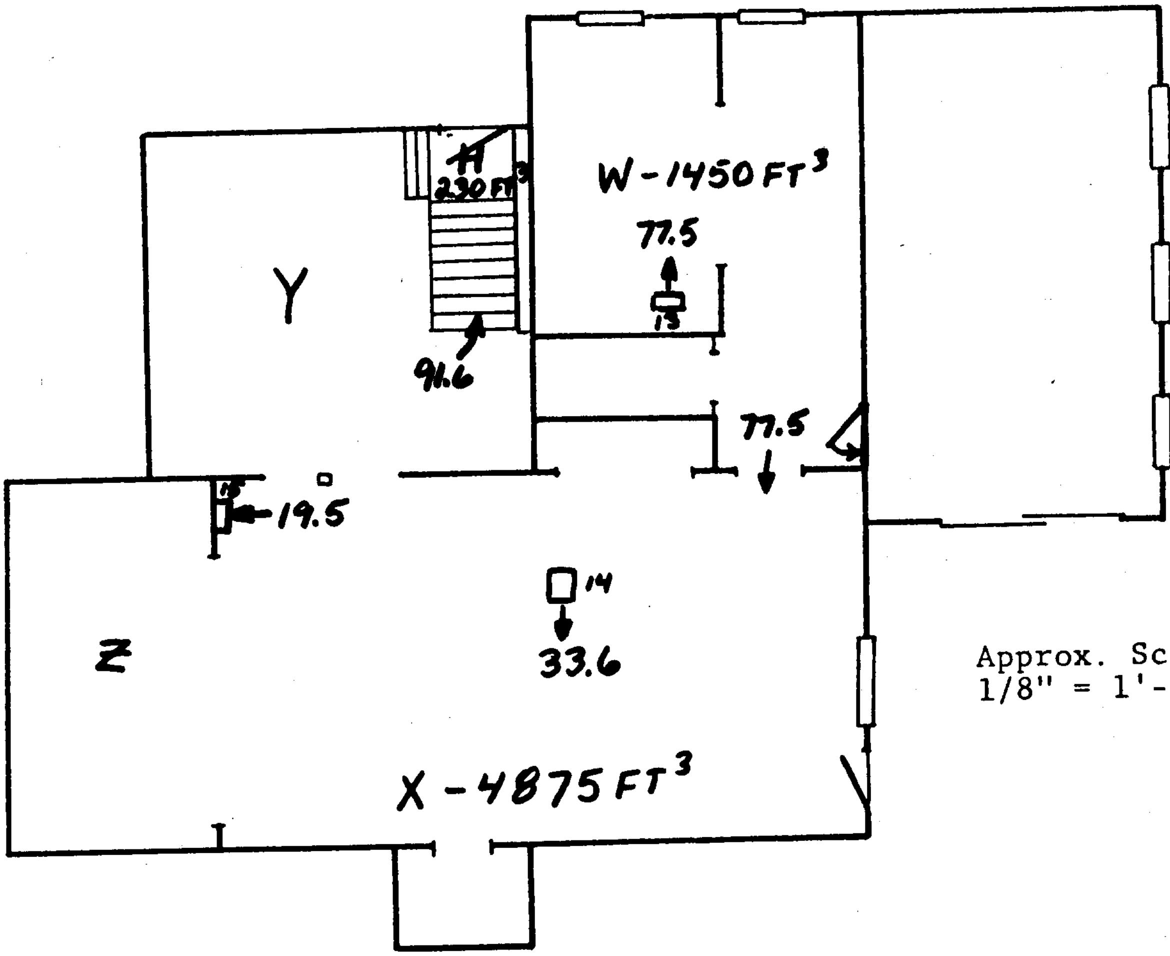
Fig. 1 FLOW RATES IN SECOND FLOOR OF WHITEHOUSE RESIDENCE - BEDROOM DOORS OPEN - CFM



Approx. Scale:
1/8" = 1'-0

1ST FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

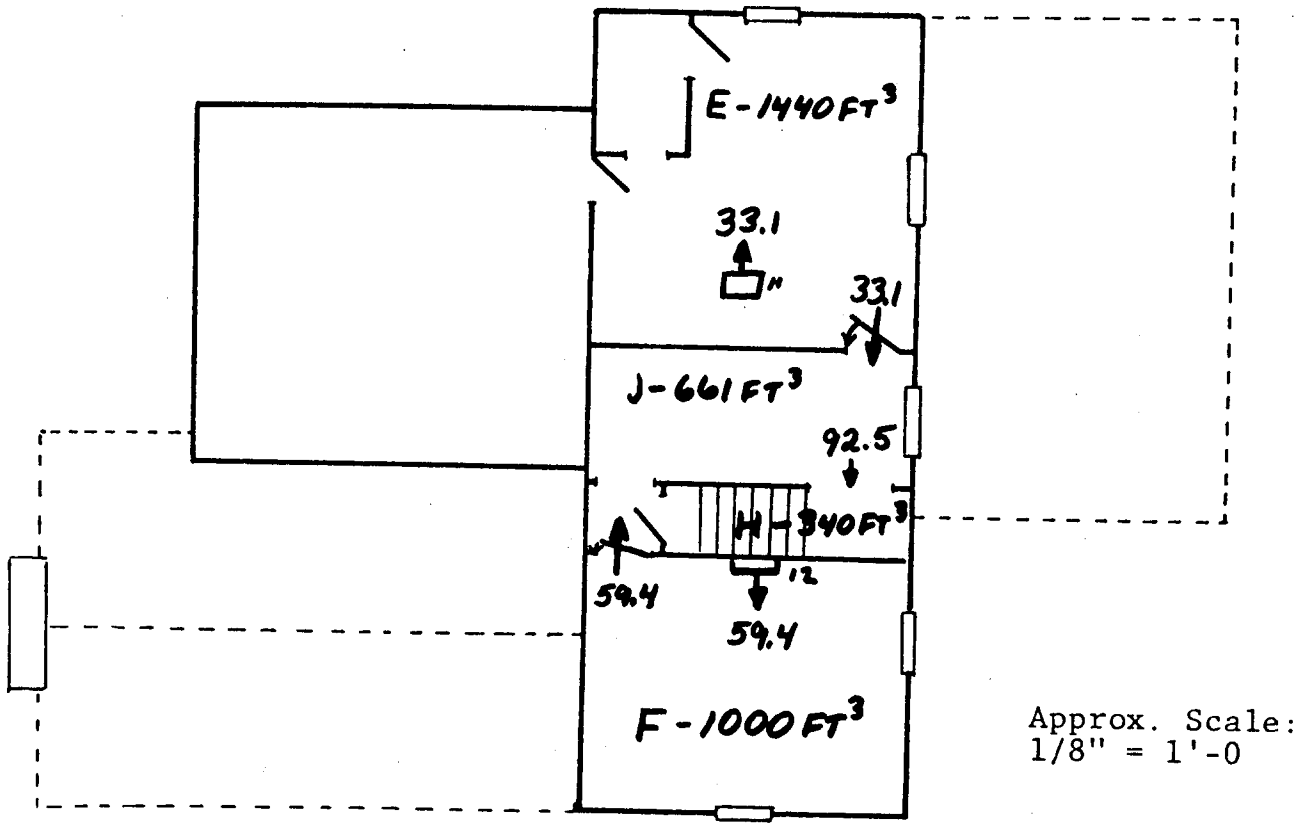
Fig. 2 FLOW RATES IN FIRST FLOOR OF WHITEHOUSE RESIDENCE - BEDROOM DOORS OPEN - CFM



Approx. Scale:
1/8" = 1'-0

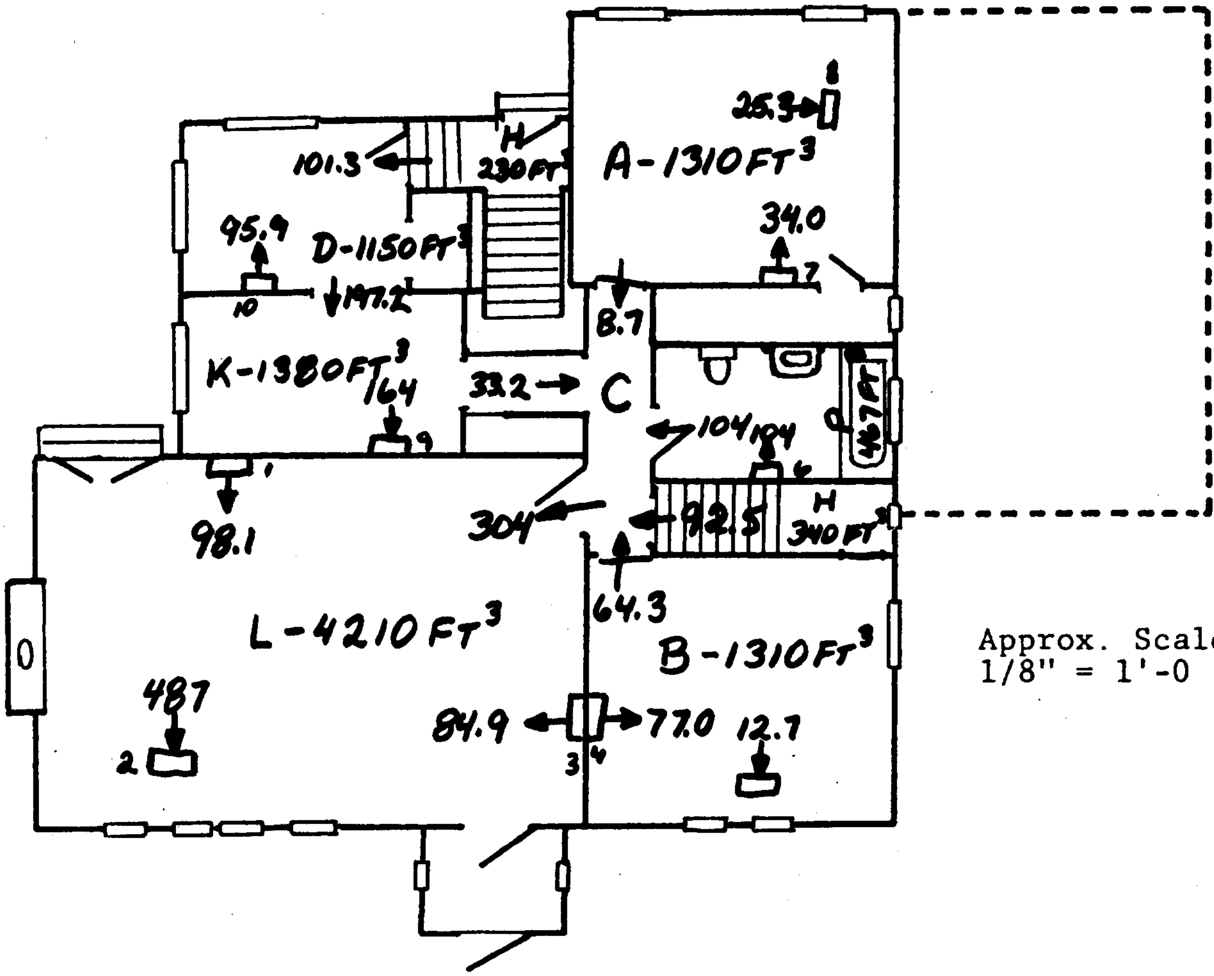
BASEMENT FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 3 FLOW RATES IN BASEMENT OF WHITEHOUSE RESIDENCE - BEDROOM DOORS OPEN - CFM



2ND FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

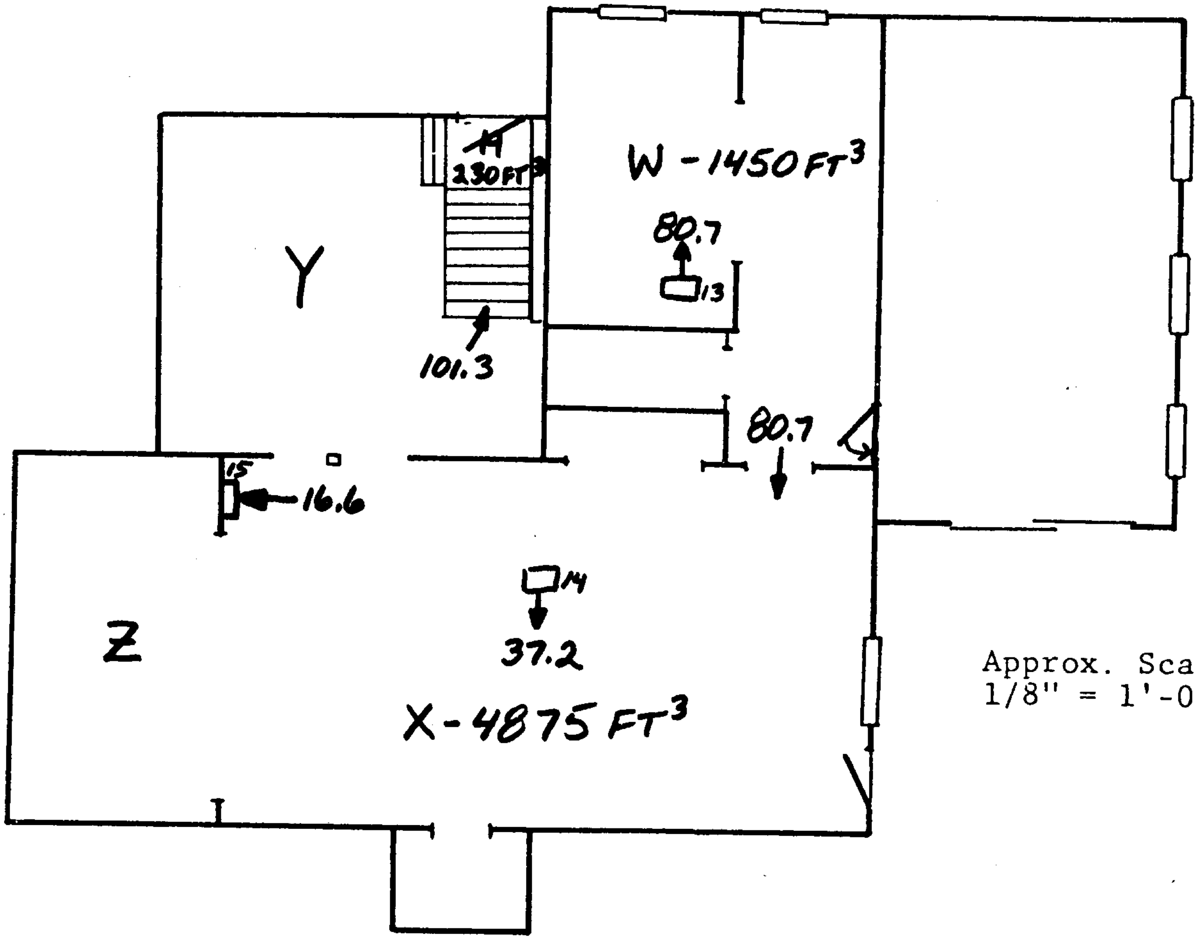
Fig. 4 FLOW RATES IN SECOND FLOOR OF WHITEHOUSE RESIDENCE - BEDROOM DOORS CLOSED - CFM



Approx. Scale:
1/8" = 1'-0

1ST FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

Fig. 5 FLOW RATES IN FIRST FLOOR OF WHITEHOUSE RESIDENCE - BEDROOM DOORS CLOSED - CFM



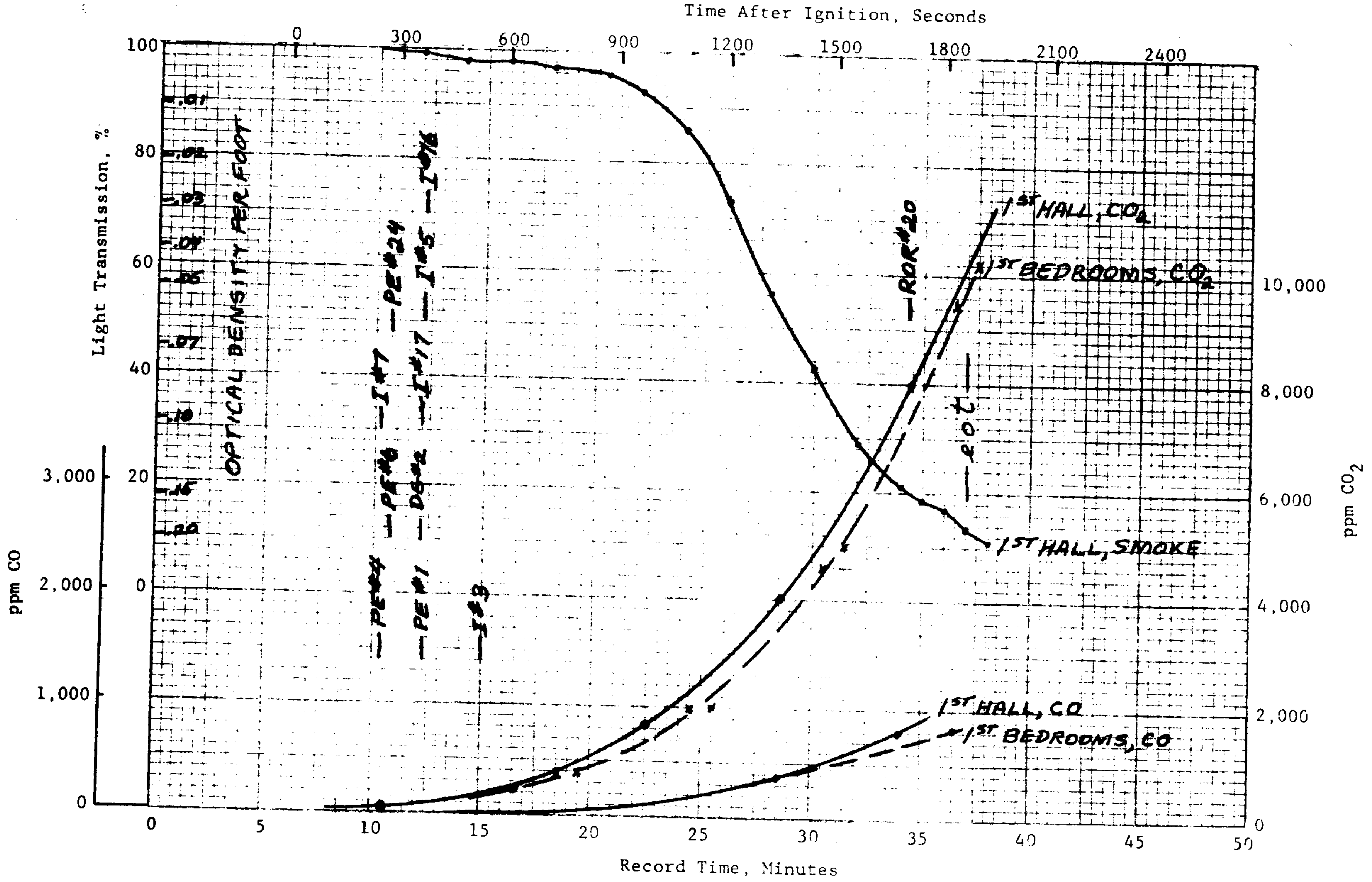
Approx. Scale:
1/8" = 1'-0

BASEMENT FLOOR PLAN - J.R. WHITEHOUSE RESIDENCE

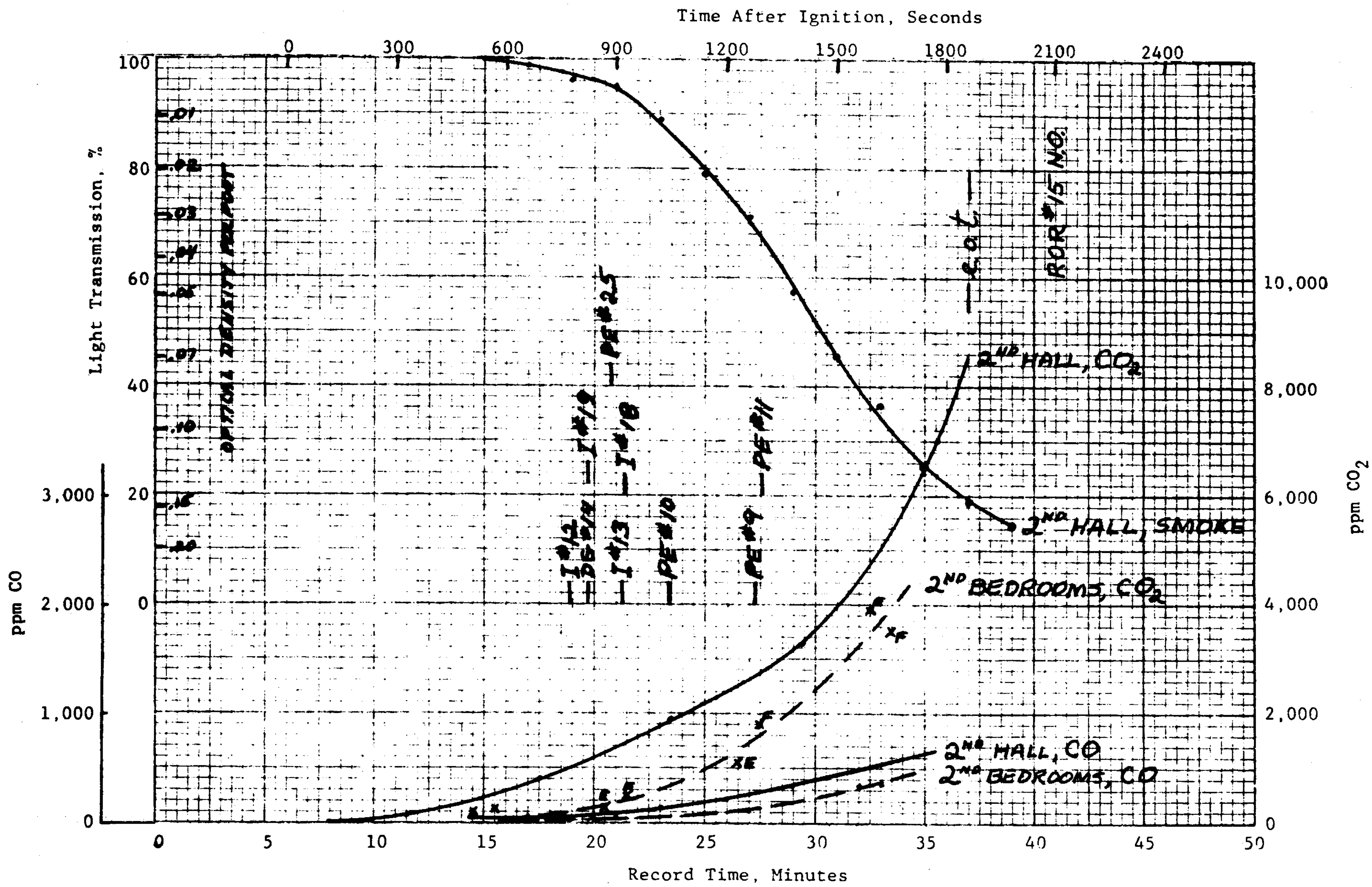
Fig. 6 FLOW RATES IN BASEMENT OF WHITEHOUSE RESIDENCE - BEDROOM DOORS CLOSED - CFM

APPENDIX J

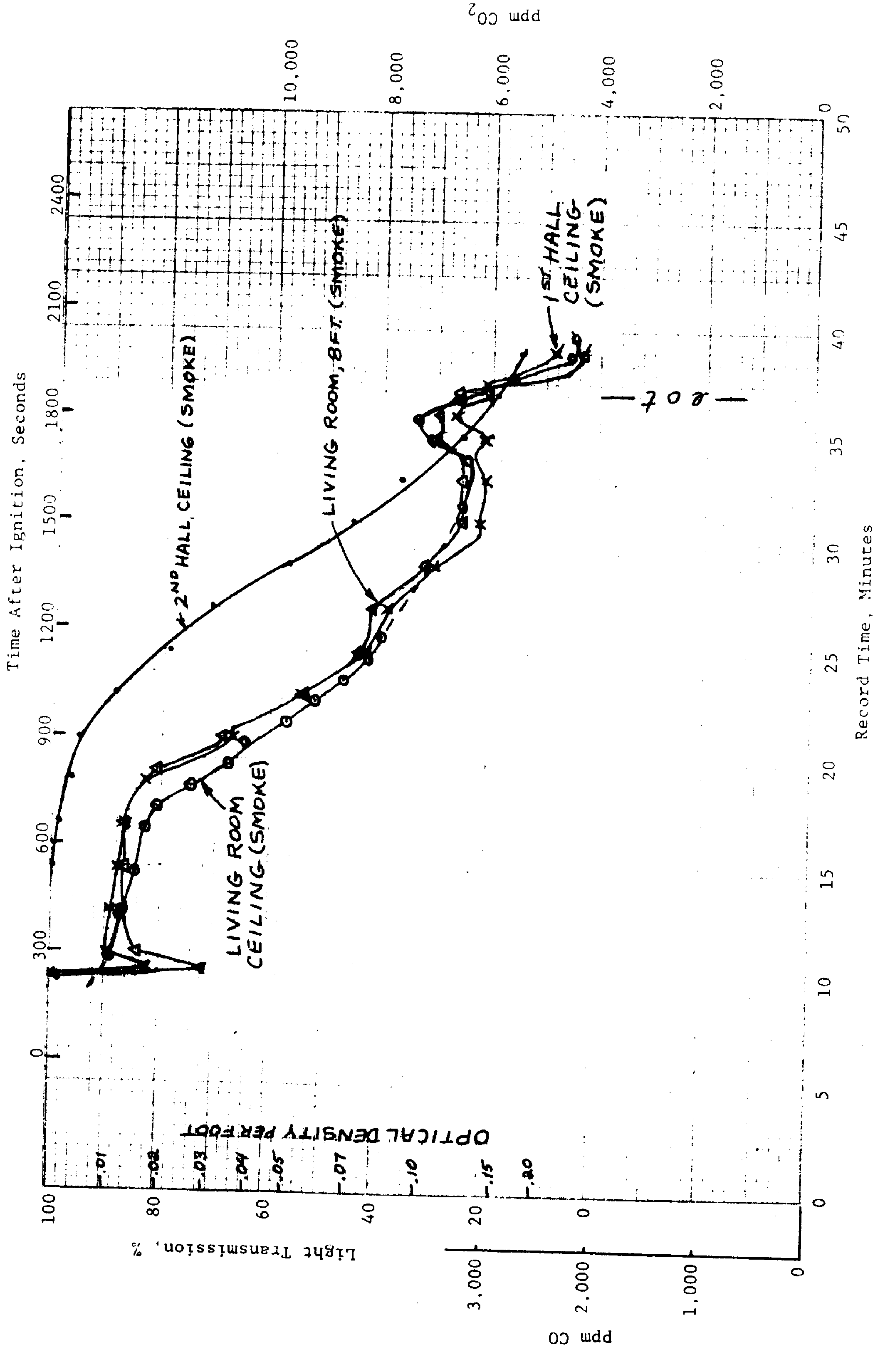
TIME HISTORIES OF SMOKE, TEMPERATURE, AND GAS CONCENTRATIONS



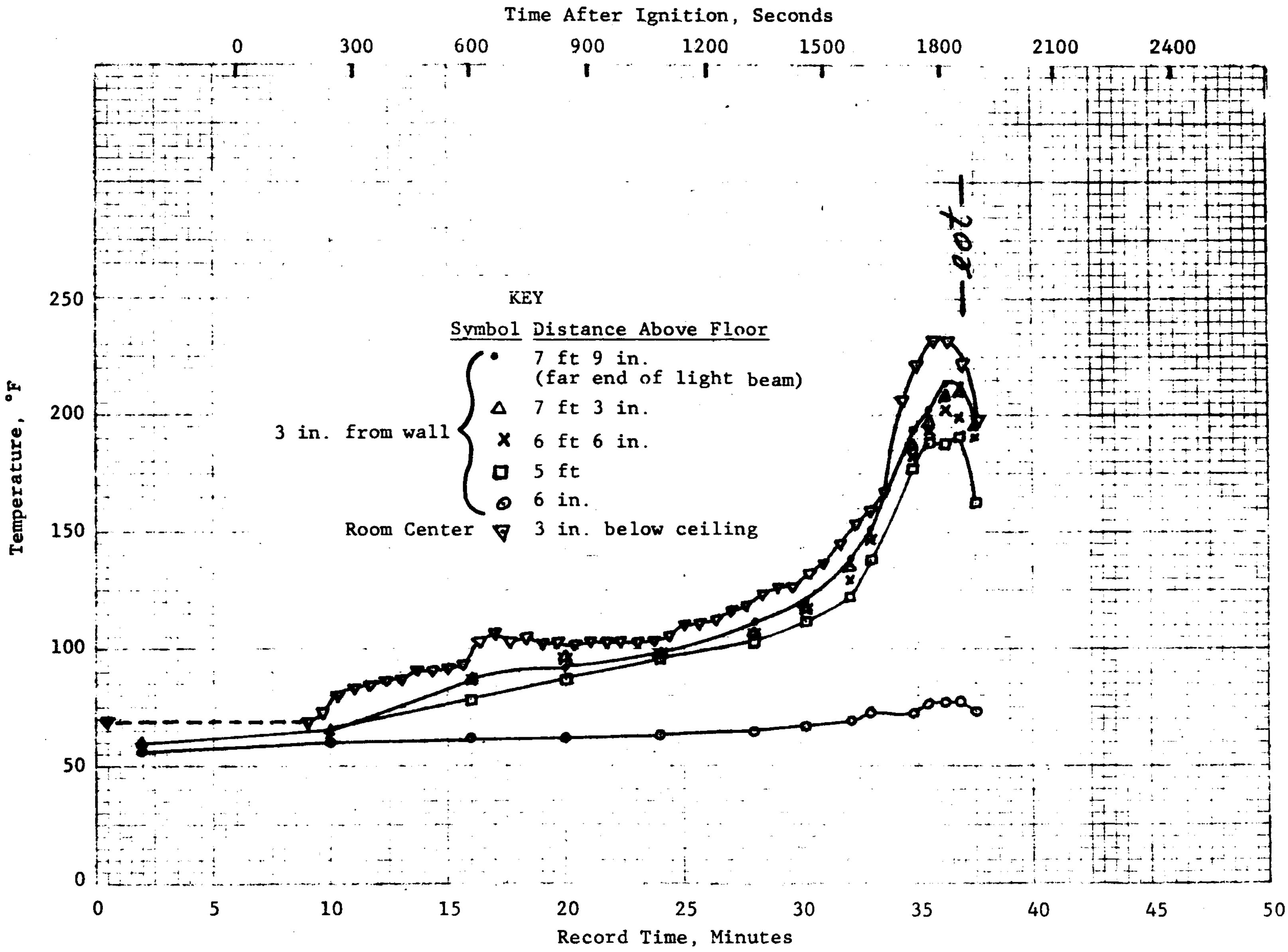
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-1



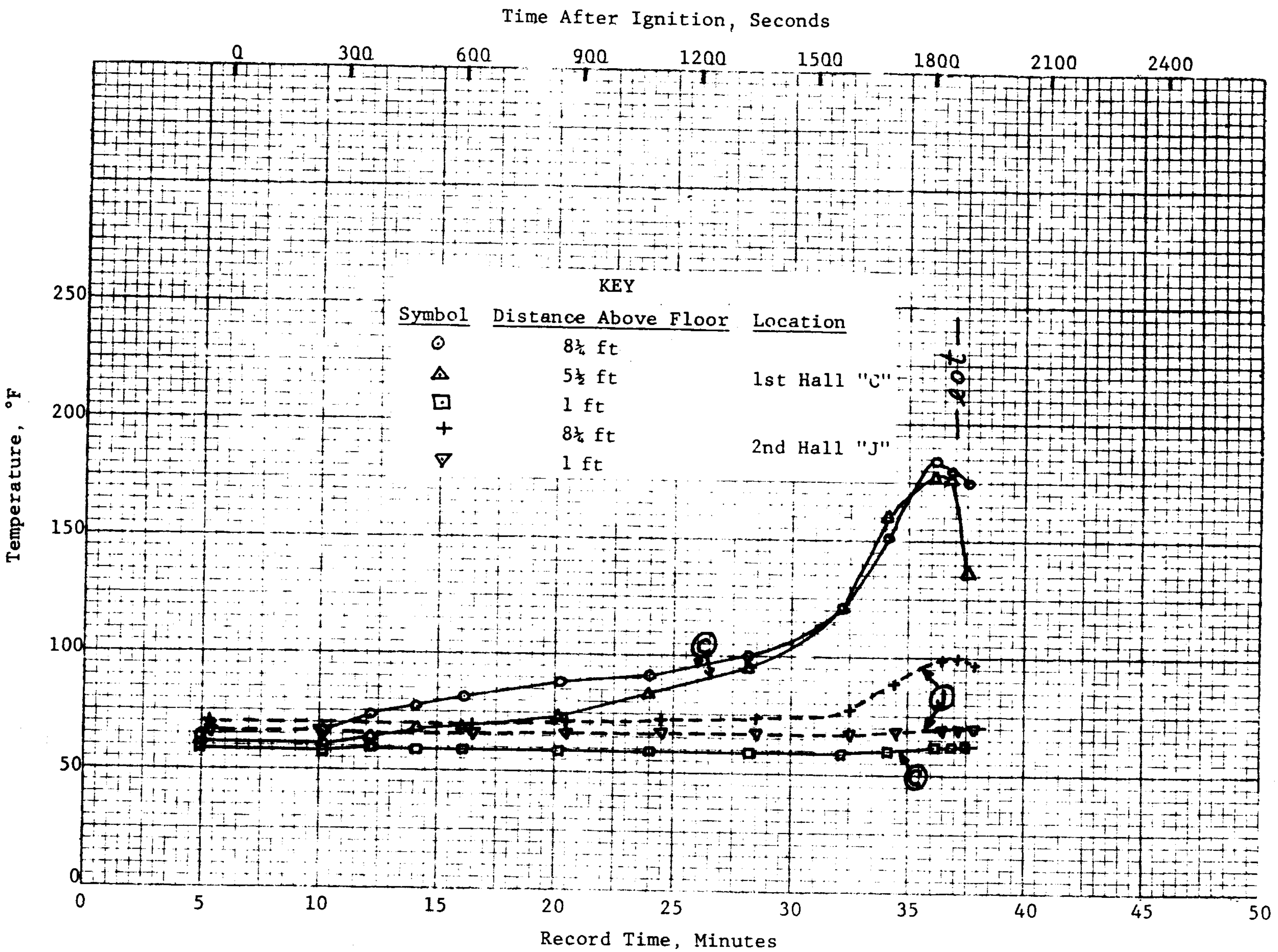
CONDITIONS ON 2ND FLOOR AT 5 FT, JR-1



VARIOUS CONDITIONS, JR-1

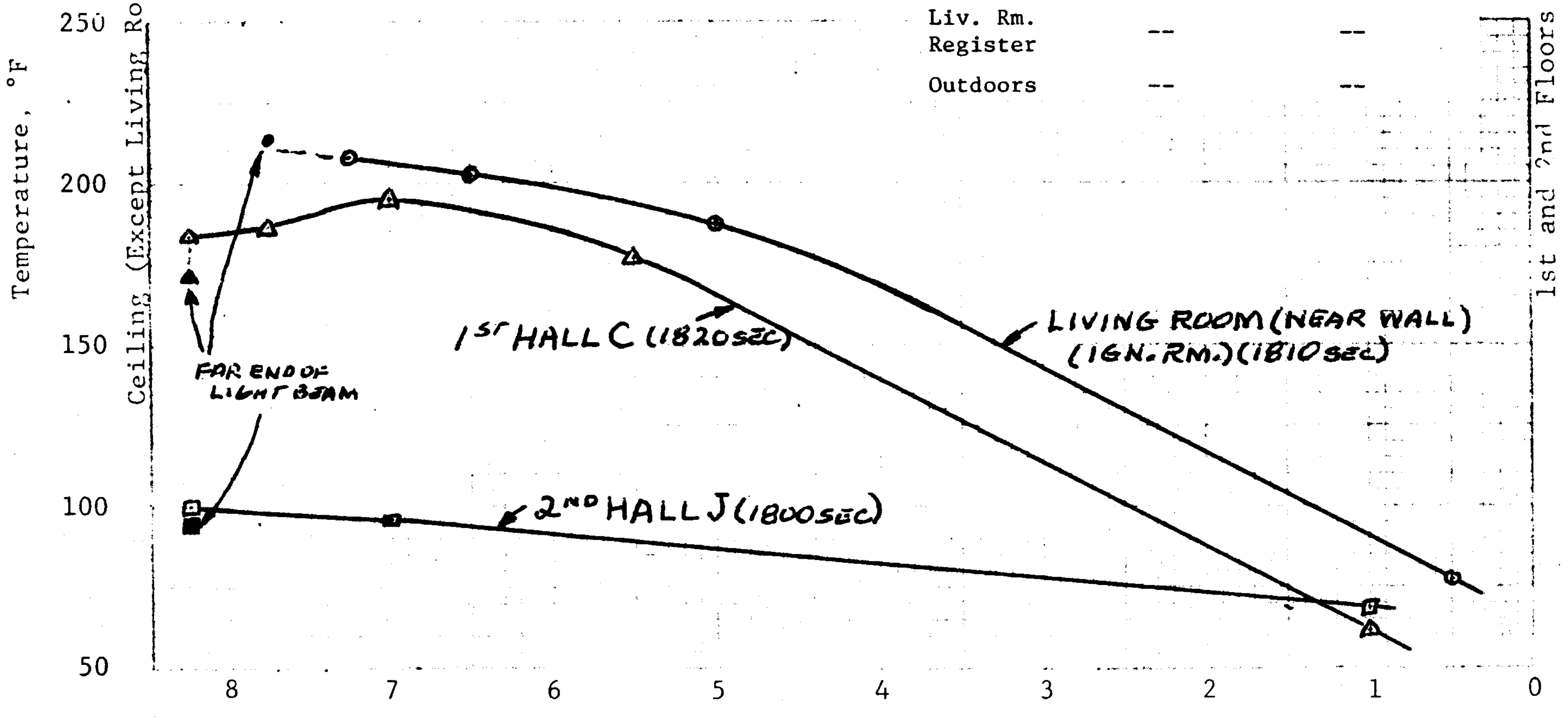


TEMPERATURES IN IGNITION ROOM (LIVING ROOM), JR-1

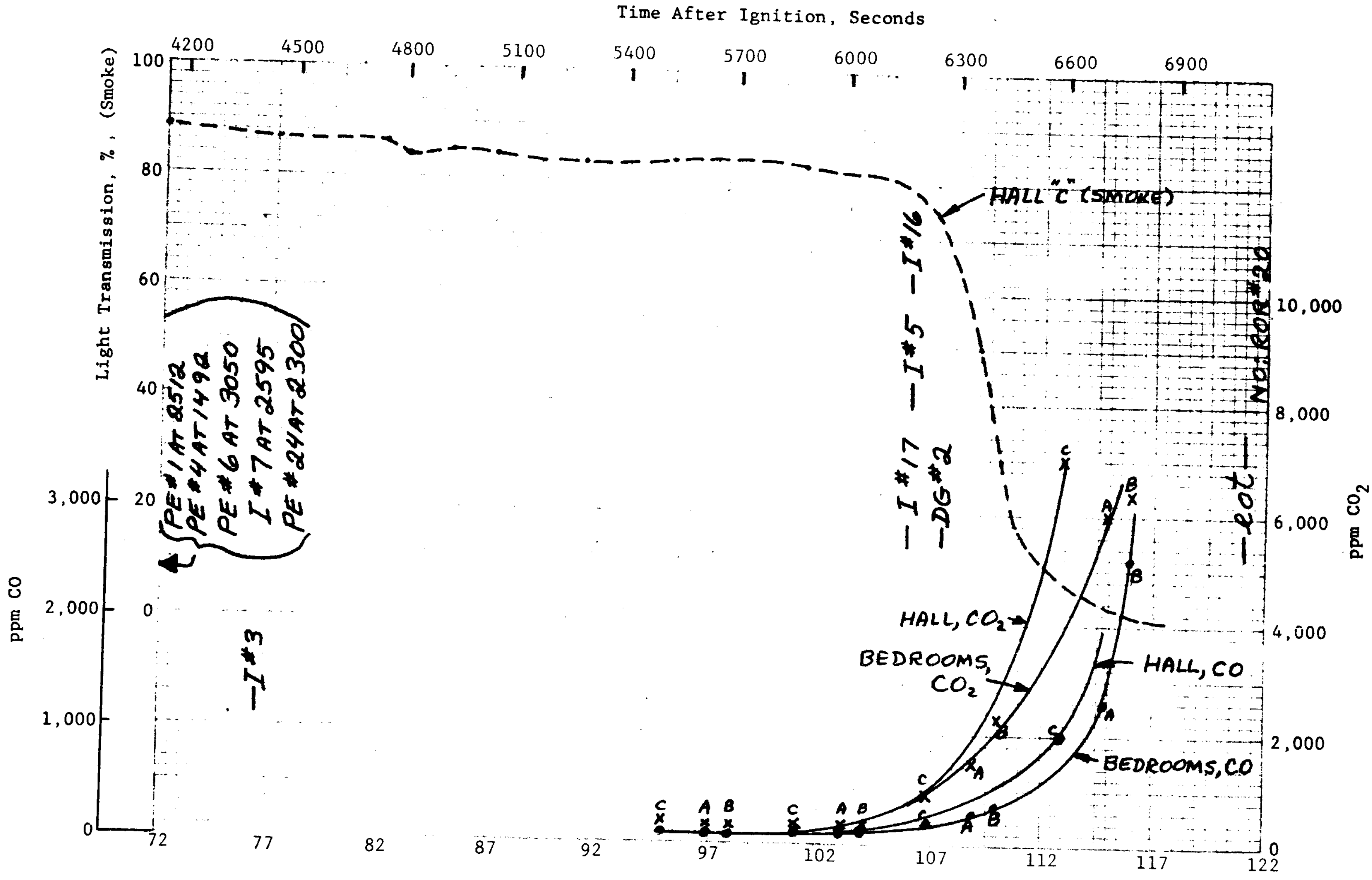


TEMPERATURES IN HALLS, JR-1

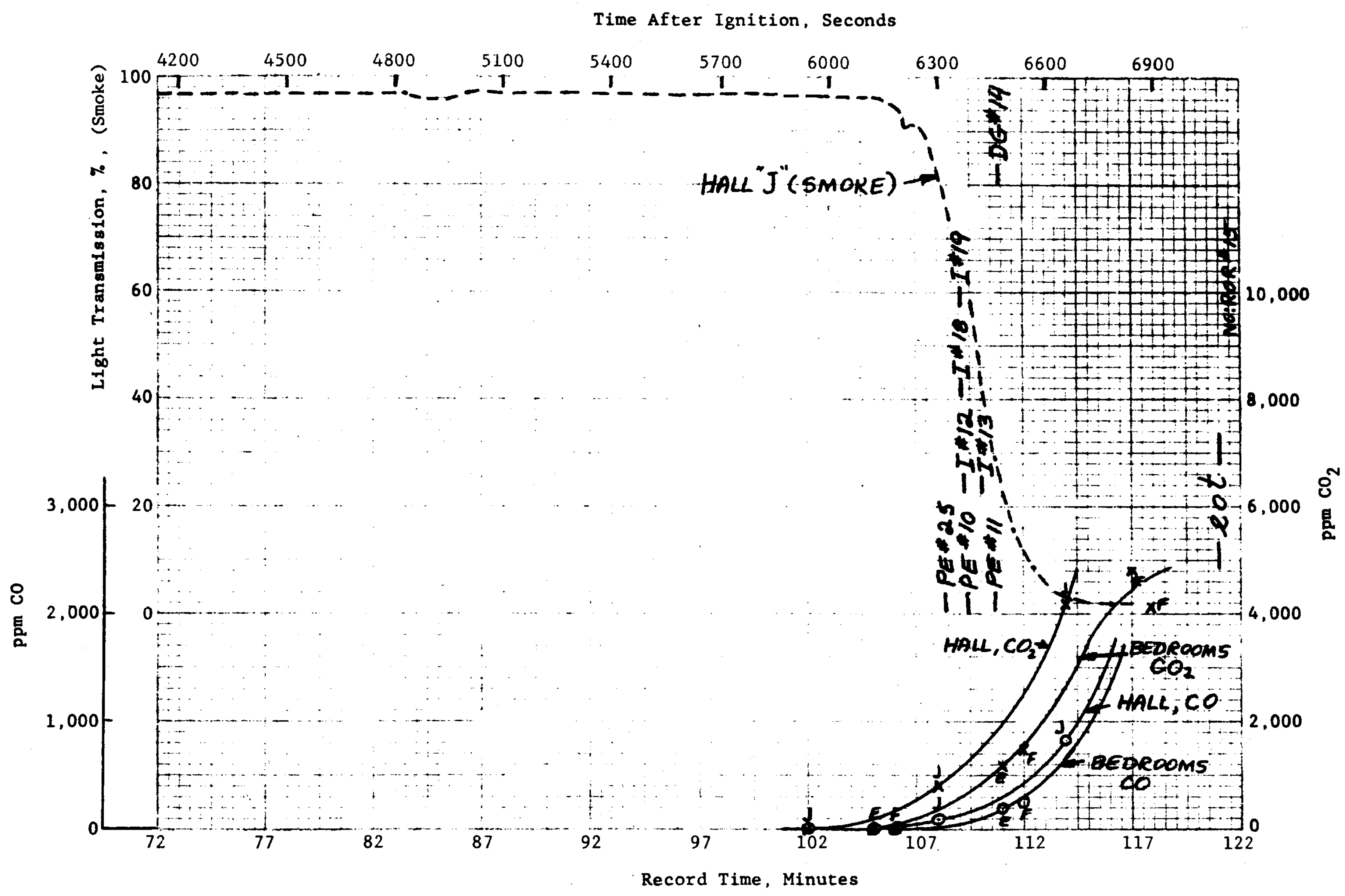
Temps 5' High, 3" From Wall, °F		
Location	Initial	Final (or max.)
1st Bed "A"	62	79
1st Bed "B"	59	86
1st Hall "C"	--	--
2nd Bed "E"	66	79
2nd Bed "F"	65	78
2nd Hall "J"	--	--
Liv. Rm. Register	--	--
Outdoors	--	--



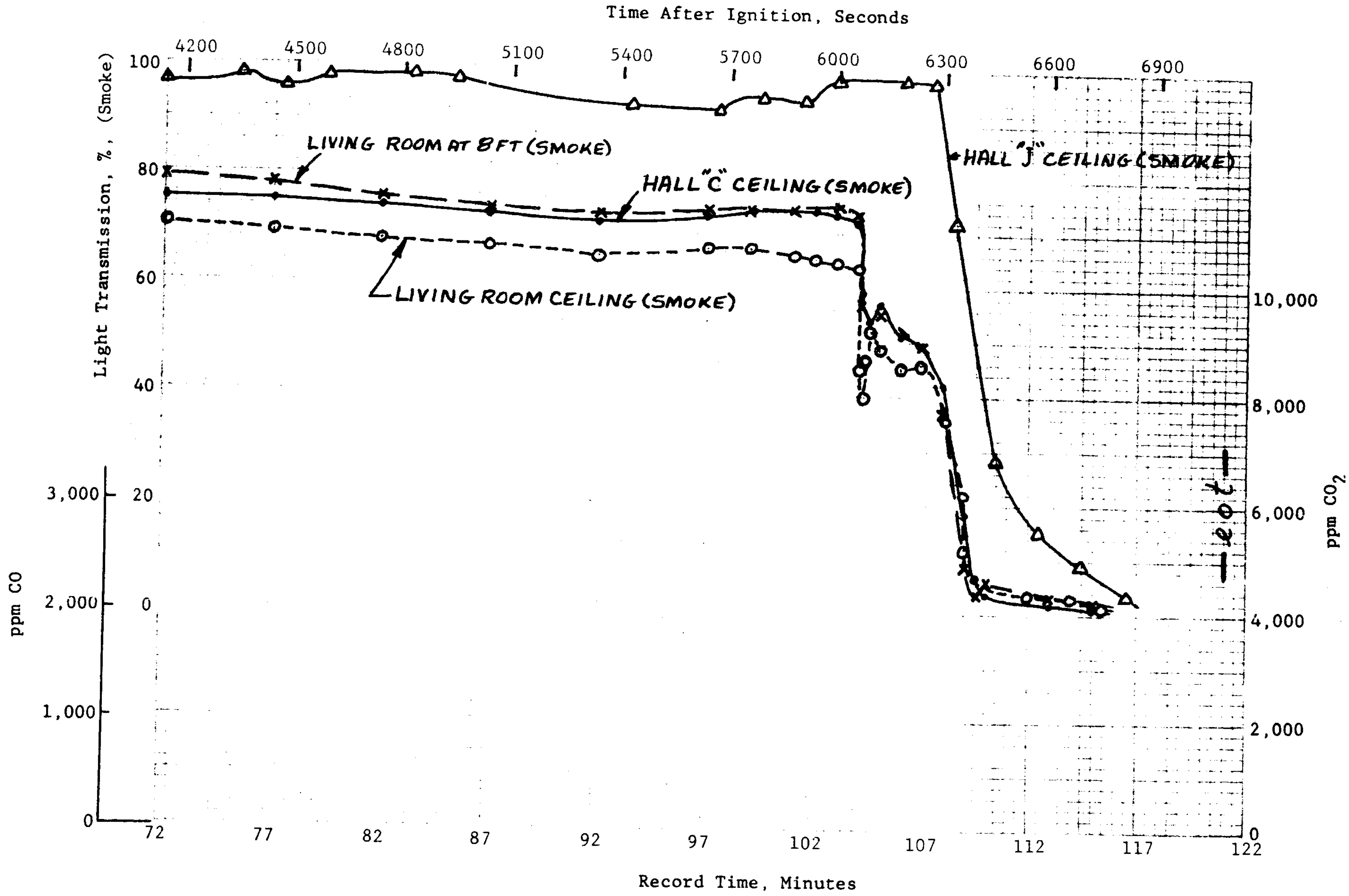
Maximum Temperature Profiles, JR-1



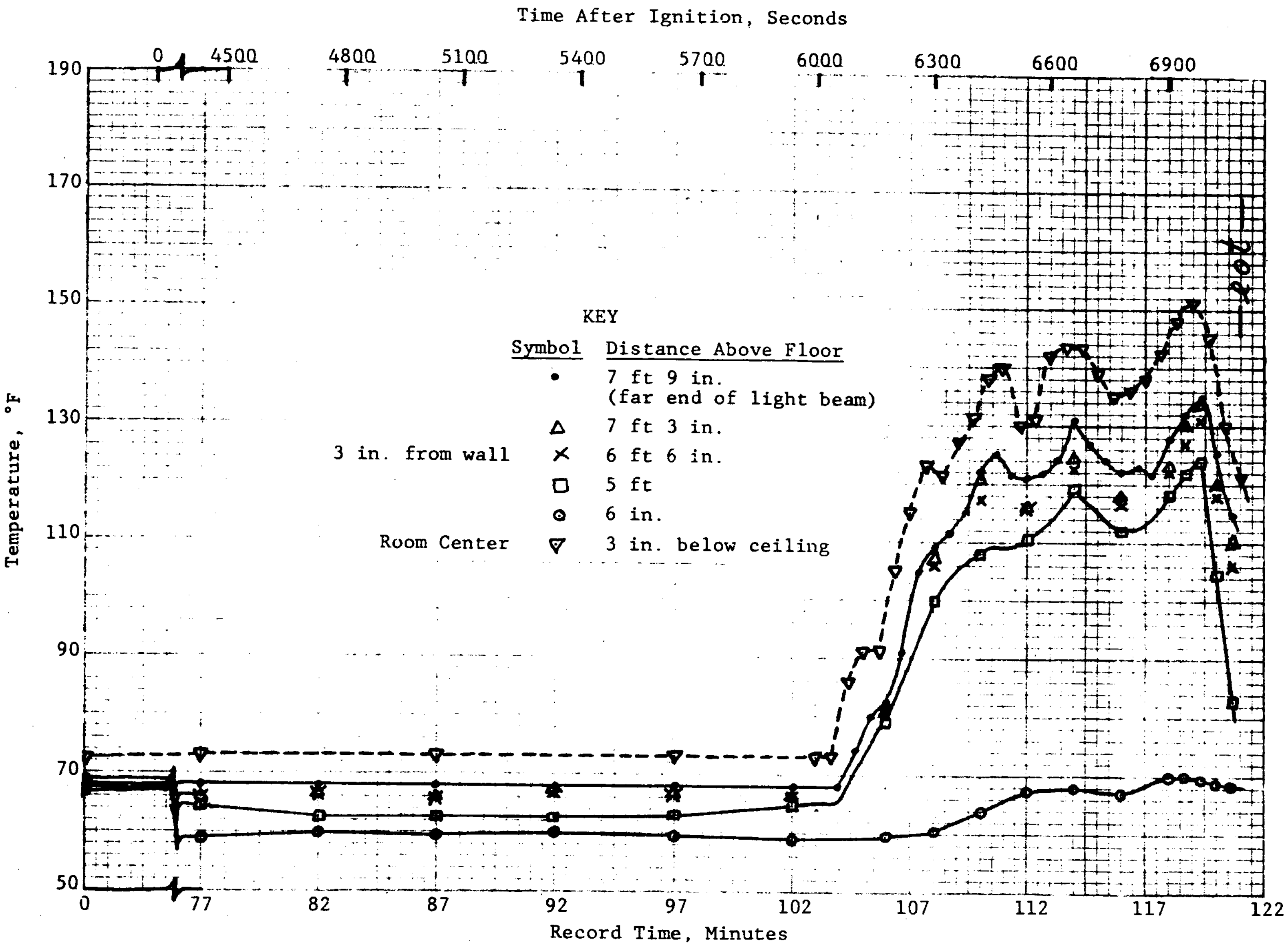
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-2



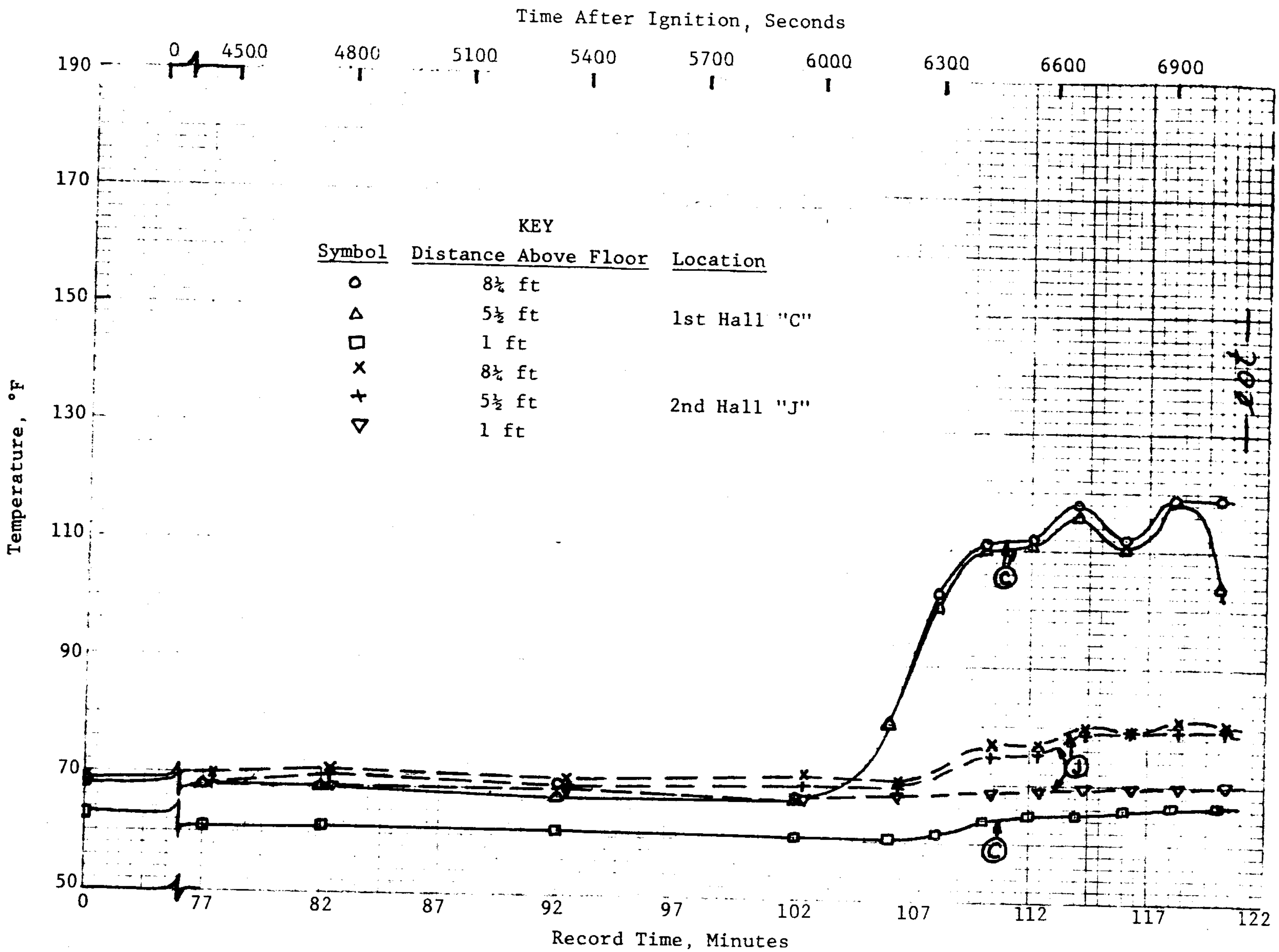
CONDITIONS ON 2ND FLOOR AT 5 FT, JR-2



VARIOUS CONDITIONS, JR-2



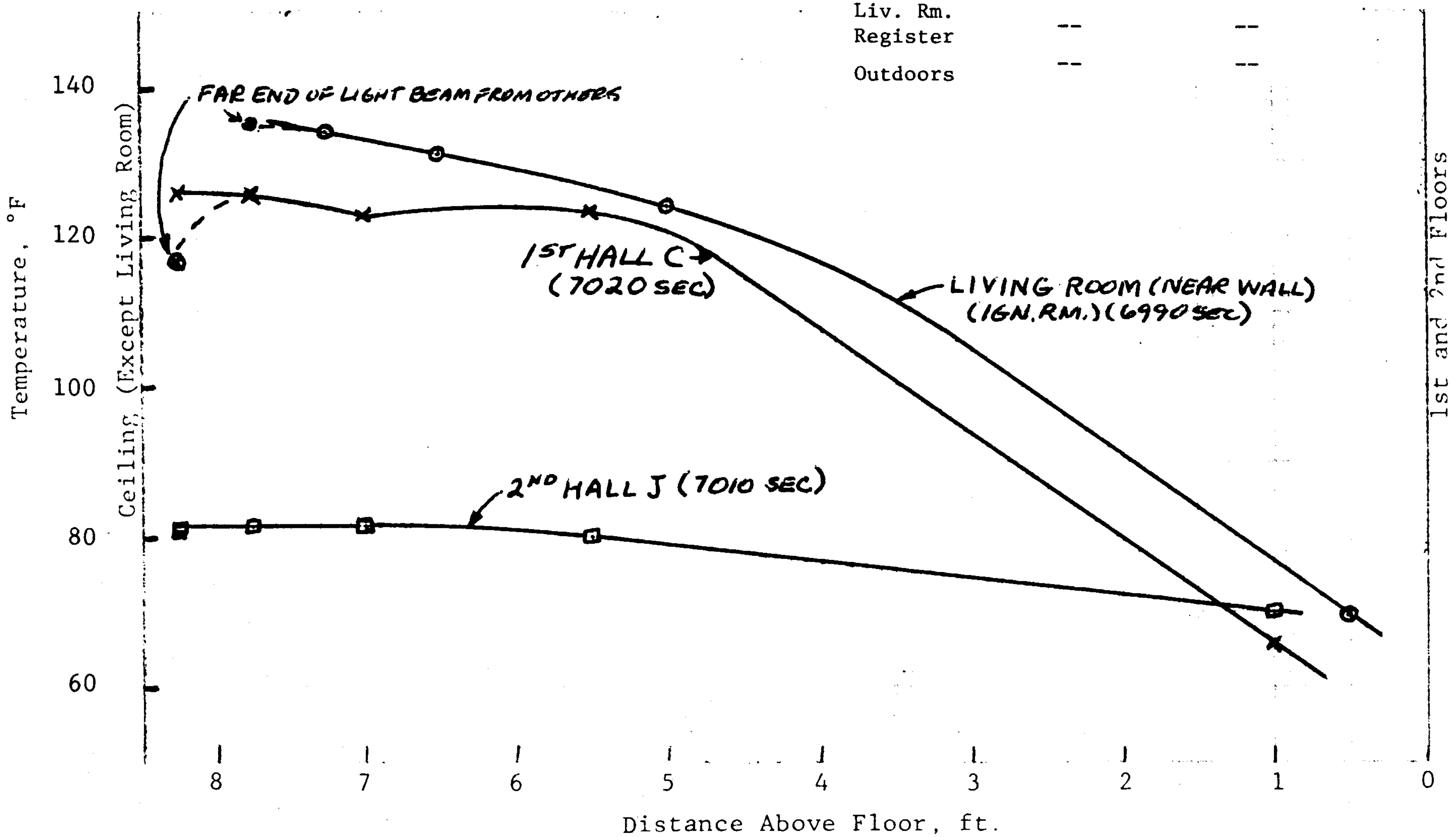
TEMPERATURES IN IGNITION ROOM (LIVING ROOM), JR-2



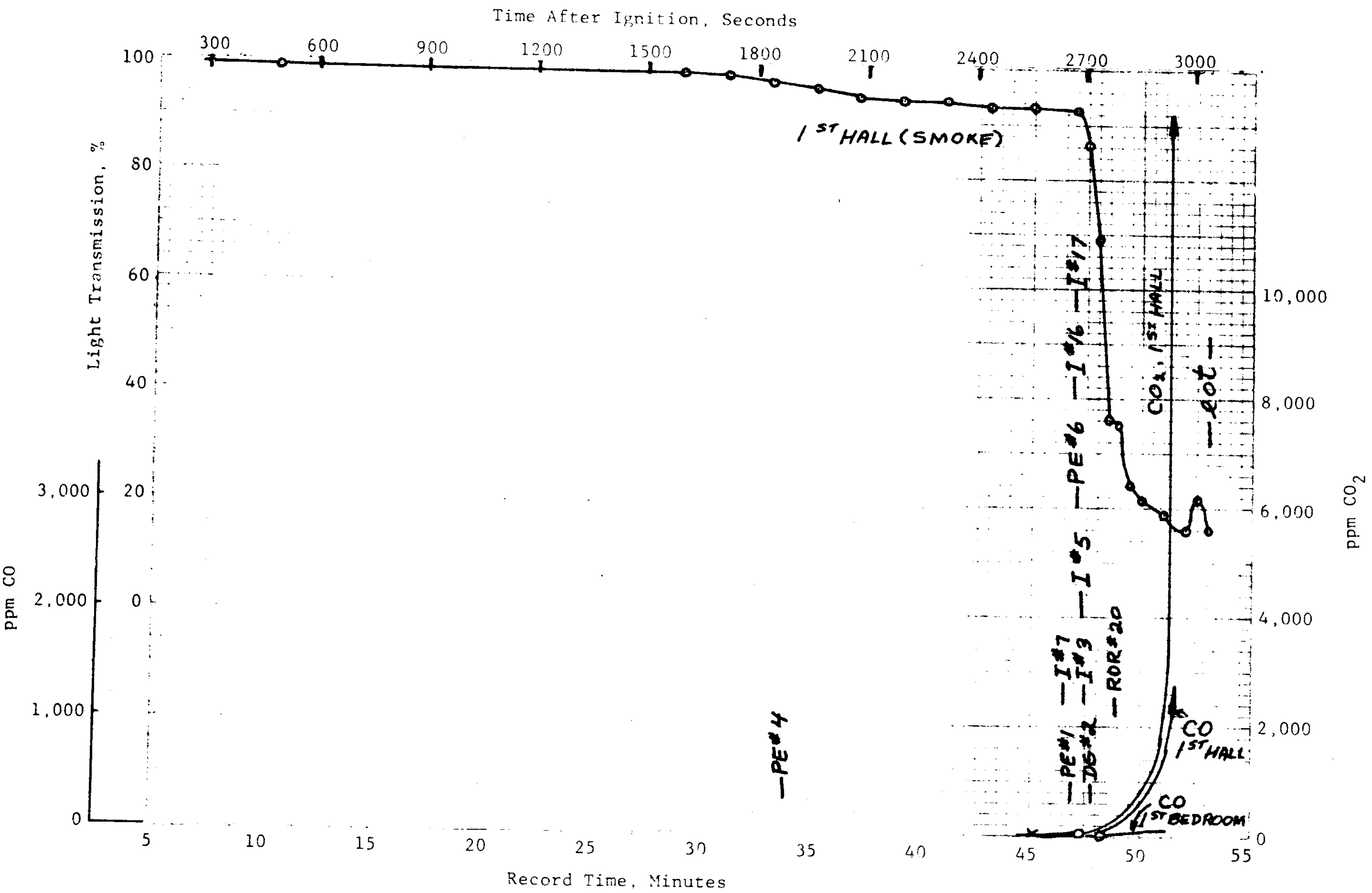
TEMPERATURES IN HALLS, JR-2

Temps 5' High, 3" From Wall, °F

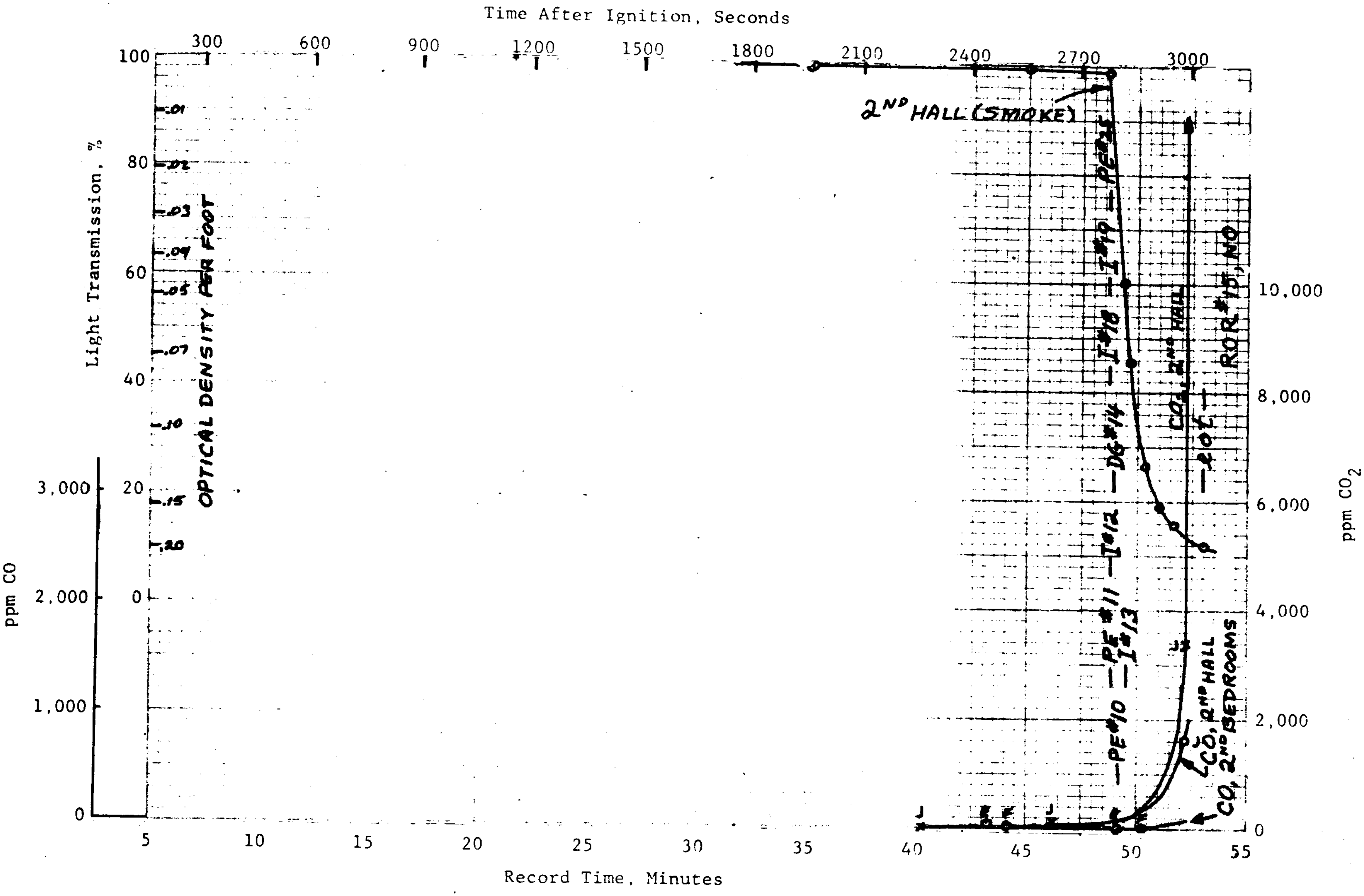
Location	Initial	Final (or max.)
1st Bed "A"	64	69
1st Bed "B"	65	73
1st Hall "C"	62	76
2nd Bed "E"	64.5	71
2nd Bed "F"	63.5	70
2nd Hall "J"	64	75
Liv. Rm. Register	--	--
Outdoors	--	--



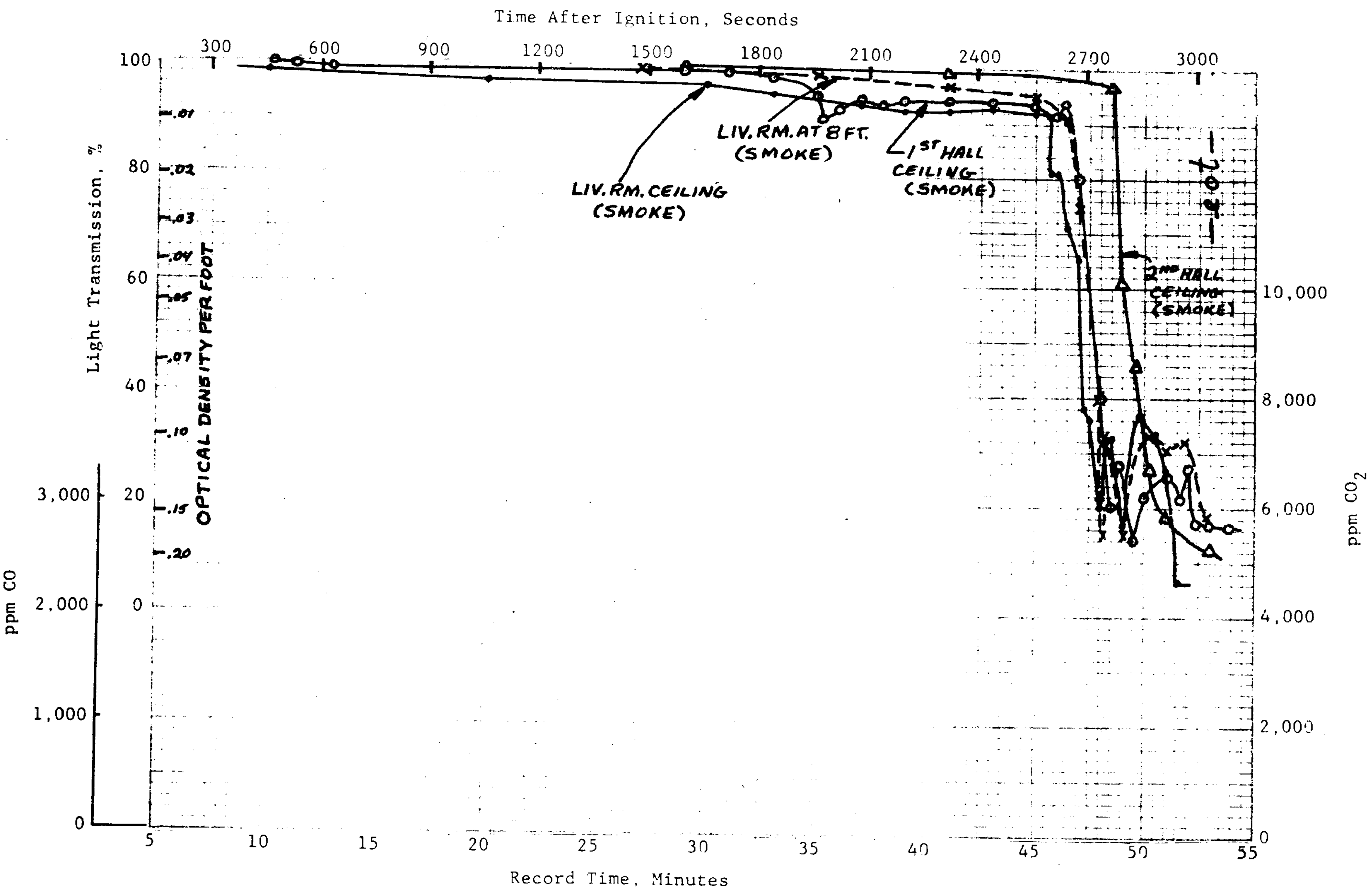
Maximum Temperature Profiles, JR-2



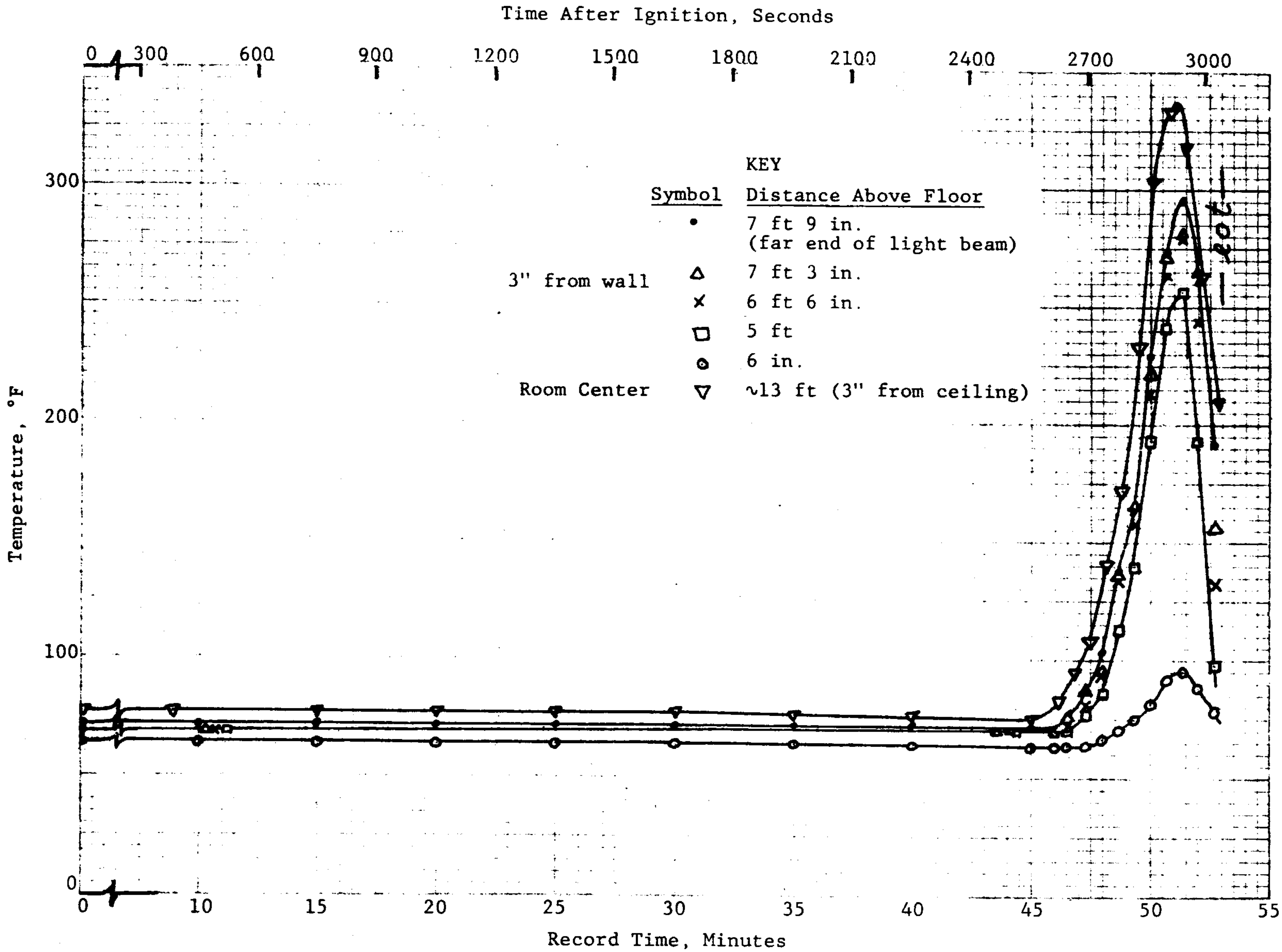
CONDITIONS 5 FT ABOVE 1ST FLOOR, JR-3



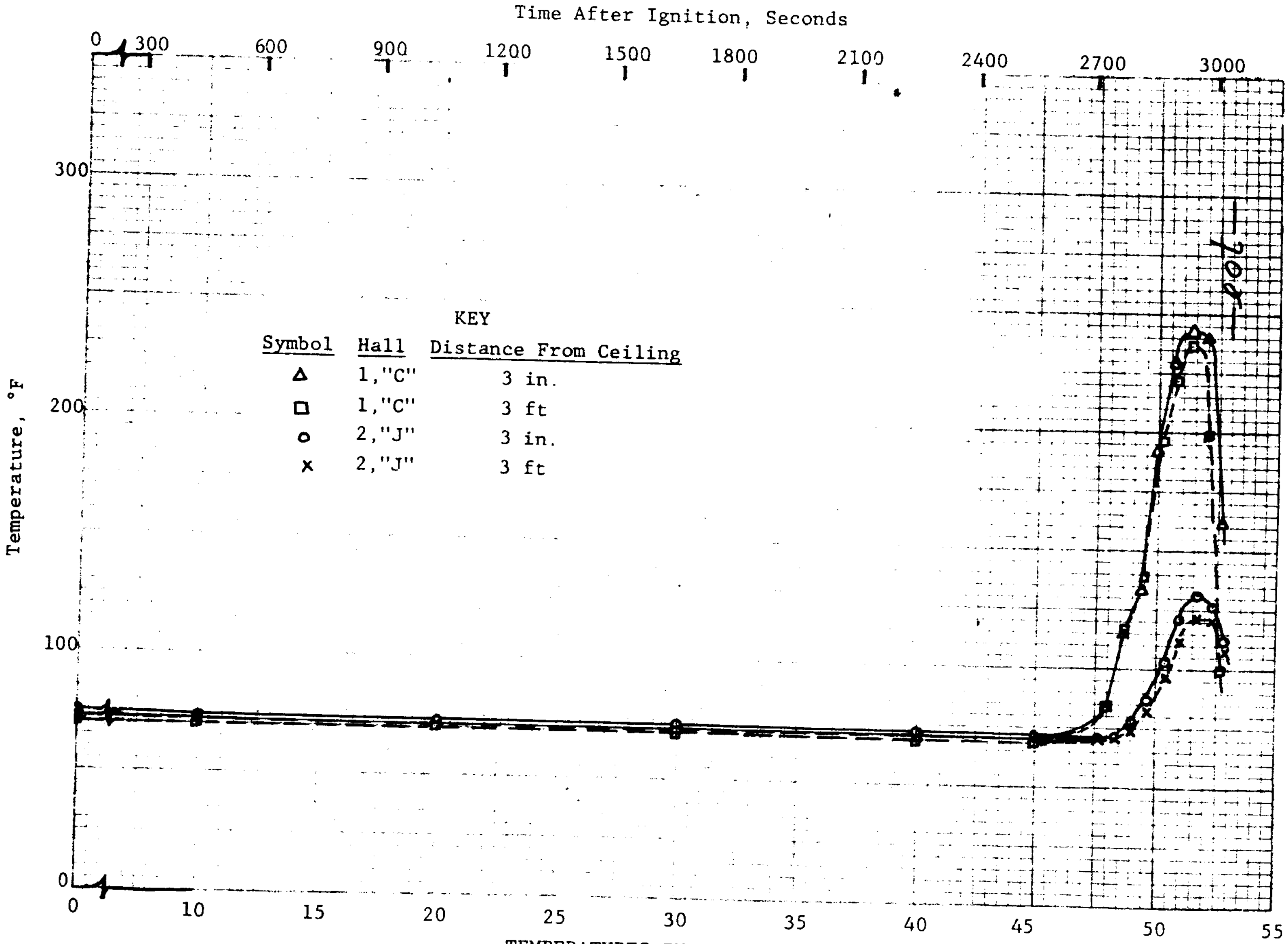
CONDITIONS 5 FT ABOVE 2ND FLOOR, JR-3



VARIOUS CONDITIONS, JR-3

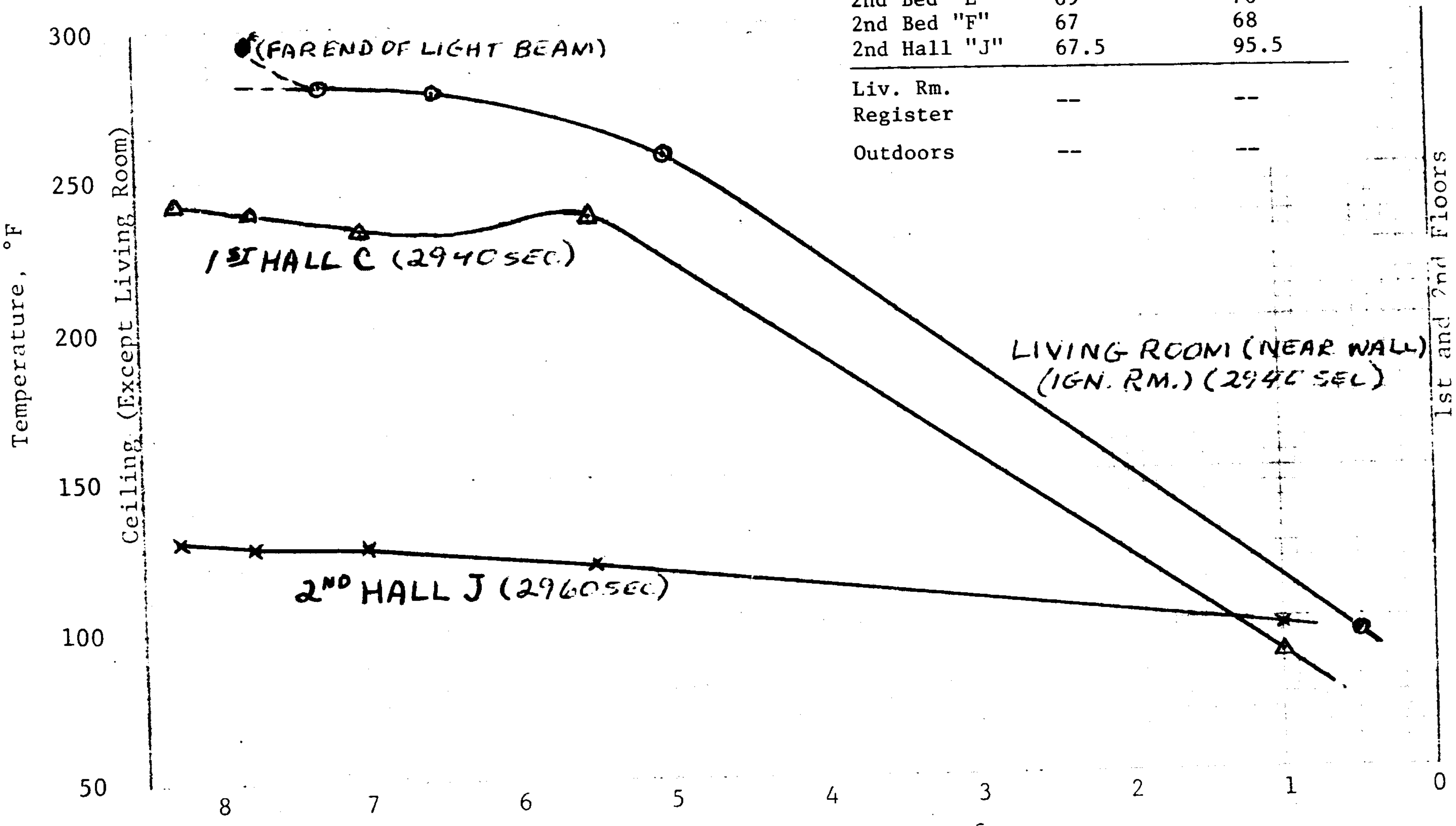


TEMPERATURES IN IGNITION ROOM (LIVING ROOM), JR-3

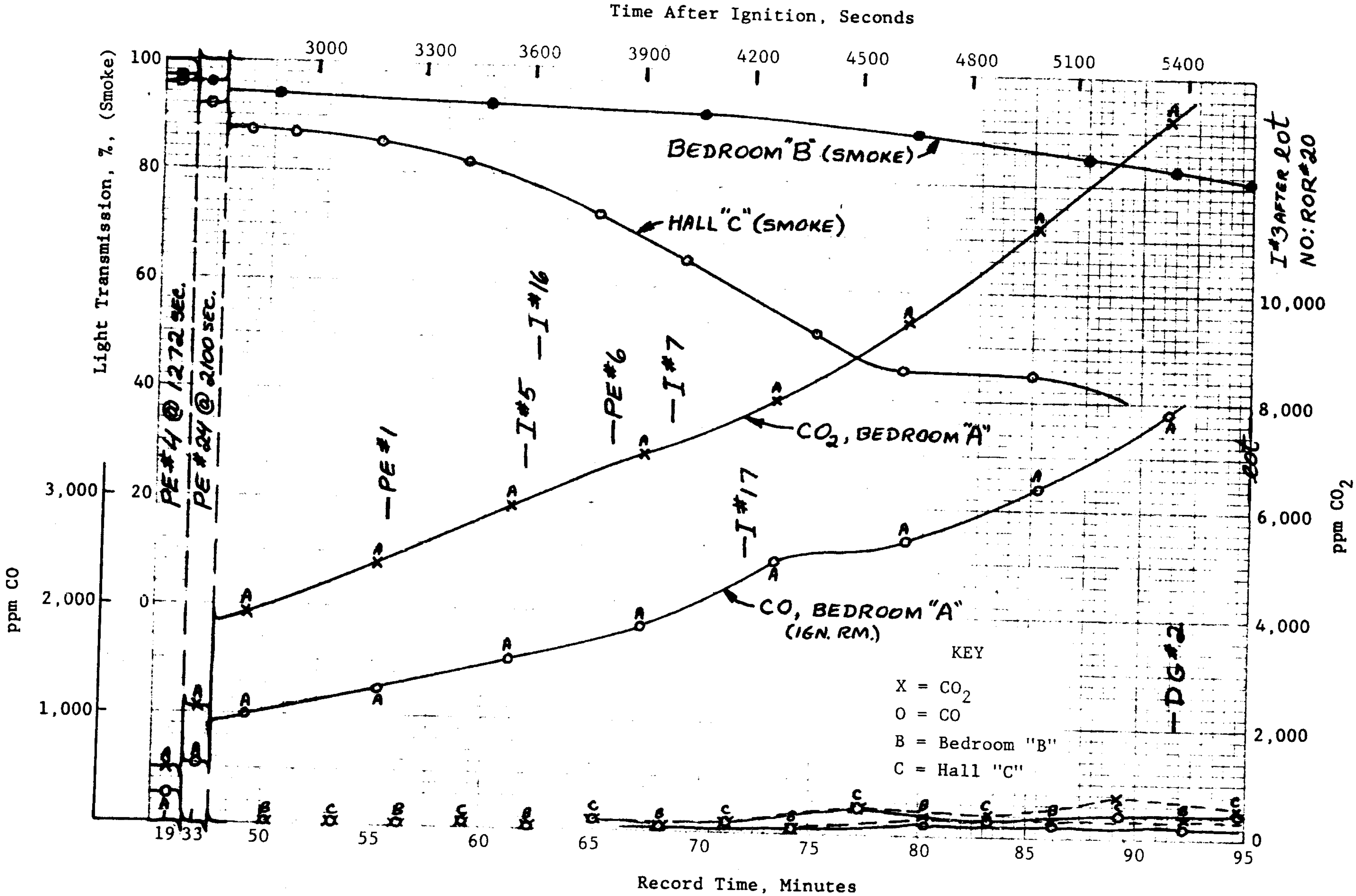


TEMPERATURES IN HALLS, JR-3

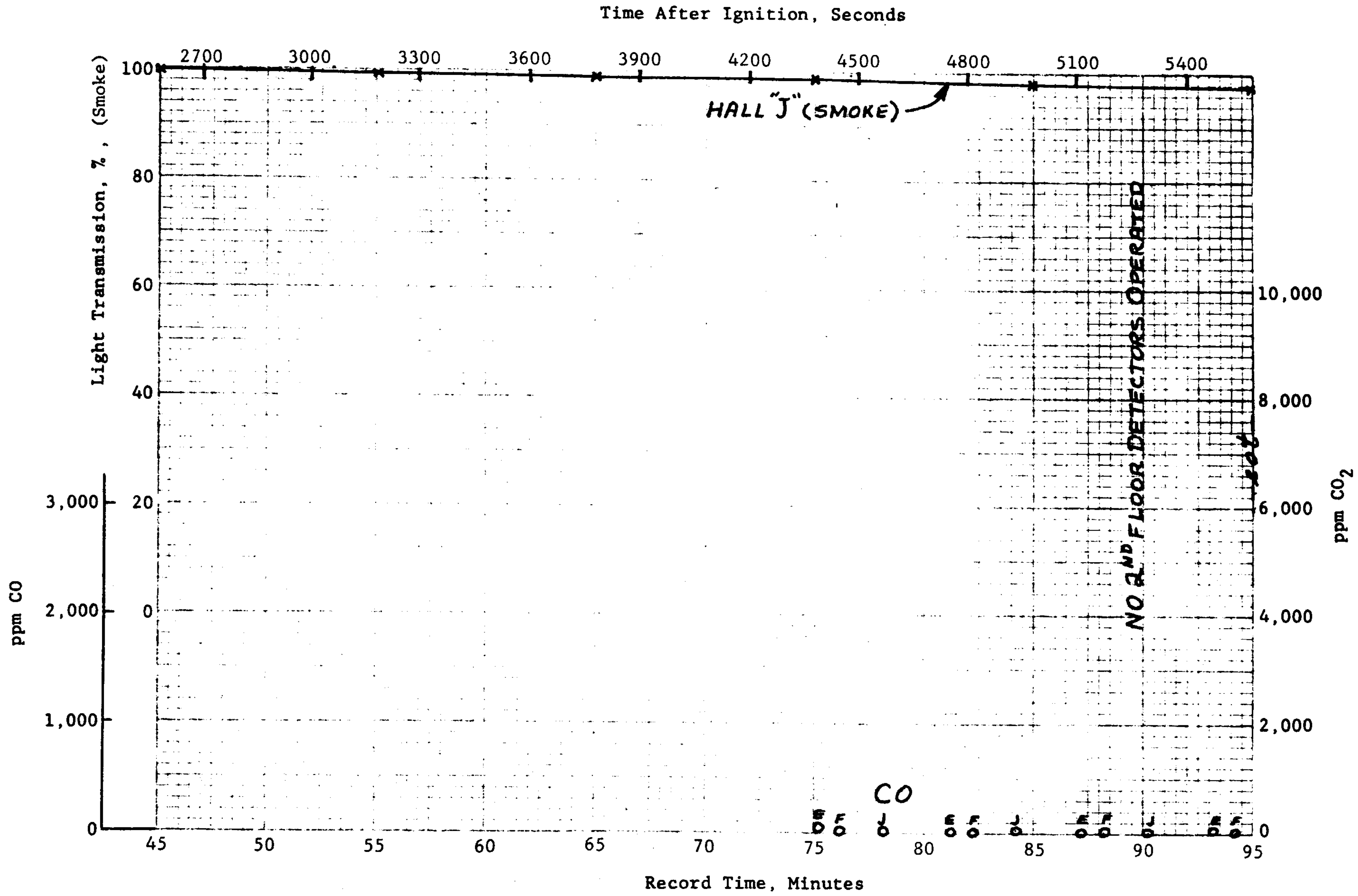
Location	Initial	Final (or max.)
Temps 5' High, 3" From Wall, °F		
1st Bed "A"	64.5	64
1st Bed "B"	63.5	62.5
1st Hall "C"	65.5	165
2nd Bed "E"	69	70
2nd Bed "F"	67	68
2nd Hall "J"	67.5	95.5
Liv. Rm. Register	--	--
Outdoors	--	--



