NISTIR 4663

Model Study of Fire Environment in Aircraft Cabins Under Forced Ventilation Conditions - Test Data

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*Deceased

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UNDER FORCED VENTILATION CONDITIONS - TEST DATA

B.J. McCaffrey, W.D. Walton, W.R. Rinkinen

ABSTRACT

This report contains 15 complete sets of test data from a series of experiments performed in a reduced scale simulated aircraft cabin for the determination of the effects of ventilation on the environment created by an interior fire. Measurements reported include gas temperature and gas species concentrations in both the cabin and the ventilation exhaust, light attenuation by smoke, and heat transfer to the walls and ceilings. Experimental parameters include the effects of fire size, ventilation rate, and ceiling vent position (central or near wall), the direction of ventilation (inlet at the ceiling, exhaust at the floor and inlet at the floor, exhaust at the ceiling), and also the effects of open exhaust hatches in the wall near the ceiling.

Key Words: aircraft fires; compartment fires; fire growth; fire tests; room fires; toxicity; ventilation.

1. INTRODUCTION

All modern jet aircraft use air supplied by powerplant compressors to pressurize and ventilate the passenger cabin. Within the cabin, the air enters from distribution ducts in the ceiling or upper sidewalls. Air exits the cabin primarily through grilles on the lower sidewall and then travels below the cabin floor to outflow valves located on the lower part of the fuselage. The interaction of this downward ventilation flow with an upward flowing buoyant fire plume and resultant effects on the cabin environment could not be fully examined without experimental data. A basic understanding of the behavior of a fire plume and the transport of combustion products in an aircraft cabin was needed in order to evaluate promising approaches for improving in-flight emergency smoke evacuation capability.

In order to study fire behavior in an aircraft cabin, a one-half scale mockup of a fuselage cabin section was fabricated with overall dimensions of 4.9 meters long, 2.4 meters wide and 1.2 meters high. The enclosure was instrumented with thermocouples, heat flux sensors, gas analyzers, pressure transducers and light attenuation smoke meters. The fire source within the enclosure was a propane burner. The parameters varied in the tests included:

1) maximum fire heat output rates from 6 to 80 kW,
2) cabin ventilation rates with from 2 to 7.5 minutes for a single cabin air change,
3) cabin ventilation along the cabin walls or in the cabin center,
4) cabin ventilation air flowing either in the normal mode, from ceiling to floor, or in the reverse mode, from floor to ceiling,
5) hatches installed in the upper sidewalls in either the opened or closed position, and
6) with and without simulated aircraft seats.

The details and analyses of this work are contained in reference 1. The purpose of the present report is to archive the test data for 15 of the 65 experiments conducted. Table 1 is a complete list of the tests that were completed under this Federal Aviation Administration sponsored program. The 15 tests shown by an underline were selected by the Federal Aviation Administration for inclusion in this report.

2. EXPERIMENTAL APPARATUS

The nominal one-half scale aircraft cabin had overall dimensions of 4.9 m × 2.4 m × 1.2 m and no interior partitions. For the purpose of locating objects within the cabin a north, east, south, and west orientation was used. The 4.9 m dimension of the cabin ran from east to west. Figure 1 shows an interior view of the cabin facing the east wall and figure 2 shows an elevation of the cabin in which the viewer is facing south. The majority of the instrumentation was located in the east half of the cabin. The exterior skin of the cabin was galvanized sheet metal 0.7 mm thick and the ceiling and floor were made of 12.5 mm thick calcium silicate board installed to form plenums approximately 100 mm from both the top and bottom of the exterior skin. Fresh laboratory air was forced into the cabin through one plenum and combustion products were exhausted from the cabin through the other. The interior of the cabin was connected to the plenums with 25.4 mm wide slits in the floor and ceiling. These slits were oriented in the east-west direction. Exhaust hatches to the exterior of the cabin were located in the center of the east and west walls as shown in figure 1.

Four different ventilation conditions were used in the tests. These four conditions resulted from the combination of two ventilation directions and two slit locations. The ventilation direction was either in the normal mode, flow from the ceiling to the floor, or in the reverse mode, flow from the floor to the ceiling. Two ceiling slits were either centrally located in cabin or located along the walls, while the two floor slits were always located along the wall. Figure 3 schematically shows the four possible flow configurations. Small arrows near the slits in figure 1 show the direction of flow from both center and wall ceiling slits and the floor slits in the normal flow direction. This is also known as the counterflow ventilation configuration because the direction of flow is opposite to the direction of travel of the hot combustion products in the plume above the fire. The supply fans and exhaust ducts shown in figure 2 are for the normal flow direction. For the tests with the reverse flow direction the exhaust ducts were placed on top of the cabin and the supply fans under the cabin.

The fire was located in the center of the cabin at the floor. Propane (C_3H_8) was metered to a glass bead burner 0.15 m in diameter to form a pure diffusion flame. The propane flow was at a steady rate, except for two of the tests in which the propane flow was varied. The fire could be observed through windows in the cabin walls which are shown as the shaded areas in figure 1.

Thirty-two simulated seats were constructed of aluminum sheet and calcium silicate board as shown in figure 4. The seats were arranged in eight rows of four, with the seats in a row evenly spaced across the cabin and the rows evenly spaced along the length. The seats in both the east and the west half faced the north-south centerline of the cabin.

Figure 2 shows an elevation view of the cabin illustrating ventilation details, gas sampling locations and light attenuation by smoke measurement locations. Sixty channels of data, some of which are illustrated in figure 1, were recorded at 5 second intervals throughout the tests. Complete details are contained in reference 1.

Table 2 is a list of instrumentation with channel numbers corresponding to those seen on figure 1.

3. DATA

The data set from each test presented in this report contains the following separate graphs of transducer data over time:

1) Vertical temperature profile at position A.
2) Vertical temperature profile at position B.
3) Vertical temperature profile at position C.
4) Vertical temperature profile at position D.
5) Ceiling interior surface temperature: T1 - T4.
6) Exhaust temperature: east and west.
7) Wall interior surface temperature: W1 - W4.
8) Heat flux through exterior wall and exterior wall surface temperature rise:
   H1, DT H1, H2, DT H2.
9) Heat flux through exterior wall and exterior wall surface temperature rise:
   H3, DT H3, H4, DT H4.
10) Cabin differential pressure and inlet flows, east and west.
11) Cabin and exhaust gas concentrations.
12) Cabin light attenuation by smoke.

Generally a single curve from a particular test can be compared directly with the corresponding curve from another test, the notable exception being cabin and exhaust gas concentrations (item 11) where one needs to insure that the same position is being sampled in the two cases. The last column in Table 1 contains the gas sampling position. The locations of the gas sampling positions are given in Table 2.

Similarly, when comparing a normal to a reversed flow case, judgement will be required in interpreting some ventilation parameters. For example, in experiment G1406 (figures 131 to 142) which is a reverse flow case, the exhaust thermocouples are above the ceiling and reflect a much higher rate of rise than a corresponding normal ventilation case where the exhaust thermocouples are located below the floor. The cabin and exhaust O_2 levels should be similar in the reverse flow case since the gases in the upper portion of the compartment are well mixed. Notice H3 and DT H3 for test G1406 (heat flux sensor and sensor temperature difference, figure 139) show no sign of movement as the cool laboratory air coming up from the wall position at the floor sweeps by the interior mounting position of the gauge (see figure 1).

The complete set of measurements was not available for all tests. For example, due to instrumentation difficulties with the smoke meters, no attenuation measurements are available for the tests prior to G0205. Even for those attenuation measurements presented there will be some difficulties making direct comparisons. Prior to tests G2305 the smoke meters were located inside the cabin and although the components were insulated form heat, spurious signals were sometimes present towards the end of a test. Locating both the source and the detector outside the cabin and viewing the attenuation through windows for all remaining tests seems to have solved the problem. Amplifier difficulties for tests G0605 (figure 94) and G1406 (figure 142) resulted in the loss of data for one of the smoke meters.

The top thermocouple on thermocouple rake A, unlike the top thermocouple on other three rakes, does not register the highest temperature. This is due to the presence of a structural member supporting the ceiling which blocked the top thermocouple from the hottest gases. This is discussed fully in reference 1. The gas temperature indicated by the top thermocouple on rake A does not indicate a temperature inversion at that position and the cabin temperature is fully stratified everywhere.

4. ACKNOWLEDGEMENTS

The authors thank the Technical Center of the U. S. Federal Aviation Administration in Atlantic City for support of this work. The contract monitor, Dr. Thor Eklund, deserves special praise for nurturing this work and persevering along the way to guide the studies for maximum utility.

5. REFERENCE

1) McCaffrey, B., Tu, K.-M., Rinkinen, W. and Eklund, T., Model Study of Fire Environment in Aircraft Cabins Under Forced Ventilation Conditions. Fed. Avia. Admin. (U.S.); DOT/FAA/CT - 90/22; December 1990.

Table 1. Experimental design

TEST	HEAT RELEASE Q (kW)	TIME PER CABIN AIR CHANGE (min)	VENTILATION POSITION	VENTILATION DIRECTION	HATCH AREA (cm×cm)	SEATS	GAS SAMPLE POSITION
F0402	30	2.0	Wall	Normal	0×0	0	-
F1102	30	2.0	Wall	Normal	0×0	0	-
F1202	30	2.4	Wall	Normal	0×0	0	-
F1902	30	4.5	Wall	Normal	0×0	0	-
F2502	30	2.4	Center	Normal	0×0	0	-
F0403	30	2.4	Center	Normal	0×0	0	-
F0503	20	2.4	Center	Normal	0×0	0	-
F1203	10	2.4	Center	Normal	0×0	0	-
F1803	6	2.4	Center	Normal	0×0	0	-
F1903	40	2.4	Center	Normal	0×0	0	-
F2603	60	2.4	Center	Normal	0×0	0	-
F0206	30	2.4	Center	Normal	0×0	32	-
G0802	30	2.8	Center	Normal	0×0	32	1
G0902	30	2.9	Center	Normal	0×0	32	2
G1002	30	2.9	Center	Normal	0×0	32	3
G1102	30	3.0	Center	Normal	0×0	32	4
G1202	30	2.8	Center	Normal	0×0	32	5
G1702	10	2.8	Center	Normal	0×0	32	5
G1802	10	2.8	Center	Normal	0×0	32	3
G1902	10	3.0	Center	Normal	0×0	32	1
G2402	50	2.9	Center	Normal	0×0	32	2
G2502	50	3.0	Center	Normal	0×0	32	4
G2602	30	2.9	Center	Normal	0×0	32	6
G0103	30	3.1	Center	Normal	0×0	32	2
G0203	10	3.0	Center	Normal	0×0	32	2
G0303	50	3.0	Center	Normal	0×0	32	2
G0403	10	5.9	Center	Normal	0×0	32	5
G0803	10	5.8	Center	Normal	0×0	32	4
G0903	10	5.9	Center	Normal	0×0	32	2
G1103	30	6.3	Center	Normal	0×0	32	2
G1403	30	6.4	Center	Normal	0×0	32	5
G1503	10	6.2	Center	Normal	0×0	32	5
G2103	30	2.7	Center	Normal	0×0	32	5
G2203	30	2.7	Center	Normal	0×0	32	2
G2403	10	6.2	Center	Normal	0×0	32	2
G2803*	30	*	Center	Normal	0×0	32	2
G2903	0-80	3.0	Center	Normal	0×0	32	2
G0104	30	3.0	Center	Normal	0×0	32	2
G0404	30	3.1	Center	Normal	0×0	32	6
G1404	10	2.6	Center	Normal	0×0	32	2
G1504	10	2.7	Wall	Normal	0×0	32	6
G1804	10	2.7	Wall	Normal	0×0	32	6
G2904	10	2.7	Wall	Normal	0×0	32	2
G0205	10	2.6	Wall	Normal	0×0	32	4
G0305	10	2.6	Wall	Normal	0×0	32	5
G0405	10	2.8	Wall	Normal	0×0	32	2
G0505	30	2.8	Wall	Normal	0×0	32	2
G0605	10	5.4	Wall	Normal	0×0	32	2
G0905	10	2.7	Wall	Normal	2×(8×15)	32	2
G1005	30	2.8	Wall	Normal	2×(8×15)	32	2
G2305	30	2.8	Wall	Normal	2×(8×15)	32	2
G2405	30	2.9	Wall	Normal	2×(15×15)	32	2
G2505	10	3.0	Wall	Normal	2×(15×15)	32	2
G3105	10	2.9	Wall	Normal	2×(15×30)	32	2
G0106	30	3.1	Wall	Normal	2×(15×30)	32	2
G0306	10	7.5	Wall	Normal	2×(15×30)	32	2
G1006	30	2.6	Wall	Reversed	2×(15×30)	32	2
G1306	10	2.6	Wall	Reversed	2×(15×30)	32	2
G1406	30	2.6	Wall	Reversed	0×0	32	2
G1506	10	2.8	Wall	Reversed	0×0	32	2
G1706	0-80	3.0	Wall	Reversed	0×0	32	2
G2106	10	2.4	Wall	Reversed	0×0	32	2
G2206	10	5.9	Wall	Reversed	0×0	32	2
G2706	10	5.5	Wall	Reversed	0×0	32	4
G2806	10	5.3	Wall	Reversed	0×0	32	5

* variable ventilation run: ventilation turned off at 10 minutes; fire terminated at 11.7 minutes; ventilation turned on at 12.5 minutes.
Note: data from underlined test numbers included in this report.

Table 2. Instrumentation

Channel No.	Description	Location	
0	TC	North Wall W4, Interior, 0.3 m east of cabin centerline	0.3 m above floor
1	TC	Rake A, centerline, 1.22 m from east wall	0.0413 m below ceiling
2	TC	Rake A, centerline, 1.22 m from east wall	0.0889 m below ceiling
3	TC	Rake A, centerline, 1.22 m from east wall	0.152 m below ceiling
4	TC	Rake A, centerline, 1.22 m from east wall	0.216 m below ceiling
5	TC	Rake A, centerline, 1.22 m from east wall	0.292 m below ceiling
6	TC	Rake A, centerline, 1.22 m from east wall	0.397 m below ceiling
7	TC	Rake A, centerline, 1.22 m from east wall	0.518 m below ceiling
8	TC	Ventilation Exhaust	West End
9	TC	Rake B, 0.61 m from east and south walls	0.0413 m below ceiling
10	TC	Rake B, 0.61 m from east and south walls	0.0889 m below ceiling
11	TC	Rake B, 0.61 m from east and south walls	0.152 m below ceiling
12	TC	Rake B, 0.61 m from east and south walls	0.216 m below ceiling
13	TC	Rake B, 0.61 m from east and south walls	0.292 m below ceiling
14	TC	Rake B, 0.61 m from east and south walls	0.397 m below ceiling
15	TC	Rake B, 0.61 m from east and south walls	0.518 m below ceiling
16	TC	Ventilation exhaust	East End
17	TC	Rake D, 1.83 m from east, 0.30 m from south walls	0.0413 m below ceiling
18	TC	Rake D, 1.83 m from east, 0.30 m from south walls	0.0889 m below ceiling
19	TC	Rake D, 1.83 m from east, 0.30 m from south walls	0.152 m below ceiling
20	TC	Rake D, 1.83 m from east, 0.30 m from south walls	0.216 m below ceiling
21	TC	Rake D, 1.83 m from east, 0.30 m from south walls	0.292 m below ceiling
22	TC	Rake D, 1.83 m from east, 0.30 m from south walls	0.397 m below ceiling
23	TC	Rake D, 1.83 m from east, 0.30 m from south walls	0.518 m below ceiling
24	TC	Rake D, 1.83 m from east, 0.30 m from south walls	0.690 m below ceiling
25	TC	Rake C, centerline, 0.3 m from east wall	0.0413 m below ceiling
26	TC	Rake C, centerline, 0.3 m from east wall	0.0889 m below ceiling
27	TC	Rake C, centerline, 0.3 m from east wall	0.152 m below ceiling
28	TC	Rake C, centerline, 0.3 m from east wall	0.216 m below ceiling
29	TC	Rake C, centerline, 0.3 m from east wall	0.292 m below ceiling
30	TC	Rake C, centerline, 0.3 m from east wall	0.397 m below ceiling
31	TC	Rake C, centerline, 0.3 m from east wall	0.518 m below ceiling
32	TC	Rake C, centerline, 0.3 m from east wall	0.690 m below ceiling
33	TC	Ceiling T1, centerline, 0.61 m from east wall	on ceiling
34	TC	Ceiling T2, 0.30 m from north, 0.91 m from east wall	on ceiling
35	TC	Ceiling T3, centerline, 1.83 m from east wall	on ceiling
36	TC	Ceiling T4, 0.30 m from north, 1.83 m from east wall	on ceiling
37	TC	East wall W1, interior, 0.3 m north of centerline	0.61 m above floor
38	TC	North wall W2, interior, 0.3 m east of cabin centerline	0.30 m below ceiling
39	TC	North wall W3, interior, 0.76 m from east wall	0.76 m above floor
40	HF	North wall H1, exterior, 2.15 m from east wall	0.17 m below ceiling
41	TC_{HF}	North wall DT H1, exterior, 2.15 m from east wall	0.17 m below ceiling
42	HF	North wall H2, exterior, 2.16 m from east wall	0.22 m above floor
43	TC_{HF}	North wall DT H2 exterior, 2.16 m from east wall	0.22 m above floor
44	HF	North wall H3, exterior, 0.30 m from east wall	0.22 m above floor
45	TC_{HF}	North wall DT H3, exterior, 0.30 m from east wall	0.22 m above floor
46	HF	North wall H4, exterior, 0.32 m from east wall	0.21 m below ceiling
47	TC_{HF}	North wall DT H4, exterior, 0.32 m from east wall	0.21 m below ceiling
48	V	Inlet flow velocity, east half	
49	V	Inlet flow velocity, west half	
50	Δp	Cabin static pressure differential	
51	O_2	Cabin O_2 concentration	locations 1-6*
52	CO_2	Cabin CO_2 concentration	locations 1-6*
53	CO	Cabin CO concentration	locations 1-6*
54	O_2	Exhaust gas O_2 concentration	
55		Light attenuation, center of west end of enclosure	0.11 m below ceiling
56		Light attenuation, center of west end of enclosure	0.24 m below ceiling
57		Light attenuation, center of west end of enclosure	0.37 m below ceiling

TC - thermocouple chromel·alumel 0.25 mm D wire (on rakes - thermocouples faced away from fire)
HF - foil type heat flow sensors (RdF Corporation 20480-3)
H - Heat flux through exterior wall, DT - exterior wall surface temperature rise
TC_{HF} - copper constantan thermocouples (integral part of heat flow sensor)
V - linearized, temp. compensated hot film anemometer (Omega FMA 603V) cross section was traversed at various fan settings in order to convert single, centerline velocity value into a flow rate. (Profile fitted nicely into 1/7 power. Re > 10^4 for all conditions).

* location 1 - north wall, 0.03 m from east wall, 0.10 m below ceiling
location 2 - north wall, 1.06 m from east wall, 0.05 m below ceiling
location 3 - north wall, 1.83 m from east wall, 0.05 m below ceiling
location 4 - north wall, 1.06 m from east wall, 0.23 m below ceiling
location 5 - north wall, 1.06 m from east wall, 0.53 m below ceiling
location 6 - east exhaust