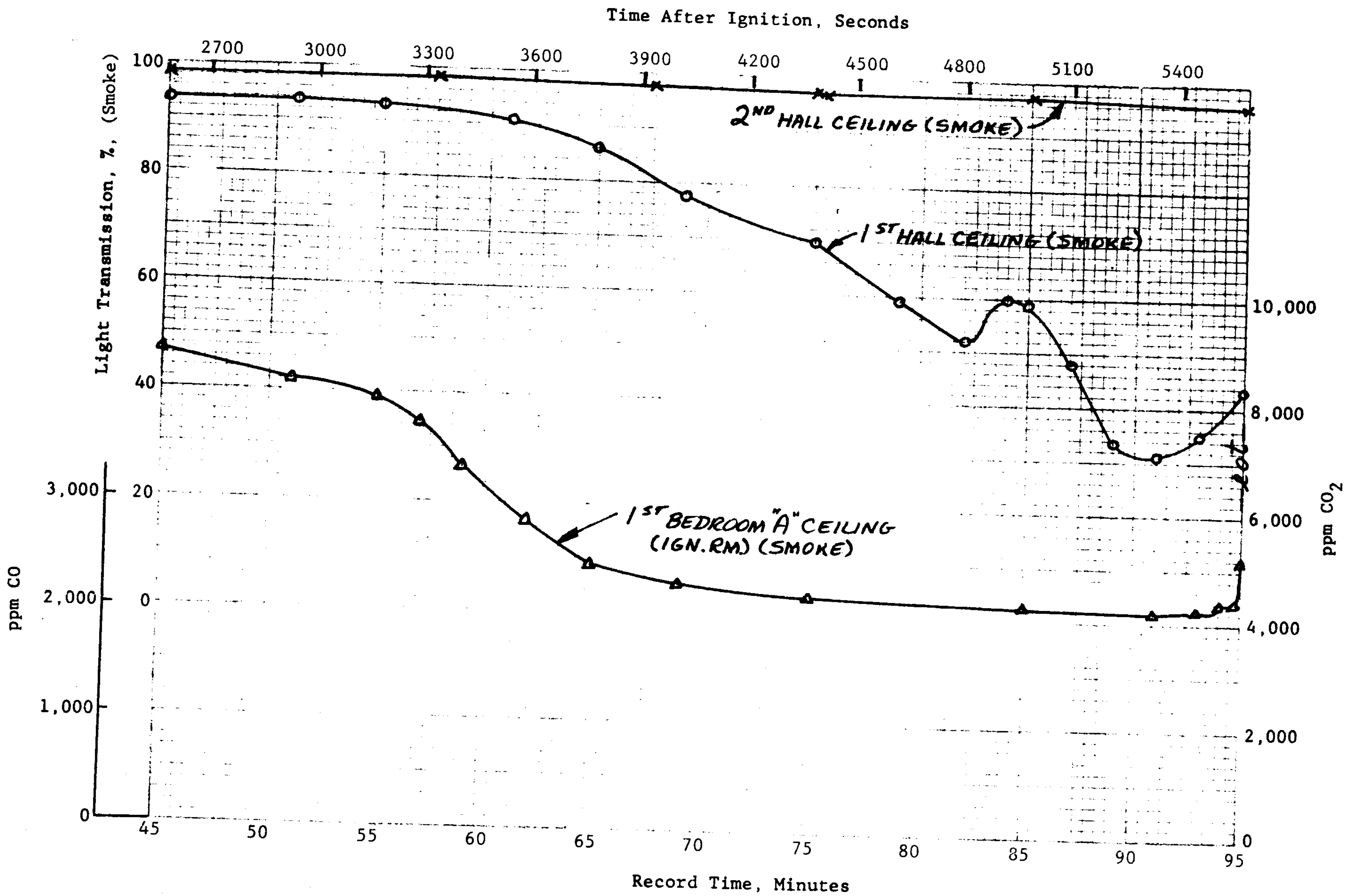
Maximum Temperature Profiles. JR-3



CONDITIONS 5 FT ABOVE 1ST FLOOR, JR-4



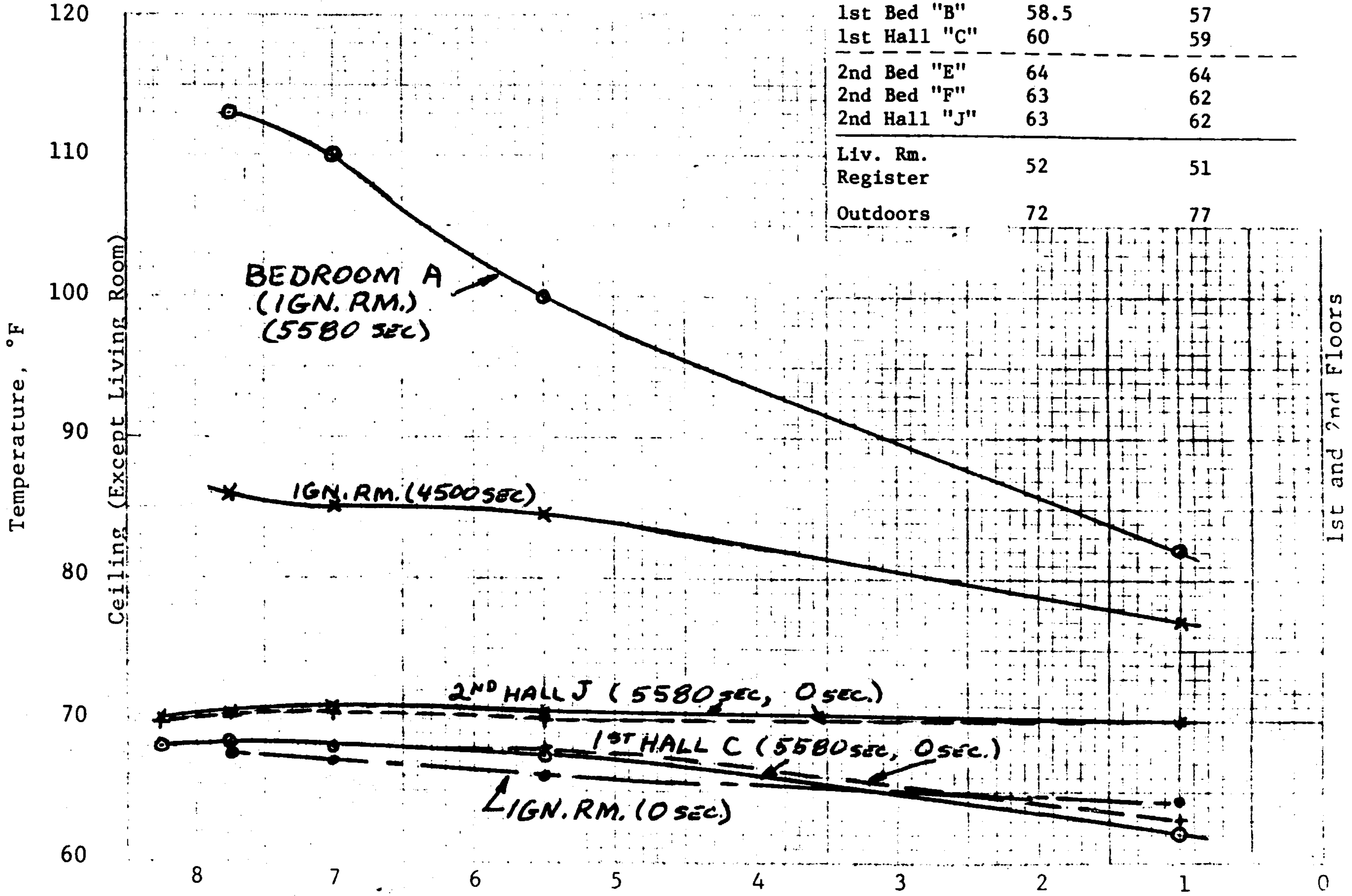
CONDITIONS 5 FT ABOVE 2ND FLOOR, JR-4



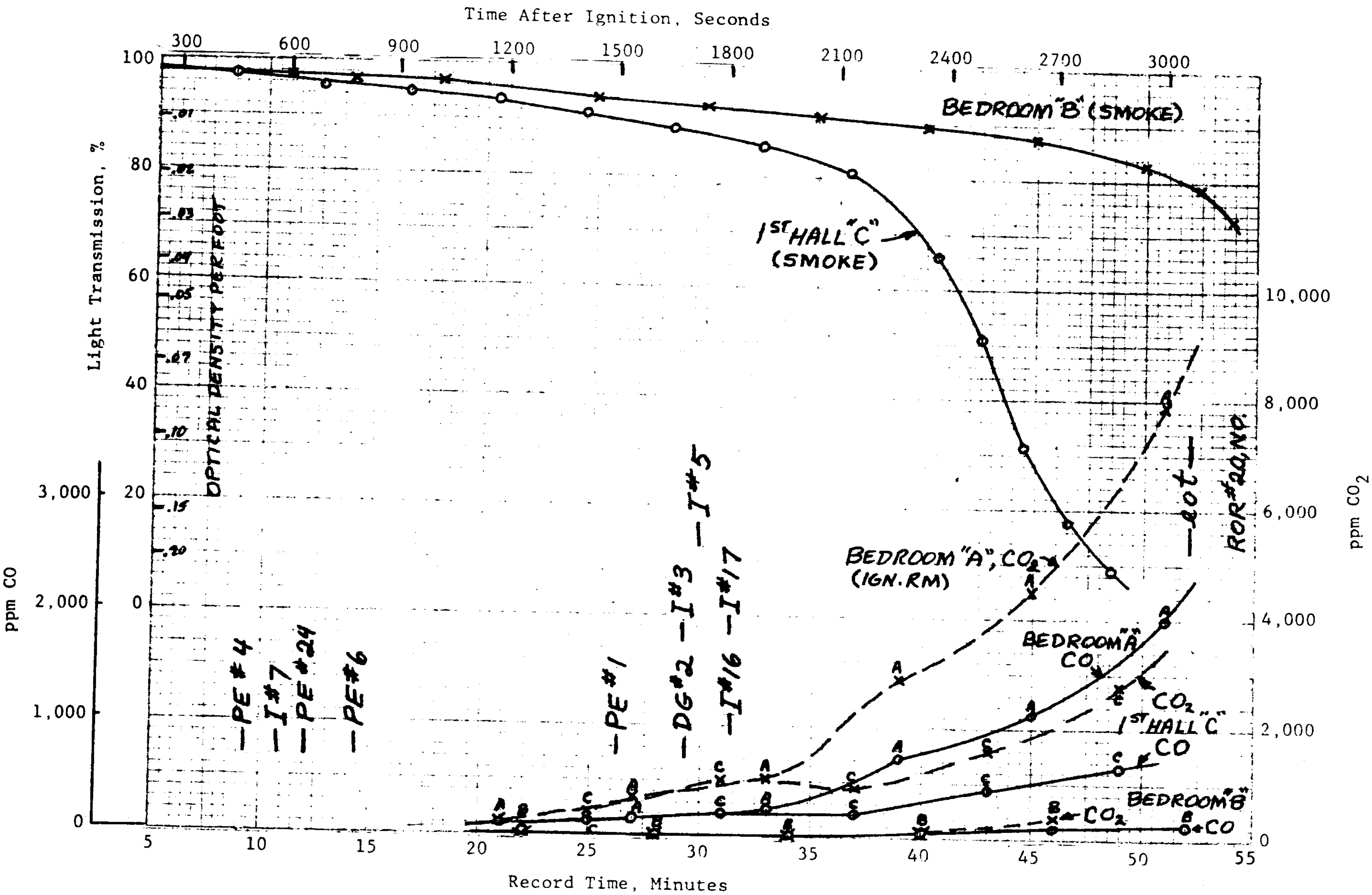
VARIOUS CONDITIONS, JR-4

Location	Initial	Final (or max.)
1st Bed "A"	64	96
1st Bed "B"	58.5	57
1st Hall "C"	60	59
2nd Bed "E"	64	64
2nd Bed "F"	63	62
2nd Hall "J"	63	62
Liv. Rm. Register	52	51
Outdoors	72	77

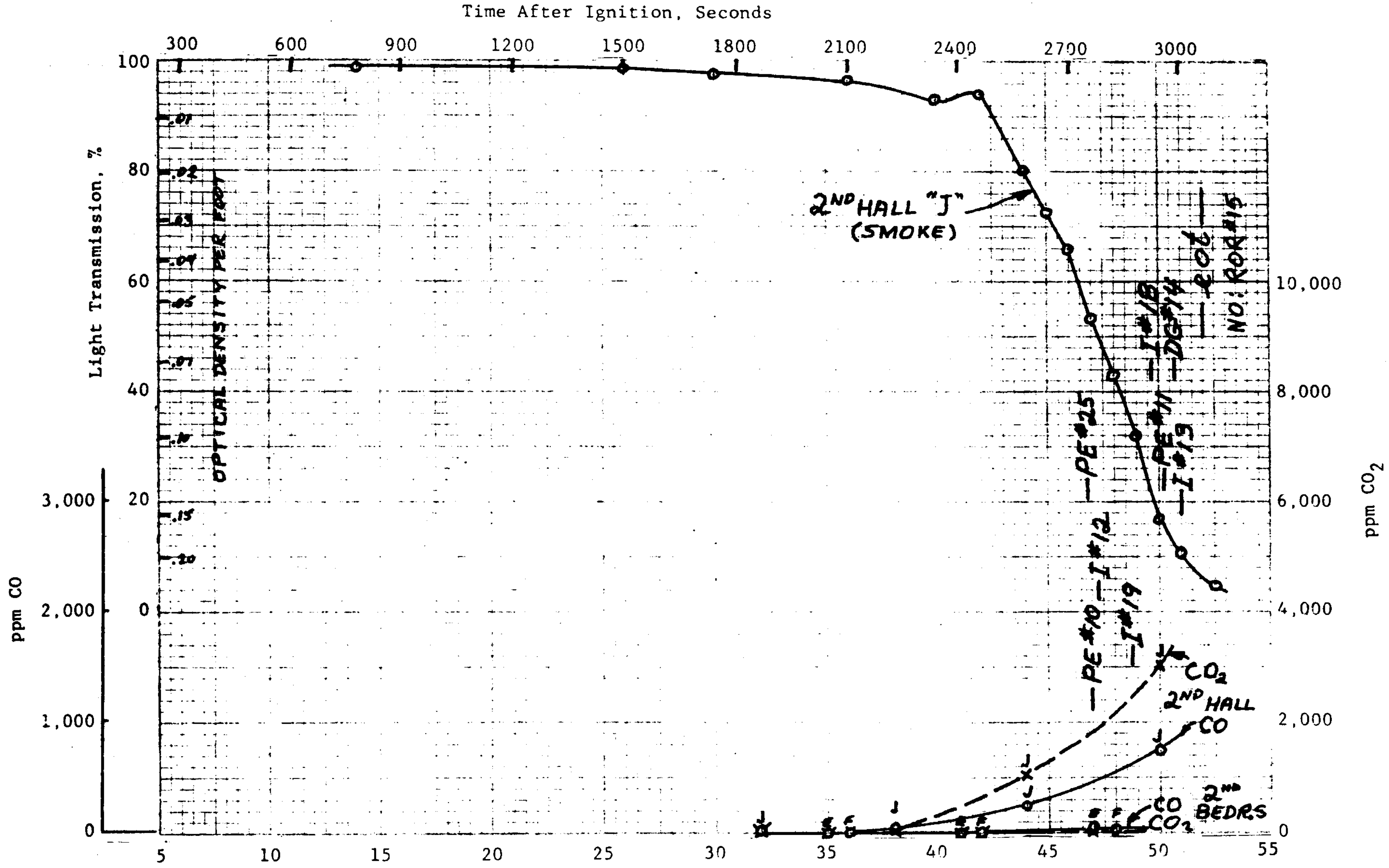
Temps 5' High, 3" From Wall, °F



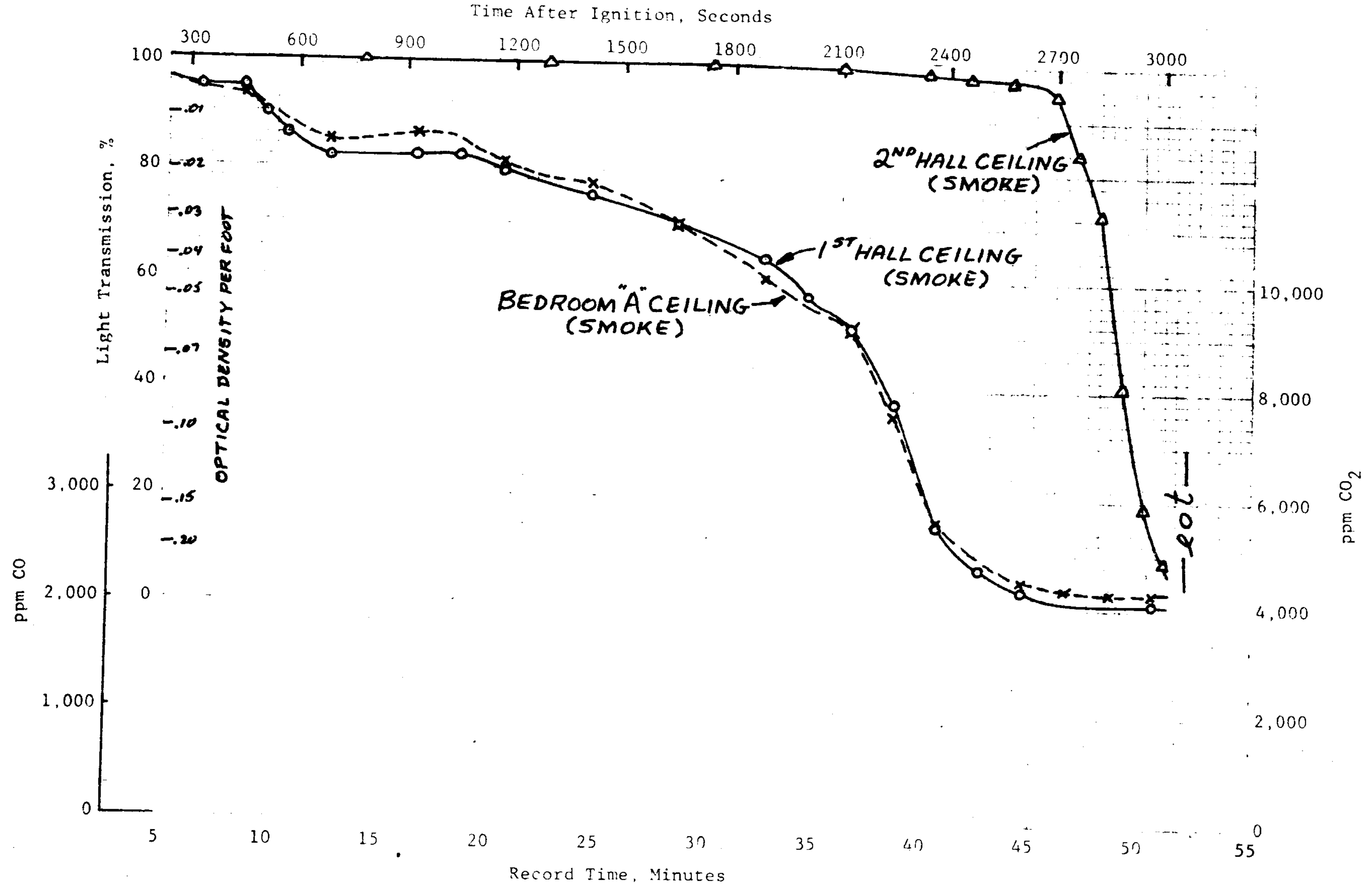
Maximum Temperature Profiles, JR-4



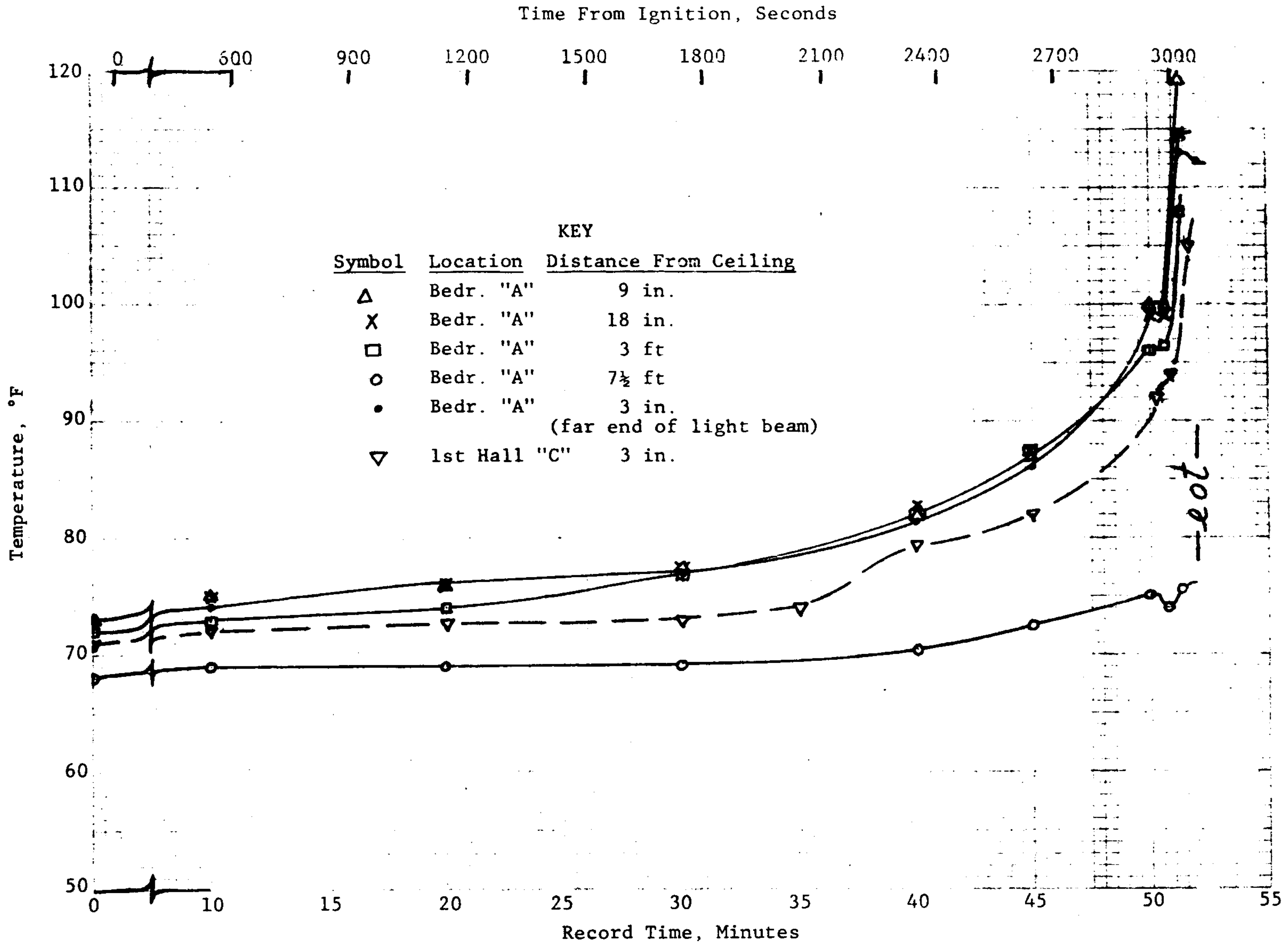
CONDITIONS 5 FT ABOVE 1ST FLOOR, JR-5



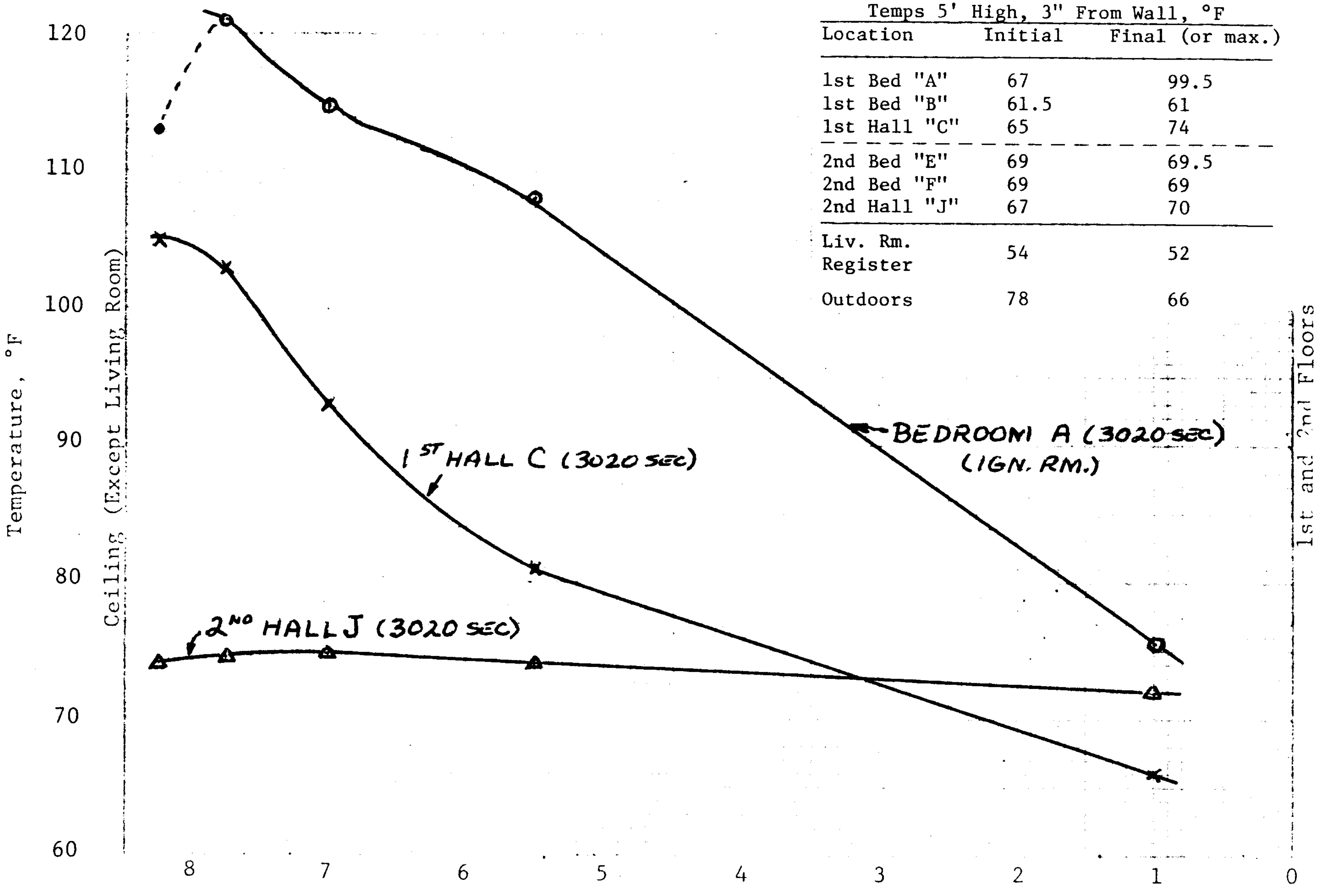
CONDITIONS 5 FT ABOVE 2ND FLOOR, JR-5



VARIOUS CONDITIONS, JR-5

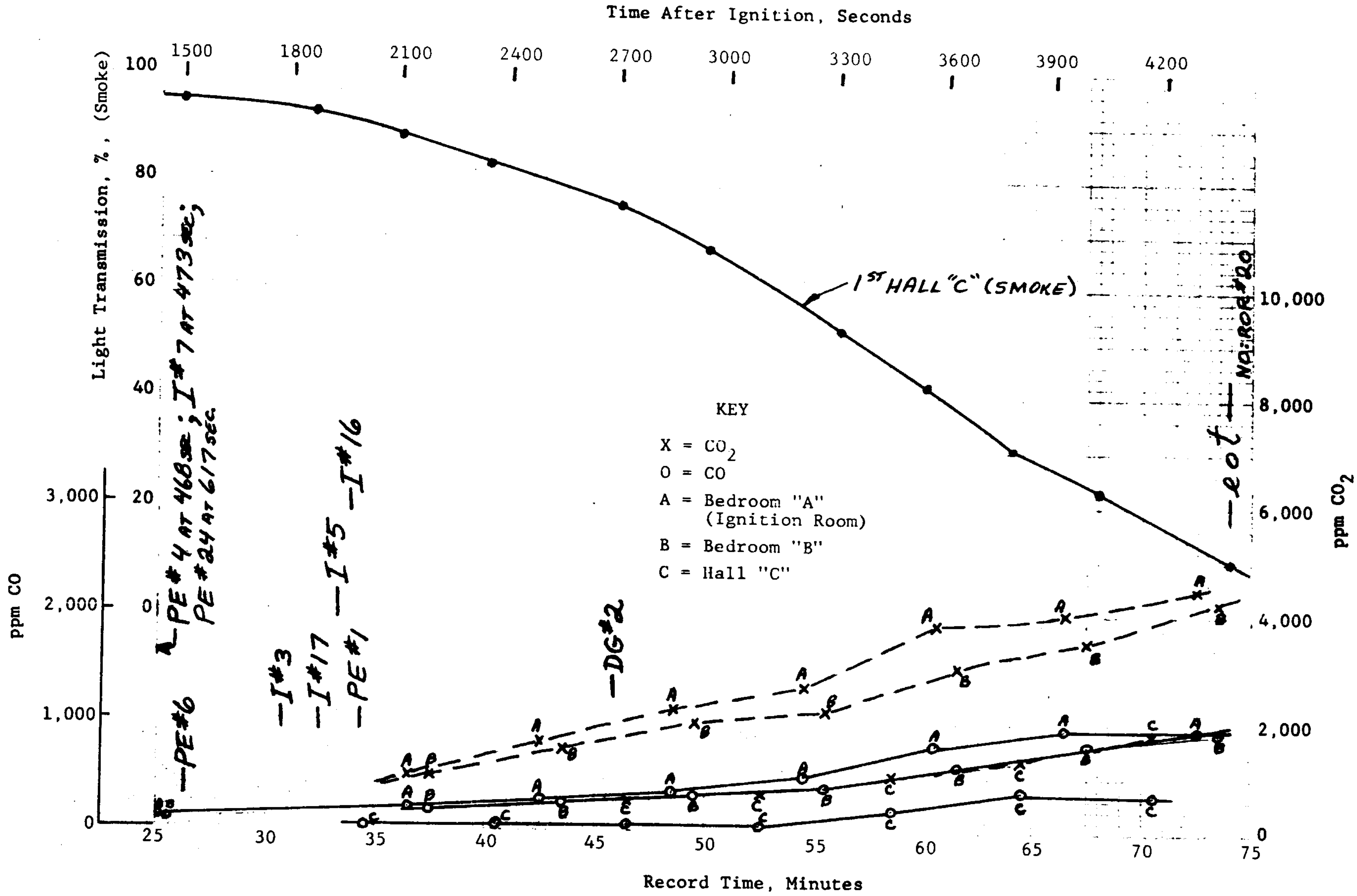


TEMPERATURES IN IGNITION ROOM (BEDROOM "A") AND 1ST HALL, JR-5

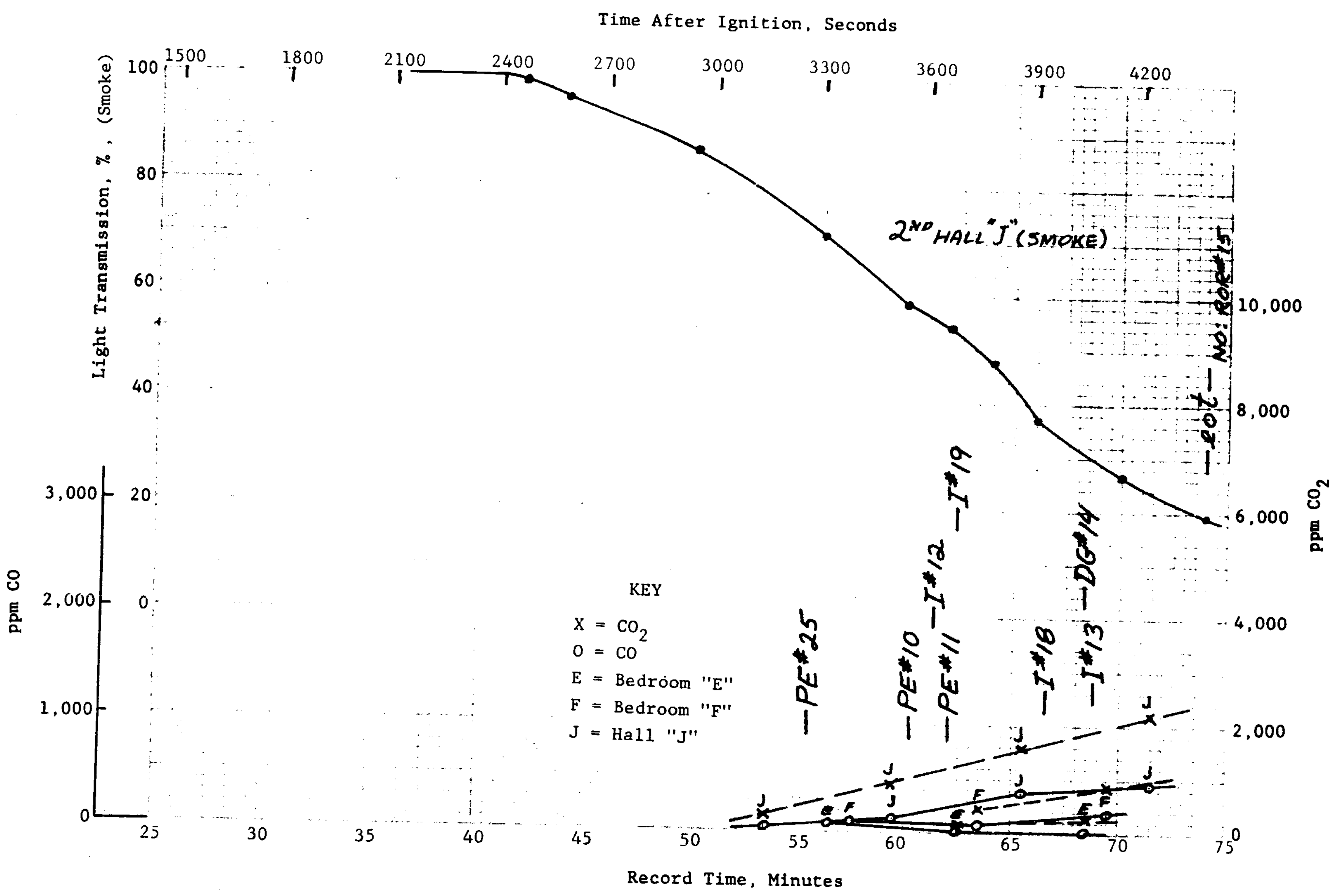


Maximum Temperature Profiles, JR-5

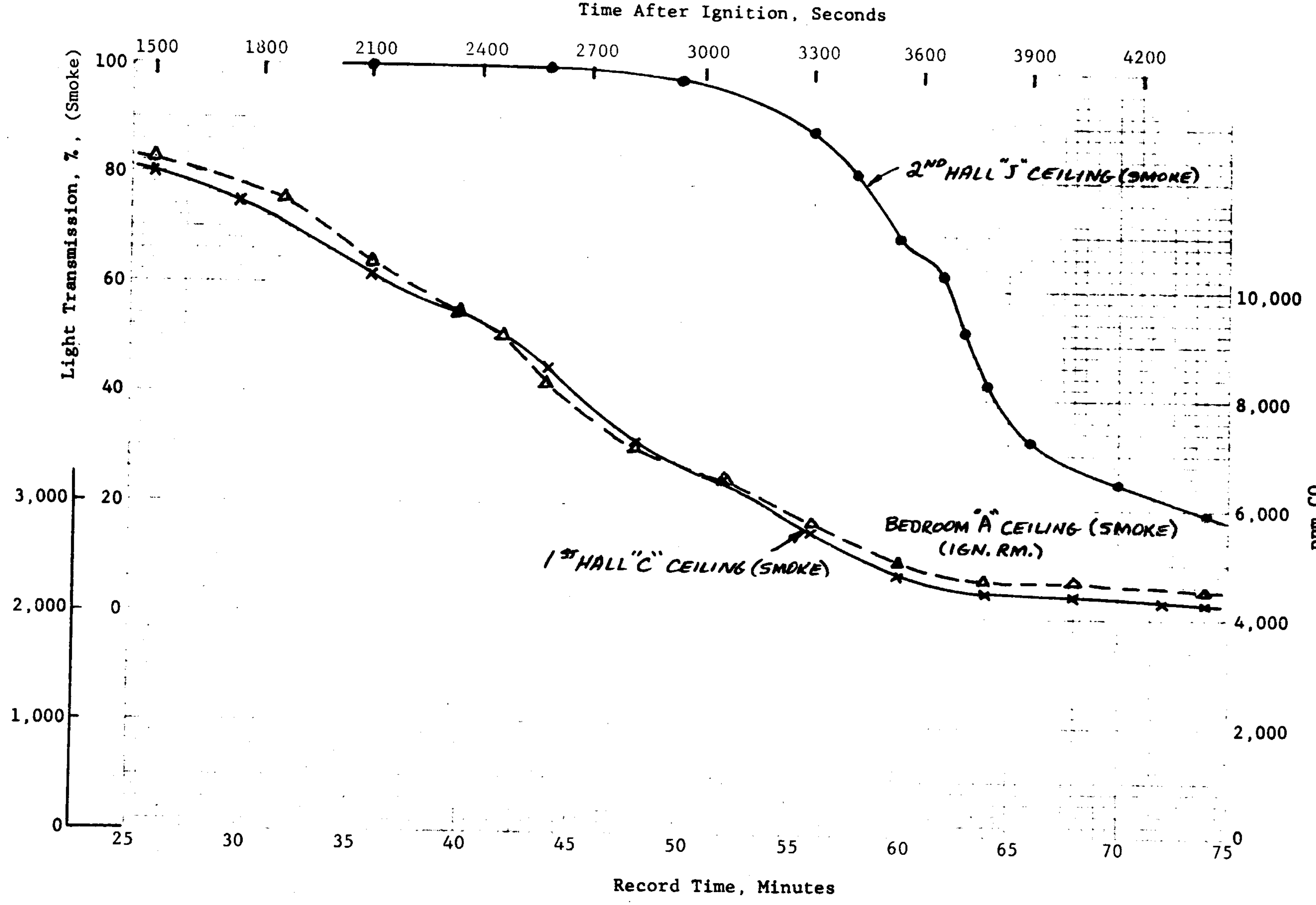
Location	Temps 5' High, 3" From Wall, °F Initial	Final (or max.)
1st Bed "A"	67	99.5
1st Bed "B"	61.5	61
1st Hall "C"	65	74
2nd Bed "E"	69	69.5
2nd Bed "F"	69	69
2nd Hall "J"	67	70
Liv. Rm. Register	54	52
Outdoors	78	66



CONDITIONS 5 FT ABOVE 1ST FLOOR, JR-6

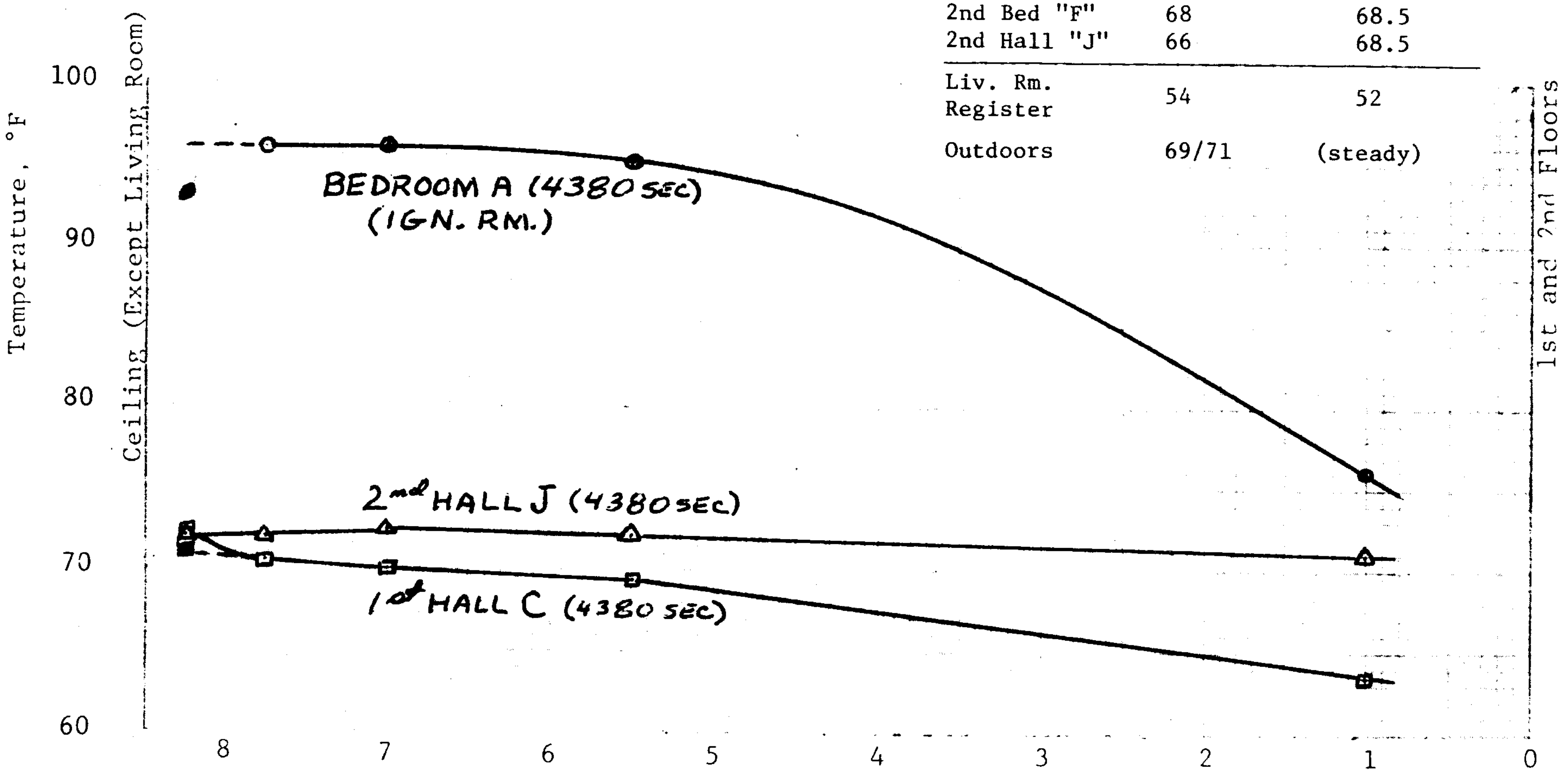


CONDITIONS 5 FT ABOVE 2ND FLOOR, JR-6

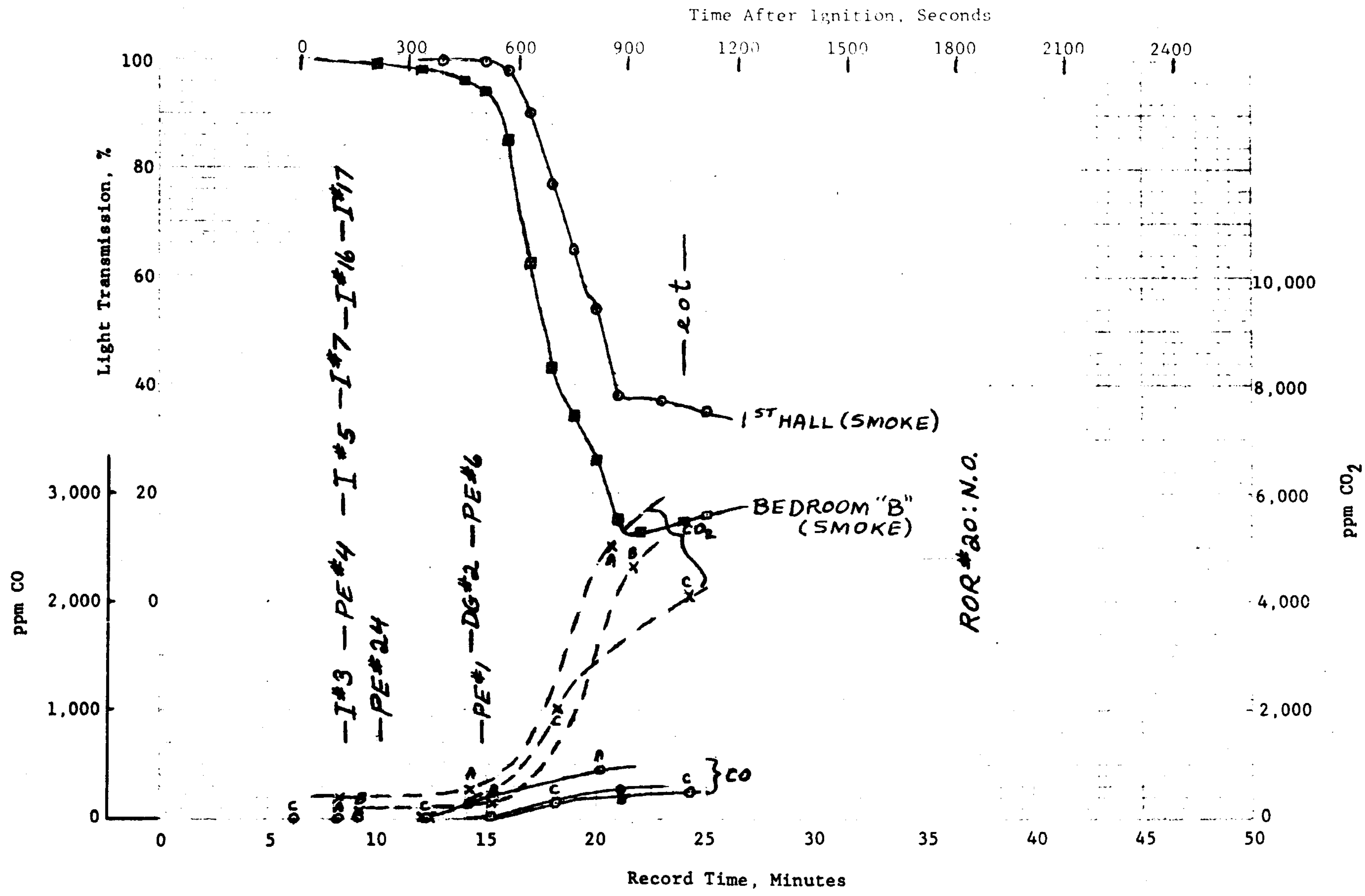


VARIOUS CONDITIONS, JR-6

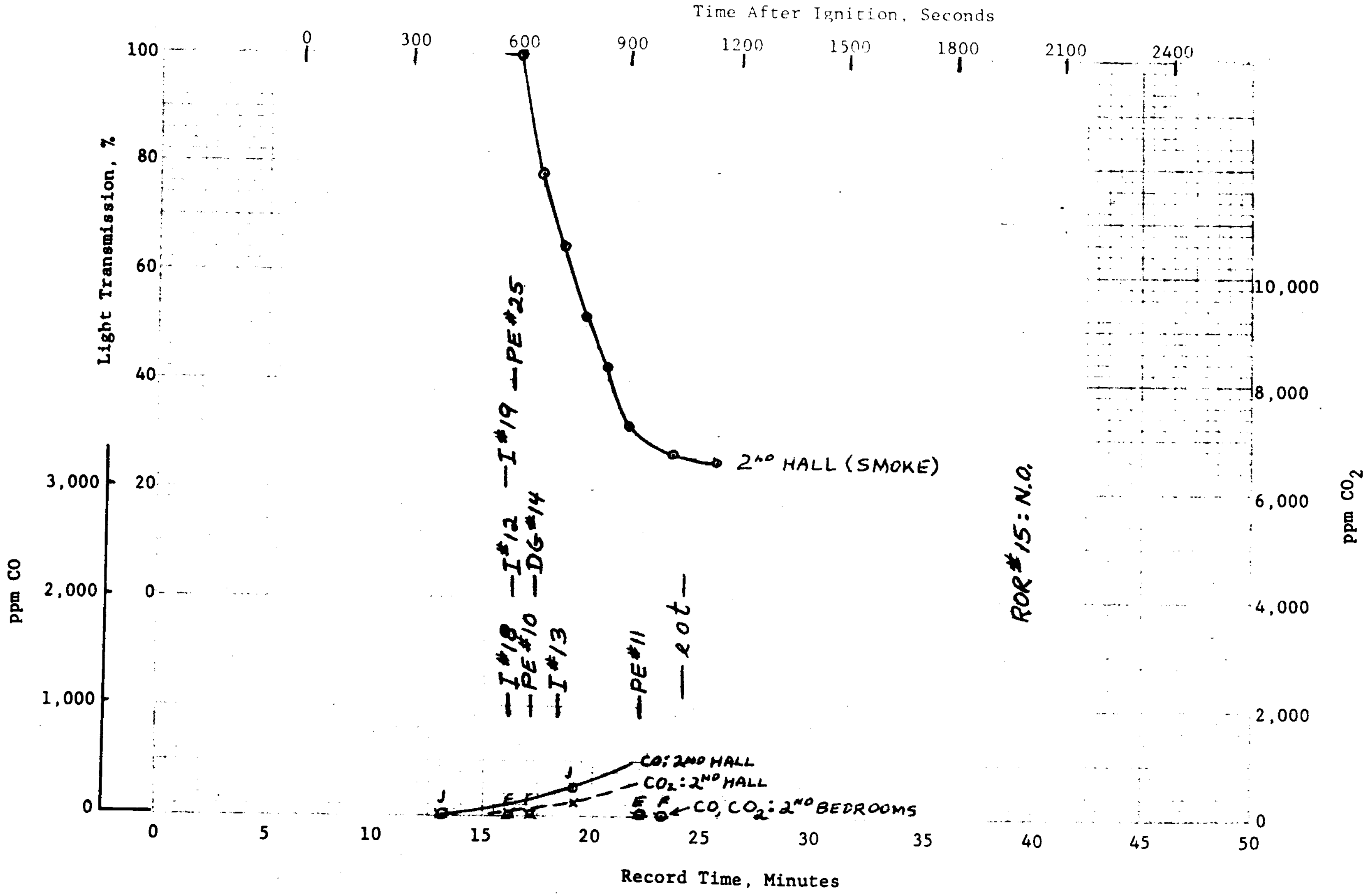
Location	Initial	Final (or max.)
Temps 5' High, 3" From Wall, °F		
1st Bed "A"	68	92.5
1st Bed "B"	62	69.5
1st Hall "C"	63	69
2nd Bed "E"	68	69.5
2nd Bed "F"	68	68.5
2nd Hall "J"	66	68.5
Liv. Rm. Register	54	52
Outdoors	69/71	(steady)



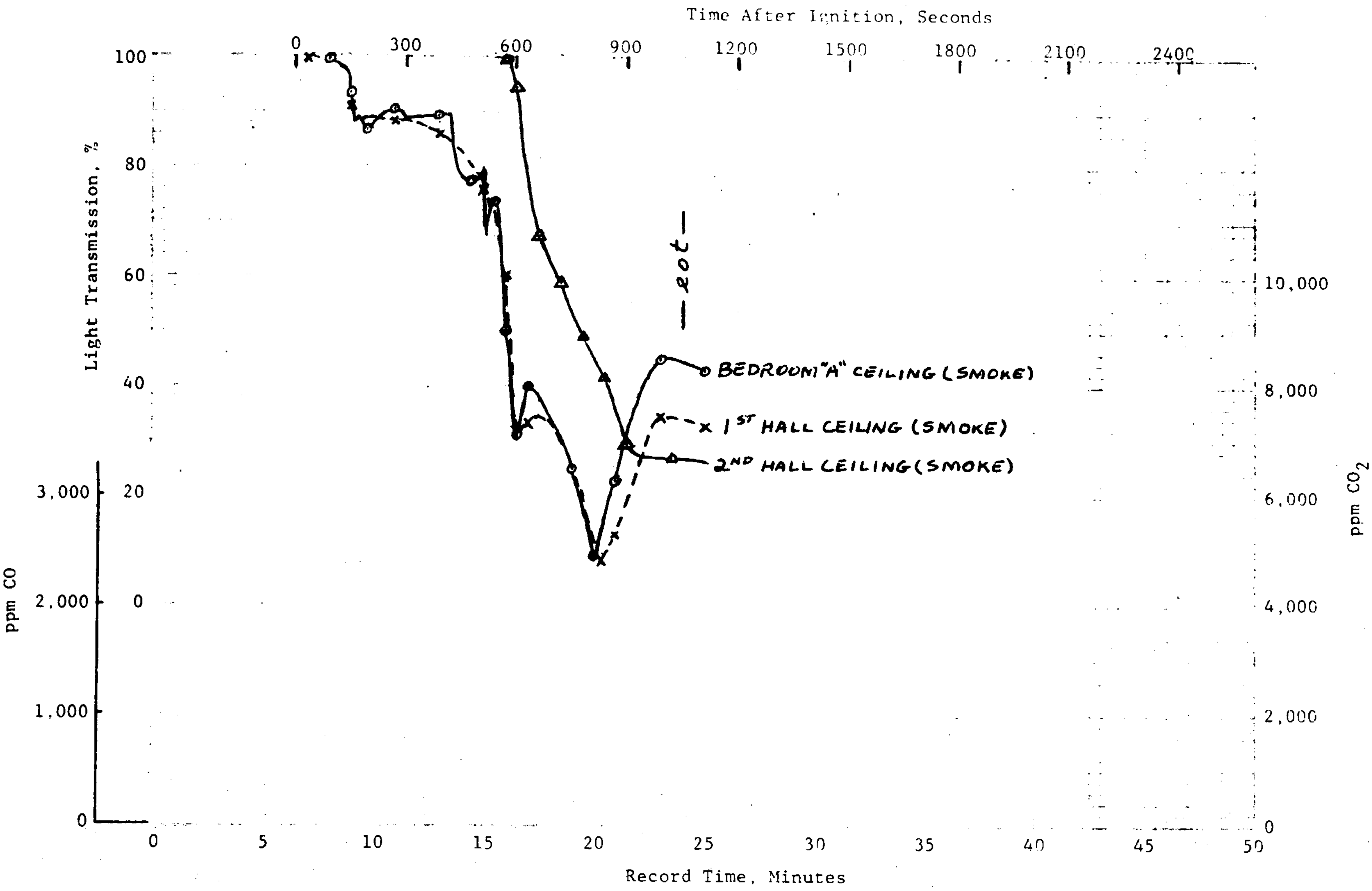
Maximum Temperature Profiles, JR-6



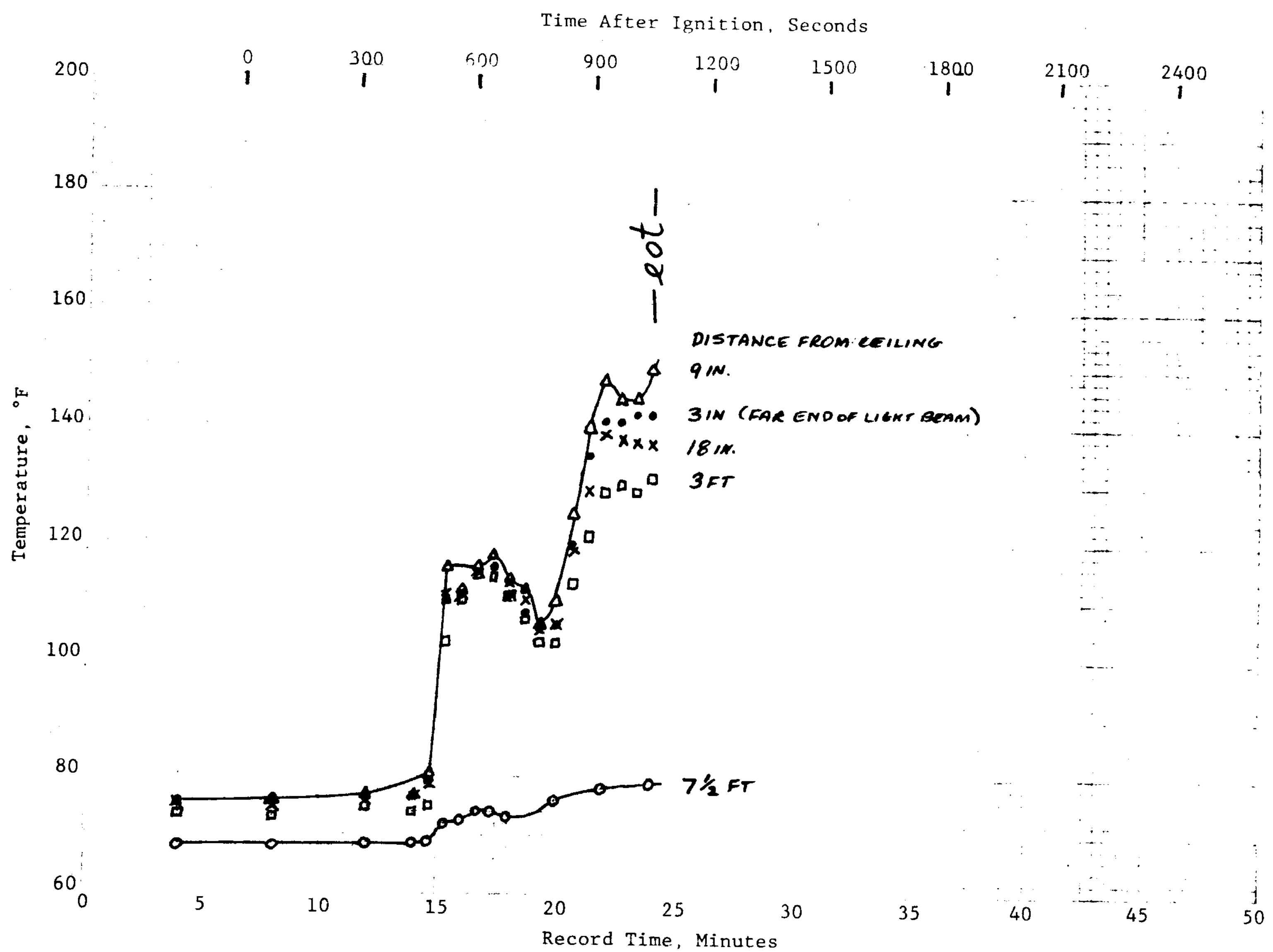
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-7



CONDITIONS ON 2ND FLOOR AT 5 FT, JR-7

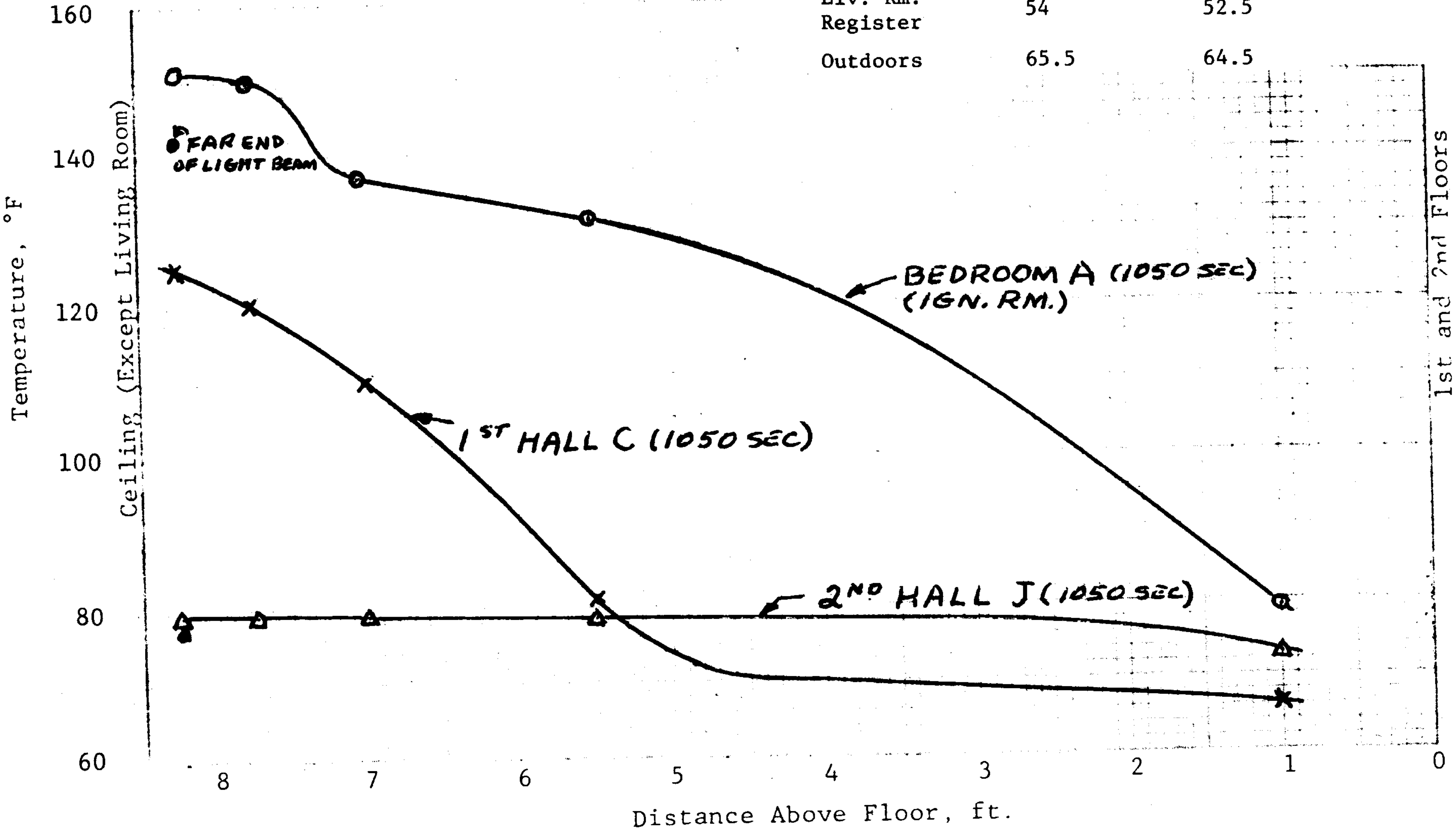


VARIOUS CONDITIONS, JR-7

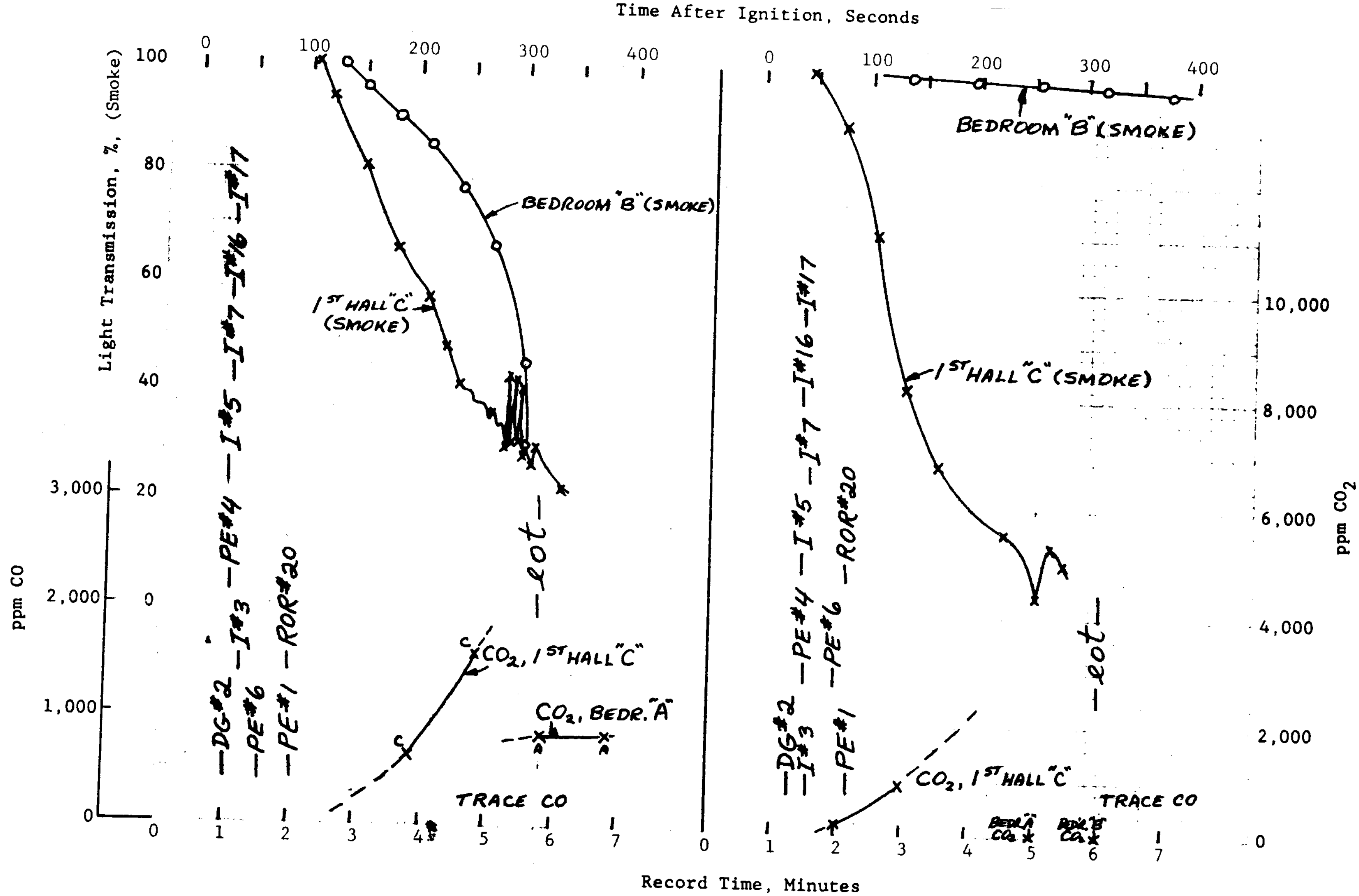


TEMPERATURES IN IGNITION ROOM (BEDROOM "A"), JR-7

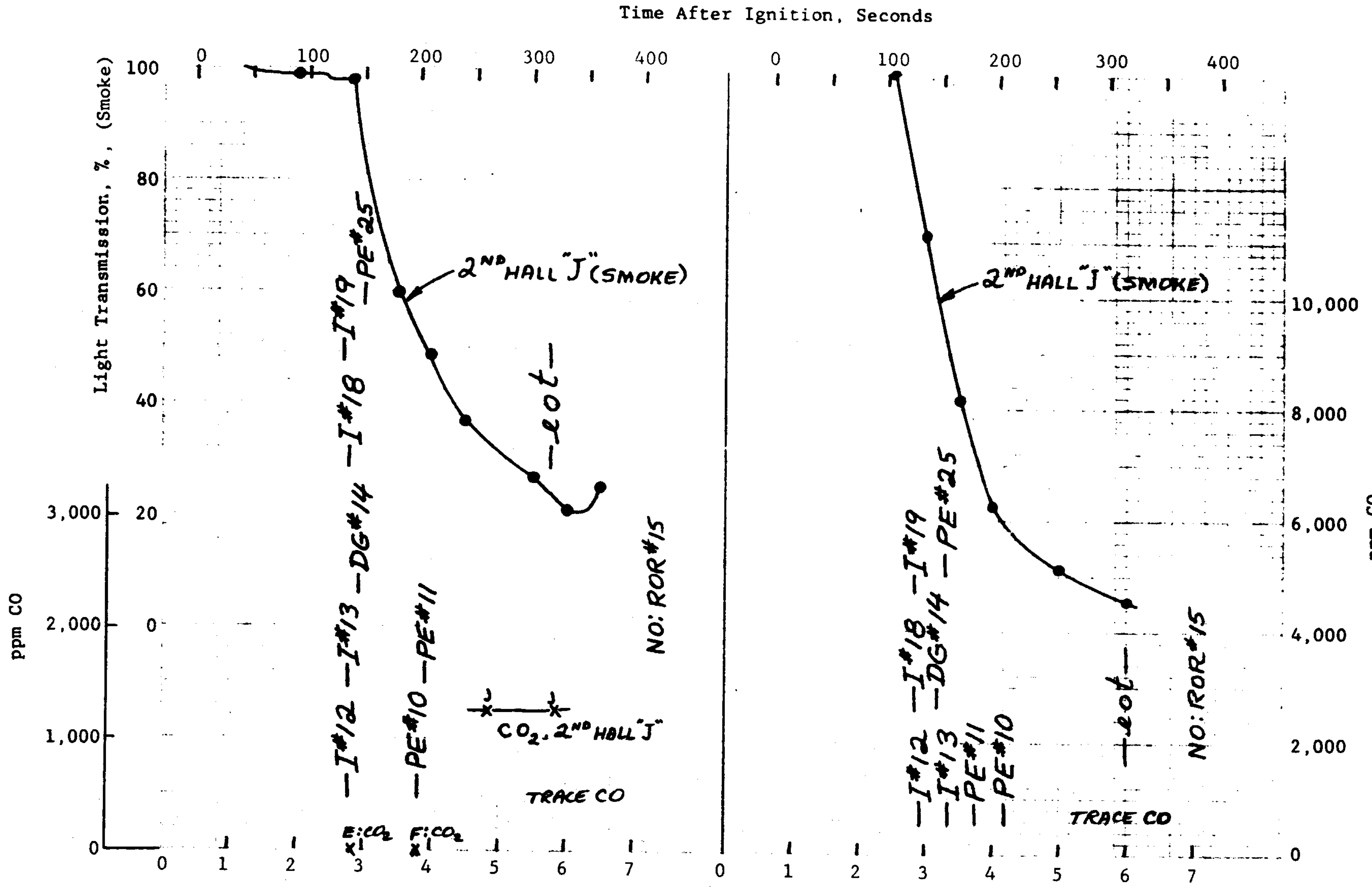
Location	Initial	Final (or max.)
Temps 5' High, 3" From Wall, °F		
1st Bed "A"	68	129
1st Bed "B"	63	79
1st Hall "C"	63	70.5
2nd Bed "E"	68	69
2nd Bed "F"	66	67
2nd Hall "J"	66	72.5
Liv. Rm. Register	54	52.5
Outdoors	65.5	64.5



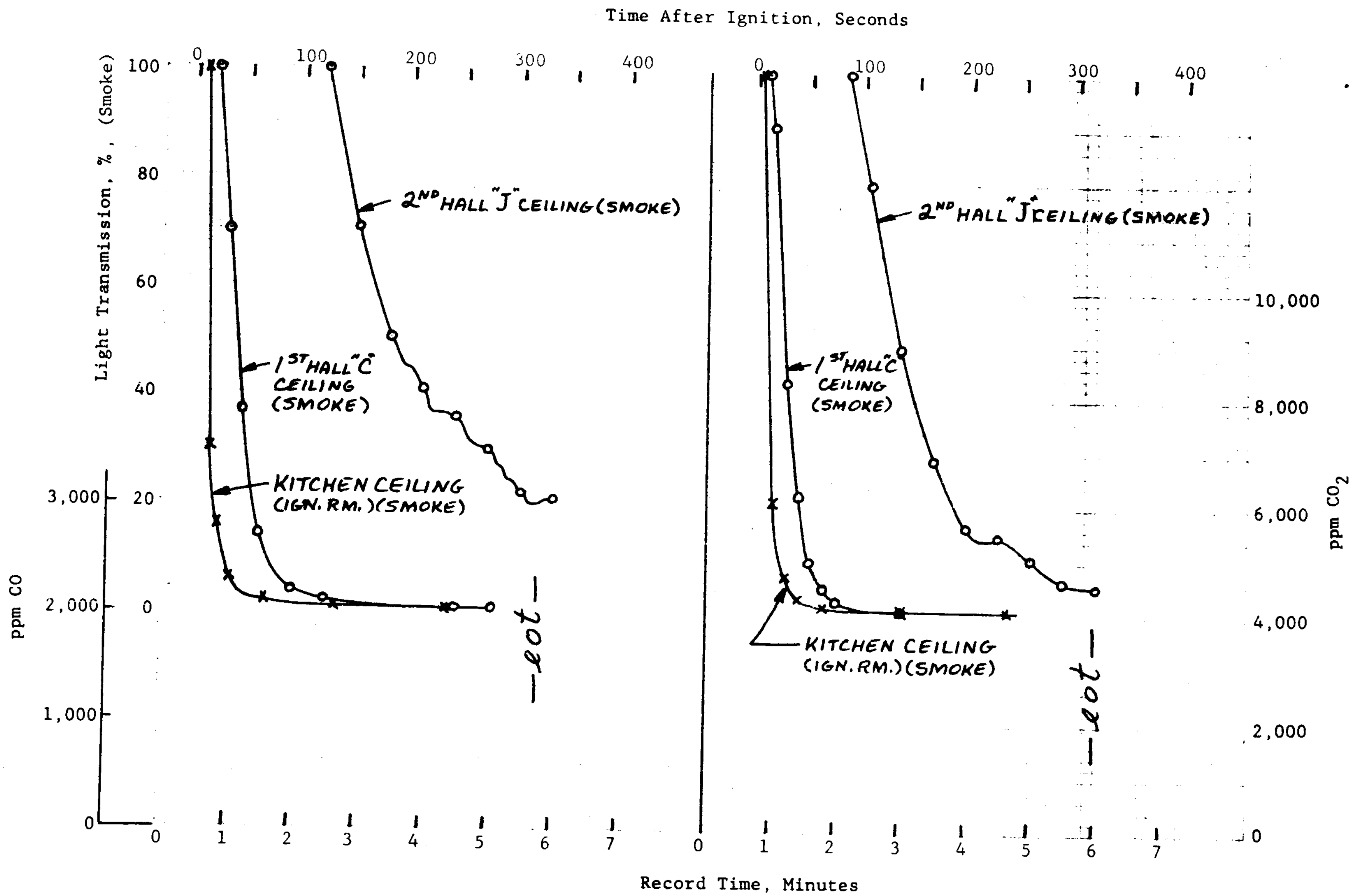
Maximum Temperature Profiles, JR-7



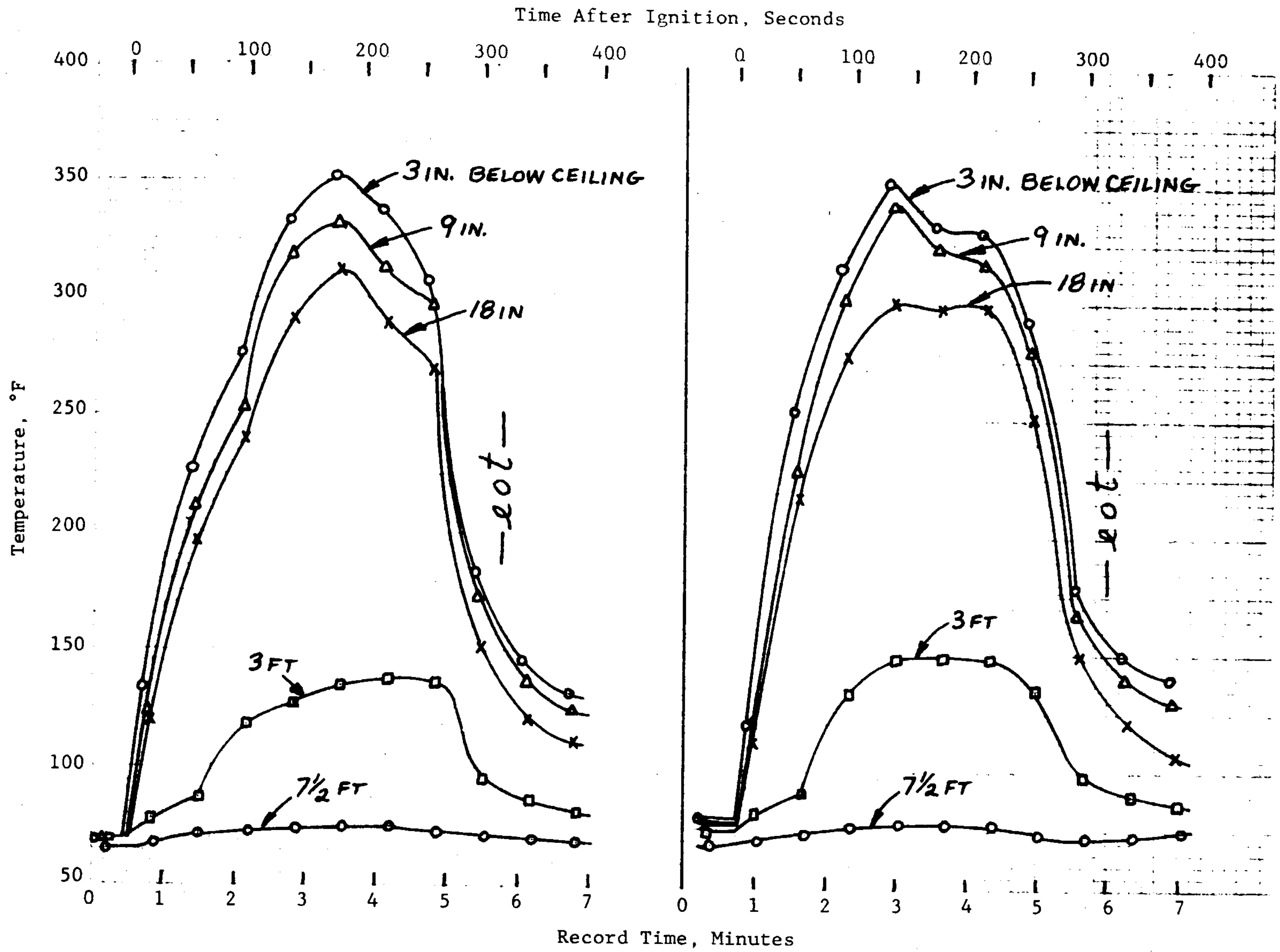
JR-8 - - - - CONDITIONS 5 FT ABOVE 1ST FLOOR - - - - JR-9