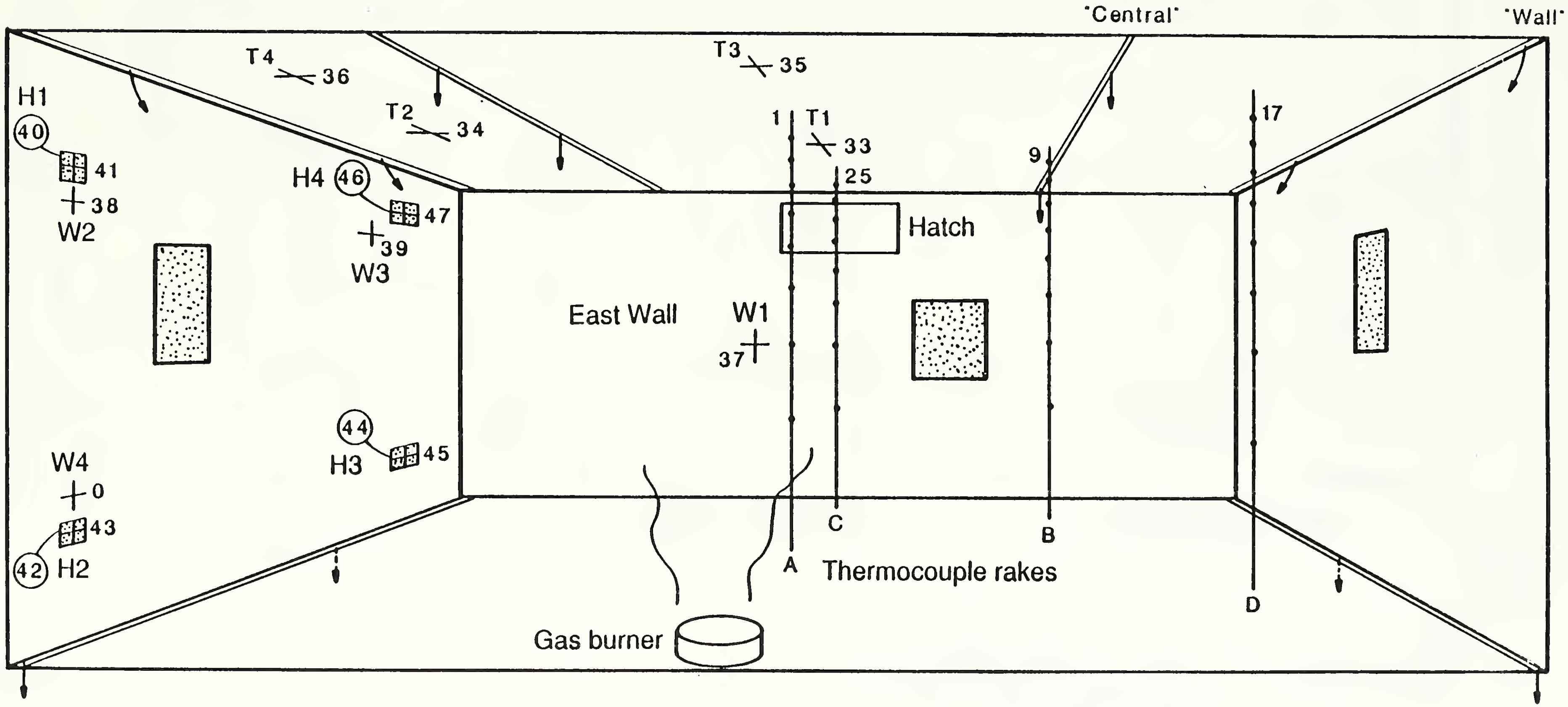

Figure 1. Interior view of east half of the one-half scale aircraft cabin

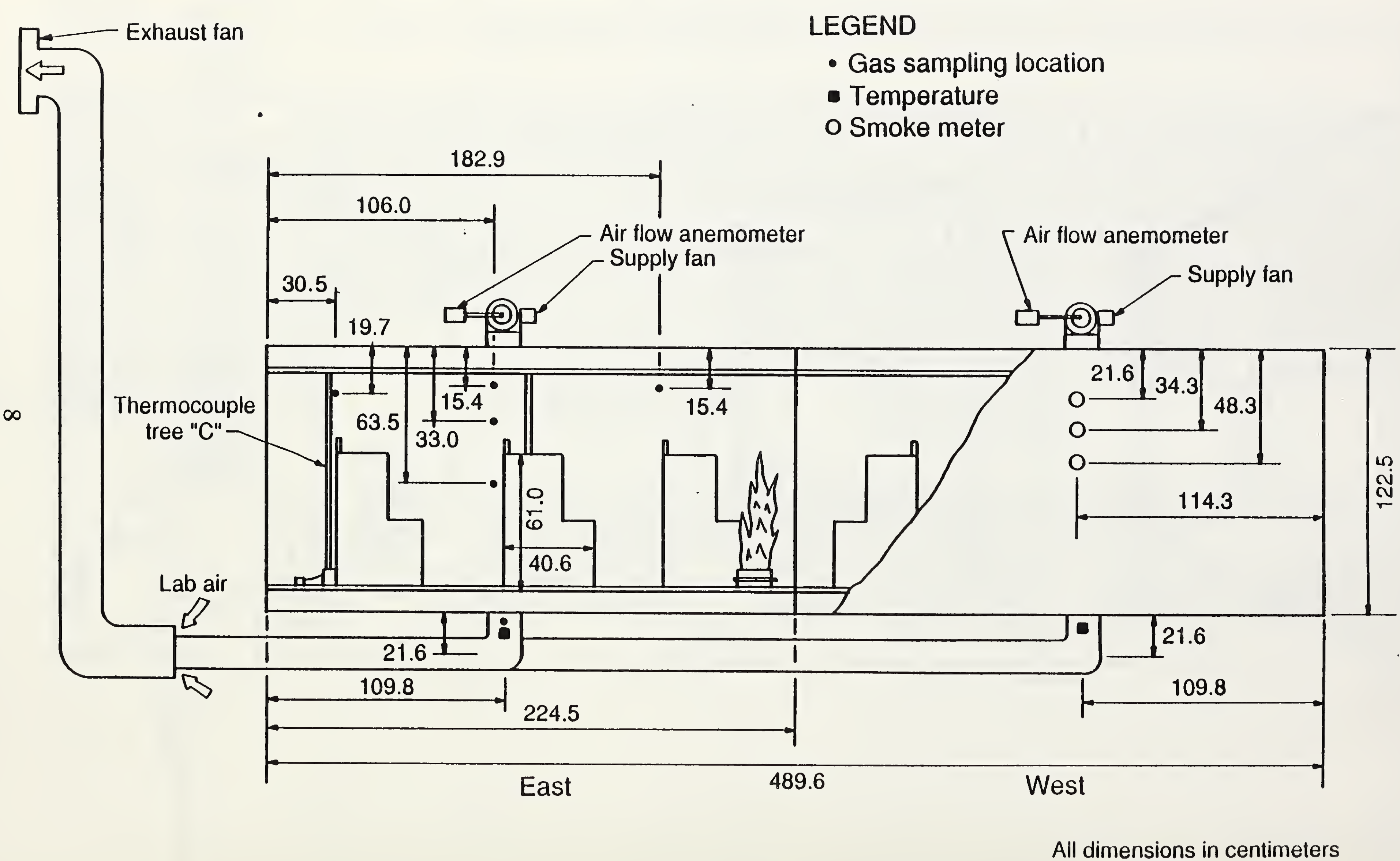

Figure 2. Elevation view of aircraft cabin for normal flow

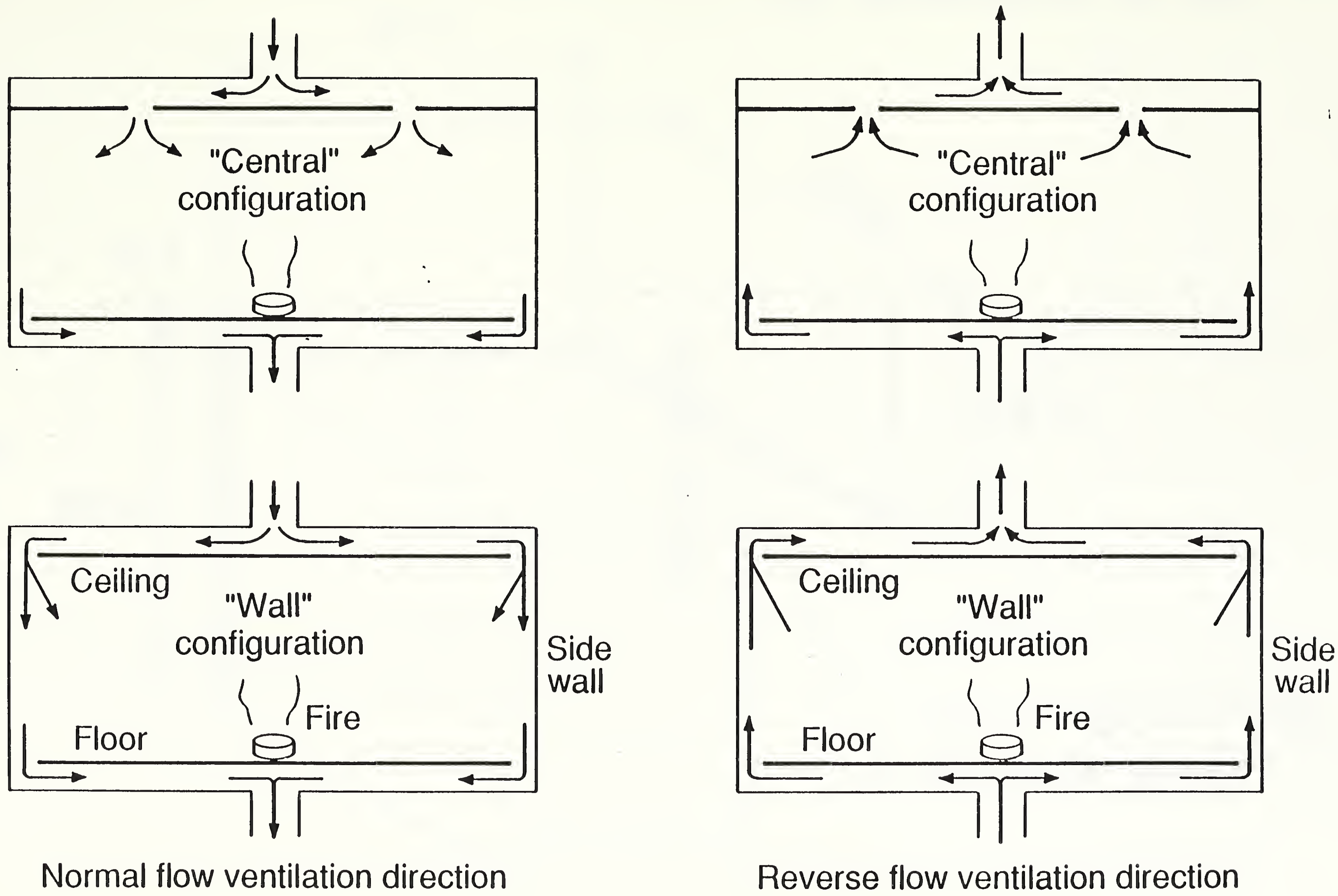

Figure 3. Flow configurations

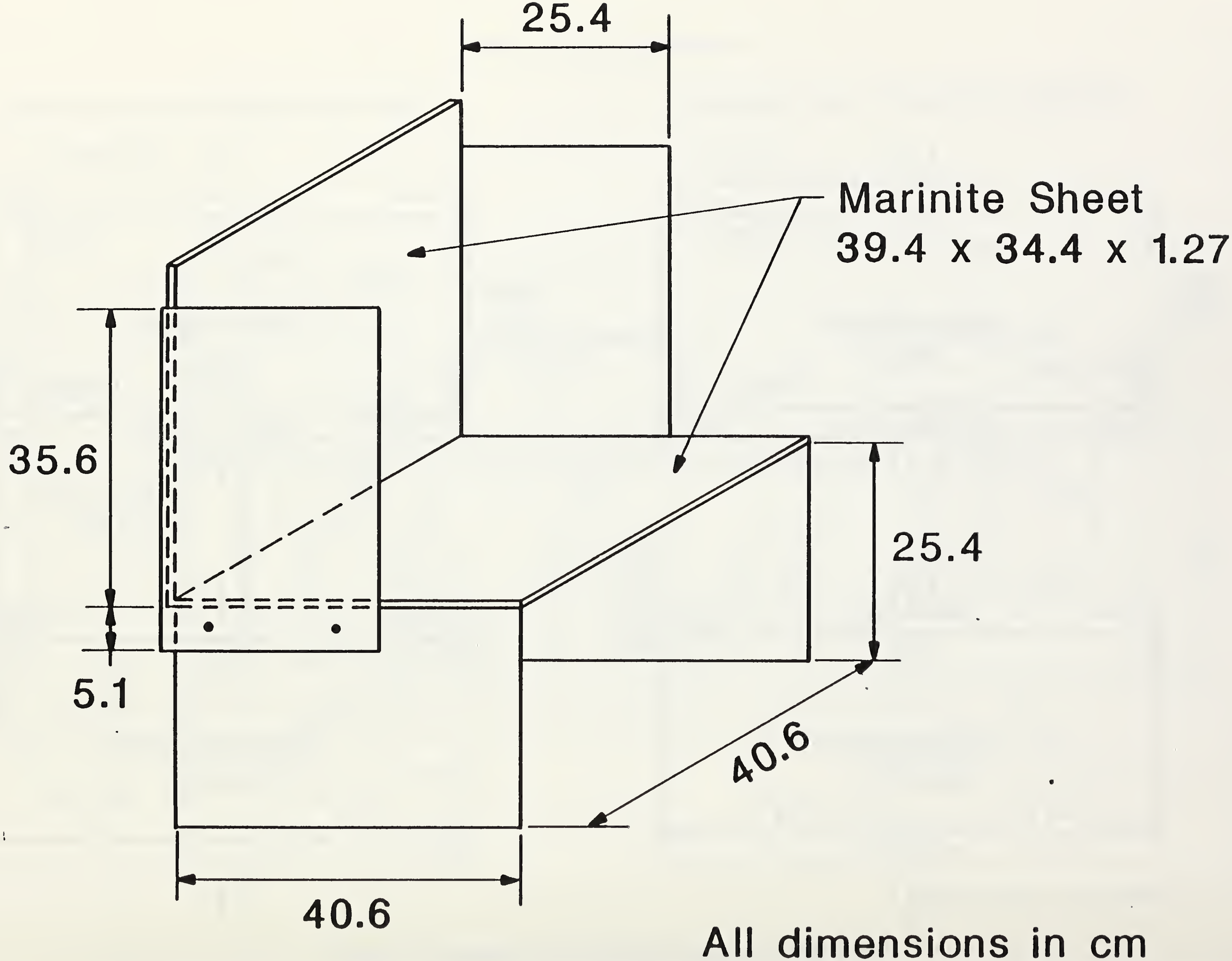

Figure 4. Typical simulated seat

TEST G1102

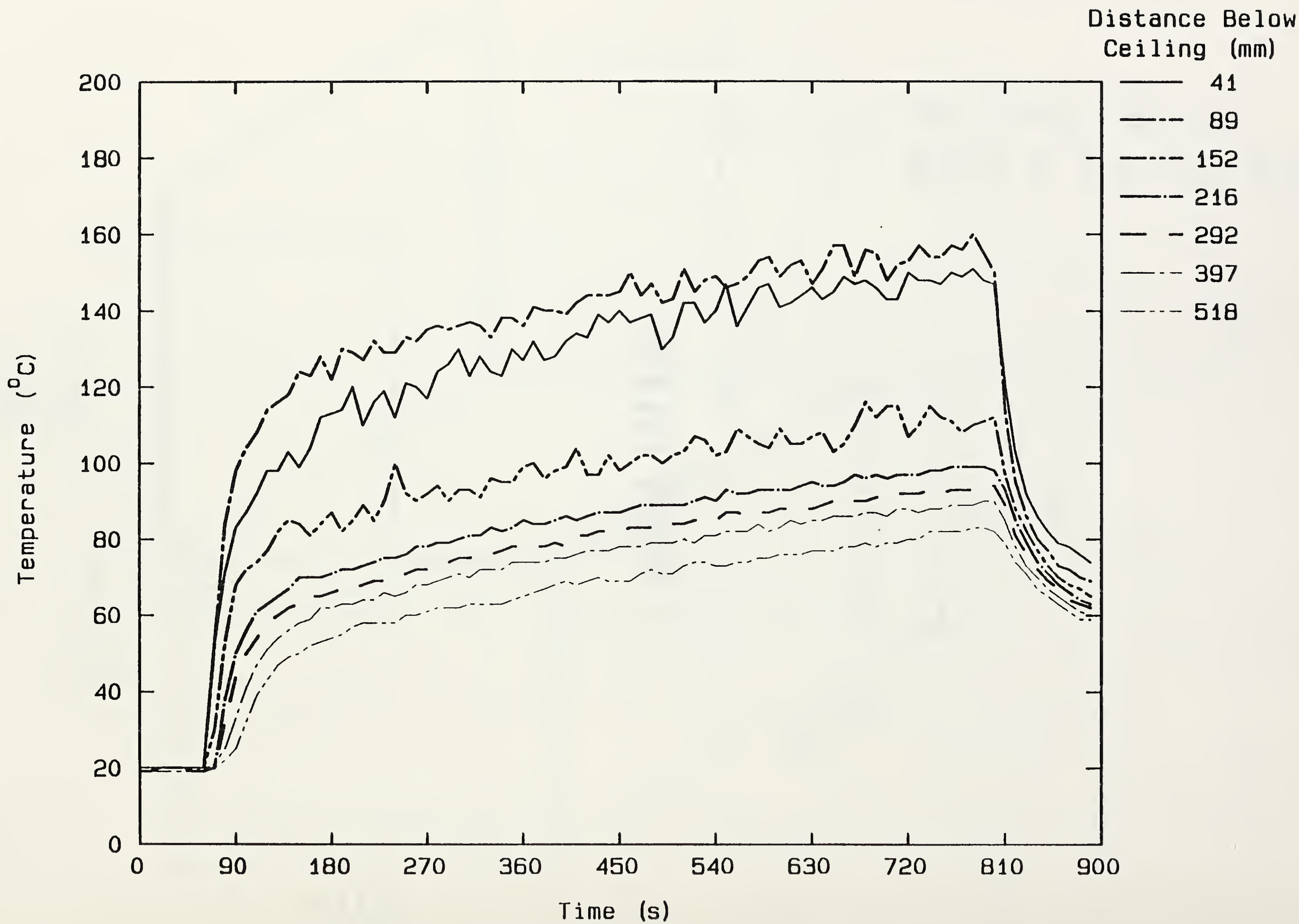

Figure 5. Test G1102 Vertical temperature profile at position A

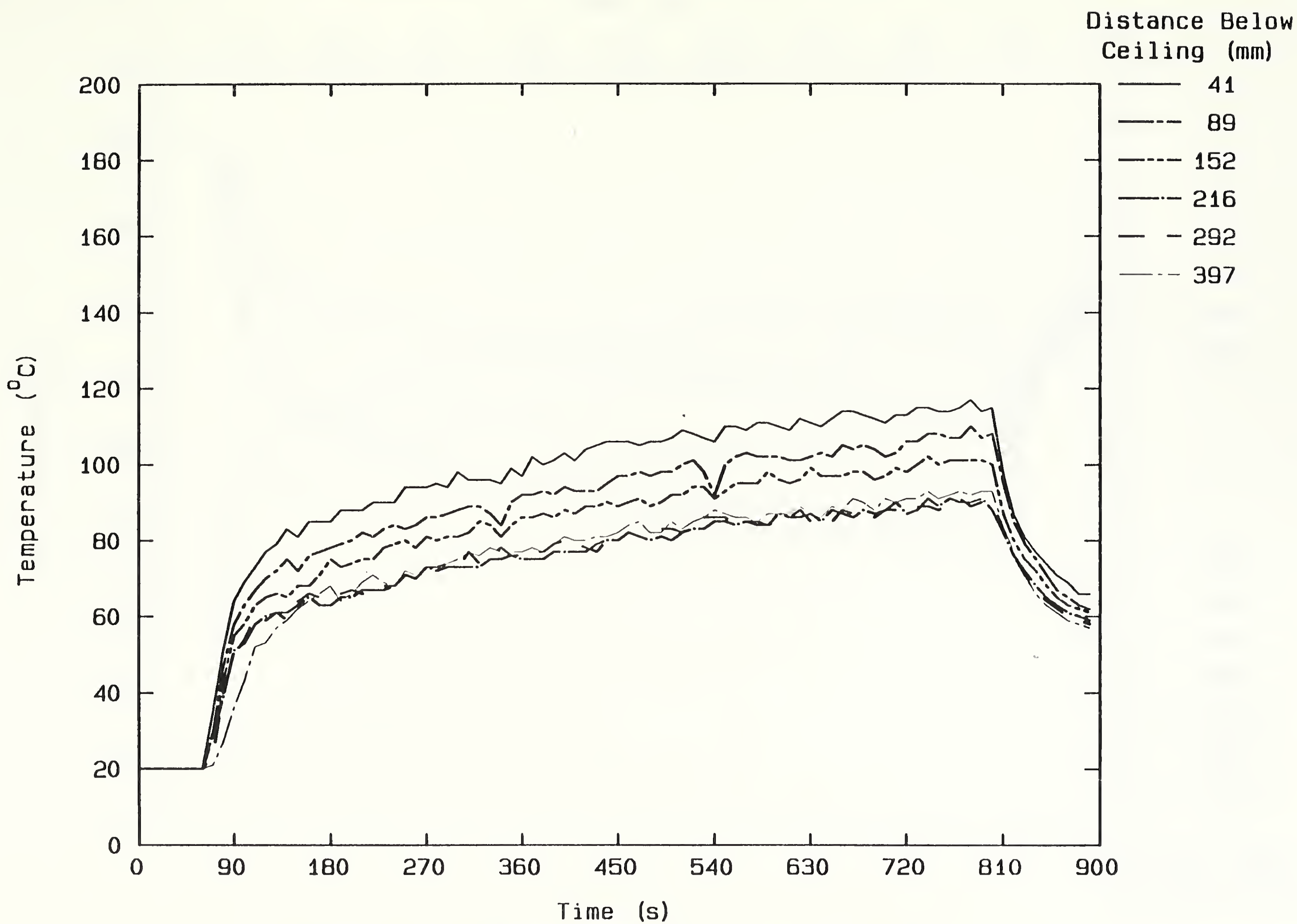

Figure 6. Test G1102 Vertical temperature profile at position B

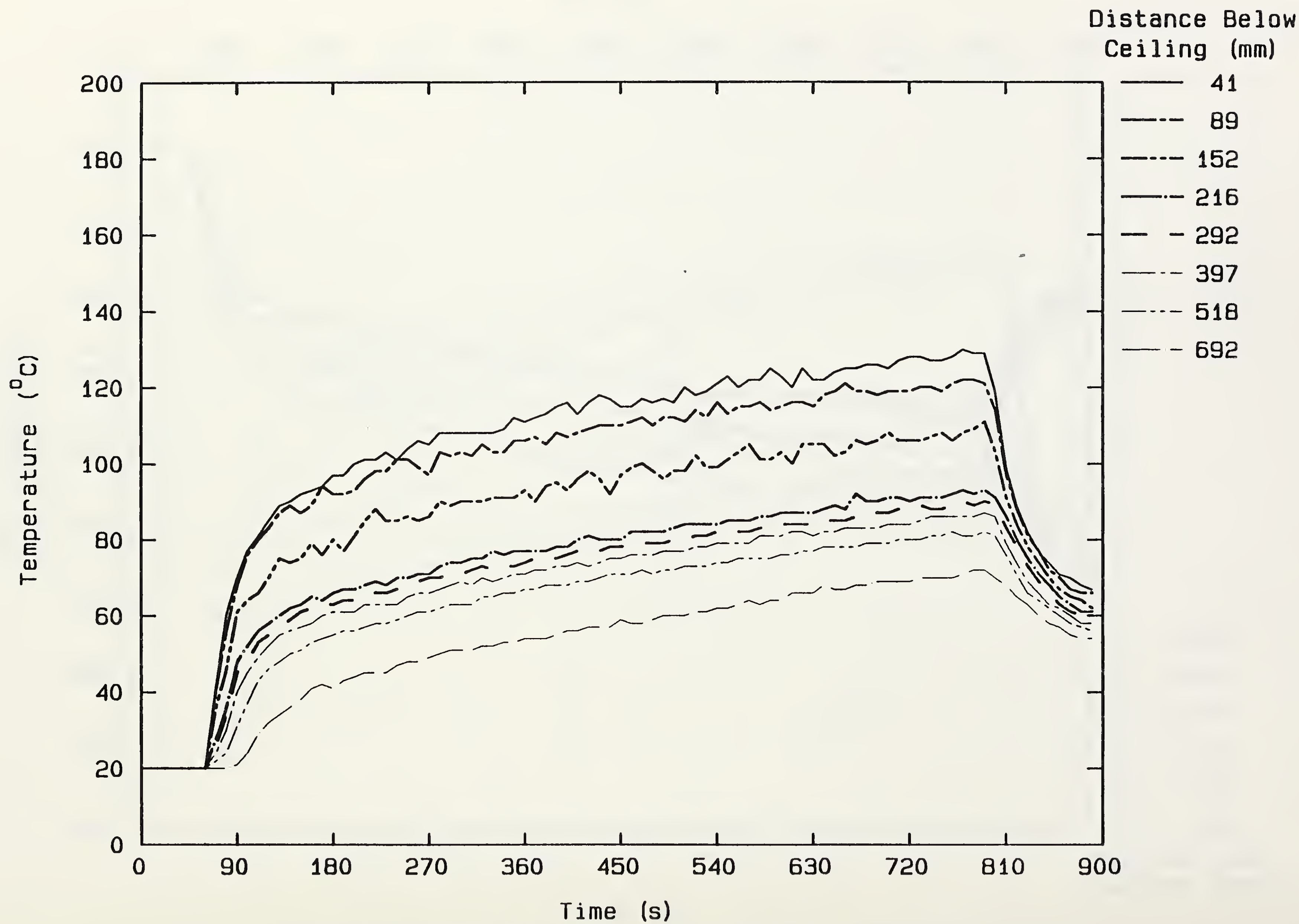

Figure 7. Test G1102 Vertical temperature profile at position C

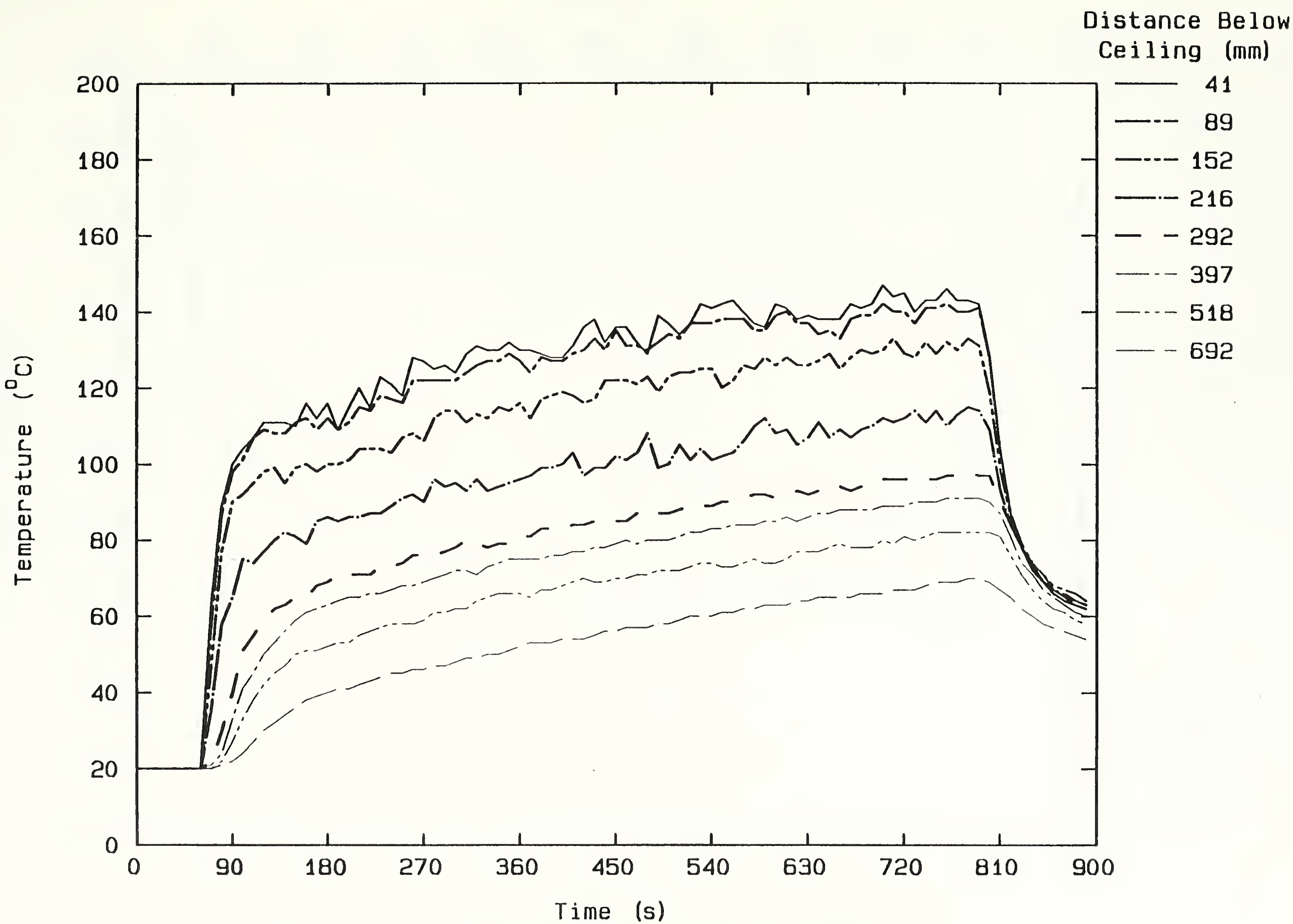

Figure 8. Test G1102 Vertical temperature profile at position D

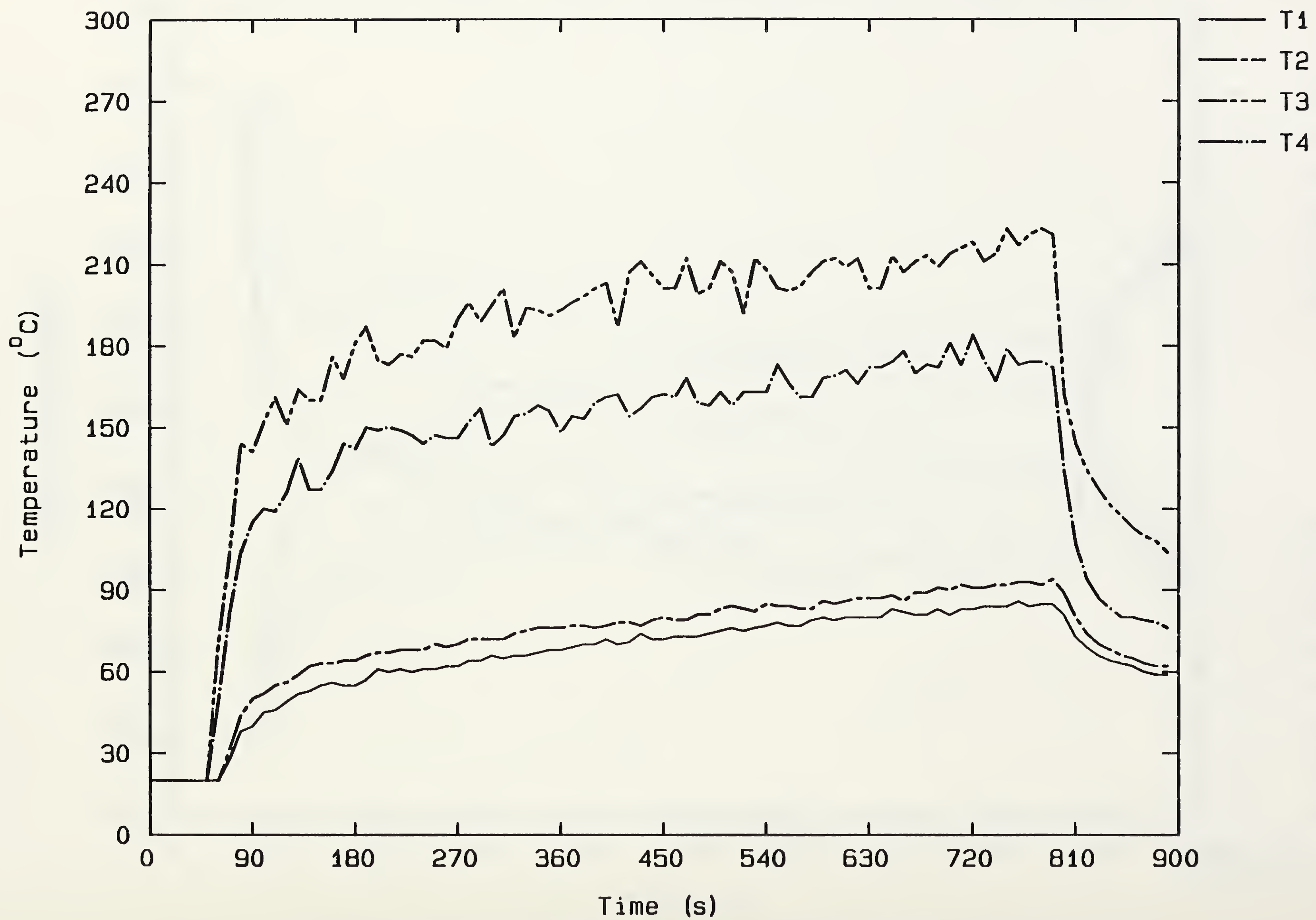

Figure 9. Test G1102 Ceiling interior surface temperature: T1 - T4

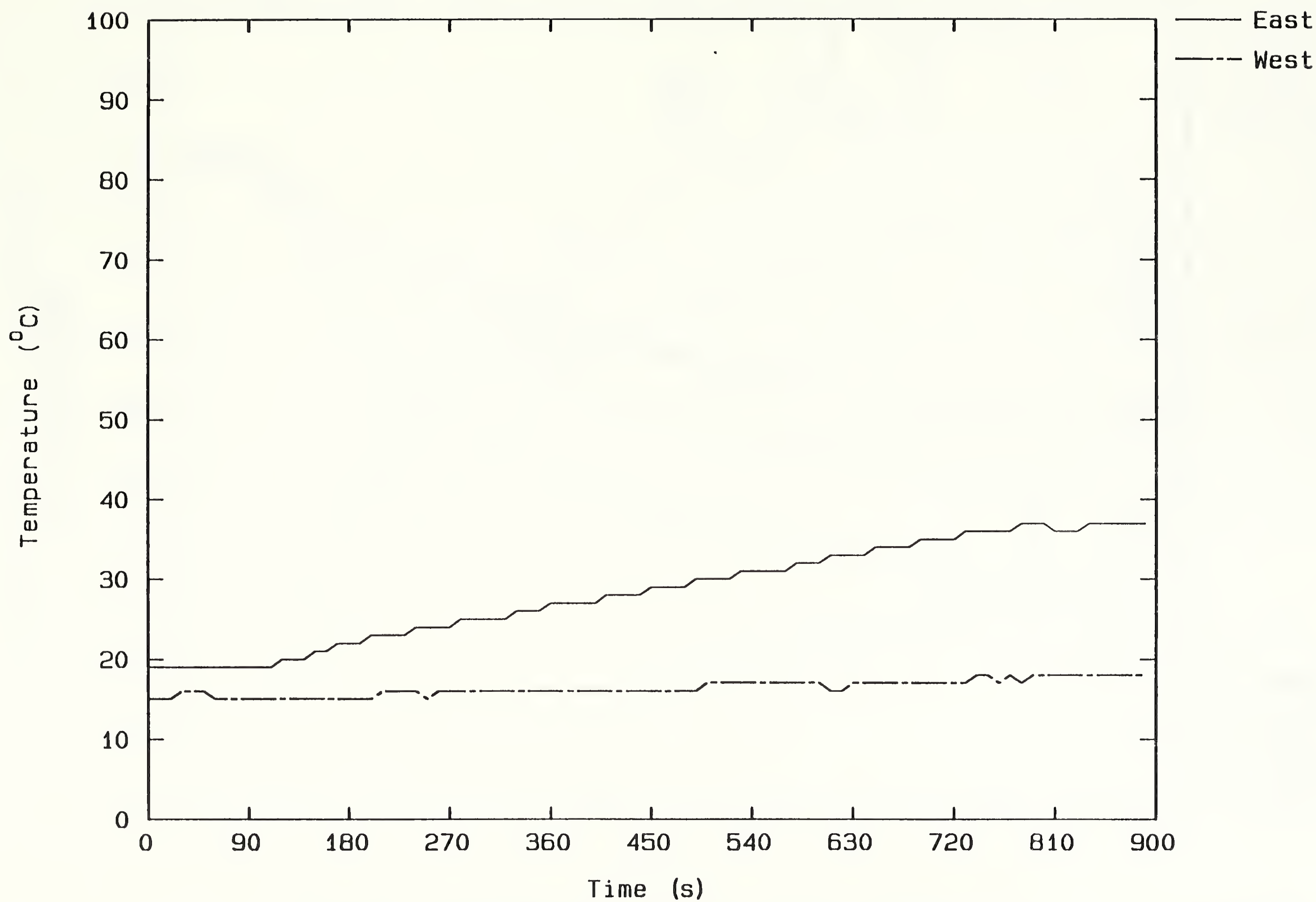

Figure 10. Test G1102 Exhaust temperature: east and west

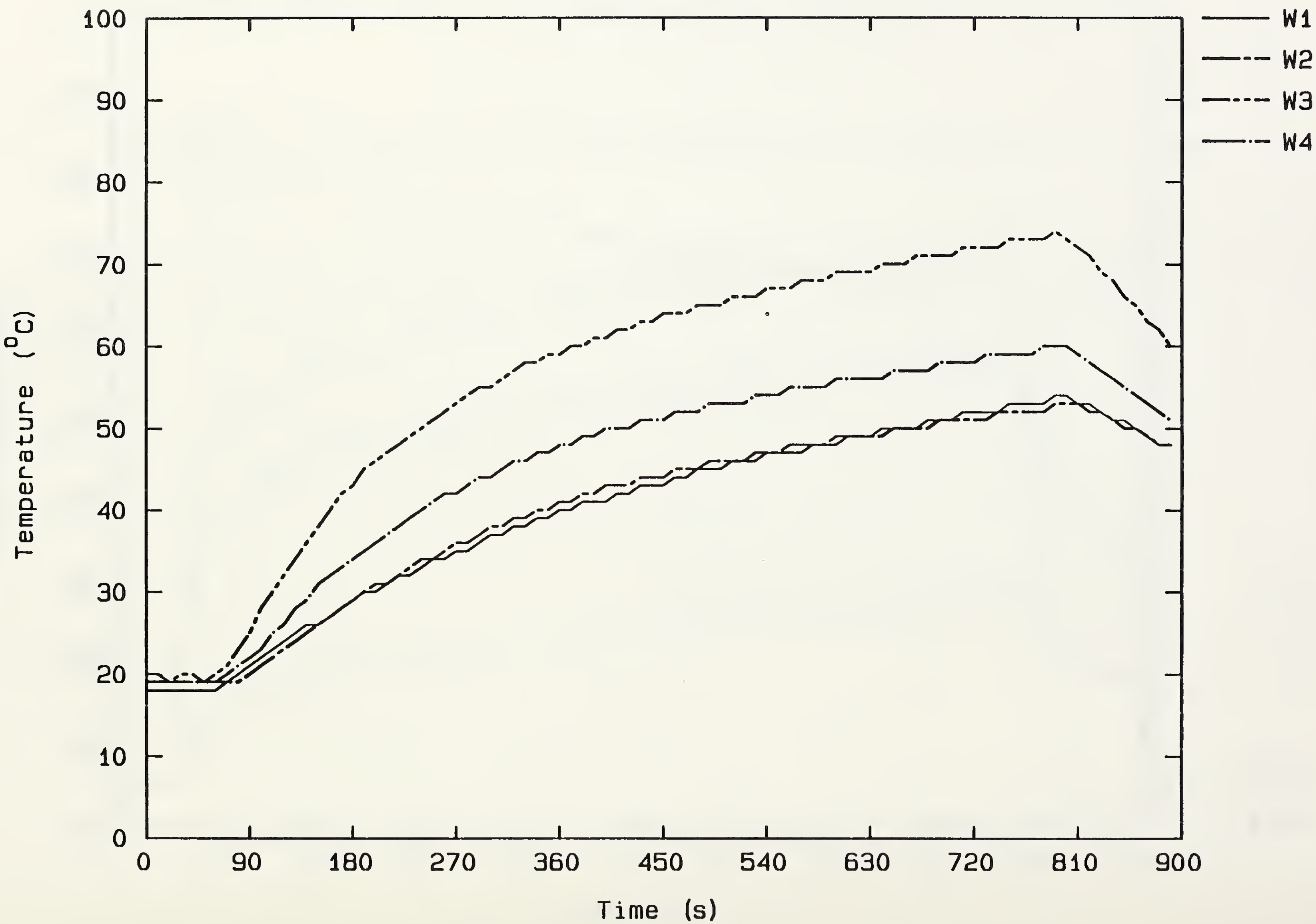

Figure 11. Test G1102 Wall interior surface temperature: W1 - W4

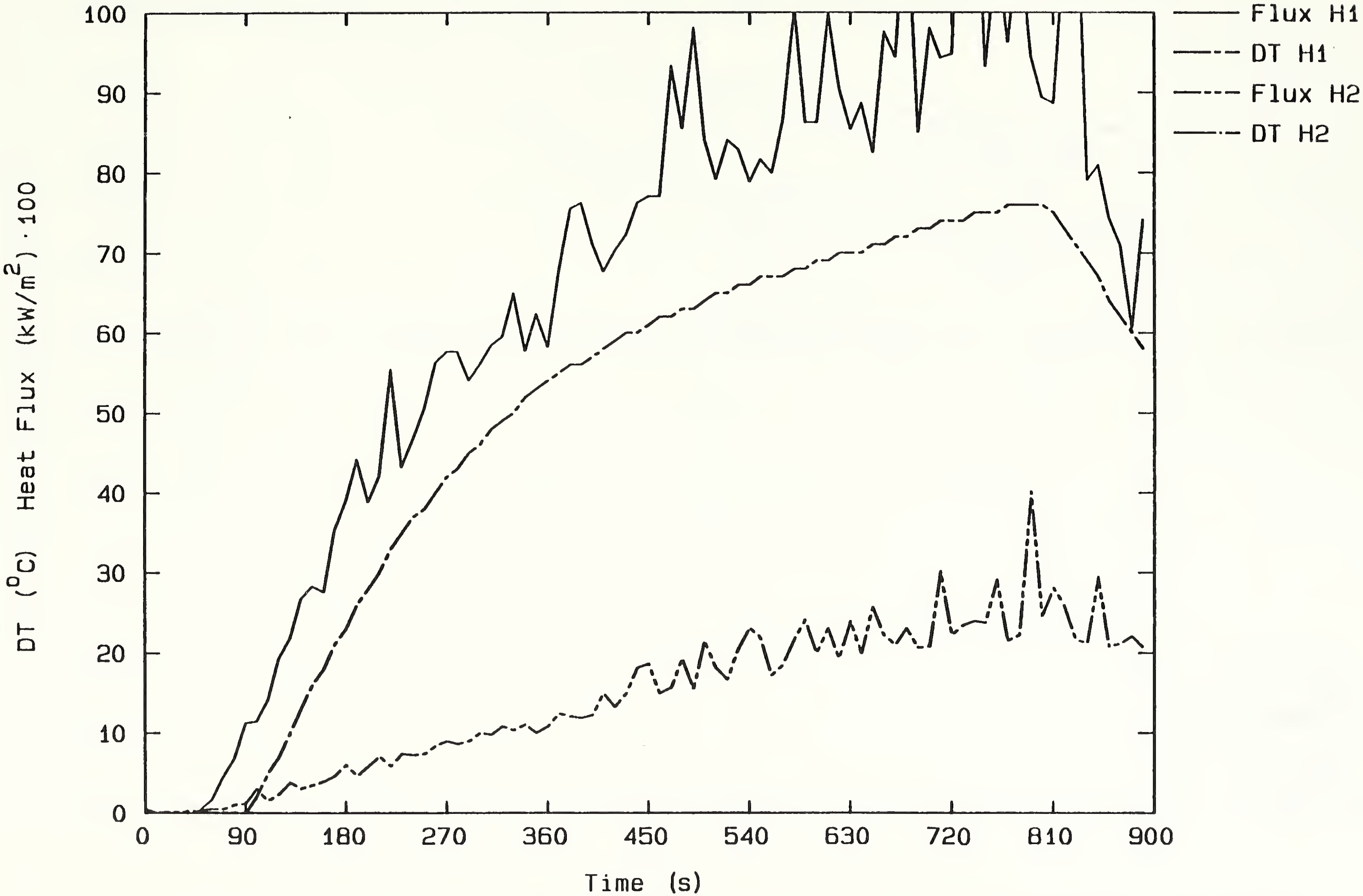

Figure 12. Test G1102 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

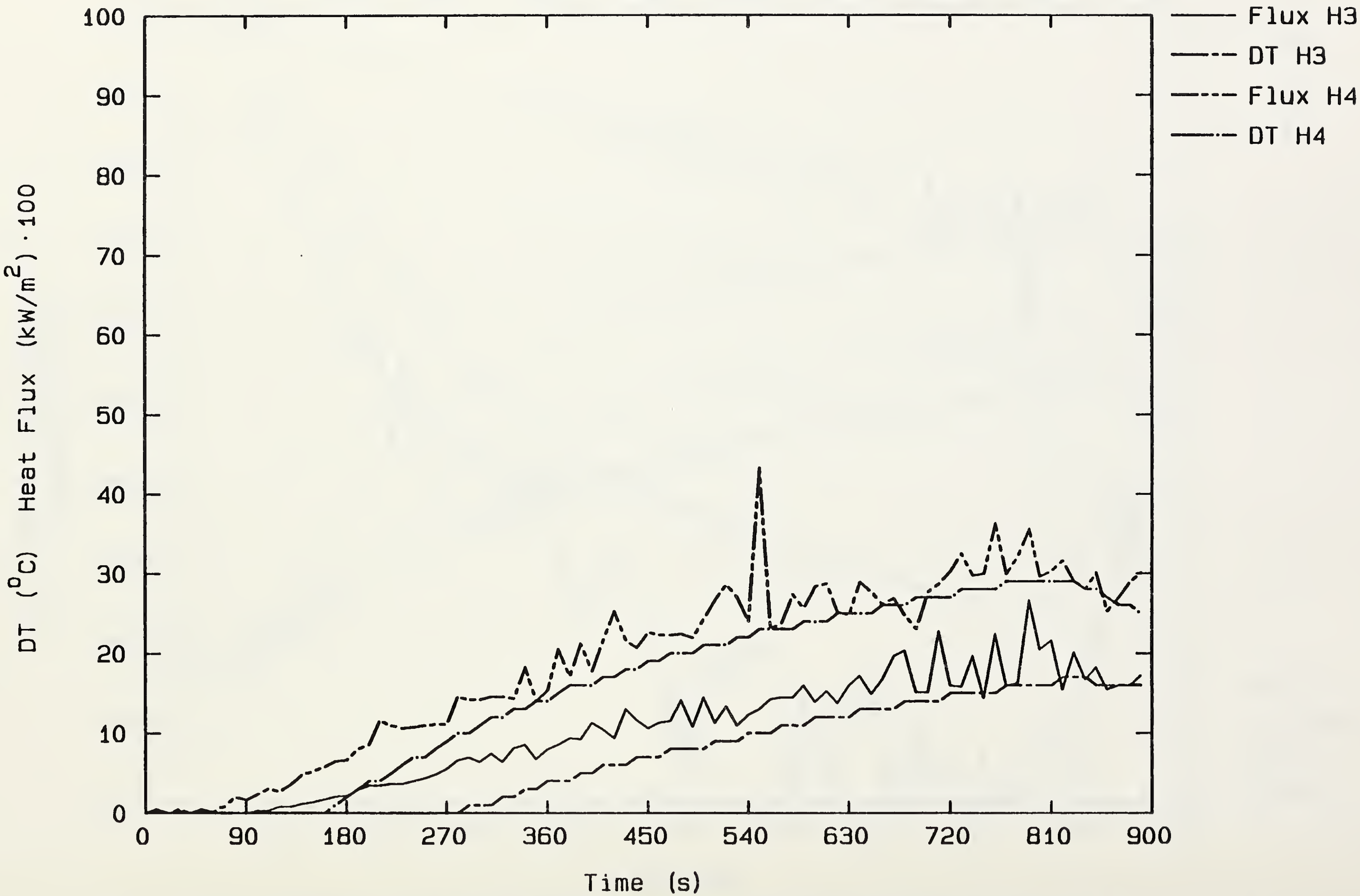

Figure 13. Test G1102 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

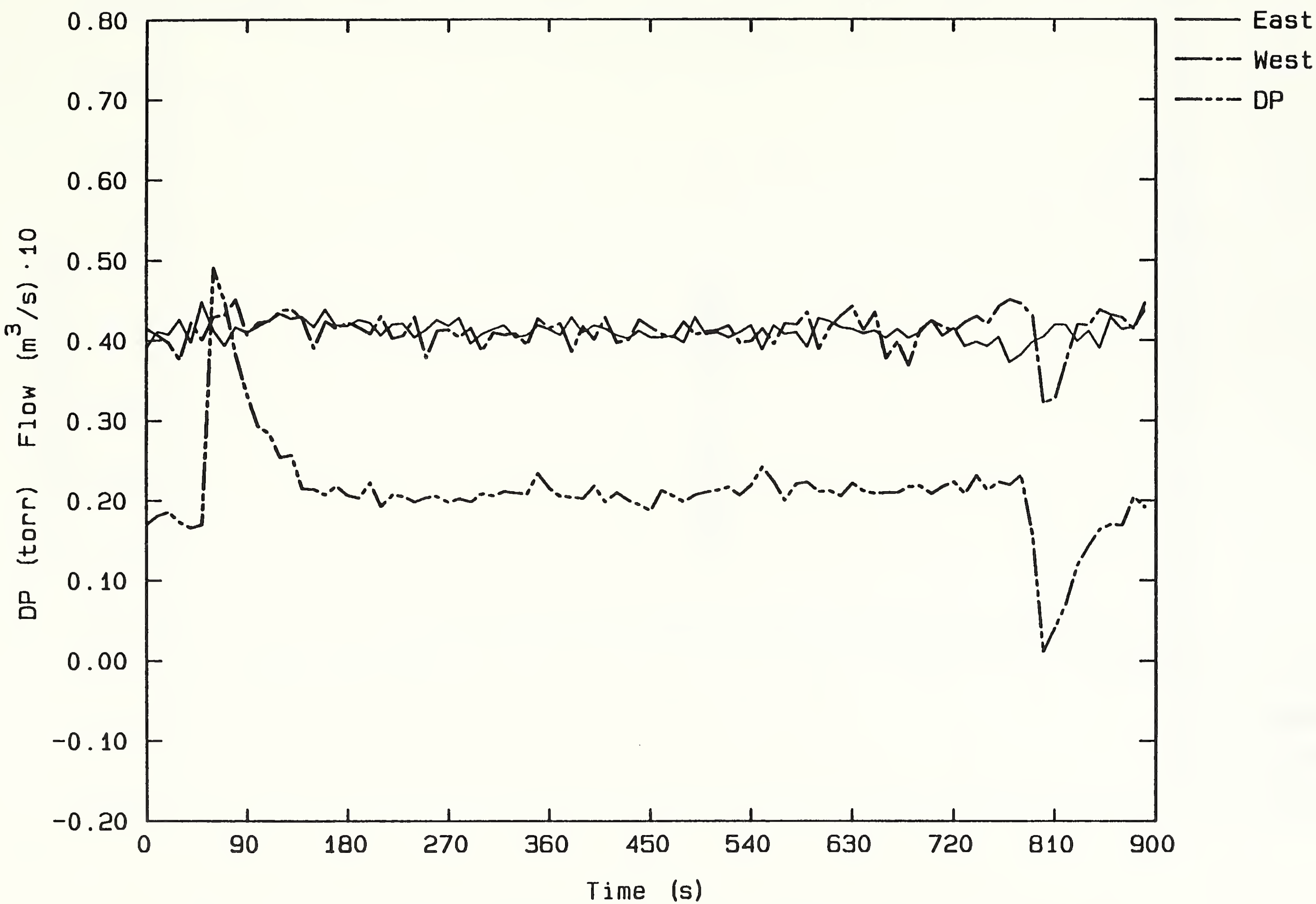

Figure 14. Test G1102 Cabin differential pressure and inlet flows, east and west

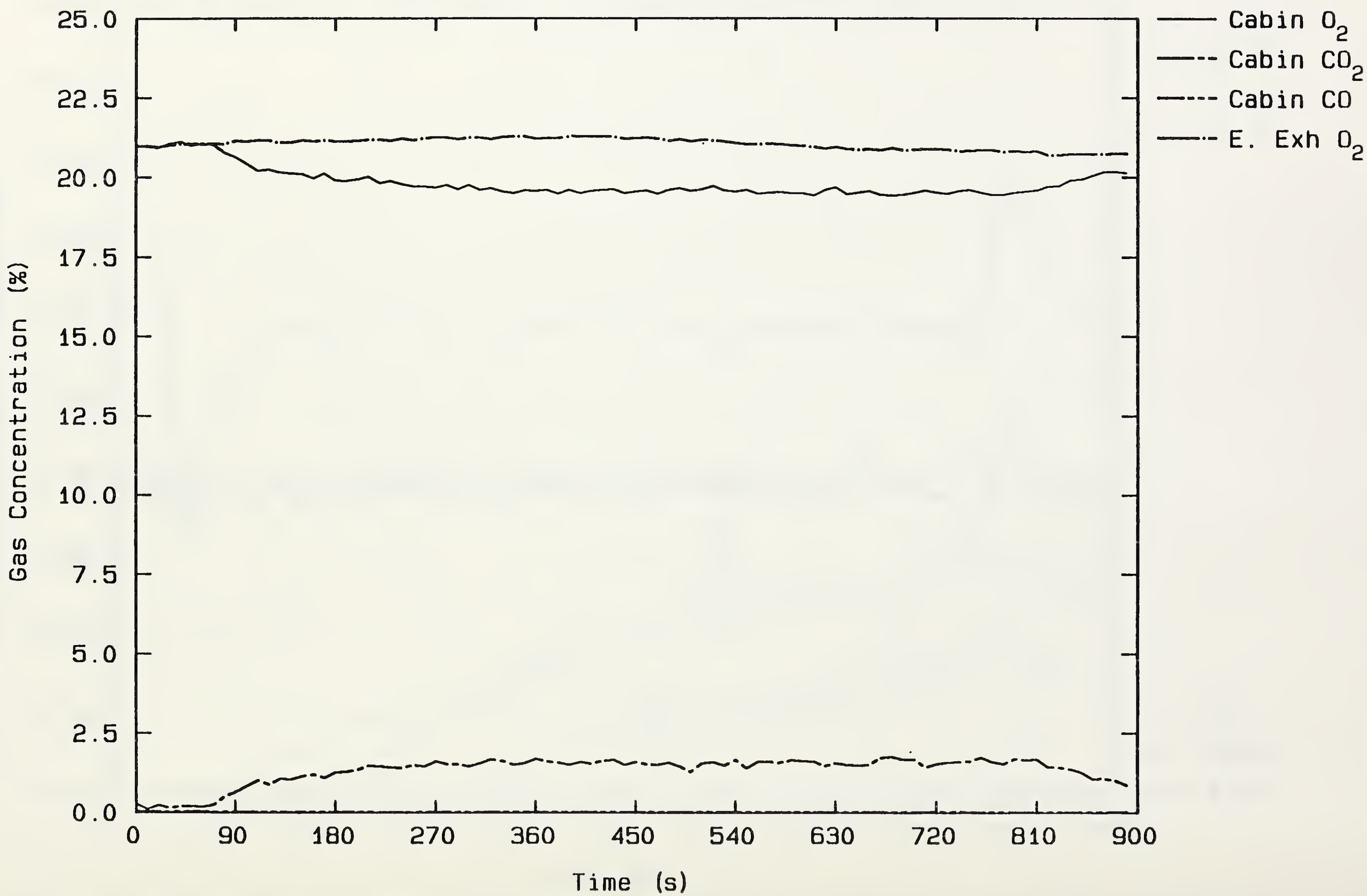