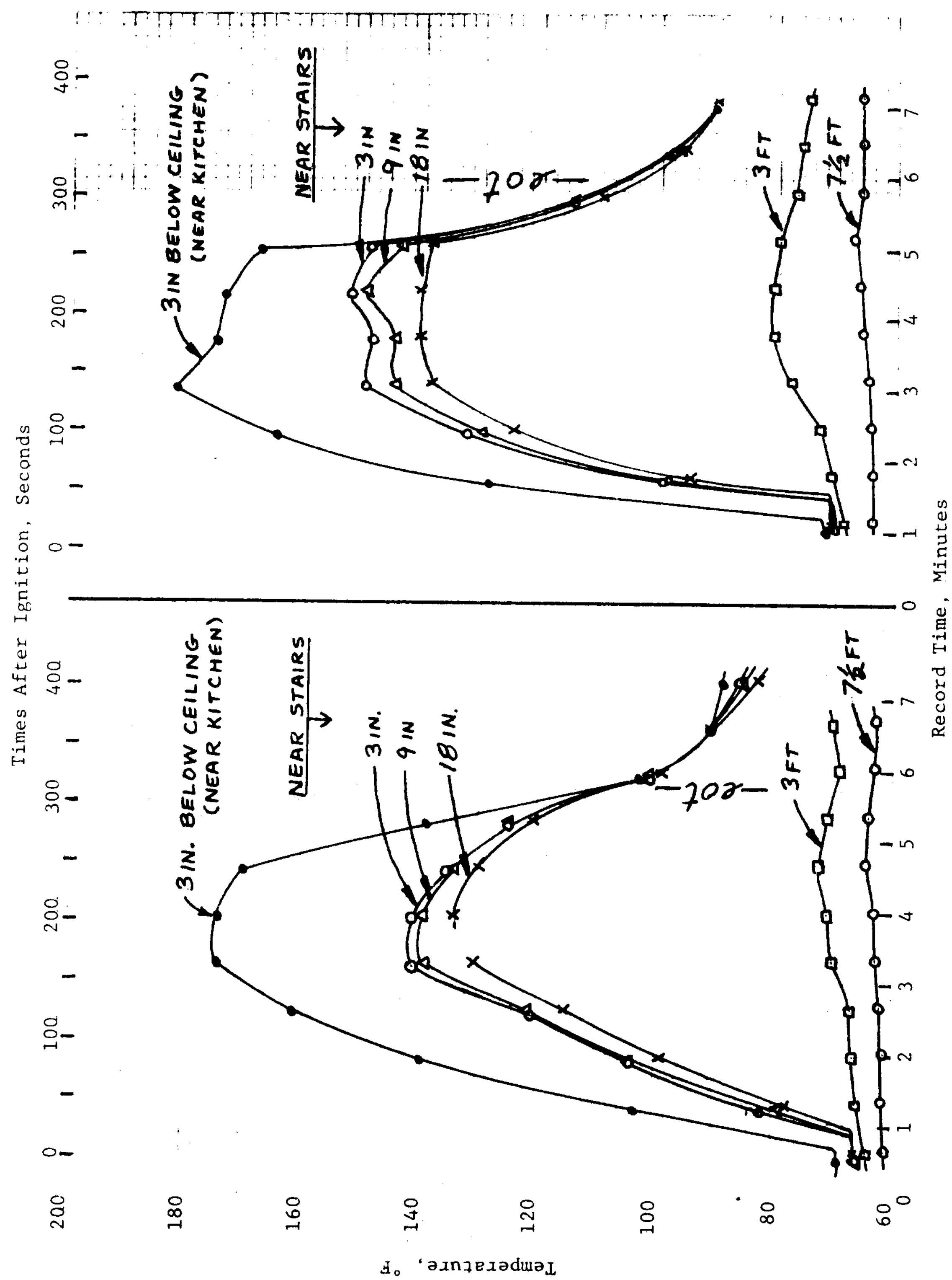
JR-8 - - - - CONDITIONS 5 FT ABOVE 2ND FLOOR - - - - JR-9



JR-8 - - - - VARIOUS CONDITIONS - - - - JR-9

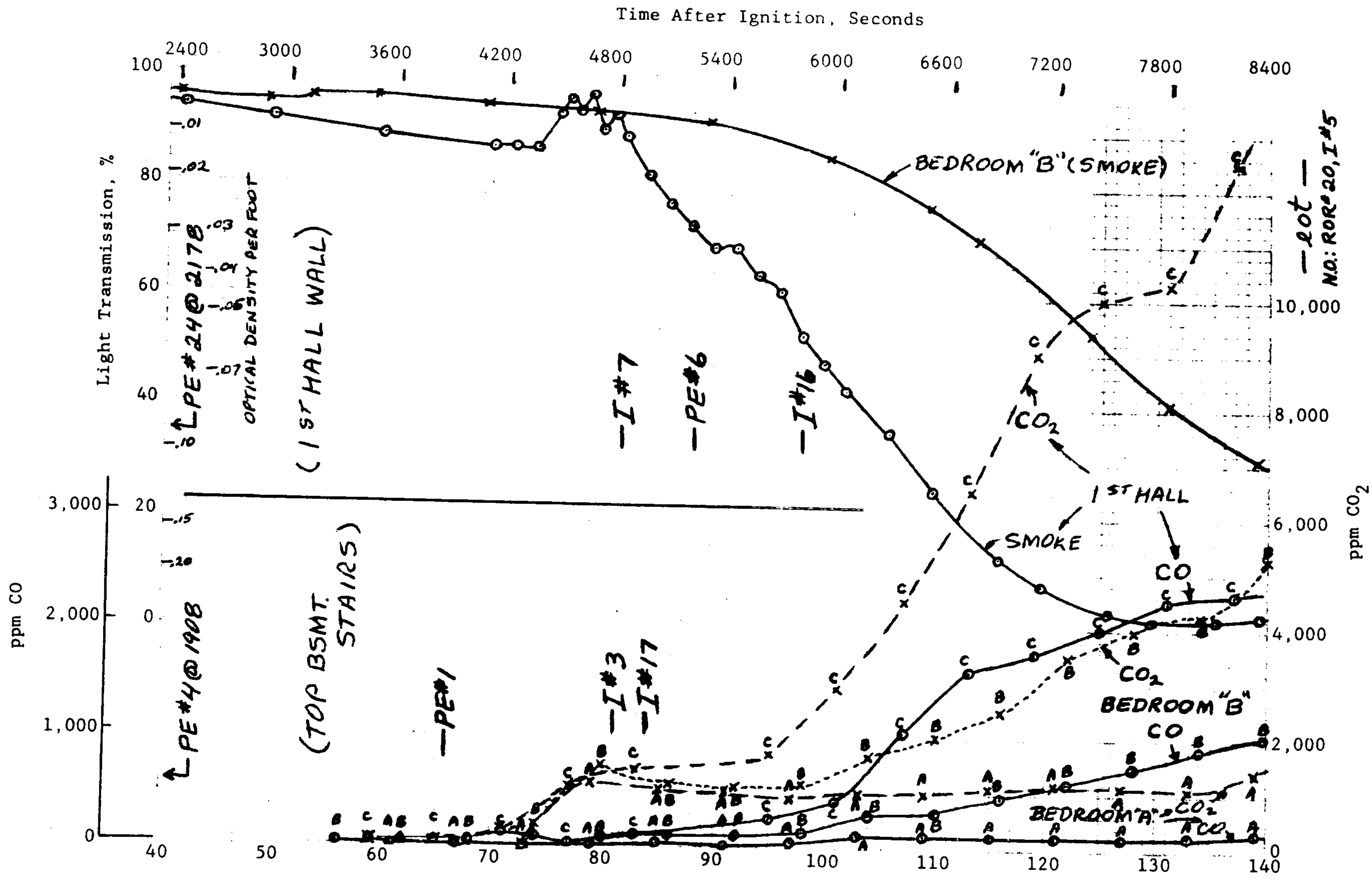


JR-8 - - - - TEMPERATURES IN IGNITION ROOM (KITCHEN) - - - - JR-9

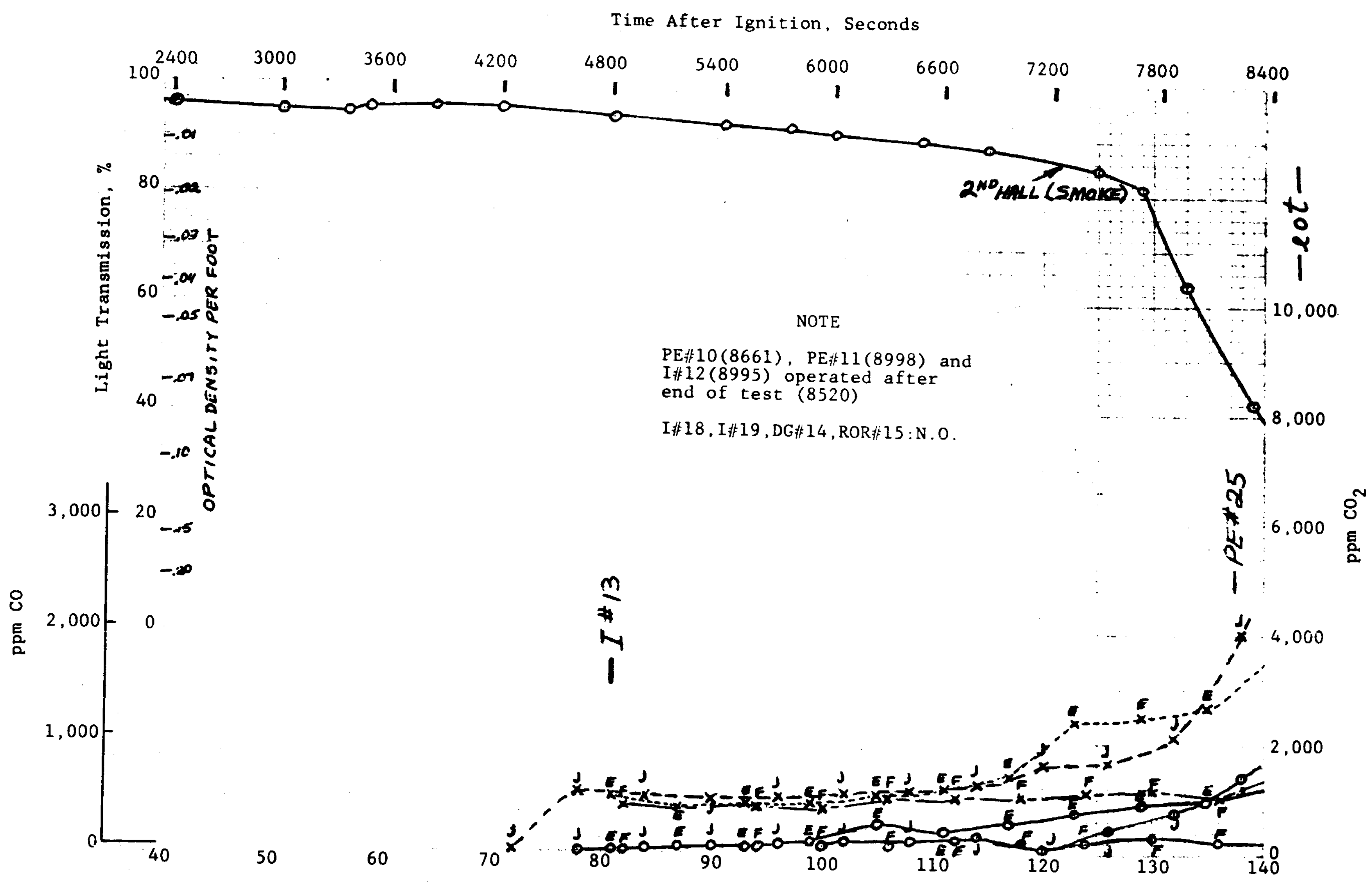


JR-8 - - - - - HALL TEMPERATURES, 1ST FLOOR - - - - - JR-9

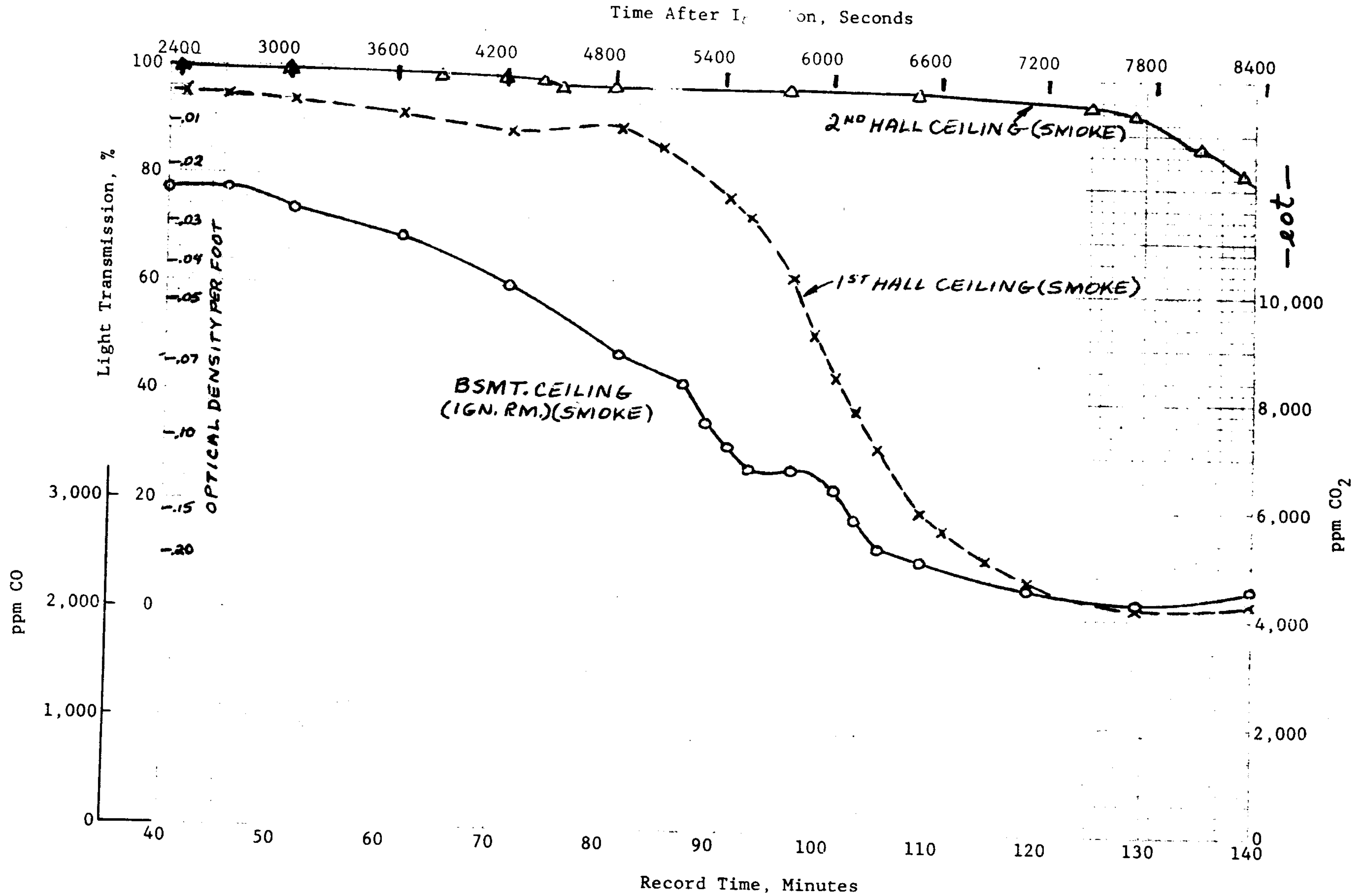
	JR#8		JR#9	
	Room Temps 5' From Floor, 3' From Wall			
Location	Initial, °F	Max, °F	Initial, °F	Max, °F
1st Bed A	61	64	62	61.5
1st Bed B	58.5	62	59	58
1st Hall C	61.5	68	64	71.5
2nd Bed E	64	65.5	64.5	65
2nd Bed F	64.5	66	64	64.5
2nd Hall J	63	65.5	63	69
Liv. Rm. Register	52	51	51	51
Outside Air	49/69 oscillating		41/50 oscillating	



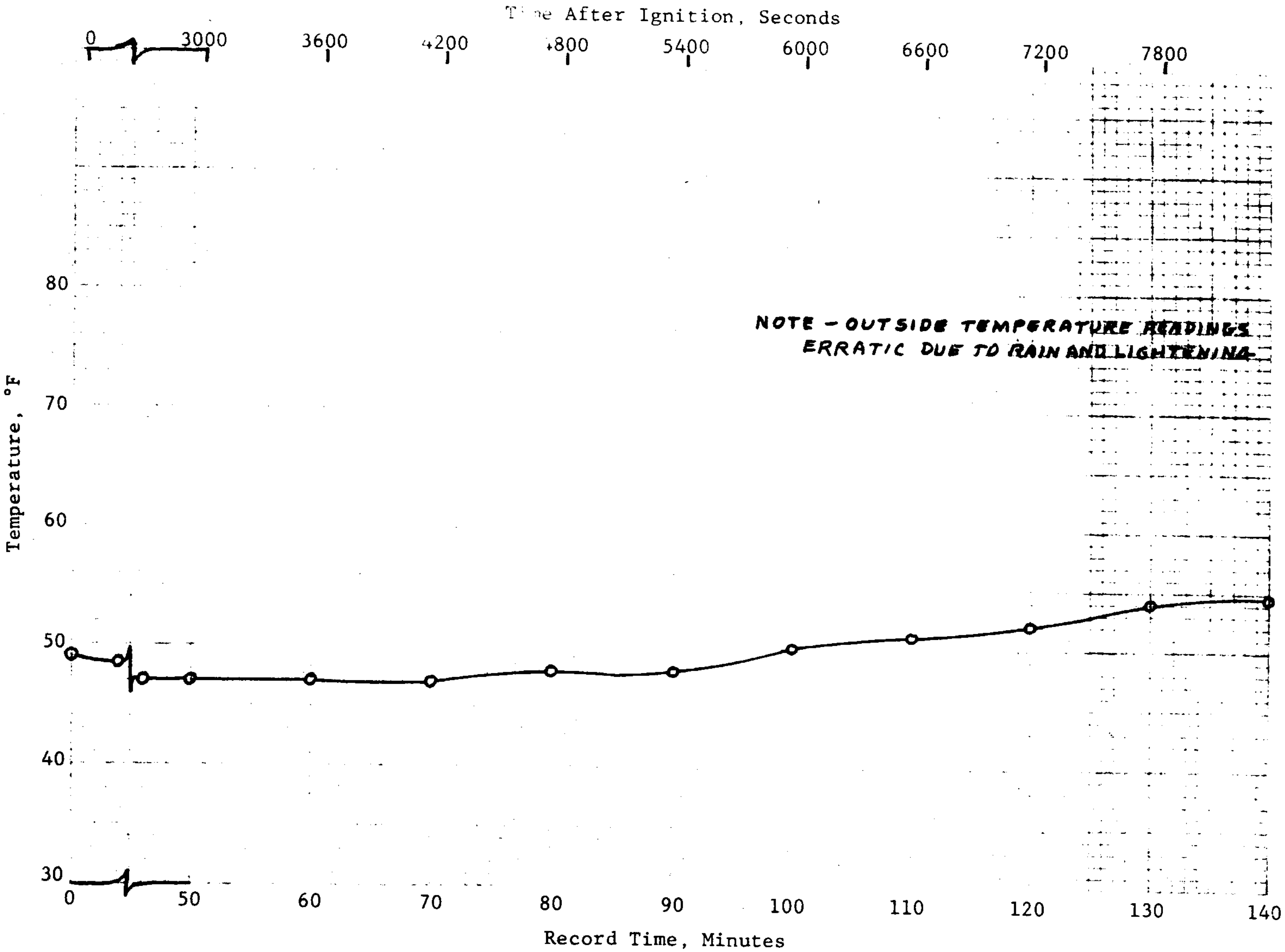
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-10



CONDITIONS ON 2ND FLOOR AT 5 FT, JR-10



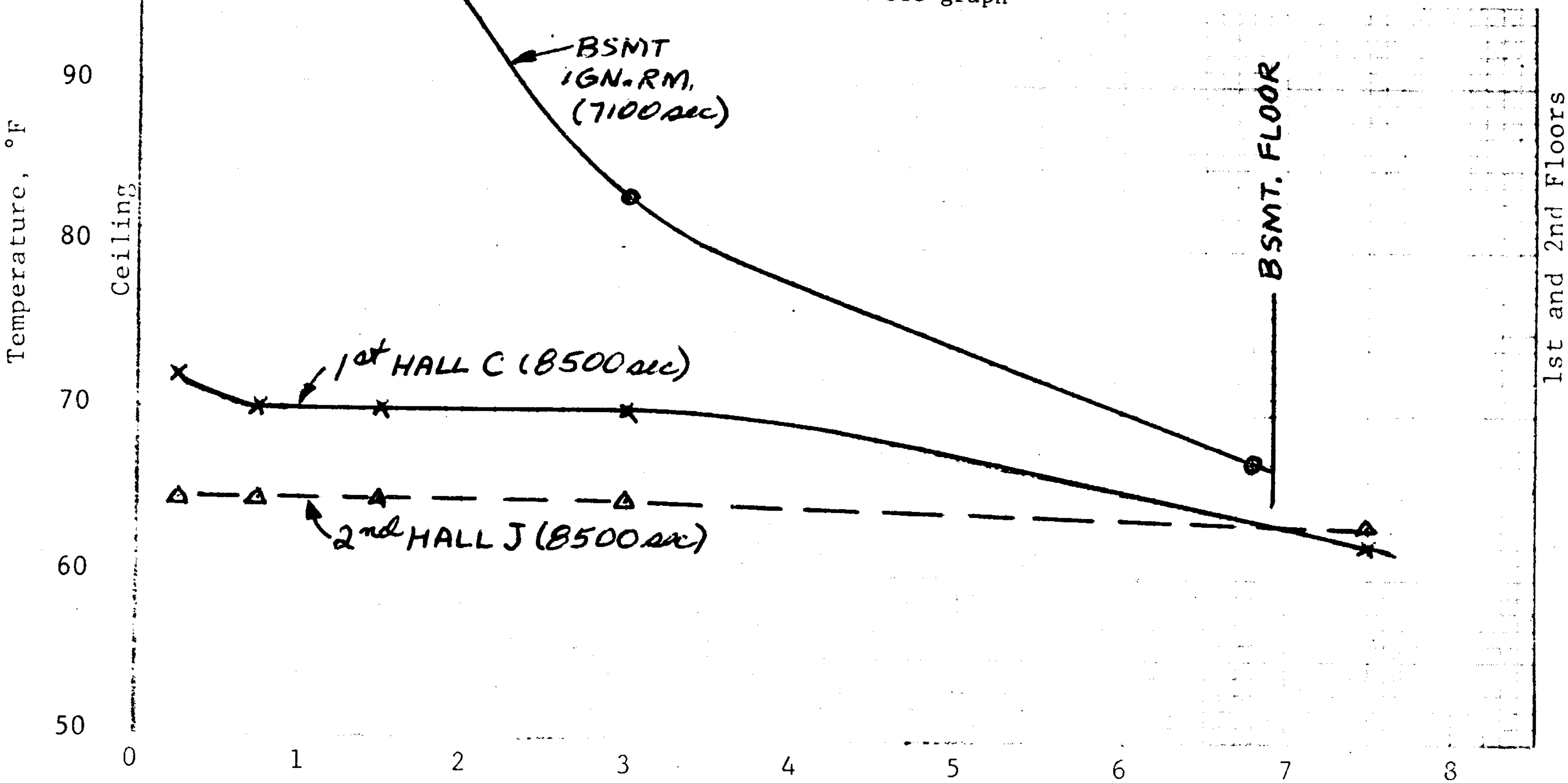
VARIOUS CONDITIONS, JR-10



TEMPERATURE AT LIVING ROOM REGISTER, JR-10

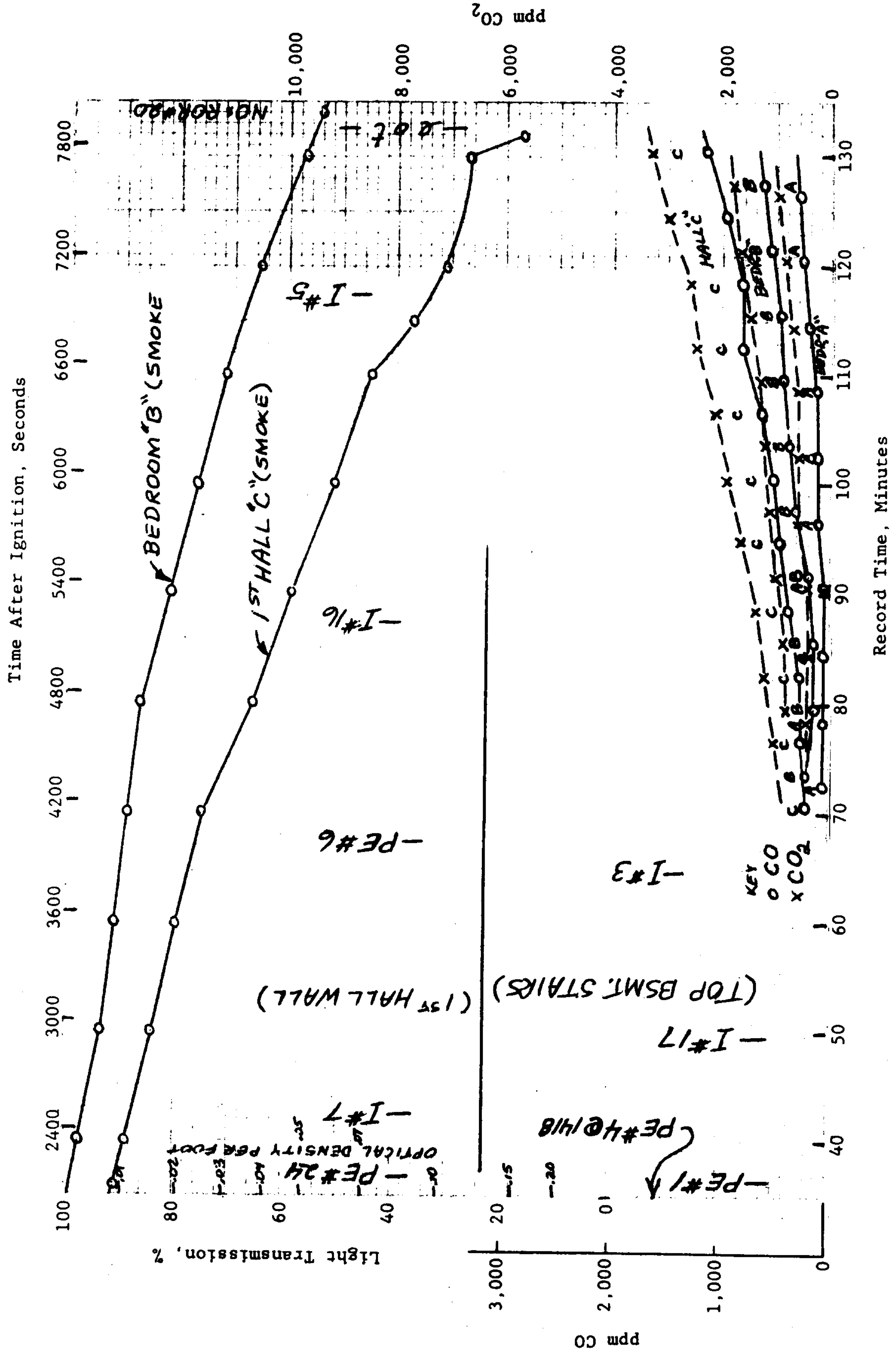
Location	Temps 5' High, 3" From Wall, °F Initial	Final (or max.)
1st Bed "A"	61	60.5
1st Bed "B"	58	58
1st Hall "C"	60	68
2nd Bed "E"	65.5	63
2nd Bed "F"	64	63
2nd Hall "J"	63	64
Liv. Rm. Register*	49	54.5

*see graph

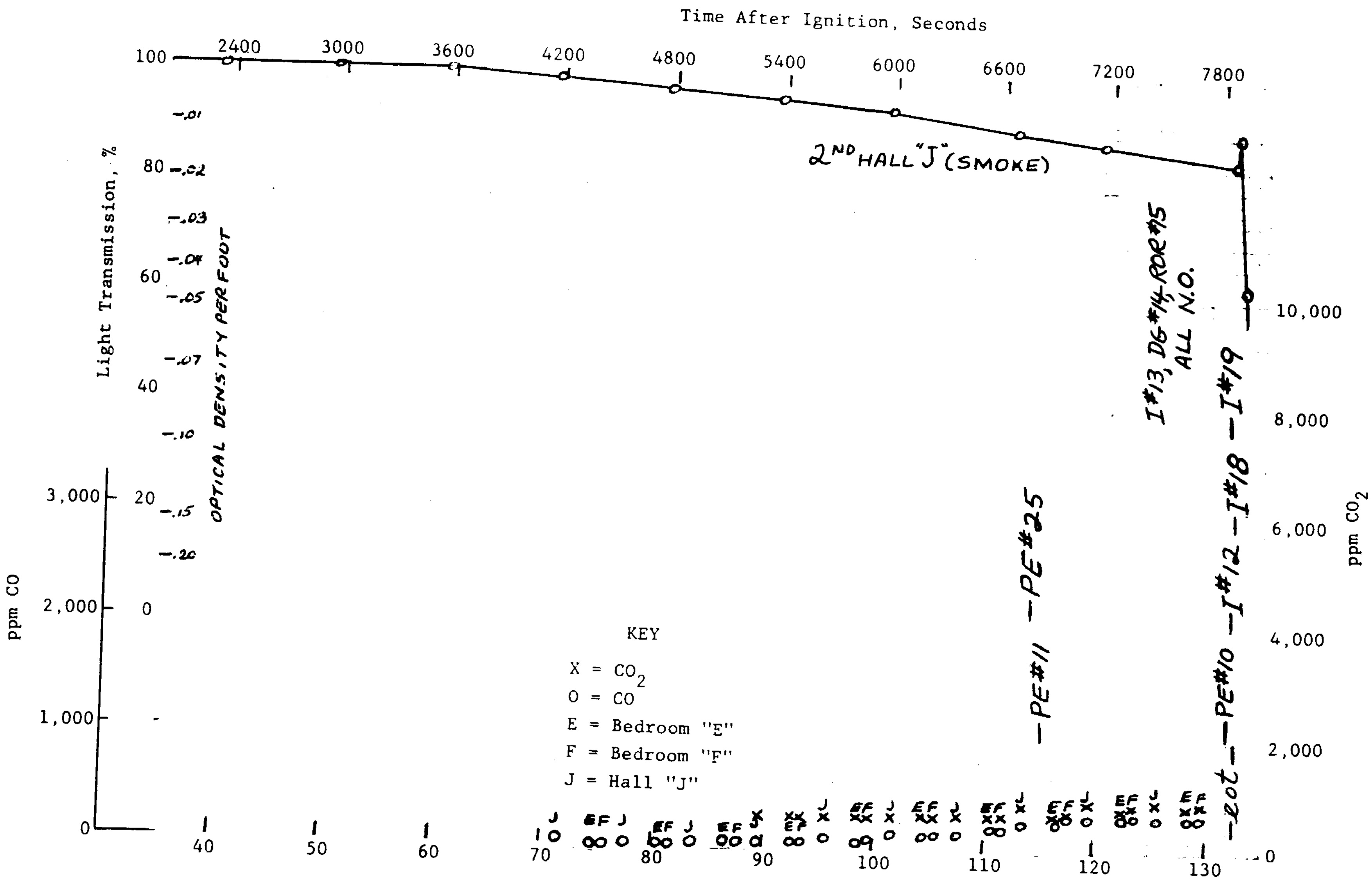


Distance From Ceiling, ft.

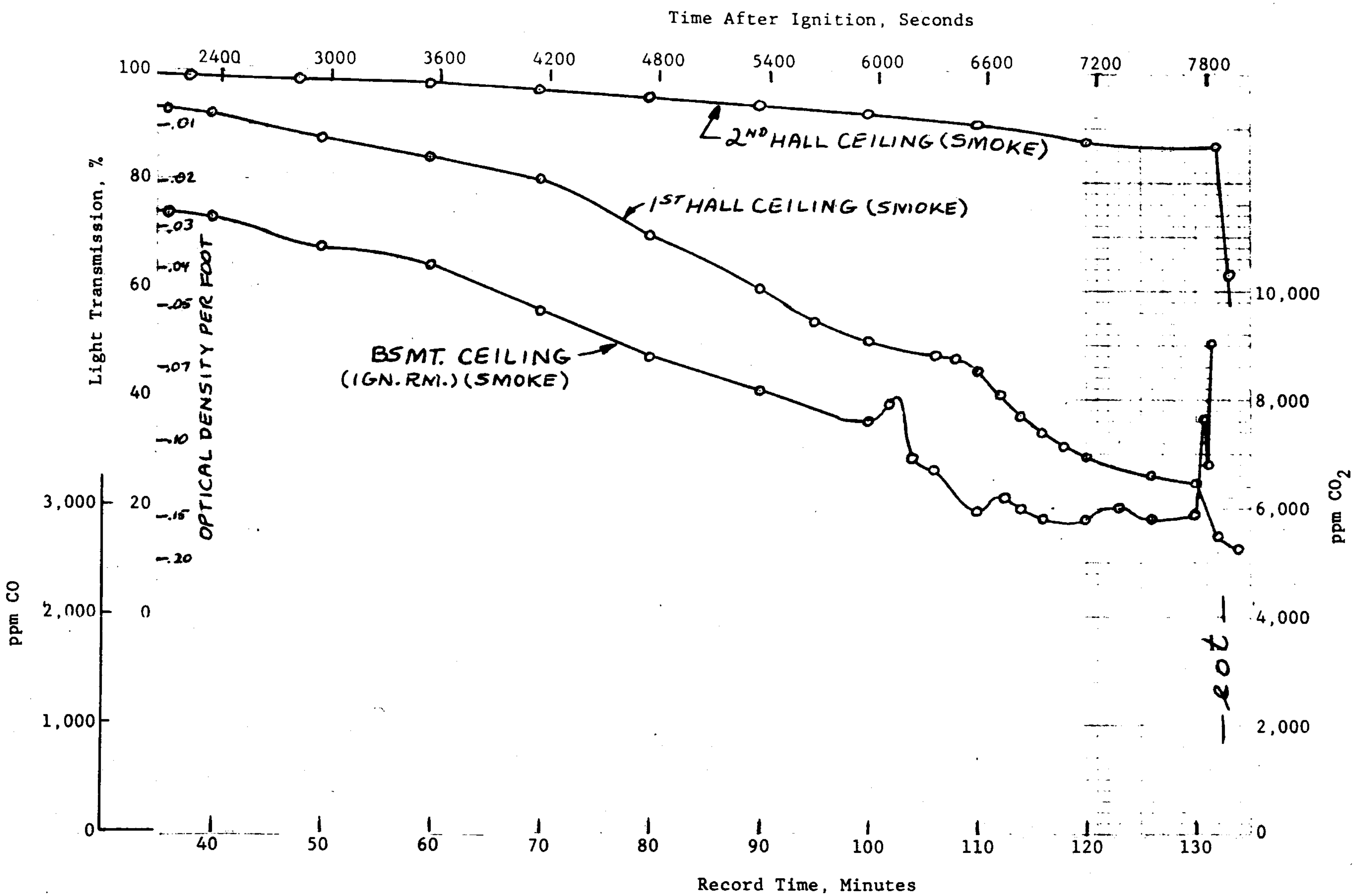
Maximum Temperature Profiles, JR-10



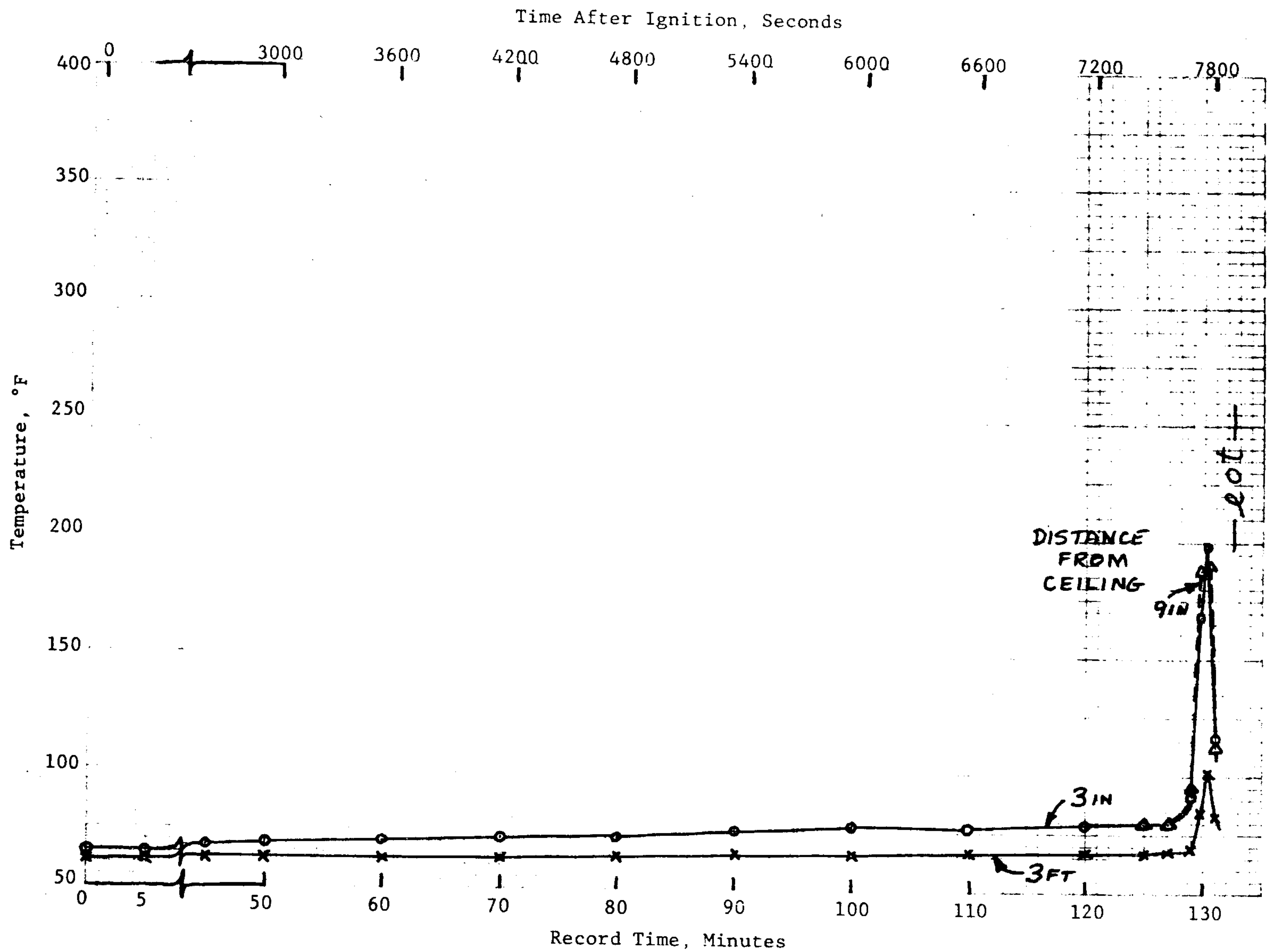
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-11



CONDITIONS ON 2ND FLOOR AT 5 FT, JR-11



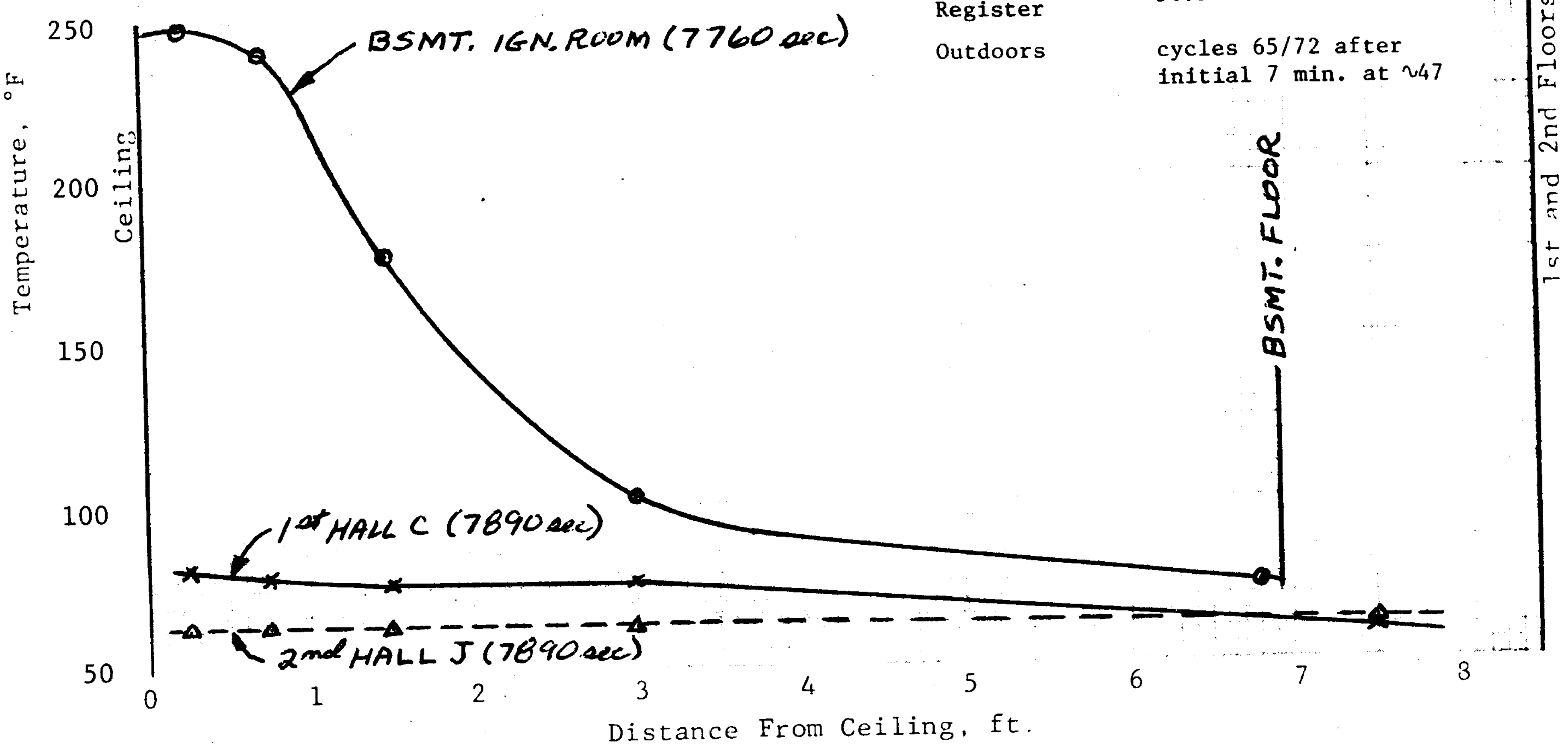
VARIOUS CONDITIONS, JR-11



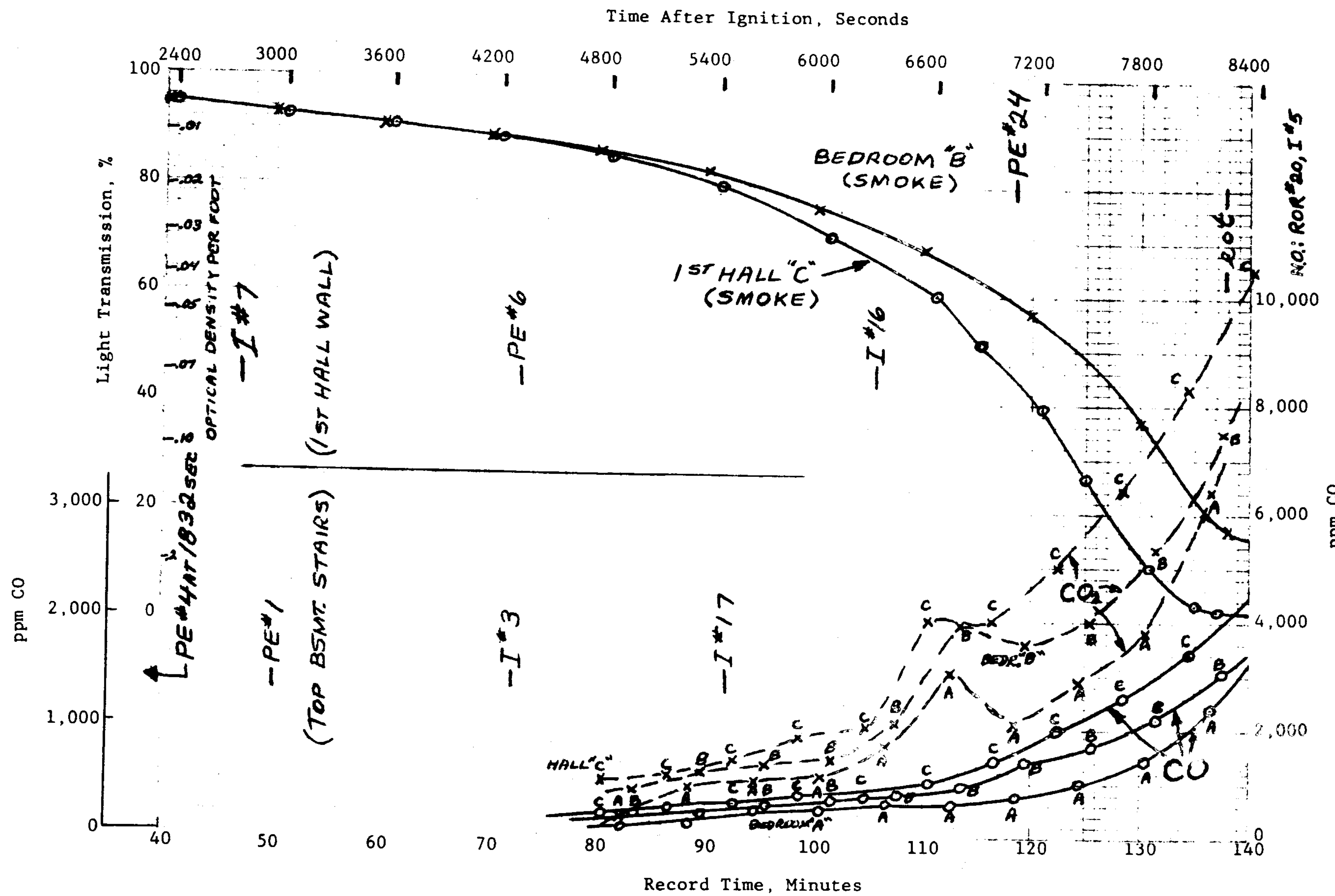
TEMPERATURES IN IGNITION ROOM (BSMT.), JR-11

Temps 5' High, 3" From Wall, °F

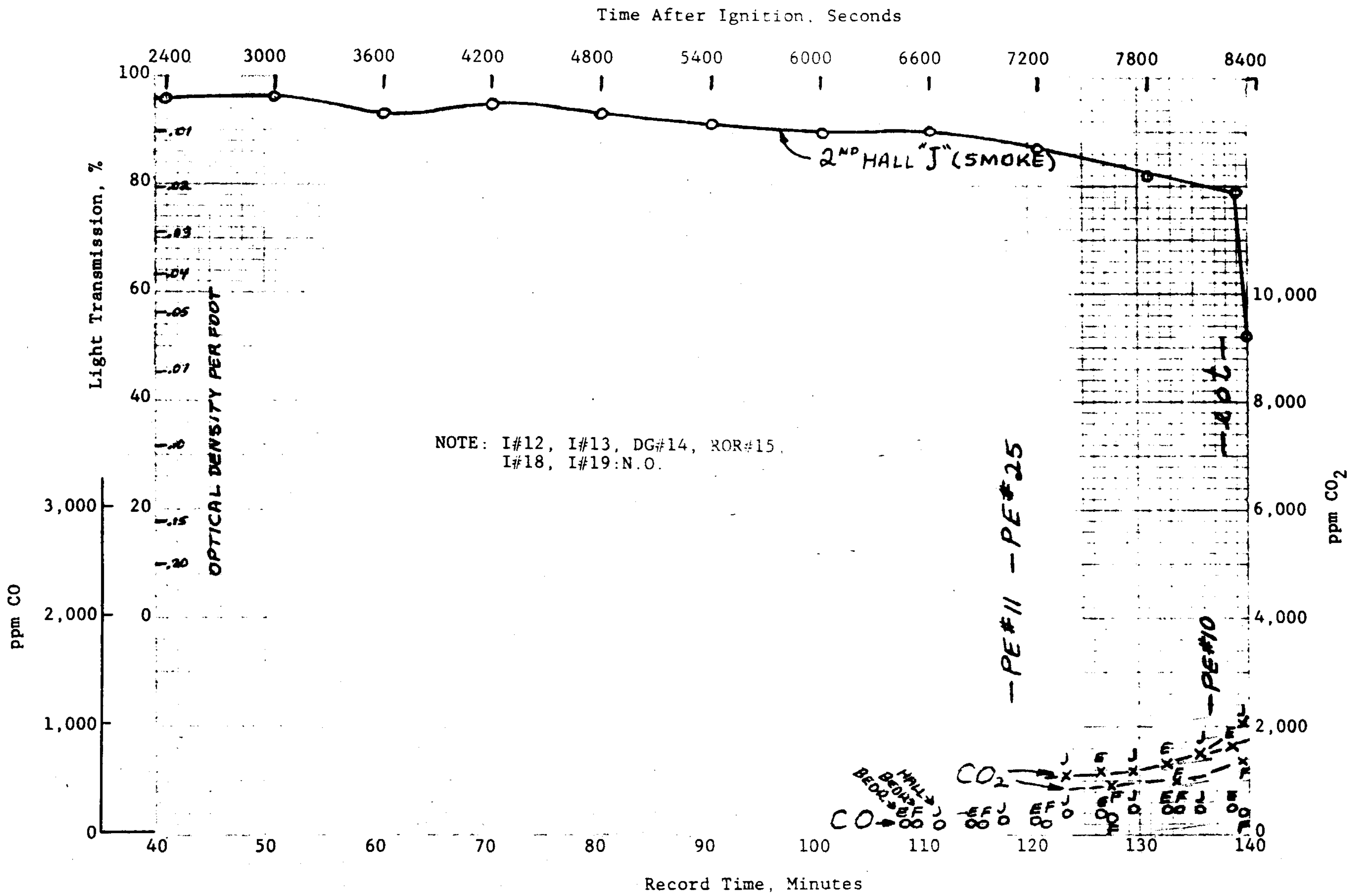
Location	Initial	Final (or max.)
1st Bed "A"	61	60
1st Bed "B"	59	57
1st Hall "C"	60.5	72
2nd Bed "E"	60.5	60.5
2nd Bed "F"	61	60
2nd Hall "J"	63	62
Liv. Rm. Register	50.5	--
Outdoors	cycles 65/72 after initial 7 min. at ~47	



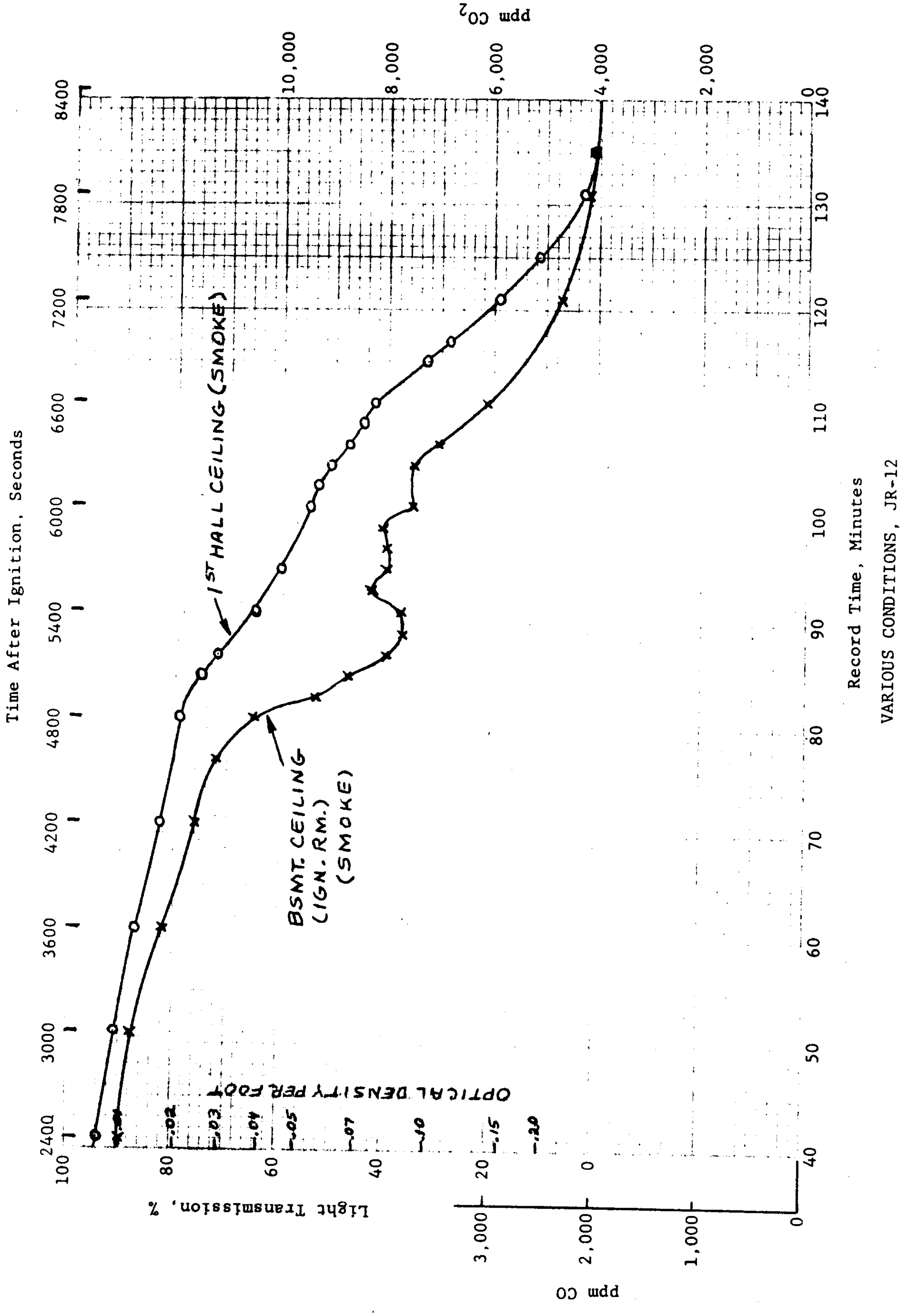
Maximum Temperature Profiles, JR-11



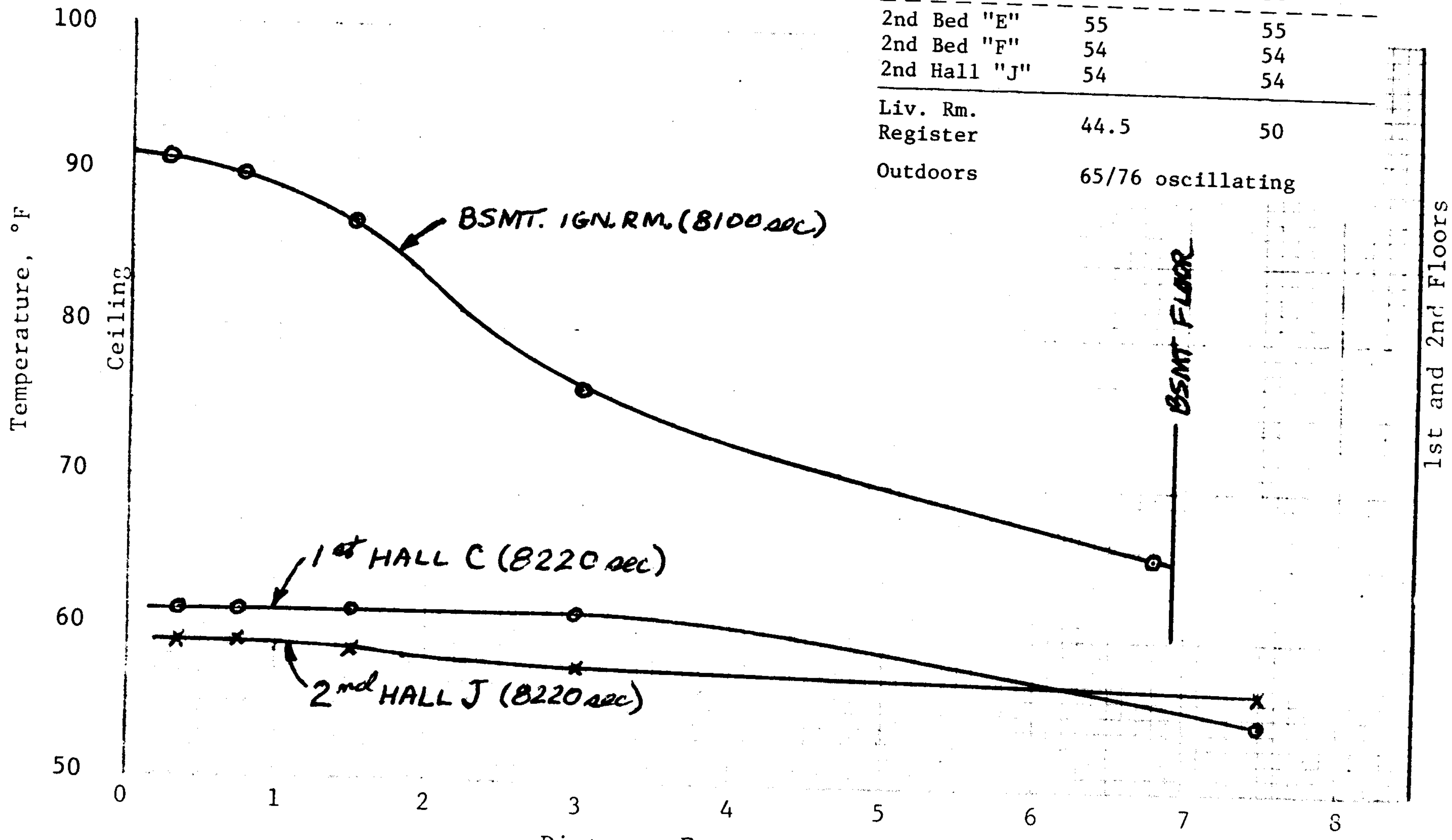
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-12



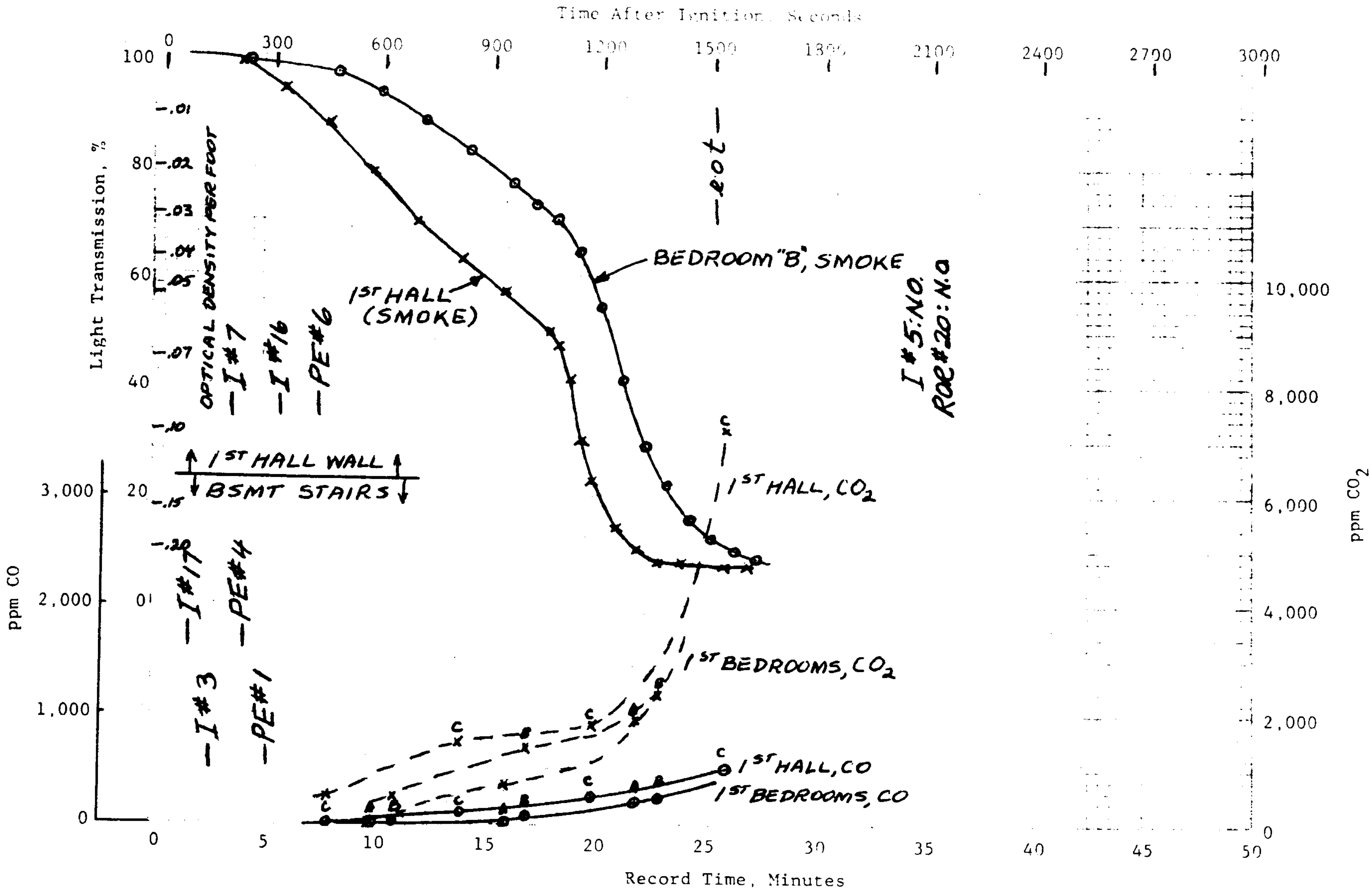
CONDITIONS ON 2ND FLOOR AT 5 FT, JR-12


Time After Ignition, Seconds
2400
3000
3600
4200
4800
5400
6000
6600
7200
7800
8400
Light Transmission, %
100
80
60
40
20
0
ppm CO
3,000
2,000
1,000
0
ppm CO_2
10,000
8,000
6,000
4,000
2,000
0
Record Time, Minutes
40
50
60
70
80
90
100
110
120
130
140
OPTICAL DENSITY PER FOOT
.02
.03
.04
.05
.07
.10
.15
.20
1ST HALL CEILING (SMOKE)
BSMT. CEILING (IGN. RM.) (SMOKE)
VARIOUS CONDITIONS, JR-12

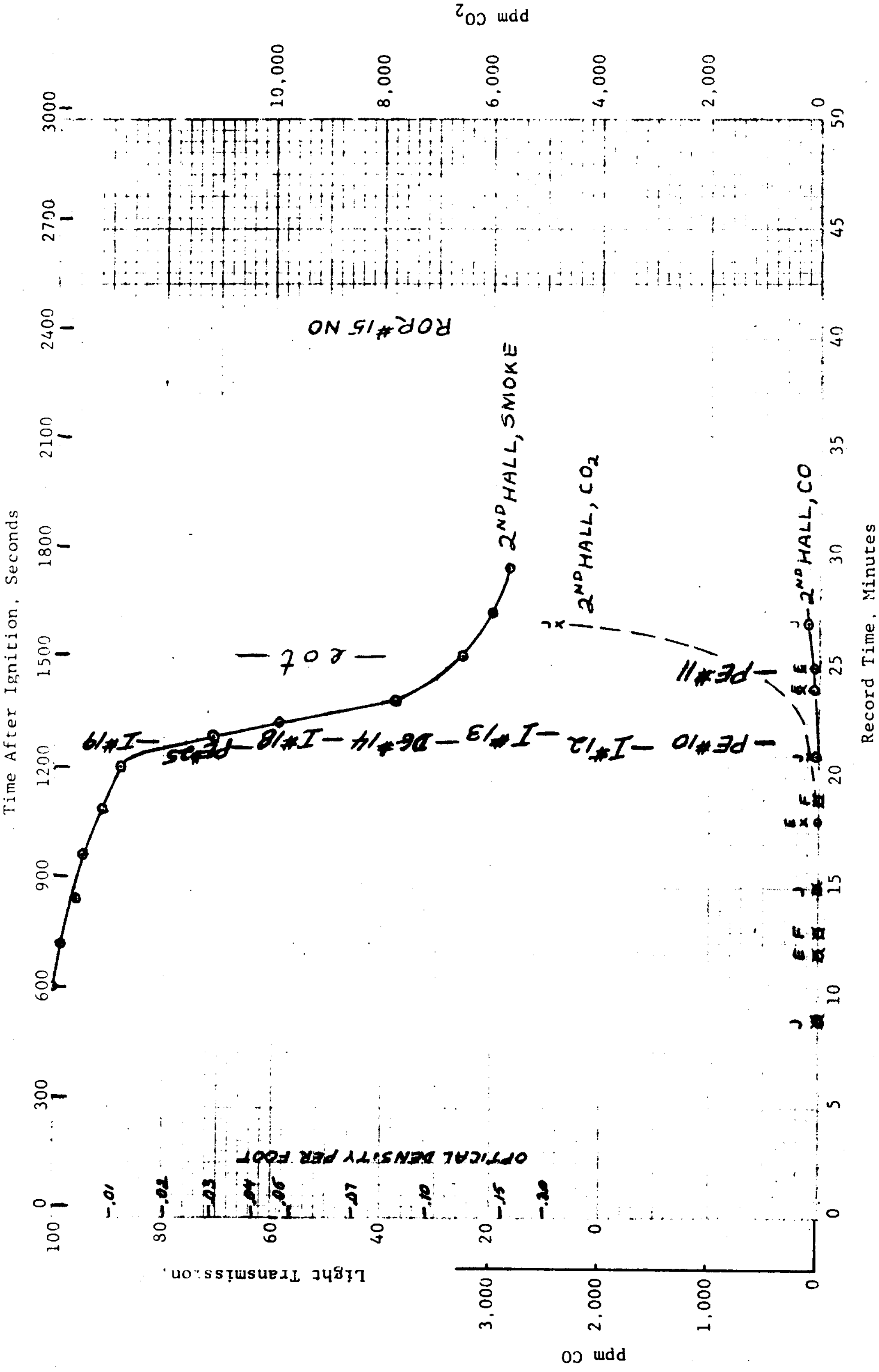
Location	Initial	Final (or max.)
Temps 5' High, 3" From Wall, °F		
1st Bed "A"	55	56
1st Bed "B"	54	54
1st Hall "C"	55	58
2nd Bed "E"	55	55
2nd Bed "F"	54	54
2nd Hall "J"	54	54
Liv. Rm. Register	44.5	50
Outdoors	65/76 oscillating	



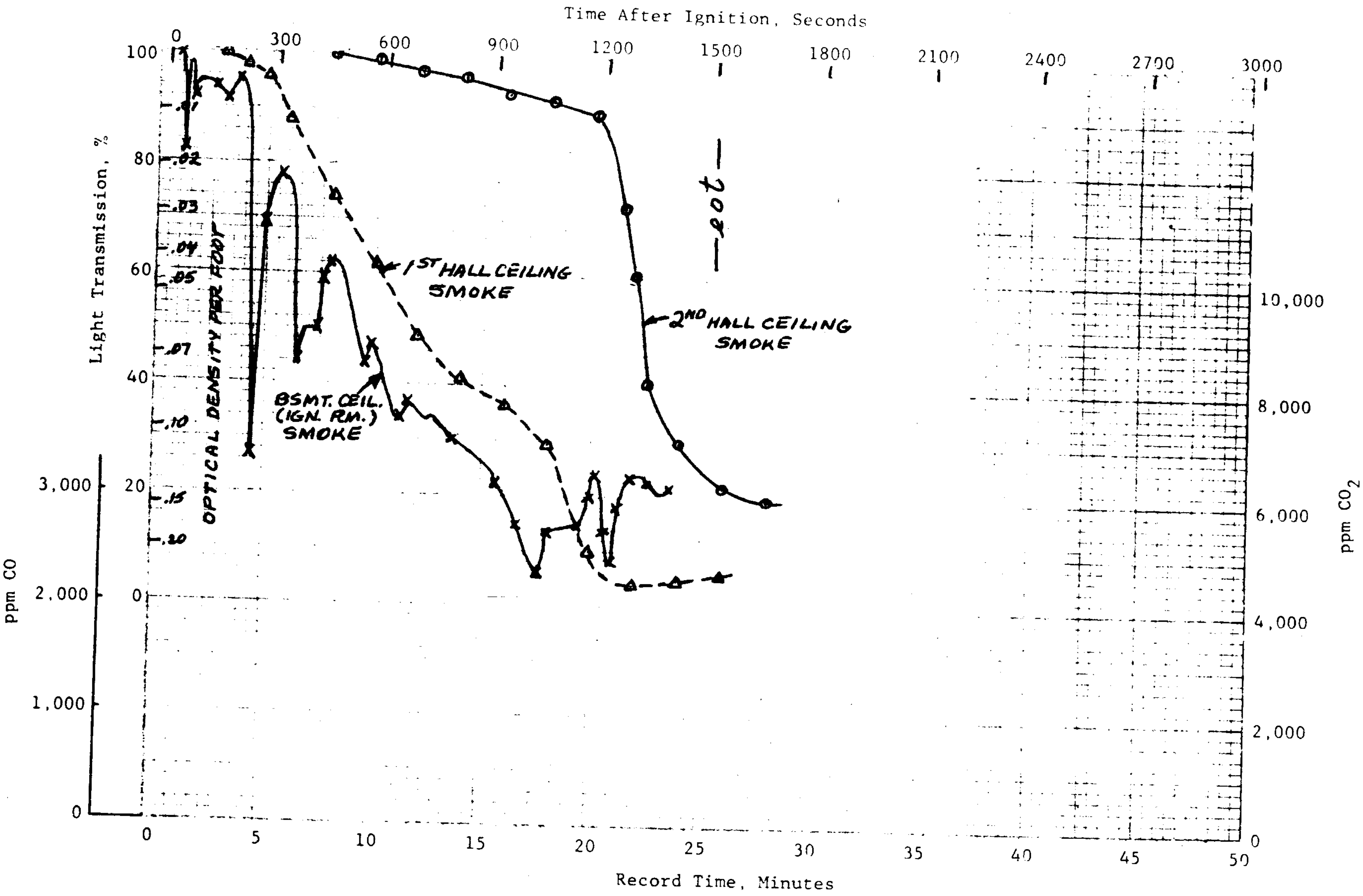
Distance From Ceiling, ft.
Maximum Temperature Profiles, JR-12



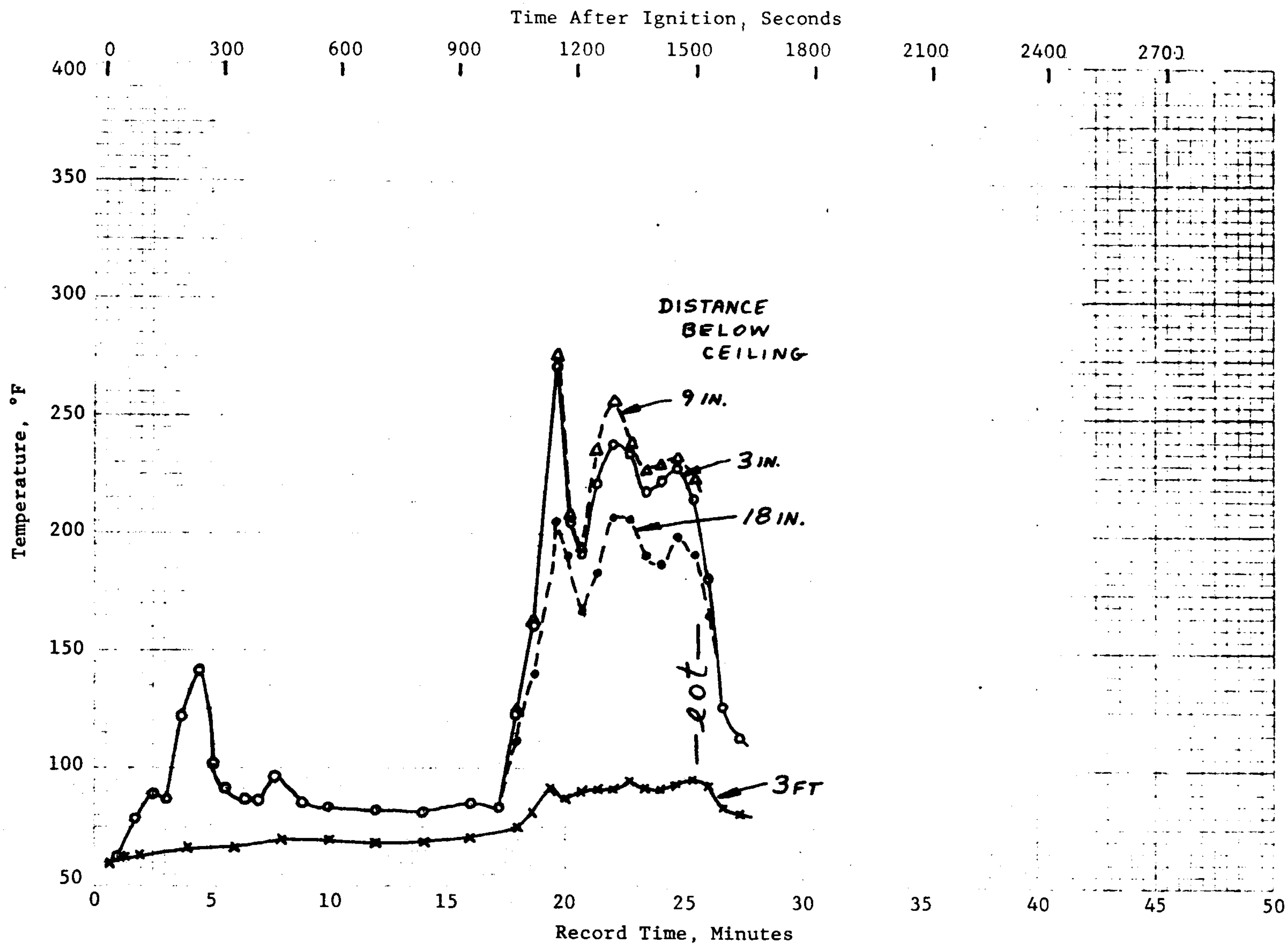
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-13



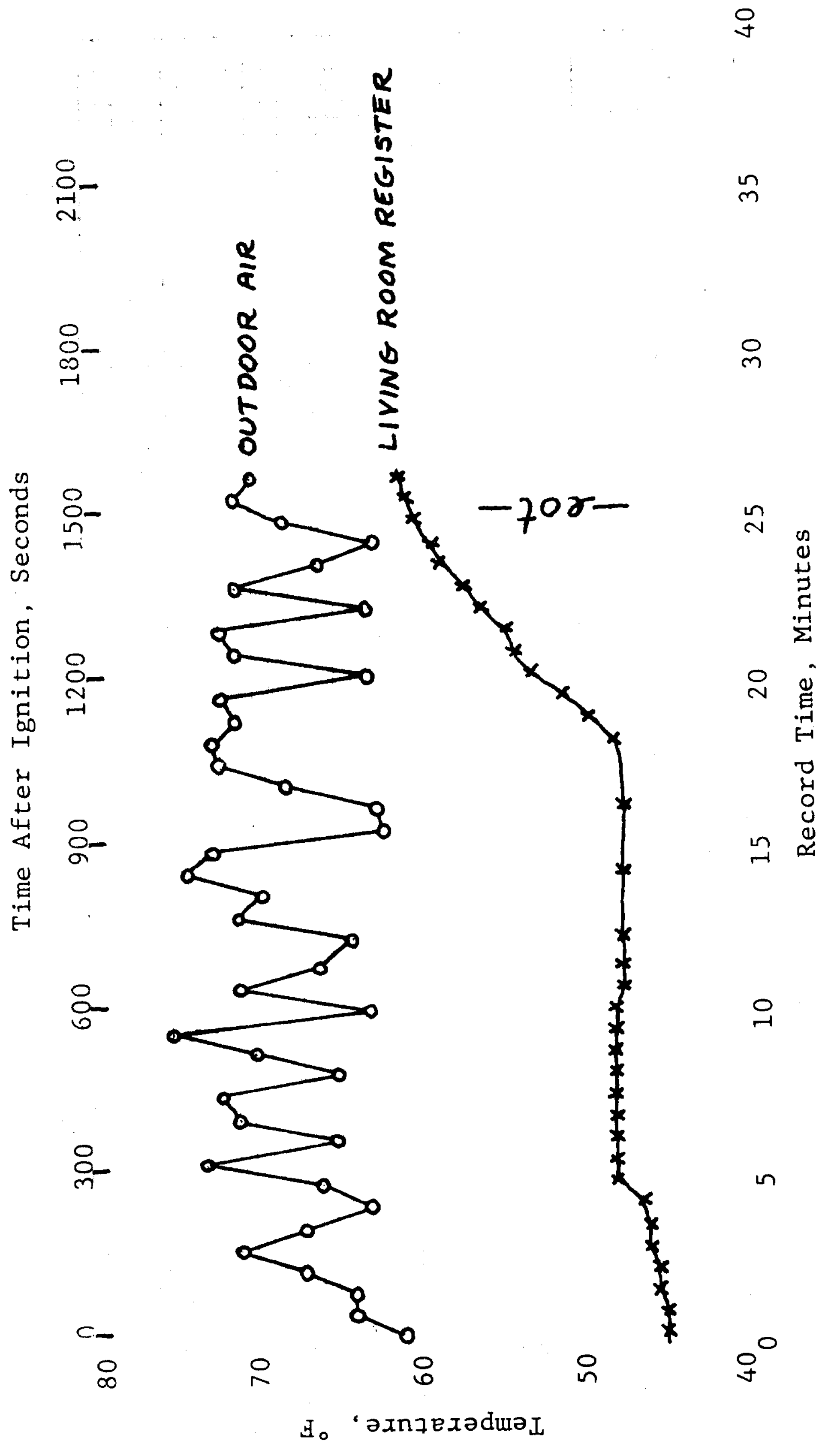
CONDITIONS ON 2ND FLOOR AT 5 FT, JR-13



VARIOUS CONDITIONS, JR-13

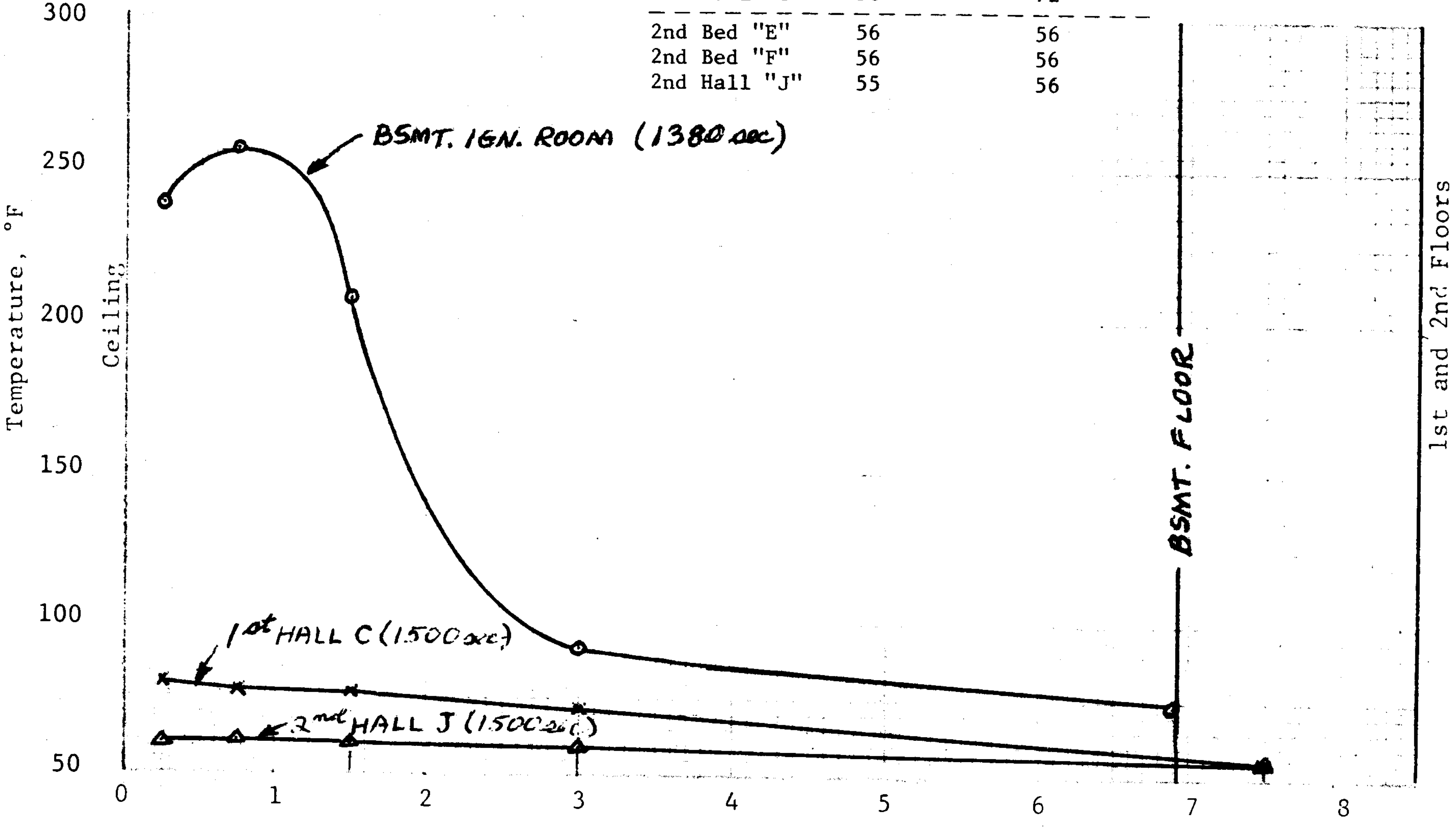


TEMPERATURES IN IGNITION ROOM (BSMT.), JR-13

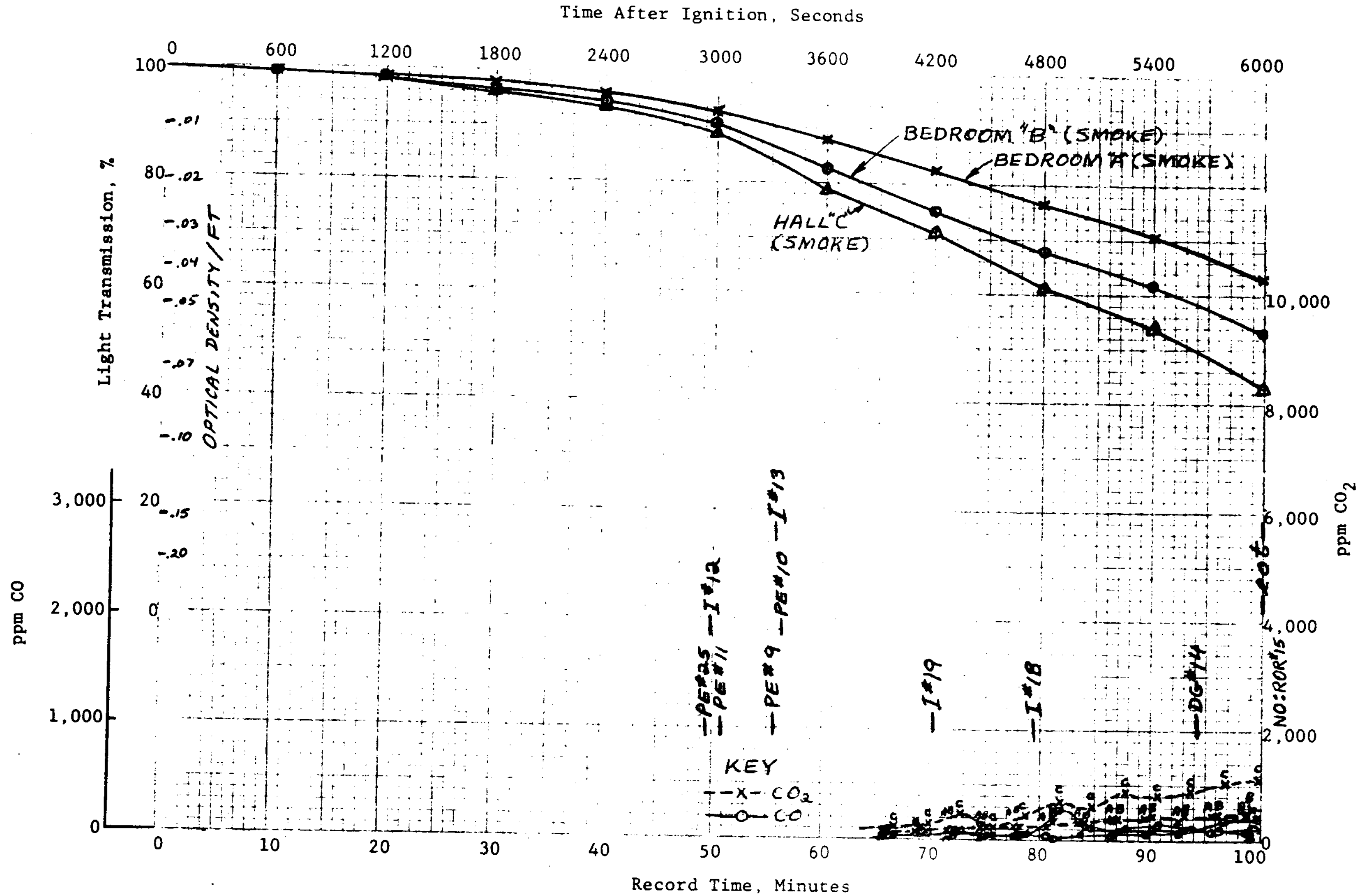


MISCELLANEOUS TEMPERATURES, JR-13

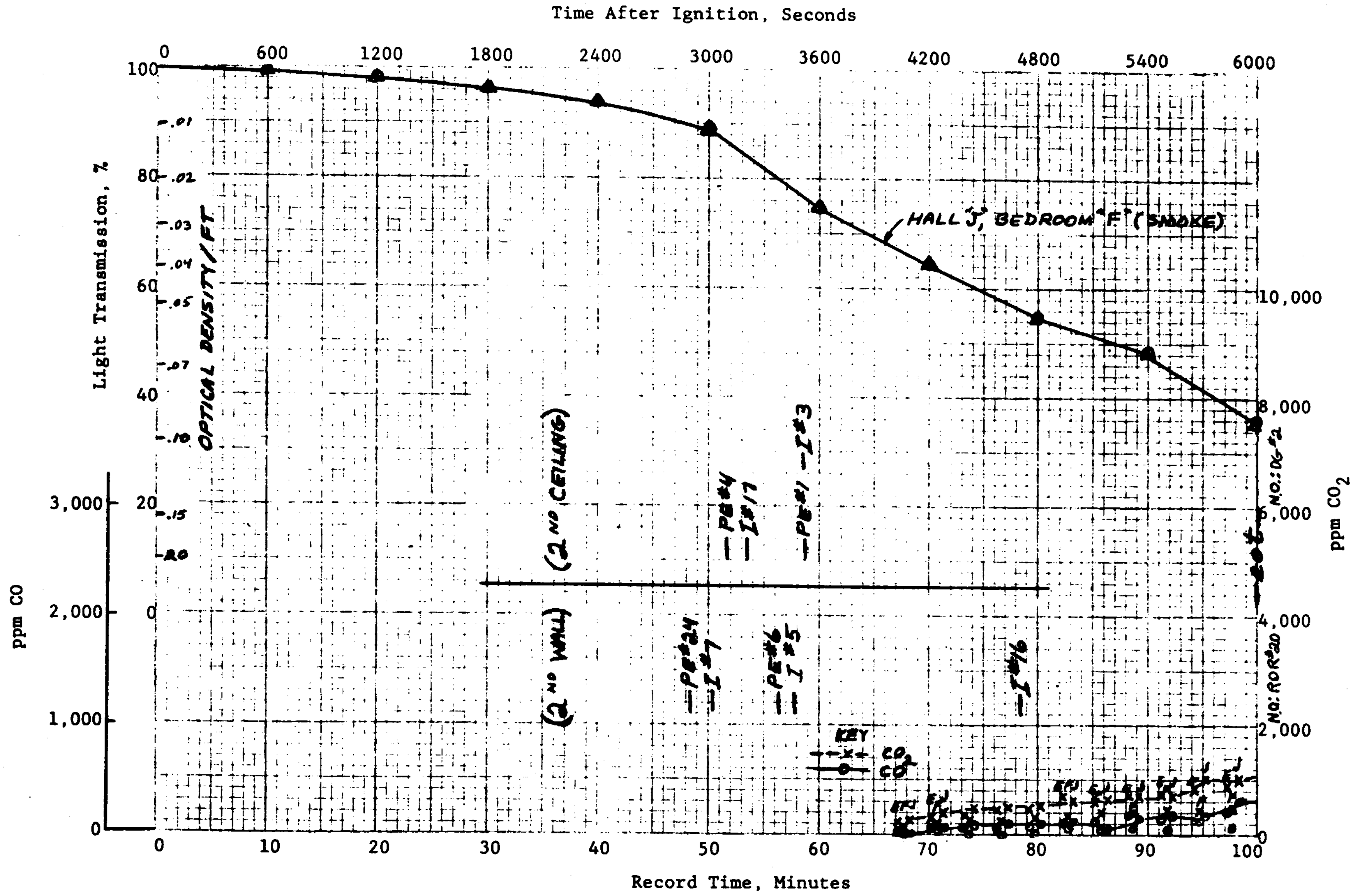
Location	Initial	Final (or max.)
Temps 5' High, 3" From Wall, °F		
1st Bed "A"	56	58
1st Bed "B"	55	58
1st Hall "C"	56	72
2nd Bed "E"	56	56
2nd Bed "F"	56	56
2nd Hall "J"	55	56



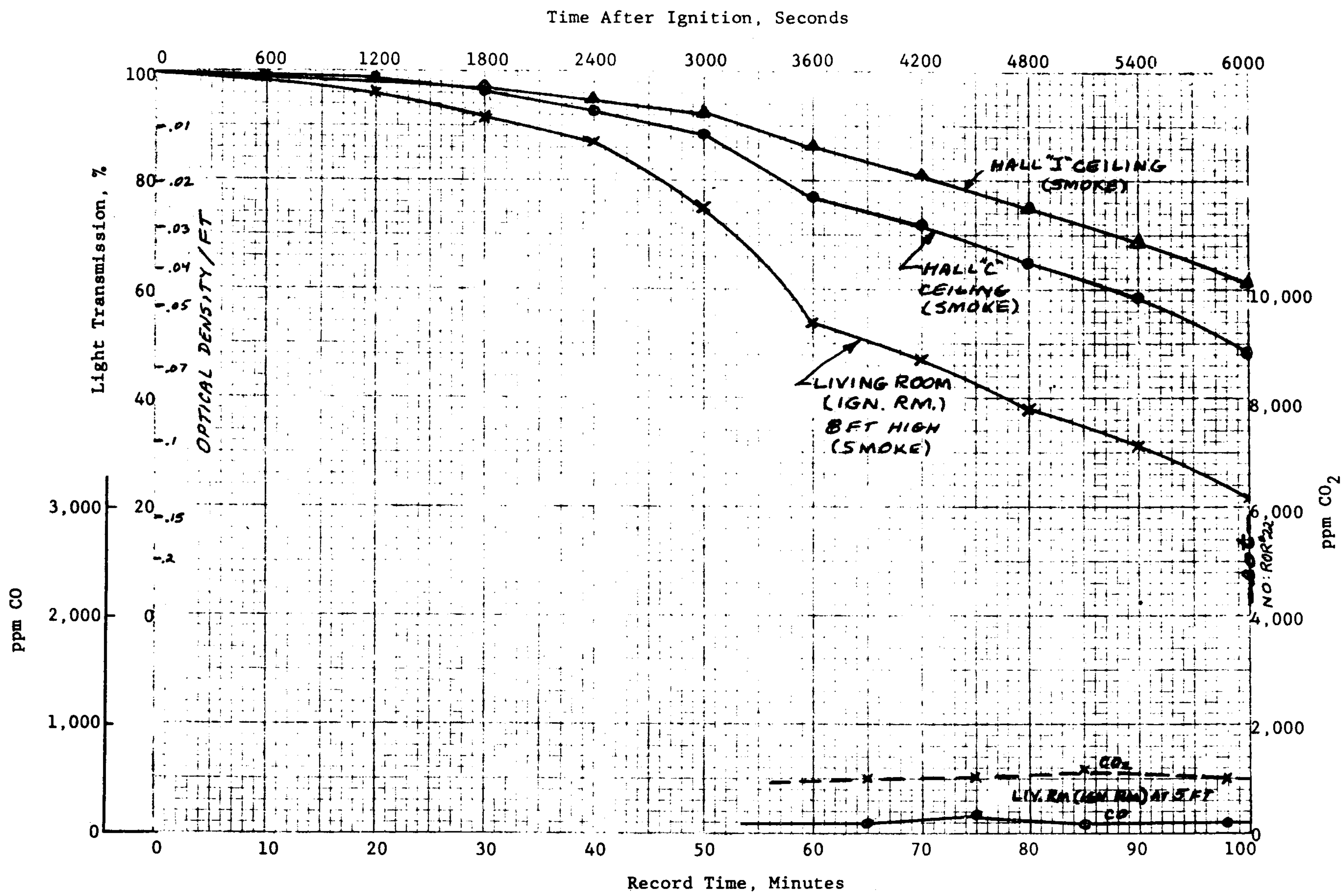
Maximum Temperature Profiles, JR-13



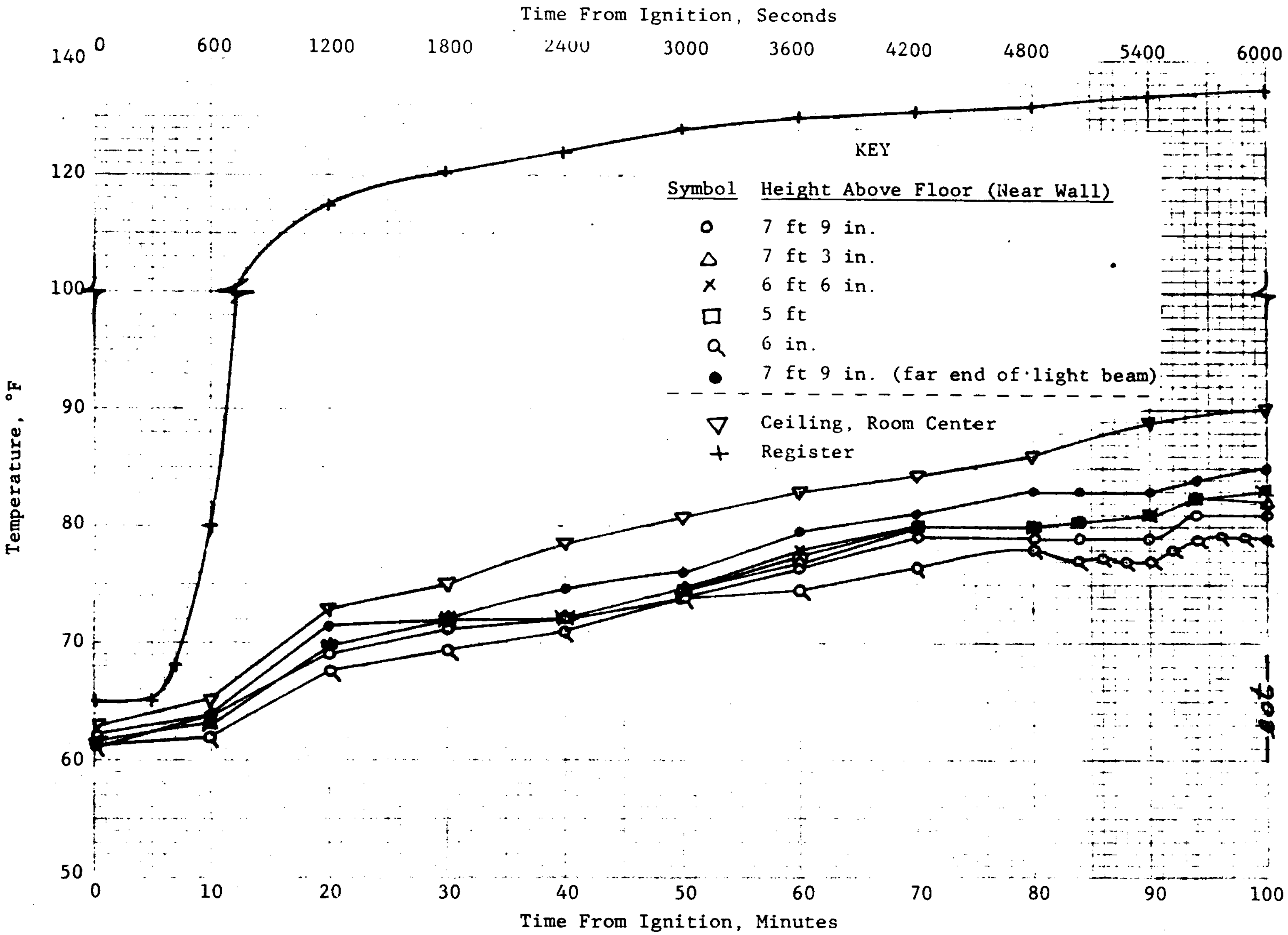
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-14



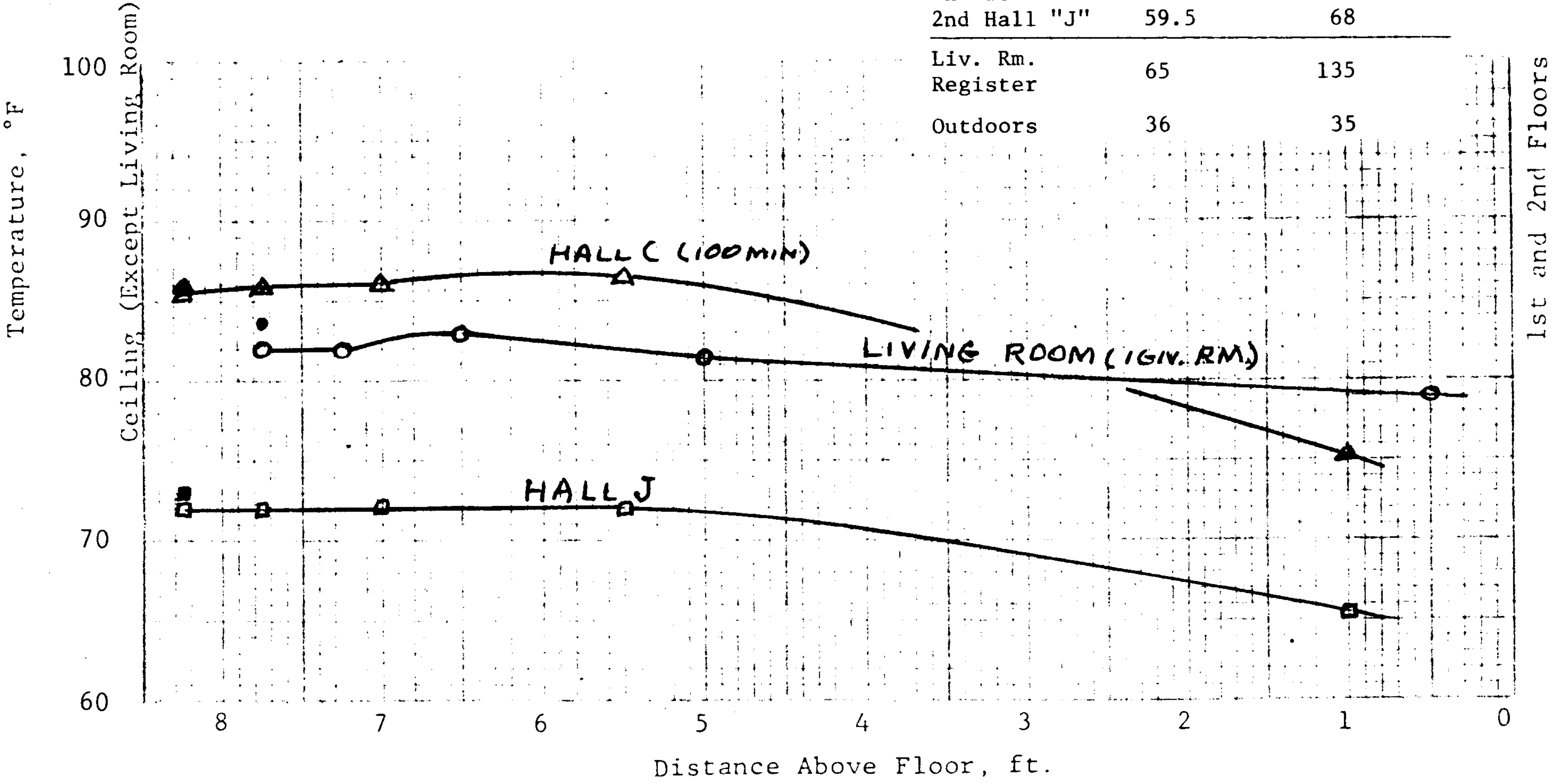
CONDITIONS ON 2ND FLOOR AT 5 FT, JR-14



VARIOUS CONDITIONS, JR-14

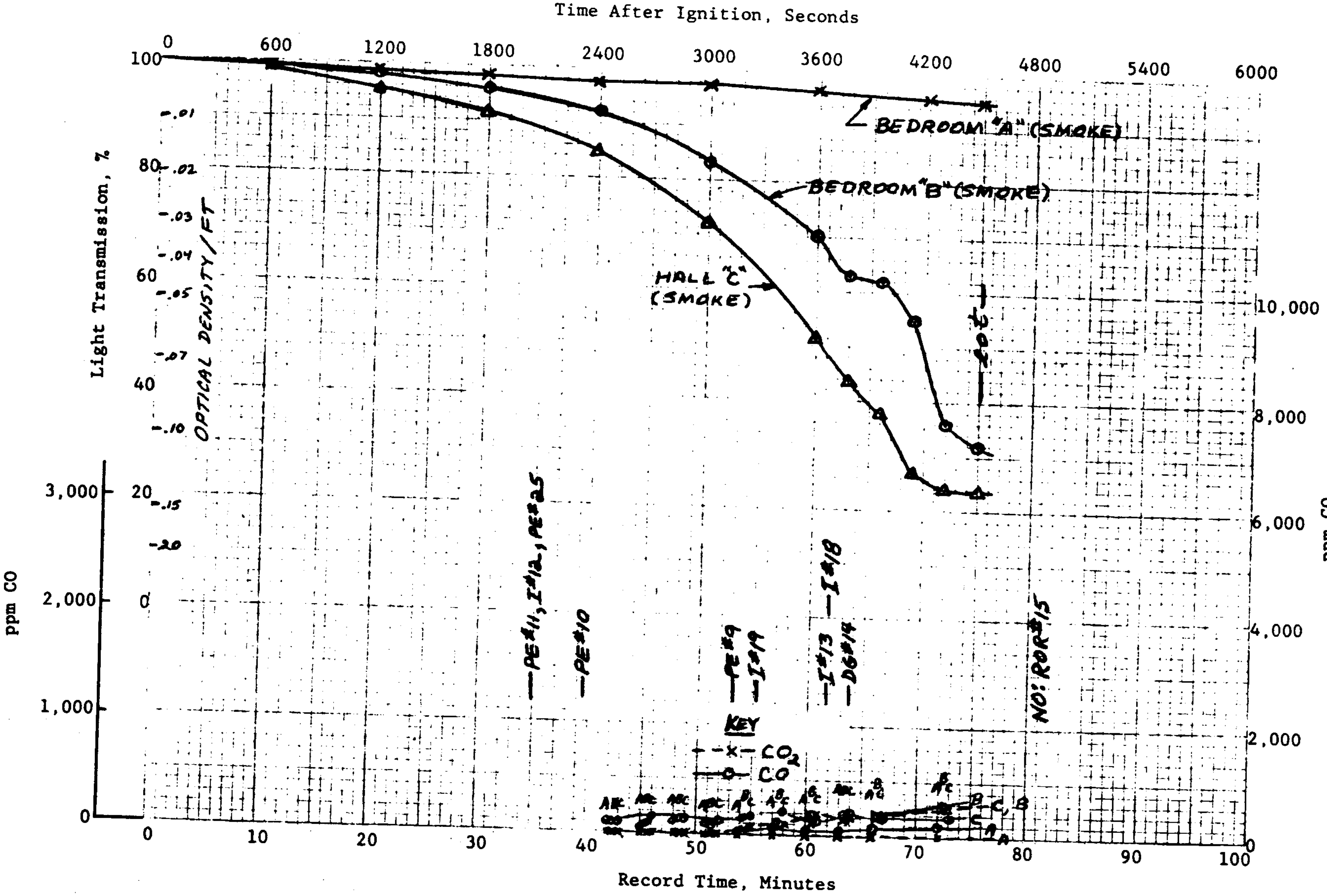


TEMPERATURES IN IGNITION ROOM (LIVING ROOM), JR-14

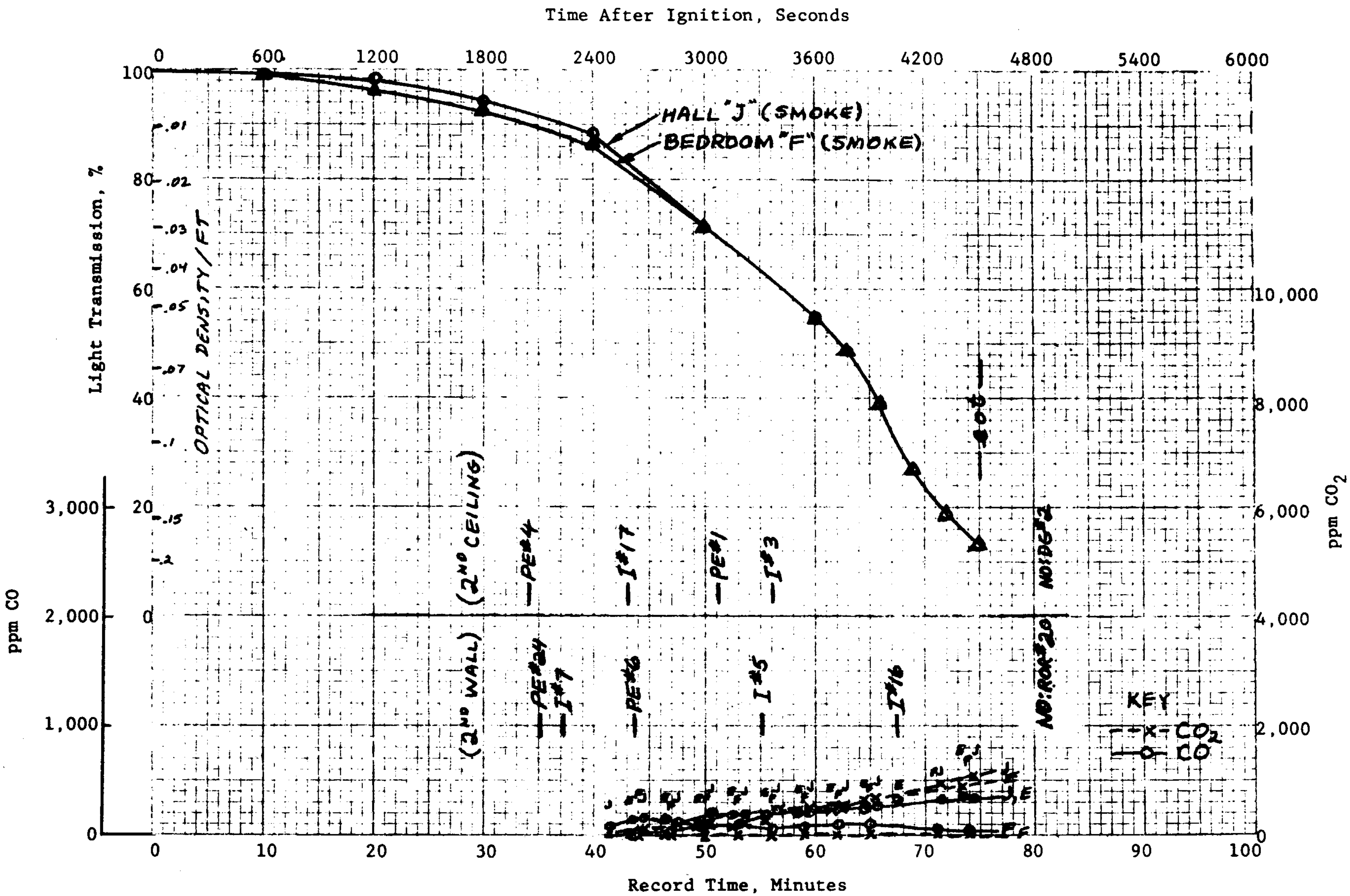


Temps 5' High, 3" From Wall, °F		
Location	Initial	Final (or max.)
1st Bed "A"	57	65.5
1st Bed "B"	59	75
1st Hall "C"	62	--
2nd Bed "E"	58	63
2nd Bed "F"	58	68
2nd Hall "J"	59.5	68
Liv. Rm. Register	65	135
Outdoors	36	35

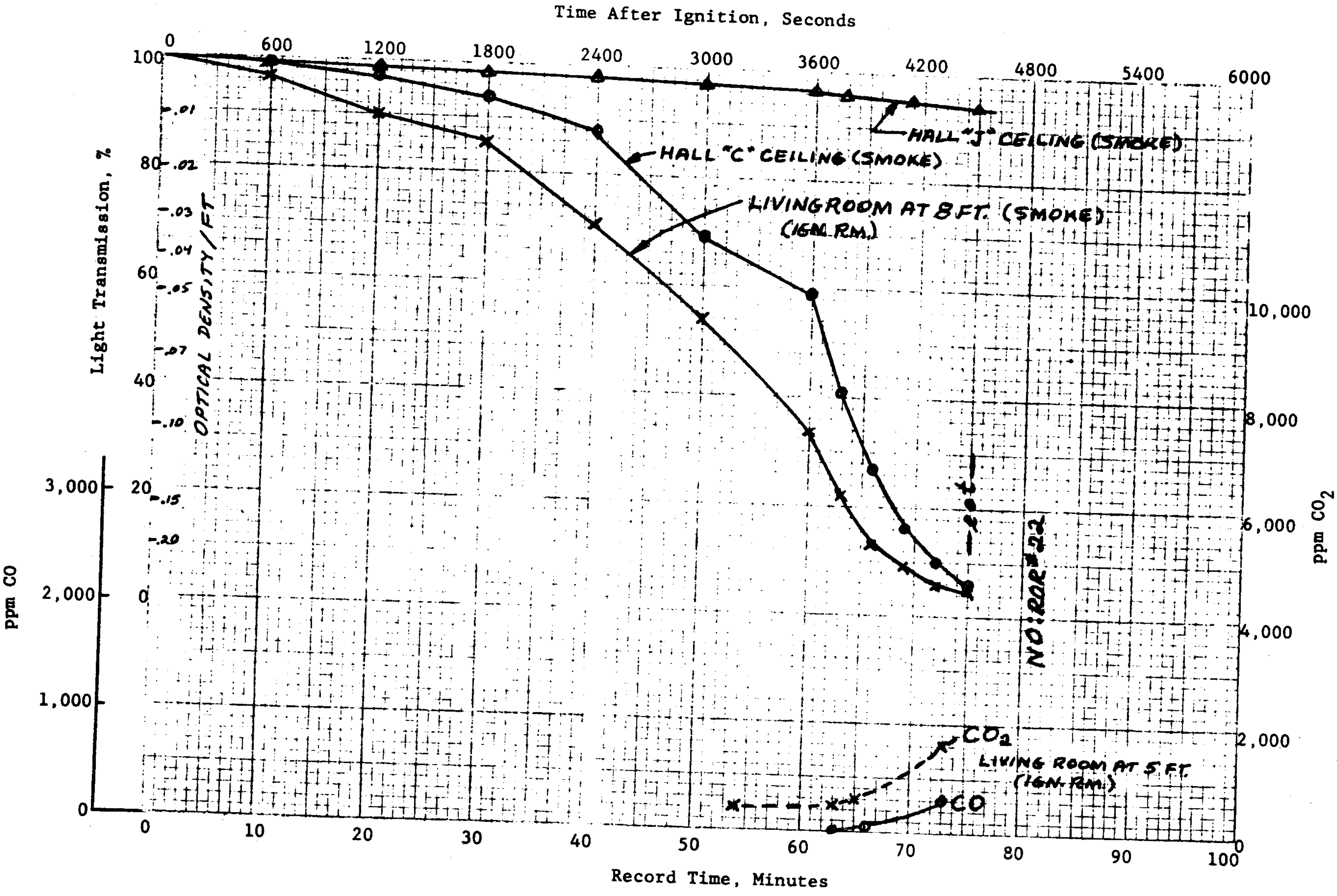
Maximum Temperature Profiles, JR-14



CONDITIONS ON 1ST FLOOR AT 5 FT, JR-15

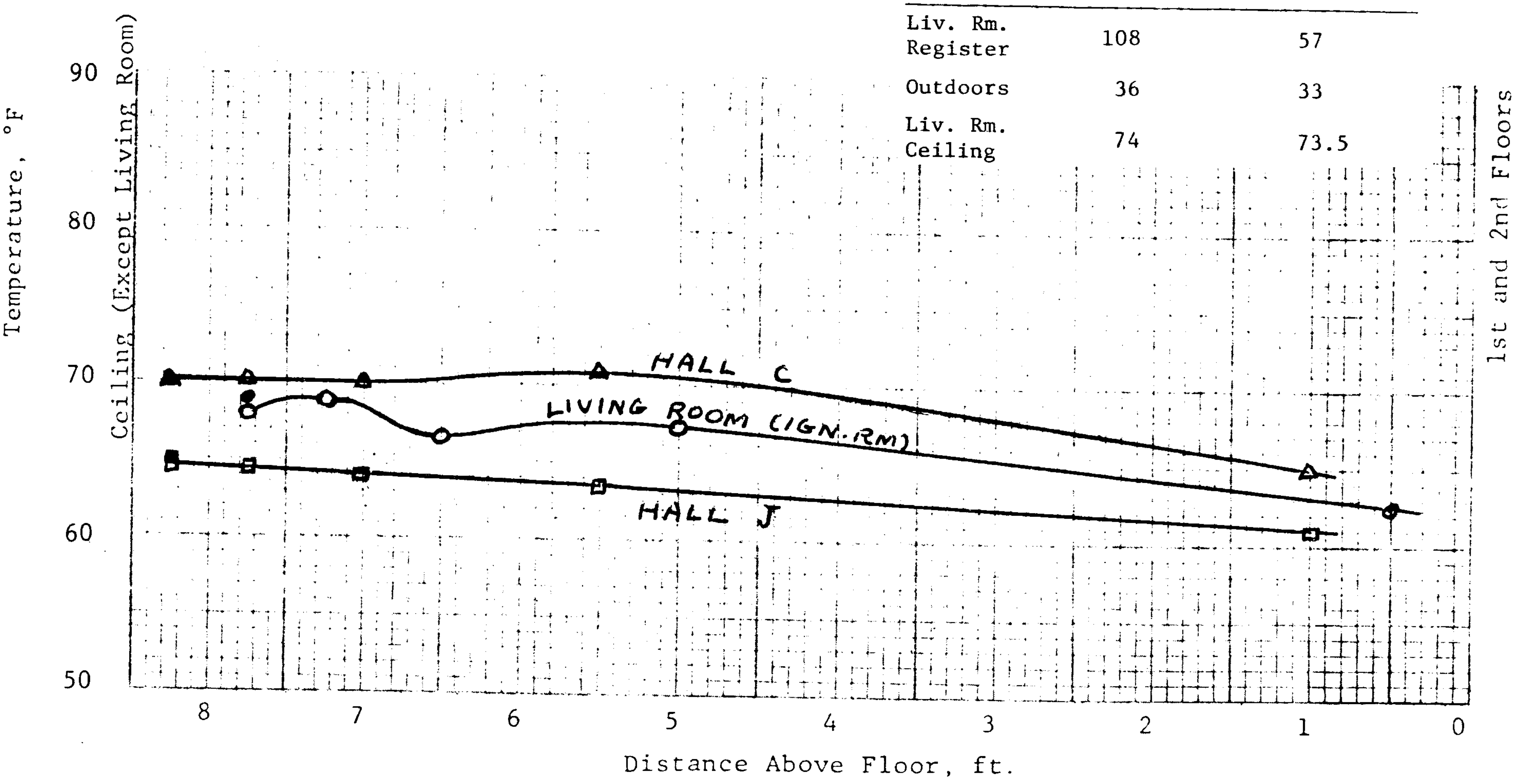


CONDITIONS ON 2ND FLOOR AT 5 FT, JR-15

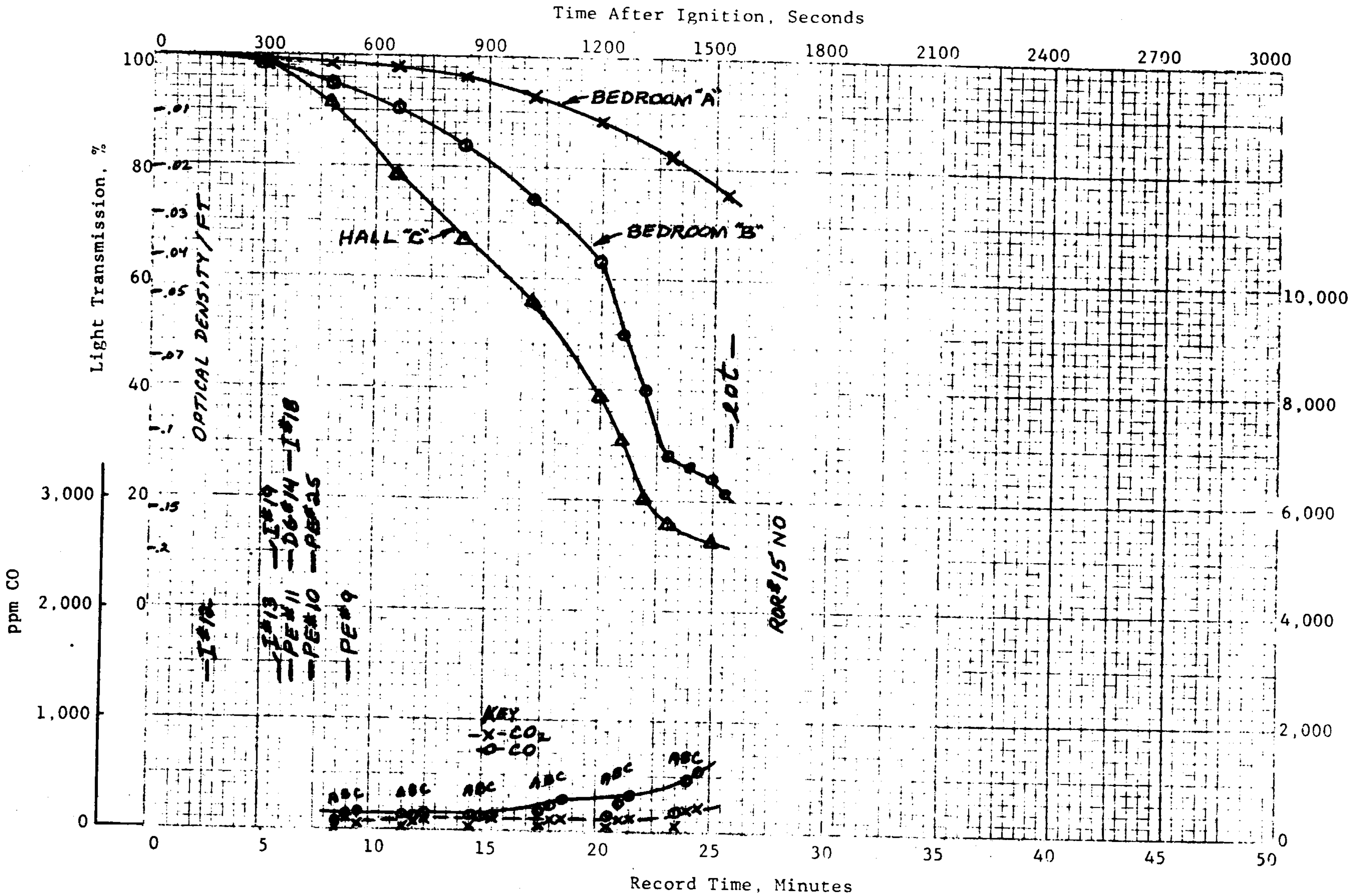


VARIOUS CONDITIONS, JR-15

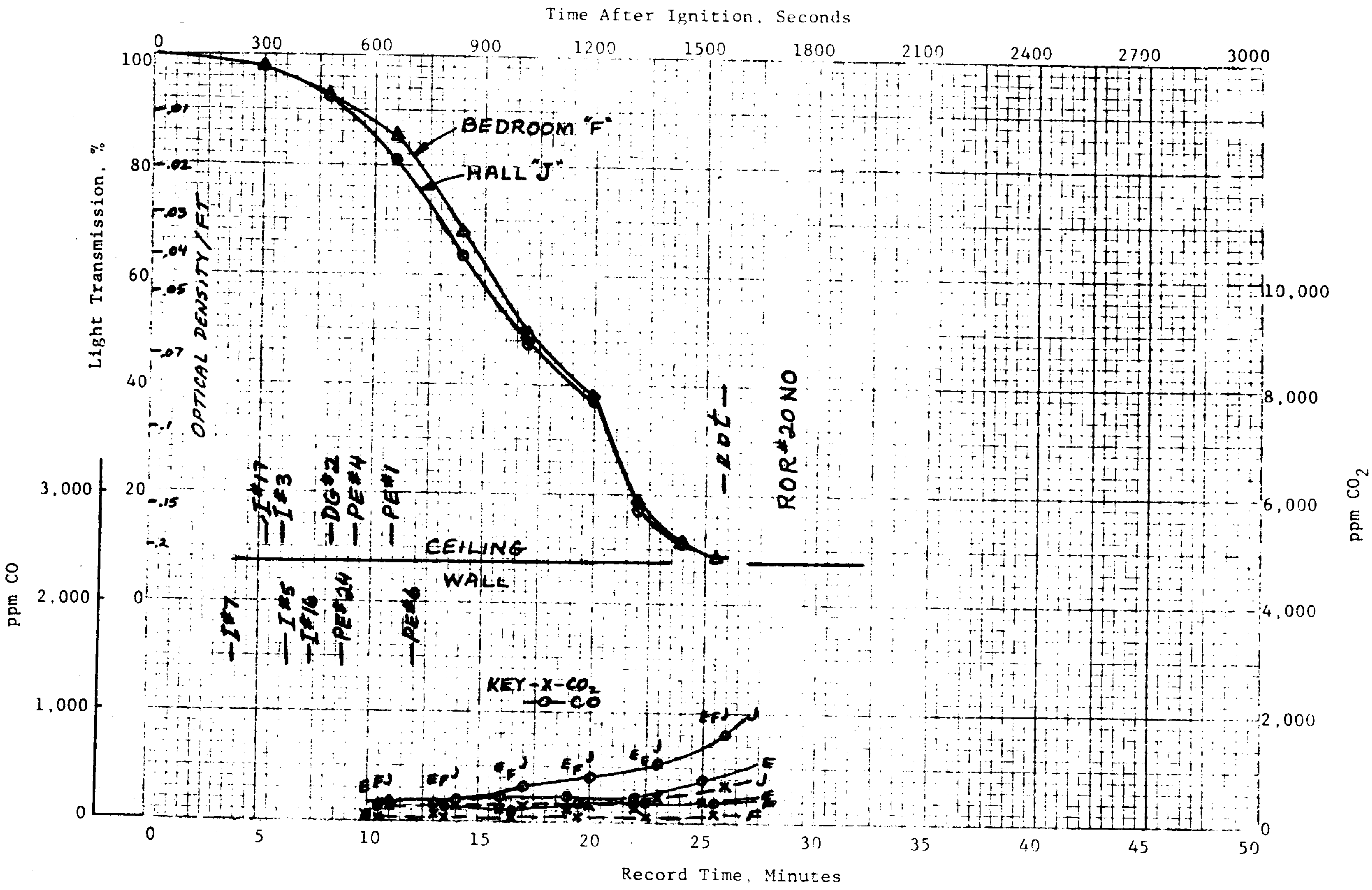
Location	Initial	Final (or max.)
Temps 5' High, 3" From Wall, °F		
1st Bed "A"	63	58
1st Bed "B"	70	64
1st Hall "C"	71	69
2nd Bed "E"	63	61
2nd Bed "F"	64	53
2nd Hall "J"	66	63
Liv. Rm. Register	108	57
Outdoors	36	33
Liv. Rm. Ceiling	74	73.5



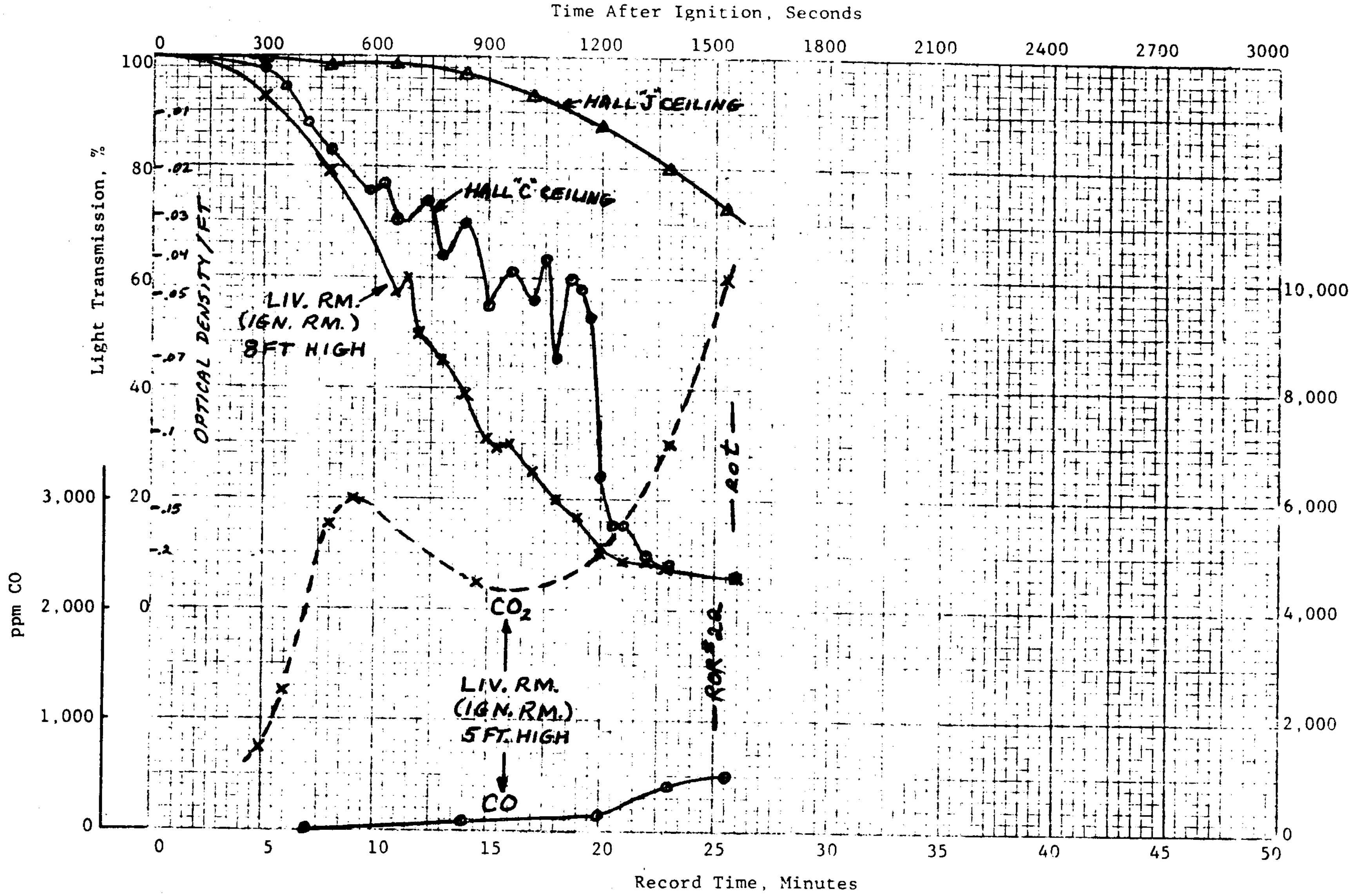
Maximum Temperature Profiles, JR-15



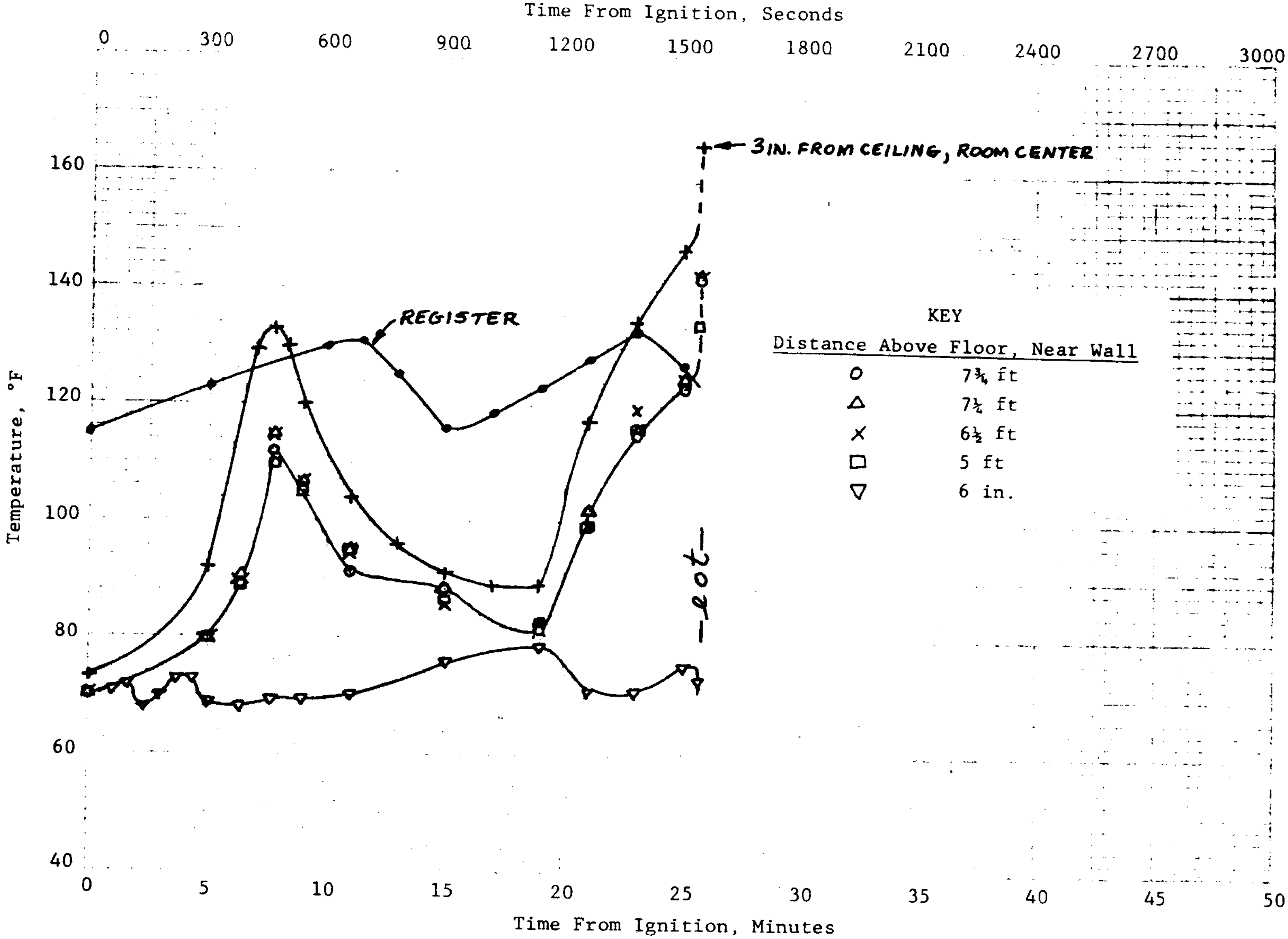
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-16



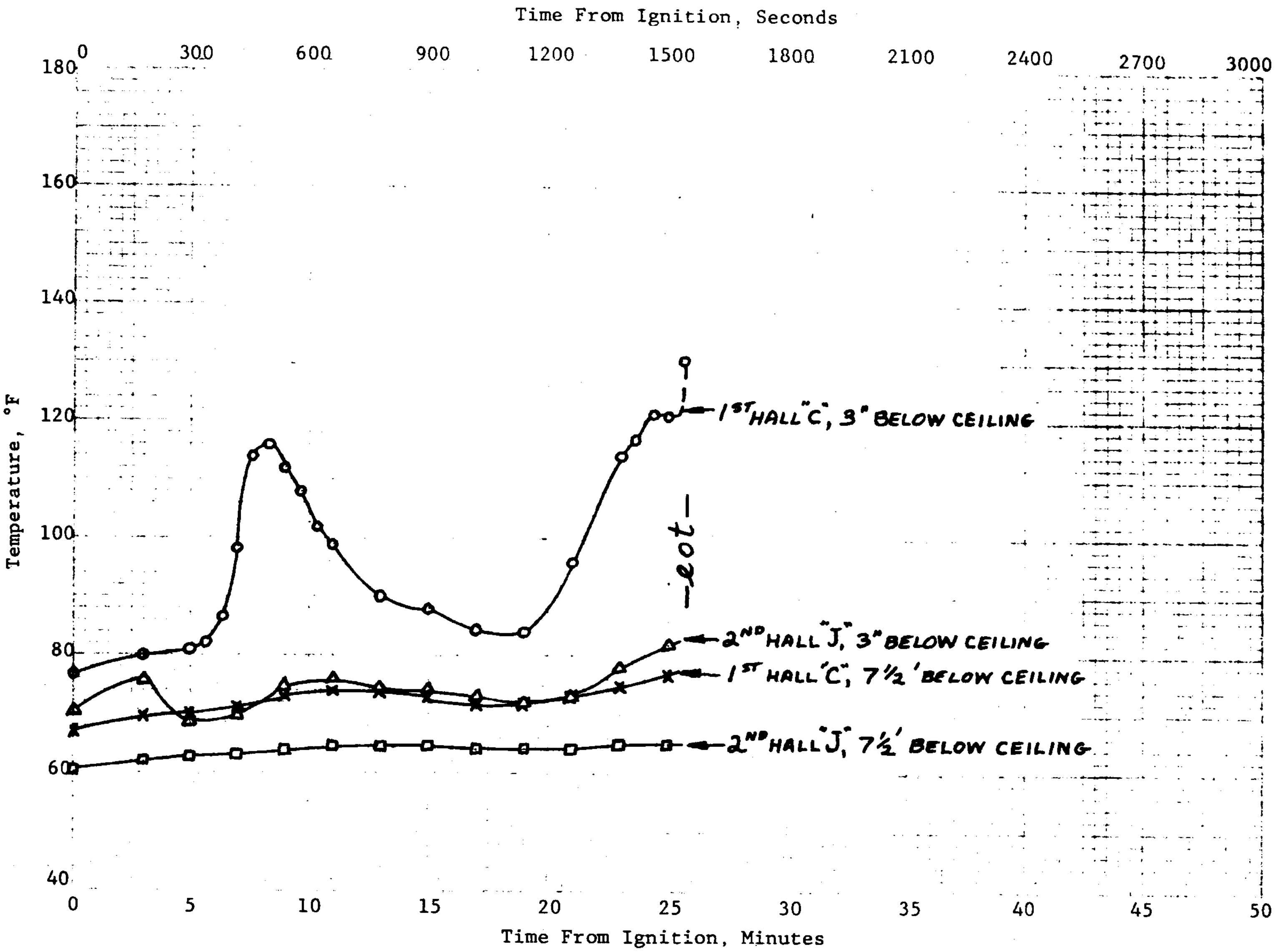
CONDITIONS ON 2ND FLOOR AT 5 FT, JR-16



VARIOUS CONDITIONS, JR-16

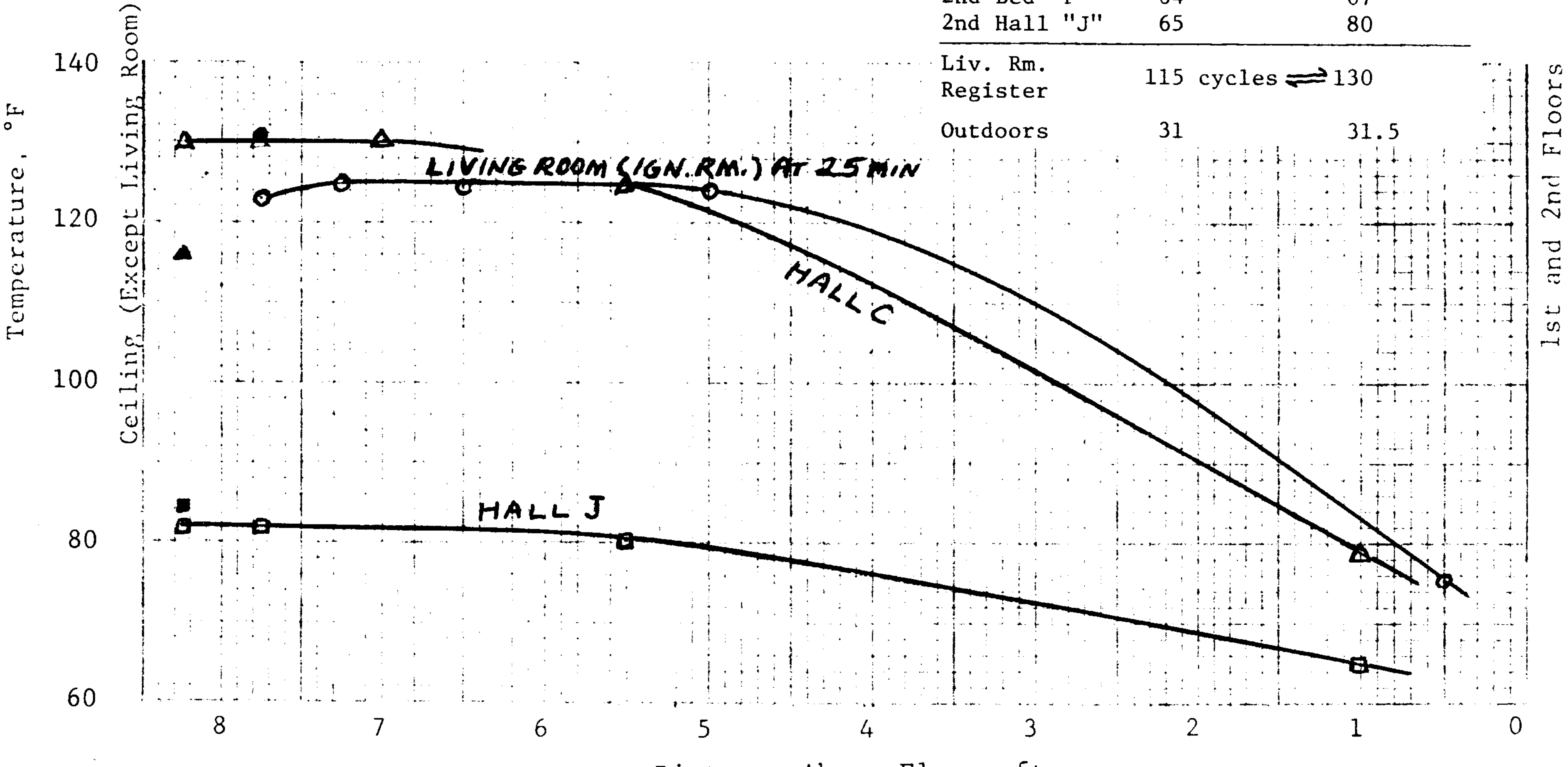


TEMPERATURES IN IGNITION ROOM (LIVING ROOM), JR-16

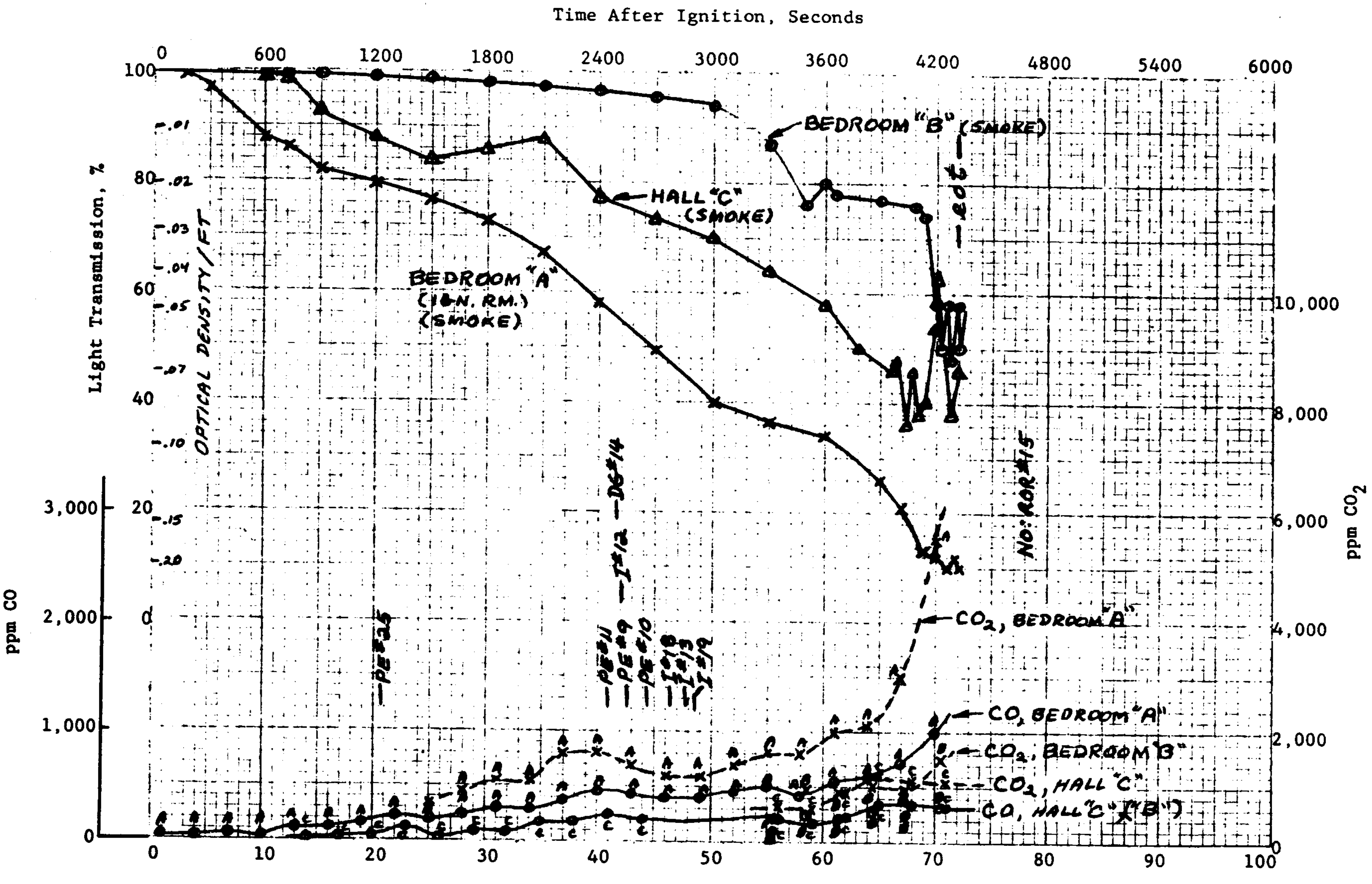


TEMPERATURES IN HALLS, JR-16

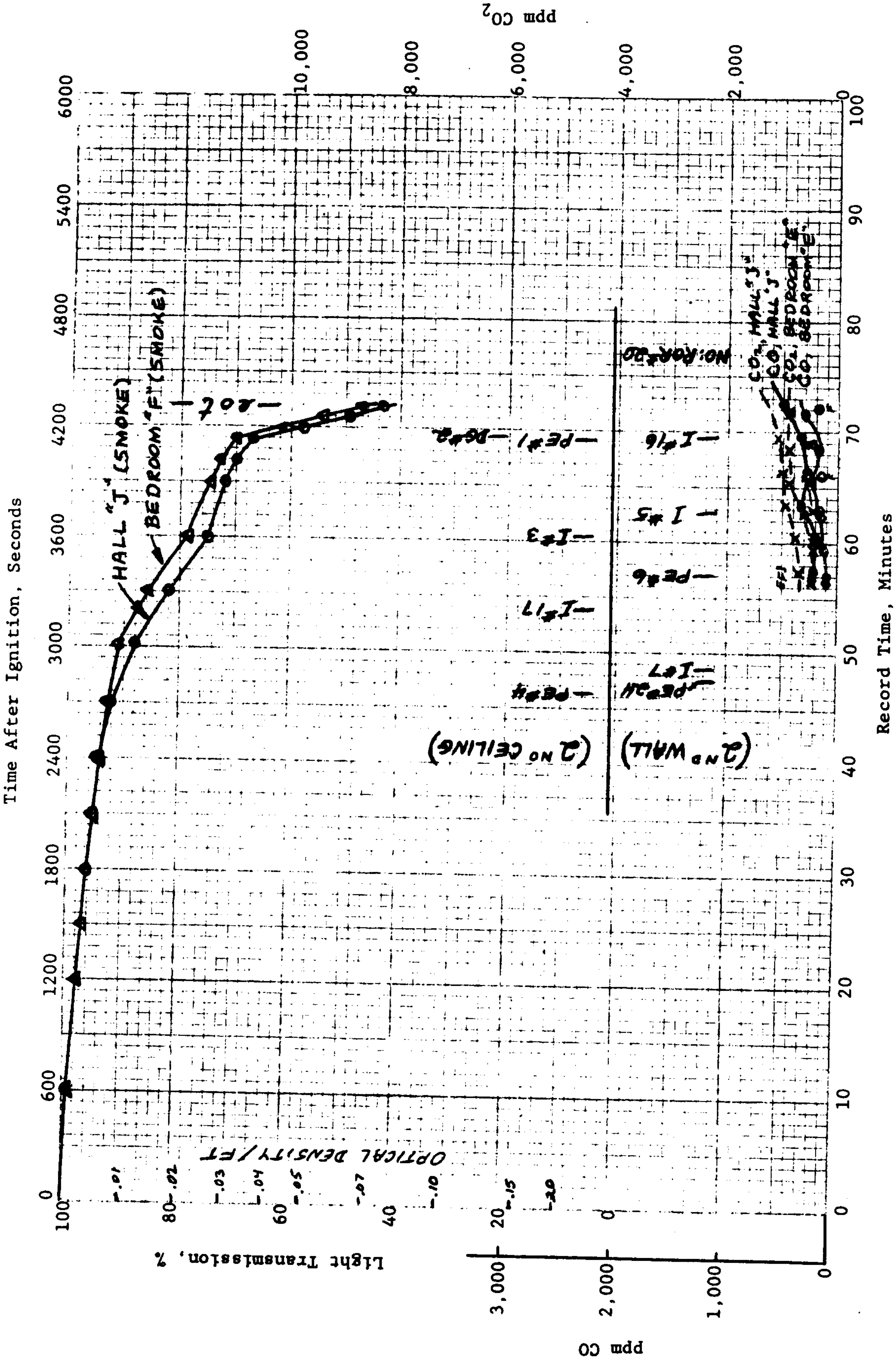
Location	Initial	Final (or max.)
Temps 5' High, 3" From Wall, °F		
1st Bed "A"	64	66
1st Bed "B"	71	84
1st Hall "C"	74	90
2nd Bed "E"	63	71
2nd Bed "F"	64	67
2nd Hall "J"	65	80
Liv. Rm. Register	115 cycles ⇄ 130	
Outdoors	31	31.5



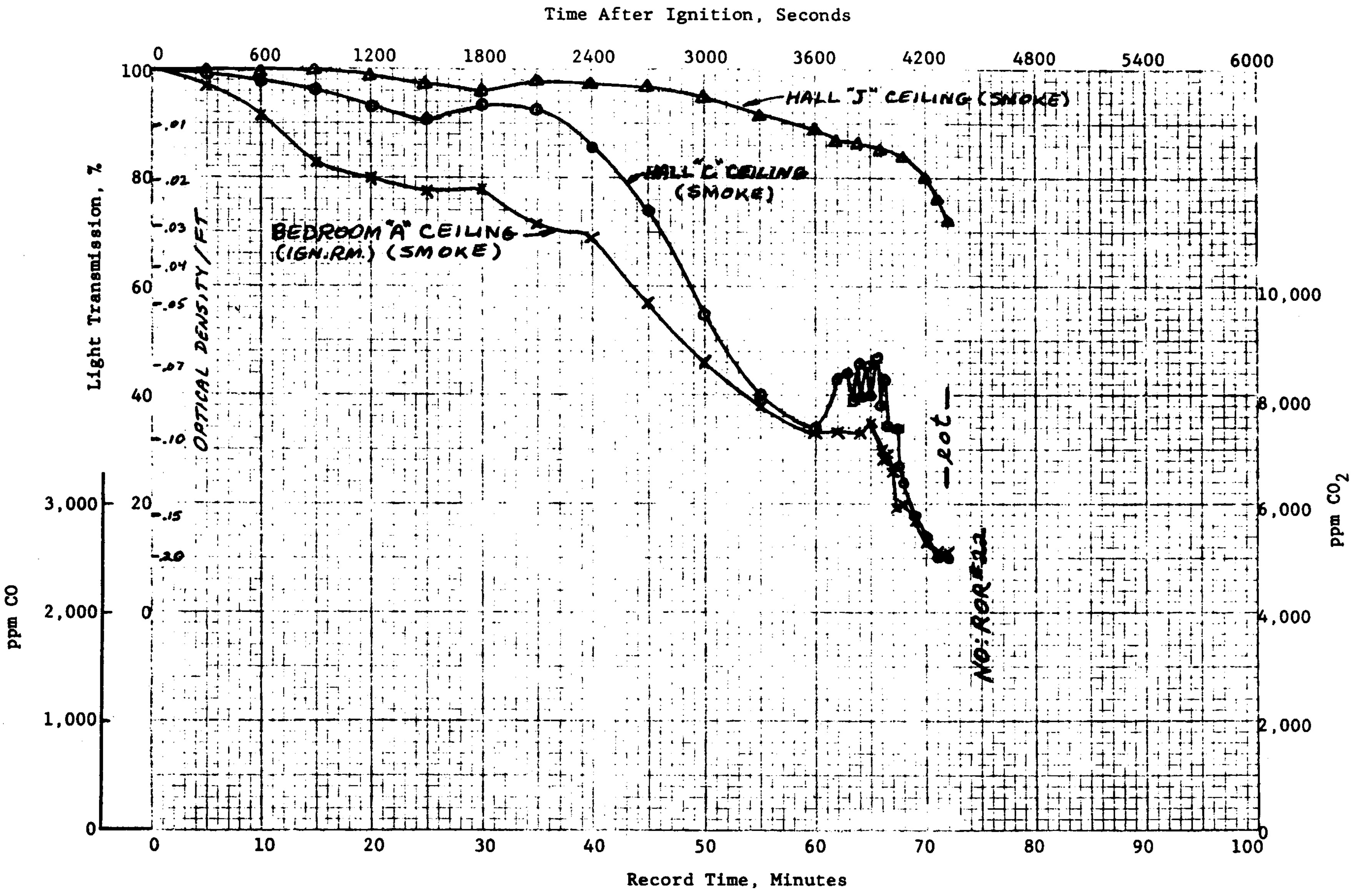
Maximum Temperature Profiles, JR-16



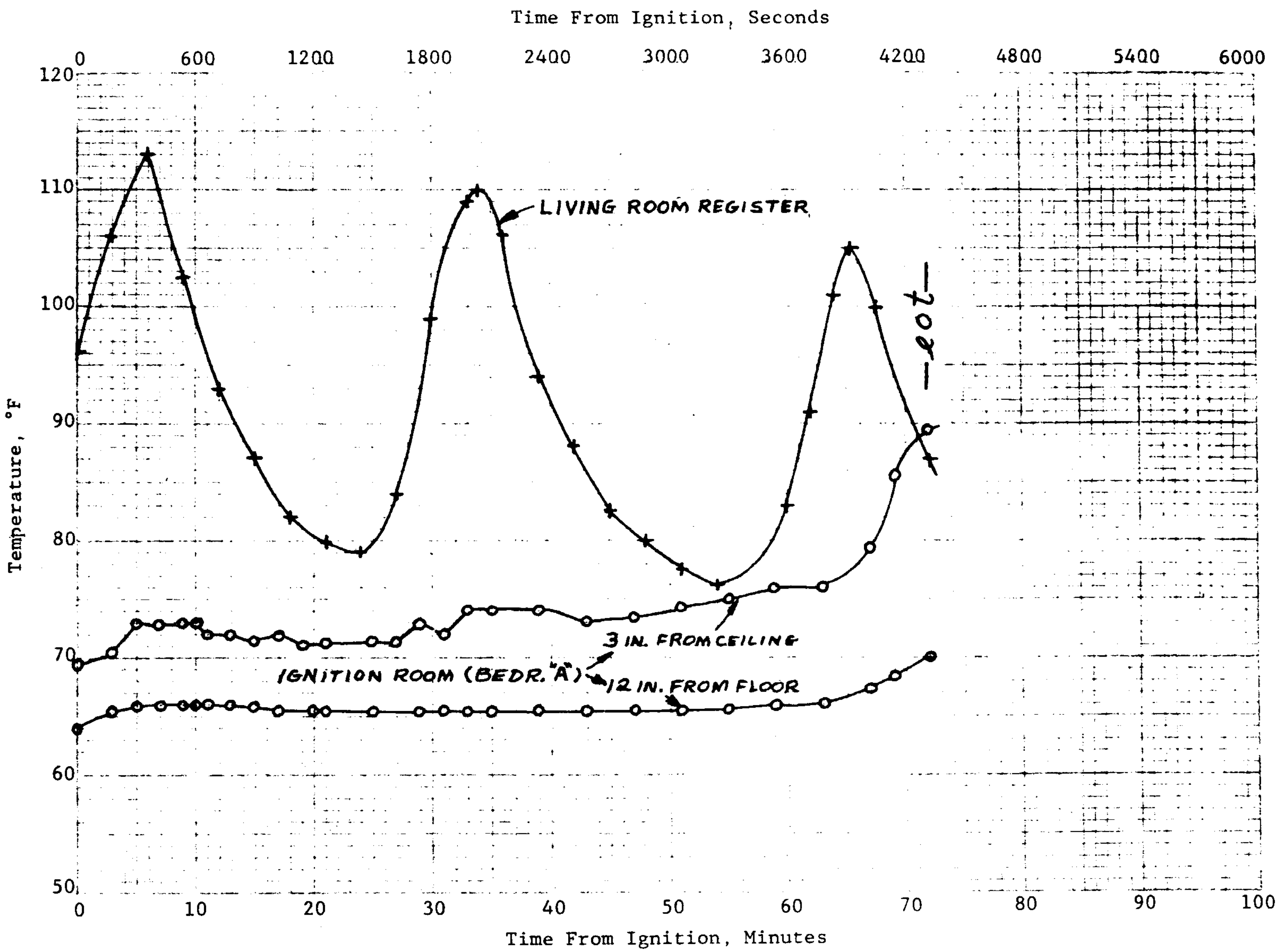
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-17



CONDITIONS ON 2ND FLOOR AT 5 FT, JR-17

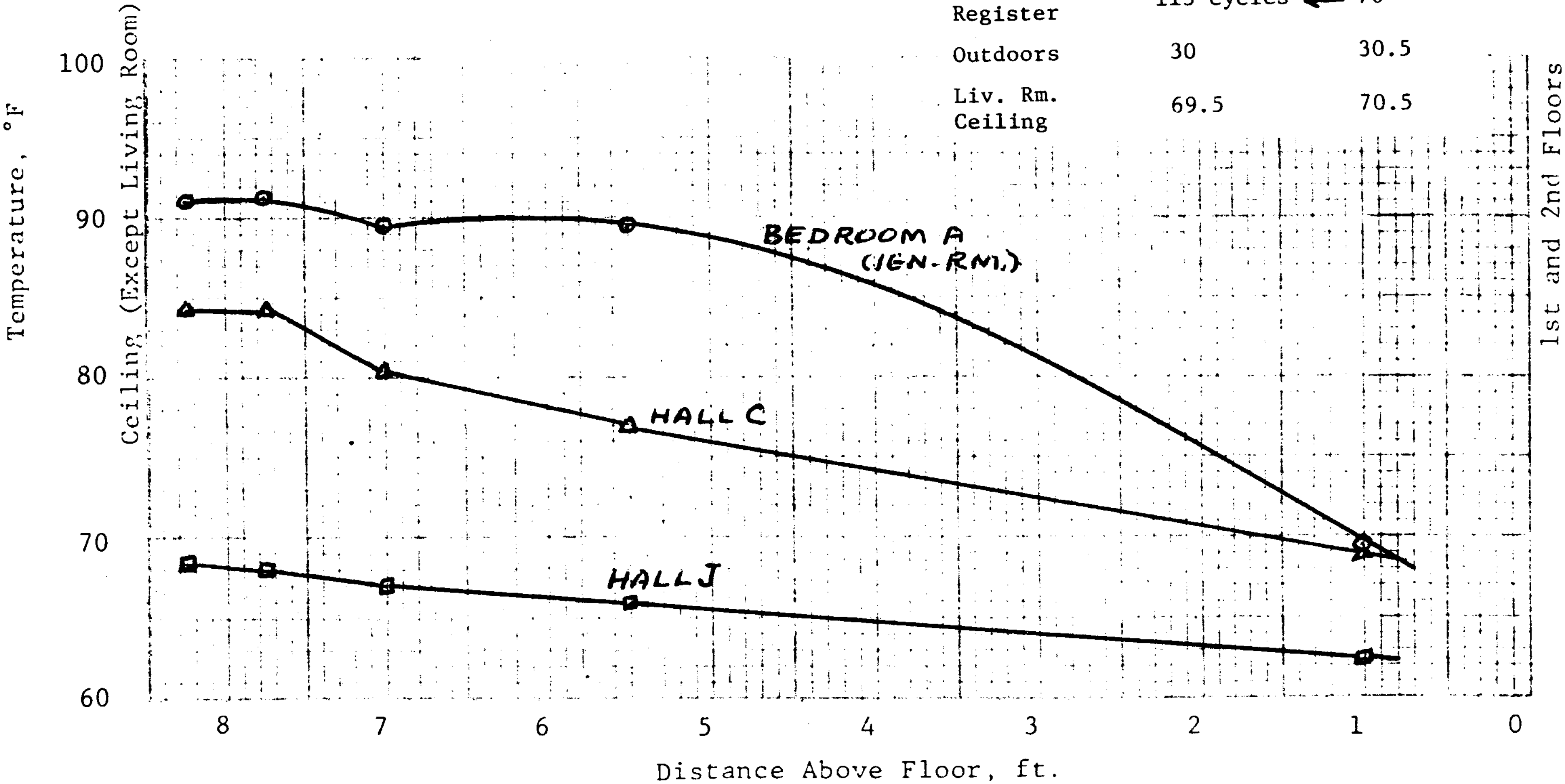


VARIOUS CONDITIONS, JR-17

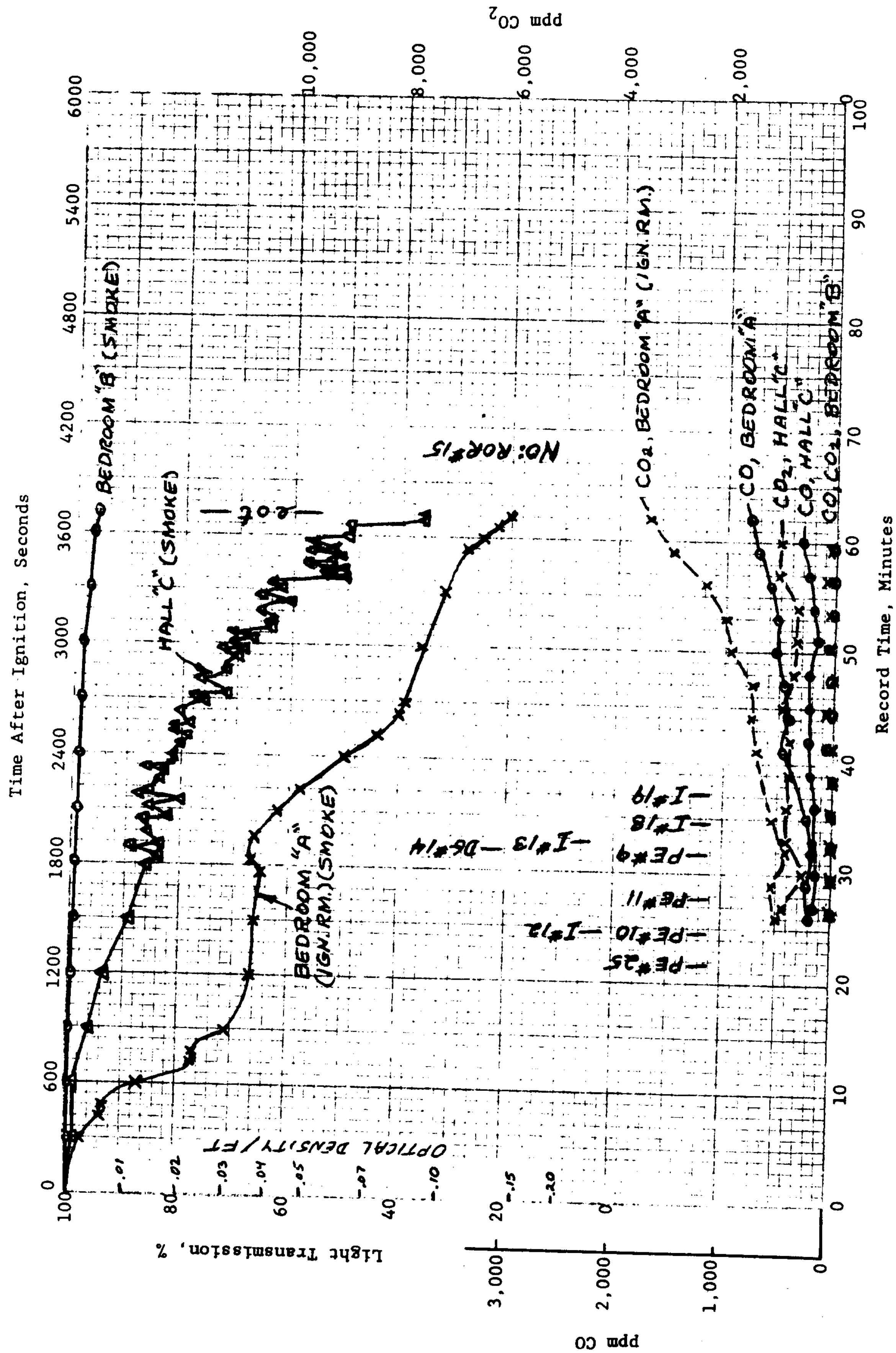


VARIOUS TEMPERATURES, JR-17

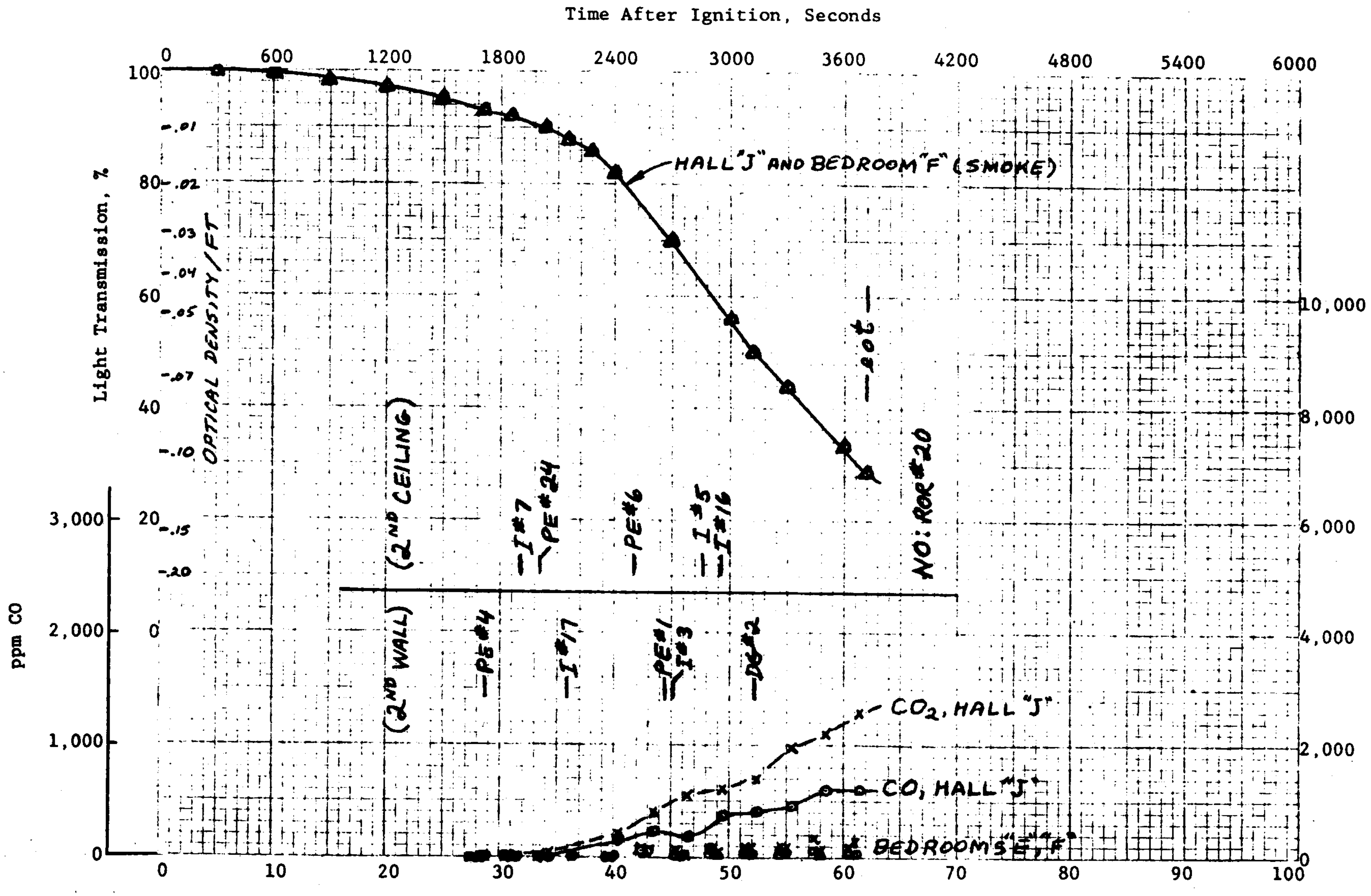
Location	Initial	Final (or max.)
Temps 5' High, 3" From Wall, °F		
1st Bed "A"	68.5	90
1st Bed "B"	69	74
1st Hall "C"	71	73
2nd Bed "E"	64	65
2nd Bed "F"	65	65.5
2nd Hall "J"	66	68
Liv. Rm. Register	113 cycles ⇄	76
Outdoors	30	30.5
Liv. Rm. Ceiling	69.5	70.5