Figure 15. Test G1102 Cabin and exhaust gas concentrations

TEST G1902

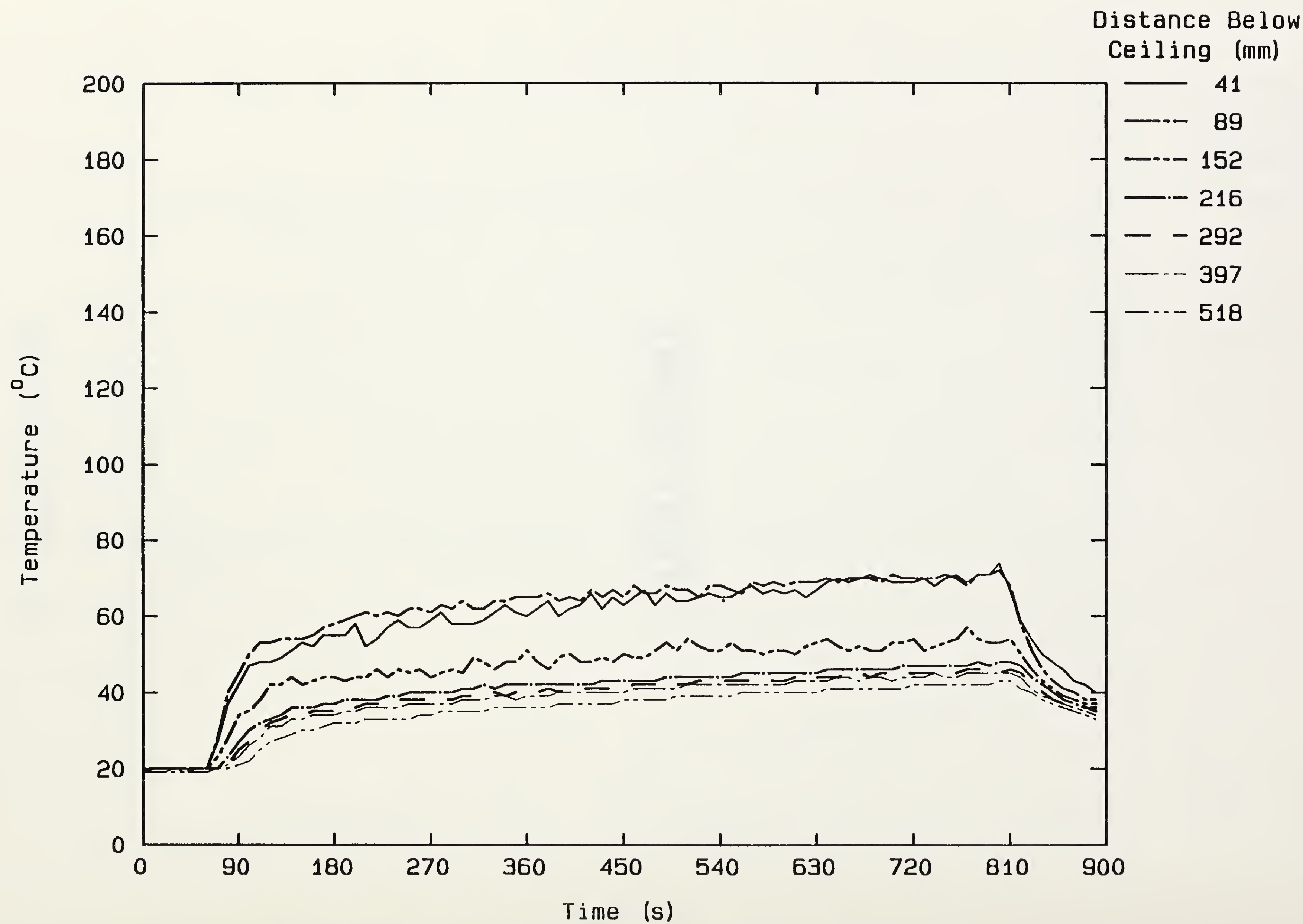

Figure 16. Test G1902 Vertical temperature profile at position A

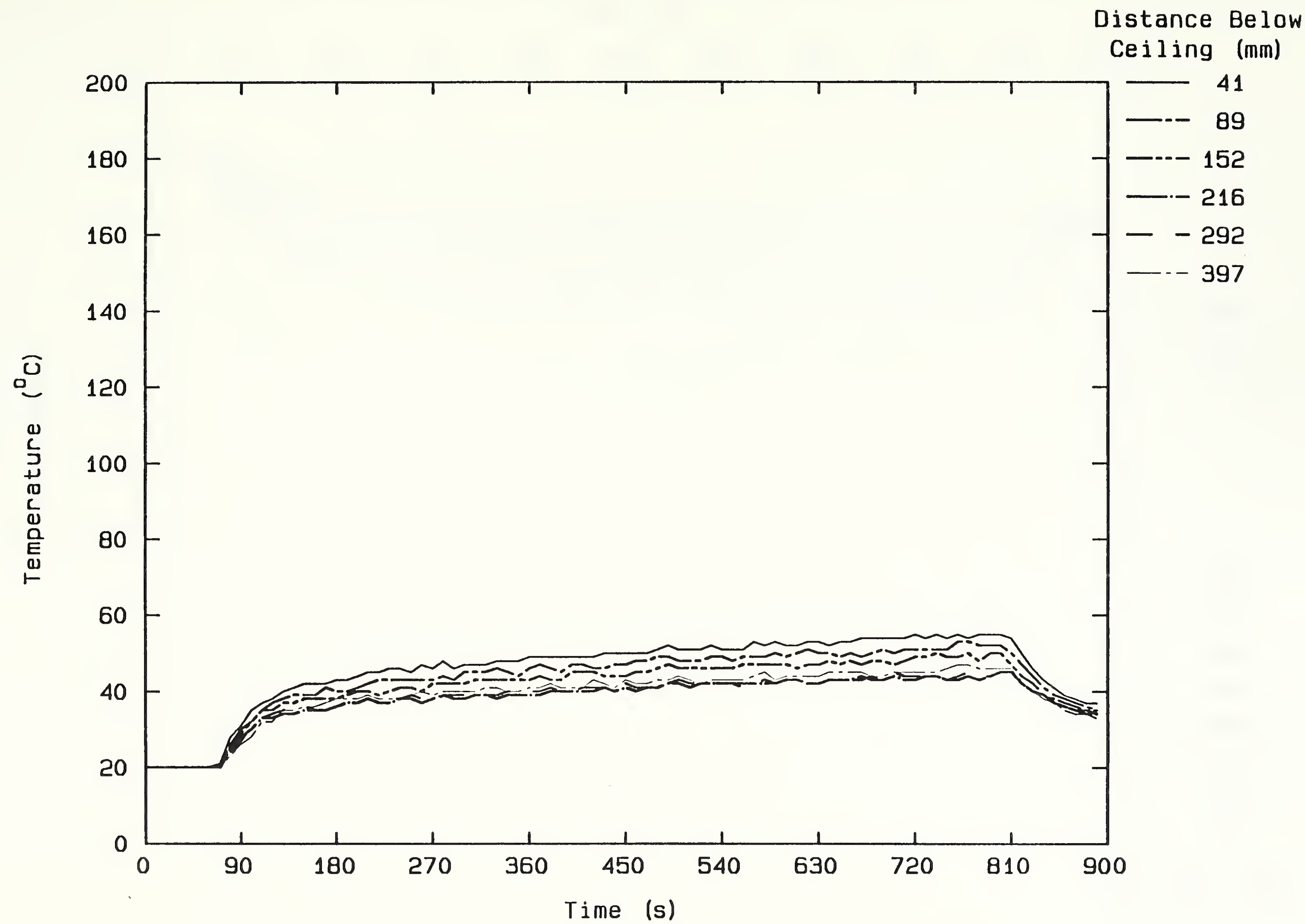

Figure 17. Test G1902 Vertical temperature profile at position B

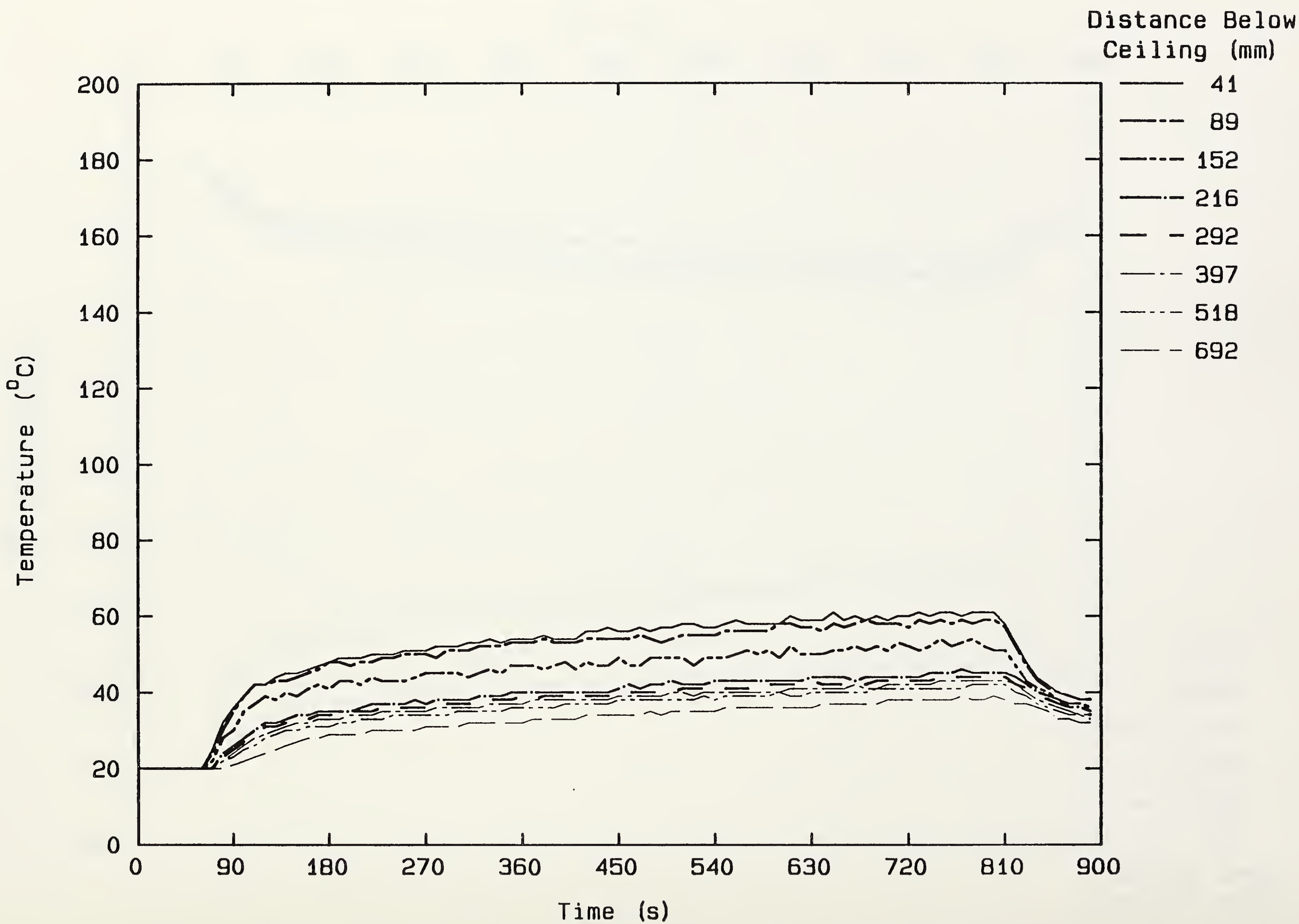

Figure 18. Test G1902 Vertical temperature profile at position C

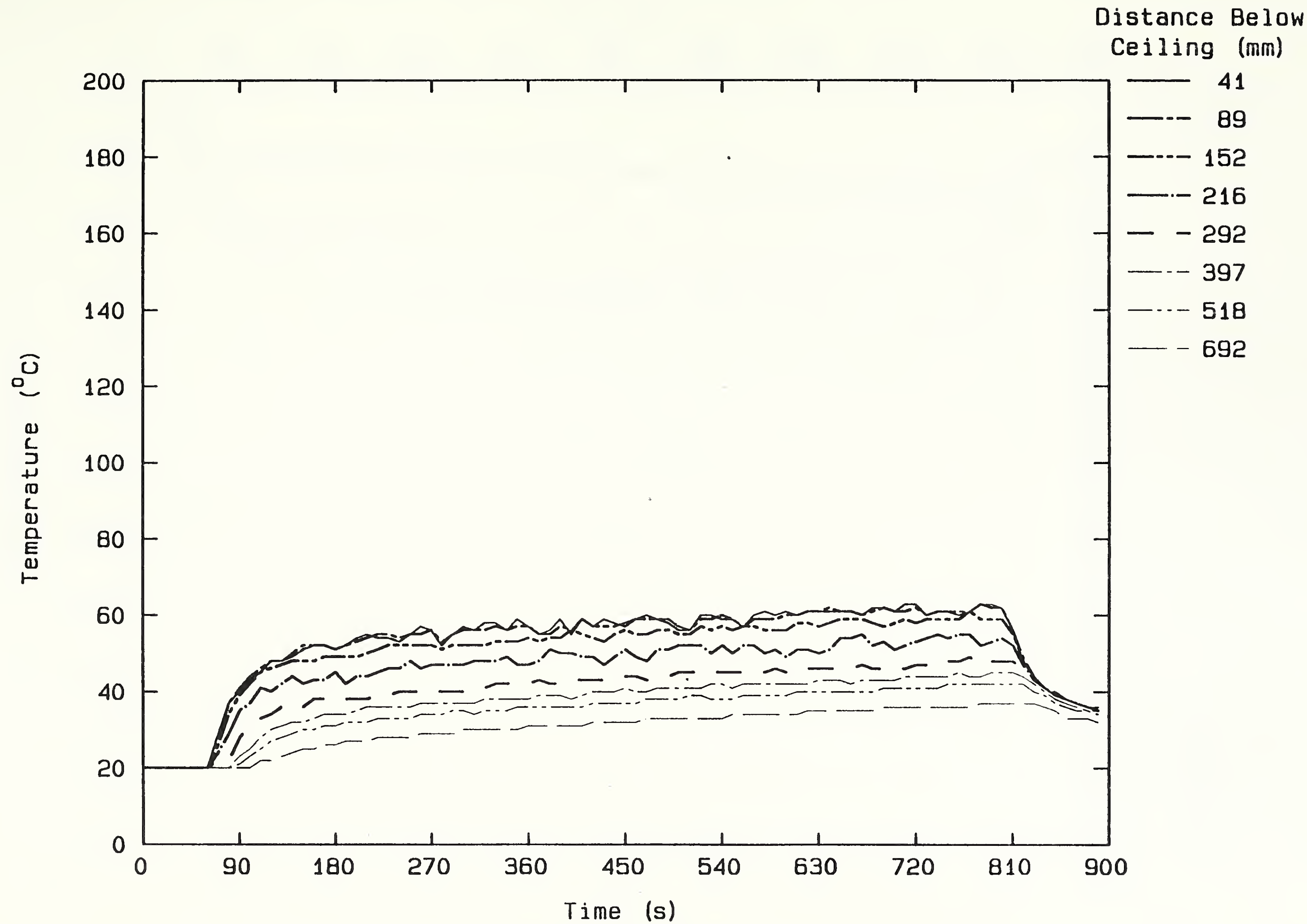

Figure 19. Test G1902 Vertical temperature profile at position D

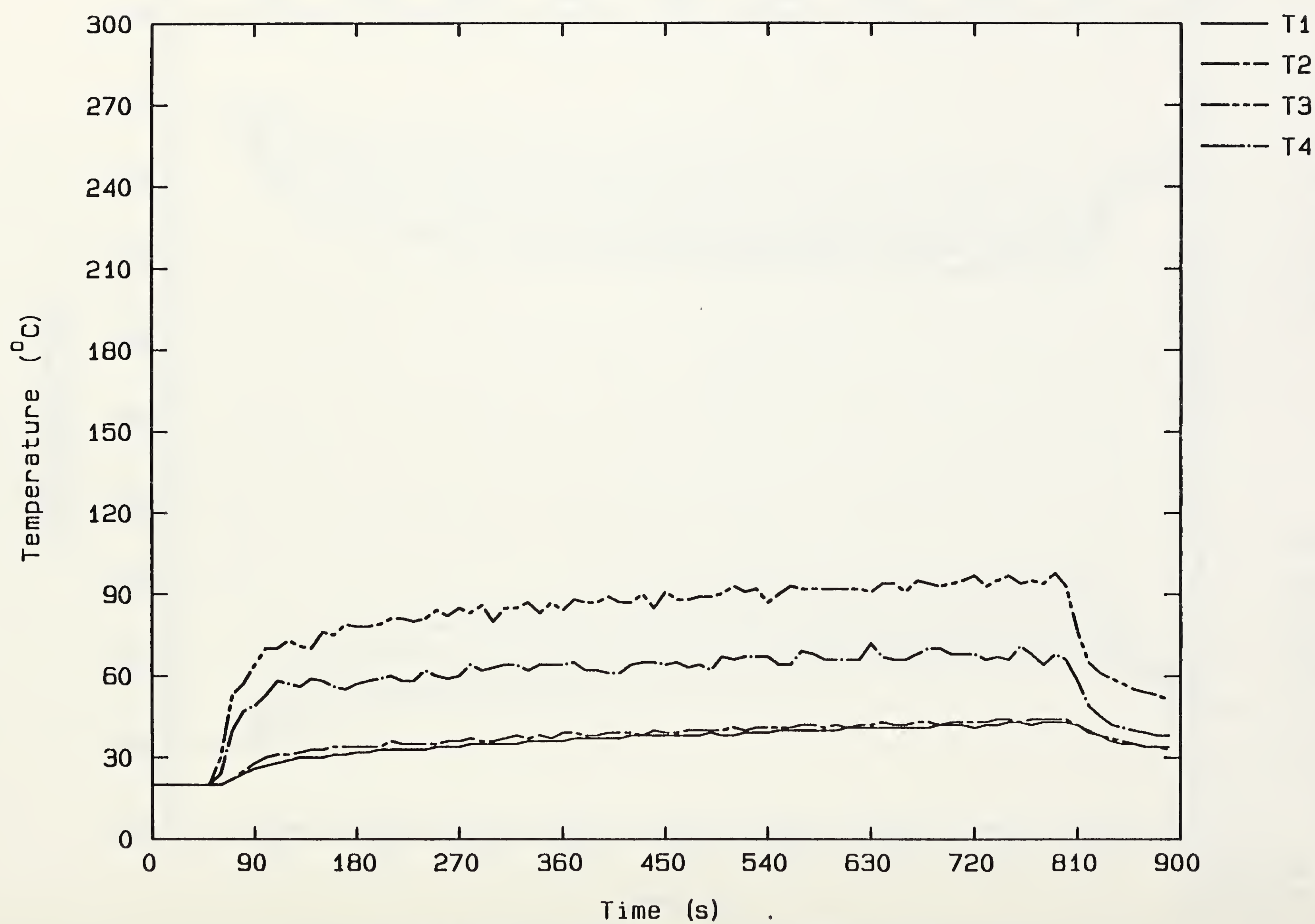

Figure 20. Test G1902 Ceiling interior surface temperature: T1 - T4

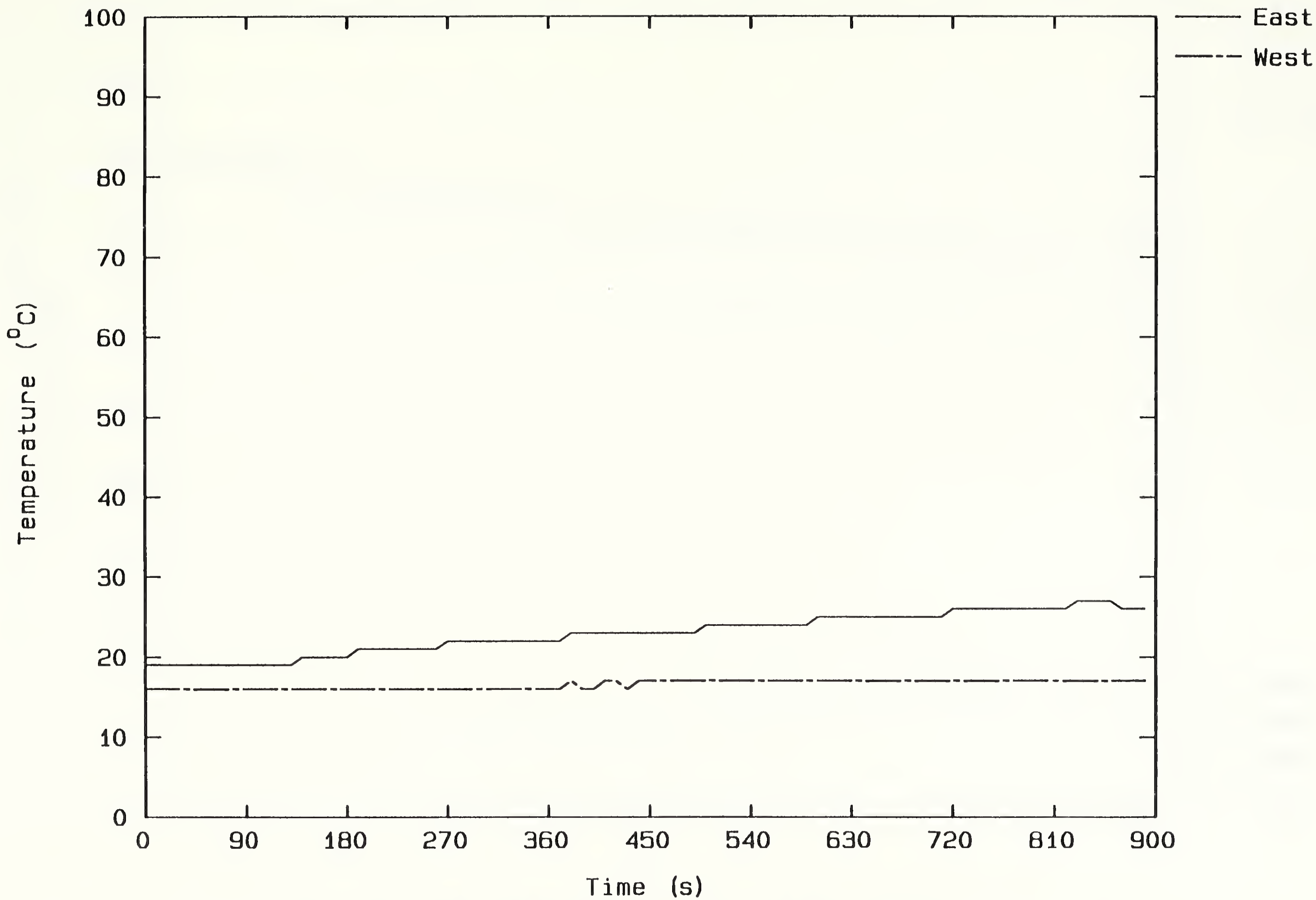

Figure 21. Test G1902 Exhaust temperature: east and west