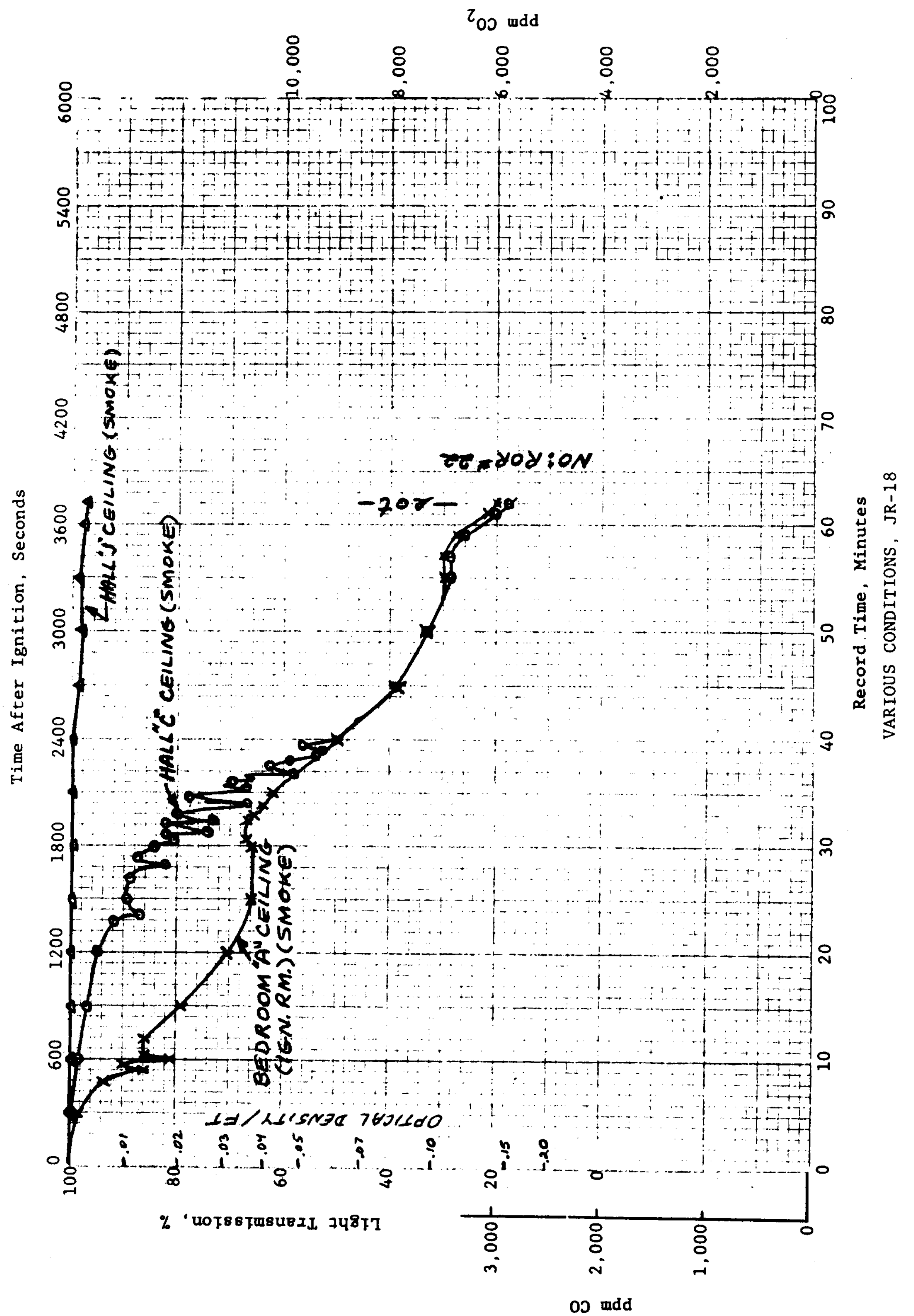
Maximum Temperature Profiles. JR-17



CONDITIONS ON 1ST FLOOR AT 5 FT, JR-18

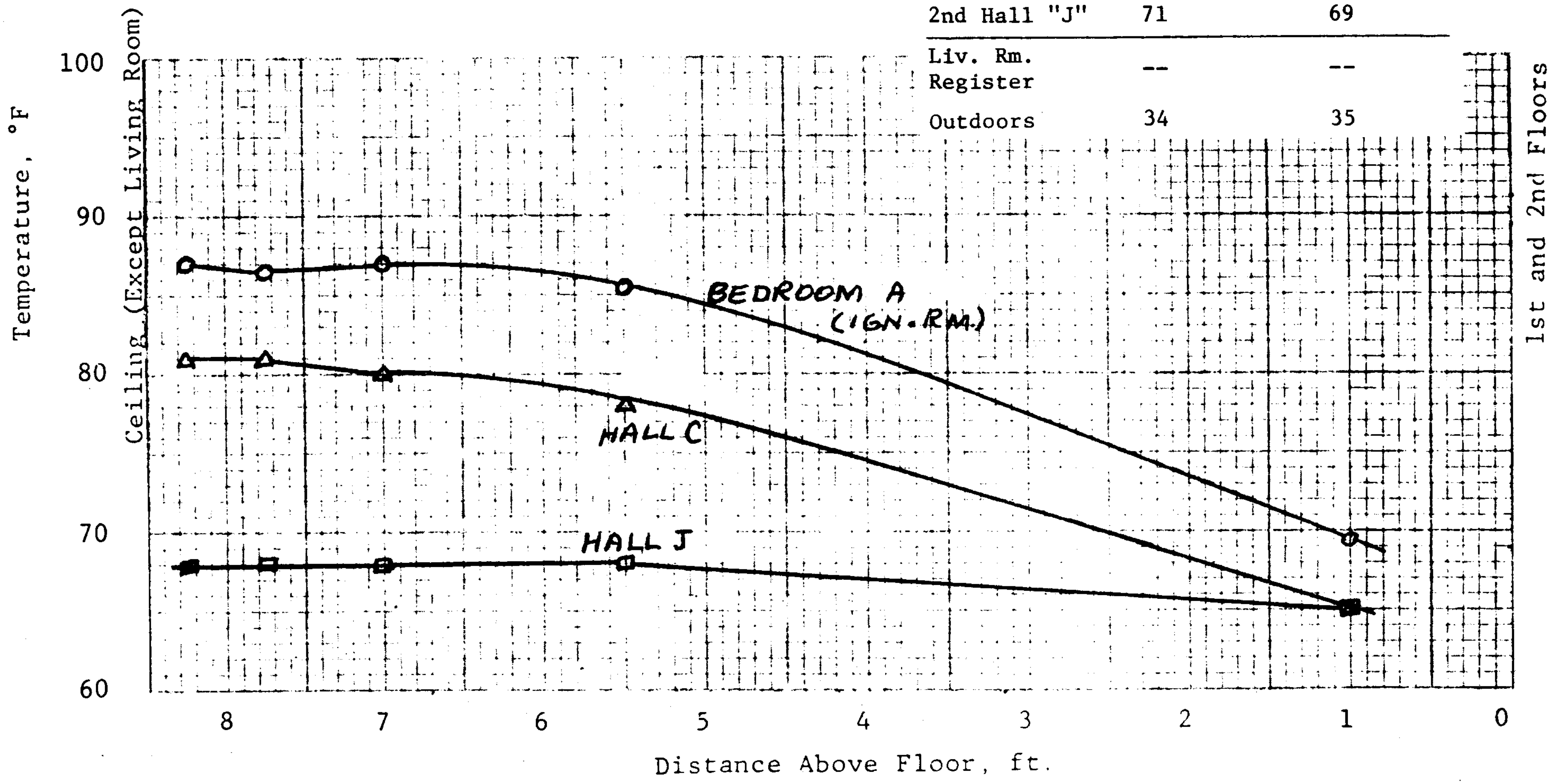


CONDITIONS ON 2ND FLOOR AT 5 FT, JR-18

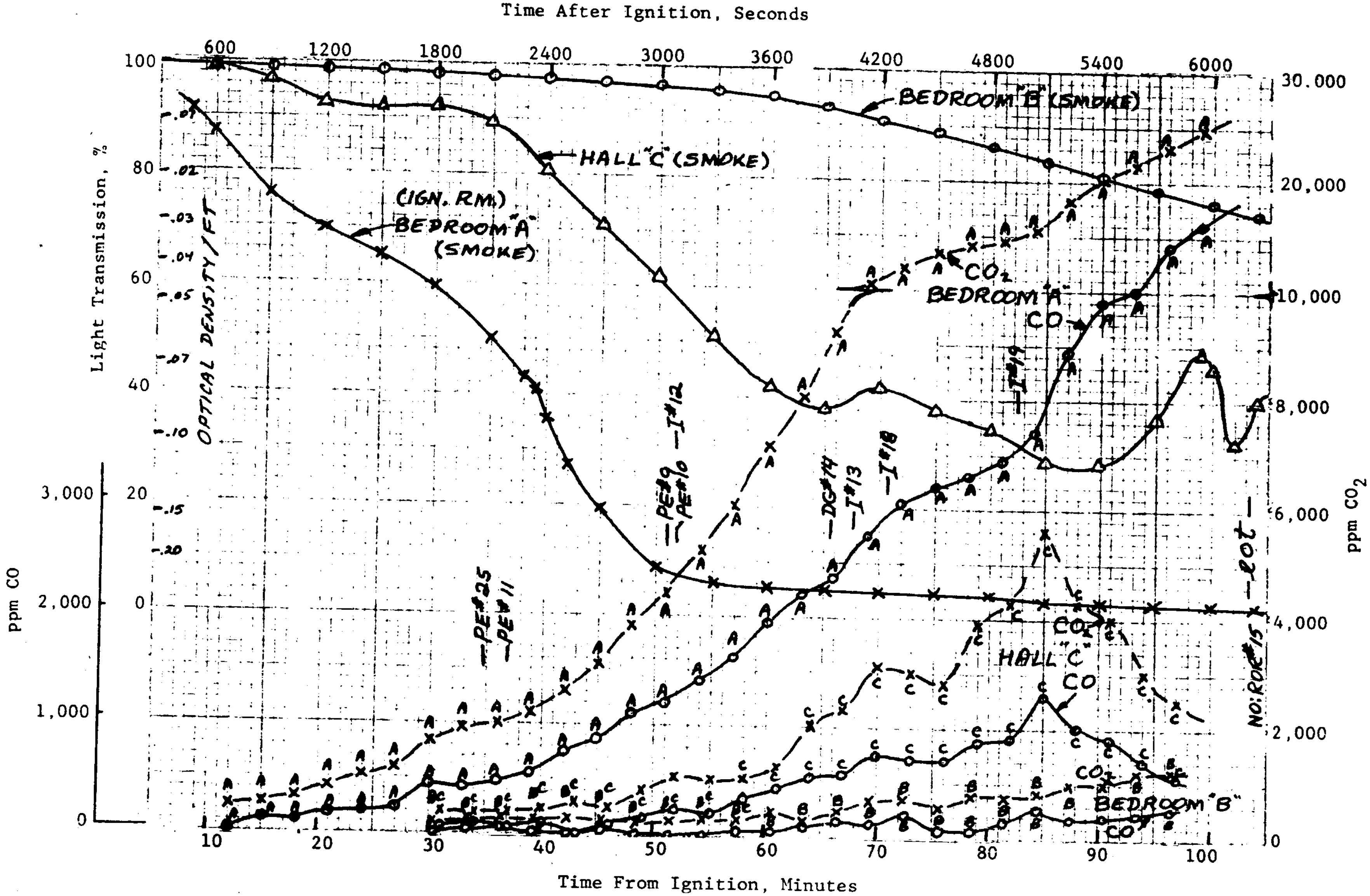


Time After Ignition, Seconds
Light Transmission, %
ppm CO_2
ppm CO
Record Time, Minutes
VARIOUS CONDITIONS, JR-18
OPTICAL DENSITY/FT
HALL "J" CEILING (SMOKE)
HALL "C" CEILING (SMOKE)
BEDROOM "A" CEILING (IGN. RM.) (SMOKE)
NO: ROR = 22

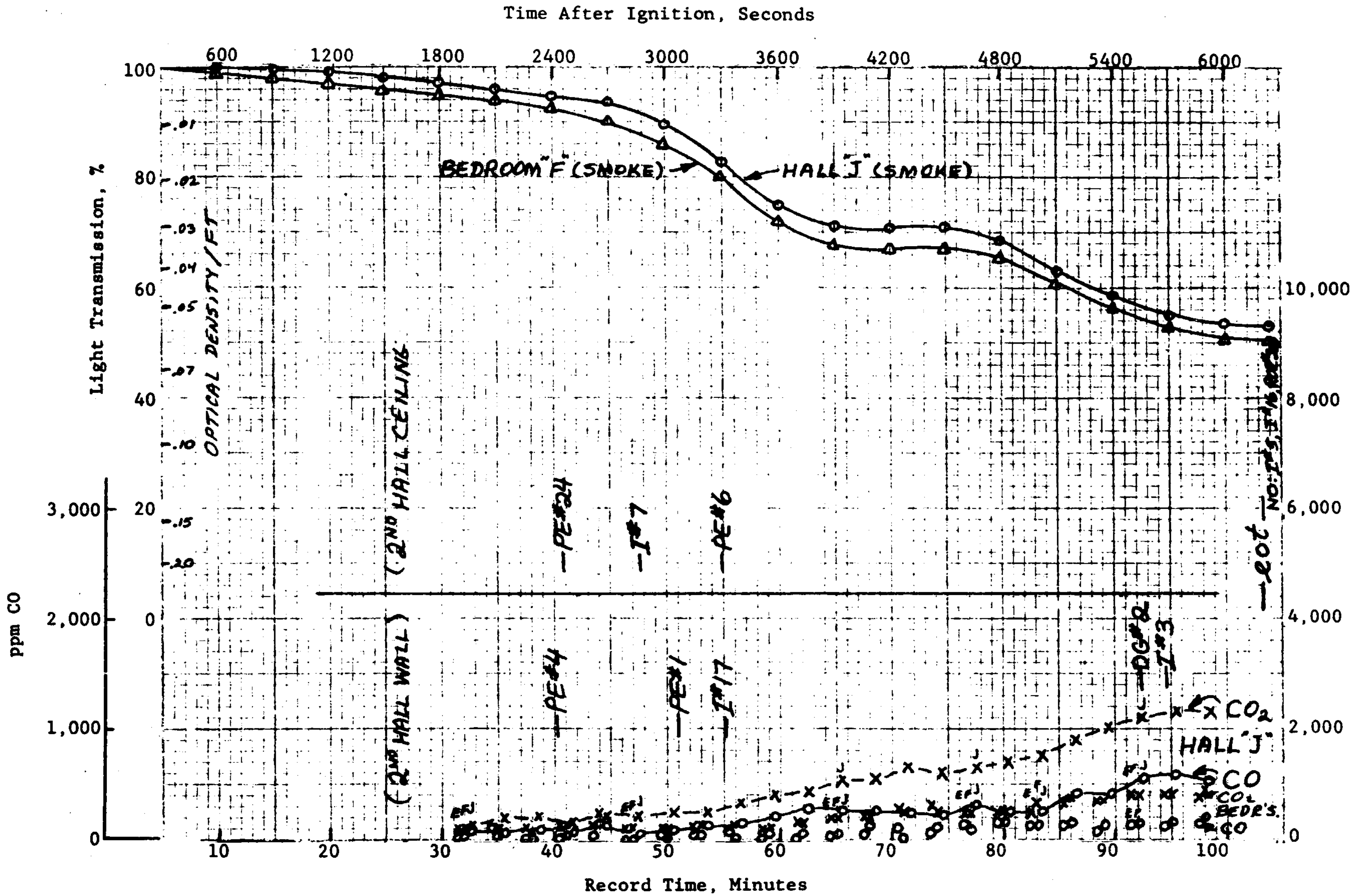
Location	Initial	Final (or max.)
Temps 5' High, 3" From Wall, °F		
1st Bed "A"	71	87
1st Bed "B"	74	66
1st Hall "C"	64.5	70
2nd Bed "E"	65	60
2nd Bed "F"	68	62
2nd Hall "J"	71	69
Liv. Rm. Register	--	--
Outdoors	34	35



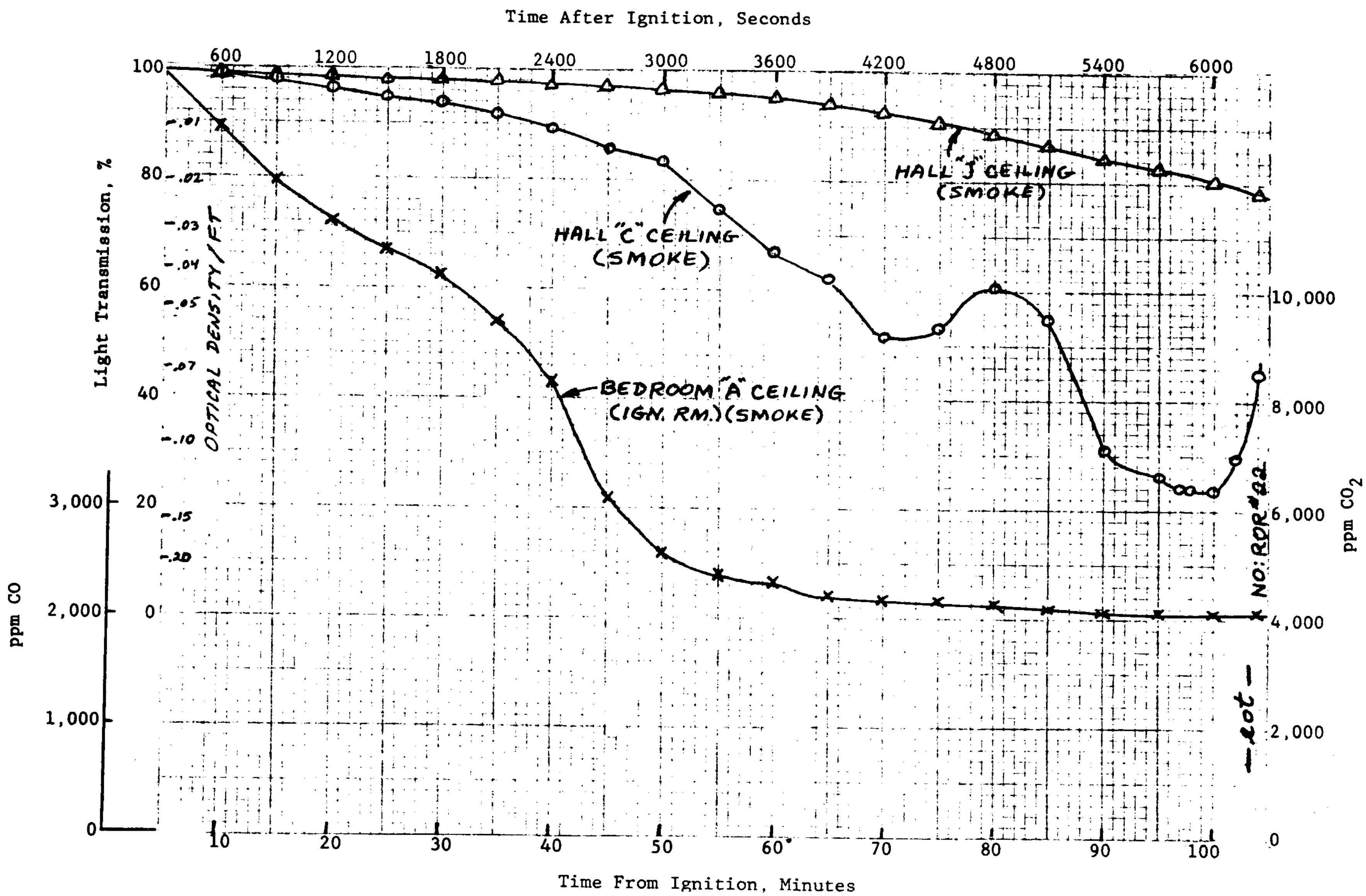
Maximum Temperature Profiles. JR-18



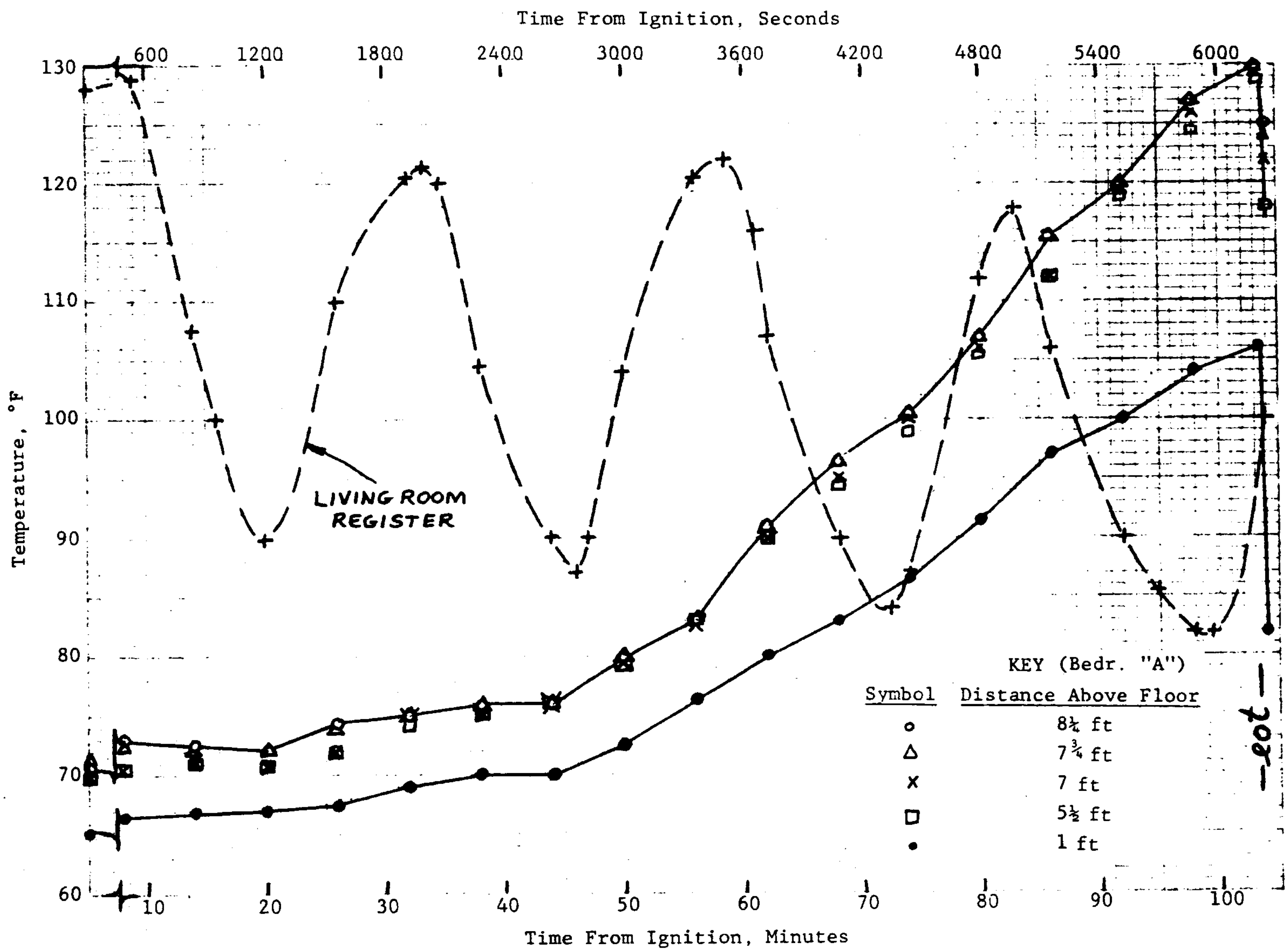
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-19



CONDITIONS ON 2ND FLOOR AT 5 FT, JR-19

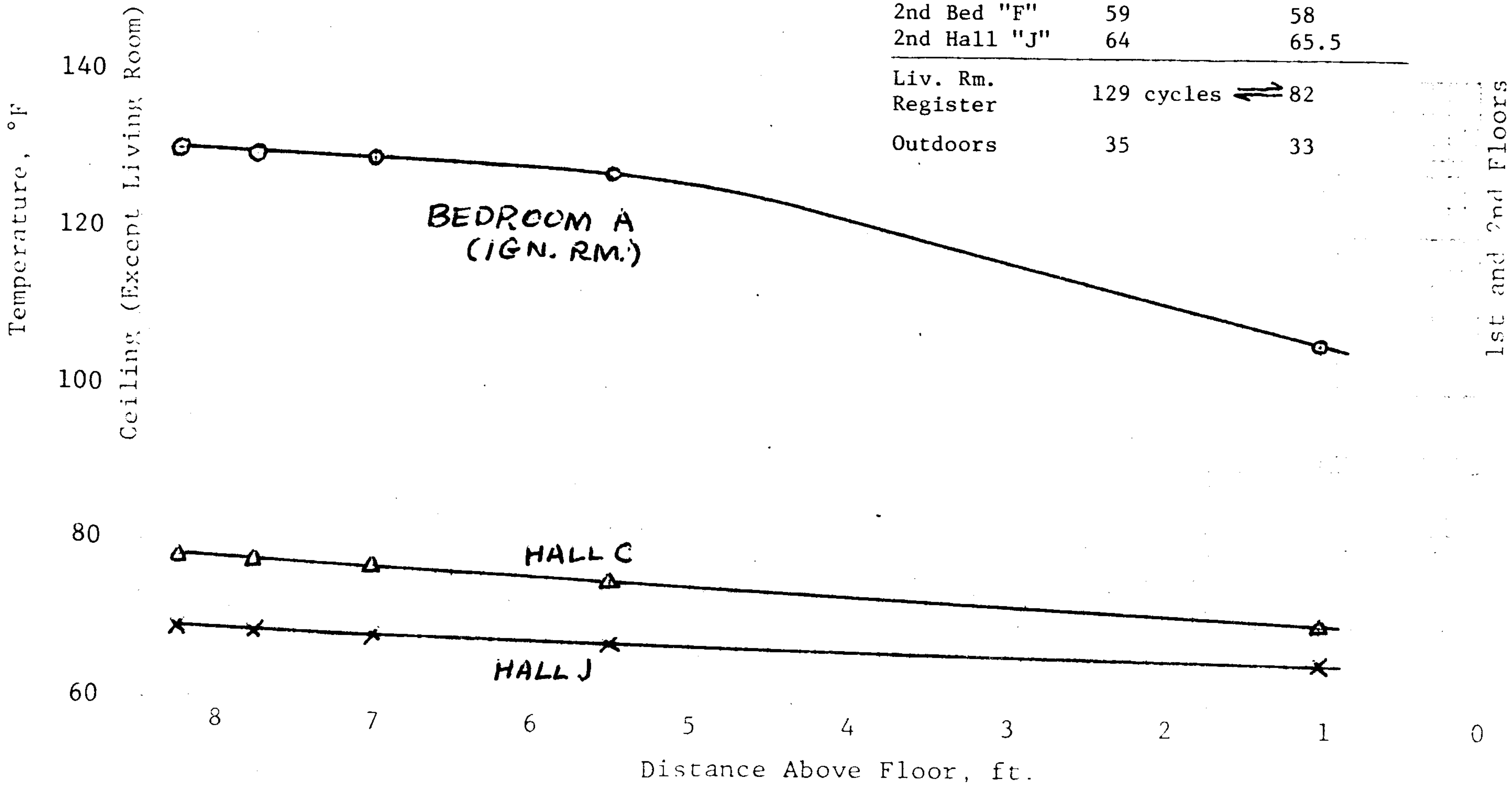


VARIOUS CONDITIONS, JR-19

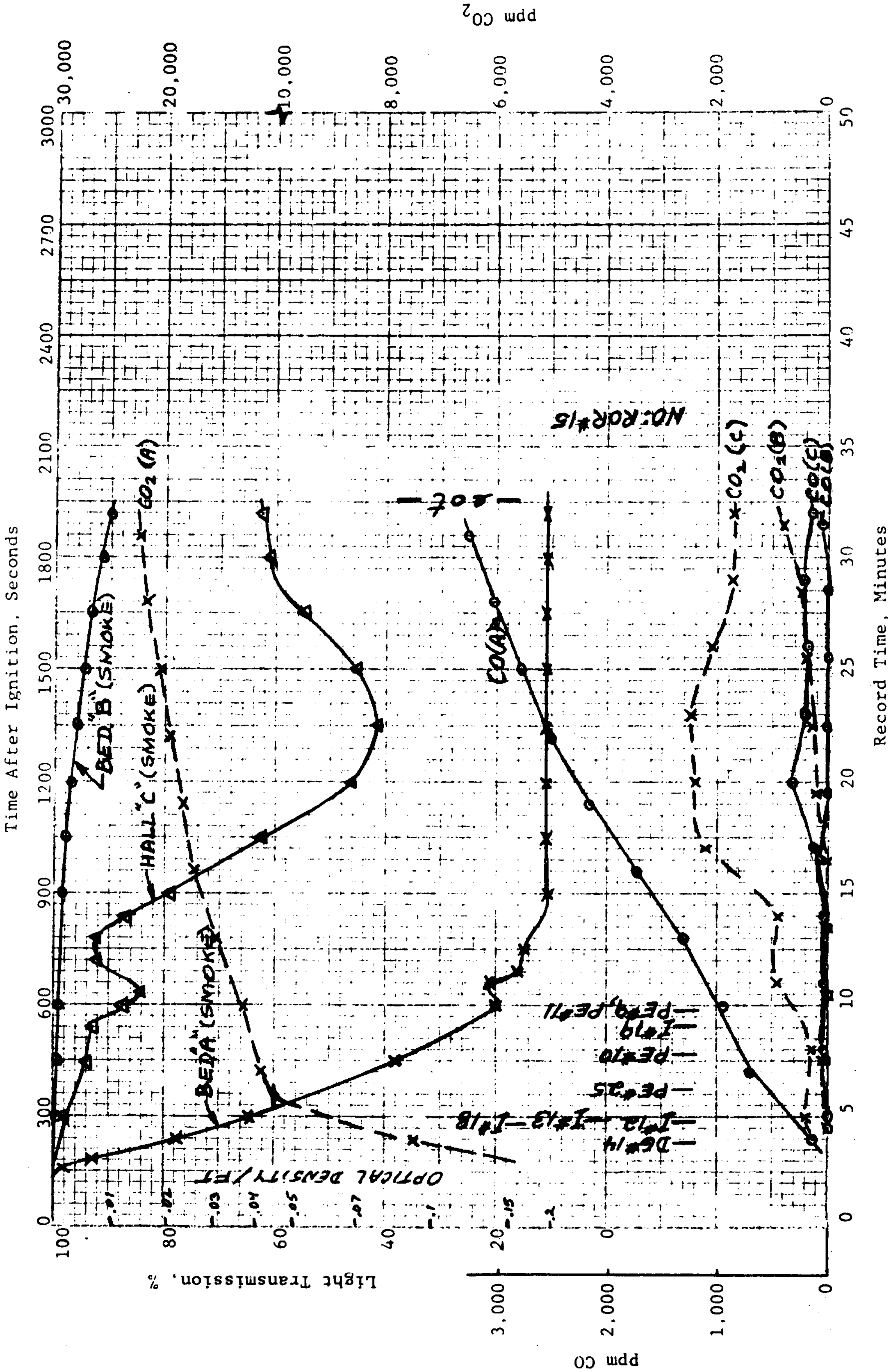


TEMPERATURES IN IGNITION ROOM (BEDROOM "A"), JR-19

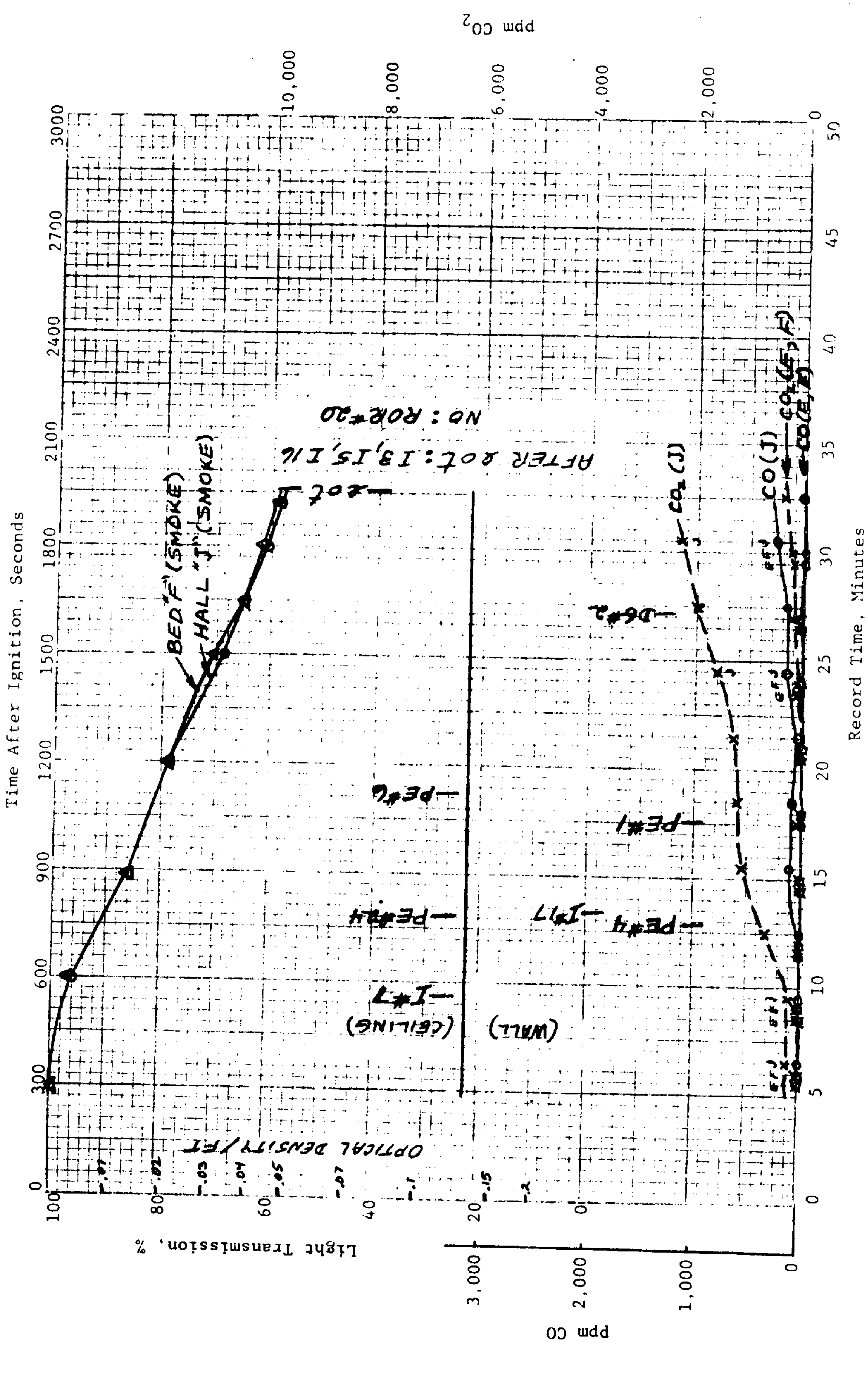
Temps 5' High, 3" From Wall, °F		
Location	Initial	Final (or max.)
1st Bed "A"	70	127
1st Bed "B"	71	69
1st Hall "C"	61	76
2nd Bed "E"	59	58.5
2nd Bed "F"	59	58
2nd Hall "J"	64	65.5
Liv. Rm. Register	129 cycles ⇄	82
Outdoors	35	33



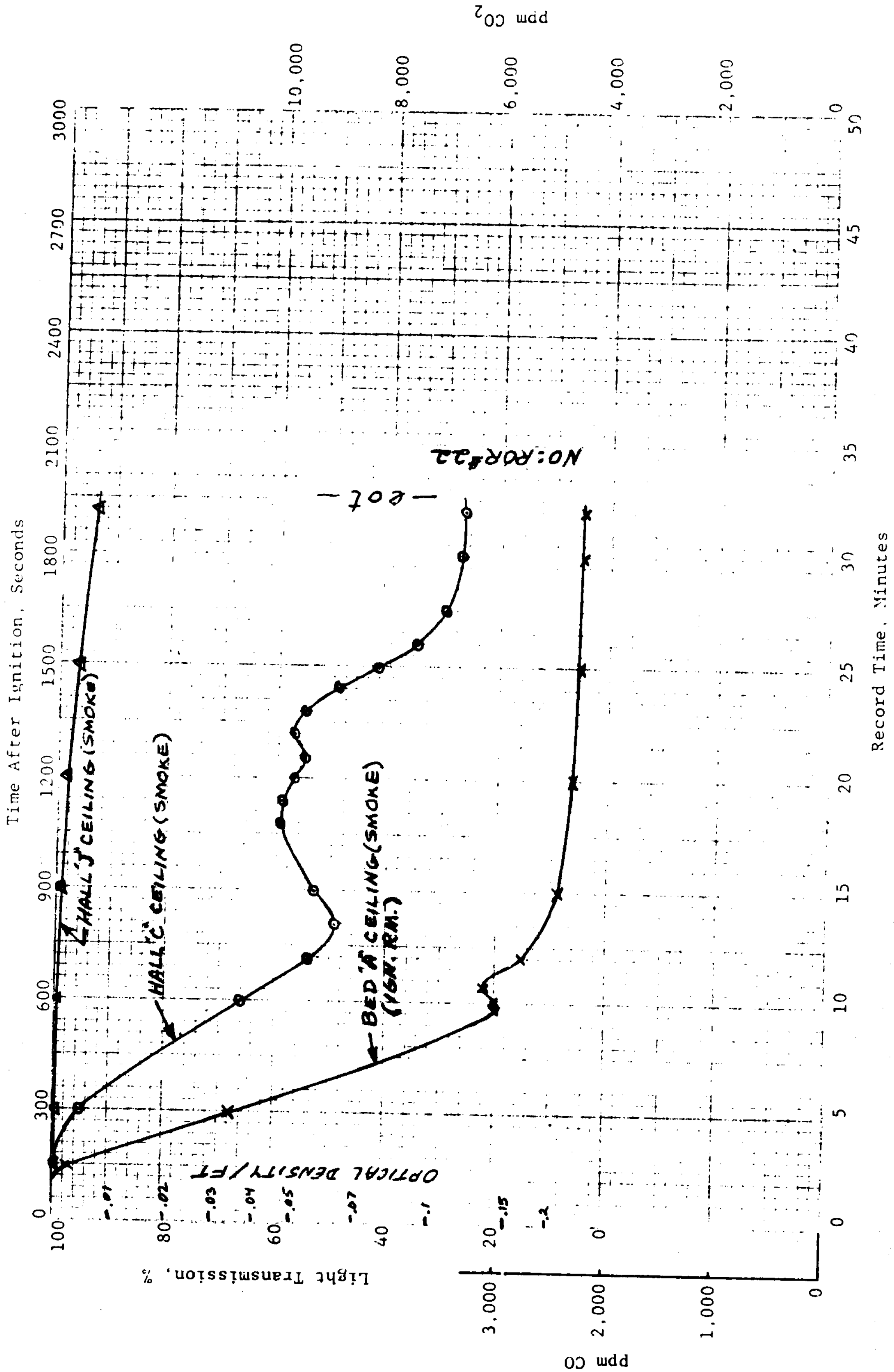
Maximum Temperature Profiles, JR-19



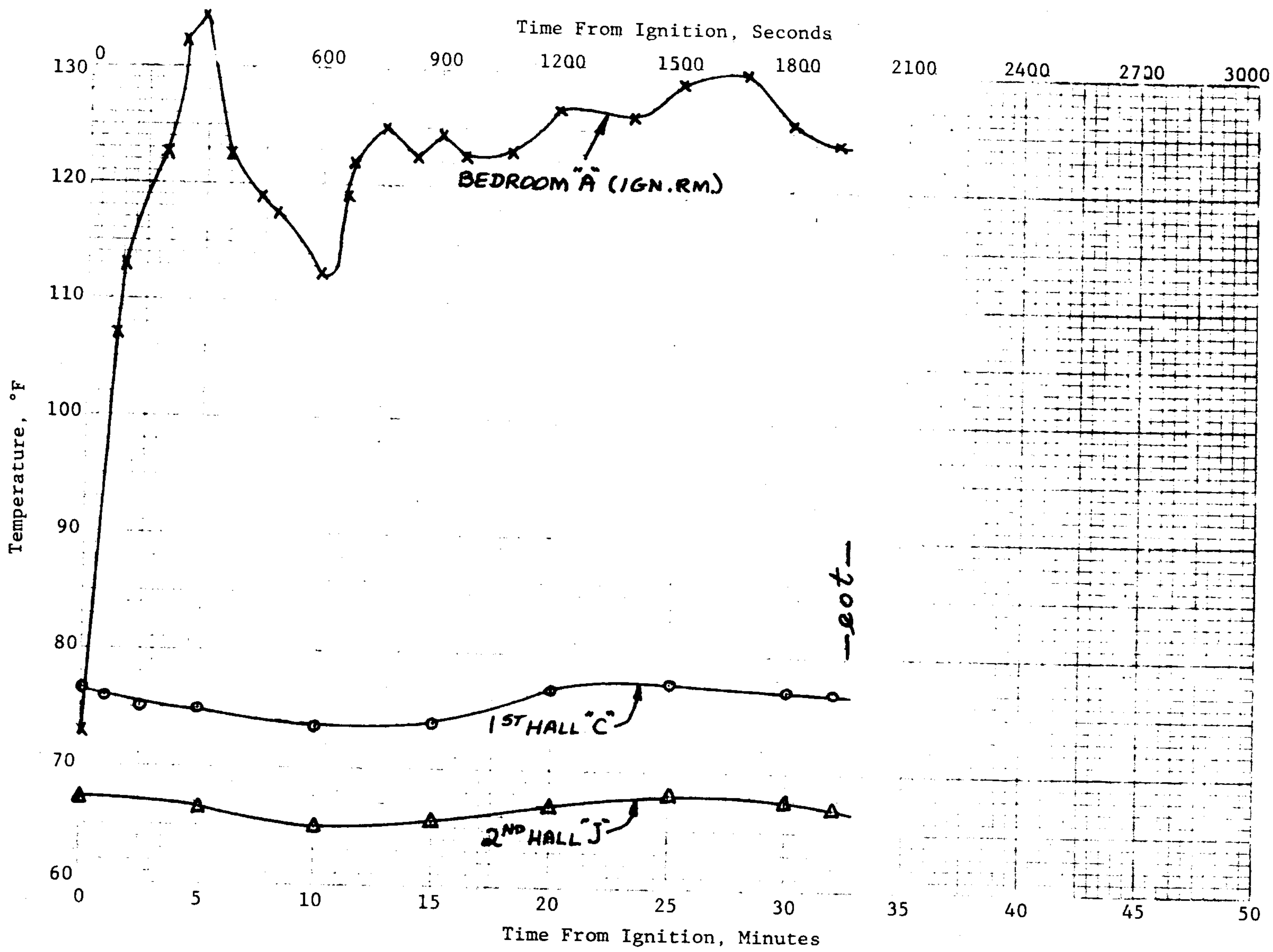
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-20



CONDITIONS ON 2ND FLOOR AT 5 FT, JR-20

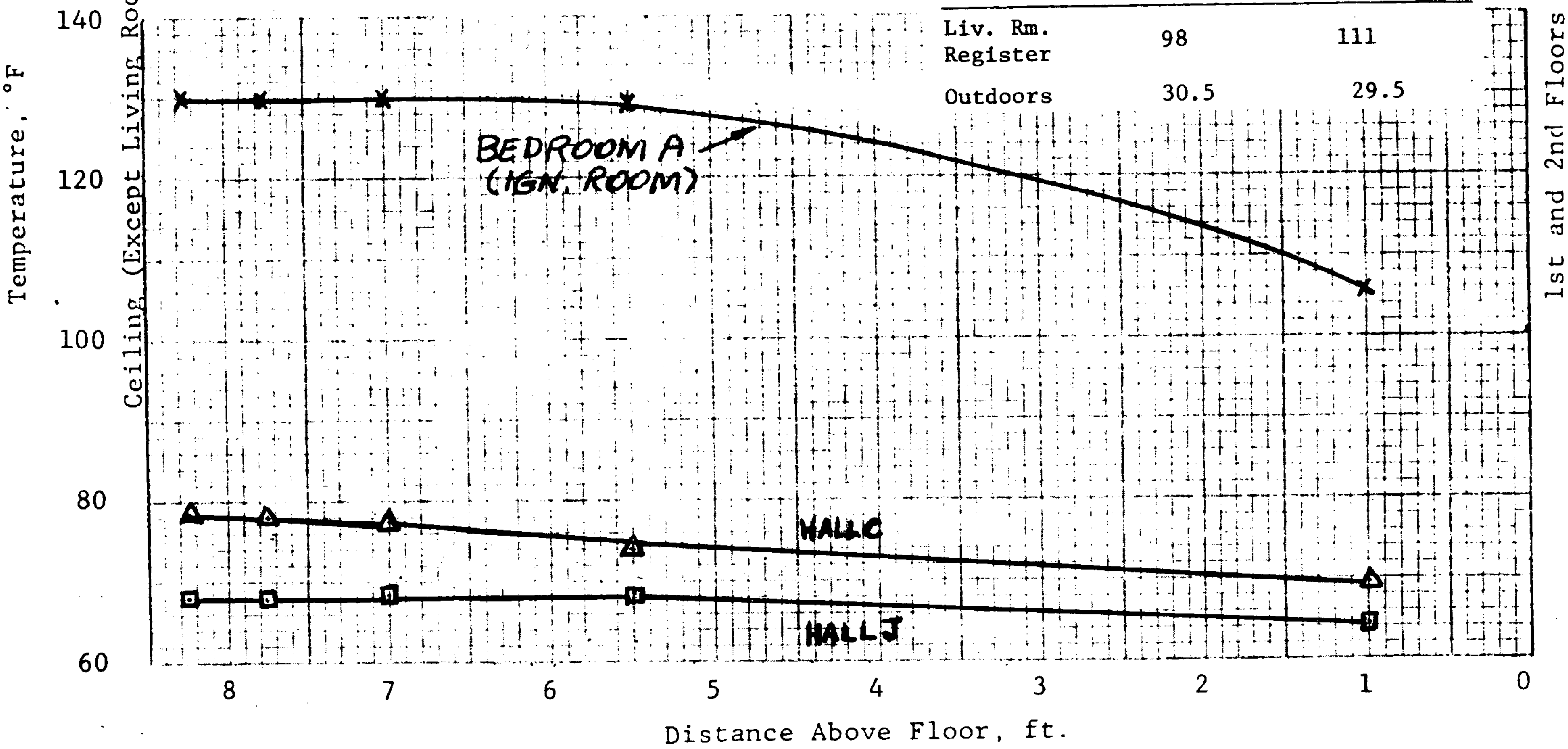


VARIOUS CONDITIONS, JR-20

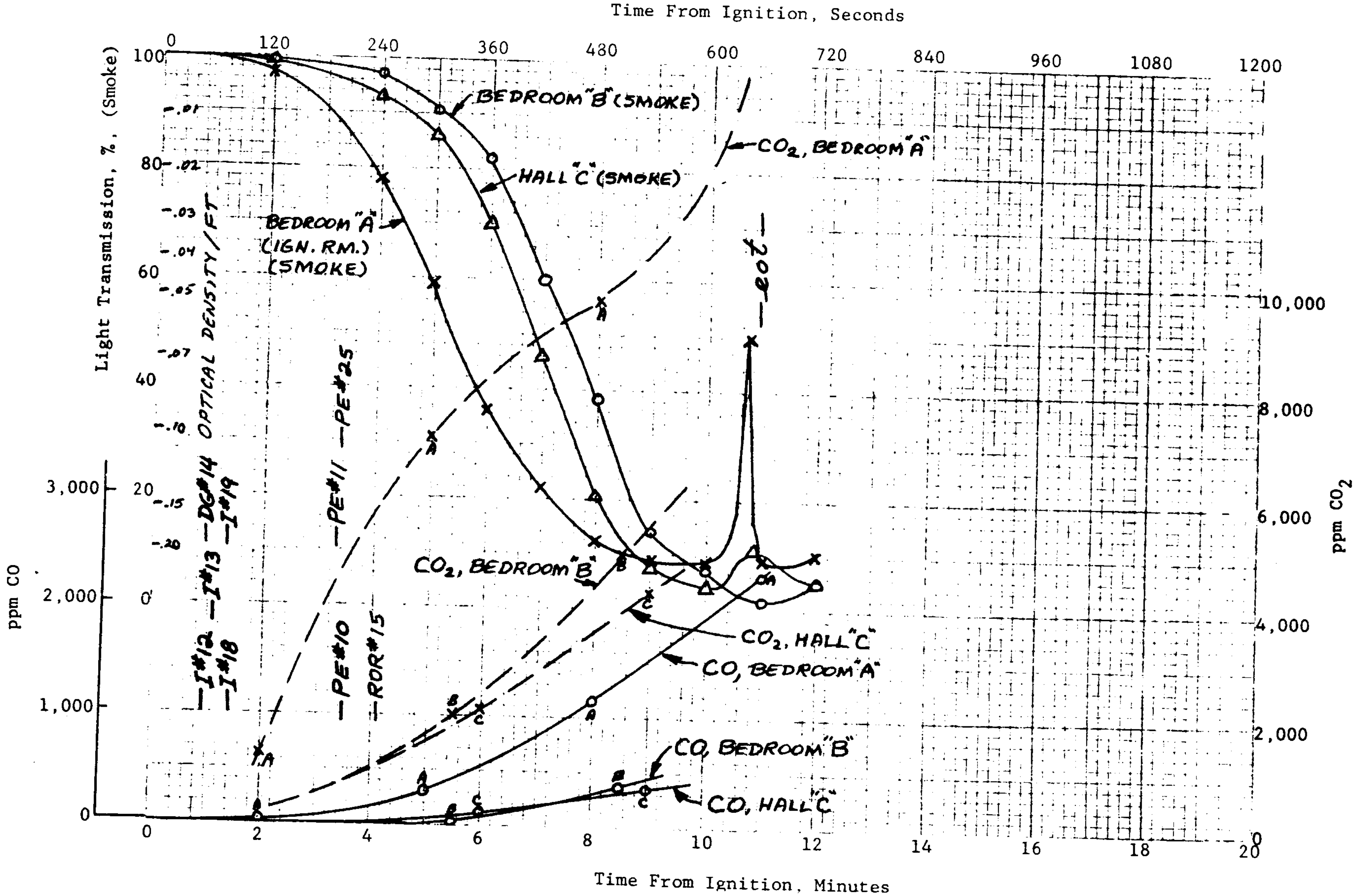


TEMPERATURES 3 IN. FROM CEILING, JR-20

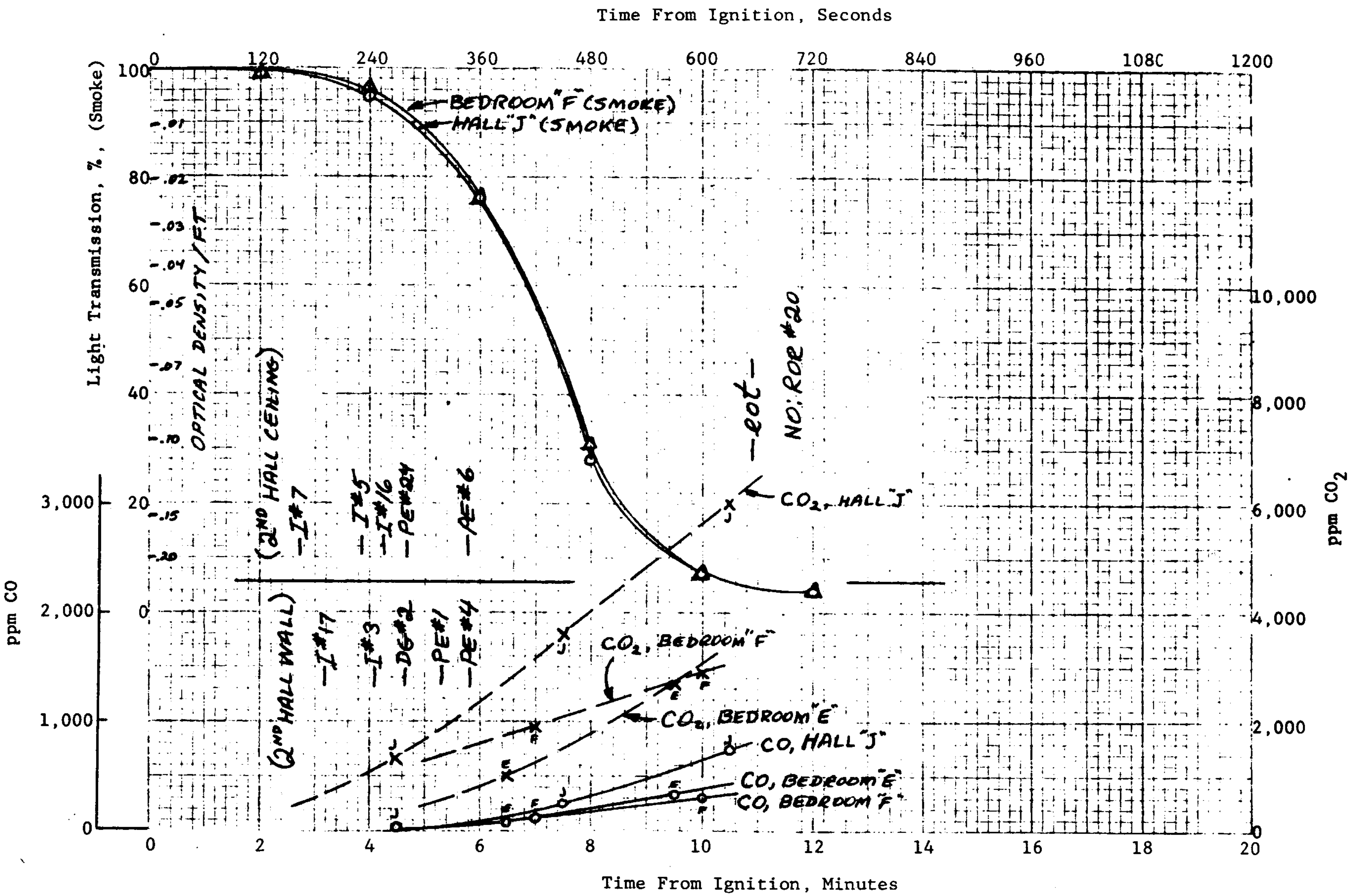
Temps 5' High, 3" From Wall, °F		
Location	Initial	Final (or max.)
1st Bed "A"	72	127
1st Bed "B"	70	69.5
1st Hall "C"	62	63
2nd Bed "E"	61	61.5
2nd Bed "F"	61.5	62.0
2nd Hall "J"	67.5	69
Liv. Rm. Register	98	111
Outdoors	30.5	29.5



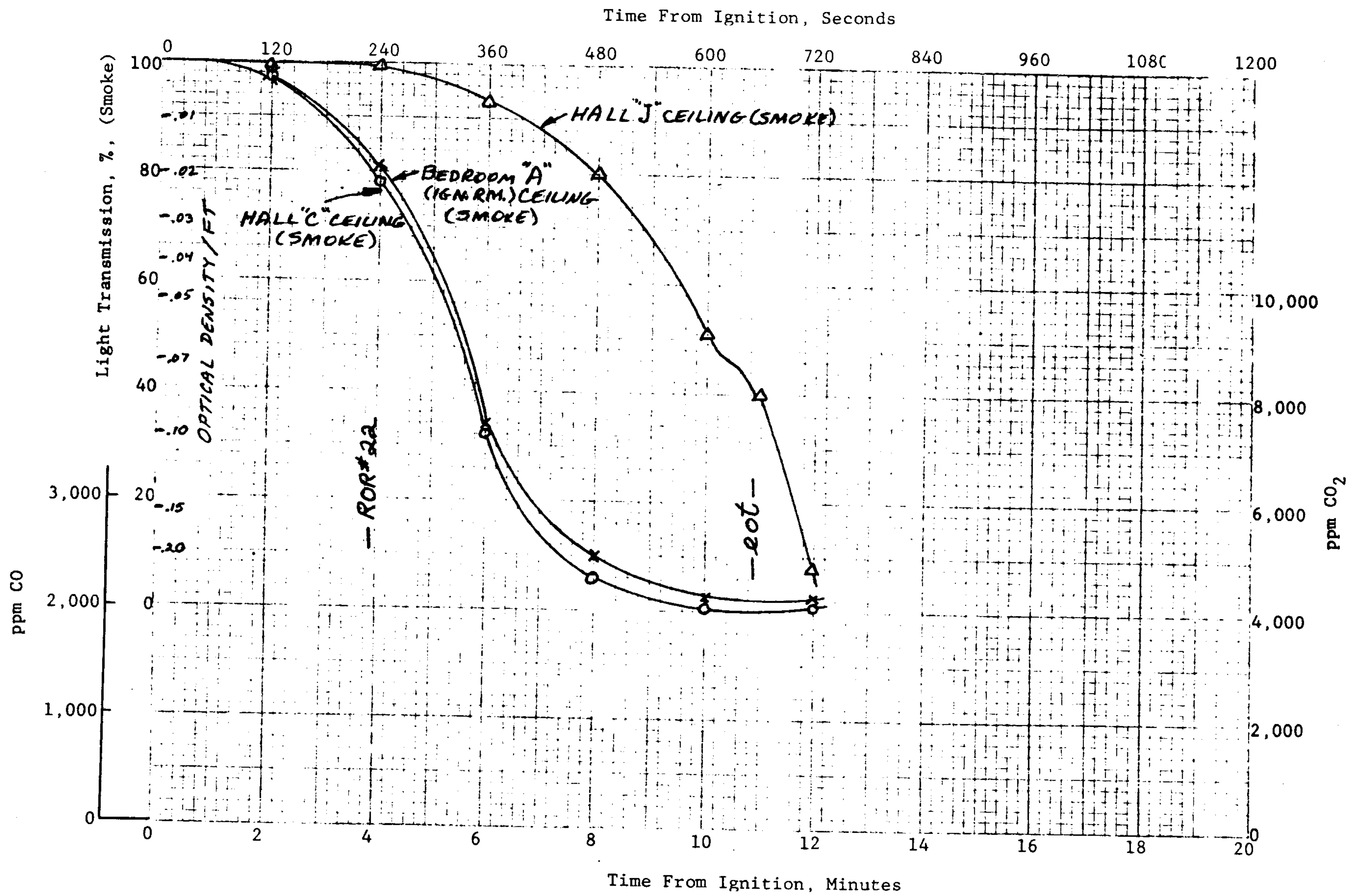
Maximum Temperature Profiles. JR-20



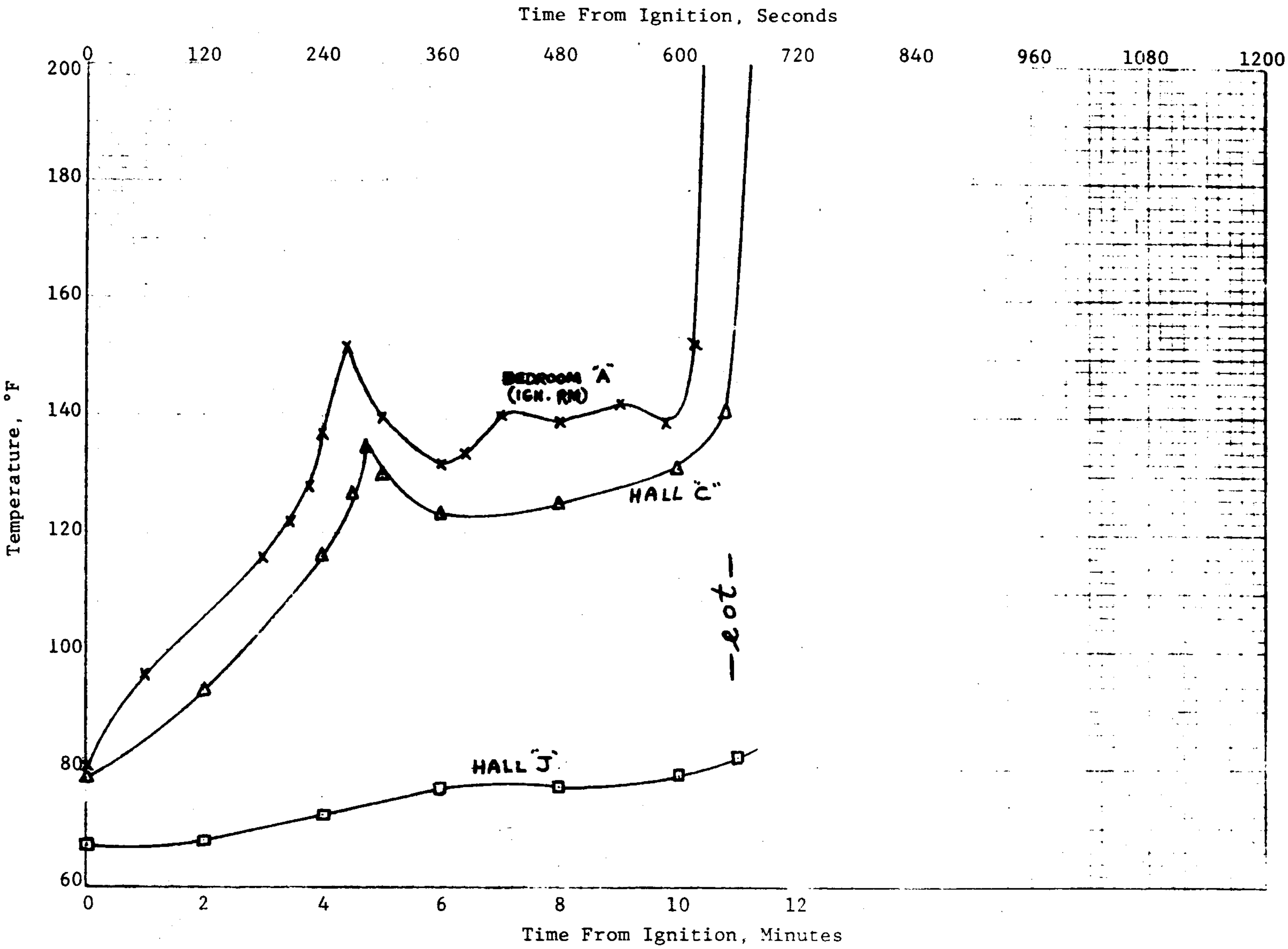
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-21



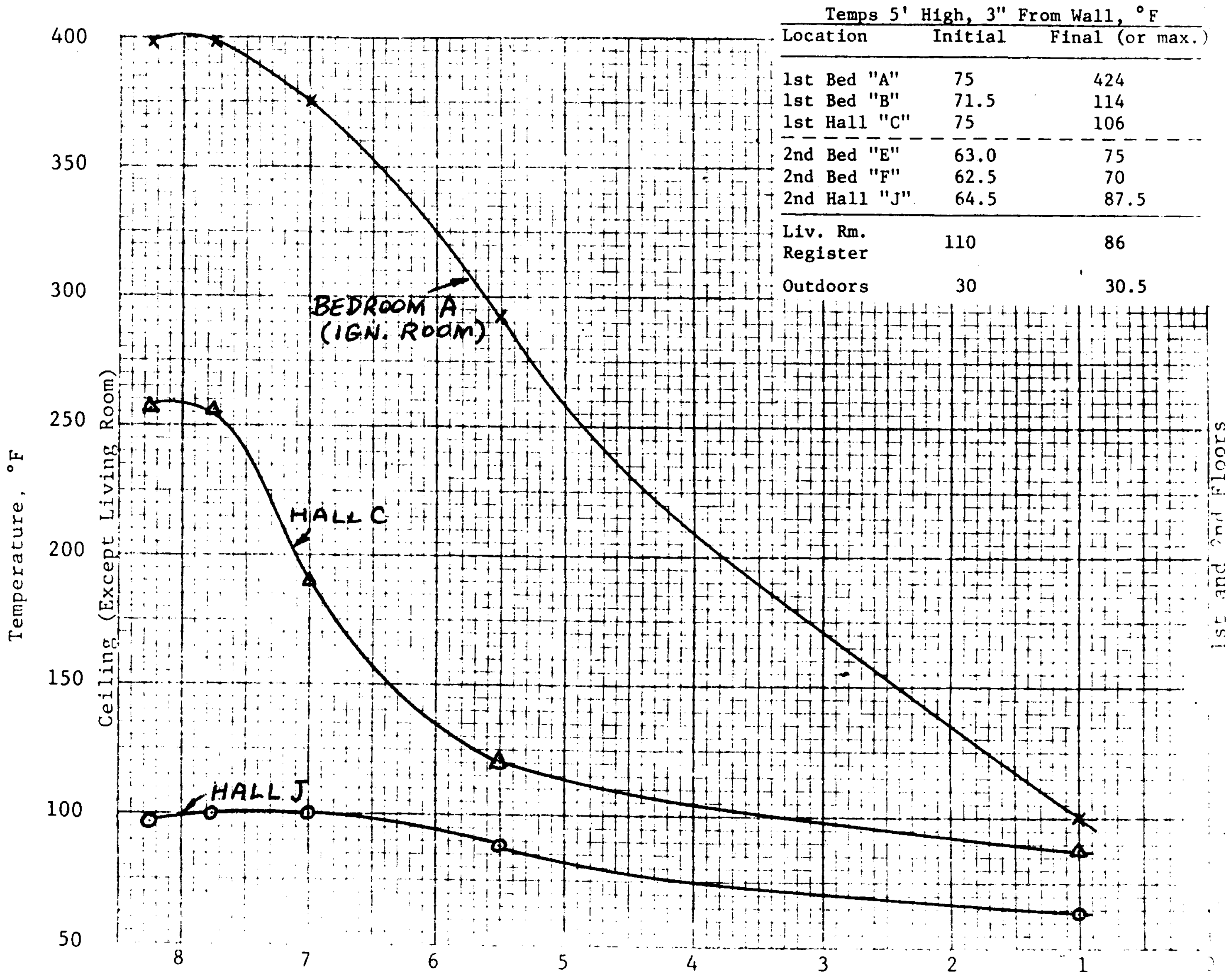
CONDITIONS ON 2ND FLOOR AT 5 FT, JR-21



VARIOUS CONDITIONS, JR-21



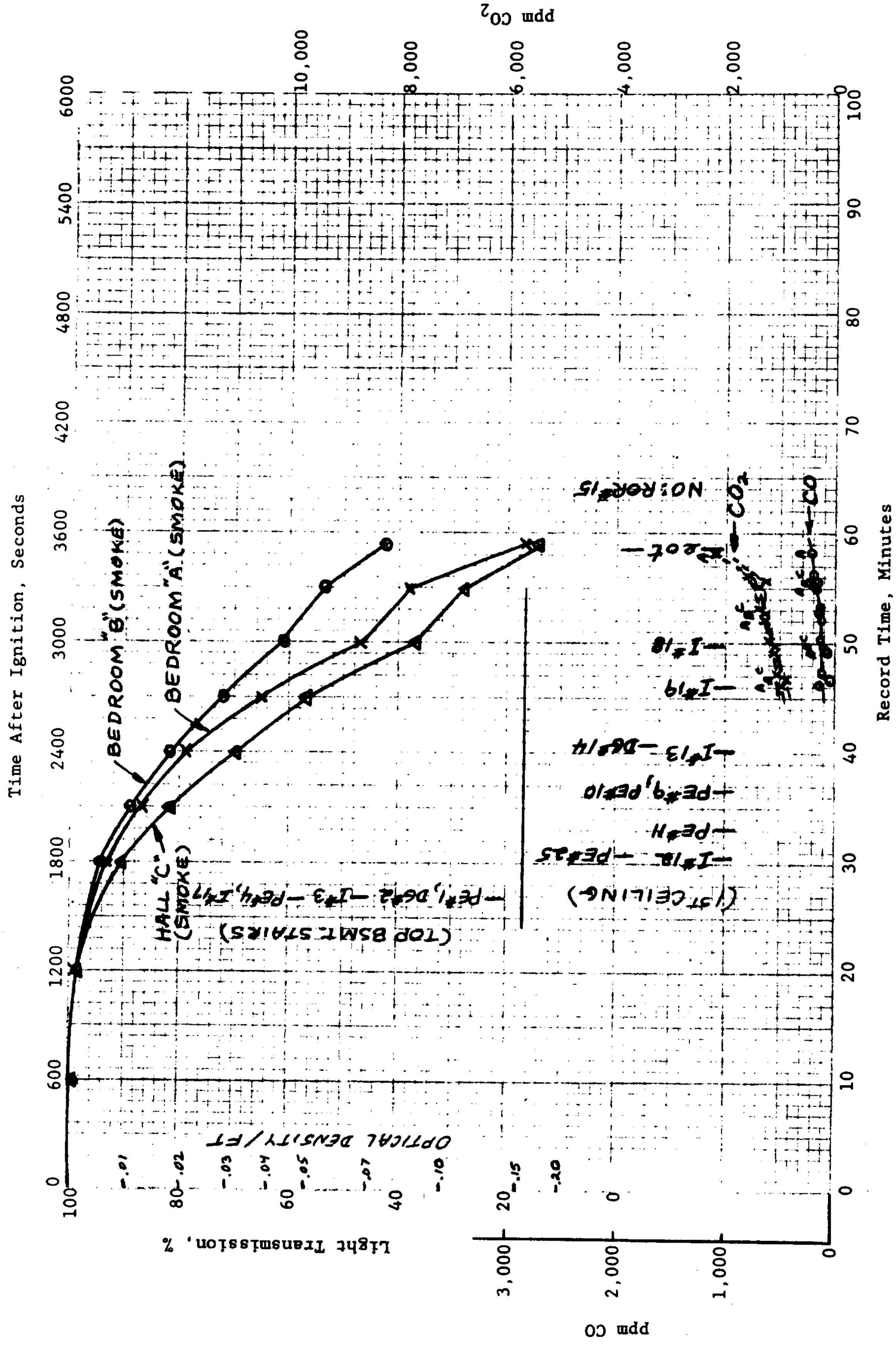
TEMPERATURES 3 IN. FROM CEILING, JR-21



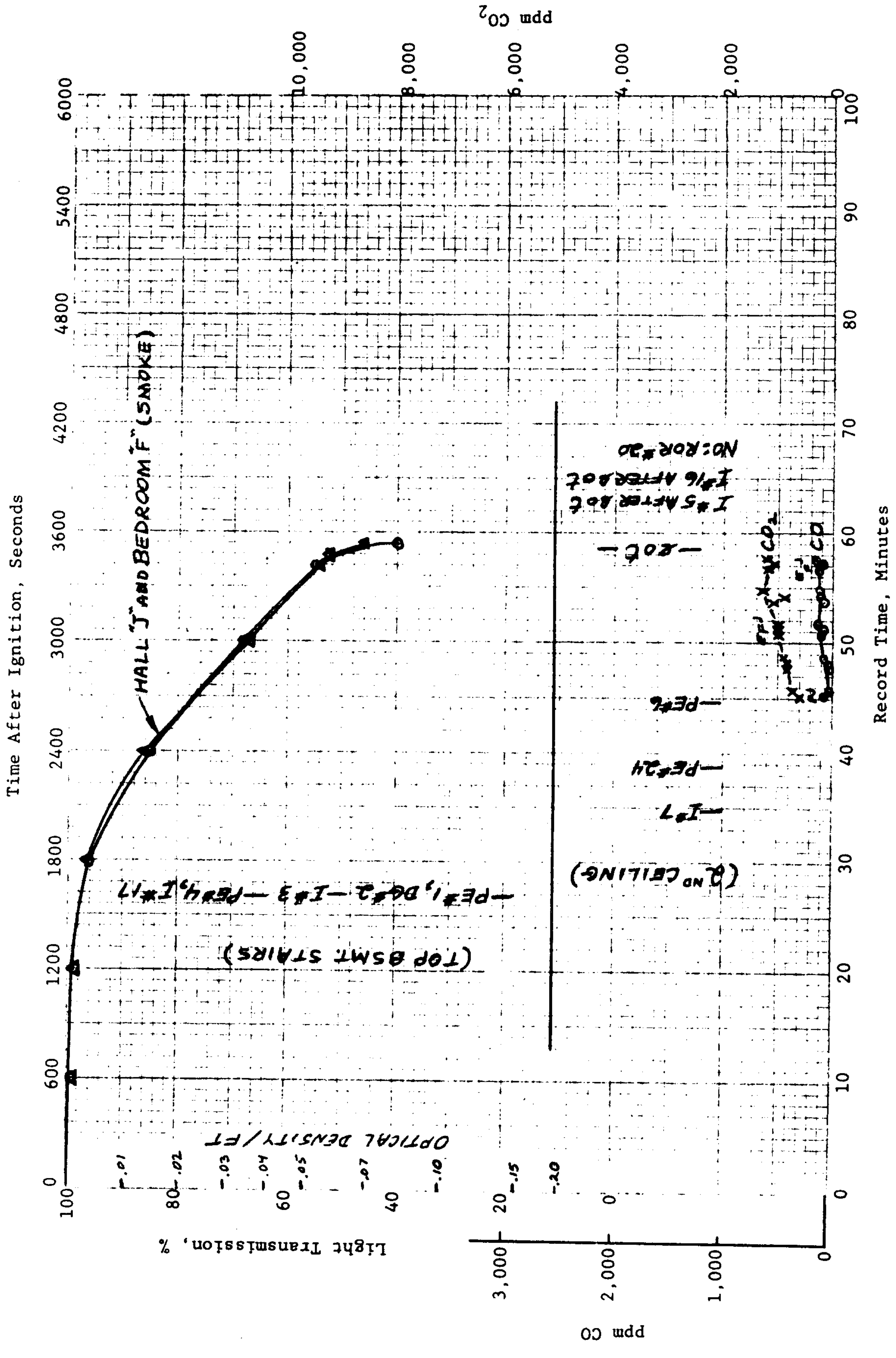
Temps 5' High, 3" From Wall, °F		
Location	Initial	Final (or max.)
1st Bed "A"	75	424
1st Bed "B"	71.5	114
1st Hall "C"	75	106
2nd Bed "E"	63.0	75
2nd Bed "F"	62.5	70
2nd Hall "J"	64.5	87.5
Liv. Rm. Register	110	86
Outdoors	30	30.5

Distance Above Floor, ft.

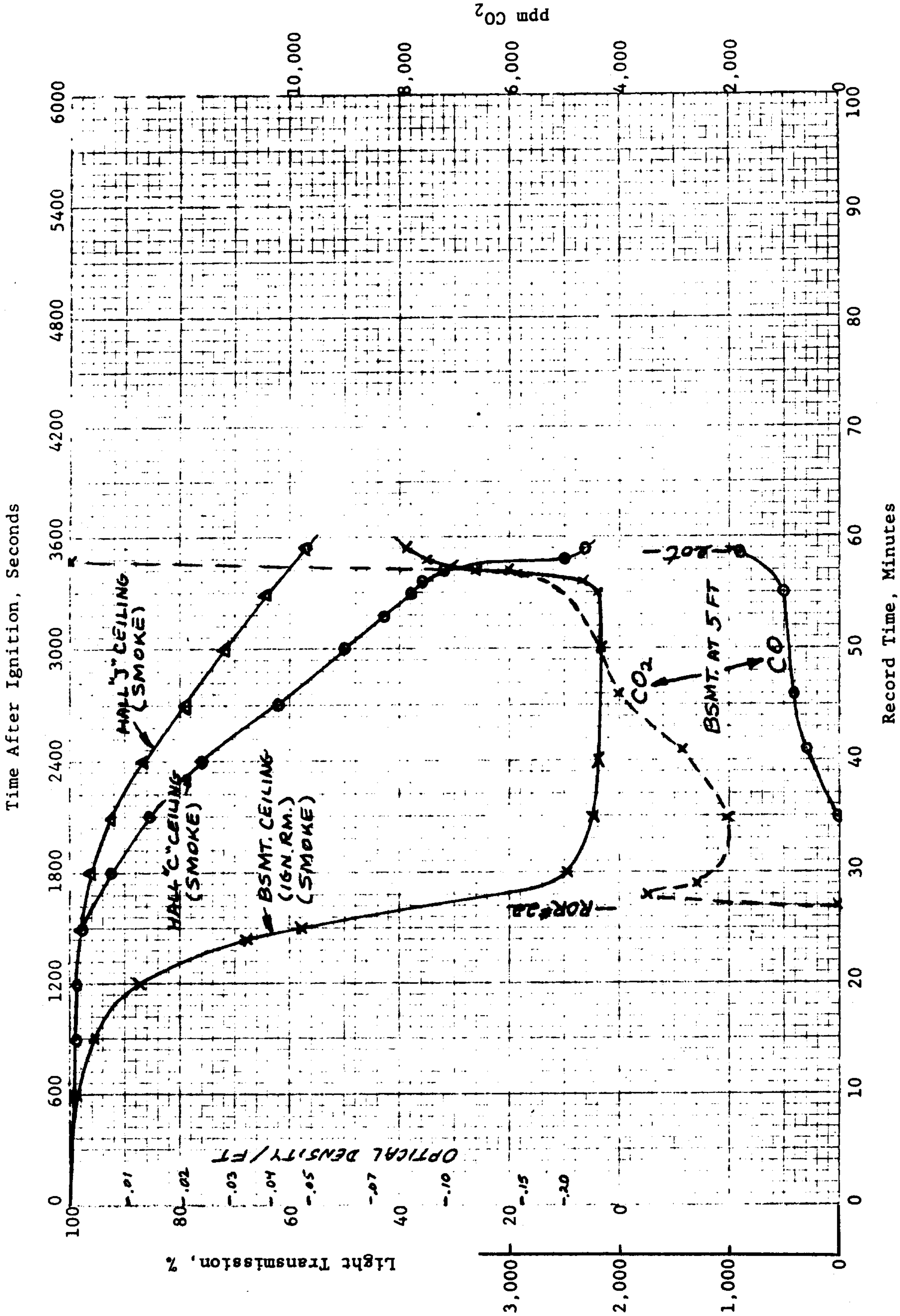
Maximum Temperature Profiles, JR-21



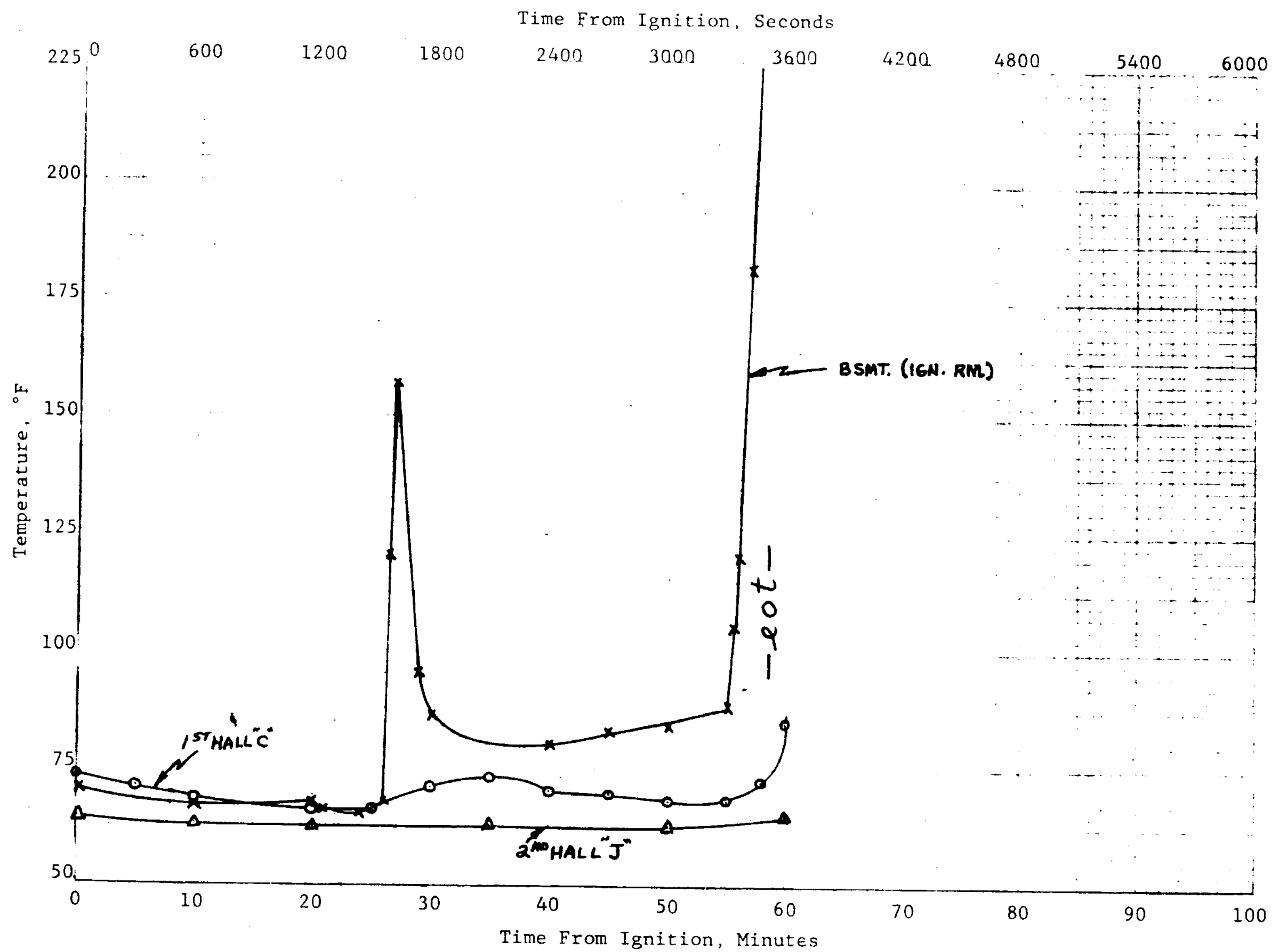
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-22



CONDITIONS ON 2ND FLOOR AT 5 FT, JR-22

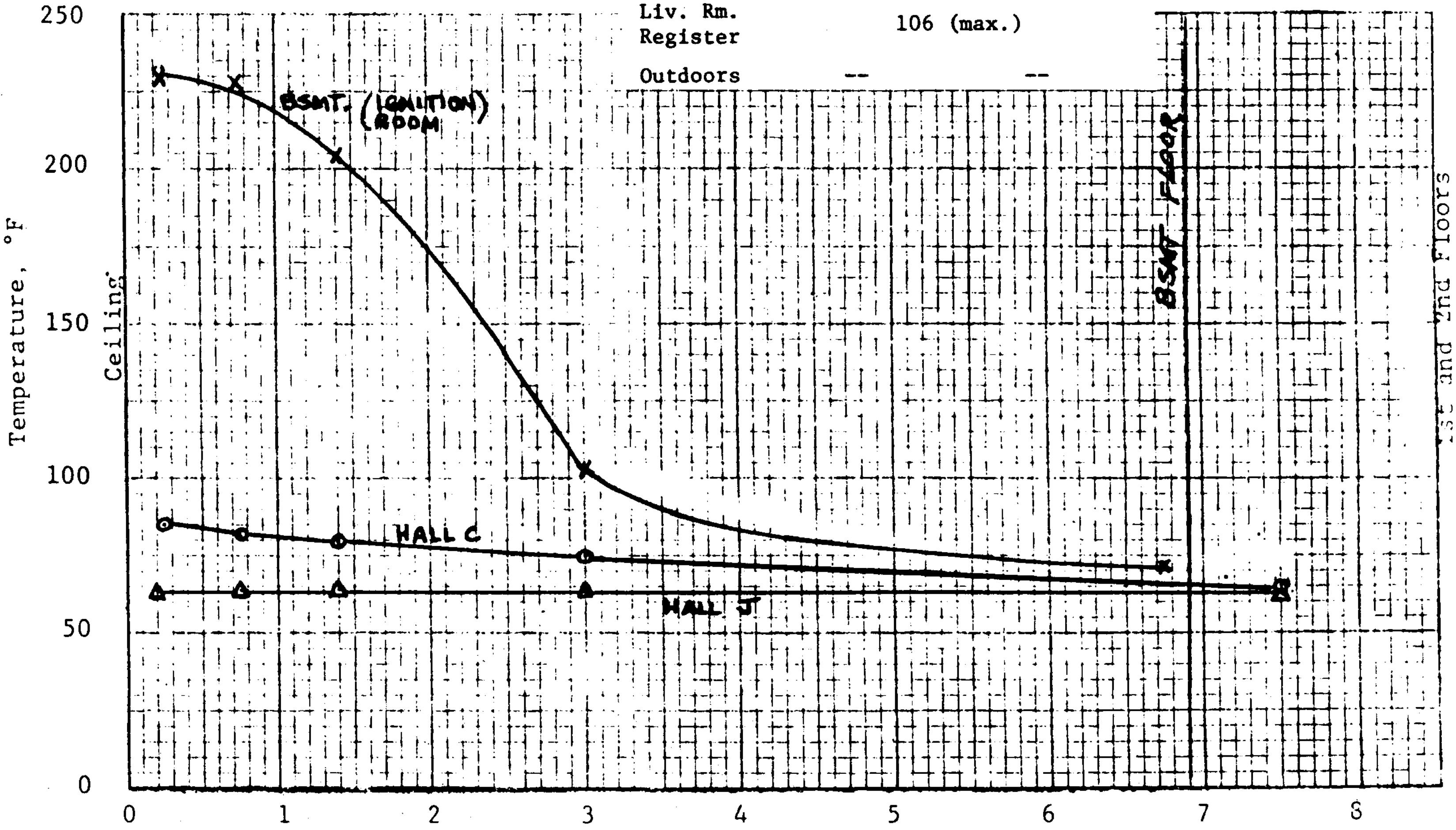


VARIOUS CONDITIONS, JR-22



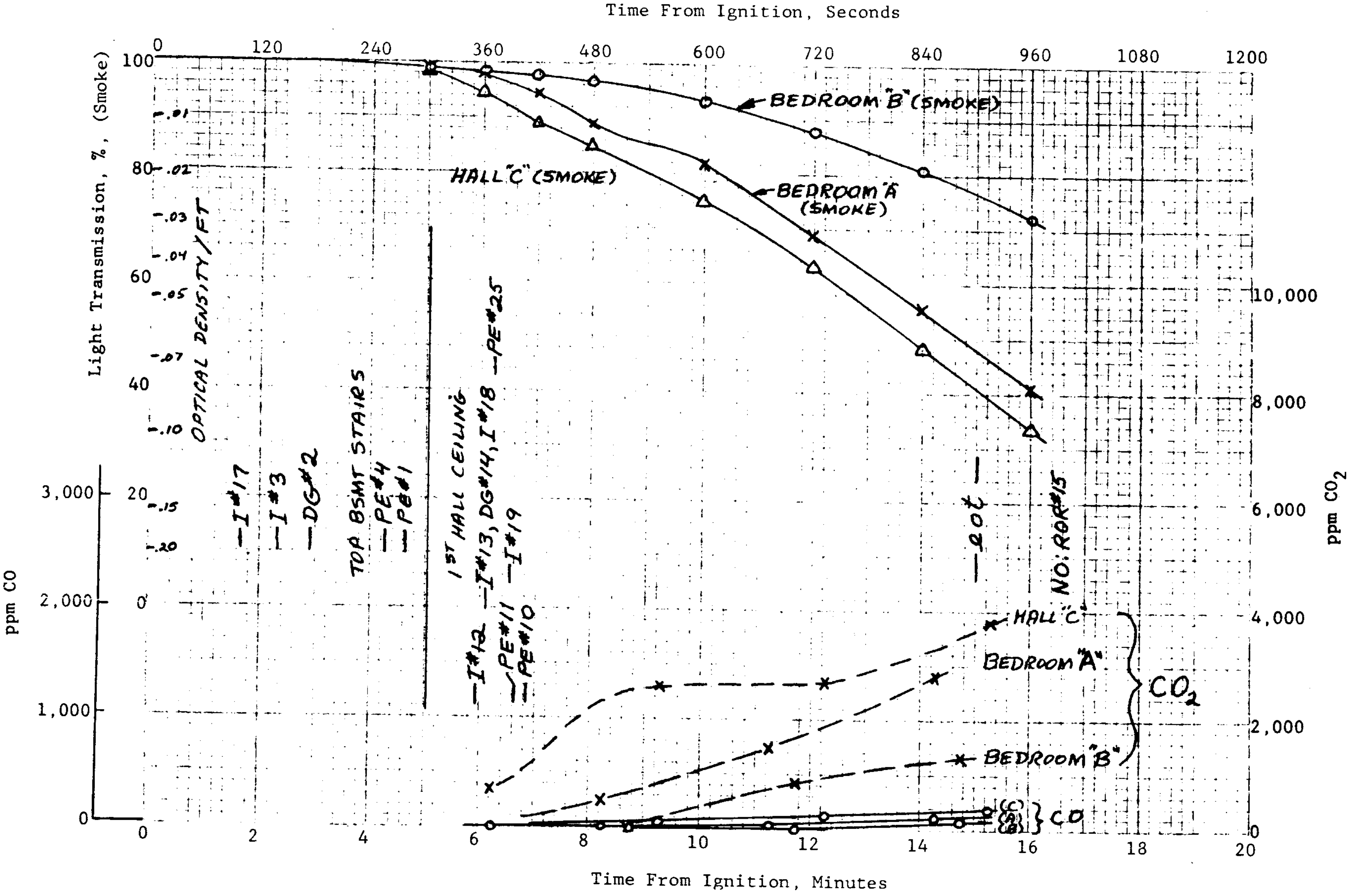
TEMPERATURES 3 IN. FROM CEILING, JR-22

Location	Initial	Final (or max.)
Temps 5' High, 3" From Wall, °F		
1st Bed "A"	65	66
1st Bed "B"	67	70
1st Hall "C"	60	74.5
2nd Bed "E"	61.5	63
2nd Bed "F"	62	64
2nd Hall "J"	63	64
Liv. Rm. Register	106 (max.)	
Outdoors	--	--

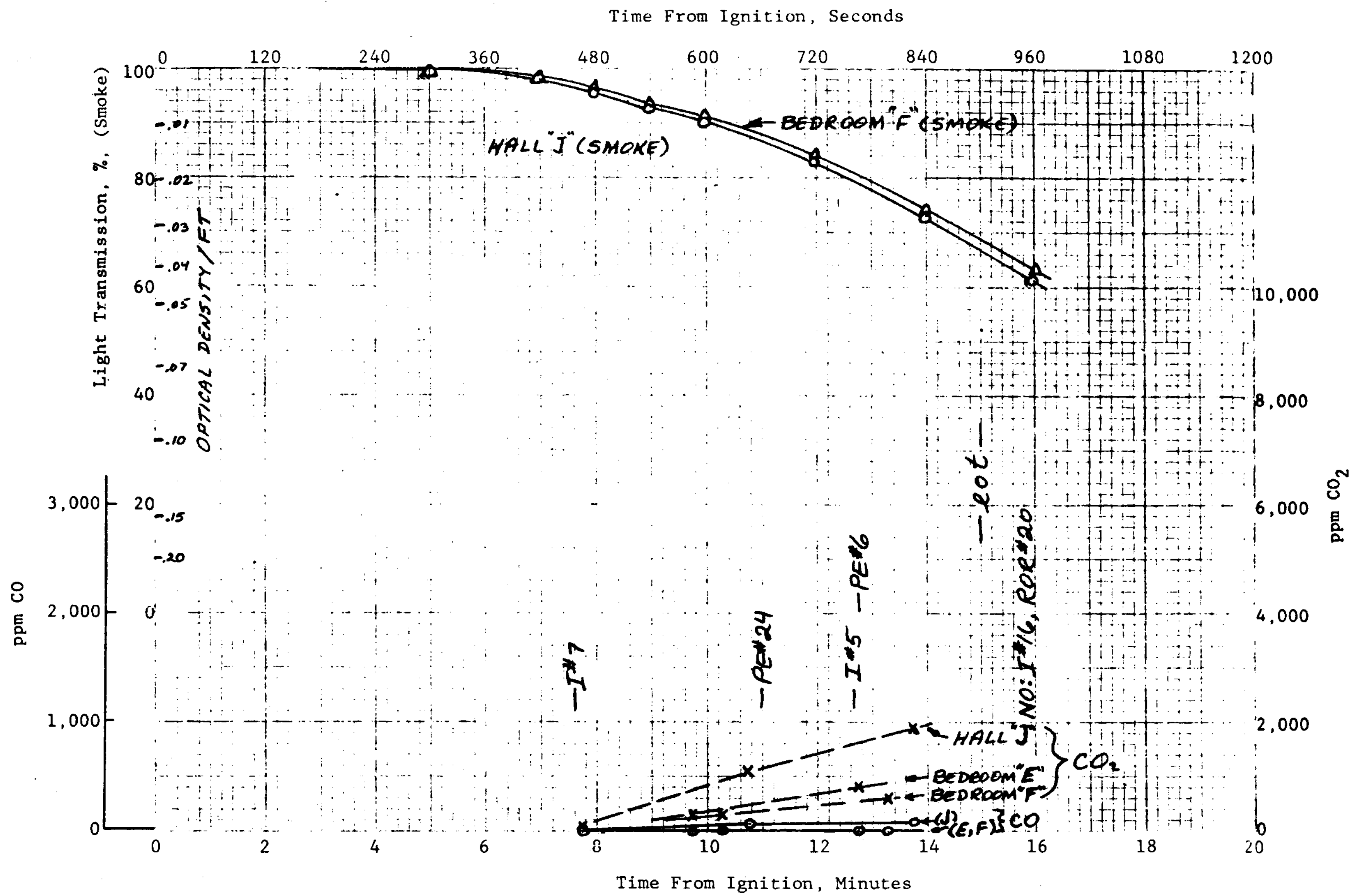


Distance From Ceiling, ft.

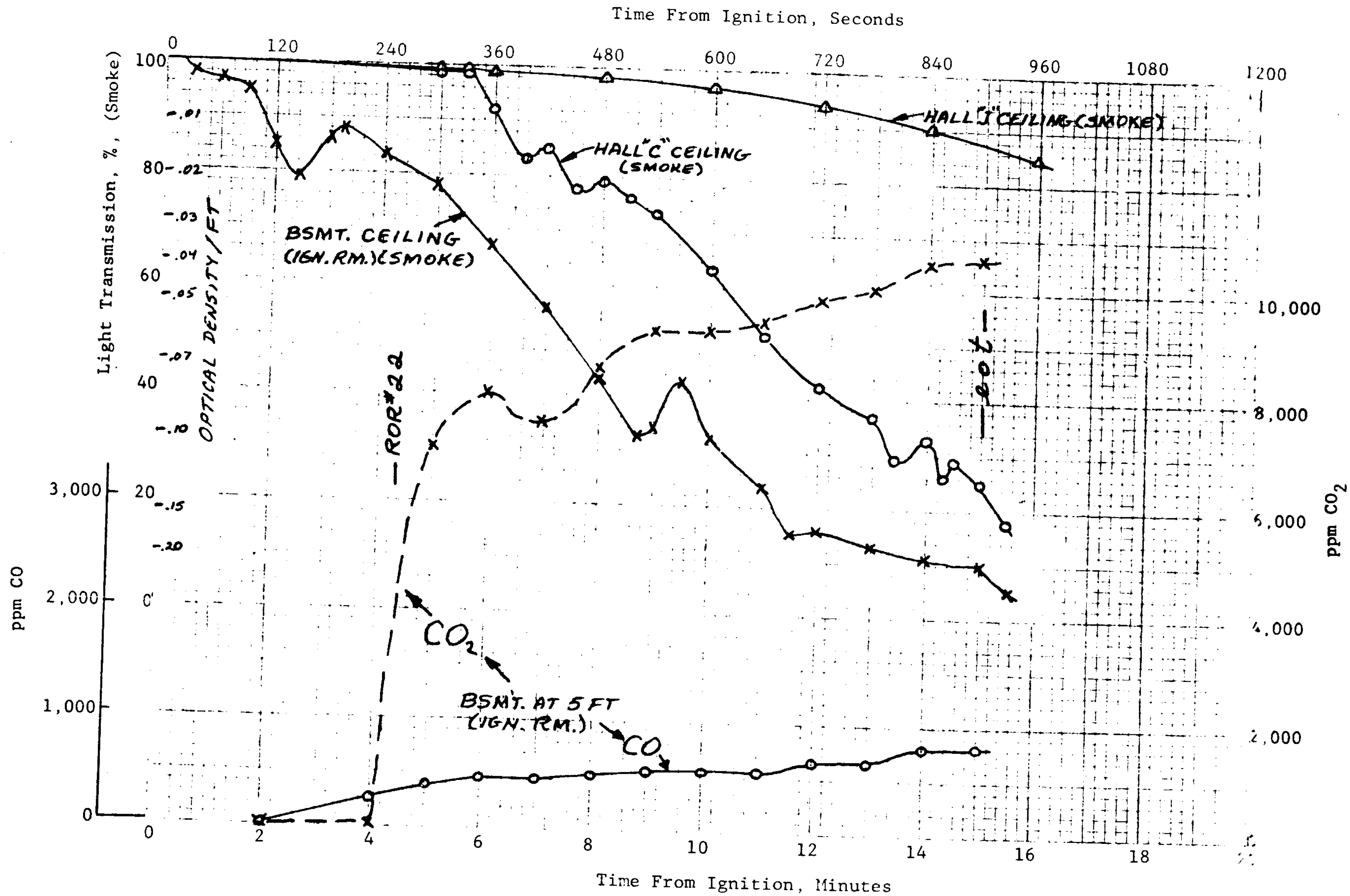
Maximum Temperature Profiles, JR-22



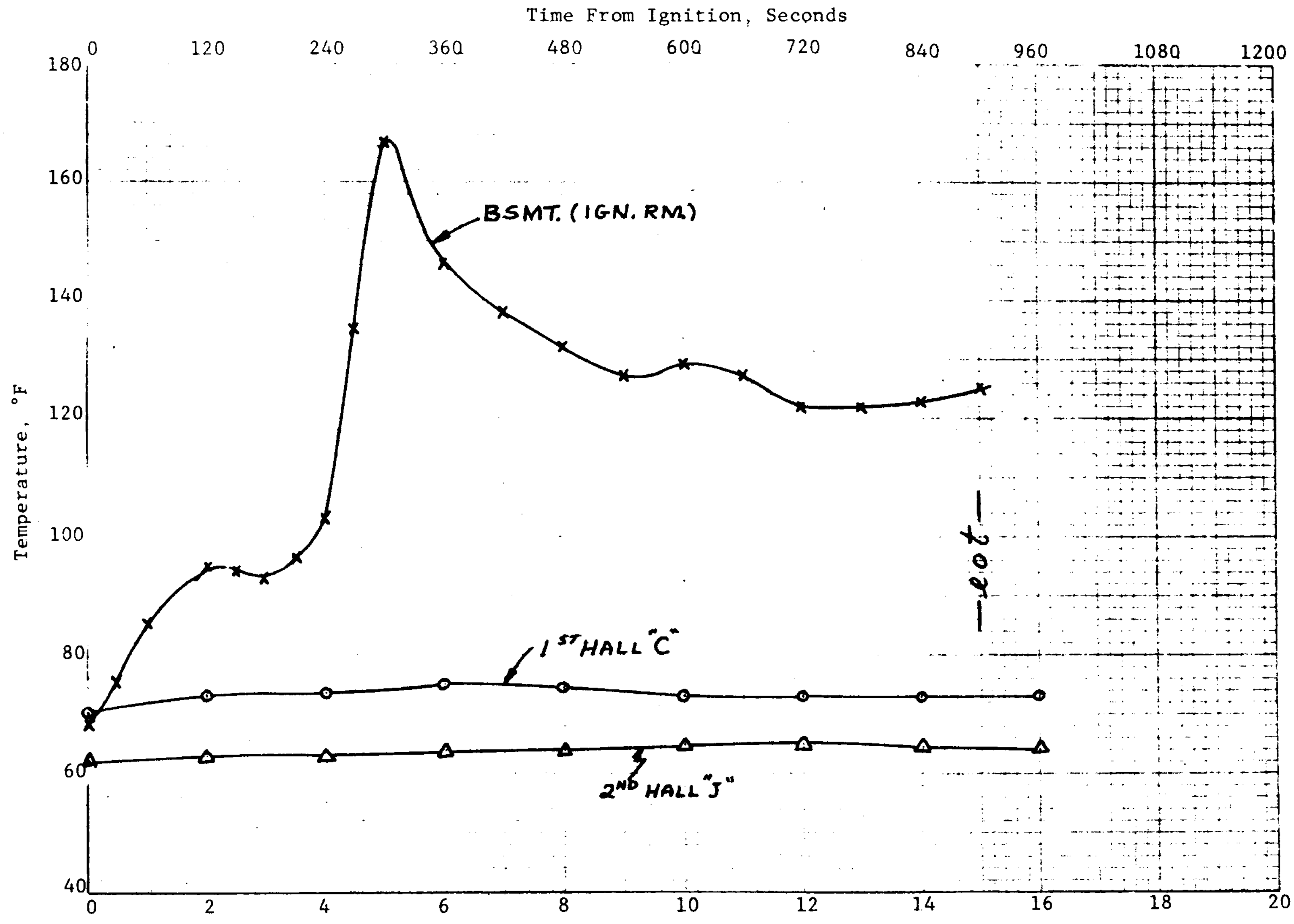
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-23



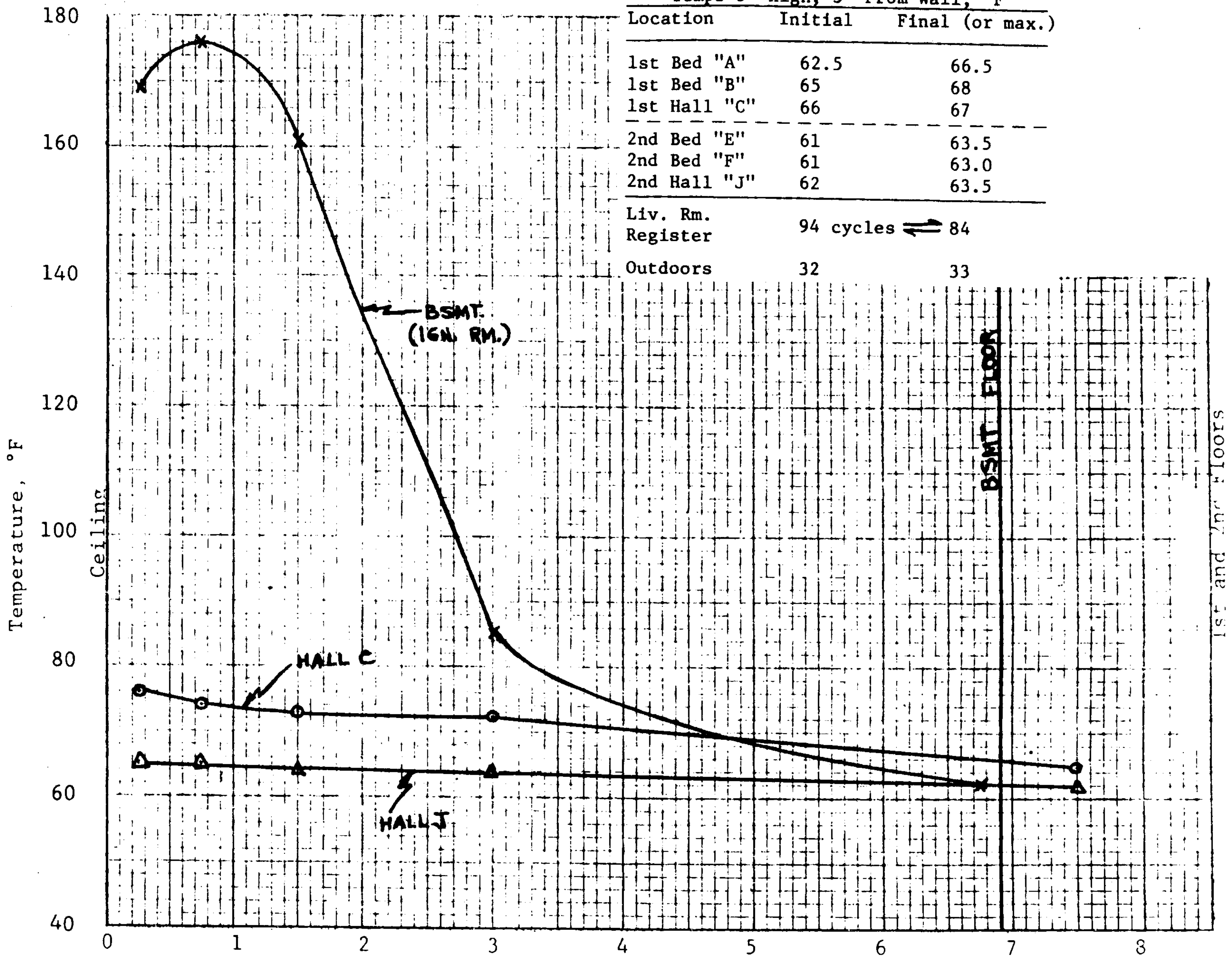
CONDITIONS ON 2ND FLOOR AT 5 FT, JR-23



VARIOUS CONDITIONS, JR-23



TEMPERATURES 3 IN. FROM CEILING, JR-23

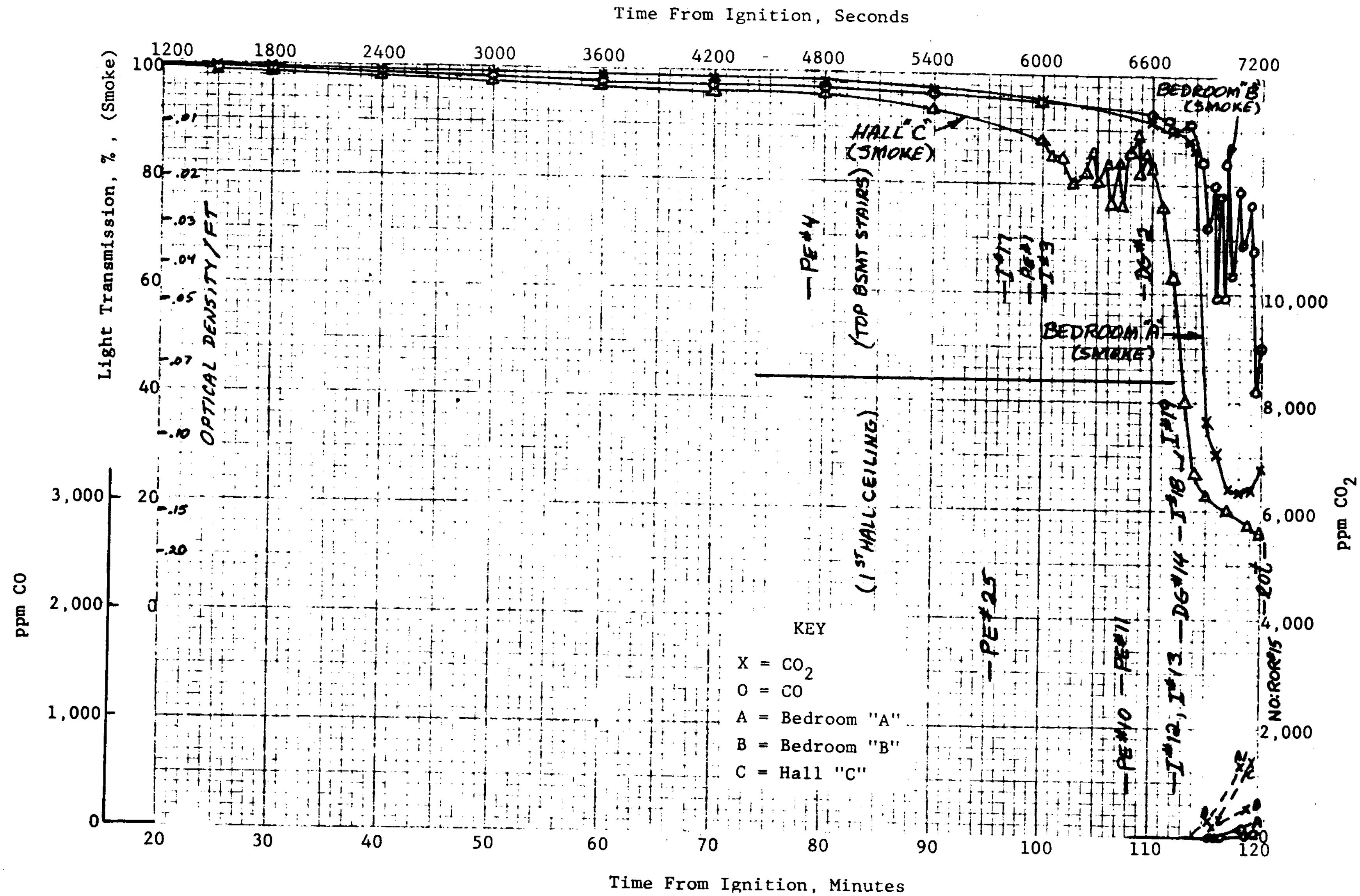


Temps 5' High, 3" From Wall, °F

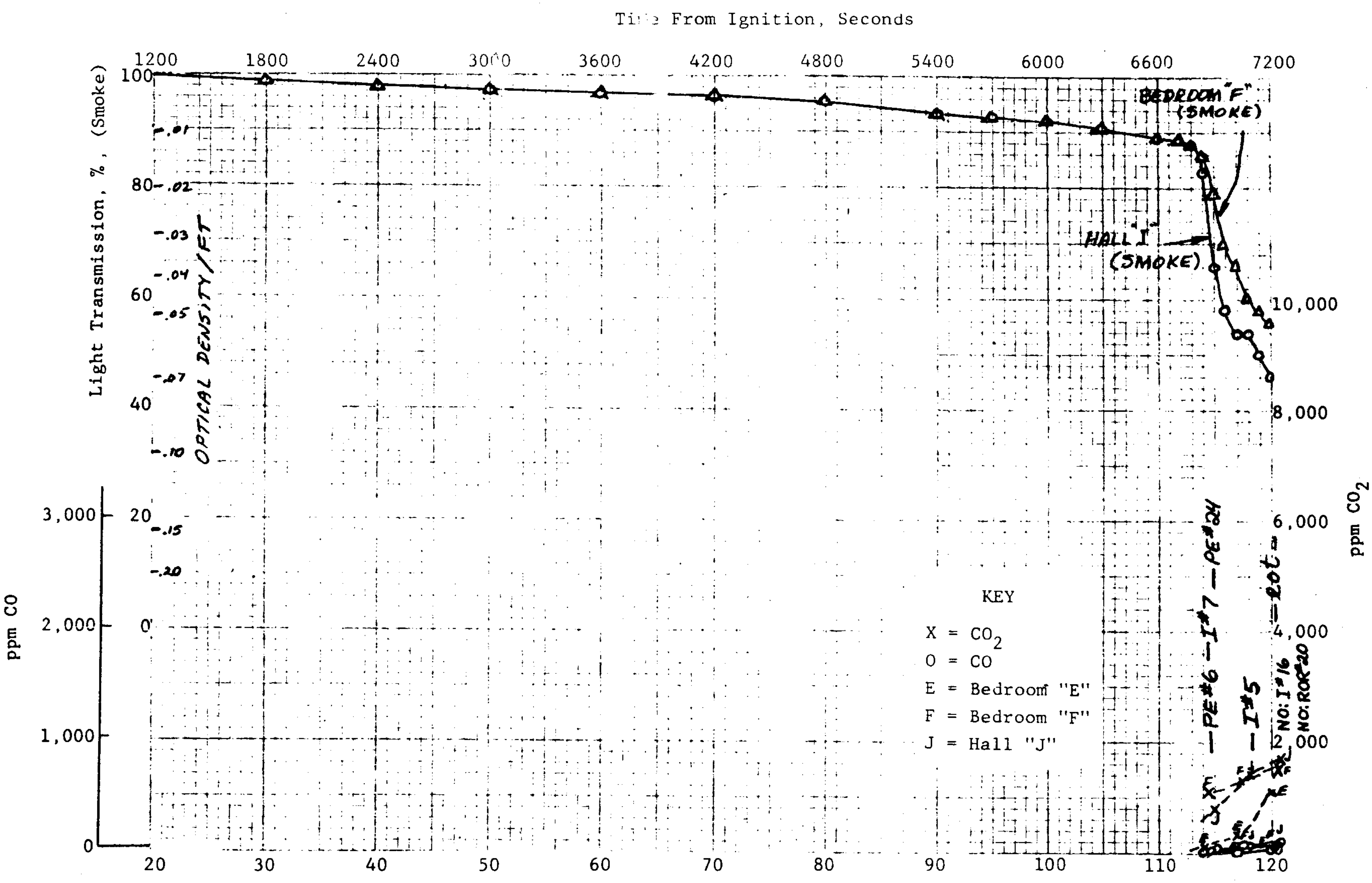
Location	Initial	Final (or max.)
1st Bed "A"	62.5	66.5
1st Bed "B"	65	68
1st Hall "C"	66	67
2nd Bed "E"	61	63.5
2nd Bed "F"	61	63.0
2nd Hall "J"	62	63.5
Liv. Rm. Register	94 cycles ⇄	84
Outdoors	32	33

Distance From Ceiling, ft.

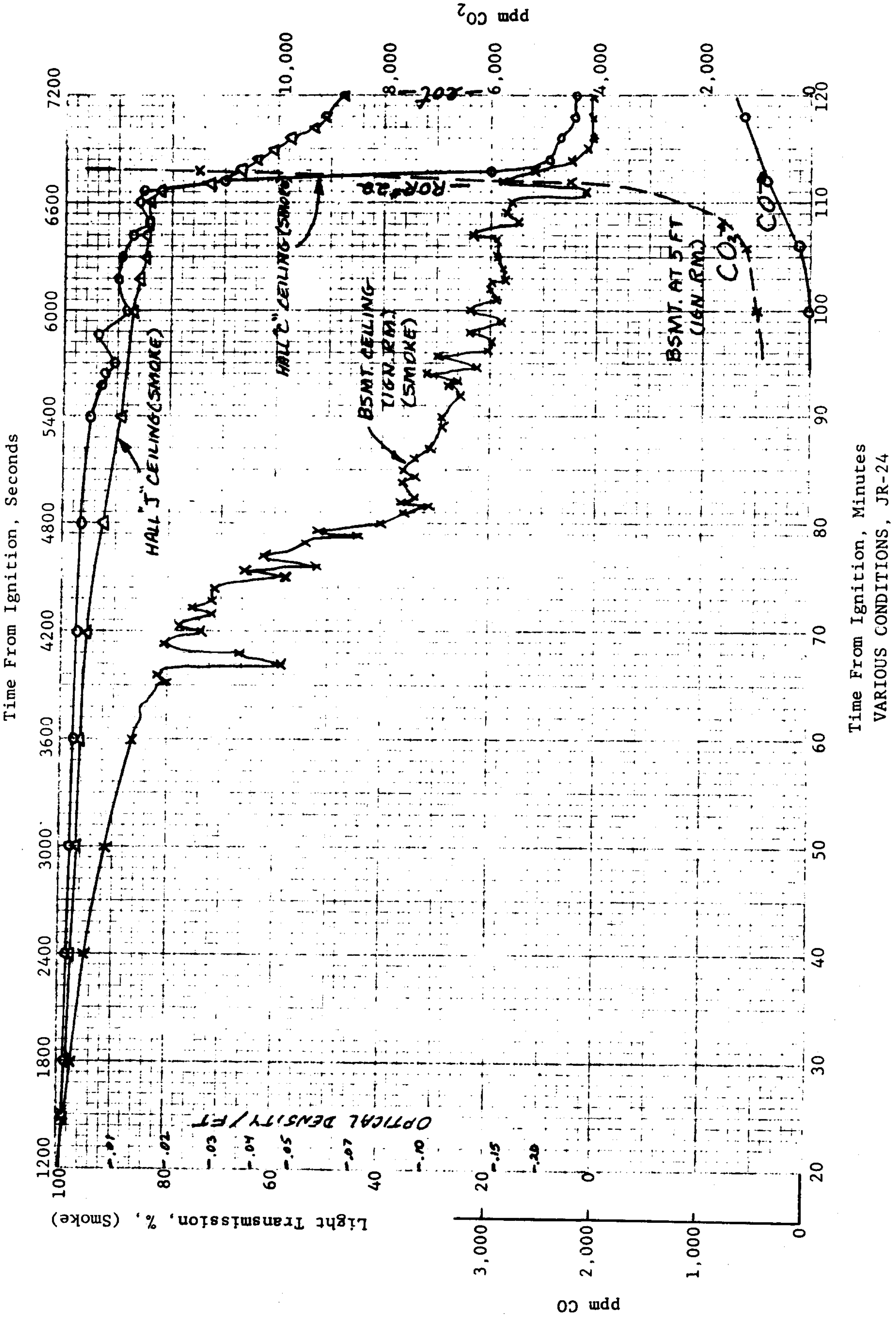
Maximum Temperature Profiles, JR-23

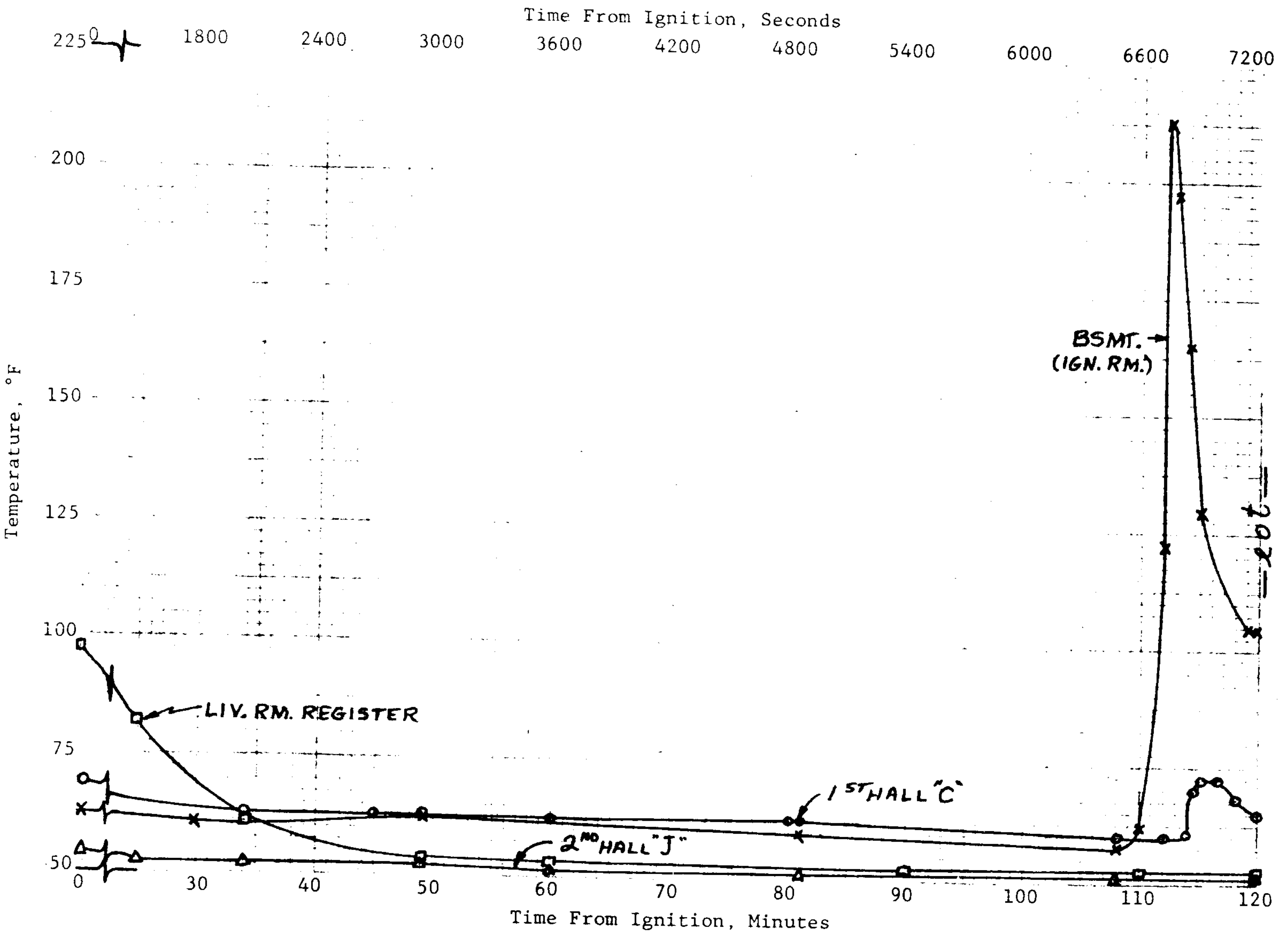


CONDITIONS ON 1ST FLOOR AT 5 FT, JR-24

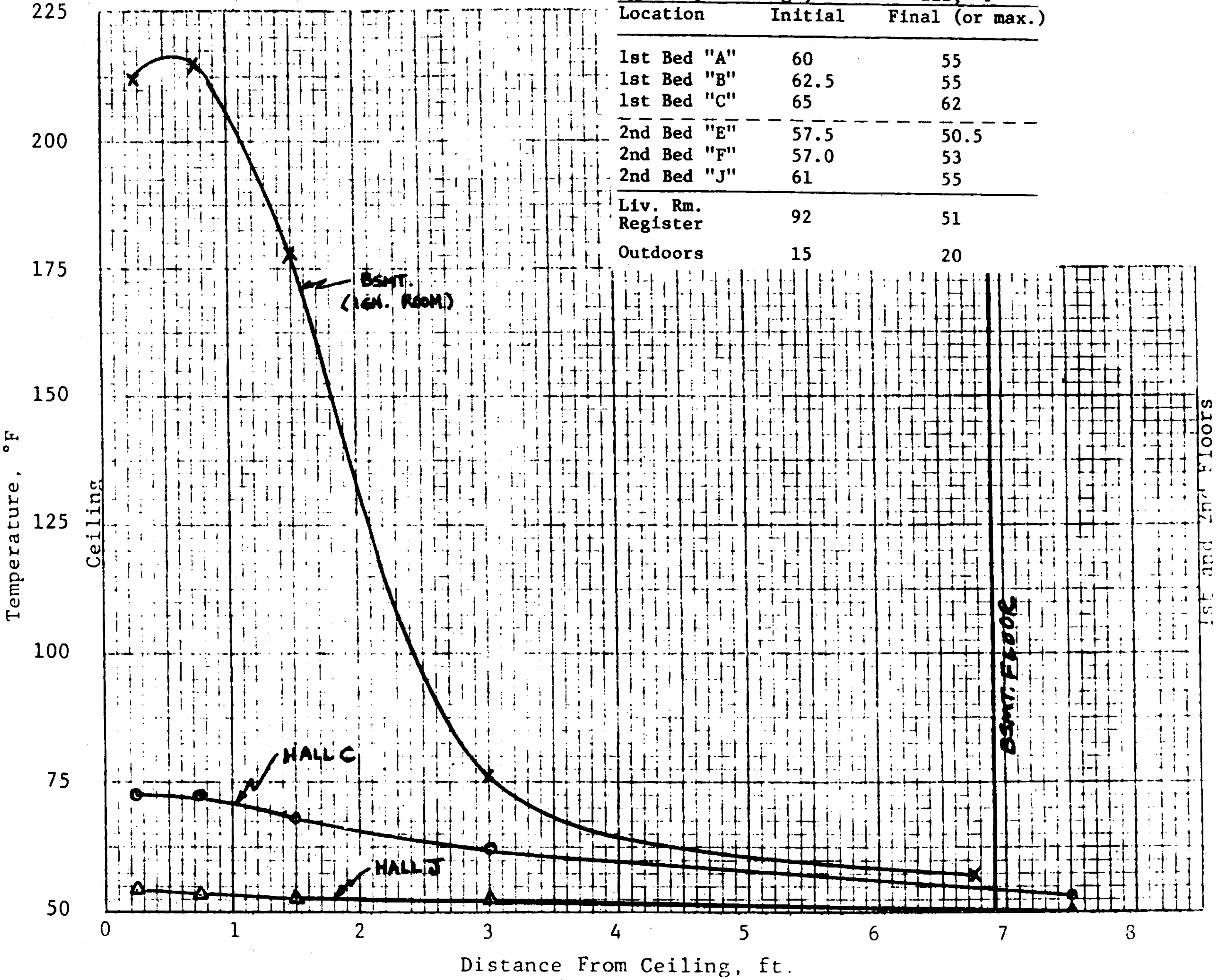


CONDITIONS ON 2ND FLOOR AT 5 FT, JR-24


Time From Ignition, Seconds
1200
1800
2400
3000
3600
4200
4800
5400
6000
6600
7200
ppm CO_2
2,000
4,000
6,000
8,000
10,000
Light Transmission, %, (Smoke)
100
80
60
40
20
0
ppm CO
0
1,000
2,000
3,000
Time From Ignition, Minutes
20
30
40
50
60
70
80
90
100
110
120
VARIOUS CONDITIONS, JR-24
OPTICAL DENSITY/FT
.01
.02
.03
.04
.05
.07
.10
.15
.20
"HALL J" CEILING (SMOKE)
HALL "C" CEILING (SMOKE)
BSMT. CEILING (IGN. RM.) (SMOKE)
BSMT. AT 5 FT (IGN. RM.)
CO_2
CO
ROR # 20
ROR

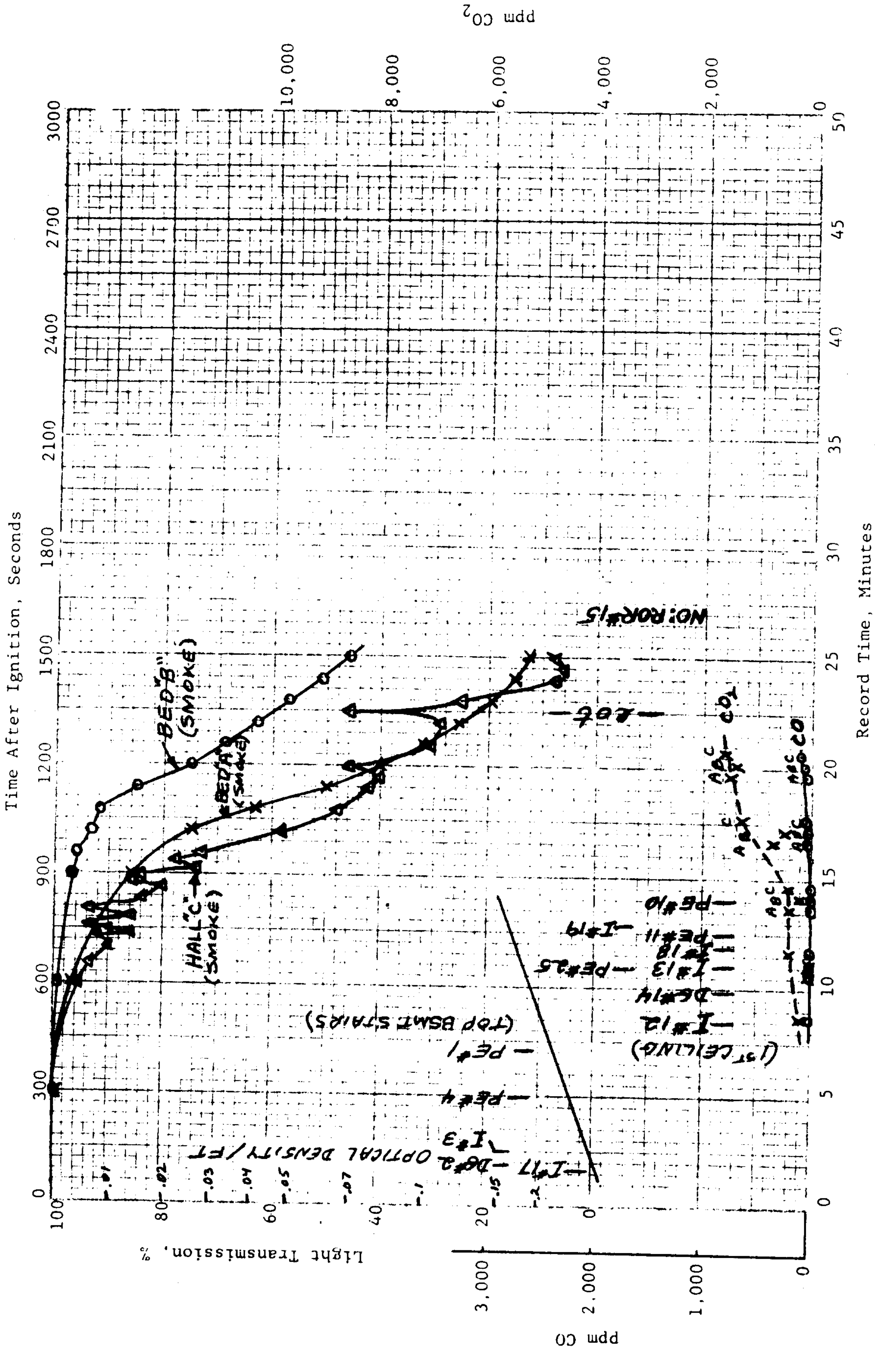


TEMPERATURES 3 IN. BELOW CEILING AND LIVING ROOM REGISTER, JR-24

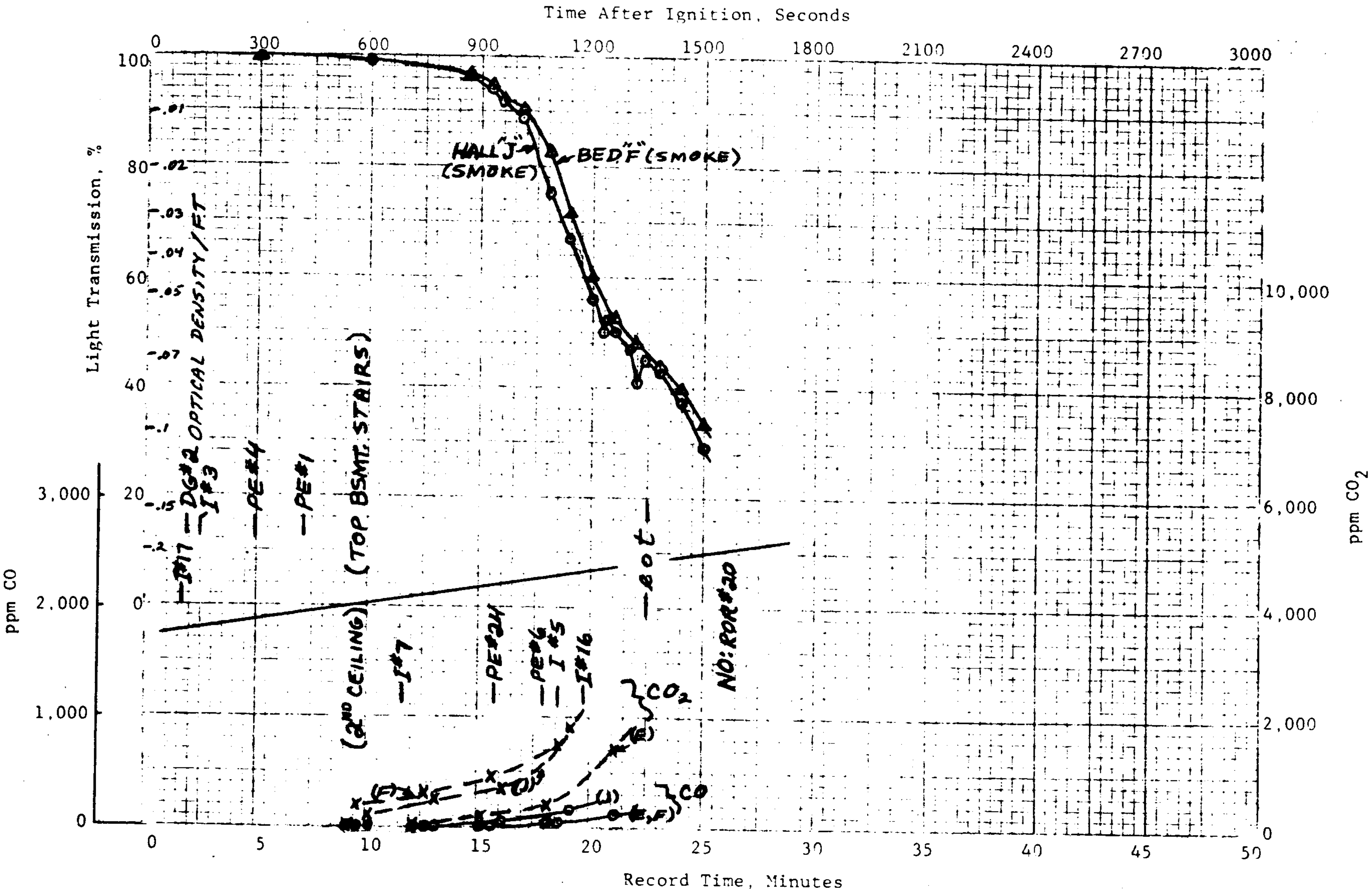


Temps 5' High, 3" From Wall, °F		
Location	Initial	Final (or max.)
1st Bed "A"	60	55
1st Bed "B"	62.5	55
1st Bed "C"	65	62
2nd Bed "E"	57.5	50.5
2nd Bed "F"	57.0	53
2nd Bed "J"	61	55
Liv. Rm. Register	92	51
Outdoors	15	20

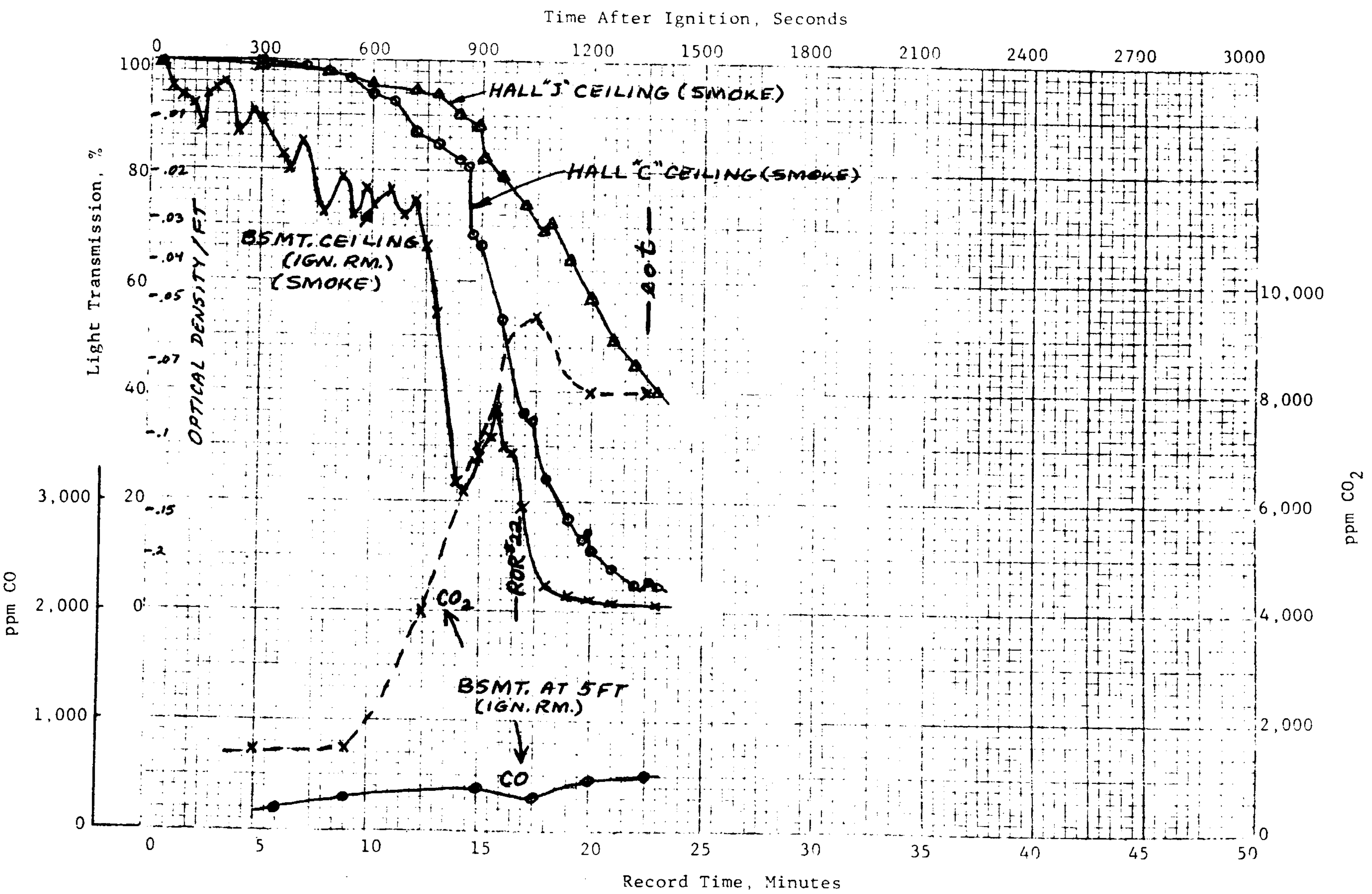
Maximum Temperature Profiles, JR-24



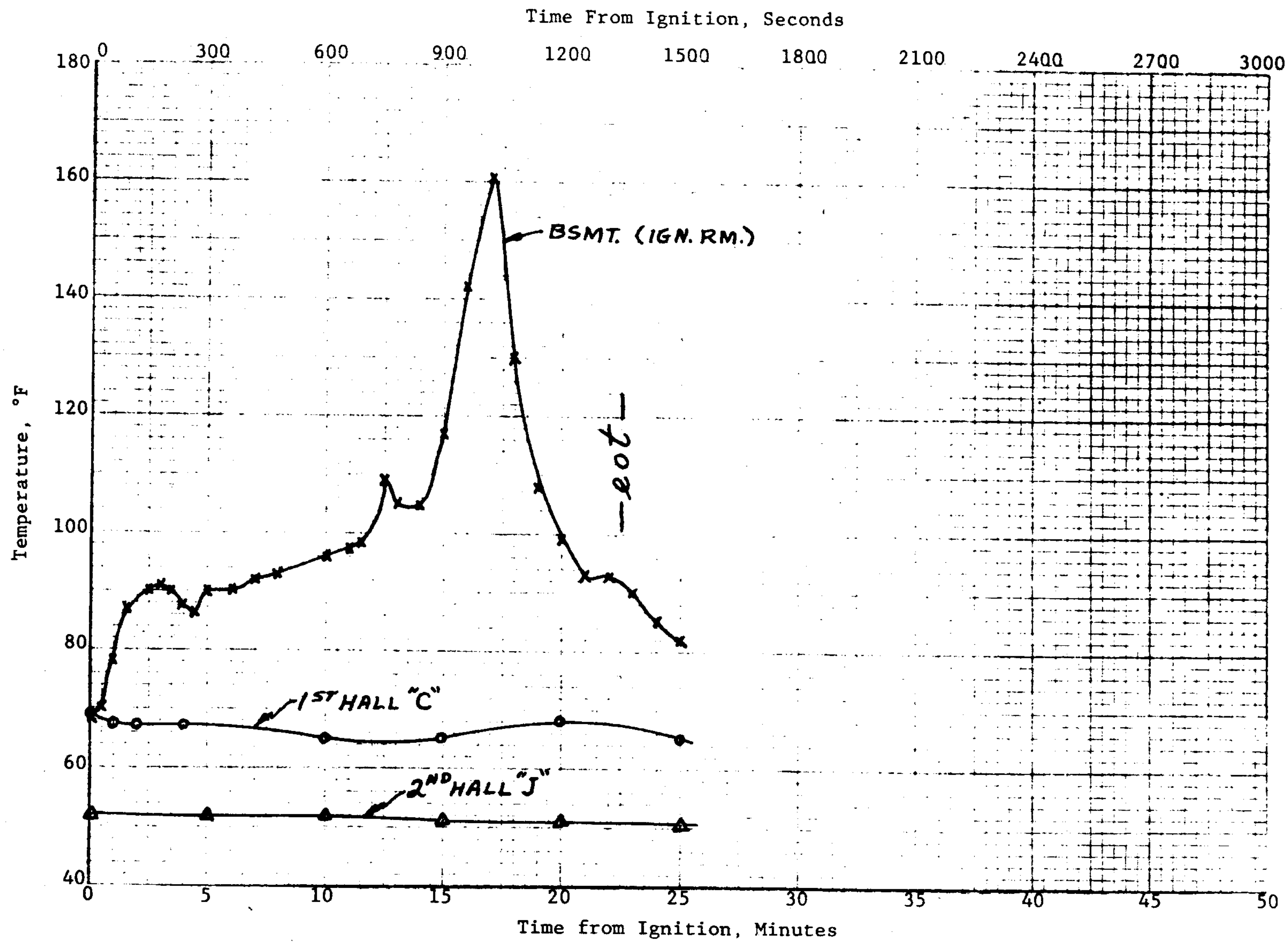
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-25



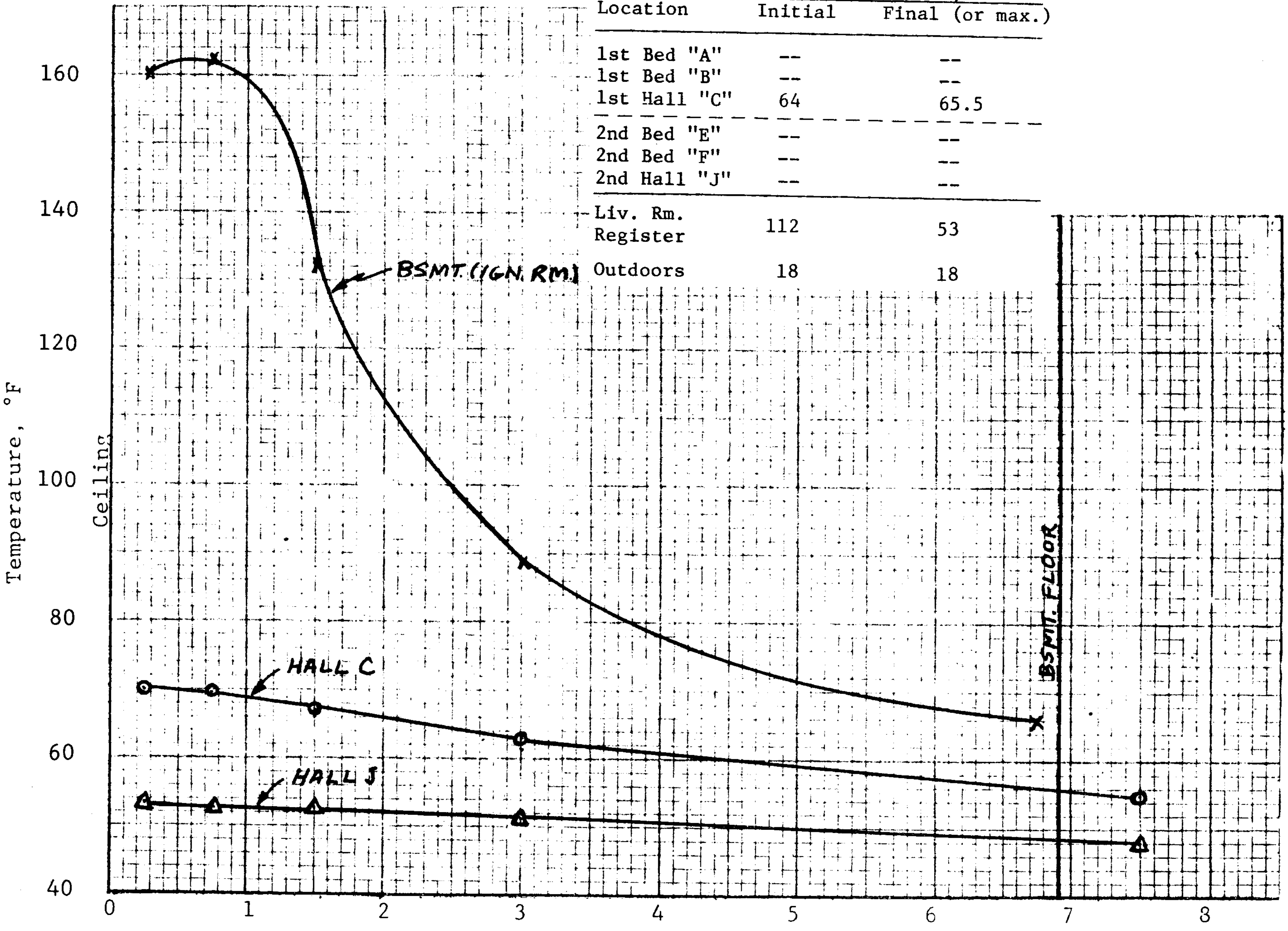
CONDITIONS ON 2ND FLOOR AT 5 FT, JR-25



VARIOUS CONDITIONS, JR-25



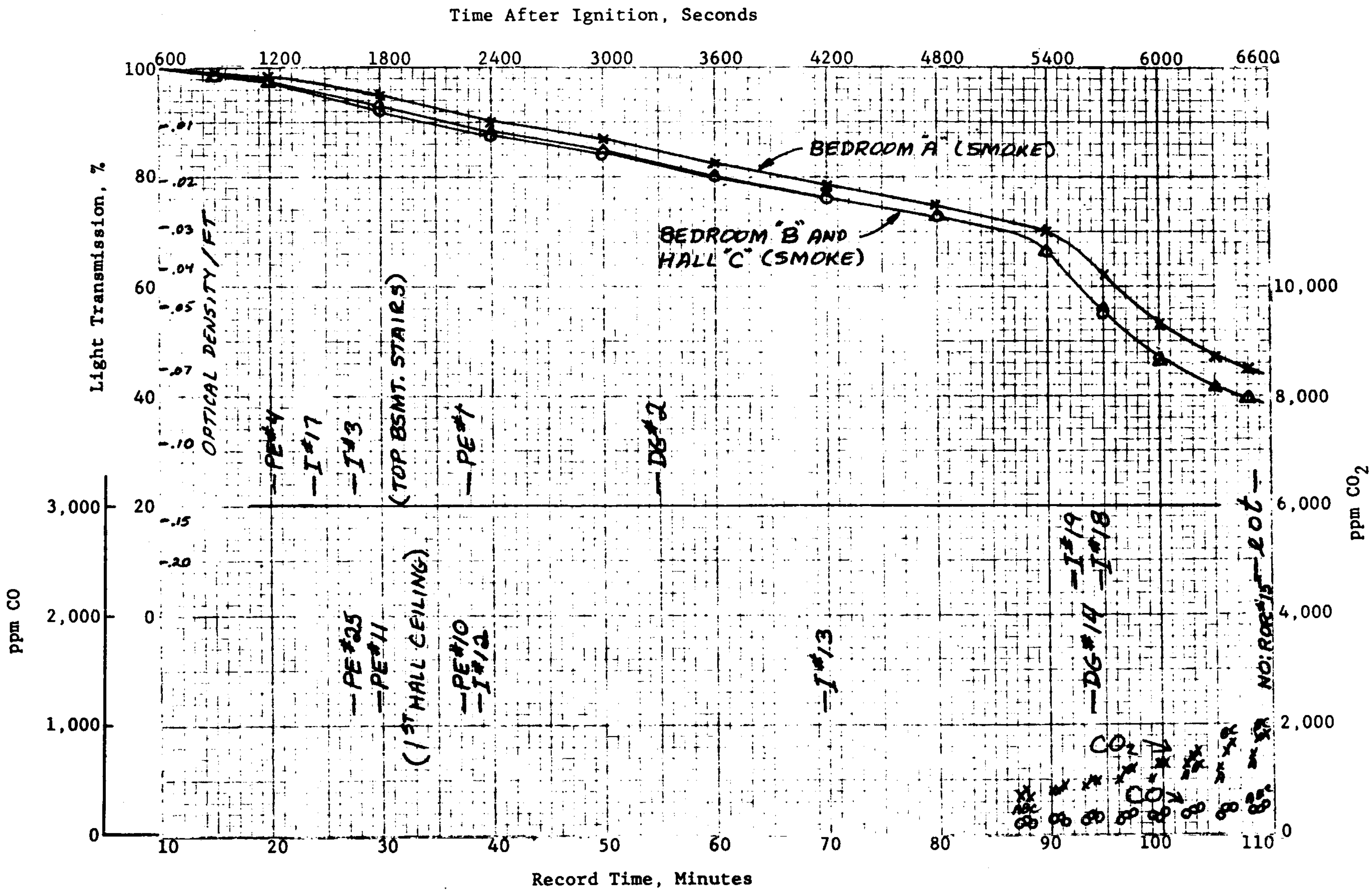
TEMPERATURES 3 IN. FROM CEILING, JR-25



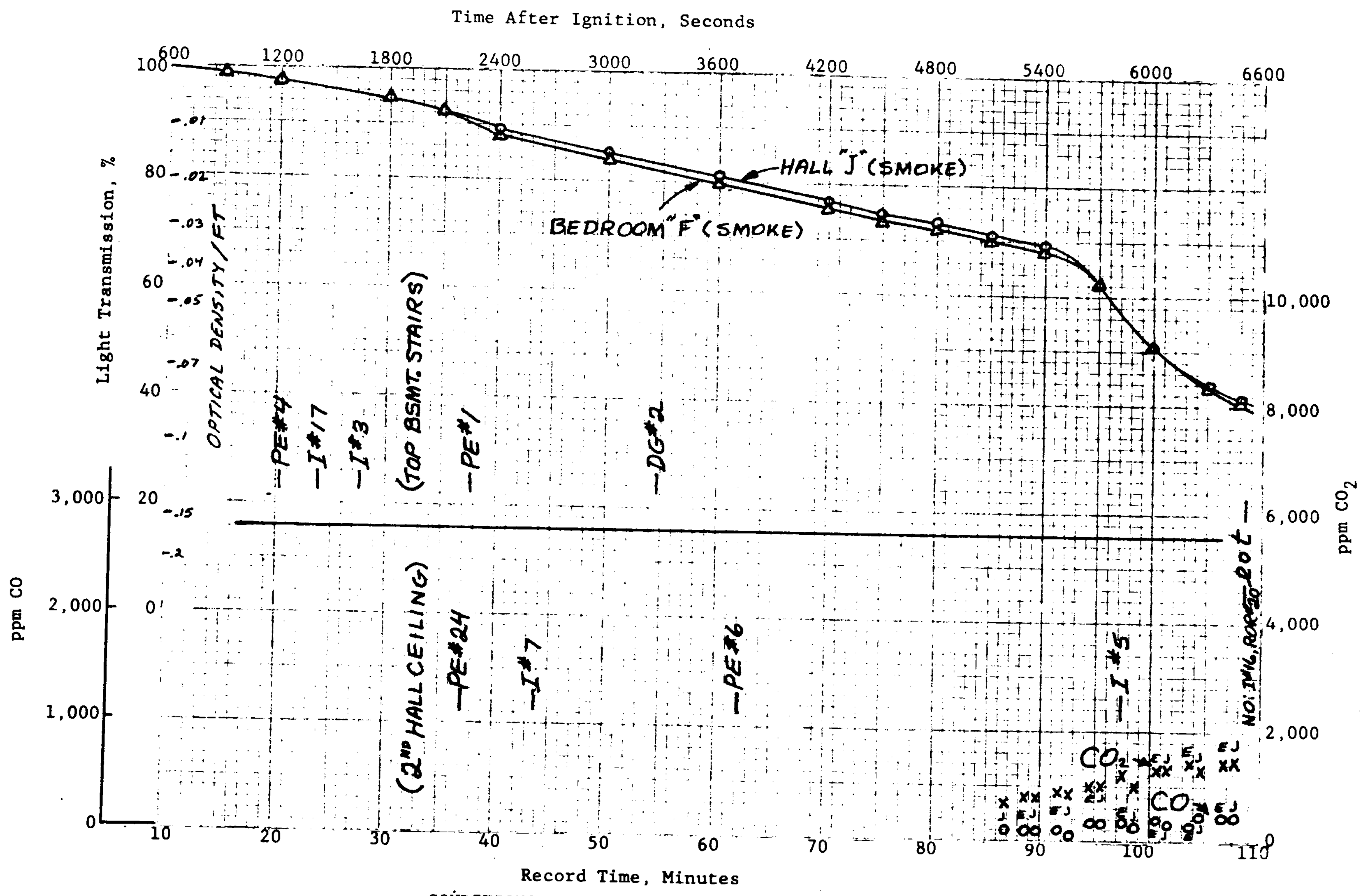
Temps 5' High, 3" From Wall, °F		
Location	Initial	Final (or max.)
1st Bed "A"	--	--
1st Bed "B"	--	--
1st Hall "C"	64	65.5
2nd Bed "E"	--	--
2nd Bed "F"	--	--
2nd Hall "J"	--	--
Liv. Rm. Register	112	53
Outdoors	18	18

Distance From Ceiling, ft.

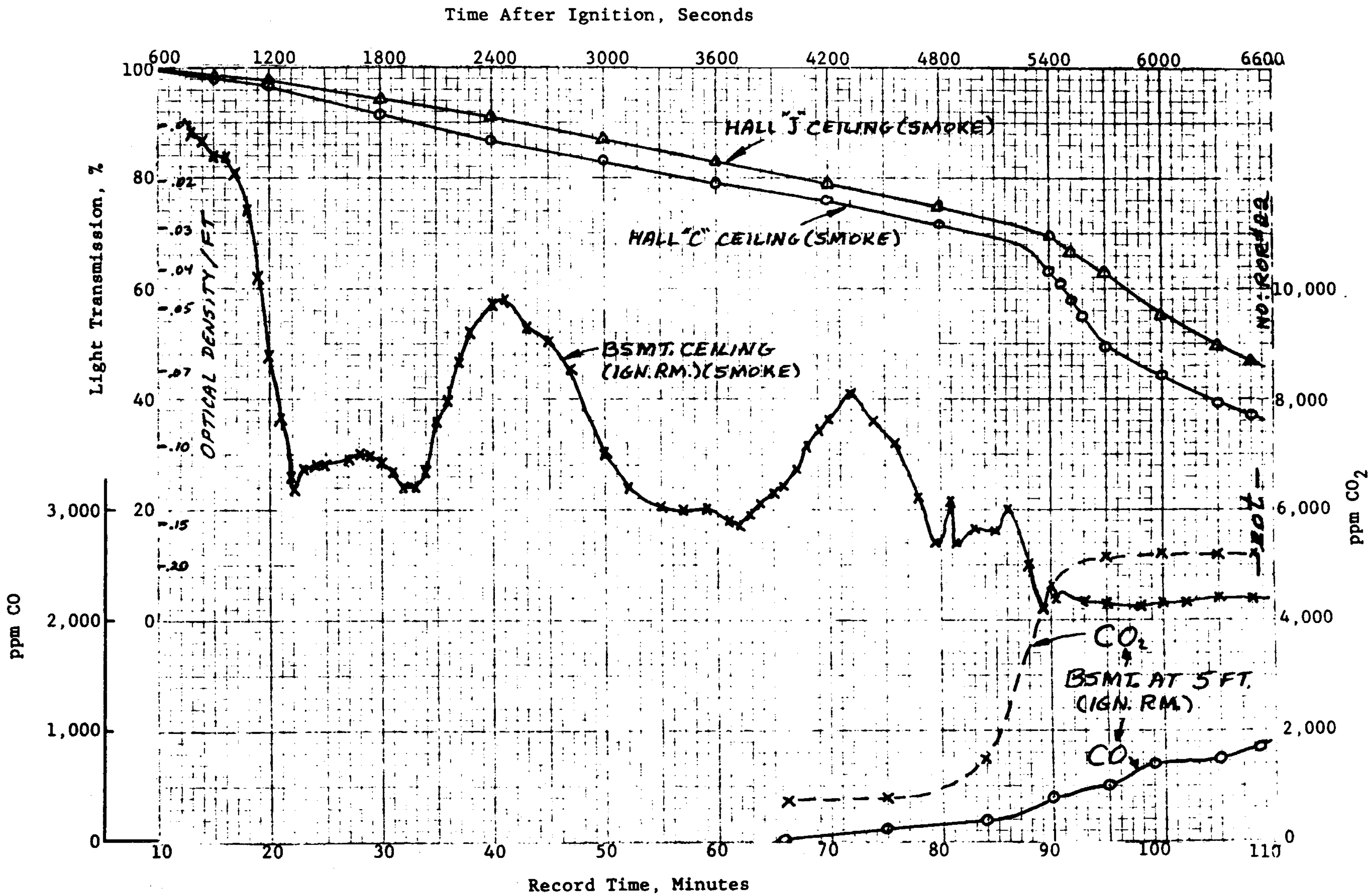
Maximum Temperature Profiles, JR-25



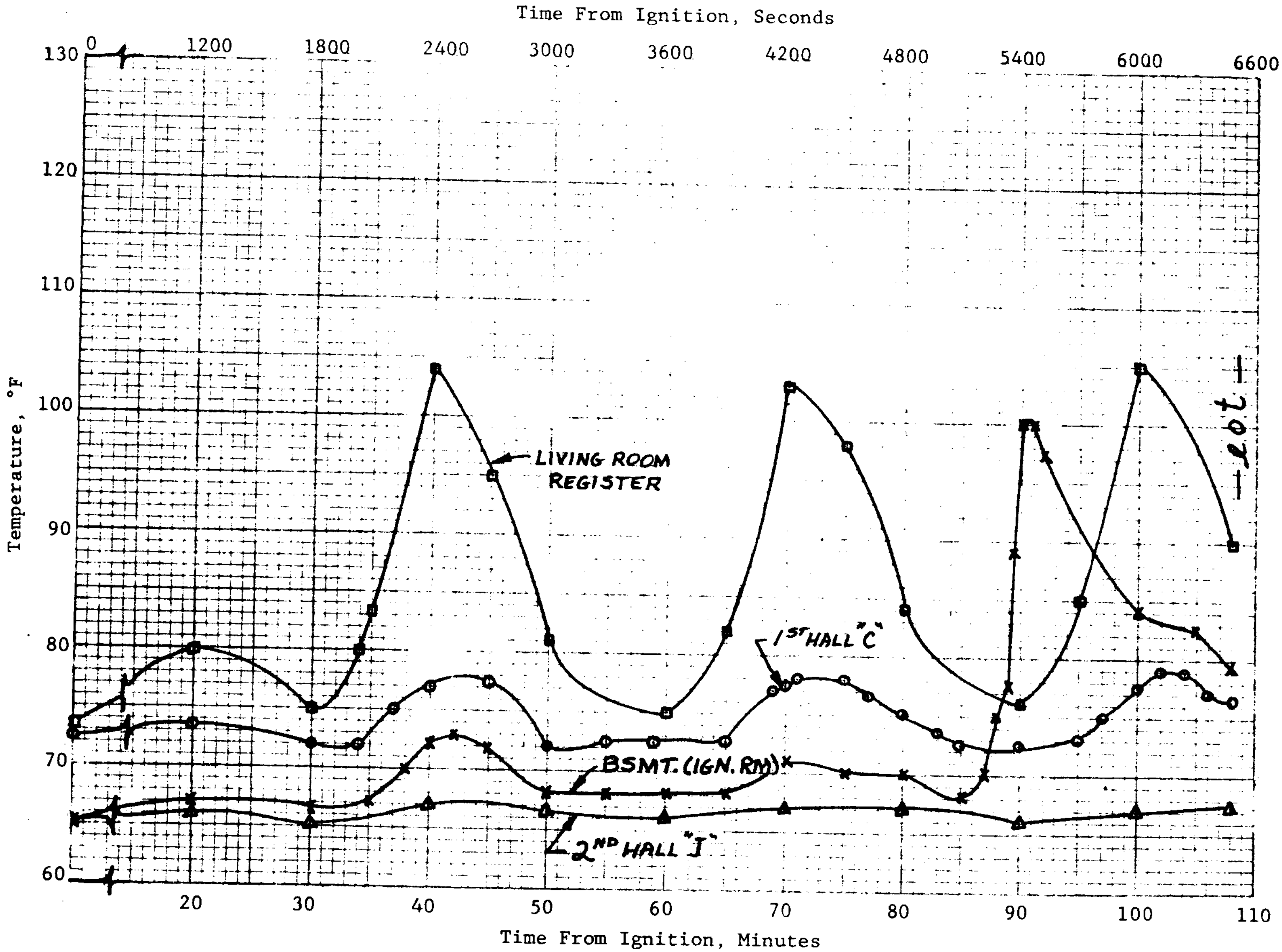
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-26



CONDITIONS ON 2ND FLOOR AT 5 FT, JR-26

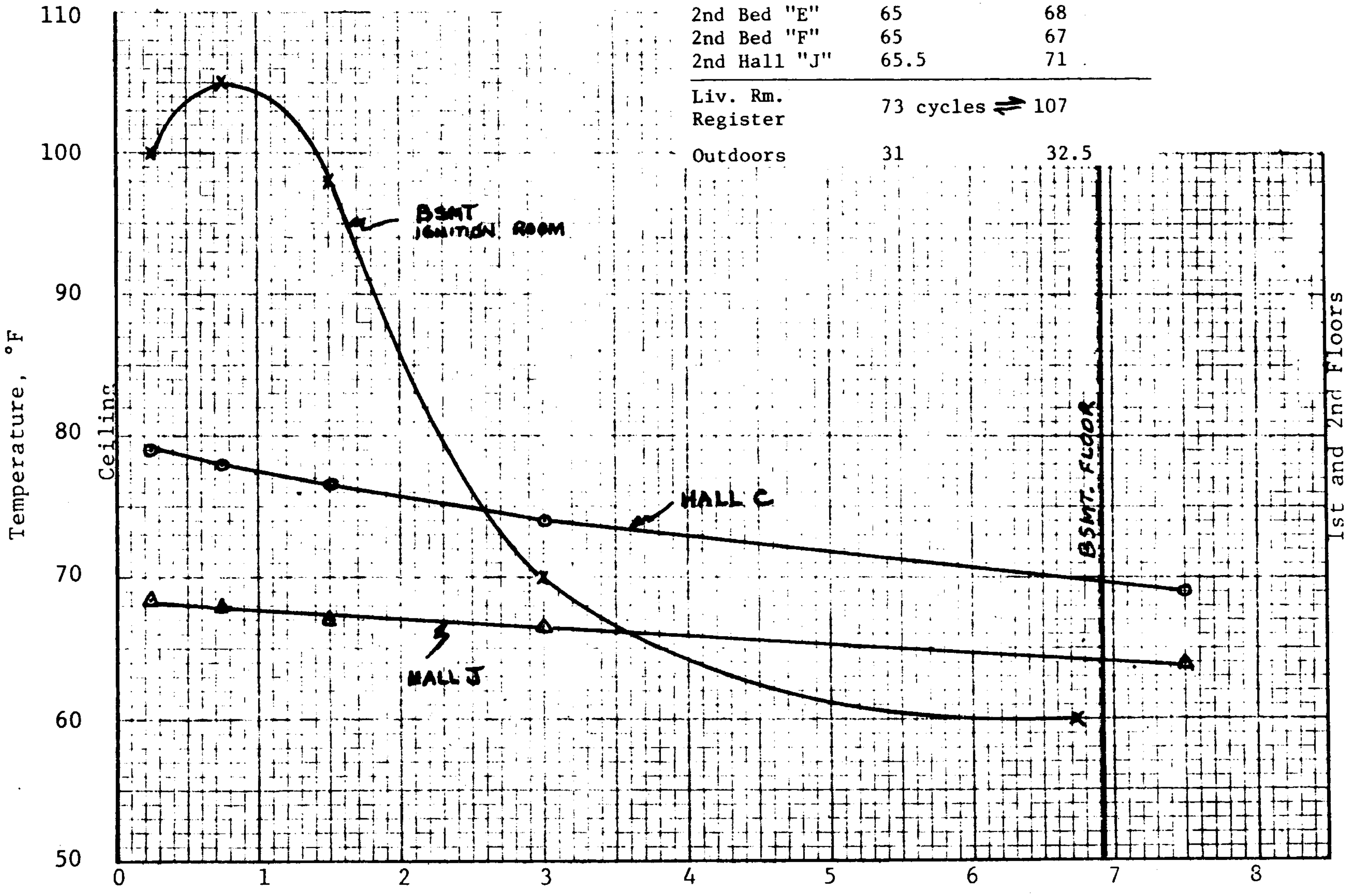


VARIOUS CONDITIONS, JR-26

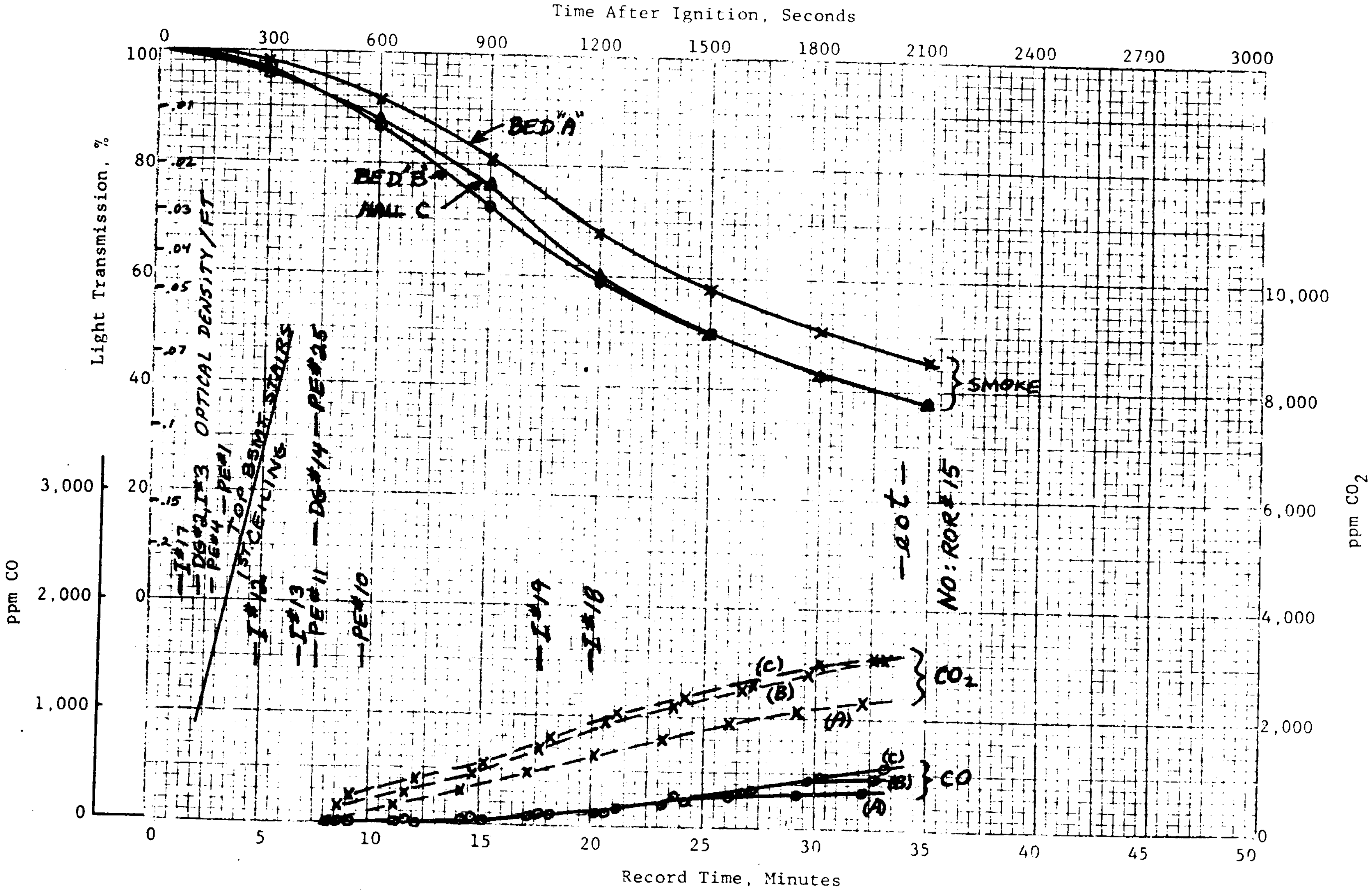


TEMPERATURES 3 IN. BELOW CEILING (AND LIV. RM. REGISTER), JR-26

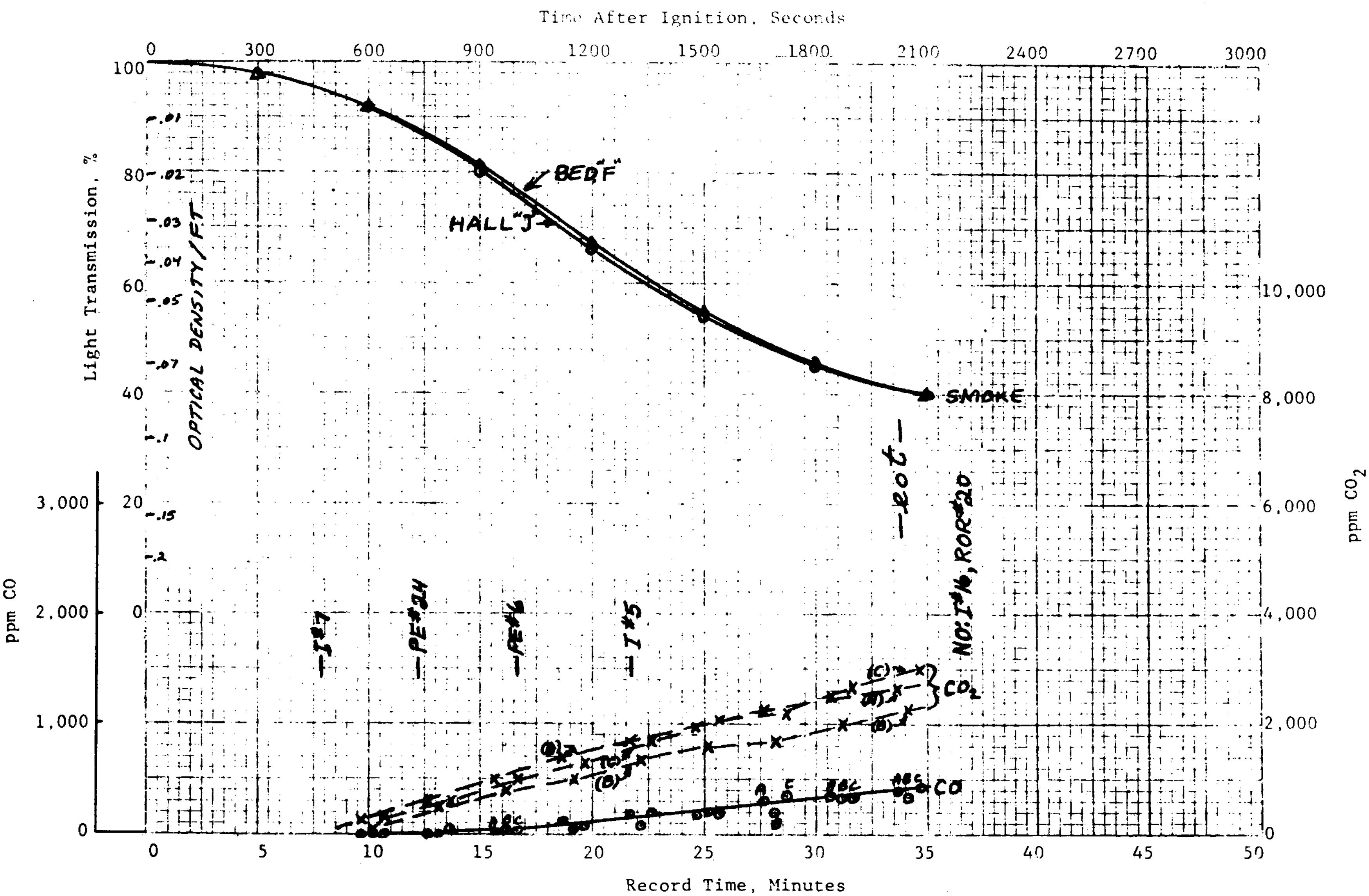
Temps 5' High, 3" From Wall, °F		
Location	Initial	Final (or max.)
1st Bed "A"	65	68.5
1st Bed "B"	69	74.5
1st Hall "C"	70	75
2nd Bed "E"	65	68
2nd Bed "F"	65	67
2nd Hall "J"	65.5	71
Liv. Rm. Register	73 cycles ⇌ 107	
Outdoors	31	32.5