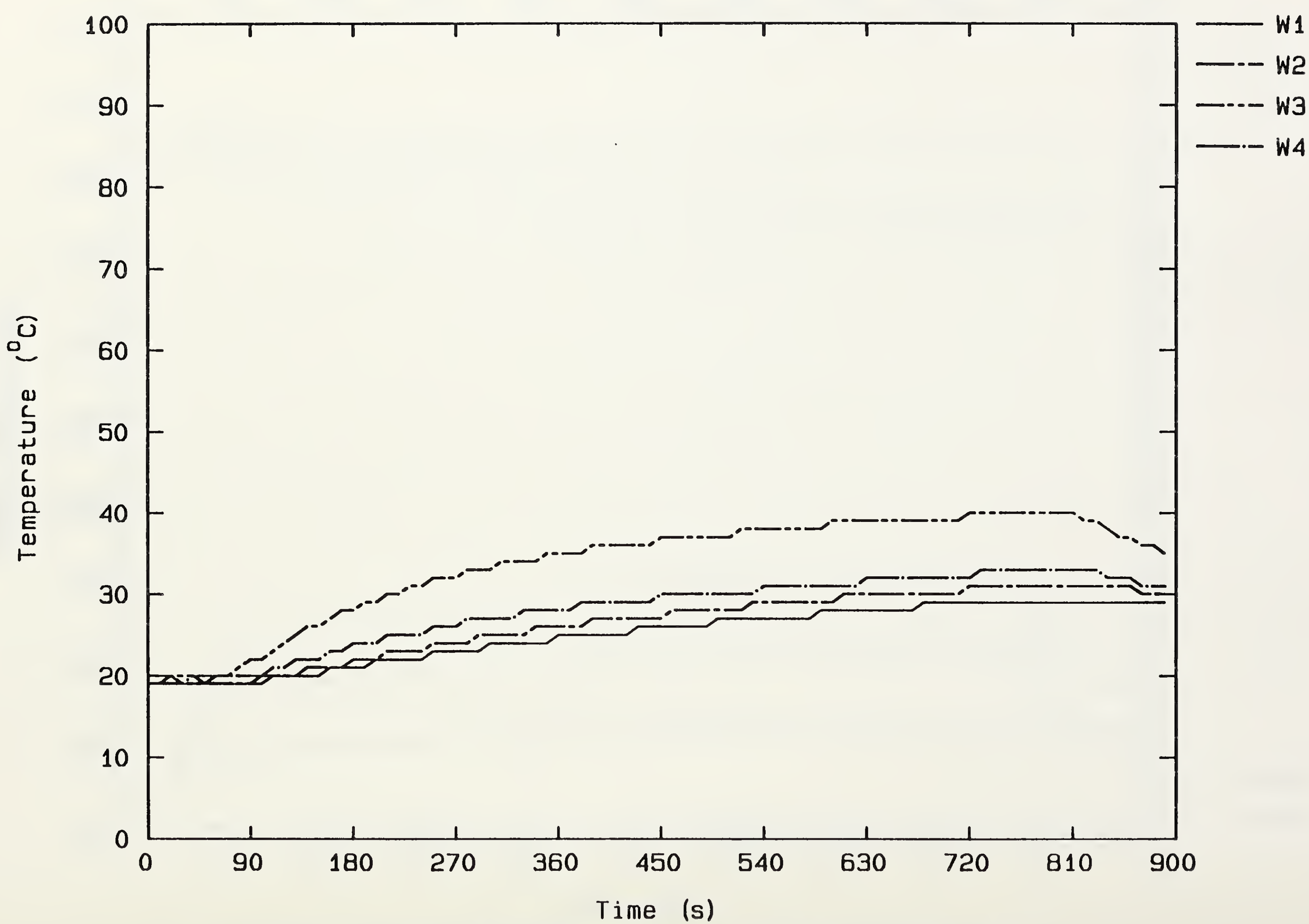

Figure 22. Test G1902 Wall interior surface temperature: W1 - W4

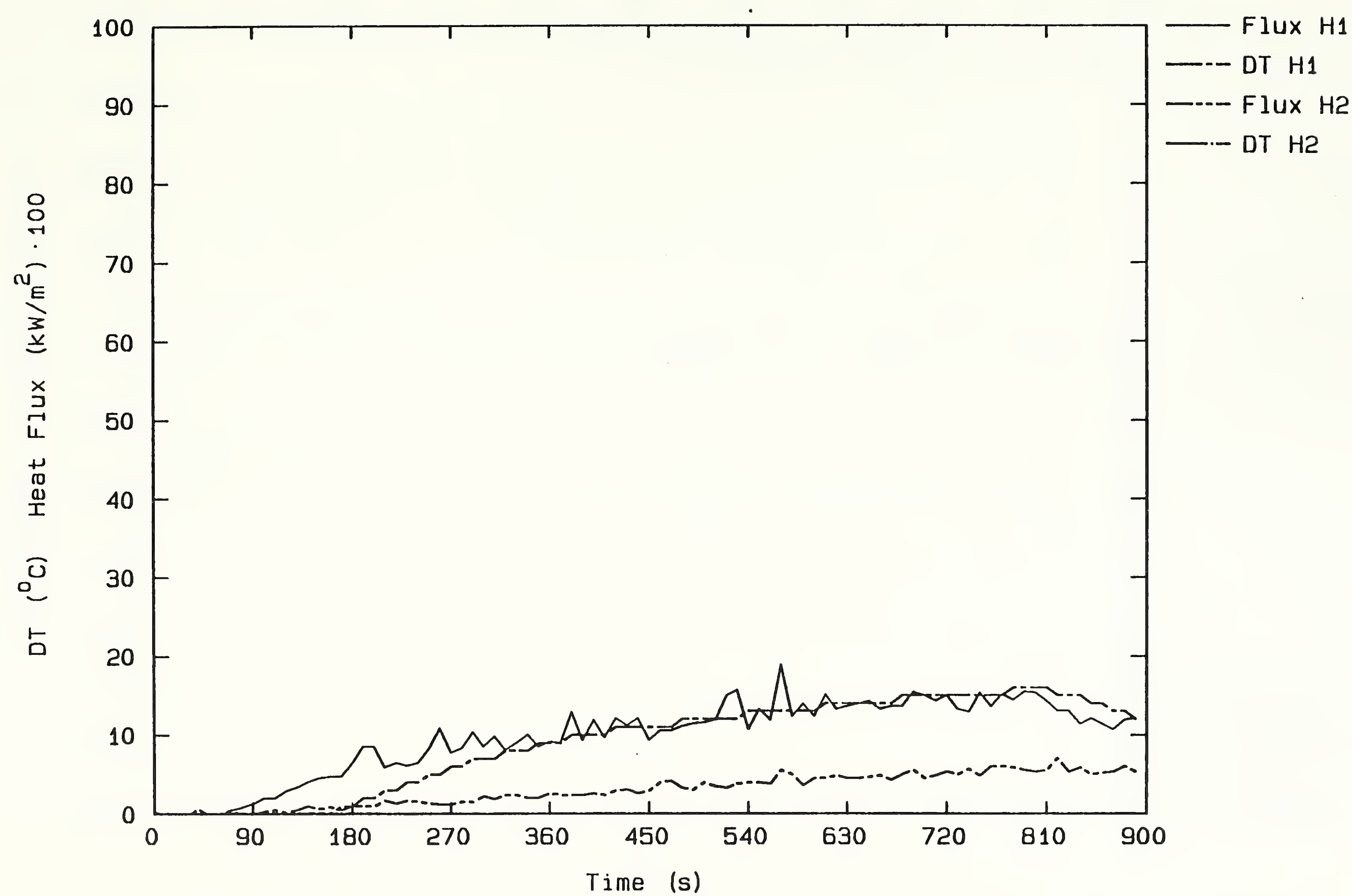

Figure 23. Test G1902 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

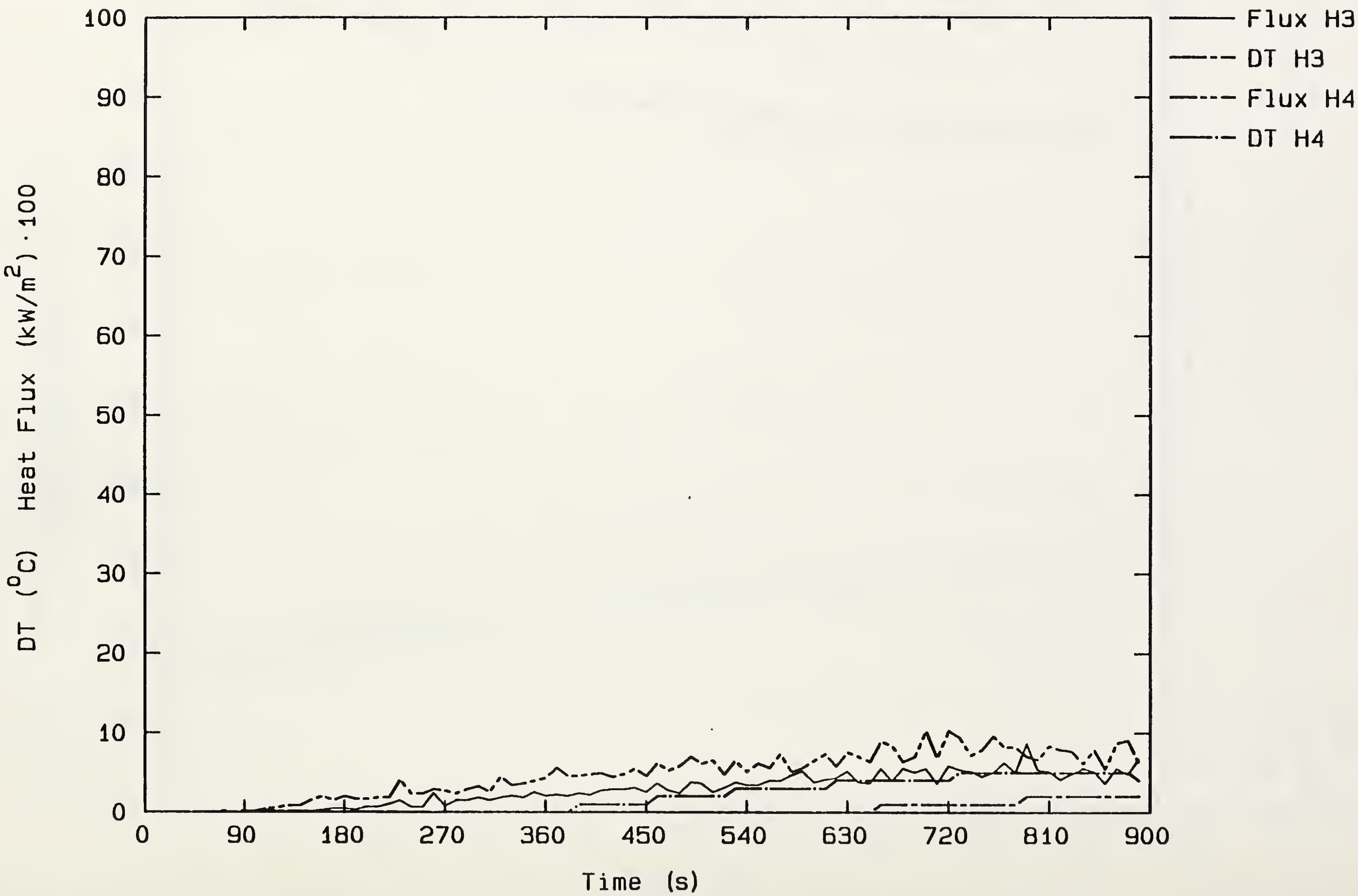

Figure 24. Test G1902 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

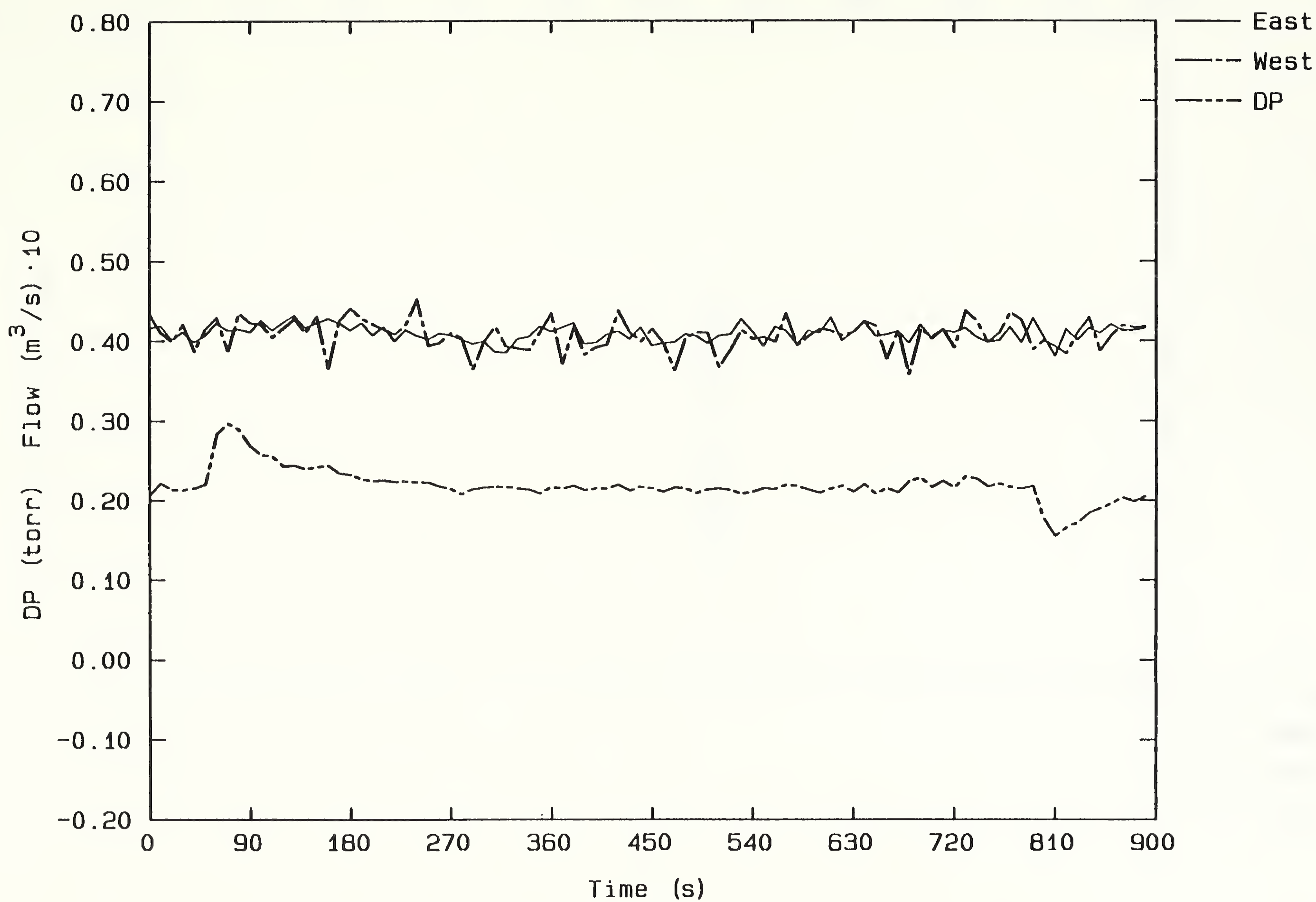

Figure 25. Test G1902 Cabin differential pressure and inlet flows, east and west

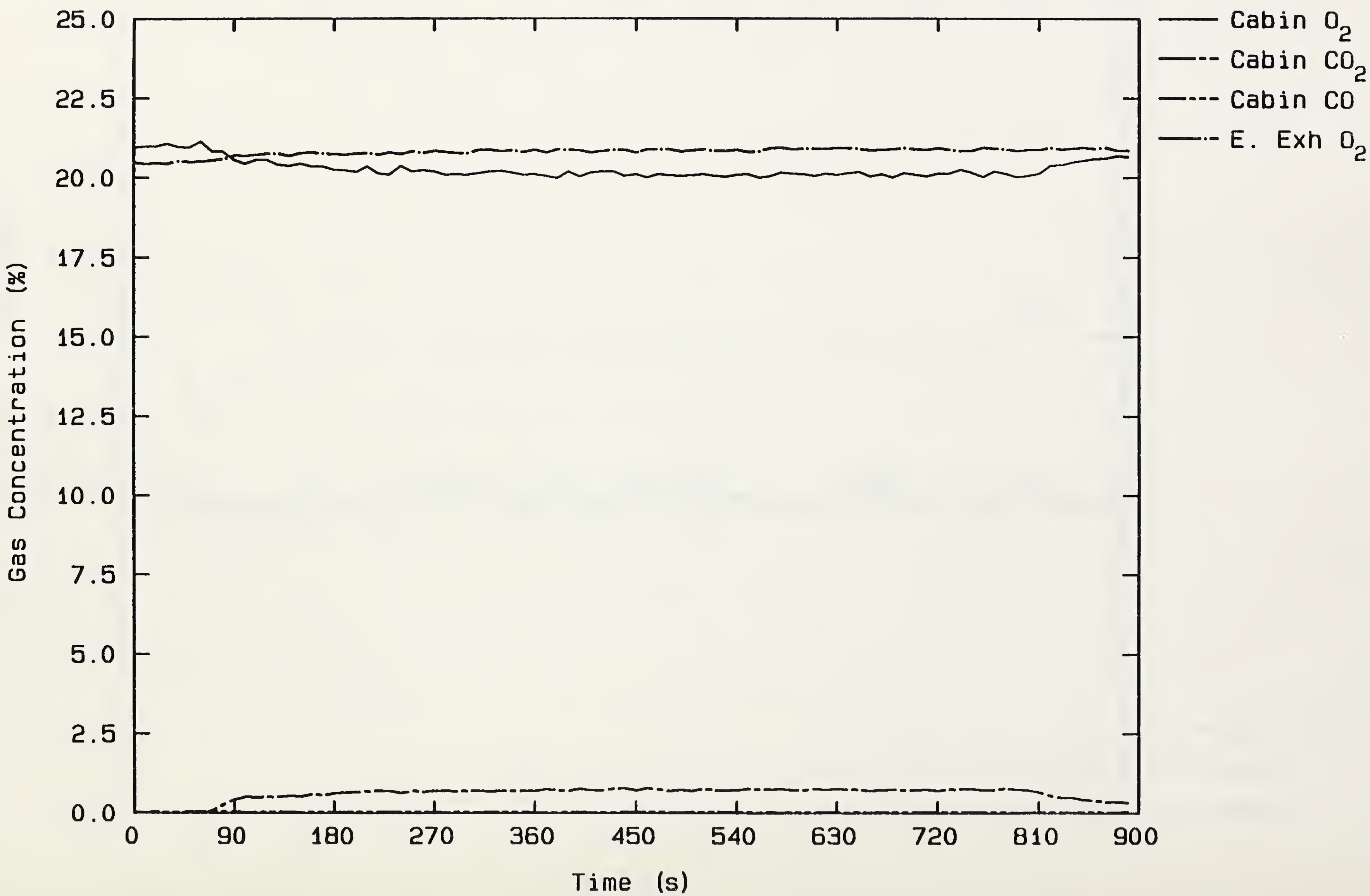

Figure 26. Test G1902 Cabin and exhaust gas concentrations

TEST G2502

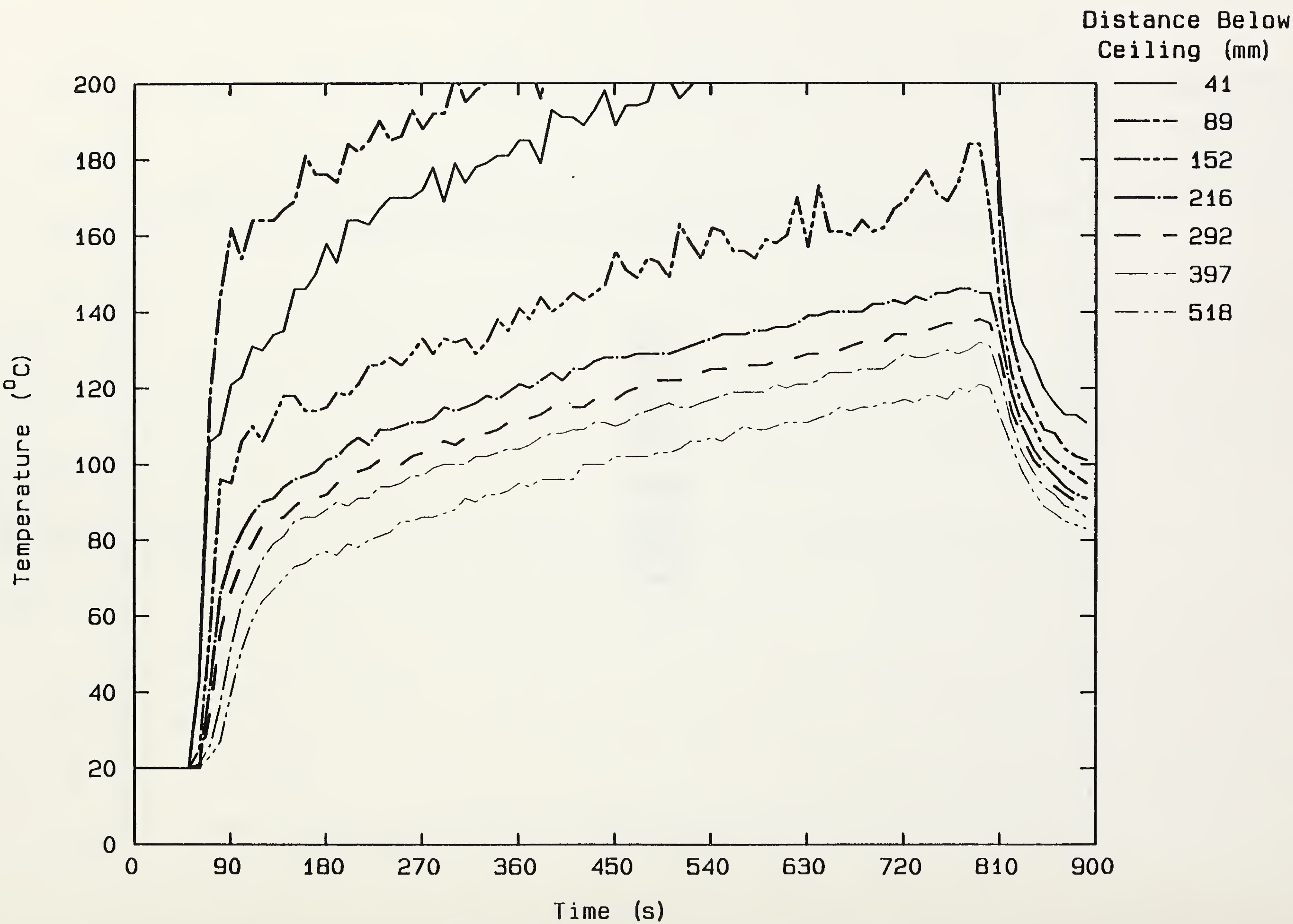

Figure 27. Test G2502 Vertical temperature profile at position A

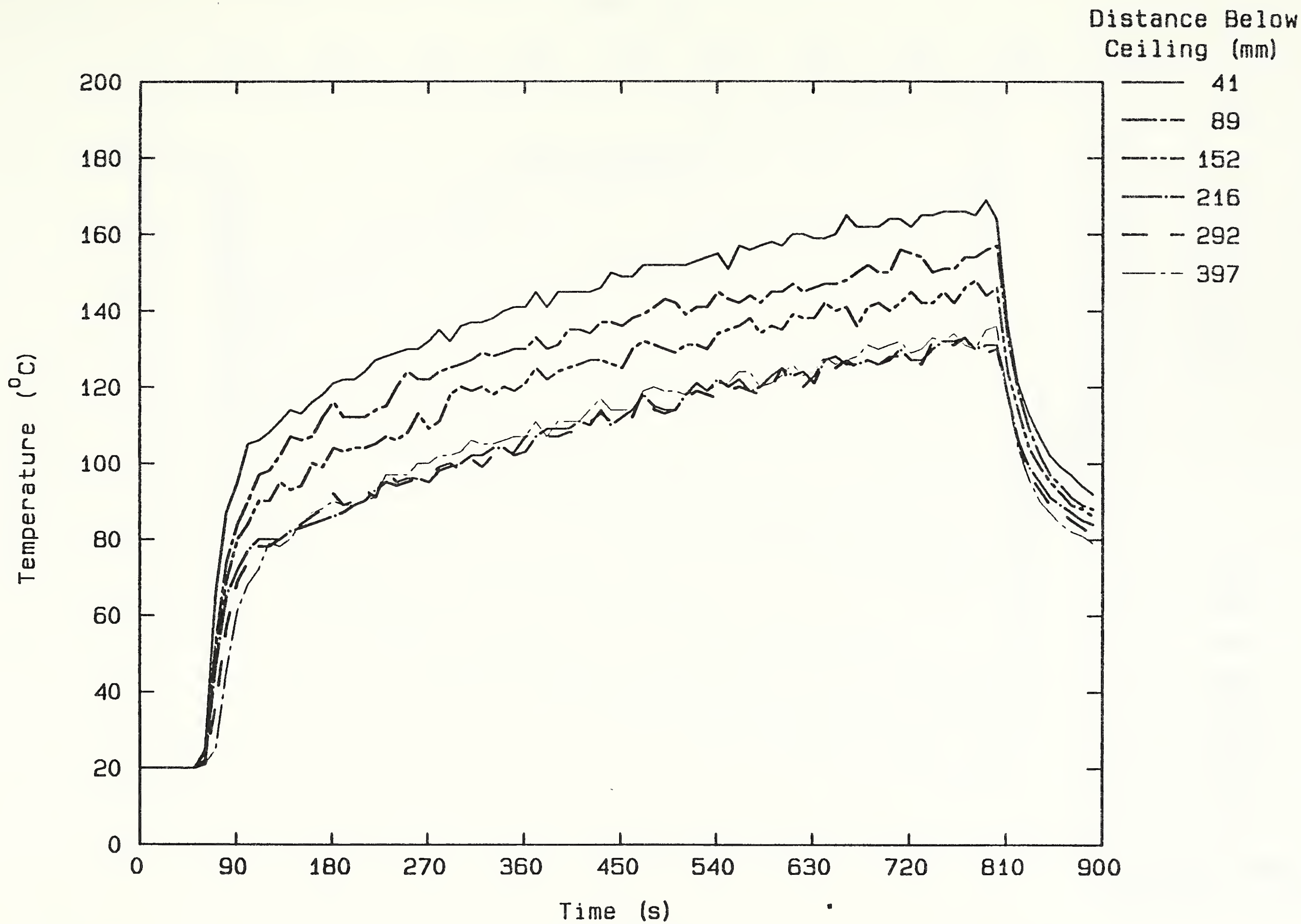

Figure 28. Test G2502 Vertical temperature profile at position B