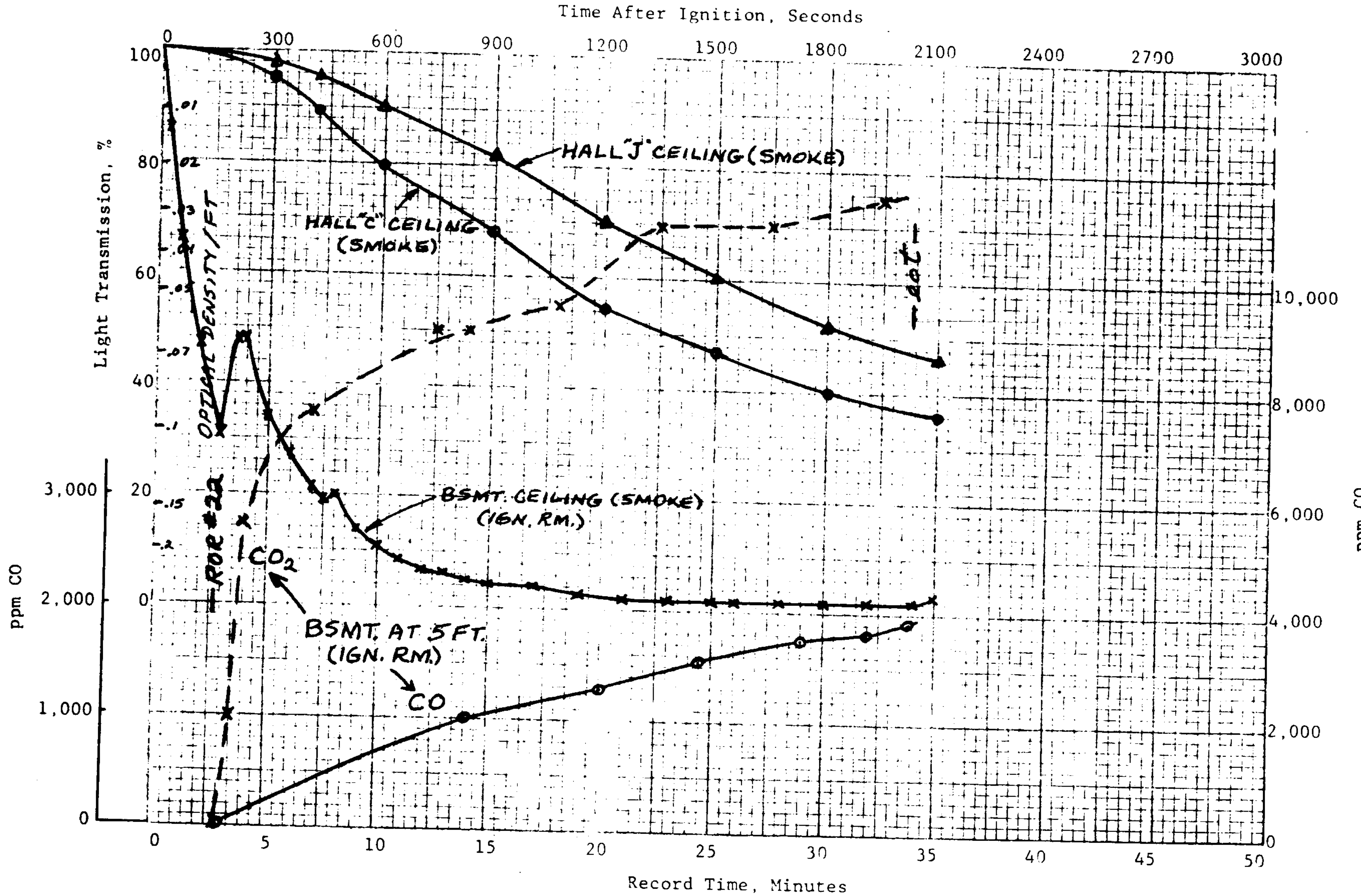
Distance From Ceiling, ft.
Maximum Temperature Profiles, JR-26



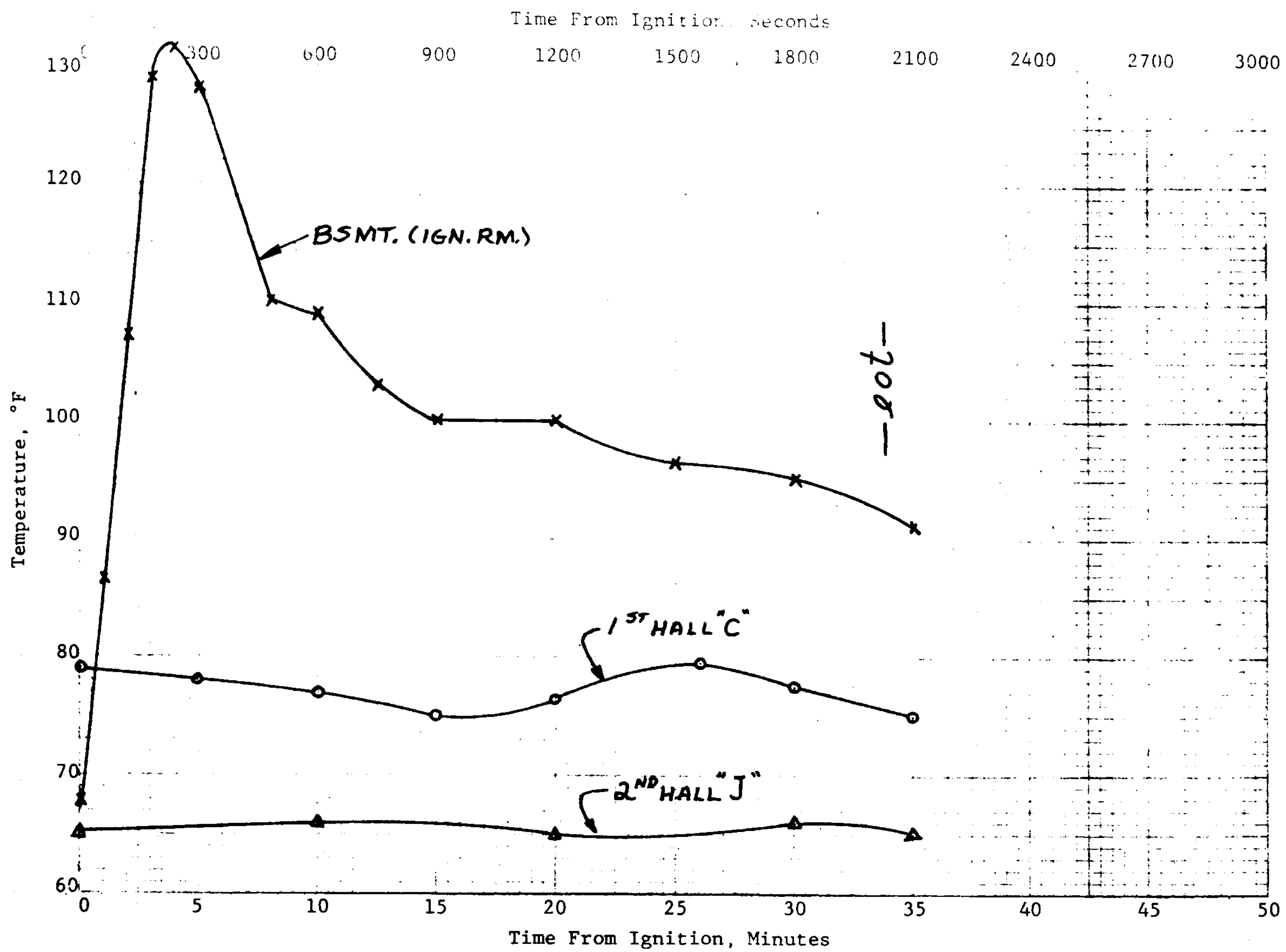
CONDITIONS ON 1ST FLOOR AT 5 FT, JR-27



CONDITIONS ON 2ND FLOOR AT 5 FT, JR-27

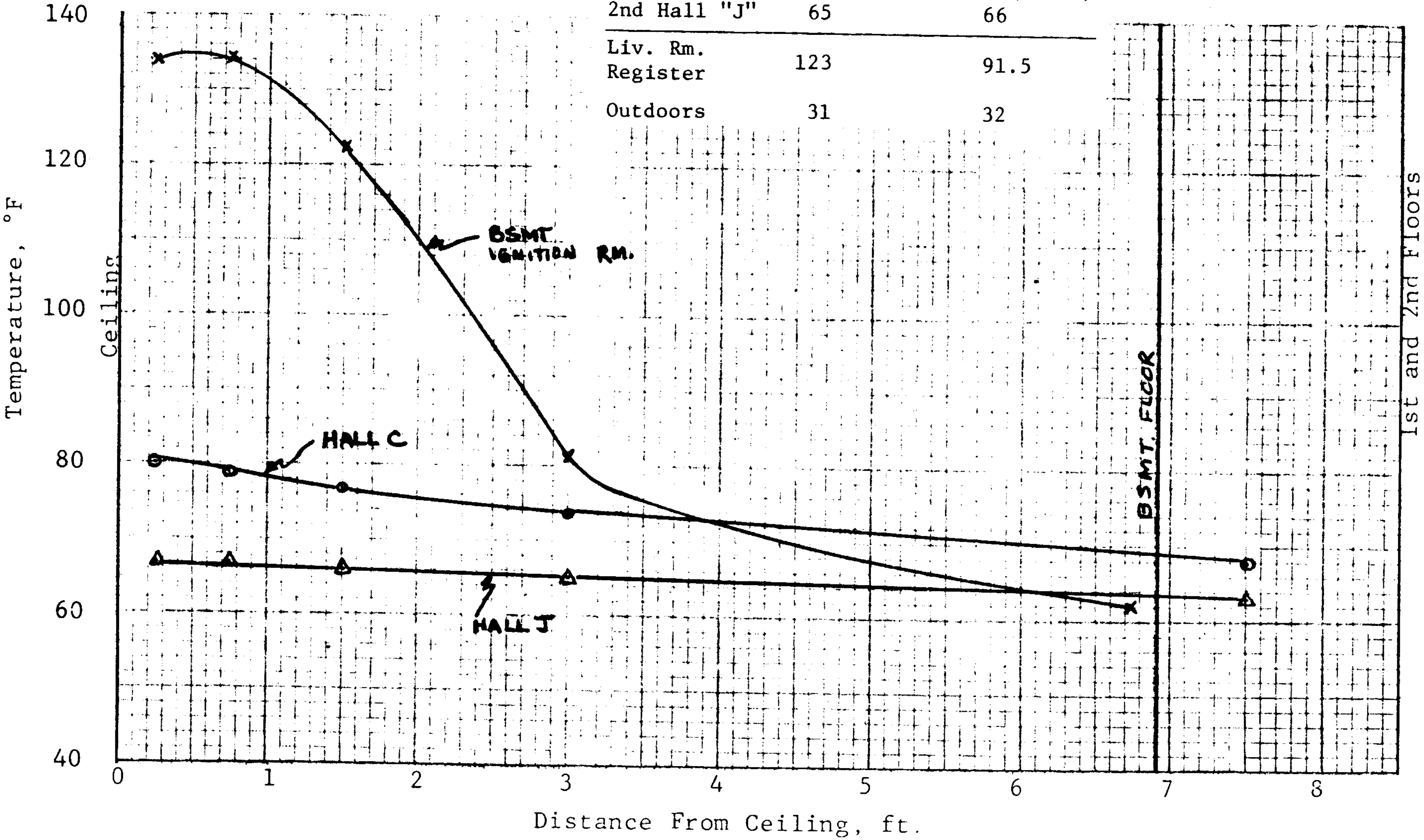


VARIOUS CONDITIONS, JR-27

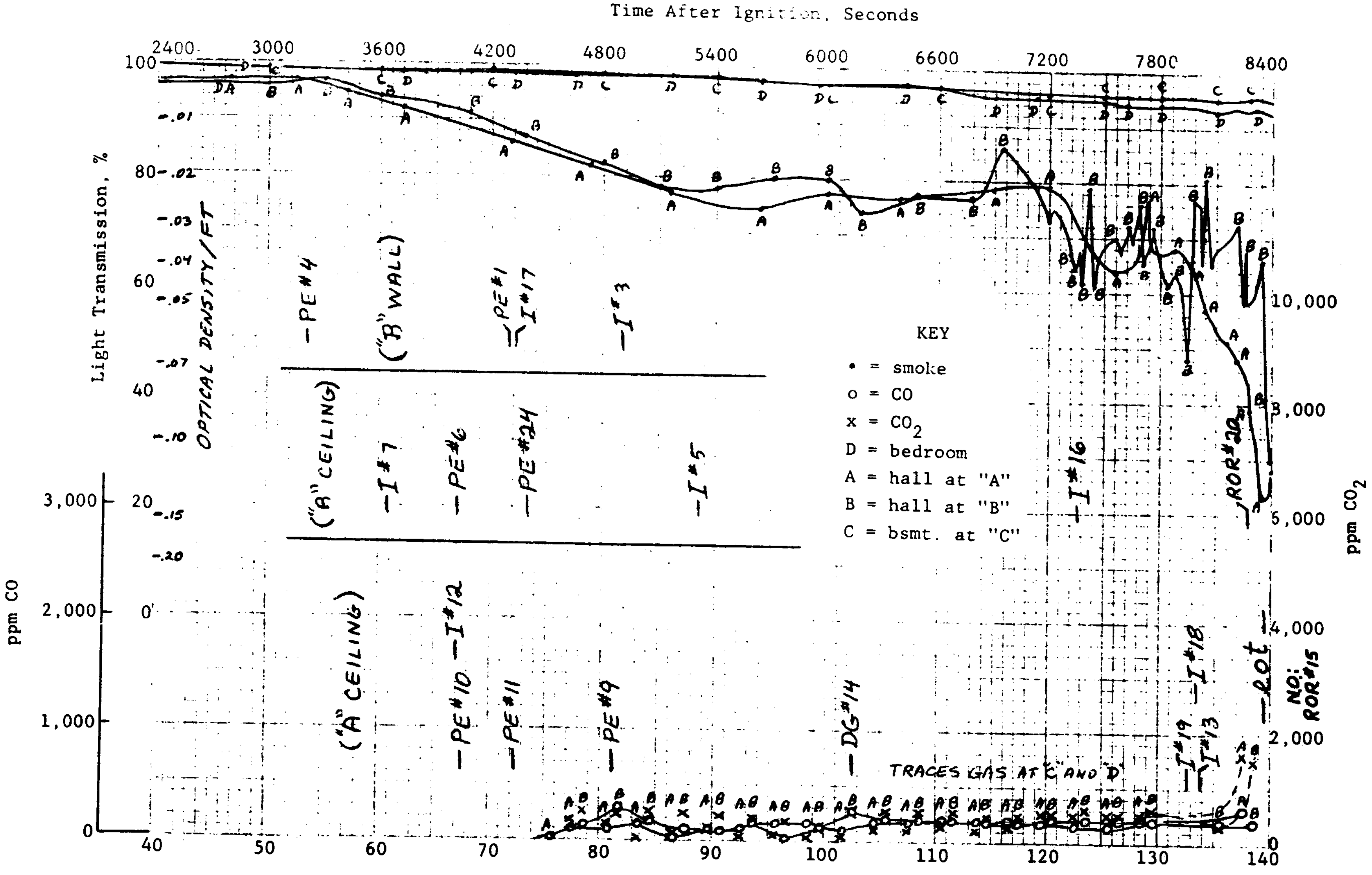


TEMPERATURES 3 IN. BELOW CEILING, JR-27

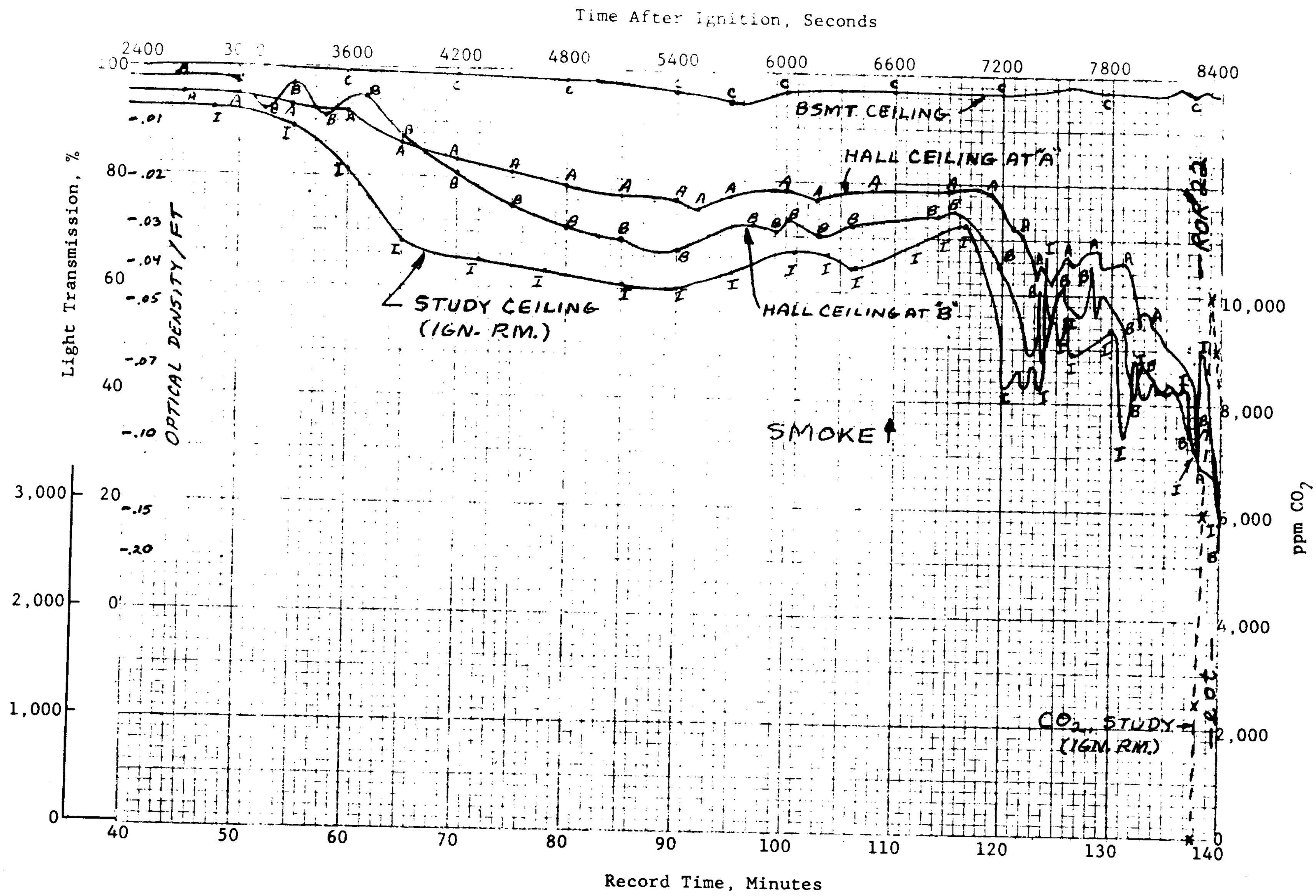
Temps 5' High, 3" From Wall, °F		
Location	Initial	Final (or max.)
1st Bed "A"	65	65
1st Bed "B"	71	71.5
1st Hall "C"	75	72
2nd Bed "E"	65	66
2nd Bed "F"	65	63(final)
2nd Hall "J"	65	66
Liv. Rm. Register	123	91.5
Outdoors	31	32



Maximum Temperature Profiles, JR-27

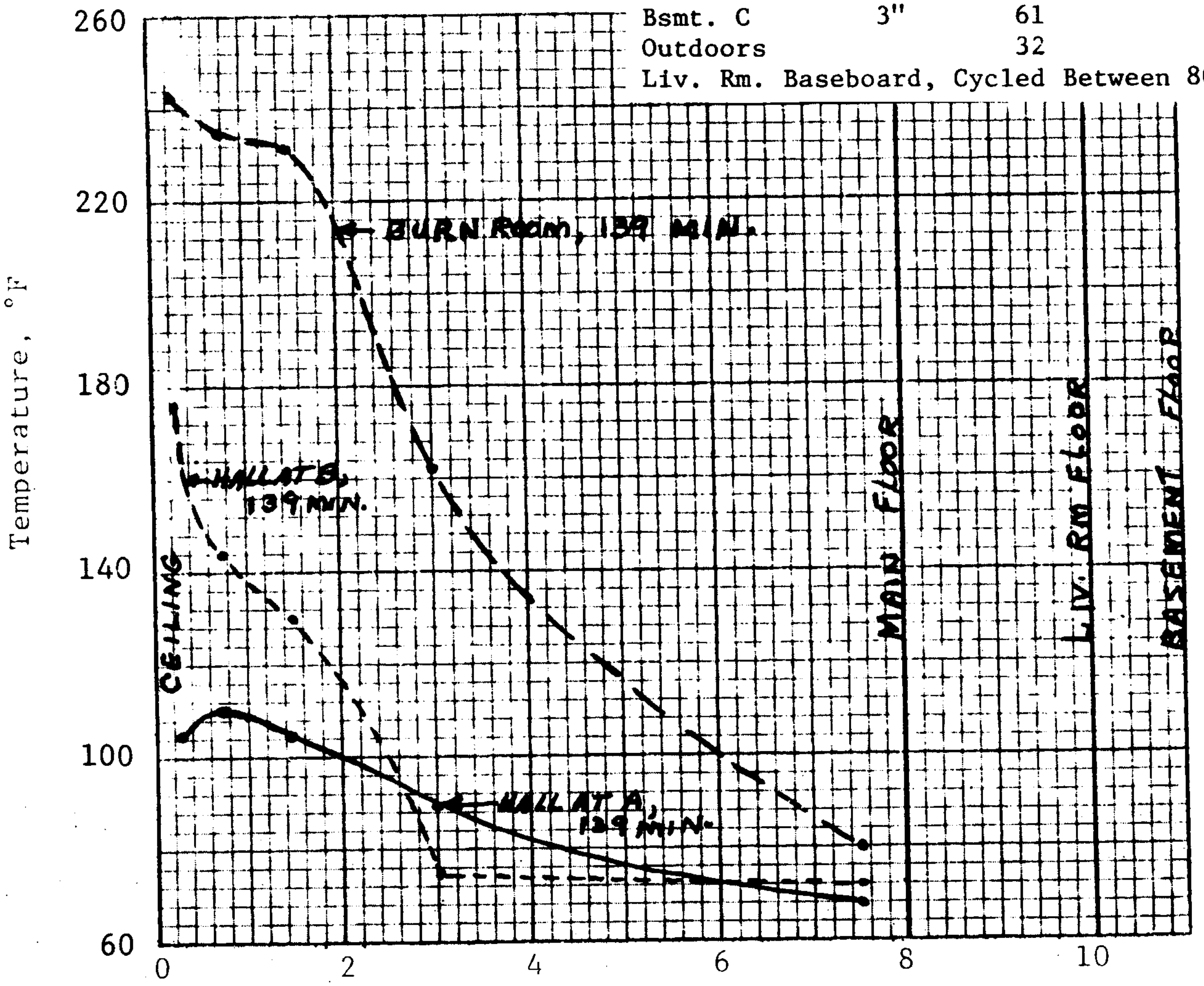


CONDITIONS 5 FT ABOVE FLOOR, LS-28

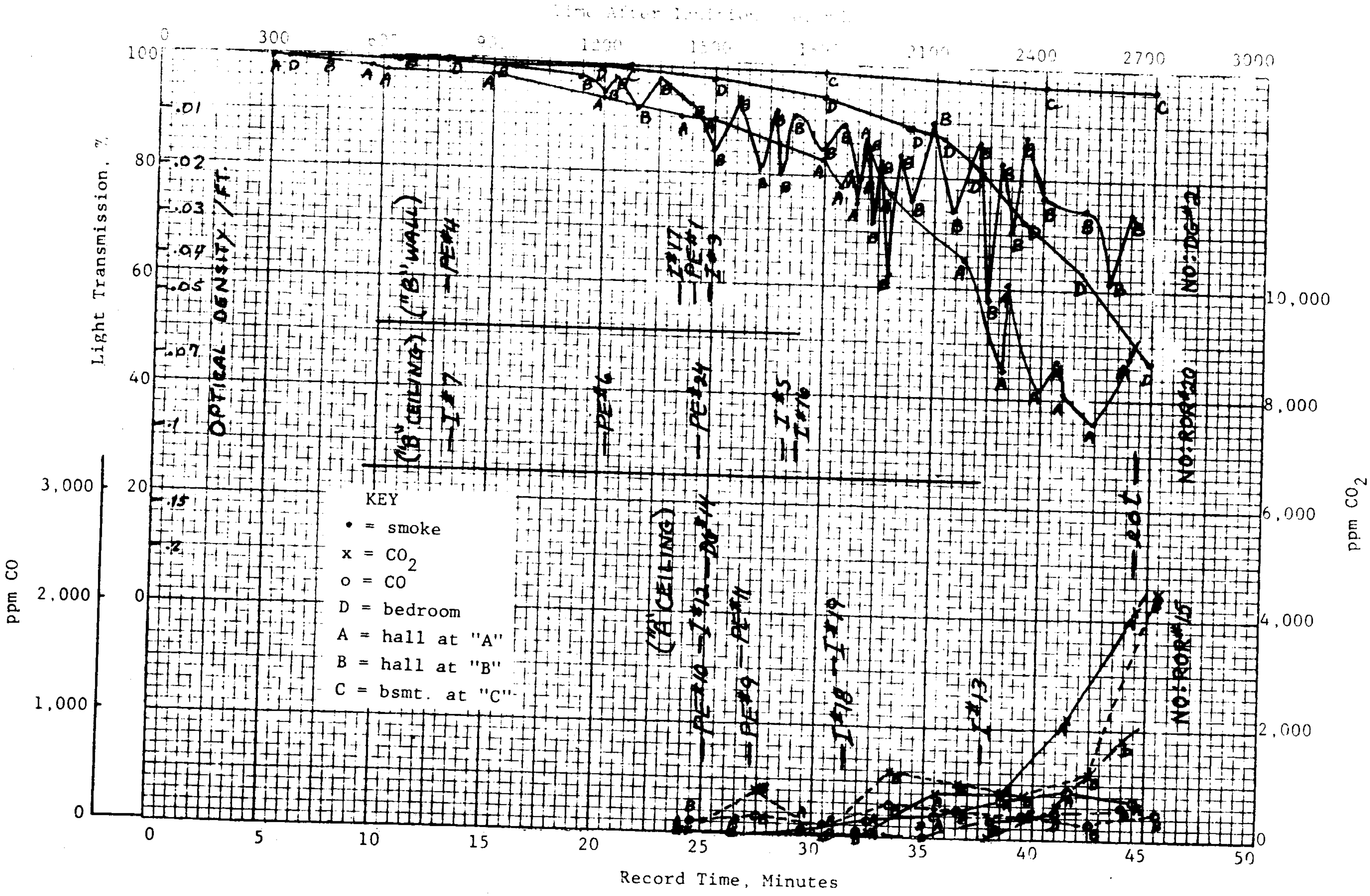


VARIOUS CONDITIONS, LS-28

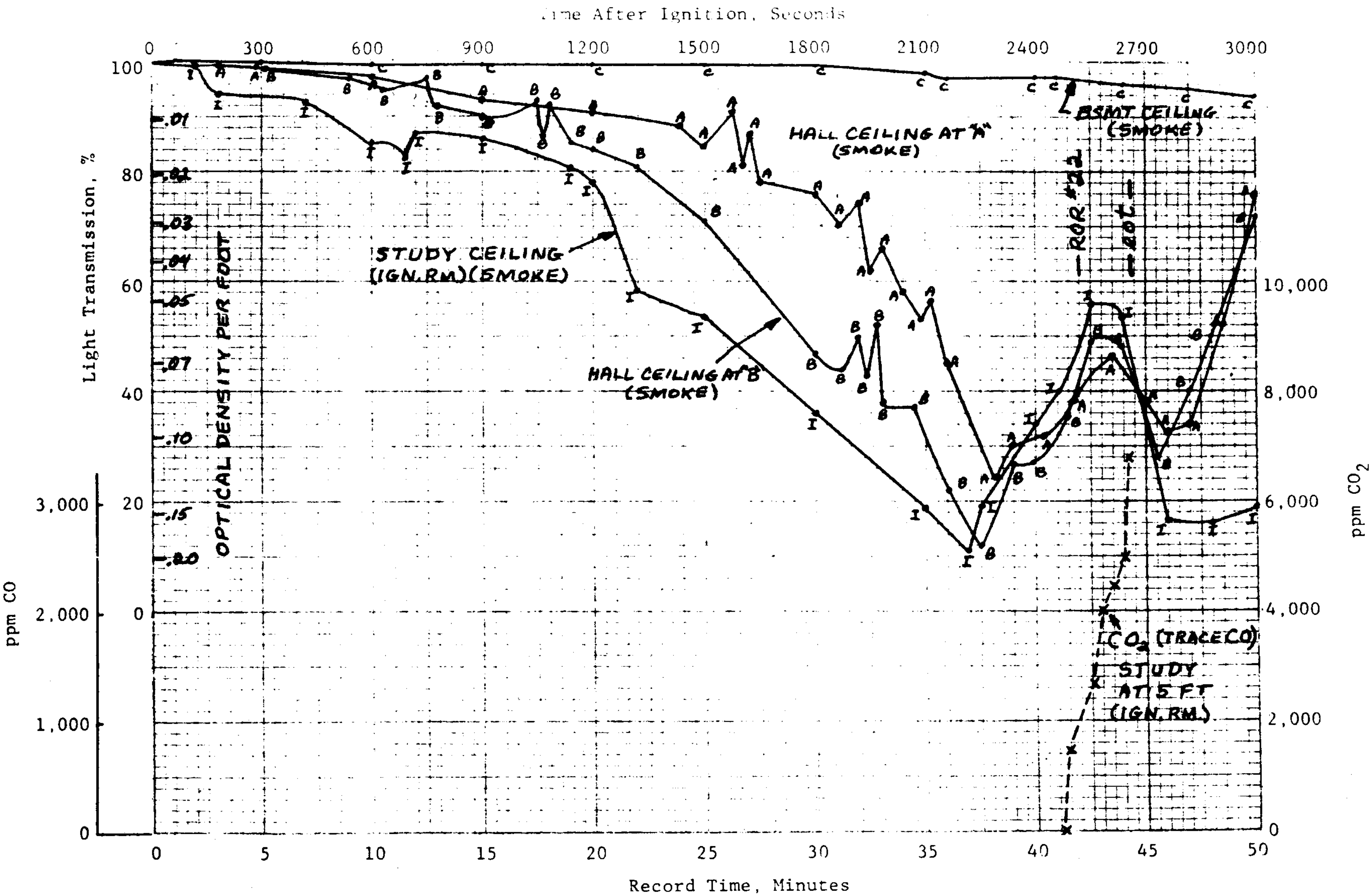
Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	66	65
Study	3"	69	210
Hall A	12"	68	86
Hall B	12"	68	75
Bsmt. C	3"	61	65
Outdoors		32	34
Liv. Rm. Baseboard, Cycled Between			80-96



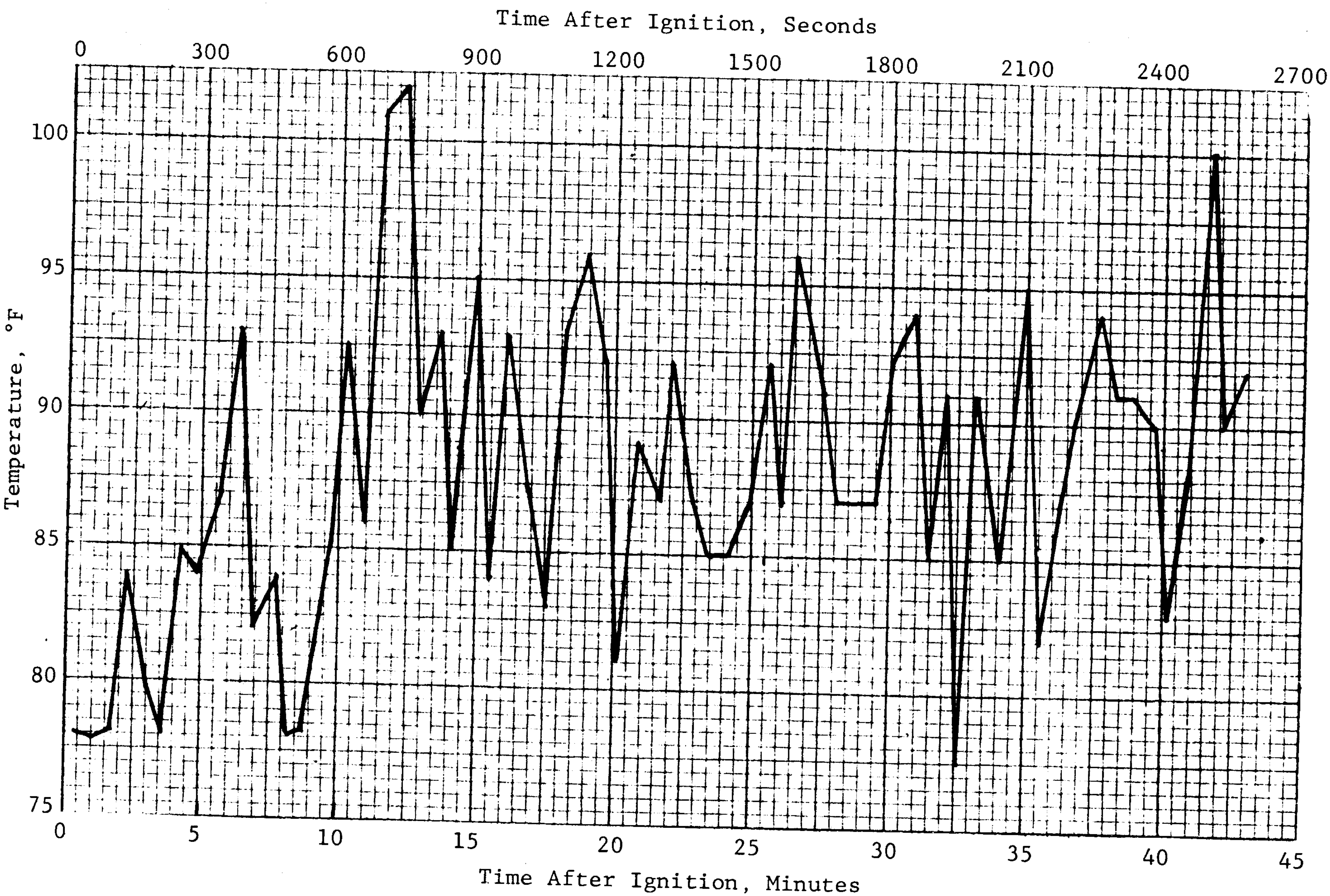
Maximum Temperature Profiles, LS-28



CONDITIONS 5 FT ABOVE FLOOR, LS-29



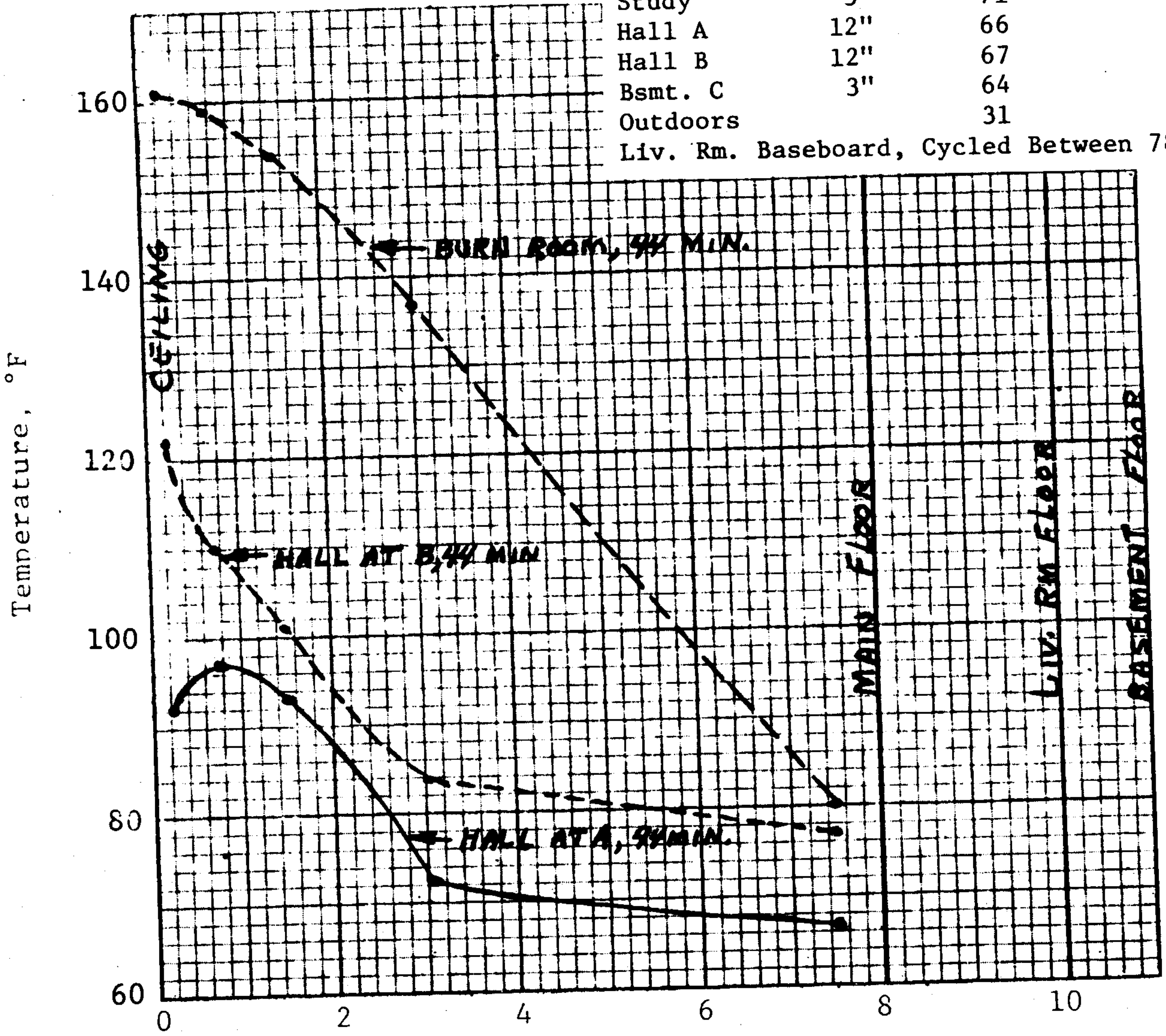
VARIOUS CONDITIONS, LS-29



TEMPERATURE 3 IN. ABOVE BASEBOARD CONVECTOR
(LIVING ROOM), LS-29

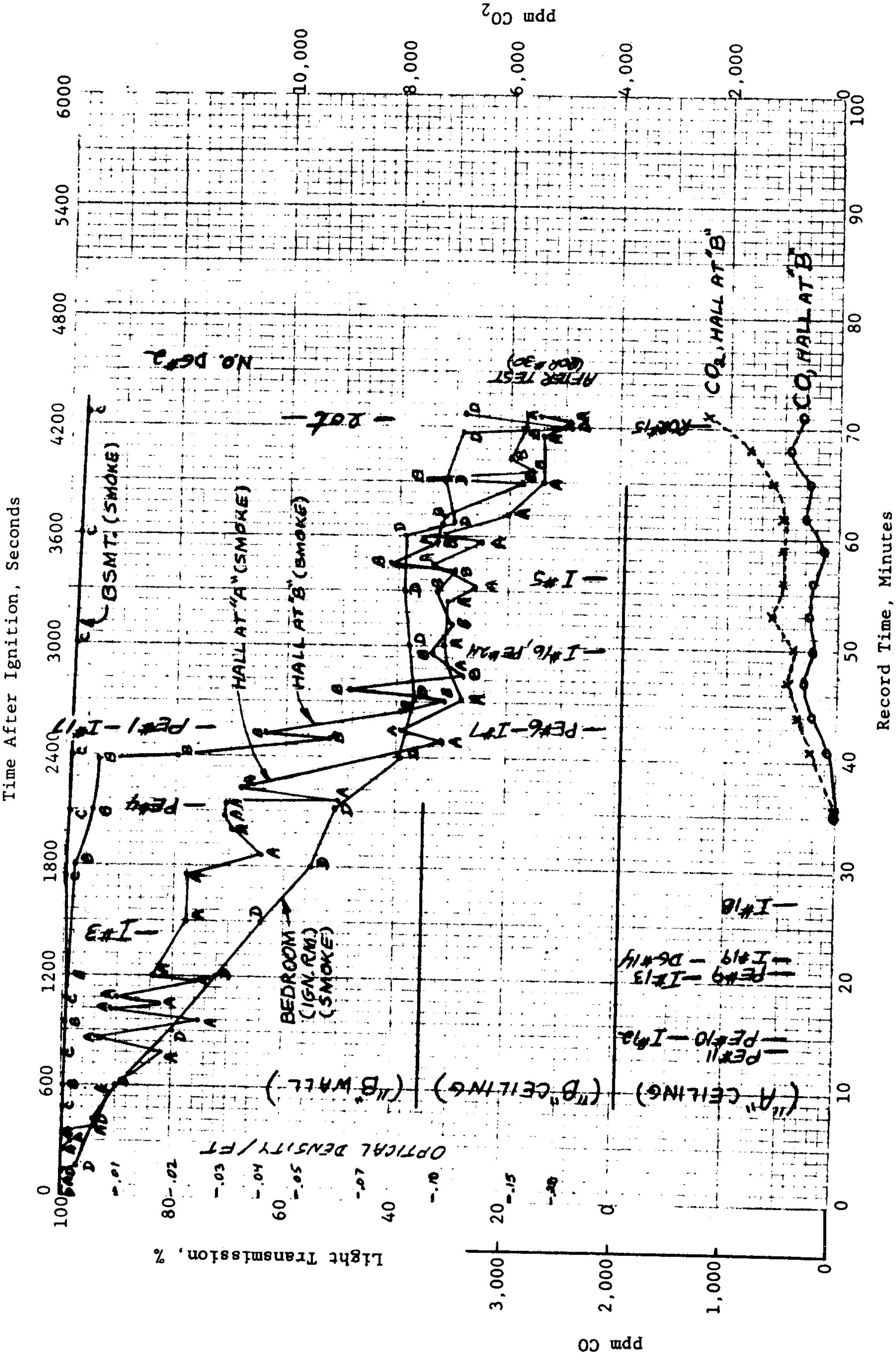
Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	64	68
Study	3"	71	146
Hall A	12"	66	74
Hall B	12"	67	73
Bsmt. C	3"	64	64
Outdoors		31	29

Liv. Rm. Baseboard, Cycled Between 78-102

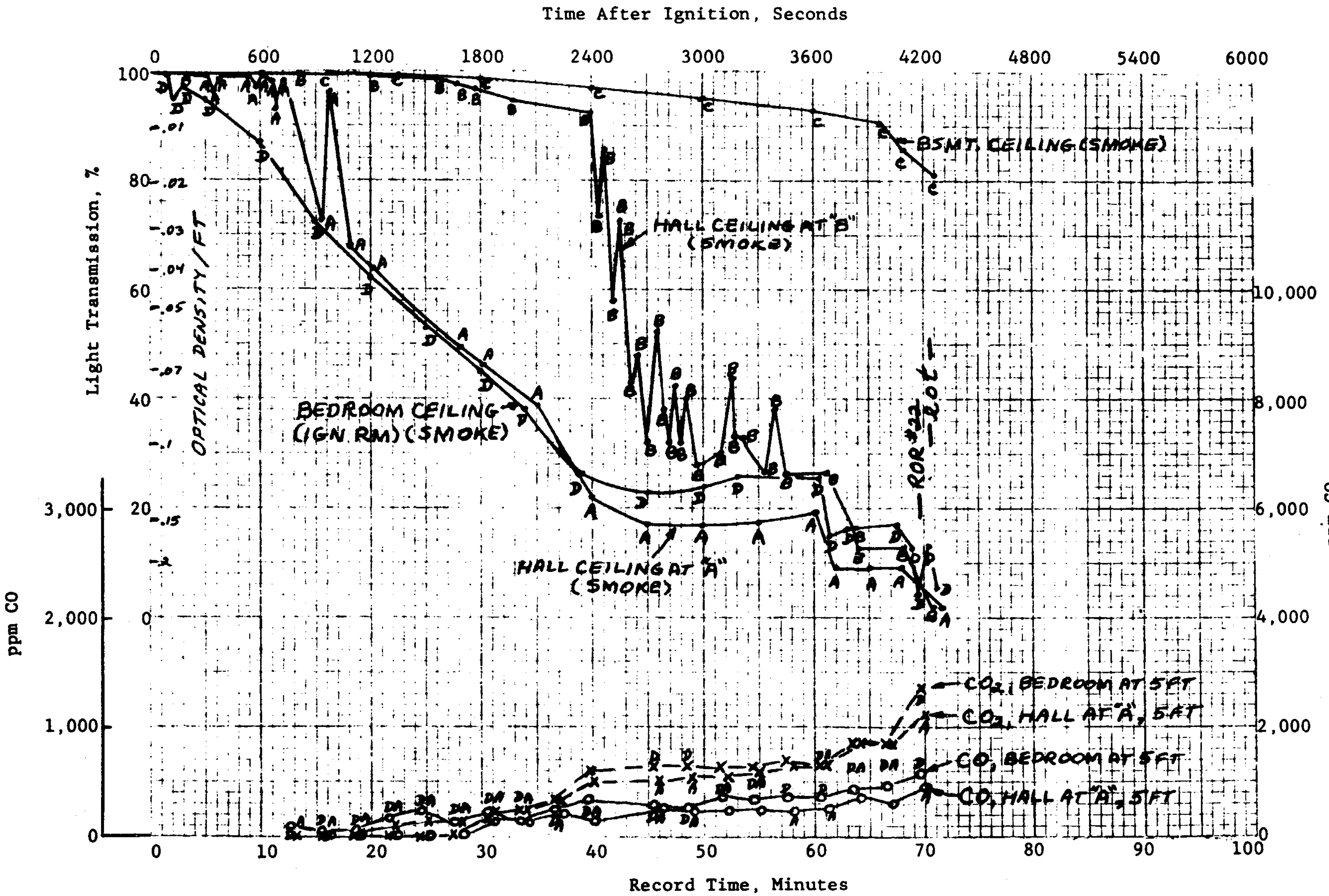


Distance From Ceiling, ft.

Maximum Temperature Profiles, LS-29

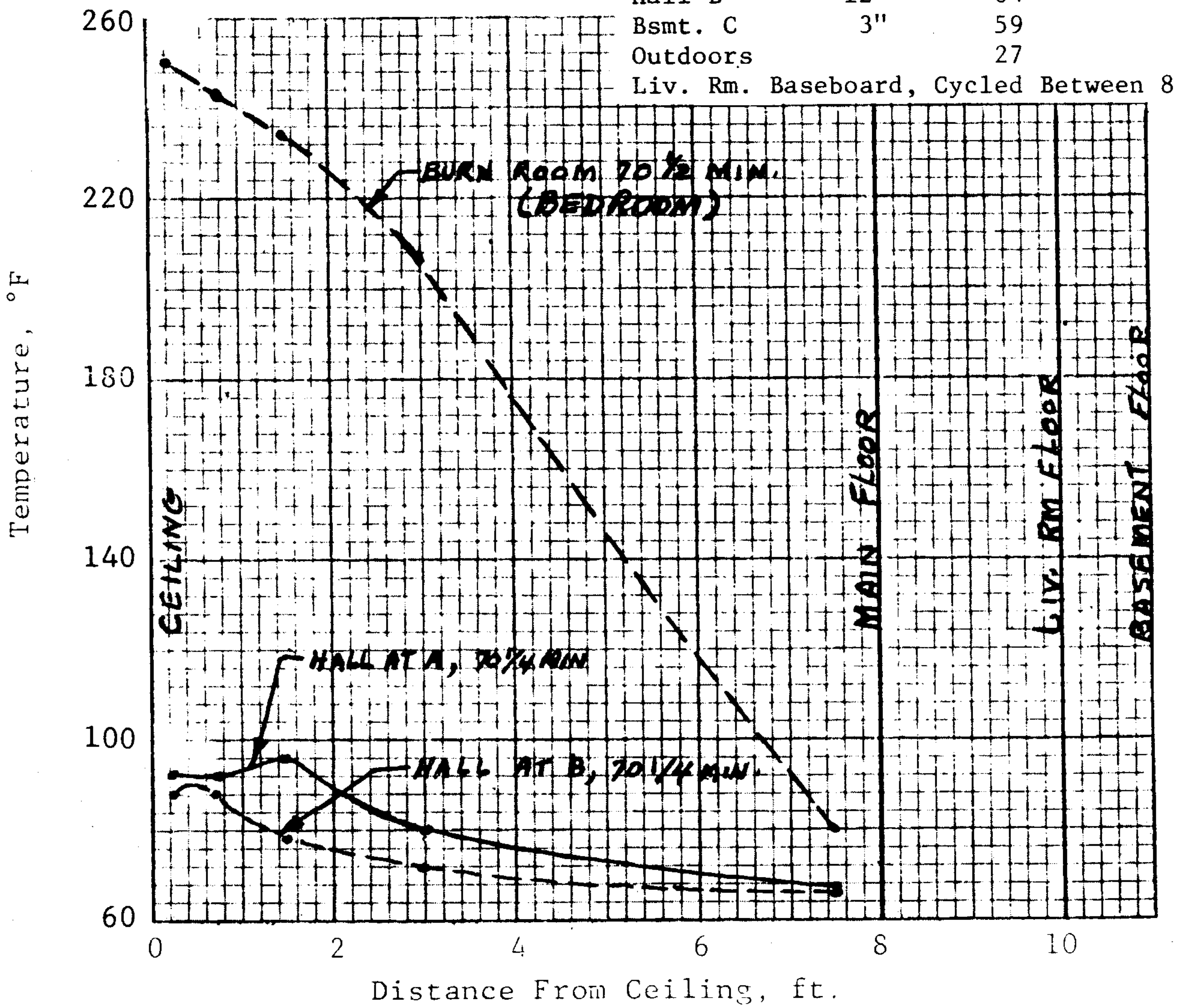


CONDITIONS AT 5 FT ABOVE FLOOR, LS-30

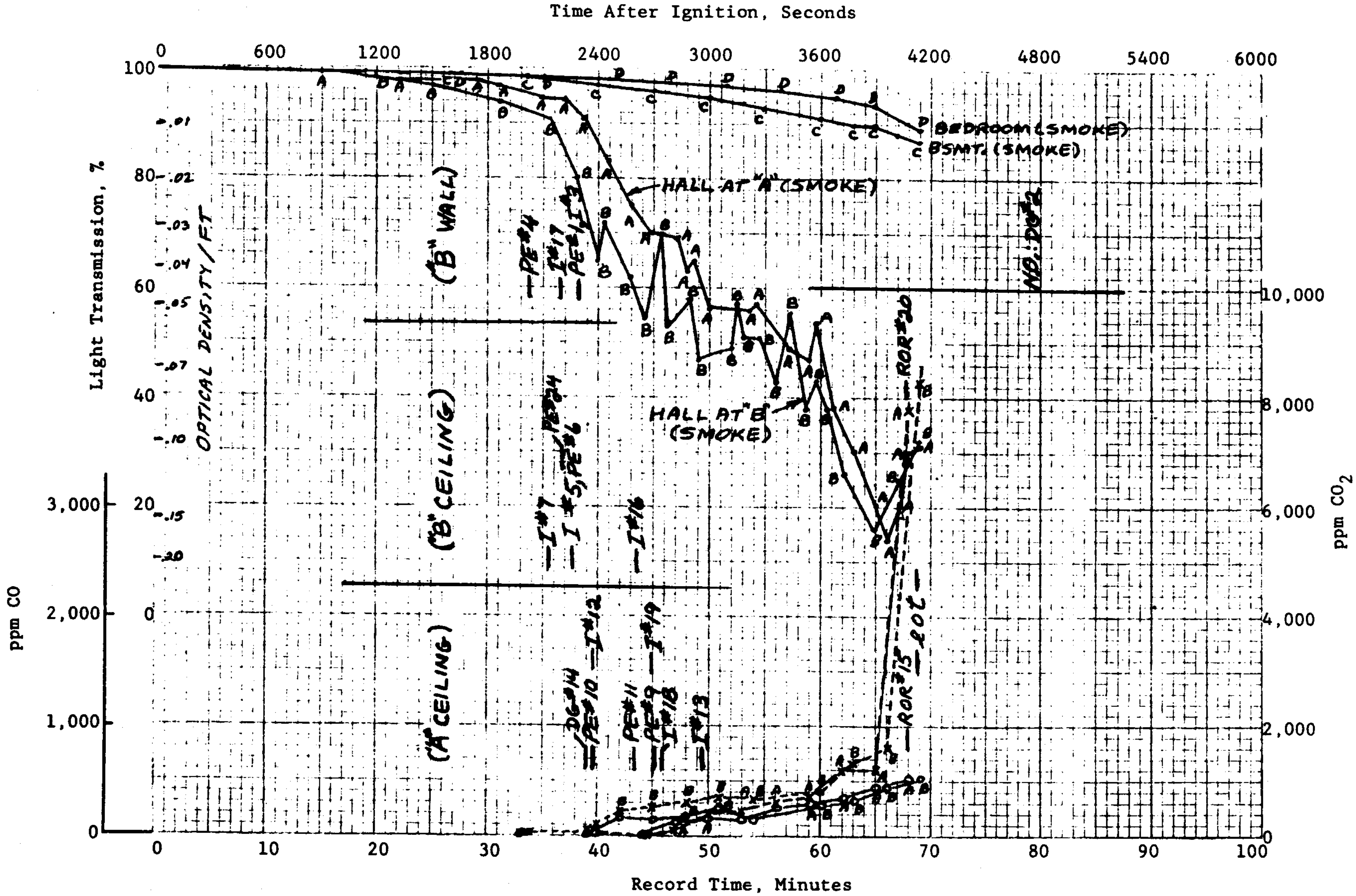


VARIOUS CONDITIONS, LS-30

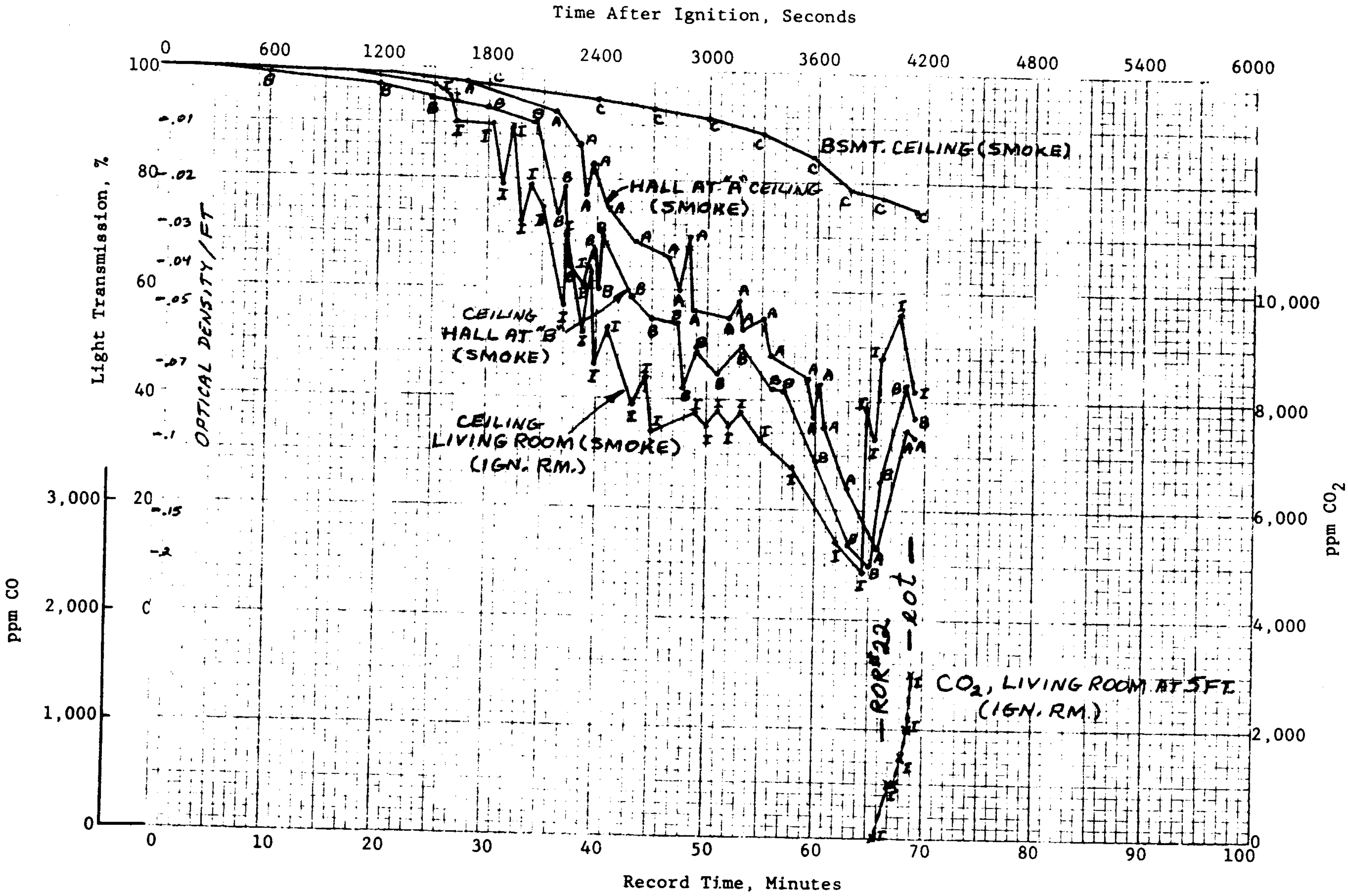
Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	63	103
Study	3"	70	68
Hall A	12"	64	80
Hall B	12"	64	71
Bsmt. C	3"	59	60
Outdoors		27	27
Liv. Rm. Baseboard, Cycled Between 83-105			



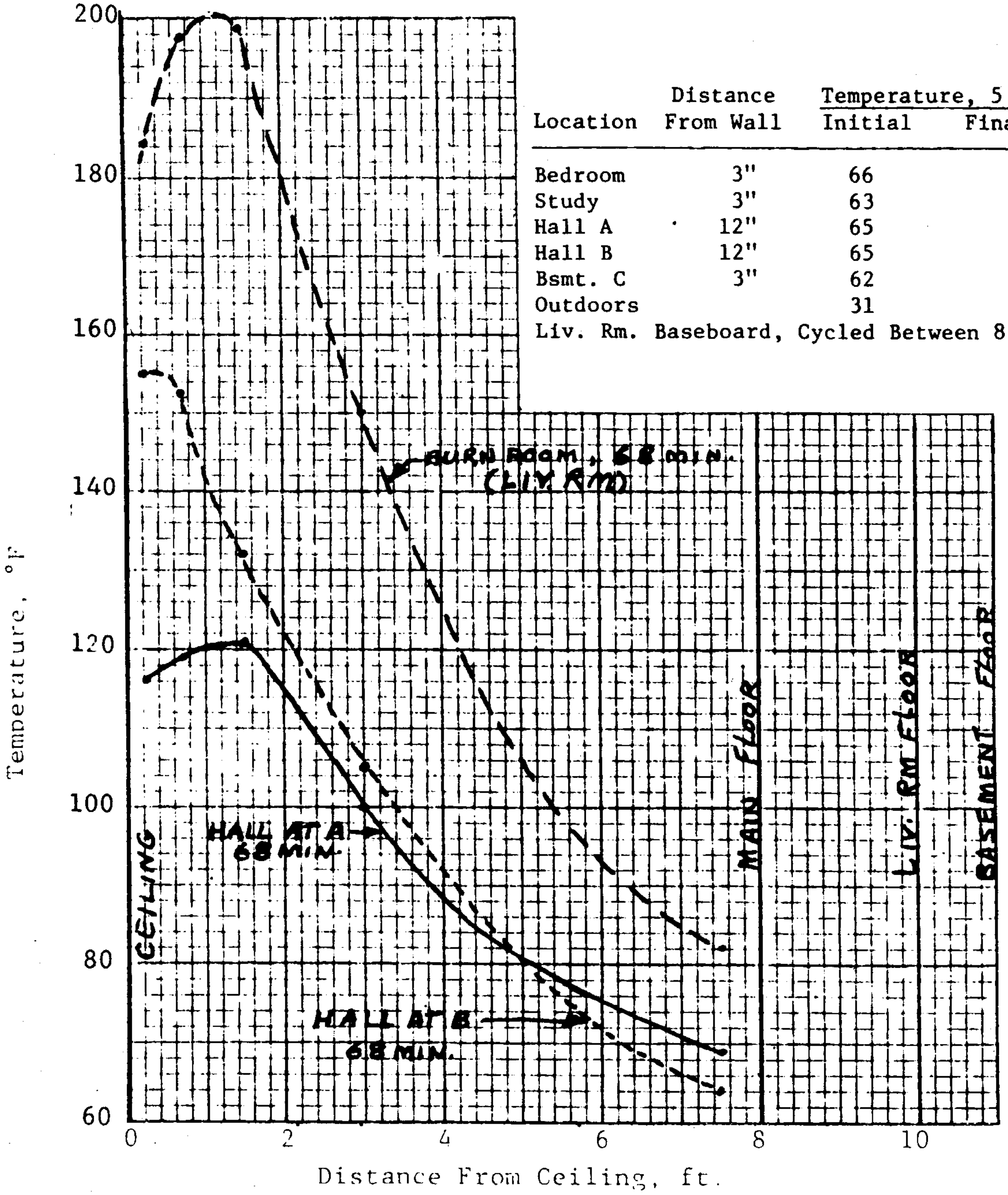
Maximum Temperature Profiles, LS-30



CONDITIONS 5 FT ABOVE FLOOR, LS-31



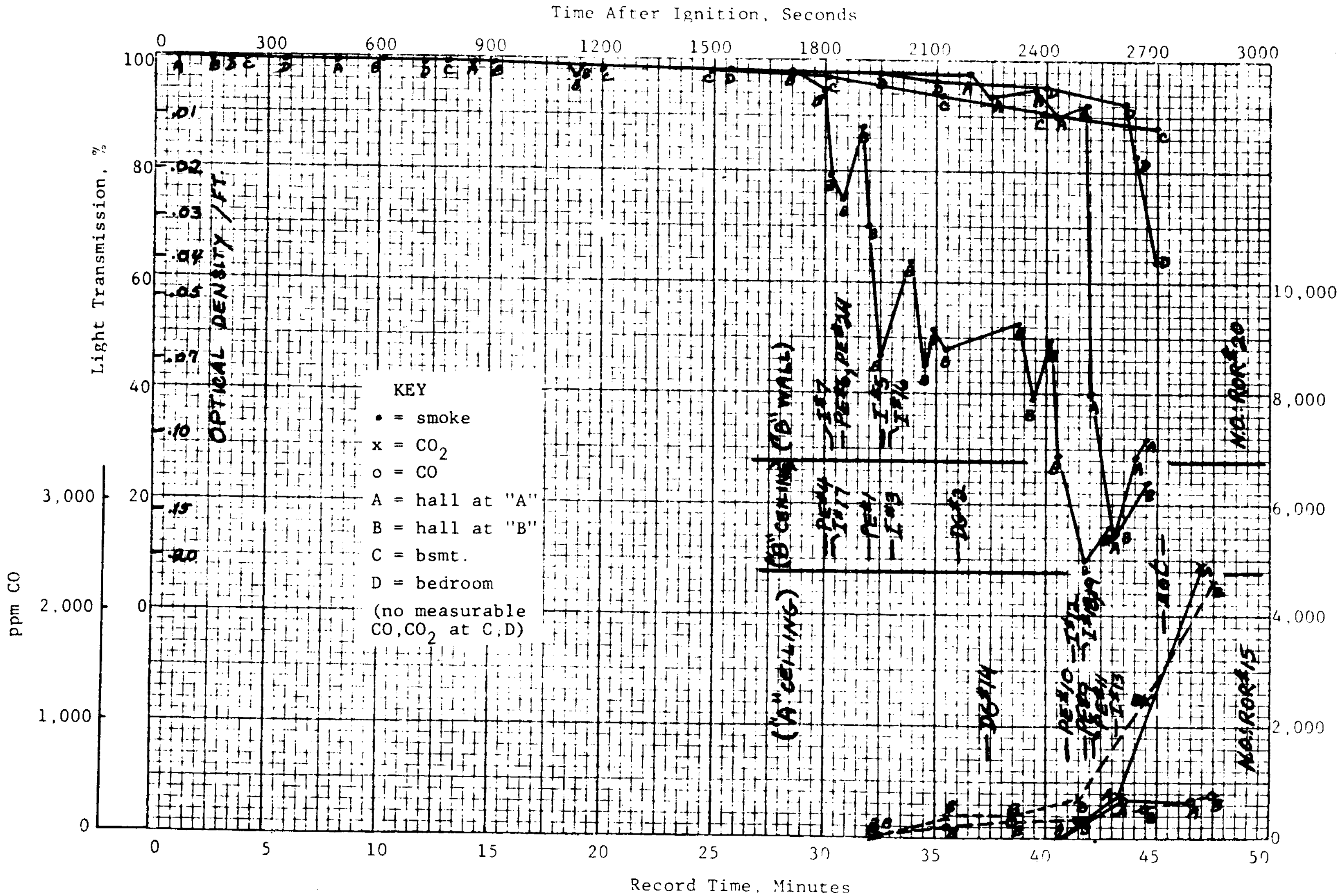
VARIOUS CONDITIONS, LS-31



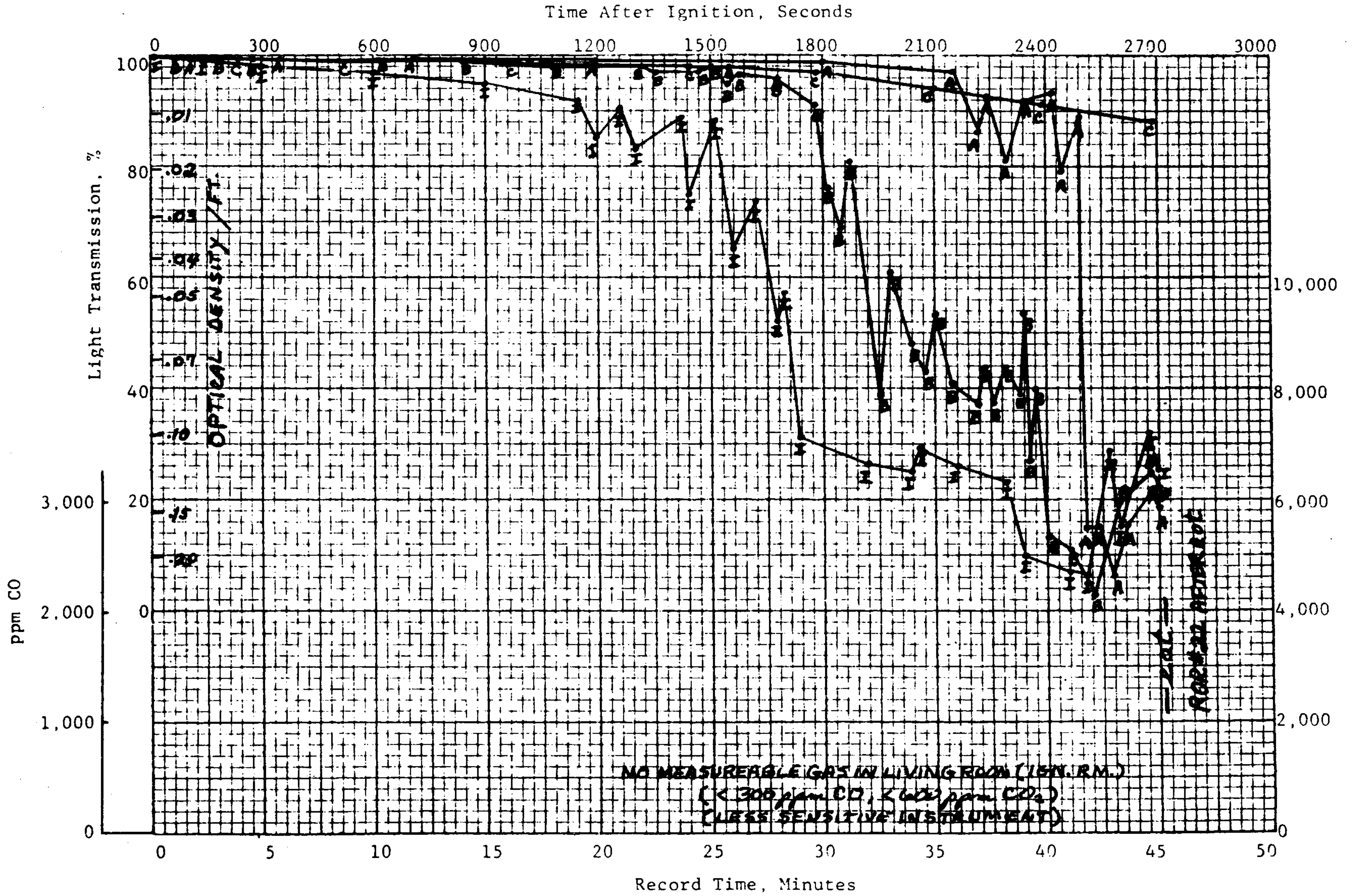
Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	66	69
Study	3"	63	74
Hall A	12"	65	102
Hall B	12"	65	104
Bsmt. C	3"	62	64
Outdoors		31	34

Liv. Rm. Baseboard, Cycled Between 83-100

Maximum Temperature Profiles, LS-31



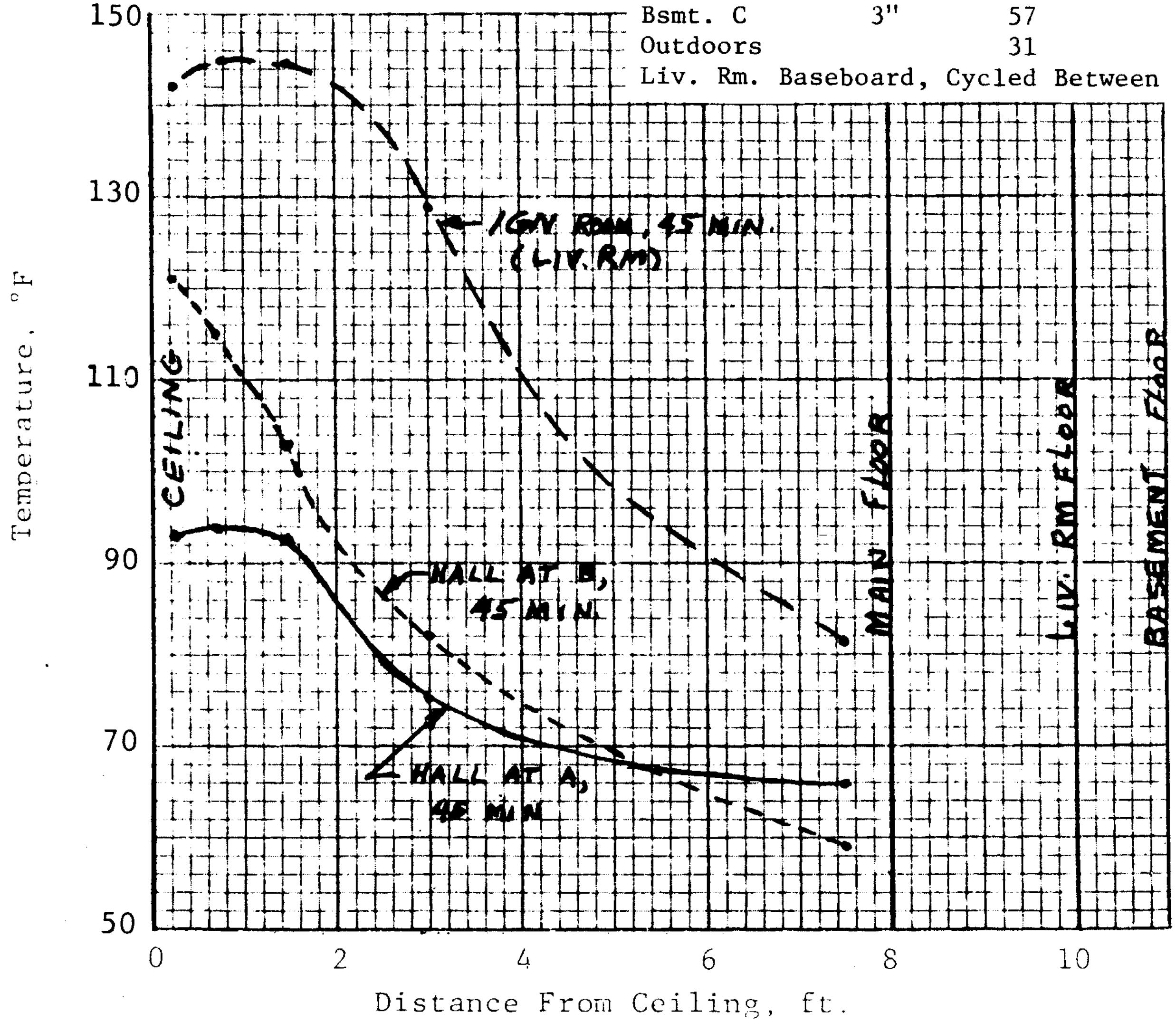
CONDITIONS 5 FT ABOVE FLOOR, LS-32



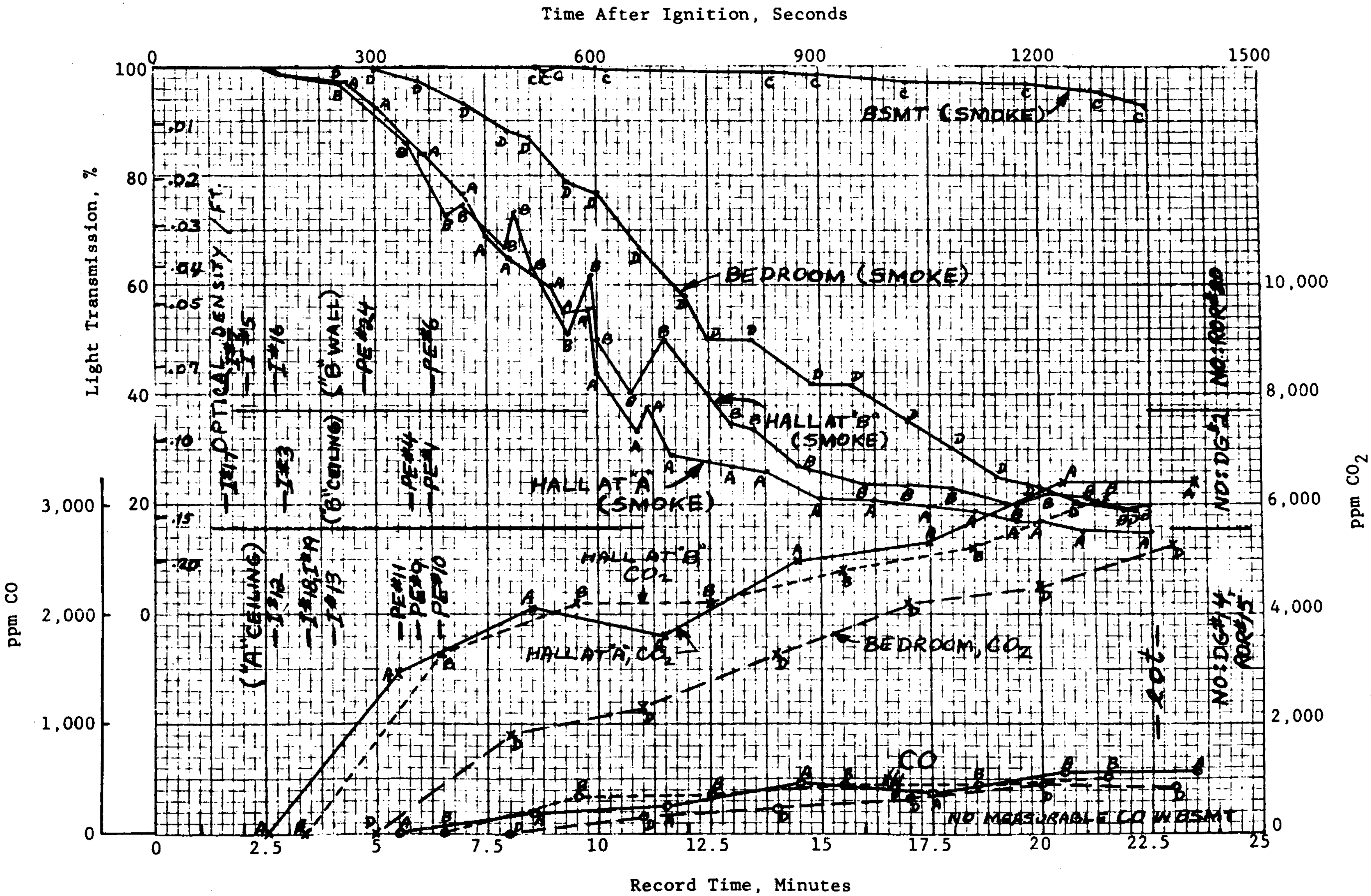
VARIOUS CONDITIONS, LS-32

Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	65	68
Study	3"	58	62
Hall A	12"	65	76
Hall B	12"	63	80
Bsmt. C	3"	57	58
Outdoors		31	31

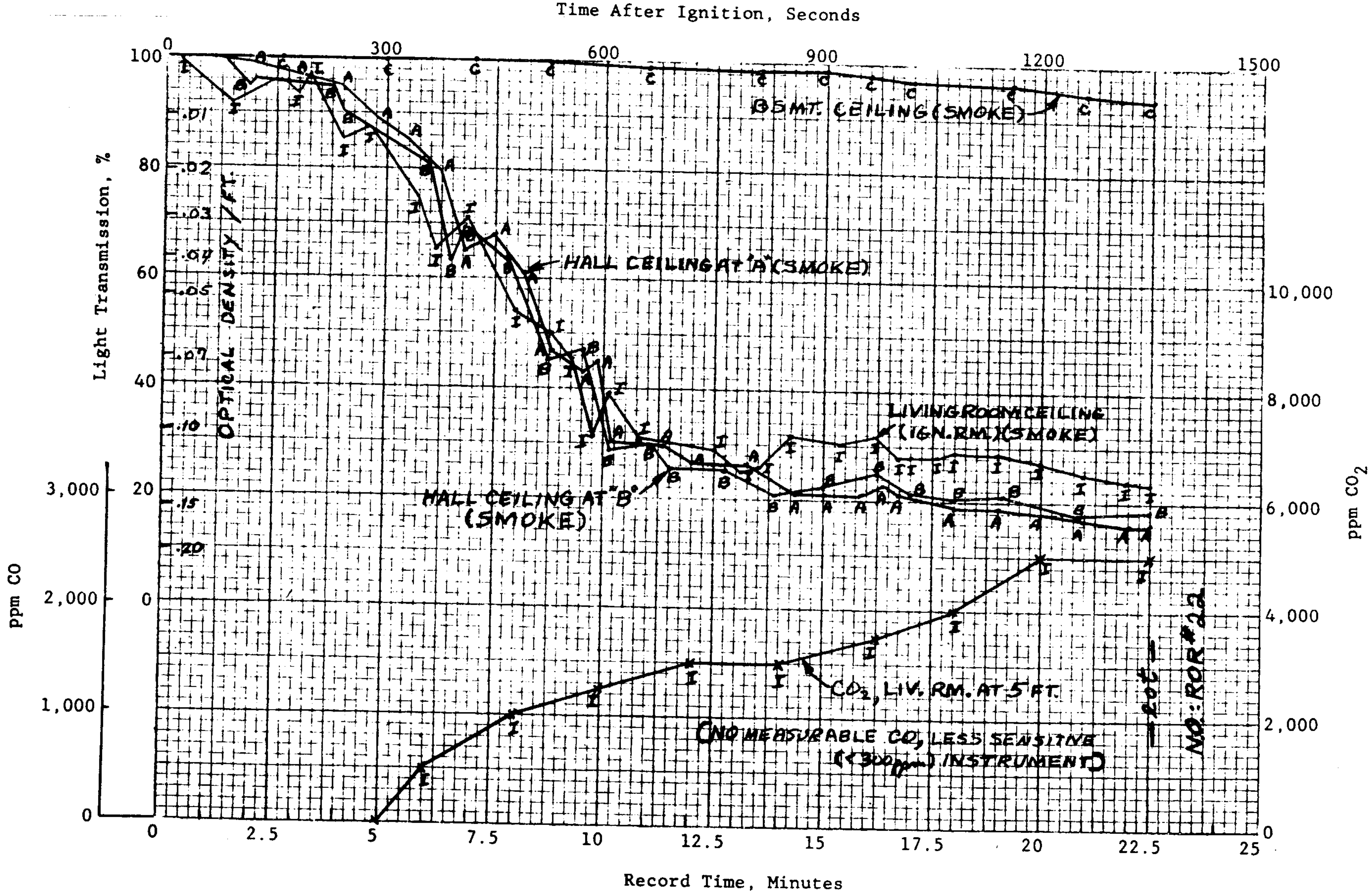
Liv. Rm. Baseboard, Cycled Between 75-94



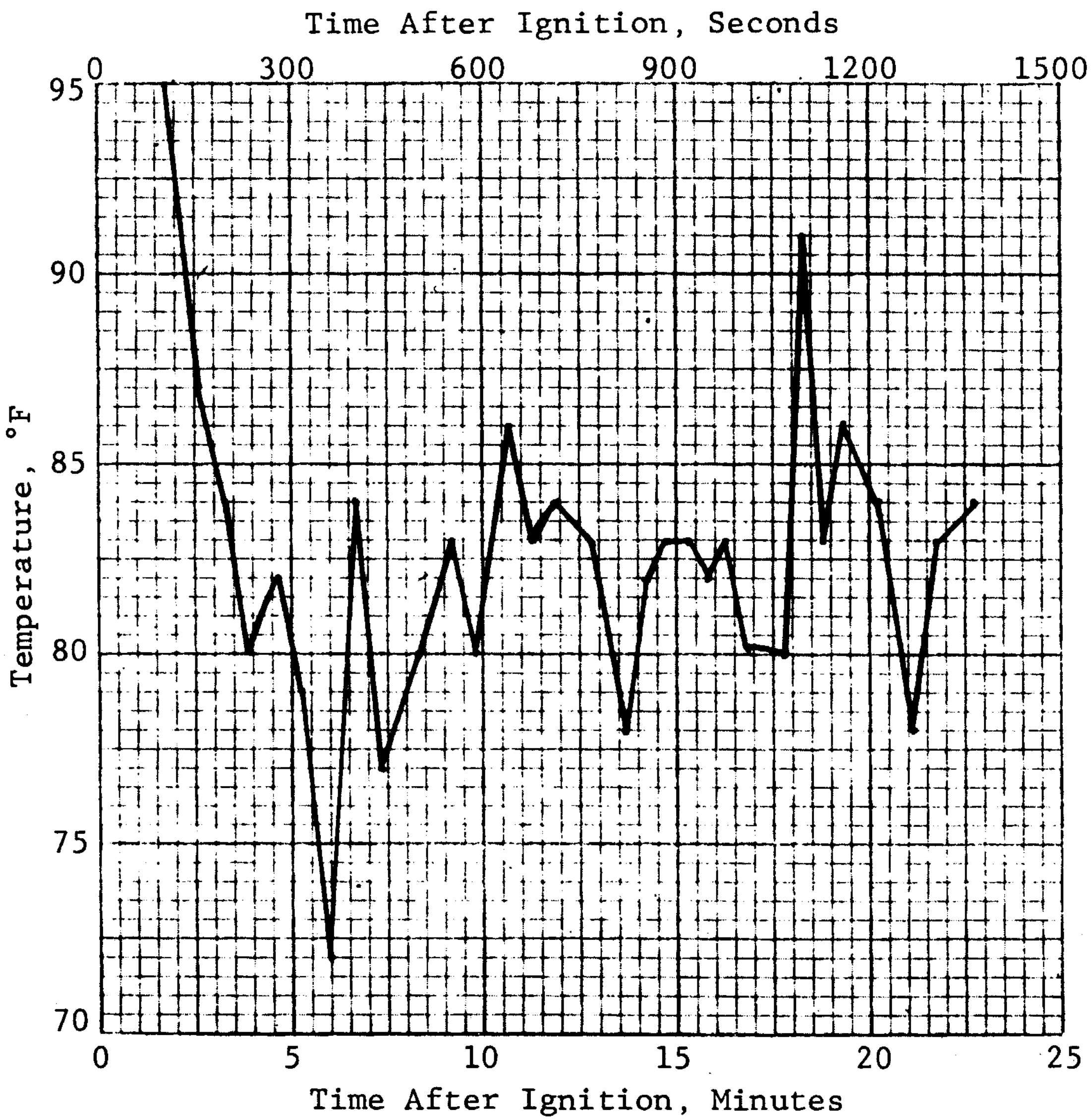
Maximum Temperature Profiles, LS-32



CONDITIONS 5 FT ABOVE FLOOR, LS-33

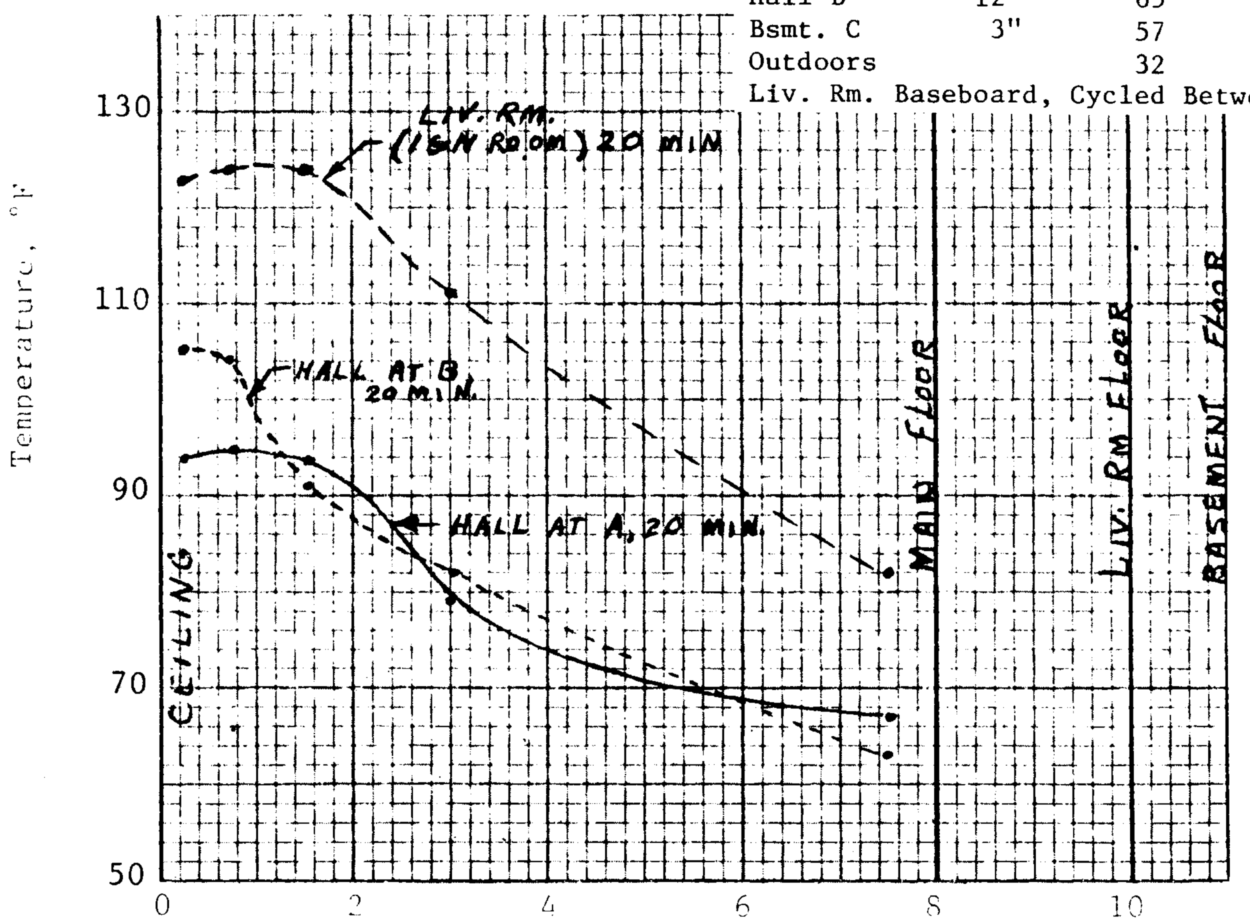


VARIOUS CONDITIONS, LS-33



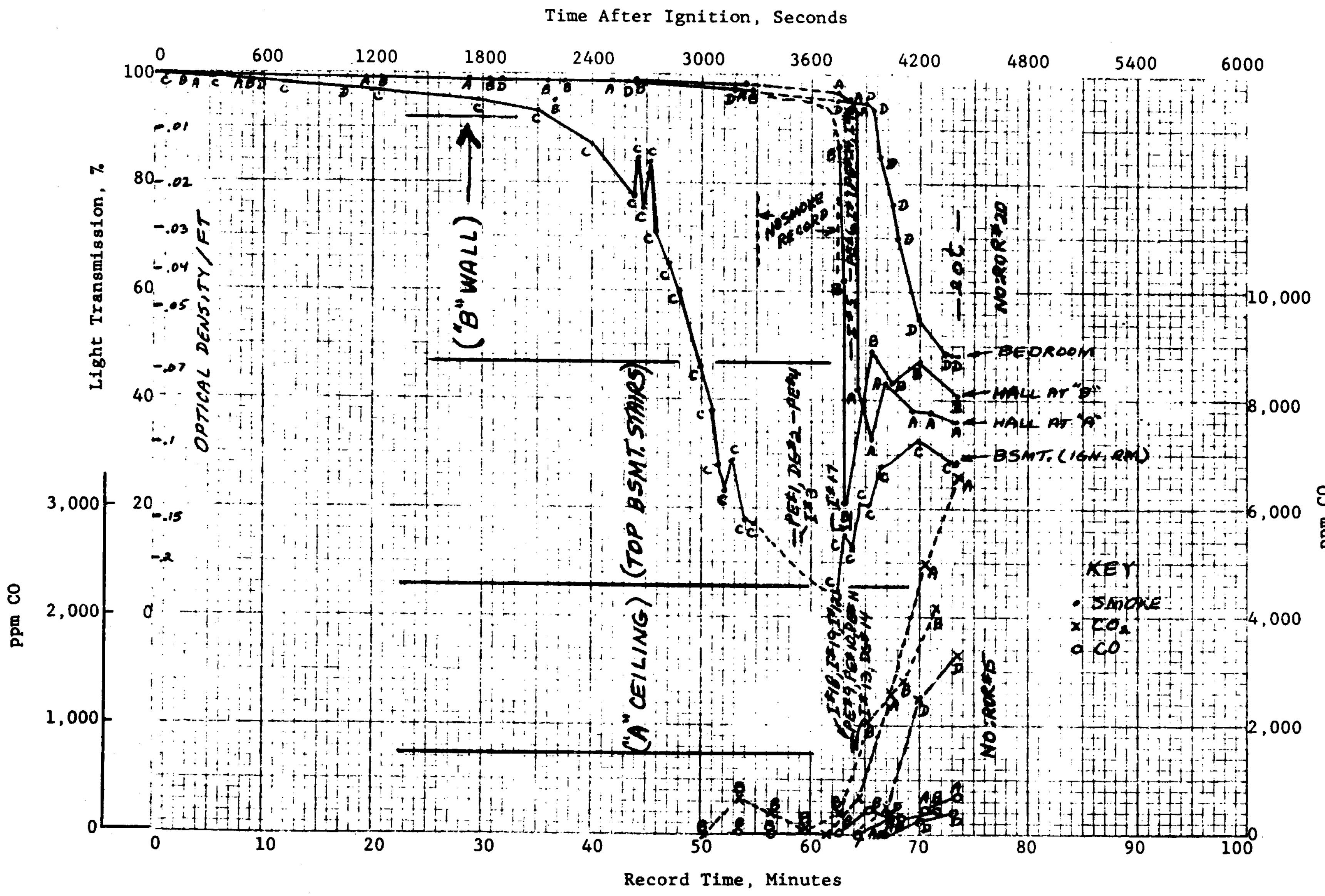
TEMPERATURE 3 IN. ABOVE BASEBOARD CONVECTOR
(LIVING ROOM), LS-33

Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	66	71
Study	3"	58	65
Hall A	12"	65	79
Hall B	12"	65	78
Bsmt. C	3"	57	56
Outdoors		32	30
Liv. Rm. Baseboard, Cycled Between 72-95			

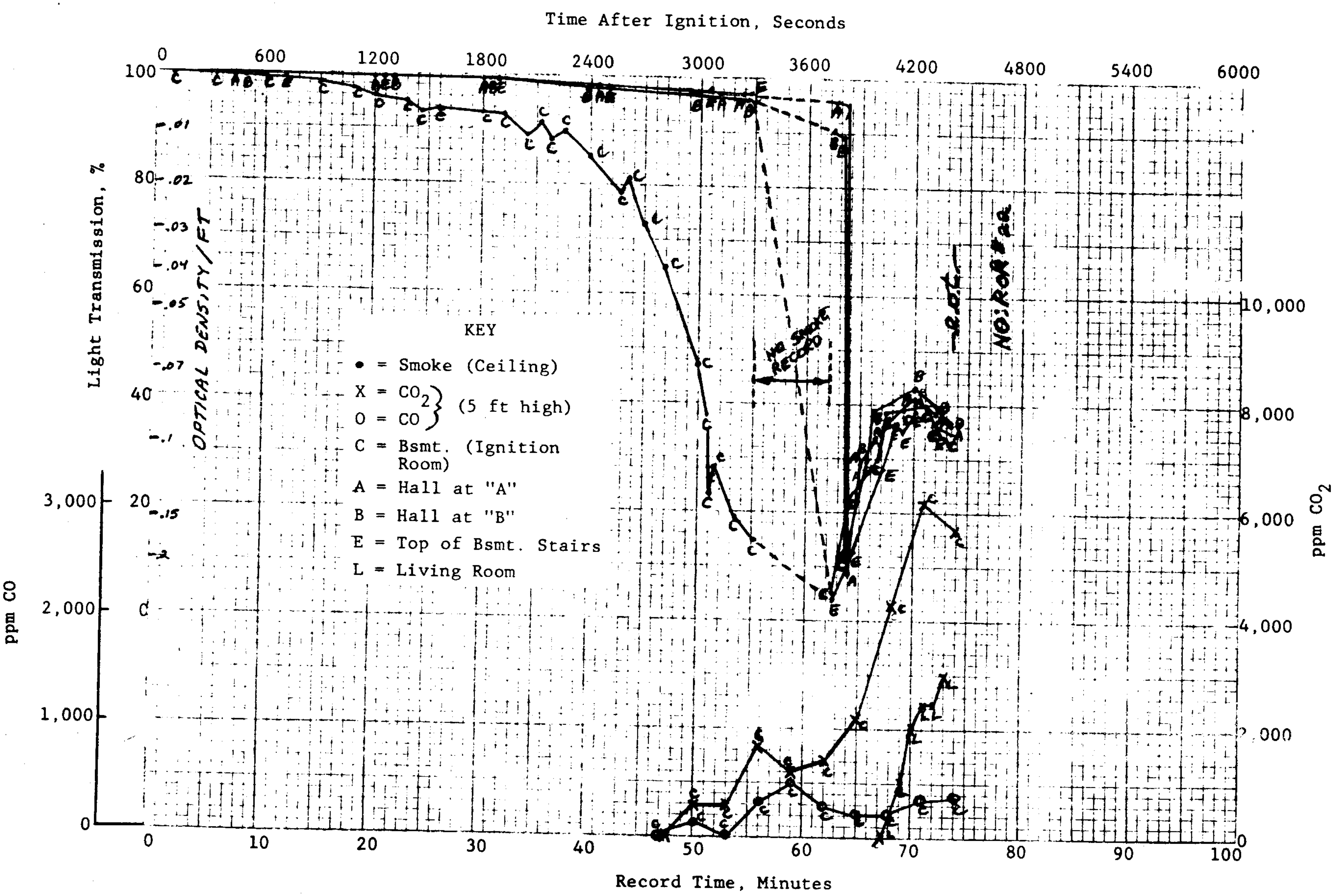


Distance From Ceiling, ft.

Maximum Temperature Profiles, LS-33



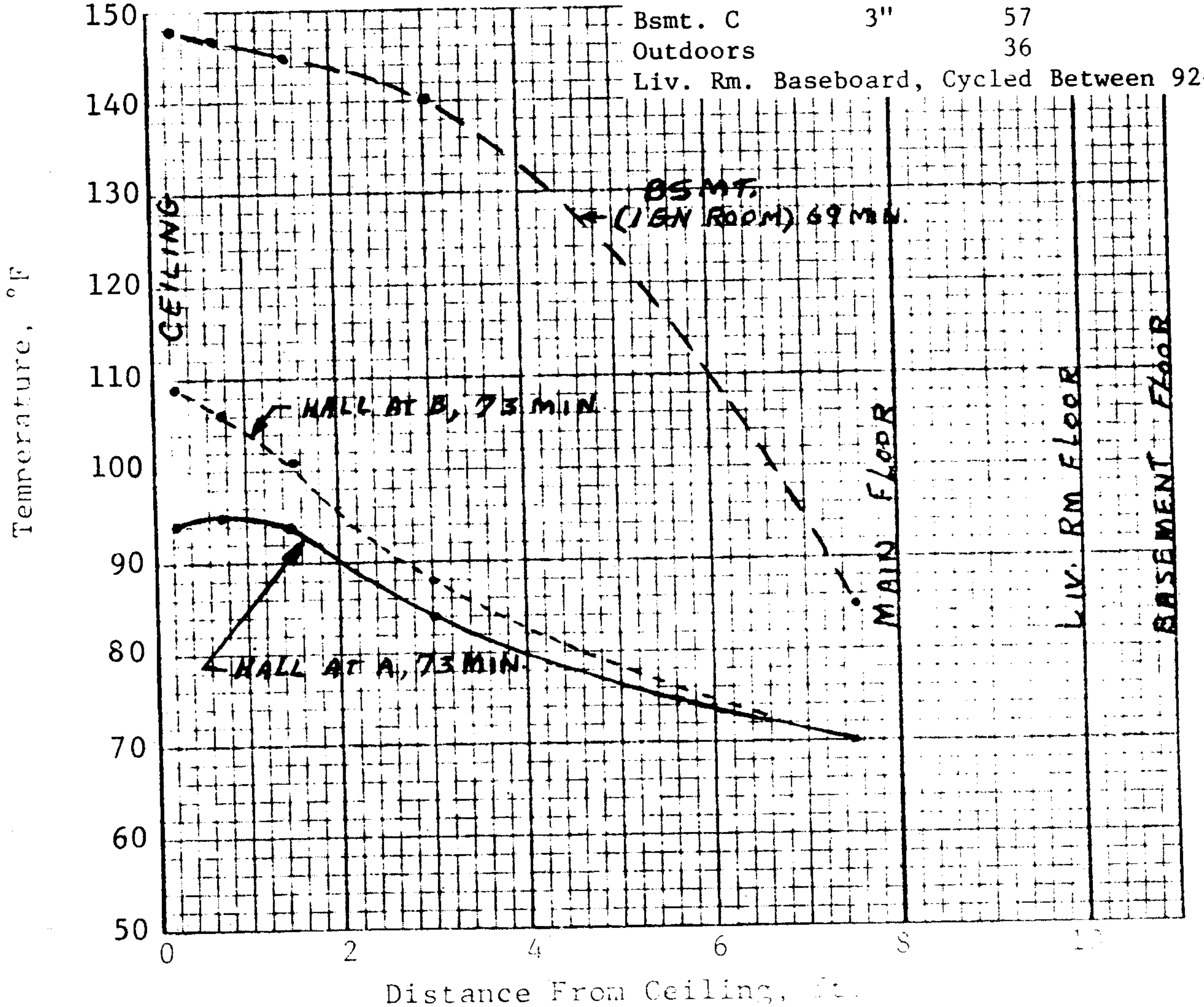
CONDITIONS 5 FT ABOVE FLOOR, LS-34



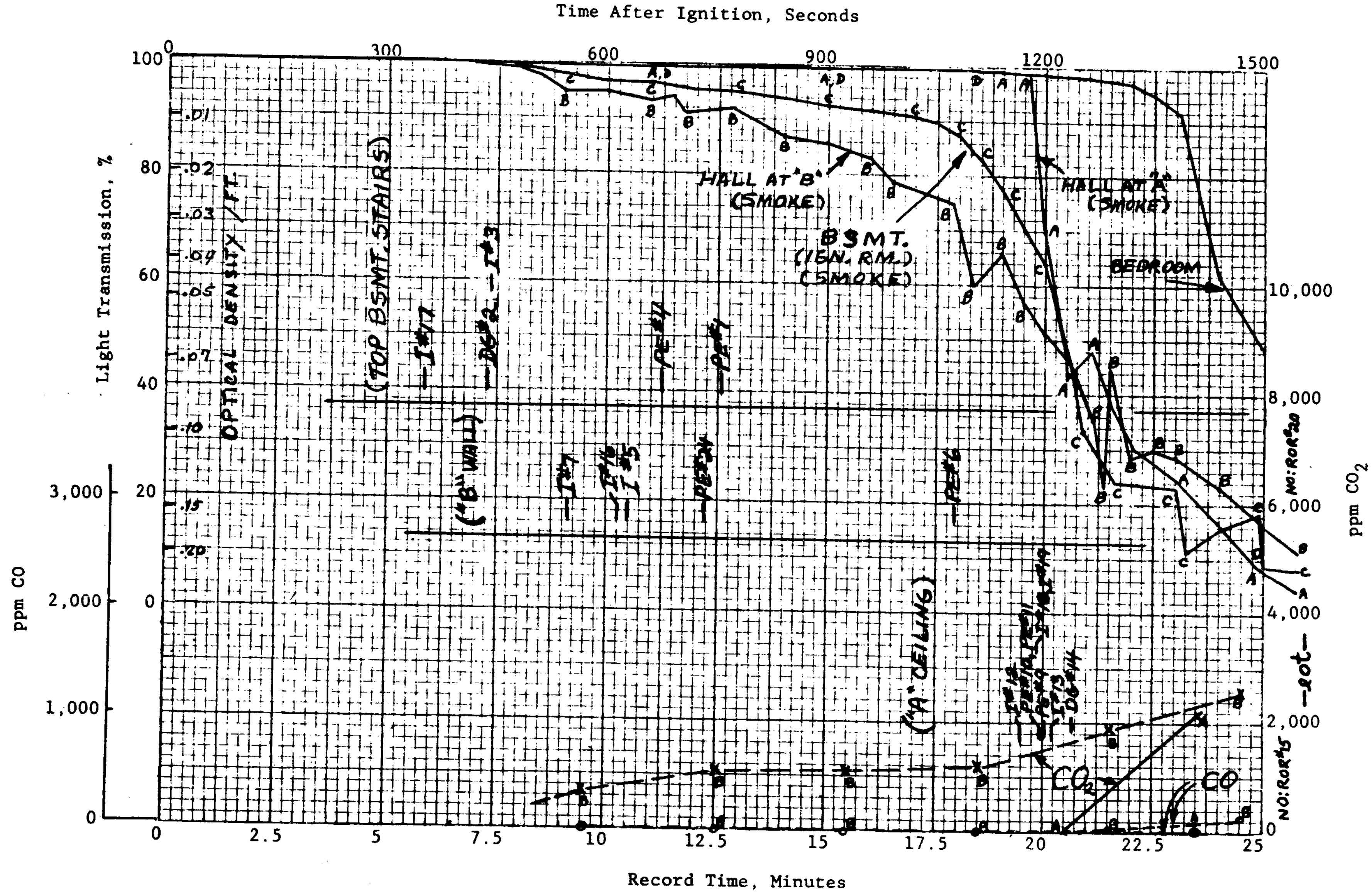
VARIOUS CONDITIONS, LS-34

Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	72	76
Study	3"	66	74
Hall A	12"	69	82
Hall B	12"	68	88
Bsmt. C	3"	57	88
Outdoors		36	40

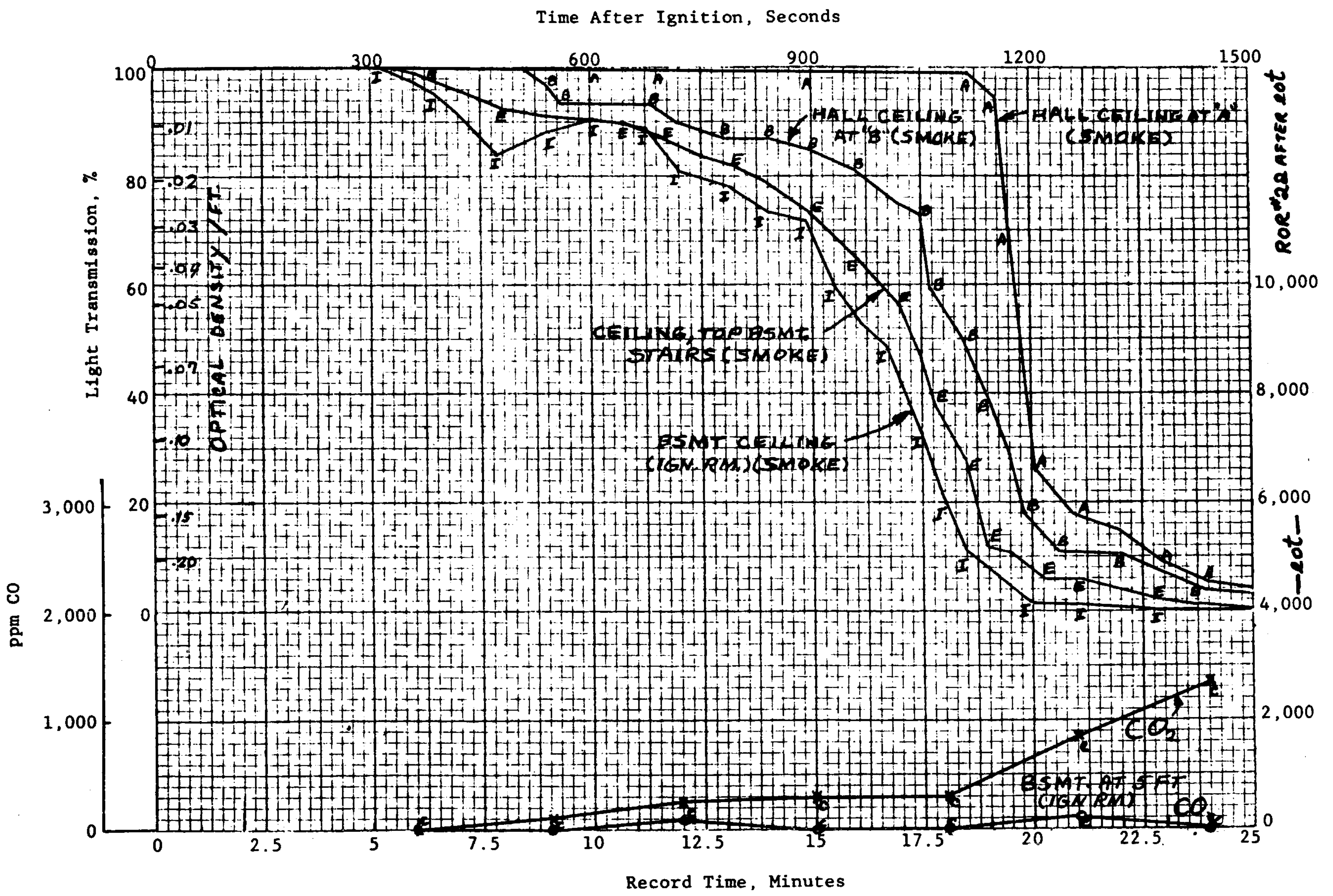
Liv. Rm. Baseboard, Cycled Between 92-110



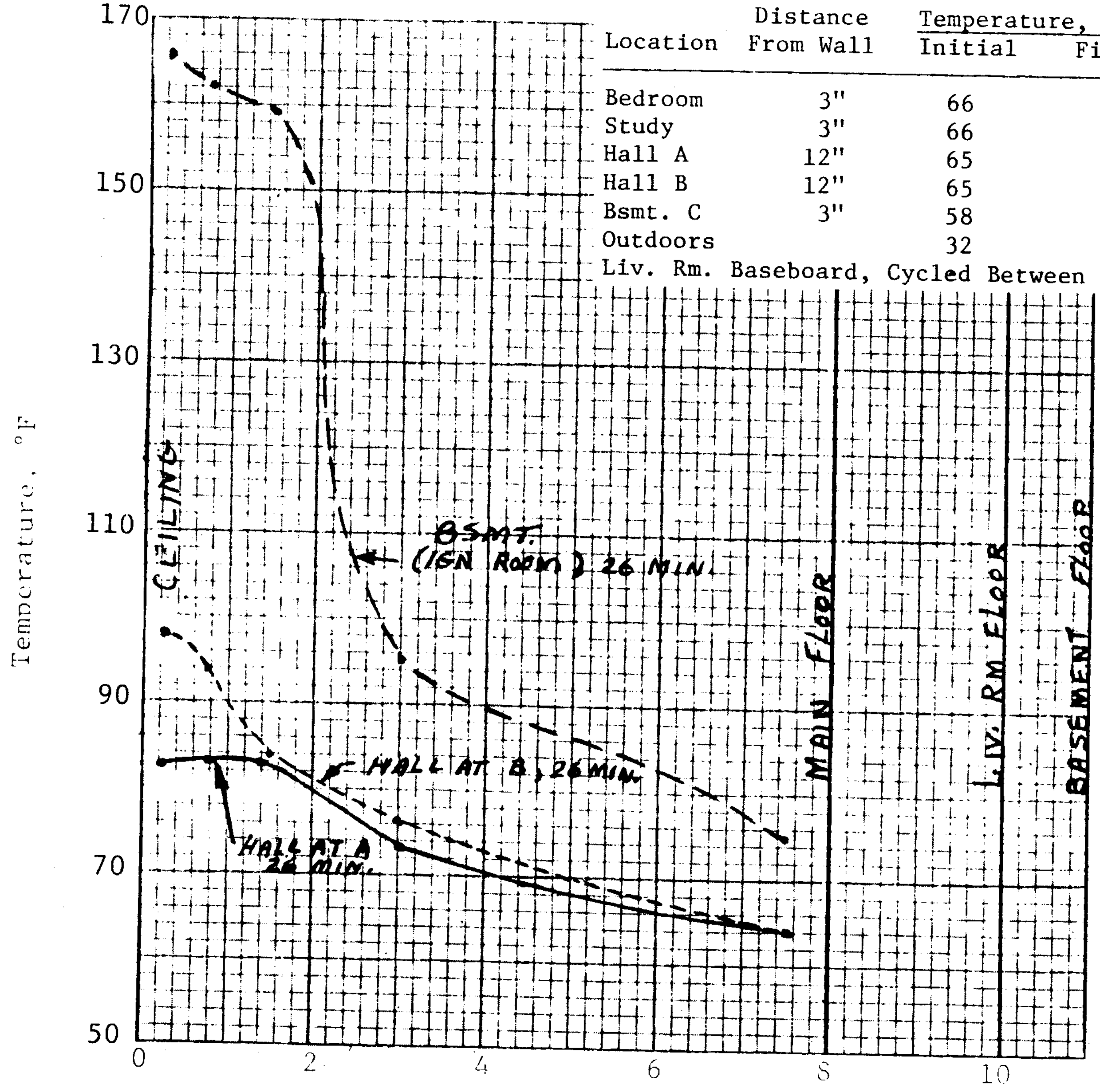
Maximum Temperature Profiles, LS-34



CONDITIONS 5 FT ABOVE FLOOR, LS-35



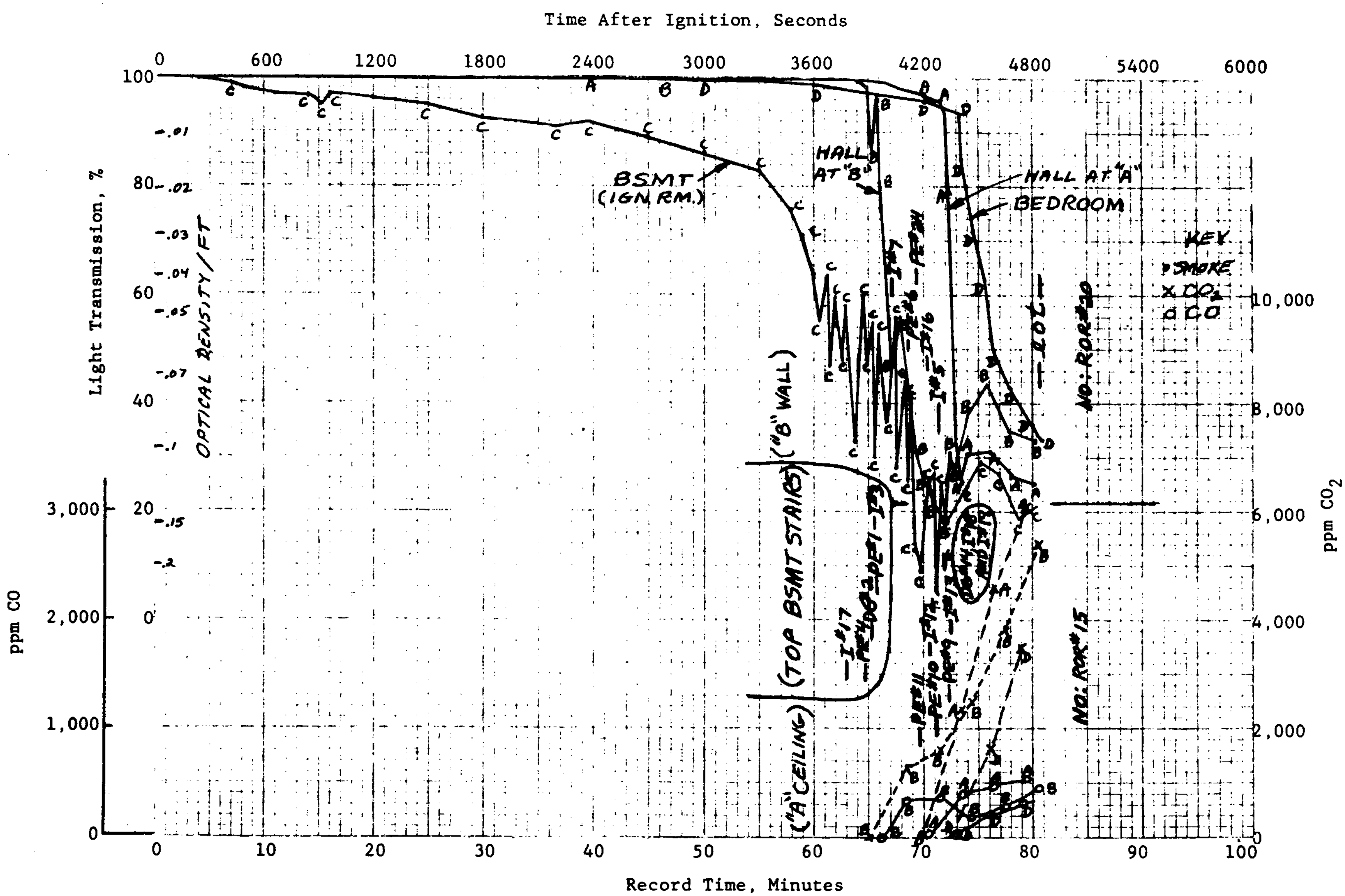
VARIOUS CONDITIONS, LS-35



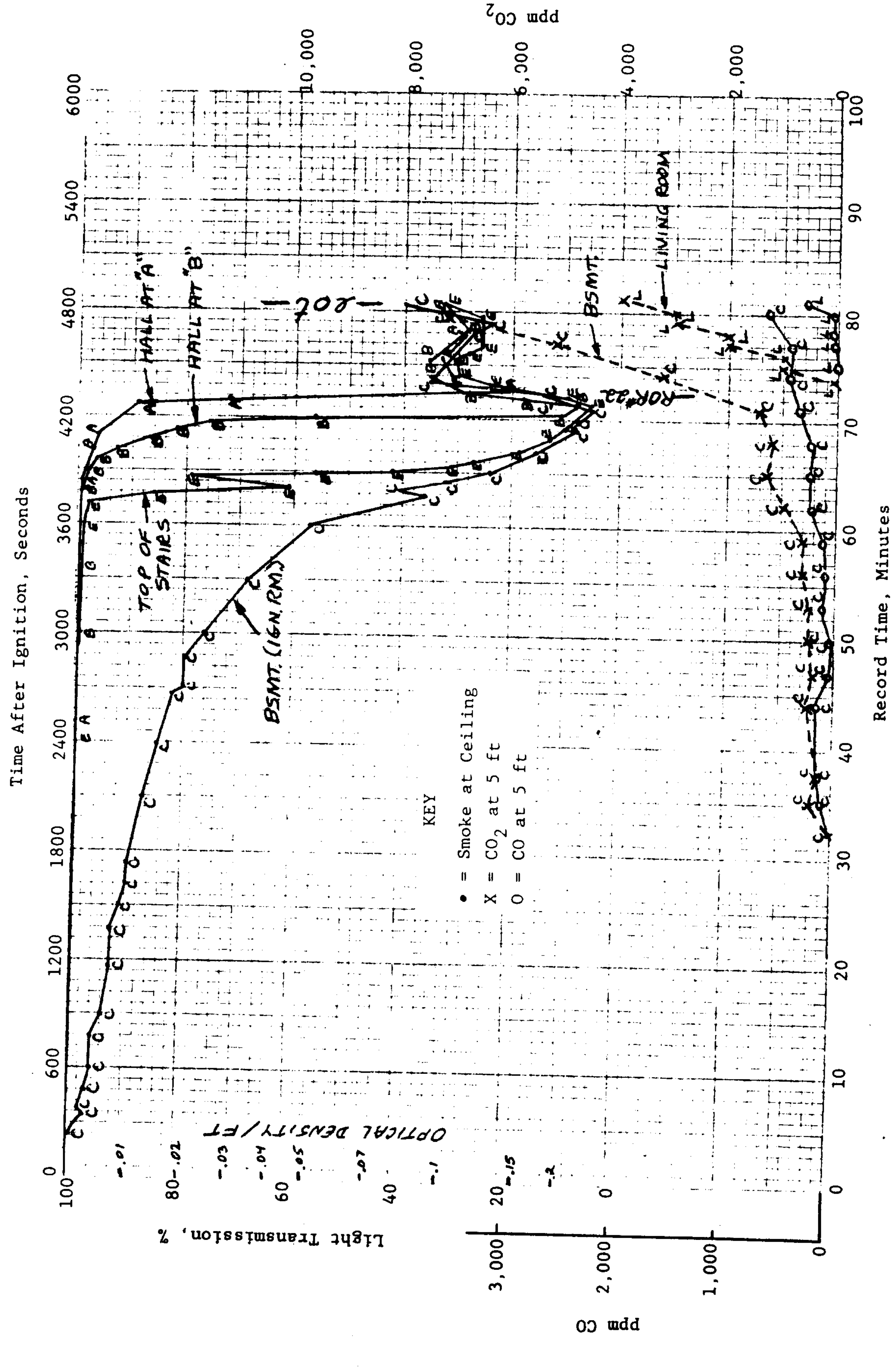
Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	66	69
Study	3"	66	67
Hall A	12"	65	73
Hall B	12"	65	78
Bsmt. C	3"	58	81
Outdoors		32	32

Liv. Rm. Baseboard, Cycled Between 85-102

Maximum Temperature Profiles, LS-35



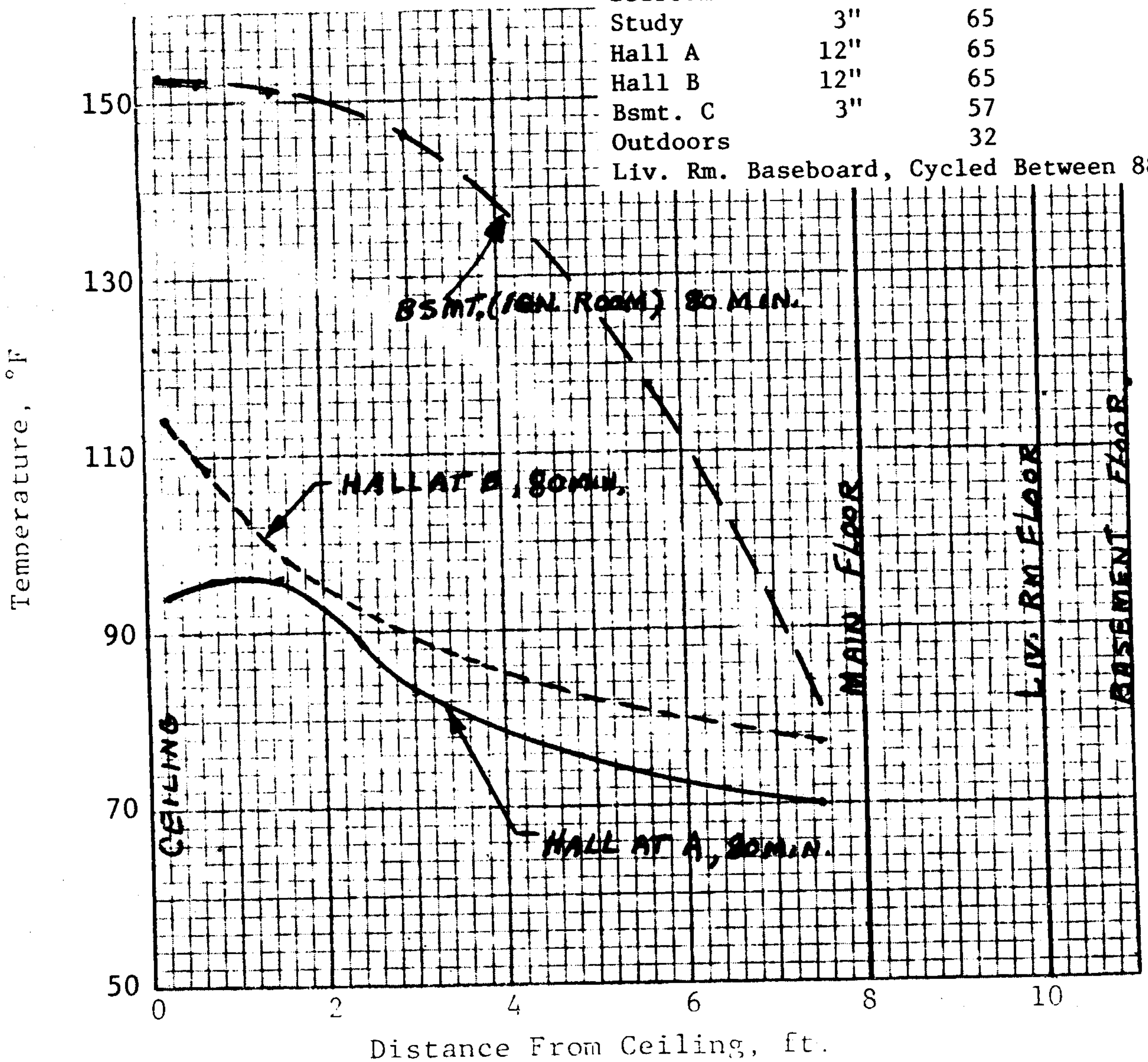
CONDITIONS 5 FT ABOVE FLOOR, LS-36



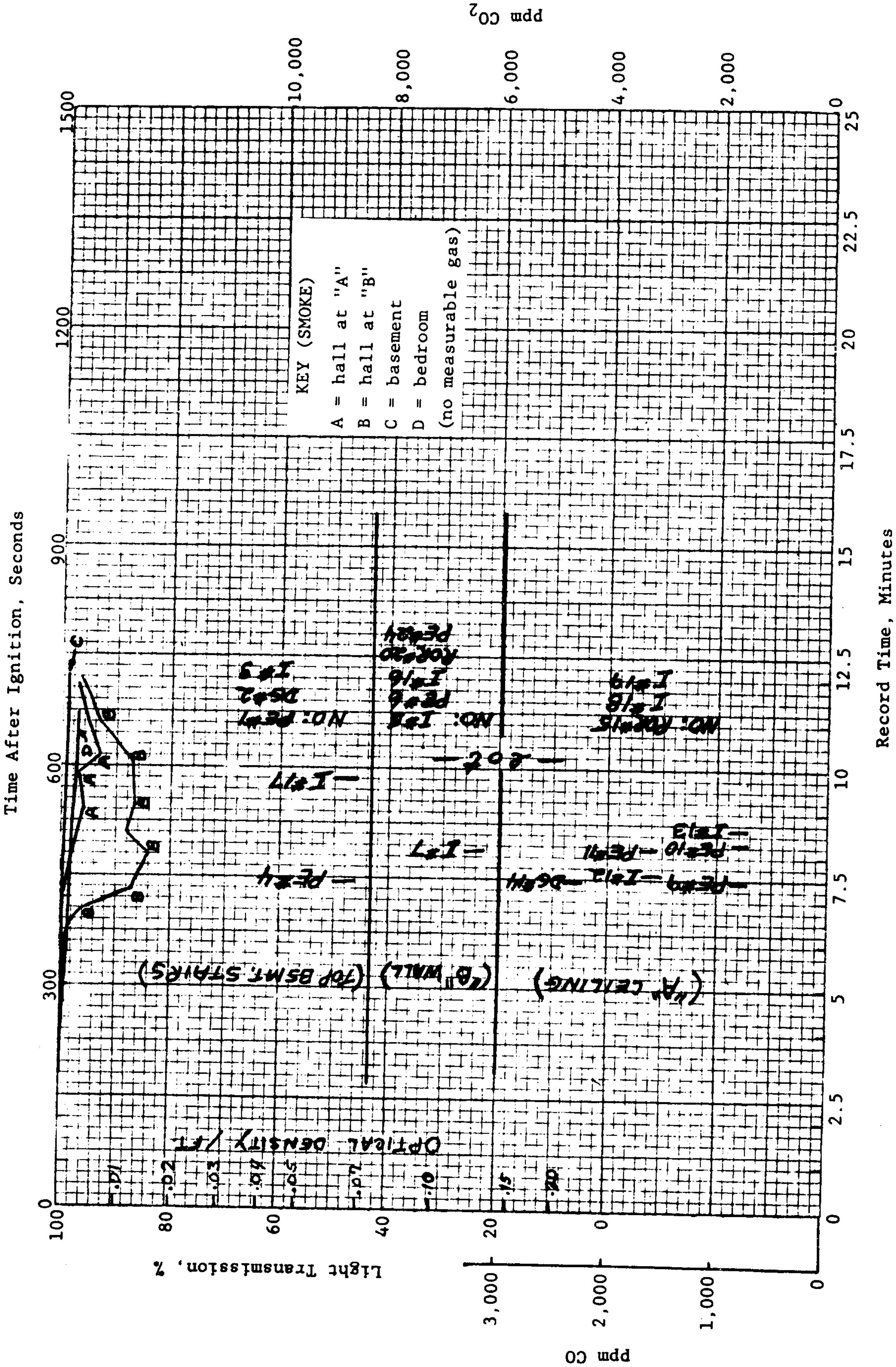
VARIOUS CONDITIONS, LS-36

Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	66	74
Study	3"	65	72
Hall A	12"	65	82
Hall B	12"	65	89
Bsmt. C	3"	57	87
Outdoors		32	34

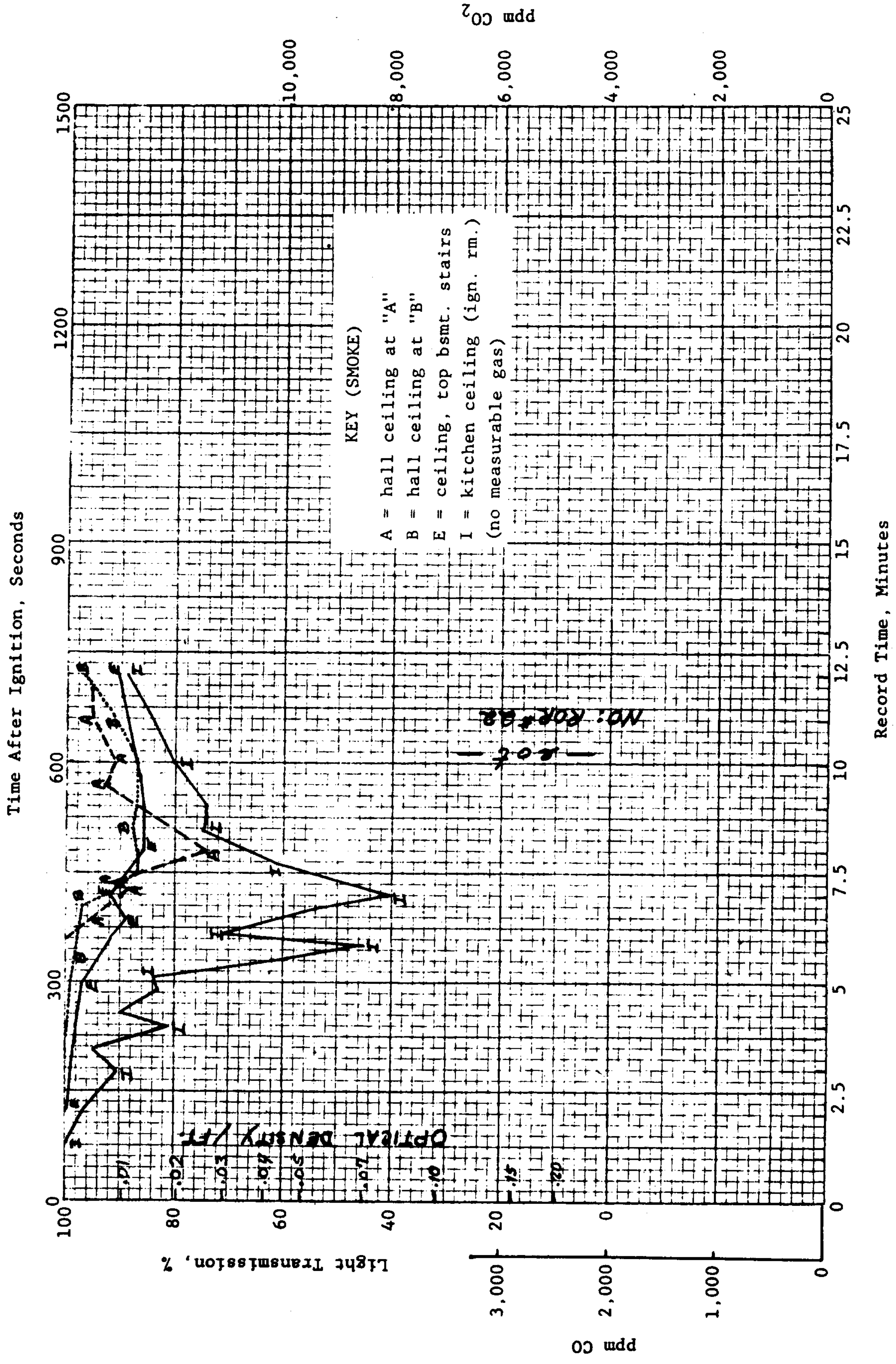
Liv. Rm. Baseboard, Cycled Between 88-101



Maximum Temperature Profiles, LS-36



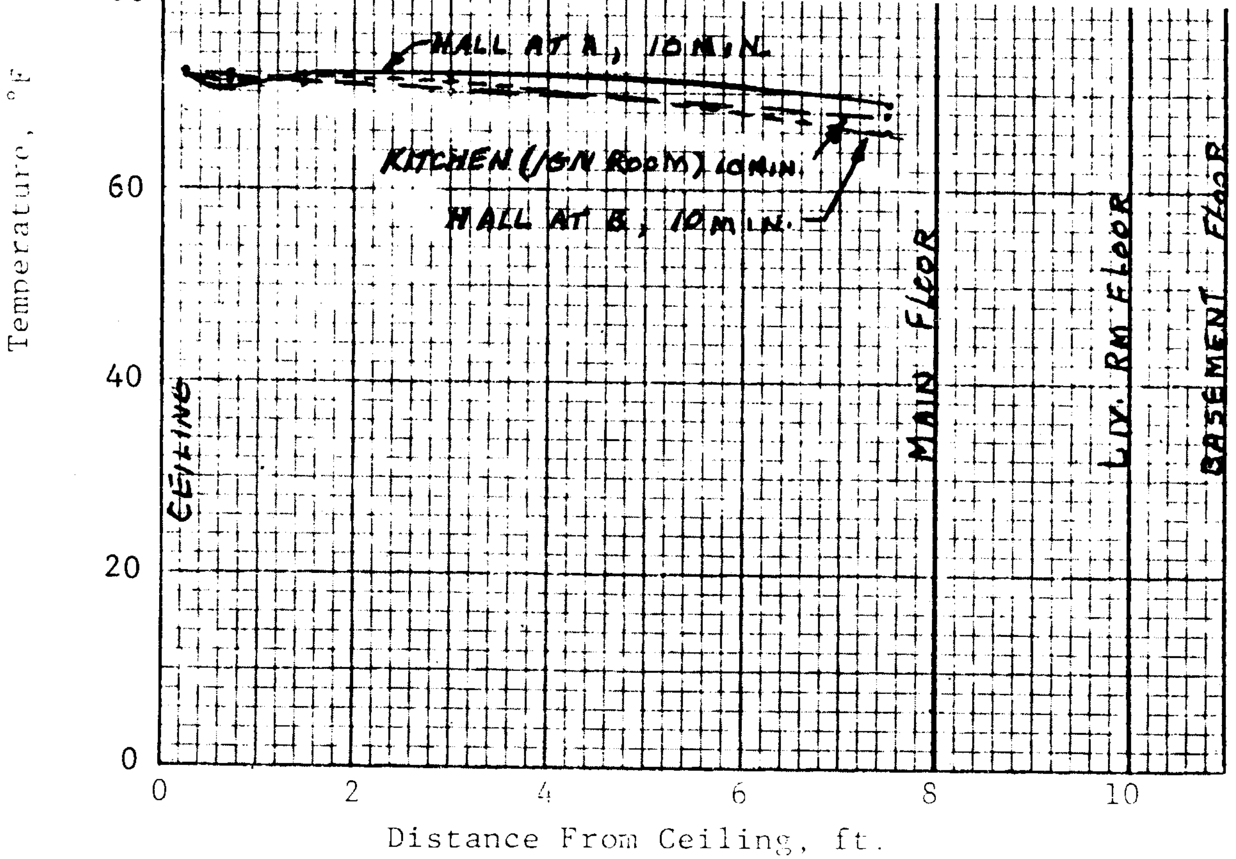
CONDITIONS 5 FT ABOVE FLOOR, LS-37



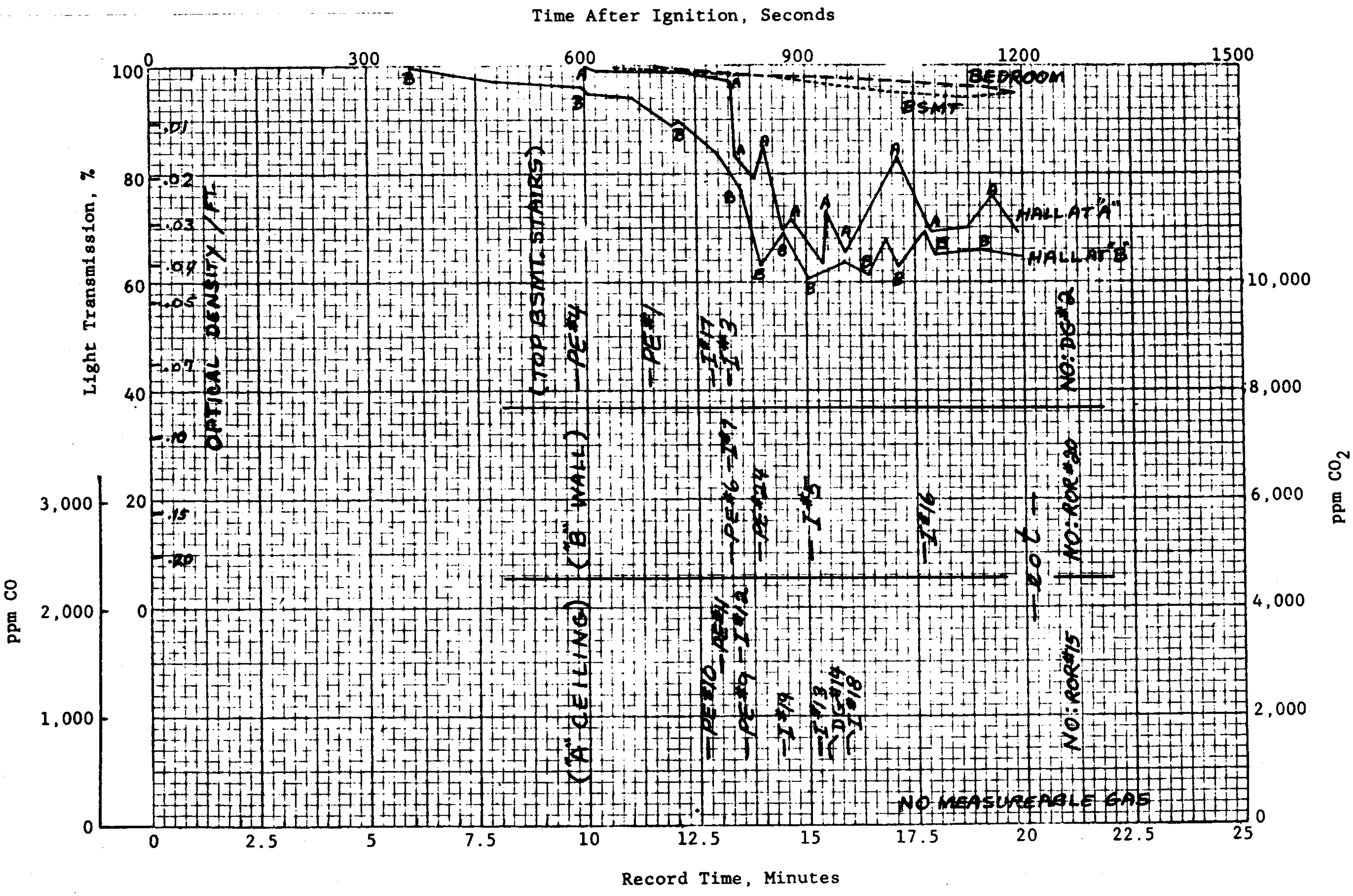
VARIOUS CONDITIONS, LS-37

Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	72	72
Study	3"	70	70
Hall A	12"	72	72
Hall B	12"	70	71
Bsmt. C	3"	54	54
Outdoors		31	31

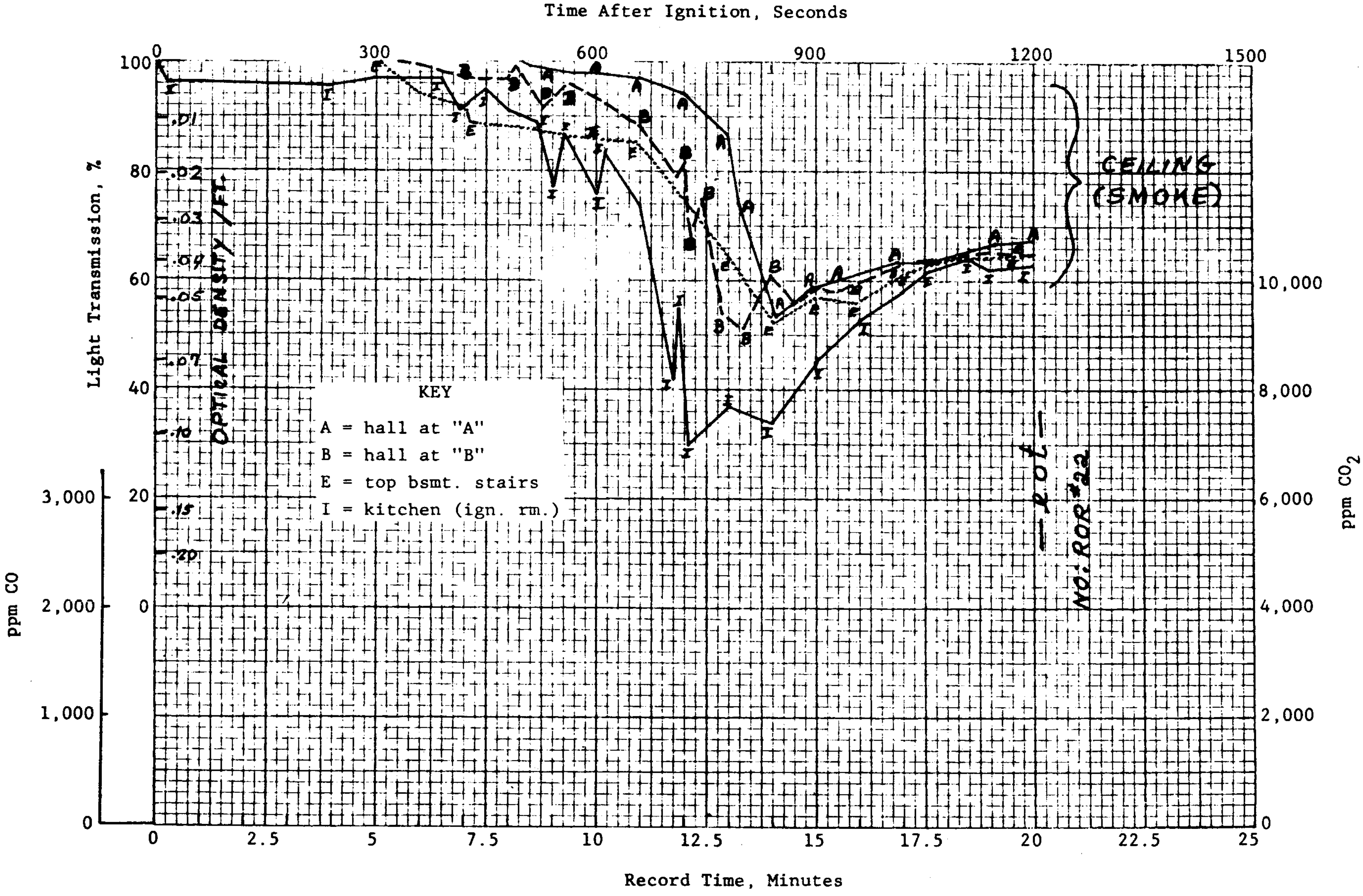
Liv. Rm. Baseboard, Cycled Between 77-90



Maximum Temperature Profiles, LS-37



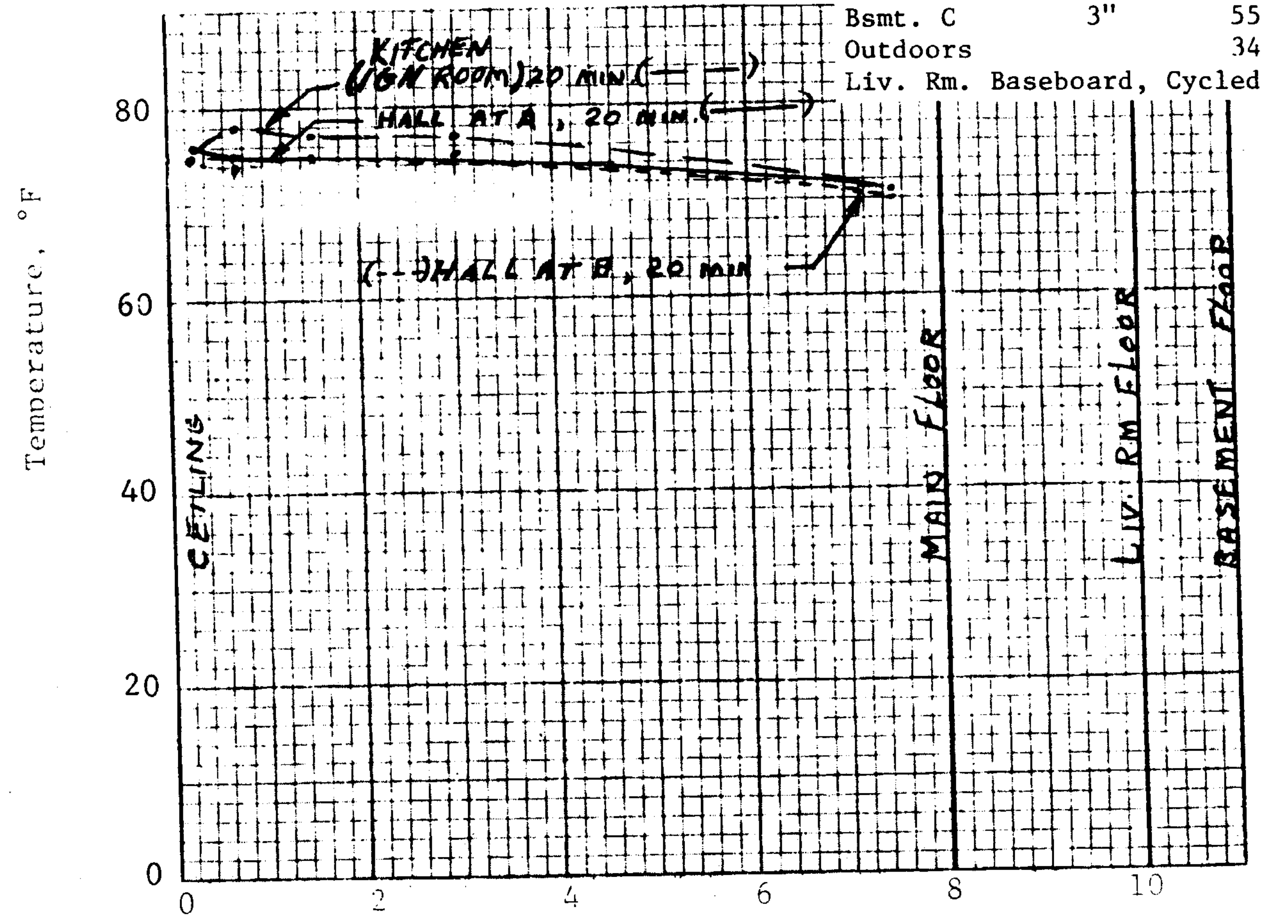
CONDITIONS 5 FT ABOVE FLOOR, LS-38



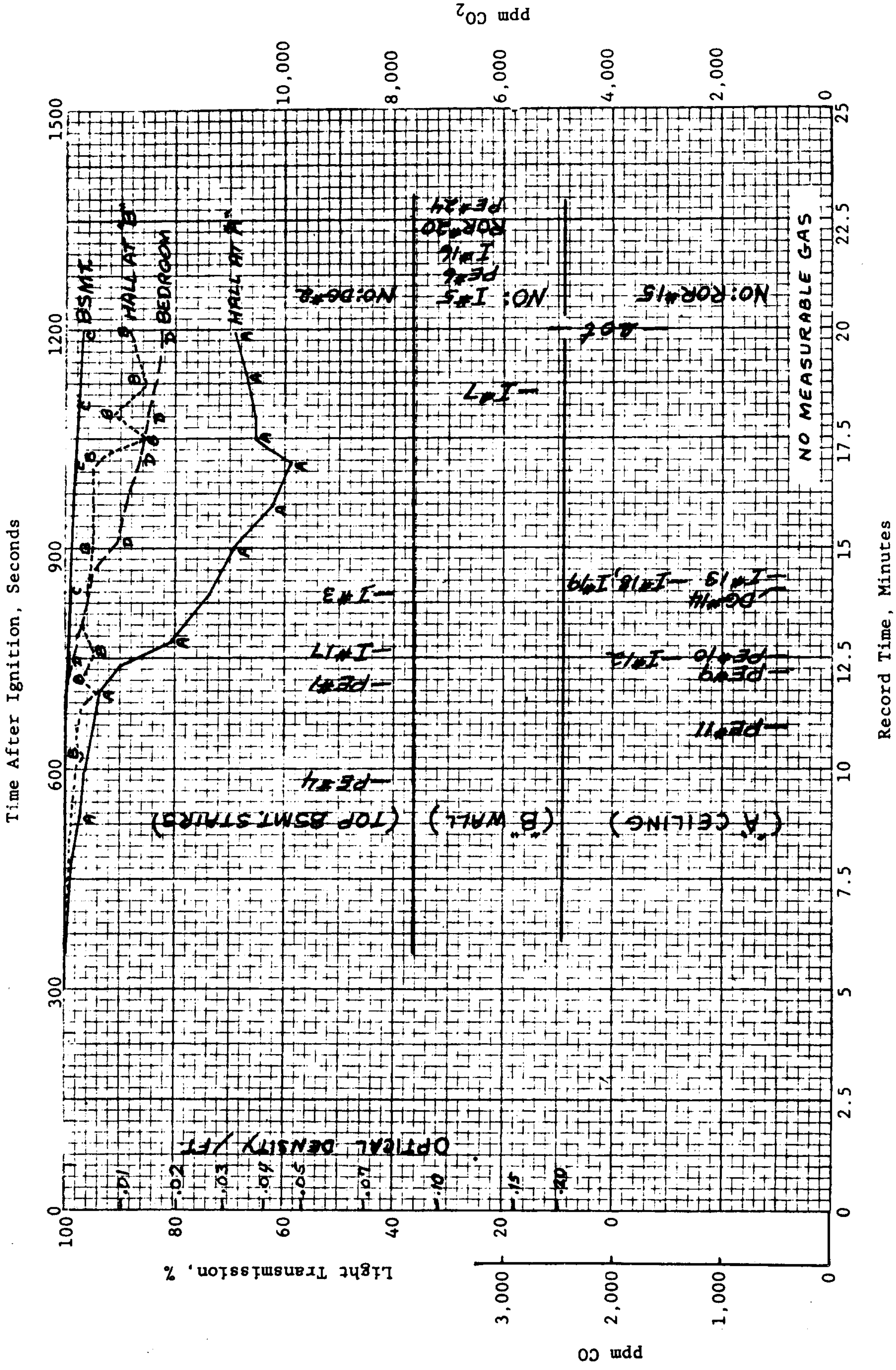
VARIOUS CONDITIONS, LS-38

Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	71	73
Study	3"	71	74
Hall A	12"	72	75
Hall B	12"	68	75
Bsmt. C	3"	55	56
Outdoors		34	33

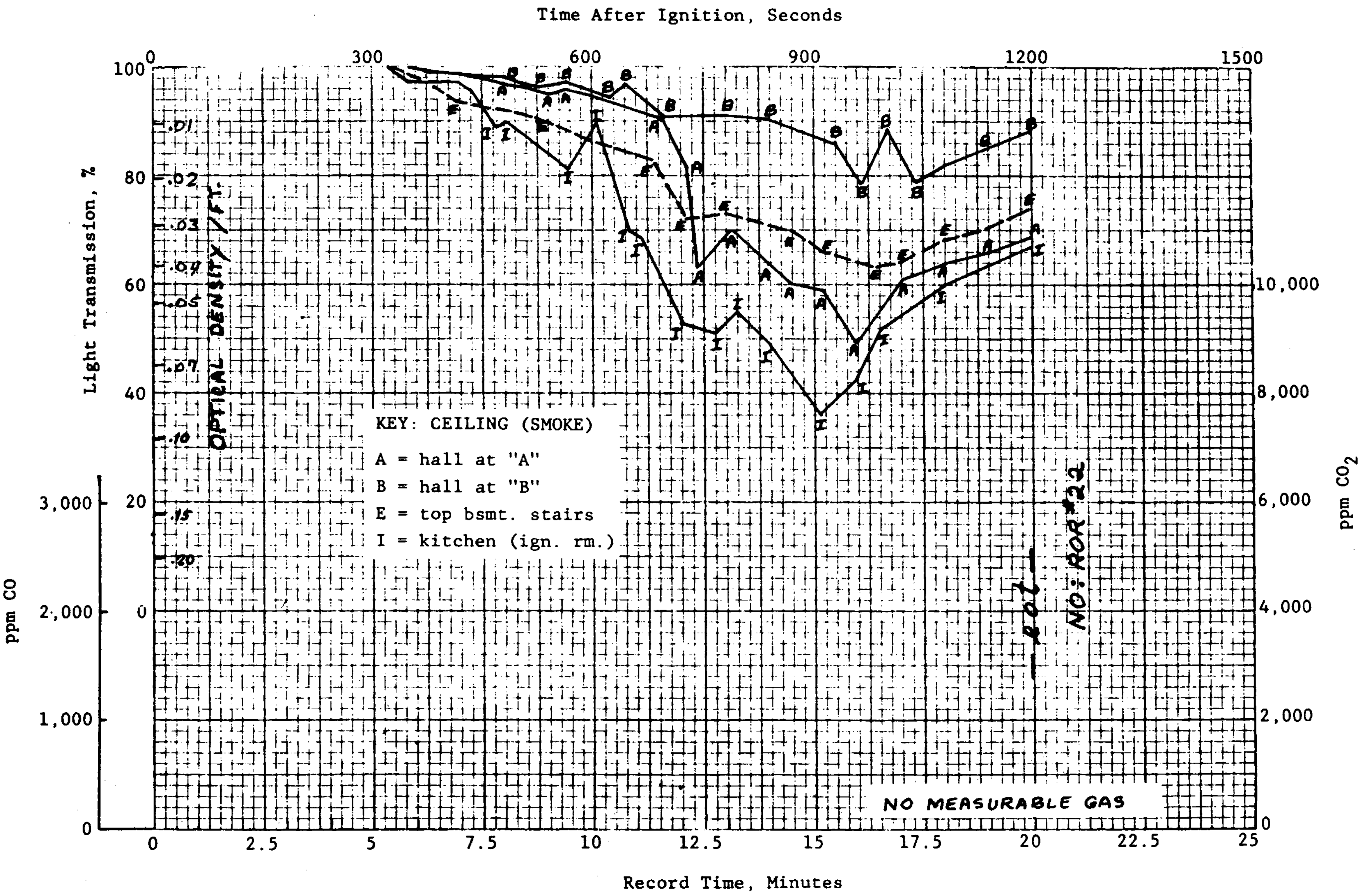
Liv. Rm. Baseboard, Cycled Between 87-100



Maximum Temperature Profiles, LS-38



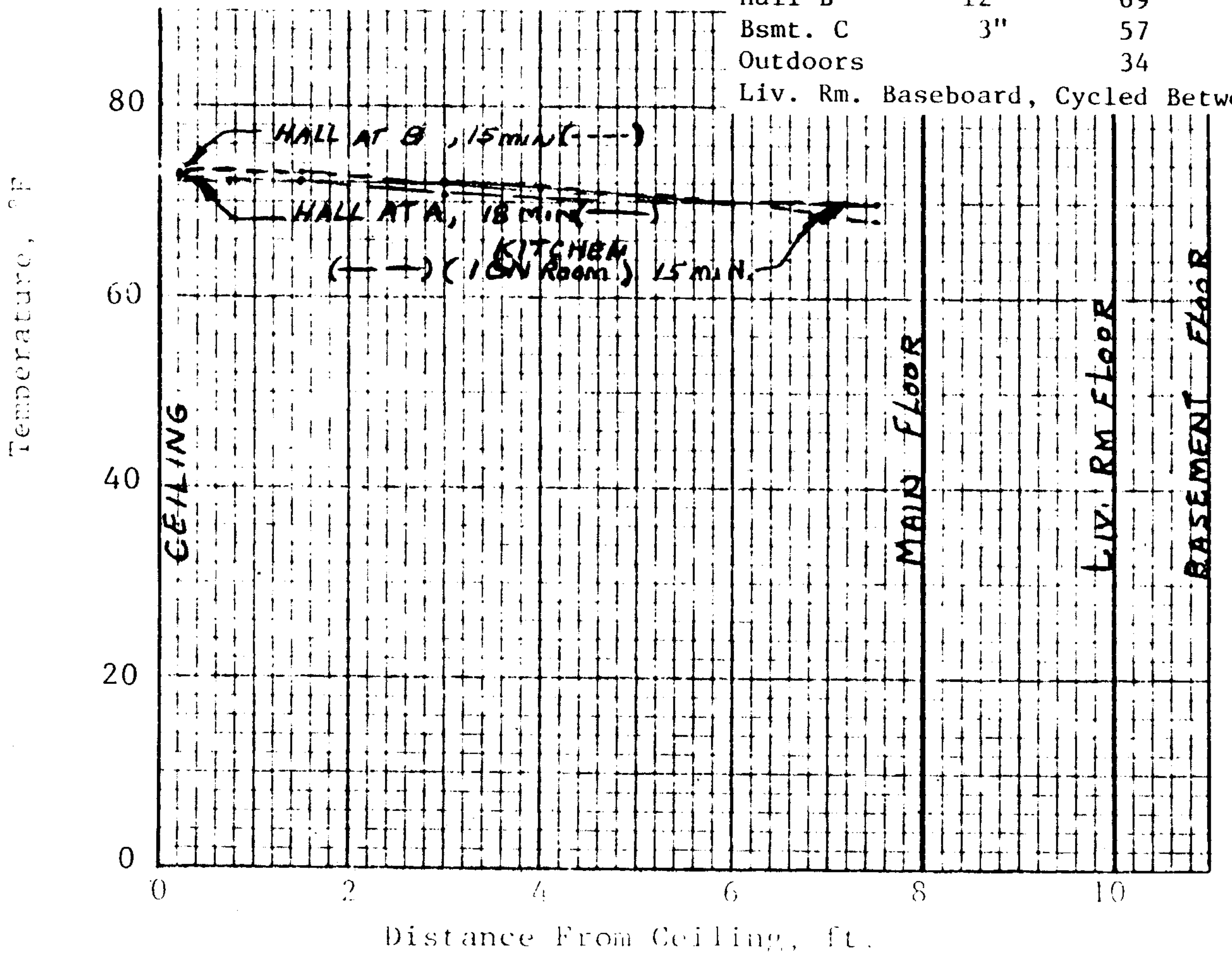
CONDITIONS 5 FT ABOVE FLOOR, LS-39



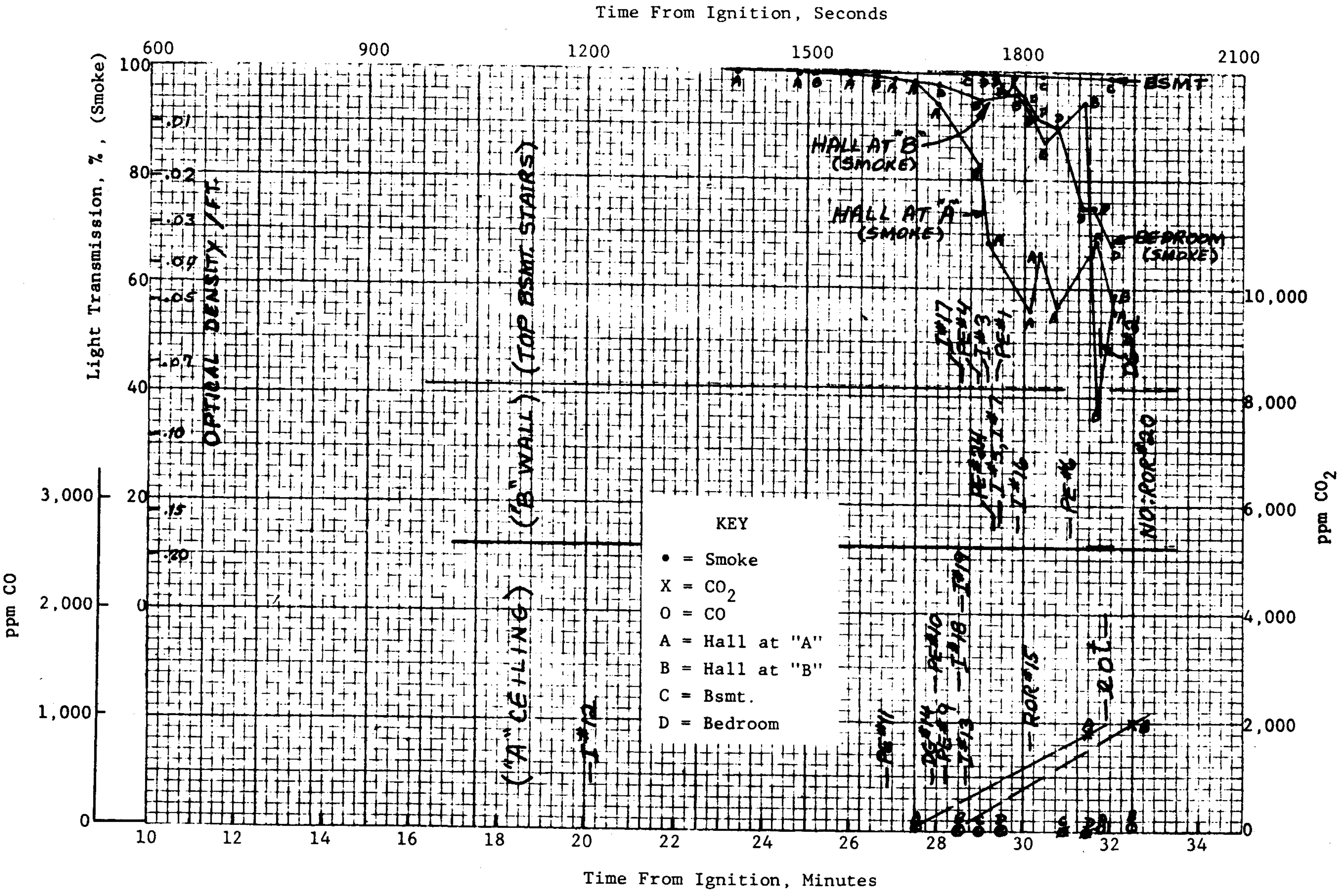
VARIOUS CONDITIONS, LS-39

Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	71	71
Study	3"	71	72
Hall A	12"	70	74
Hall B	12"	69	72
Bsmt. C	3"	57	56
Outdoors		34	33

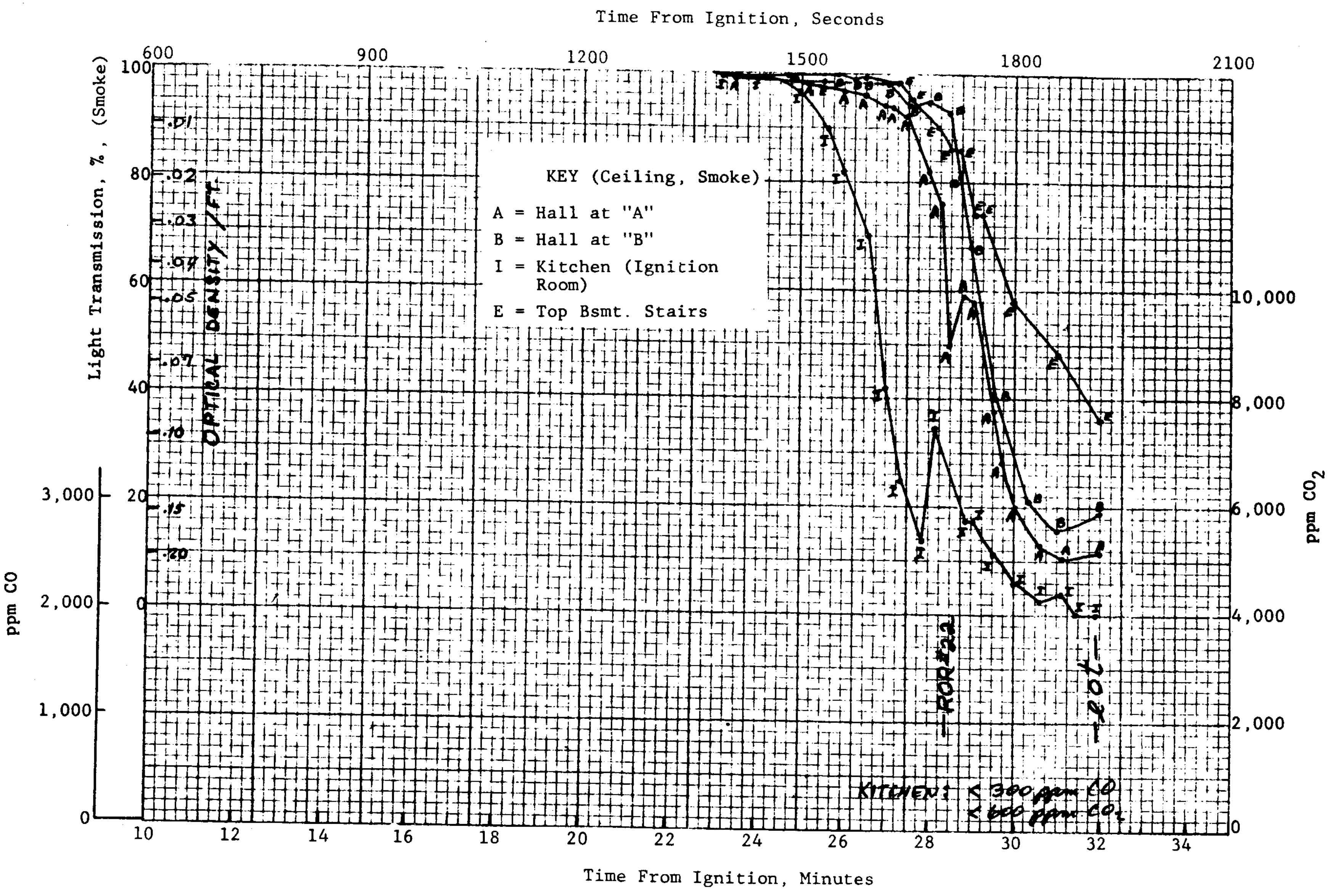
Liv. Rm. Baseboard, Cycled Between 74-89



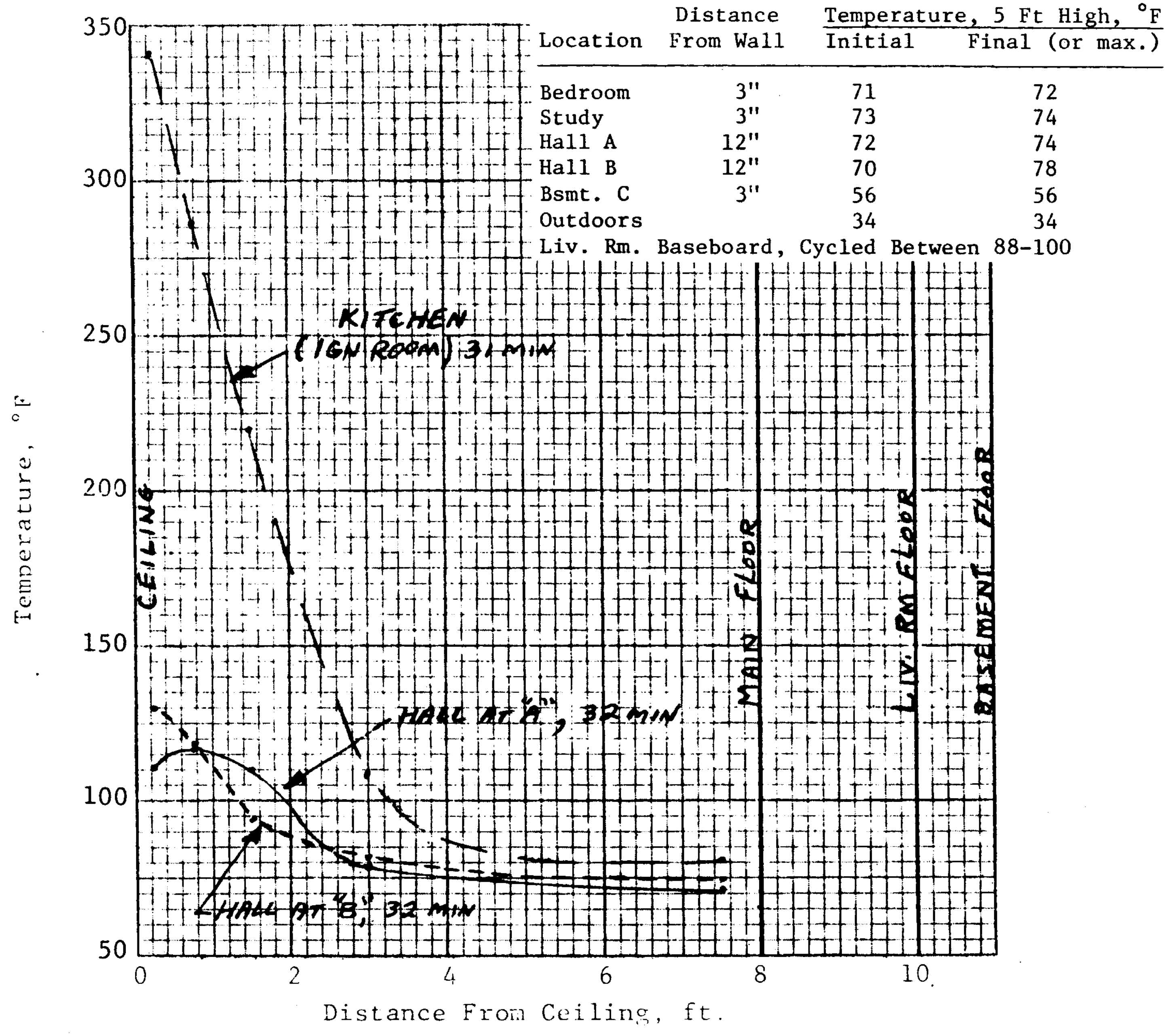
Maximum Temperature Profiles, LS-39



CONDITIONS 5 FT ABOVE FLOOR, LS-40



VARIOUS CONDITIONS, LS-40



Location	Distance From Wall	Temperature, 5 Ft High, °F Initial	Final (or max.)
Bedroom	3"	71	72
Study	3"	73	74
Hall A	12"	72	74
Hall B	12"	70	78
Bsmt. C	3"	56	56
Outdoors		34	34
Liv. Rm. Baseboard, Cycled Between 88-100			

Maximum Temperature Profiles, LS-40