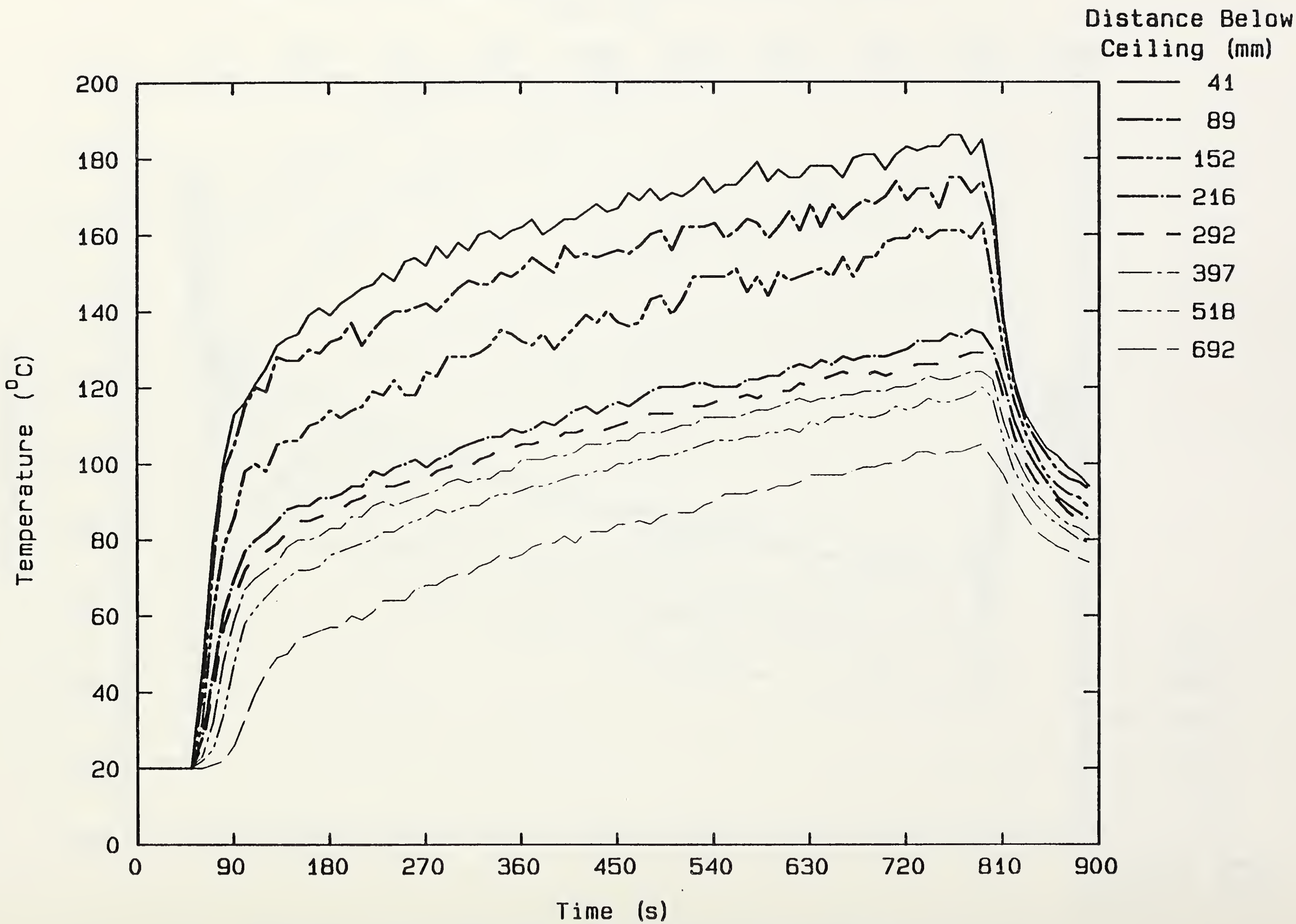

Figure 29. Test G2502 Vertical temperature profile at position C

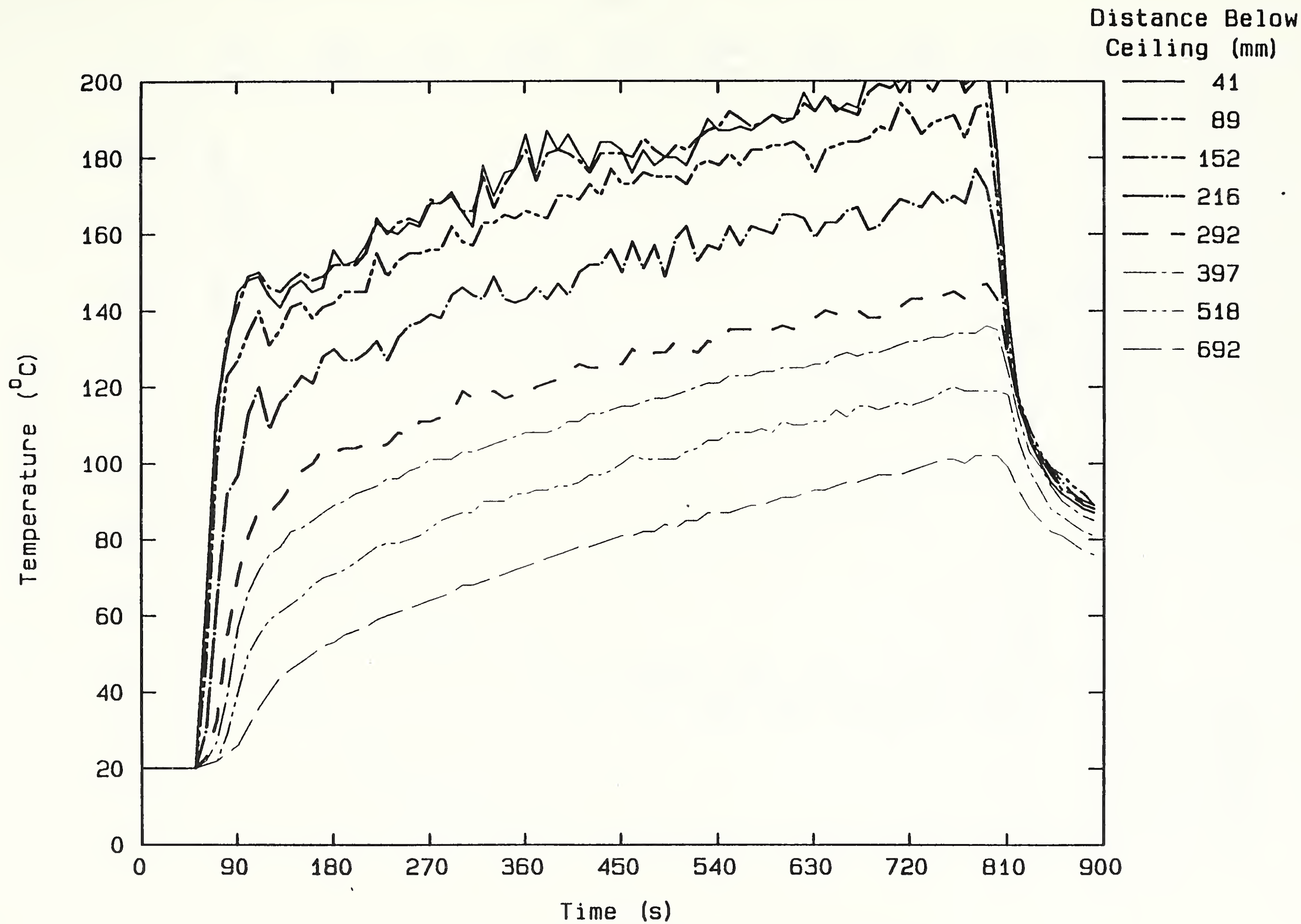

Figure 30. Test G2502 Vertical temperature profile at position D

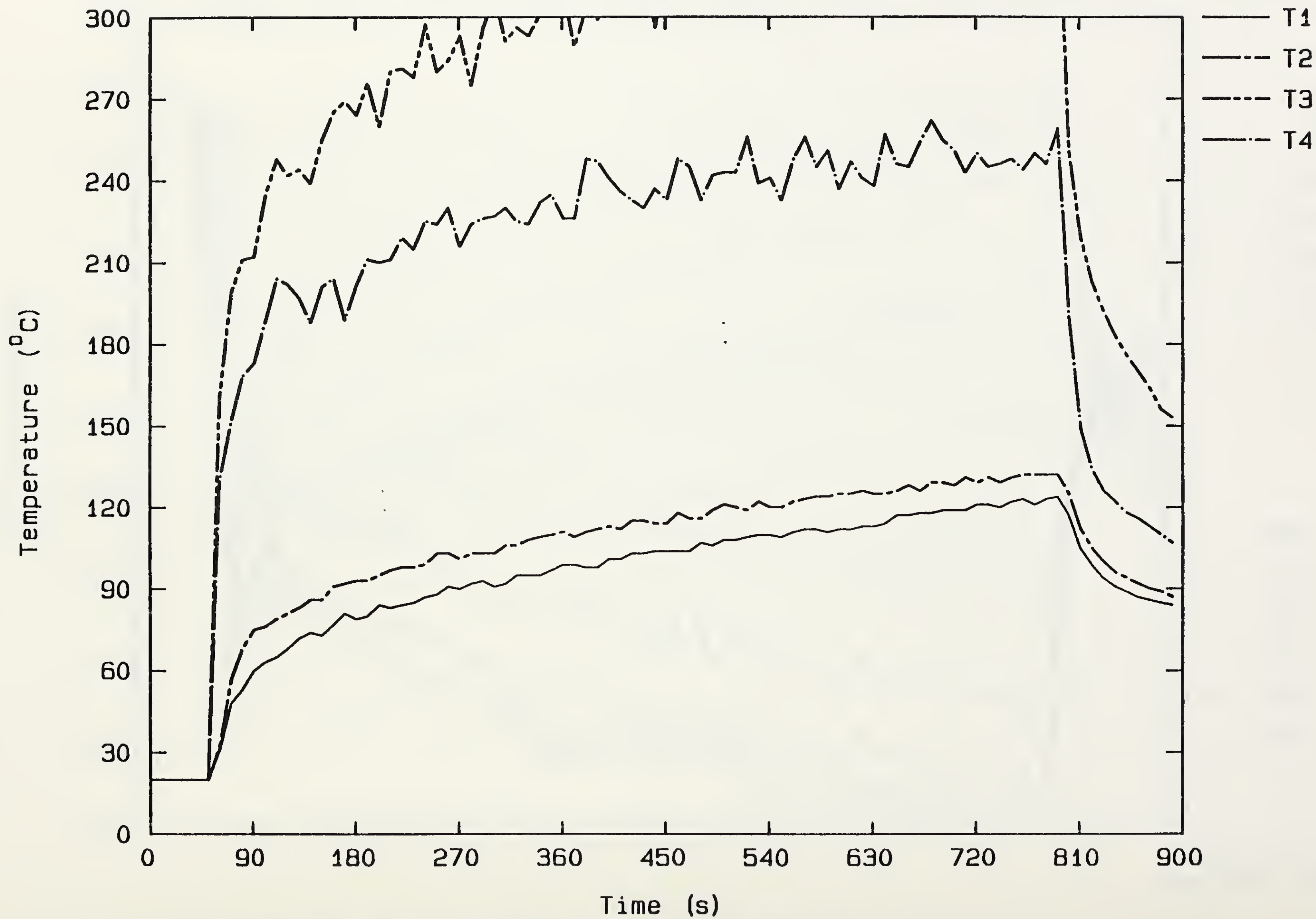

Figure 31. Test G2502 Ceiling interior surface temperature: T1 - T4

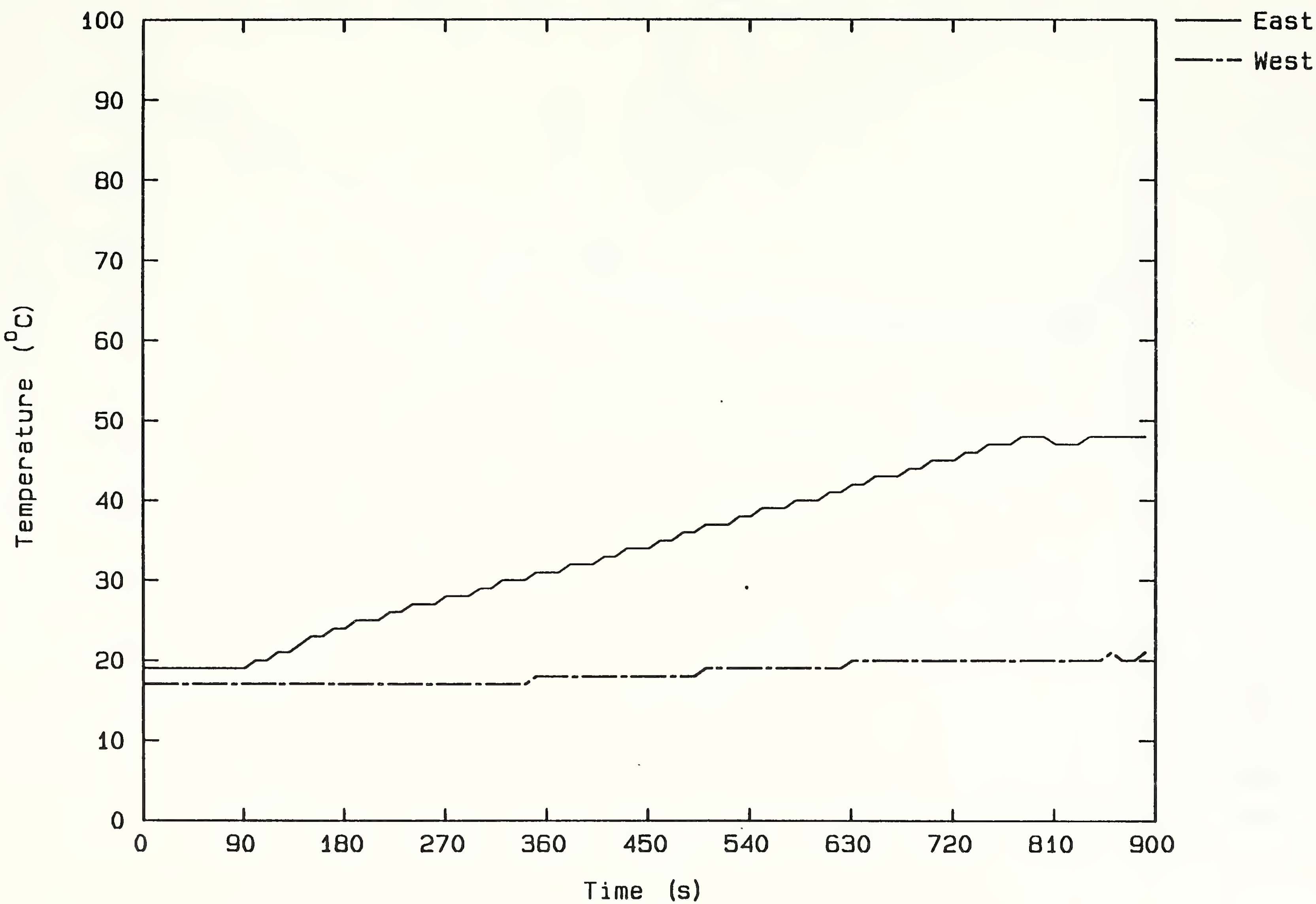

Figure 32. Test G2502 Exhaust temperature: east and west

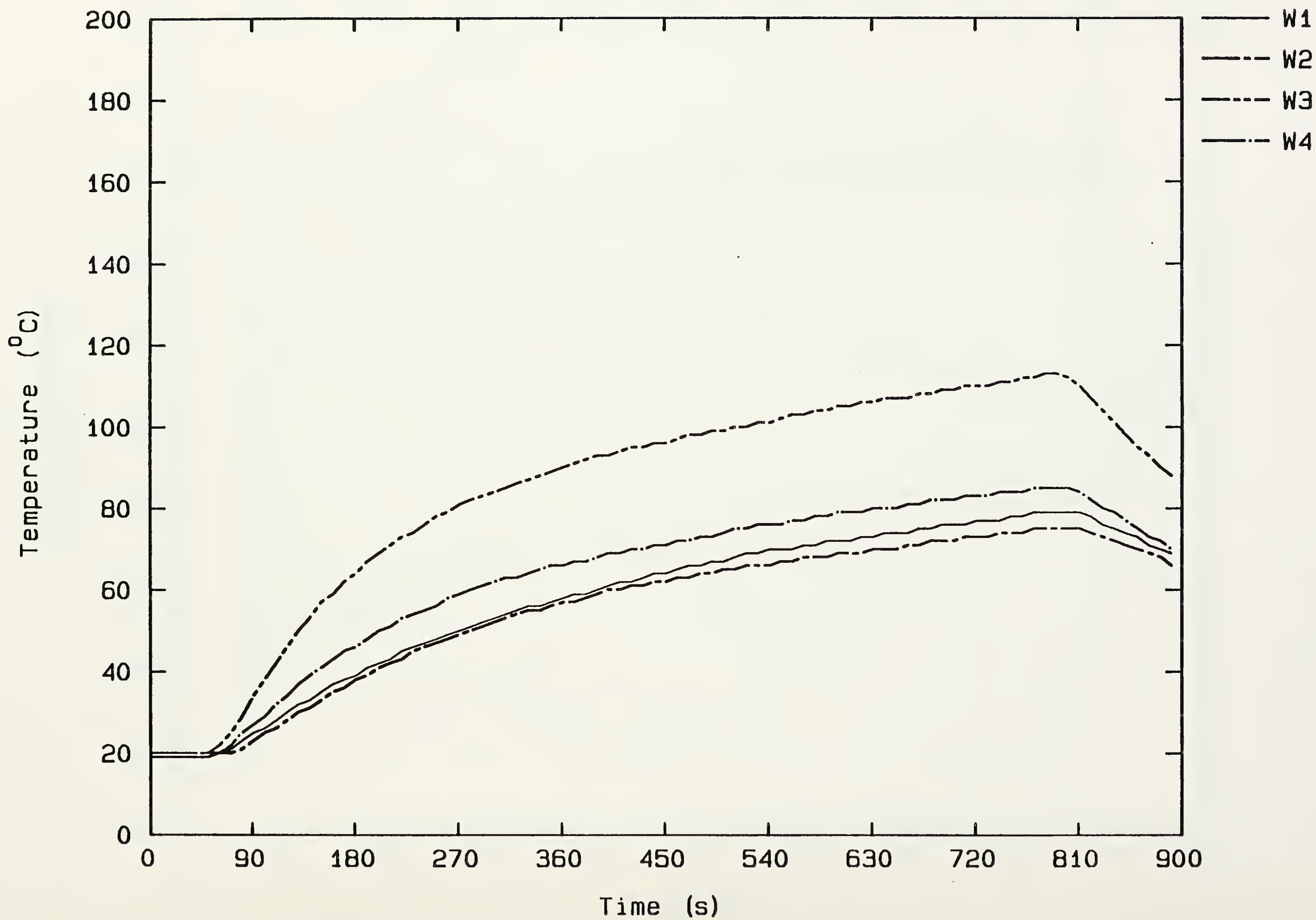

Figure 33. Test G2502 Wall interior surface temperature: W1 - W4

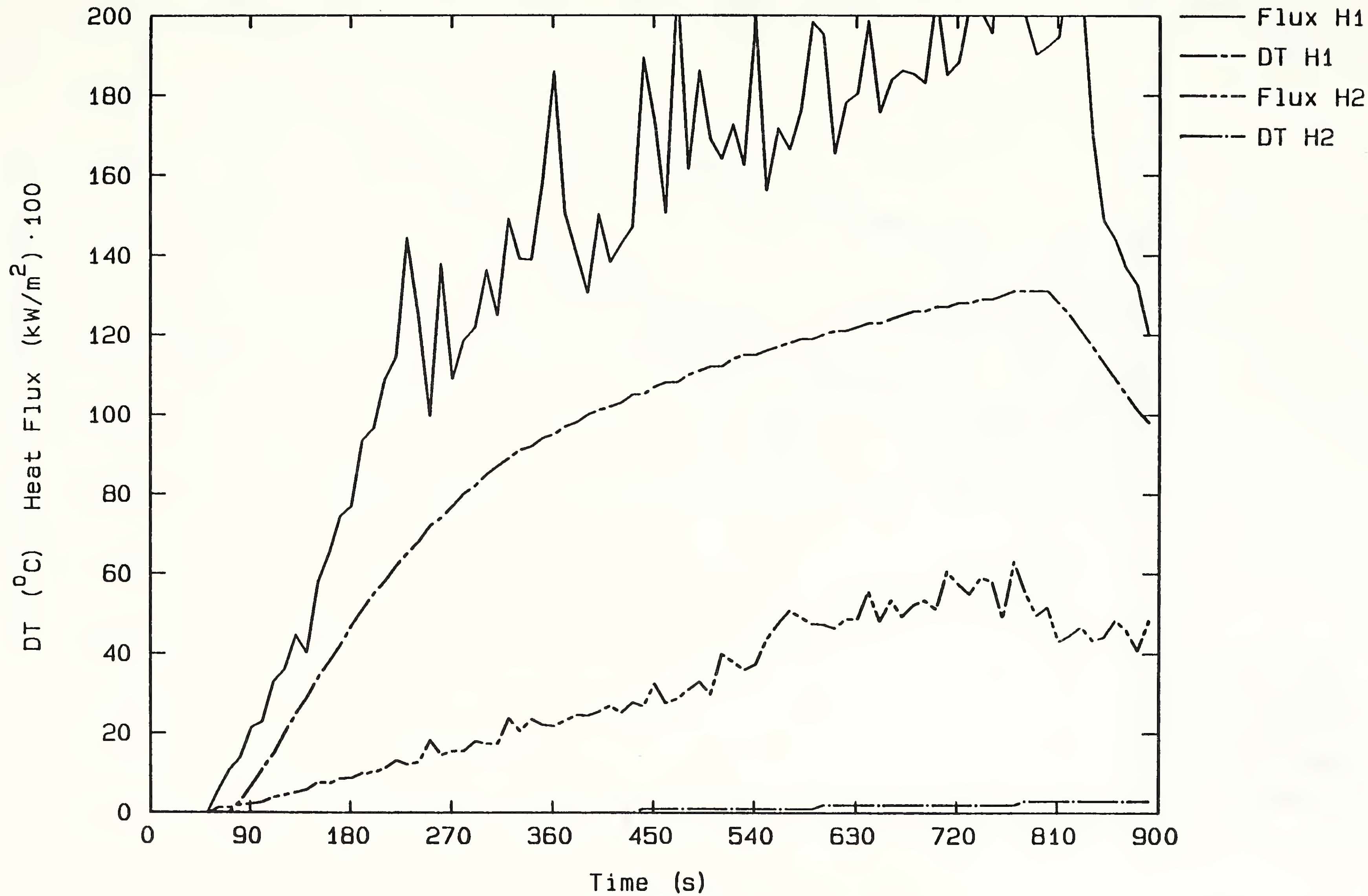

Figure 34. Test G2502 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

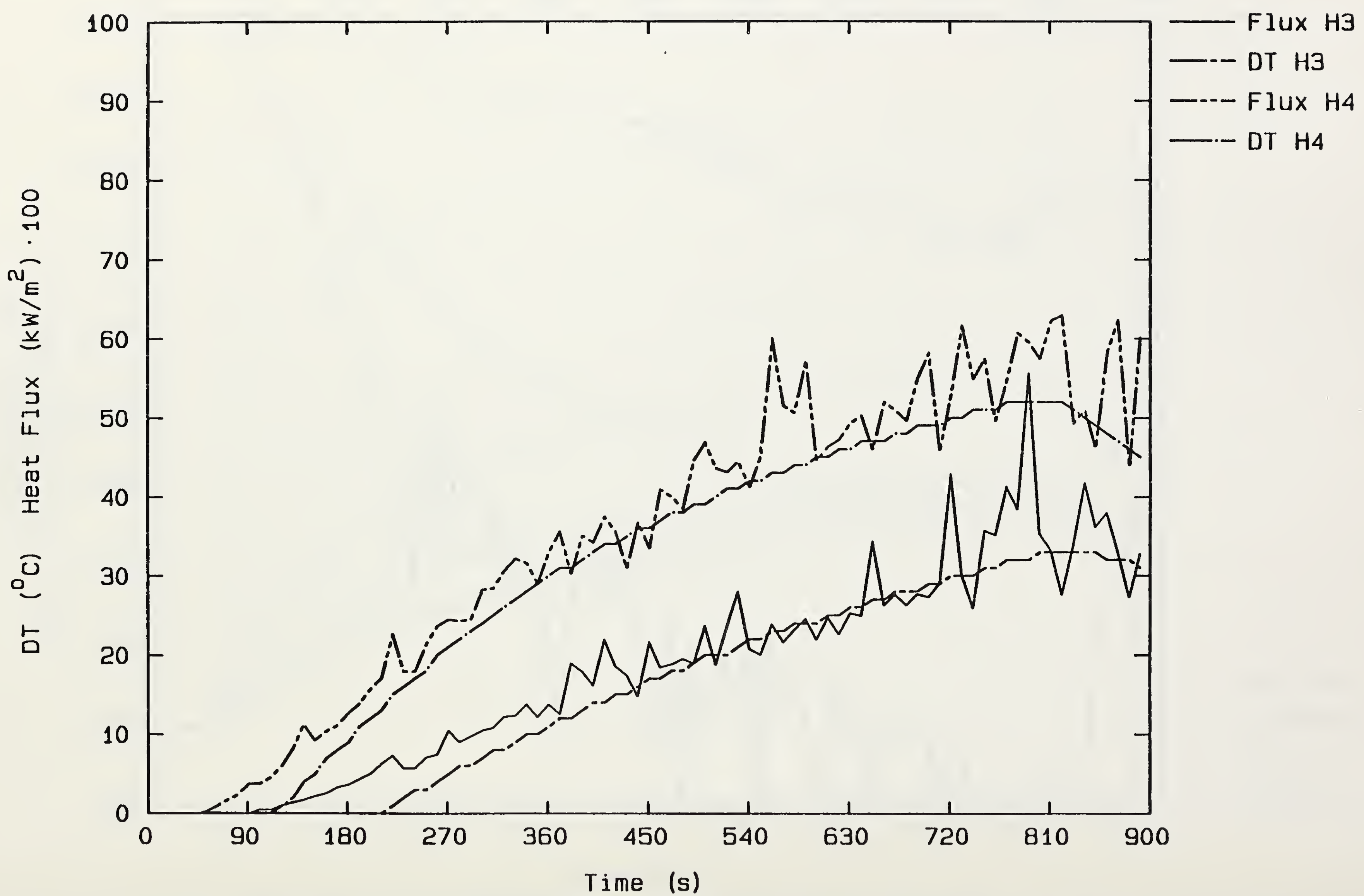

Figure 35. Test G2502 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

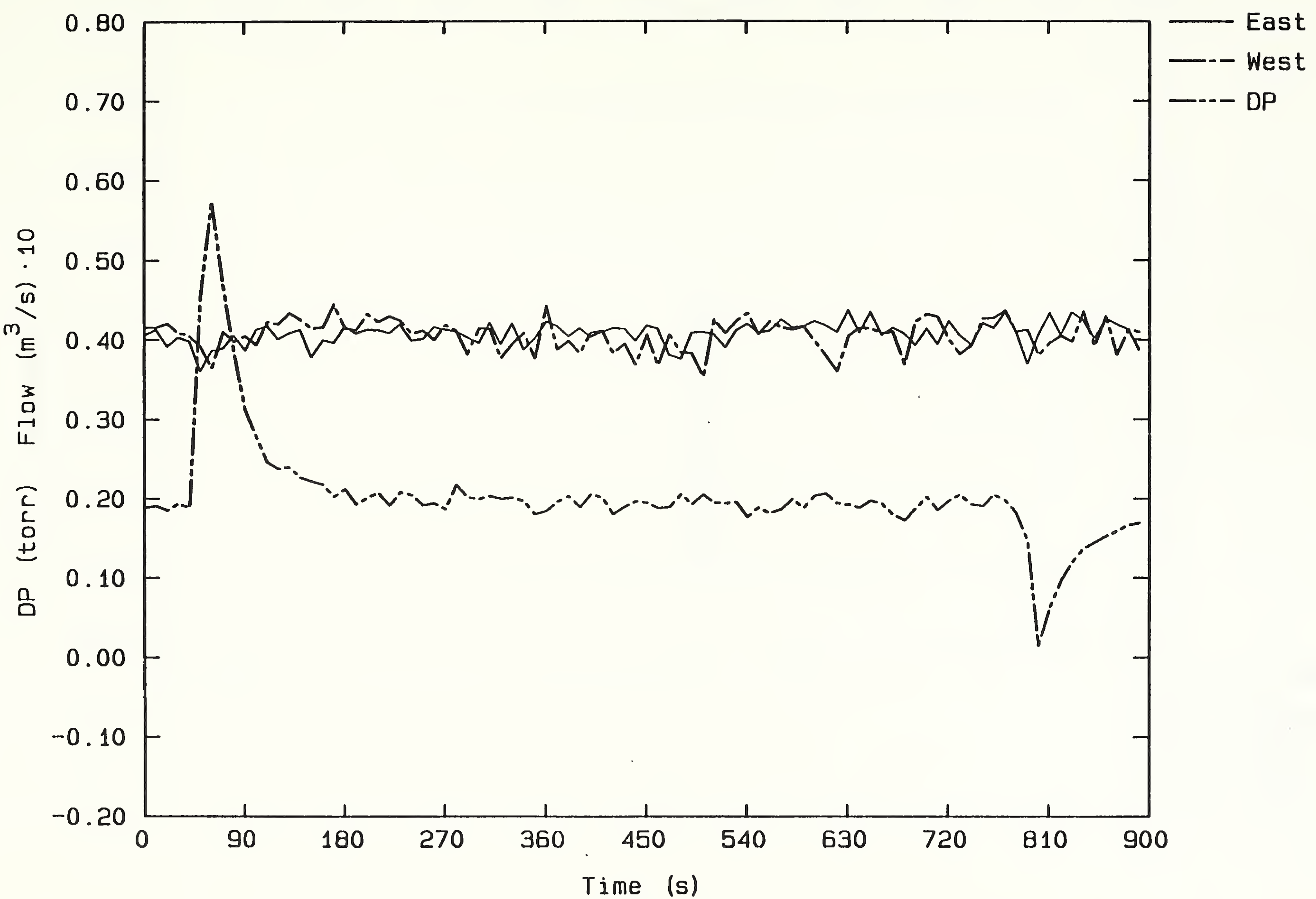

Figure 36. Test G2502 Cabin differential pressure and inlet flows, east and west

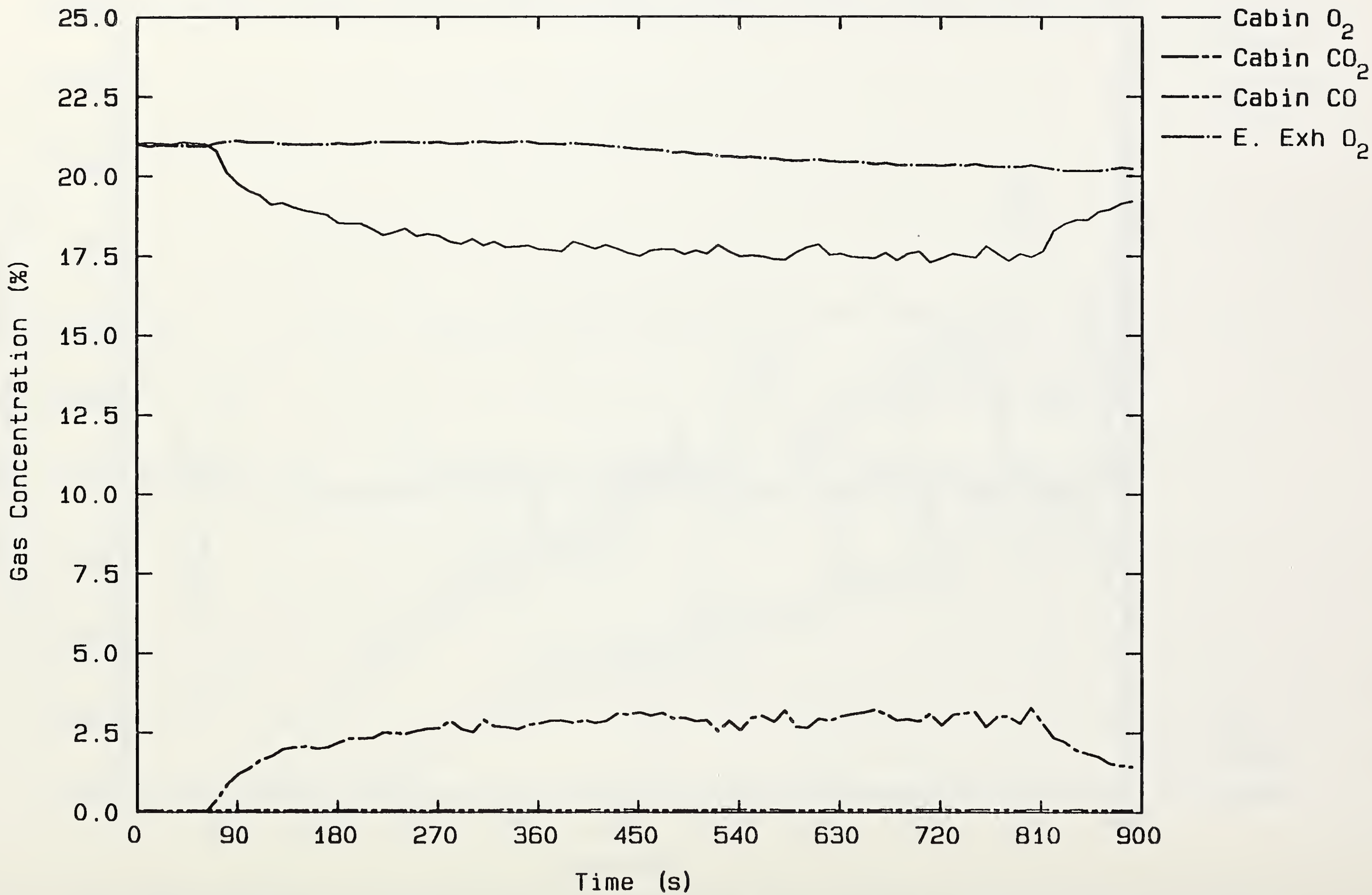

Figure 37. Test G2502 Cabin and exhaust gas concentrations

TEST G1103

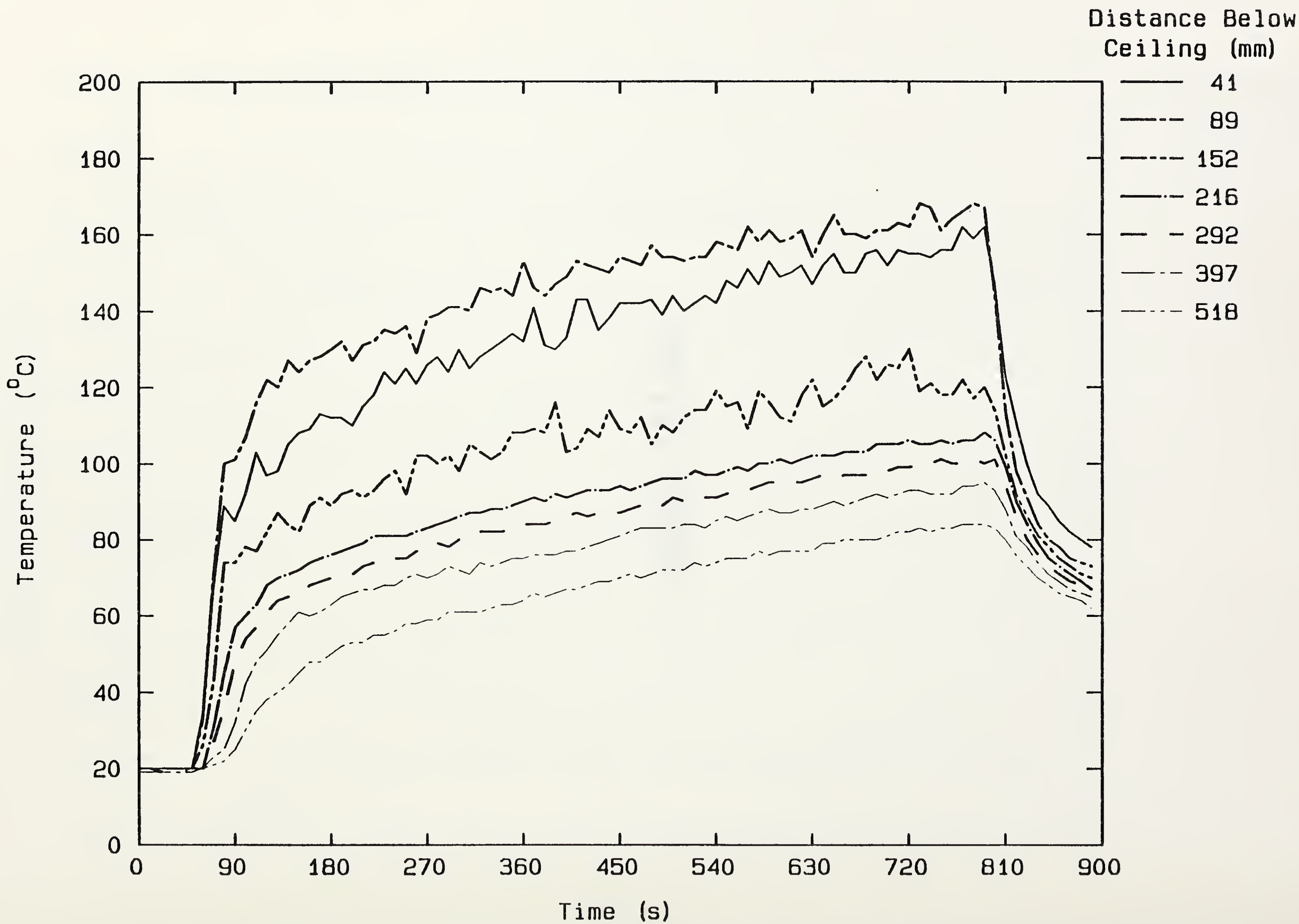

Figure 38. Test G1103 Vertical temperature profile at position A

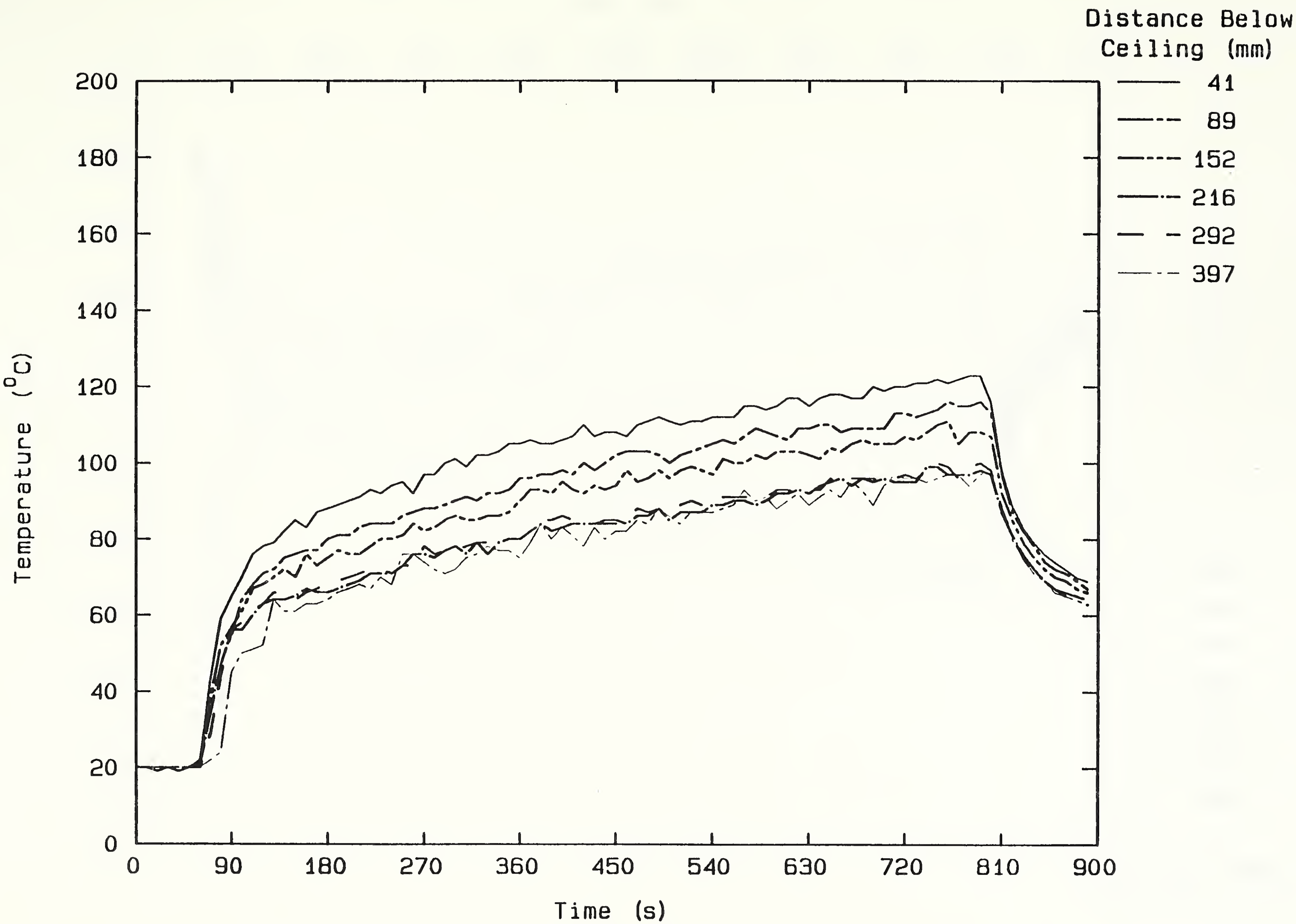

Figure 39. Test G1103 Vertical temperature profile at position B

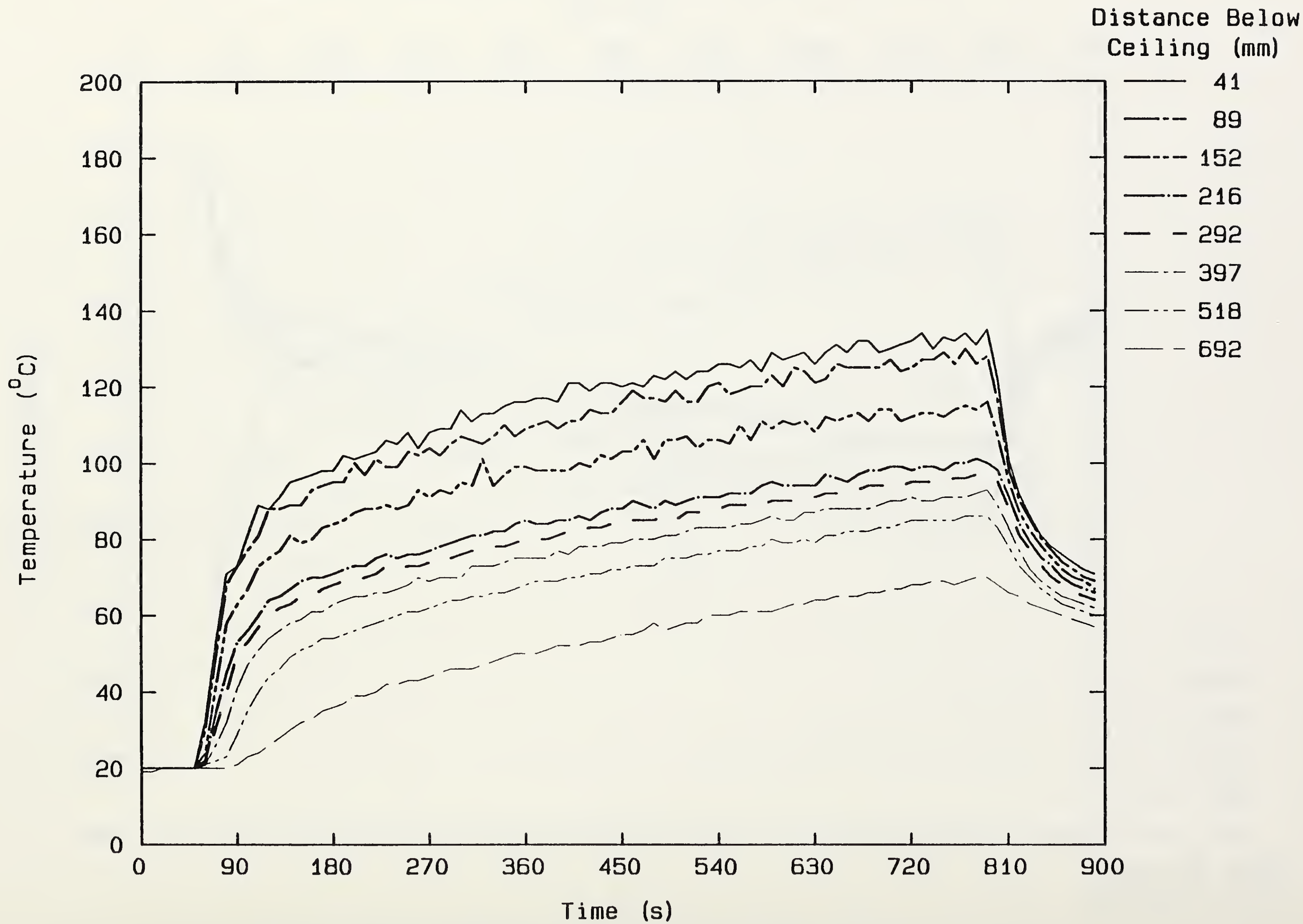

Figure 40. Test G1103 Vertical temperature profile at position C

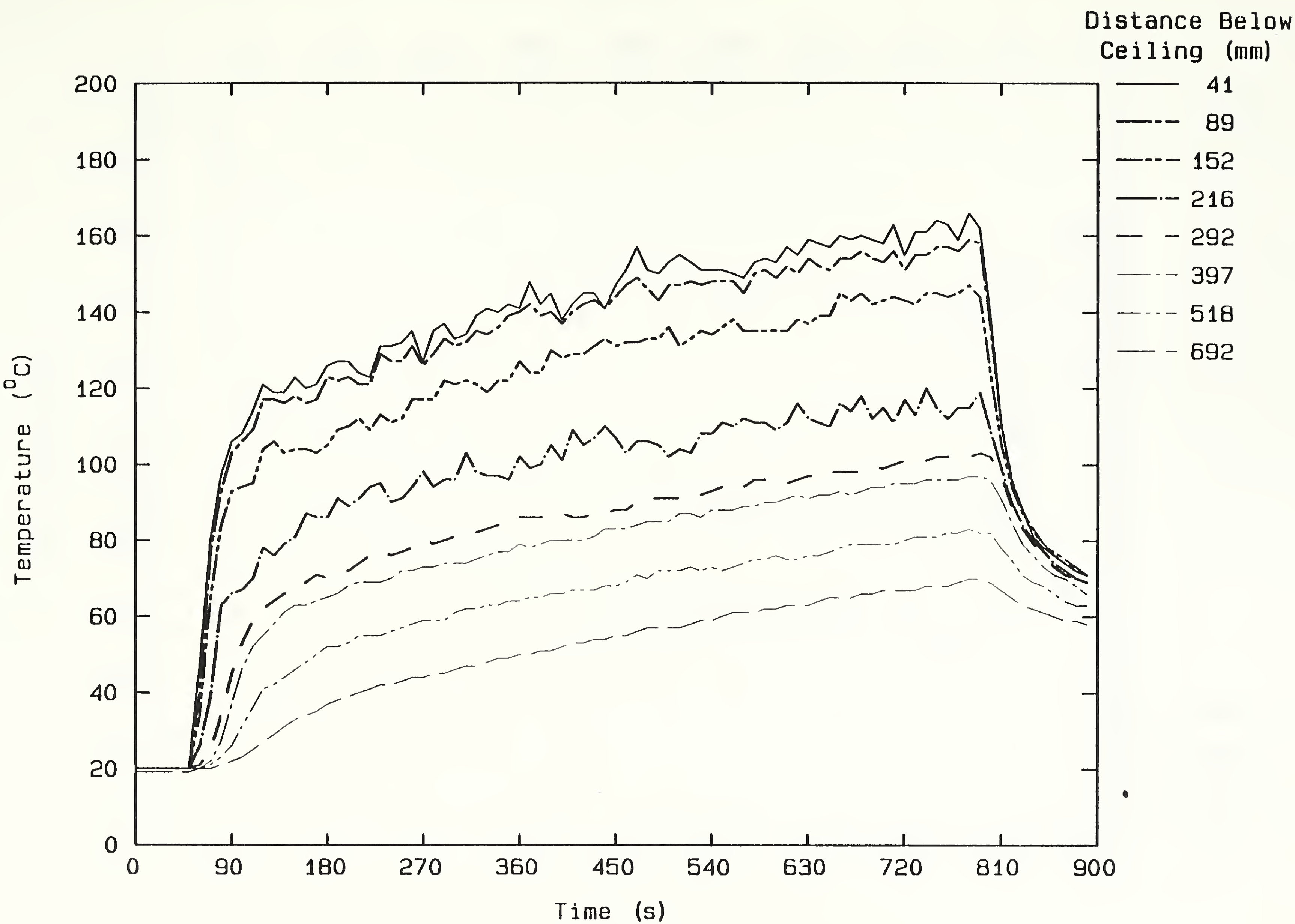

Figure 41. Test G1103 Vertical temperature profile at position D

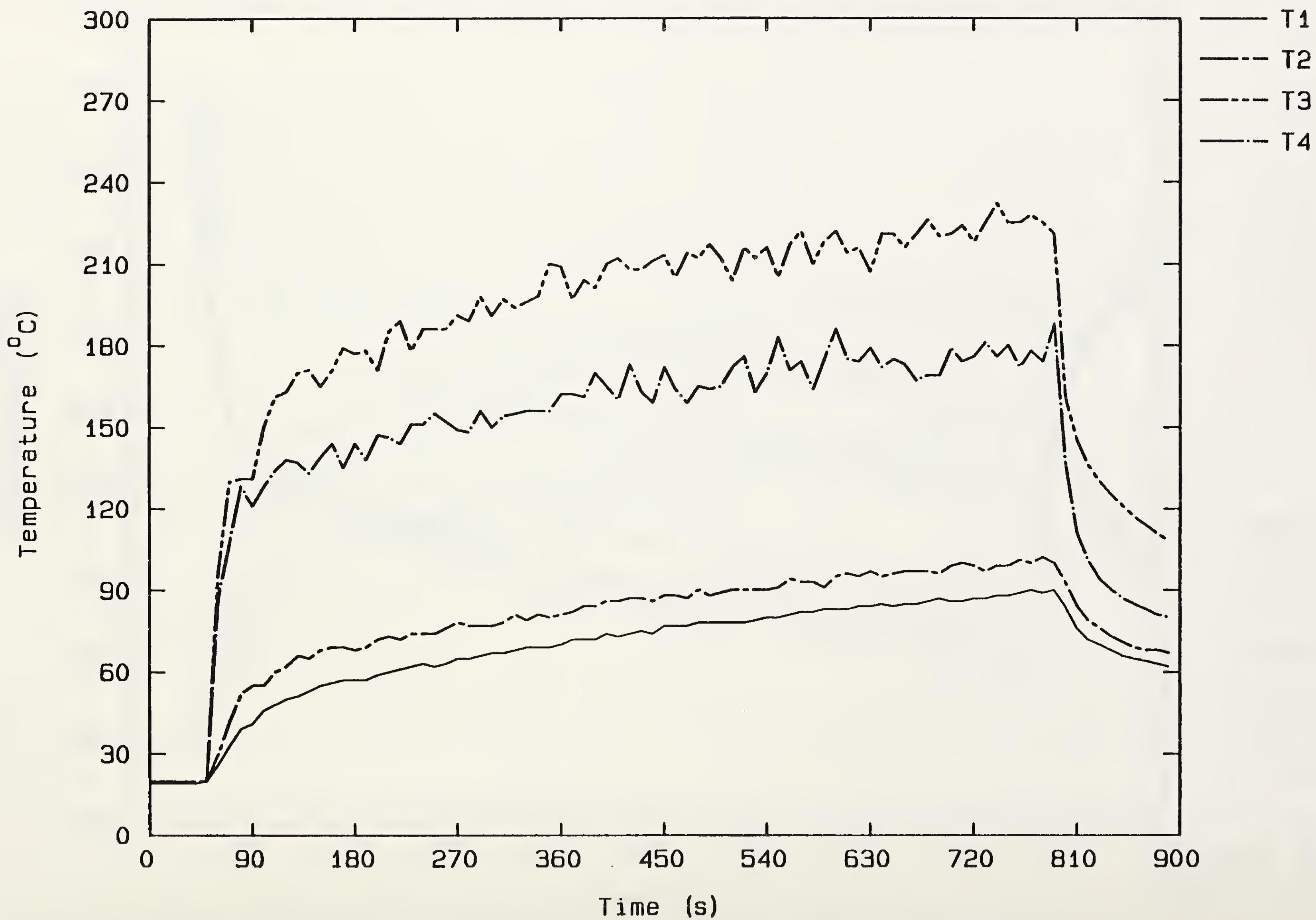

Figure 42. Test G1103 Ceiling interior surface temperature: T1 - T4

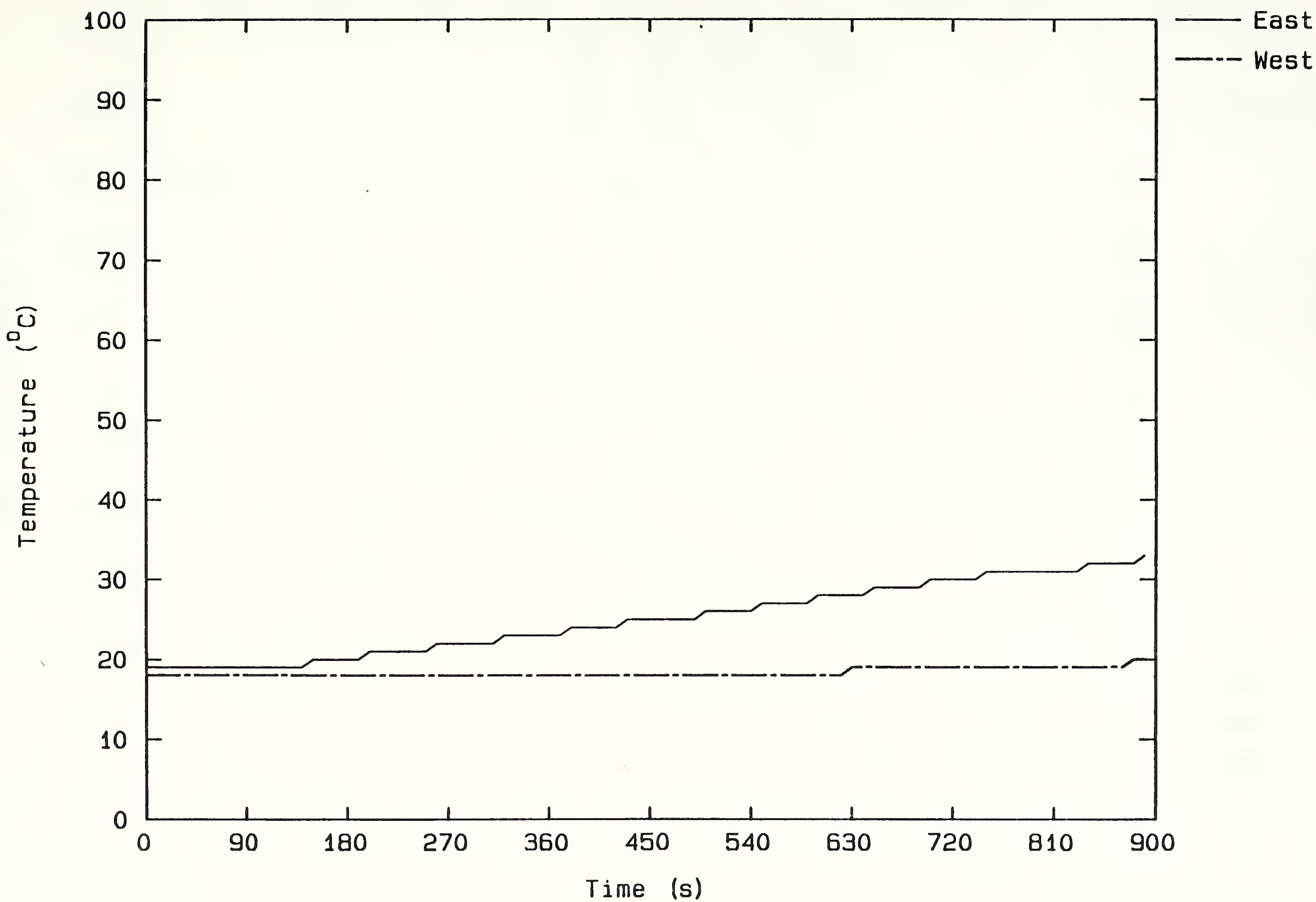

Figure 43. Test G1103 Exhaust temperature: east and west

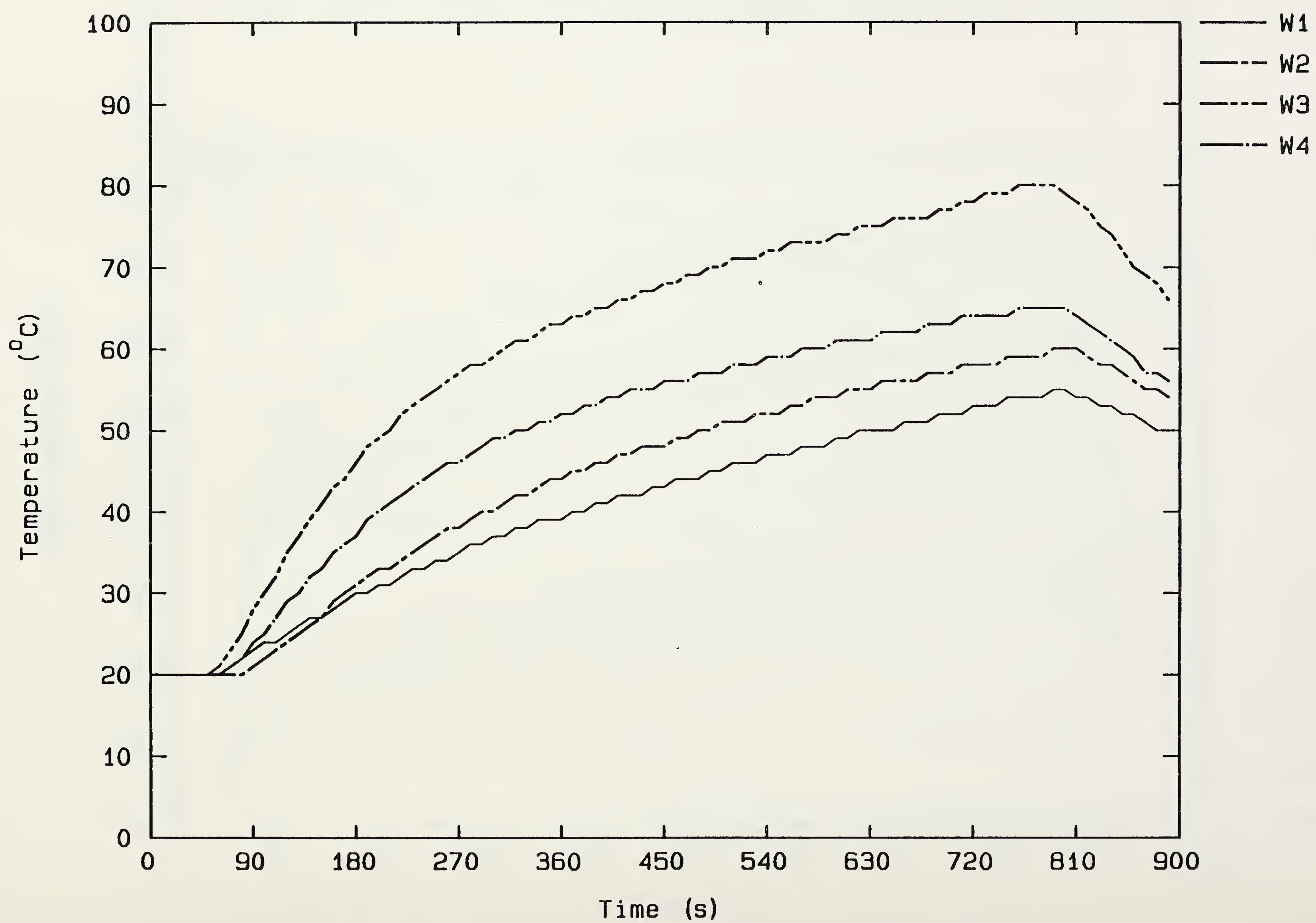

Figure 44. Test G1103 Wall interior surface temperature: W1 - W4

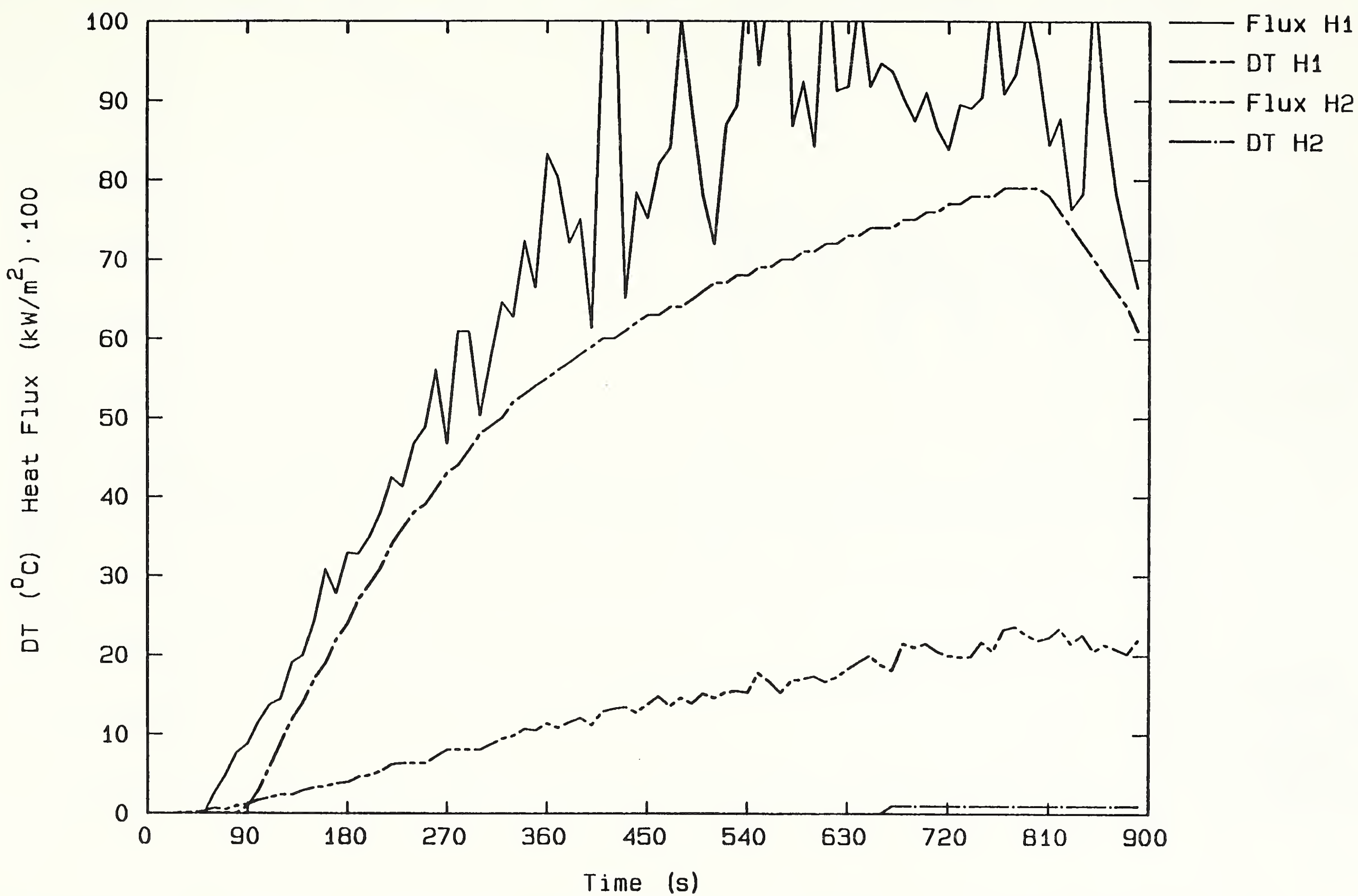

Figure 45. Test G1103 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

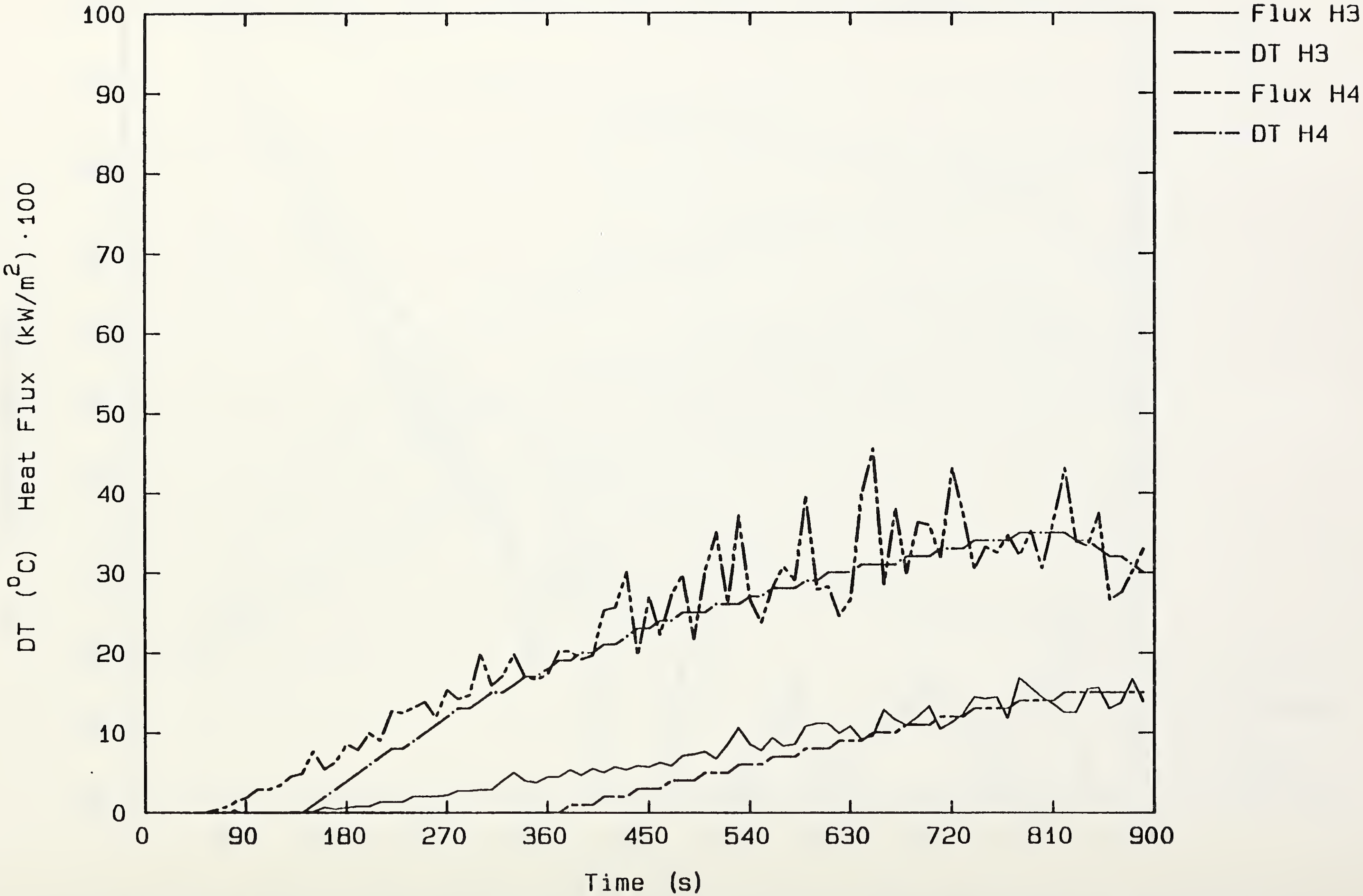

Figure 46. Test G1103 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

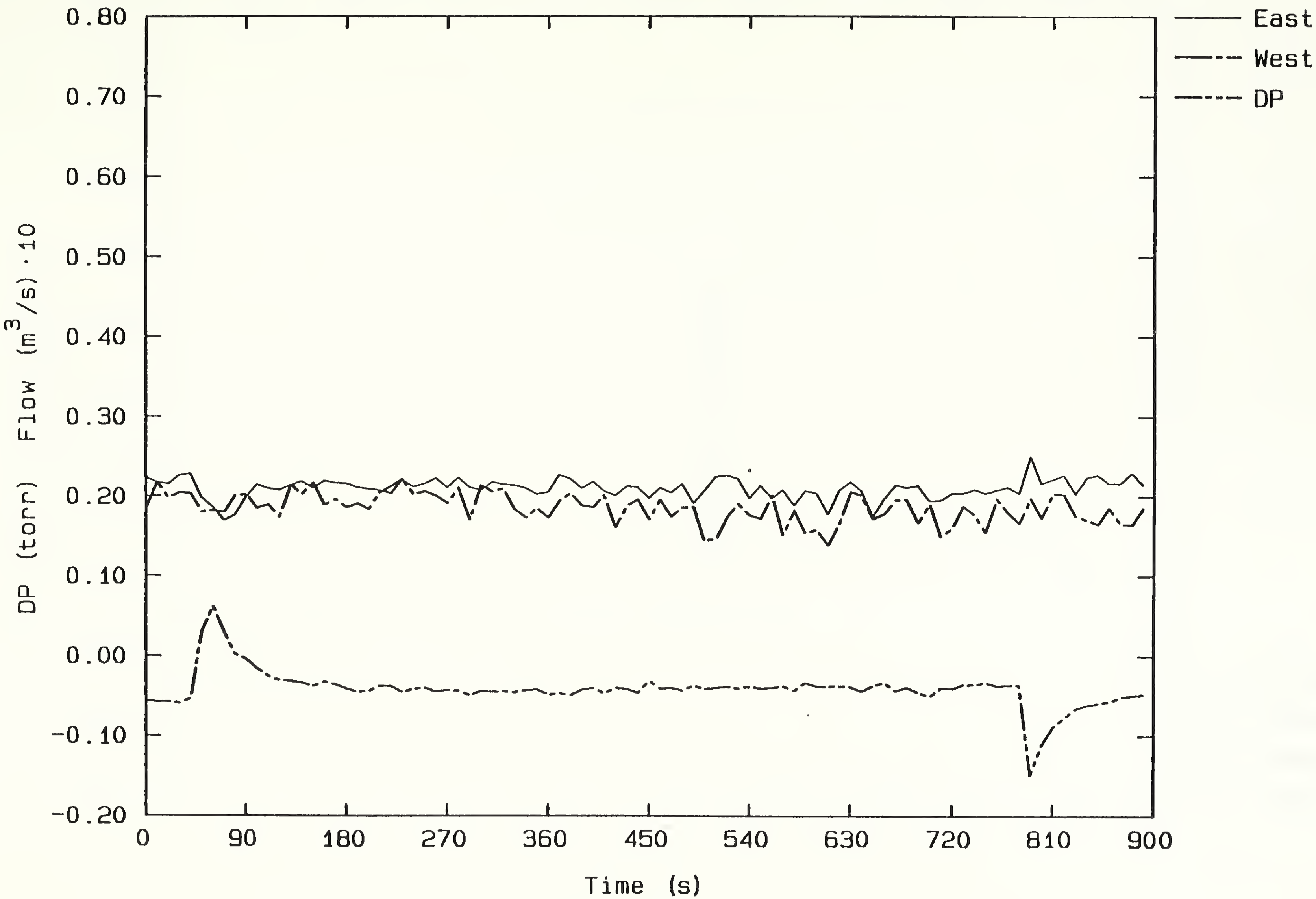

Figure 47. Test G1103 Cabin differential pressure and inlet flows, east and west

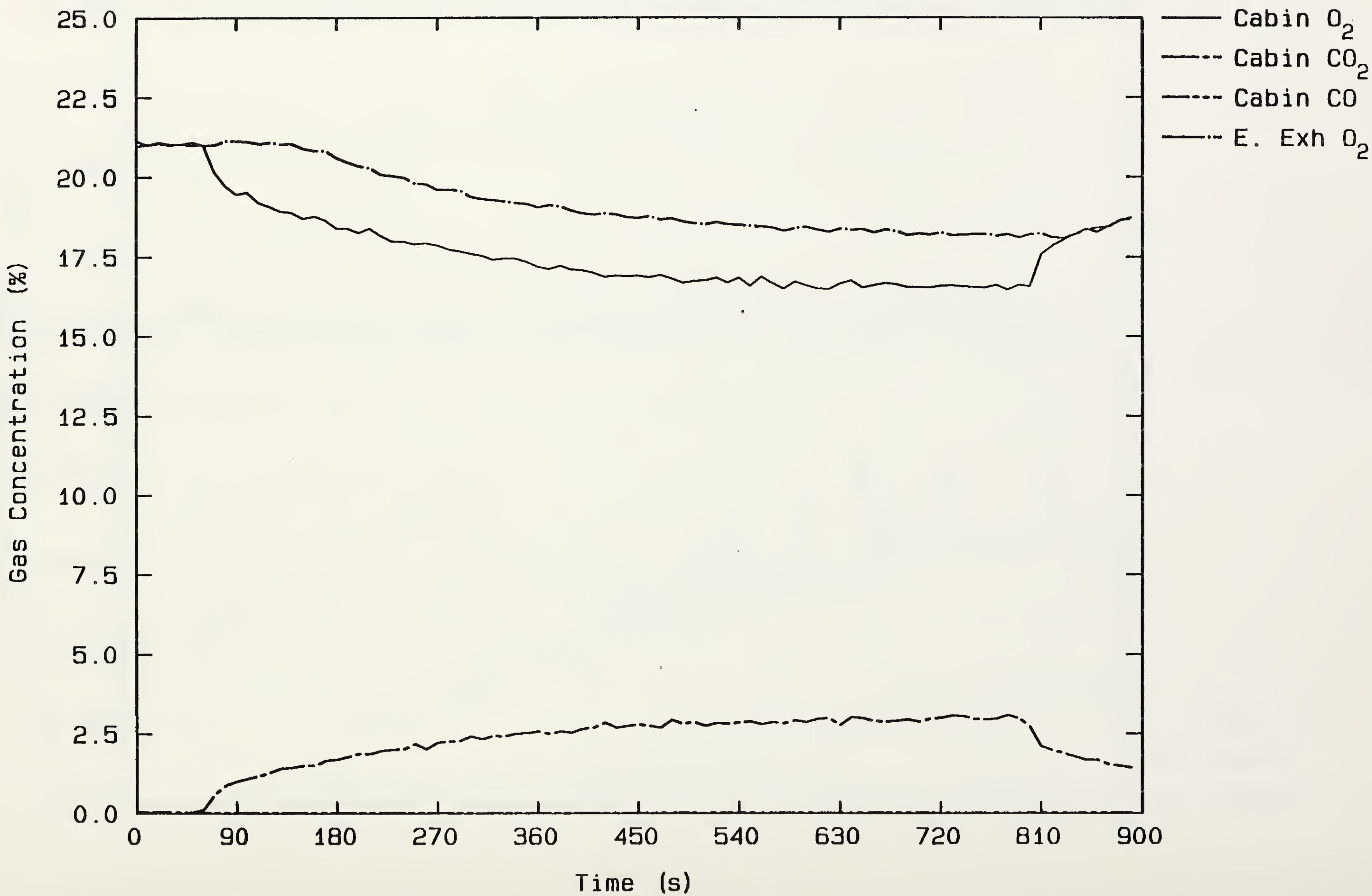

Figure 48. Test G1103 Cabin and exhaust gas concentrations

TEST G1503

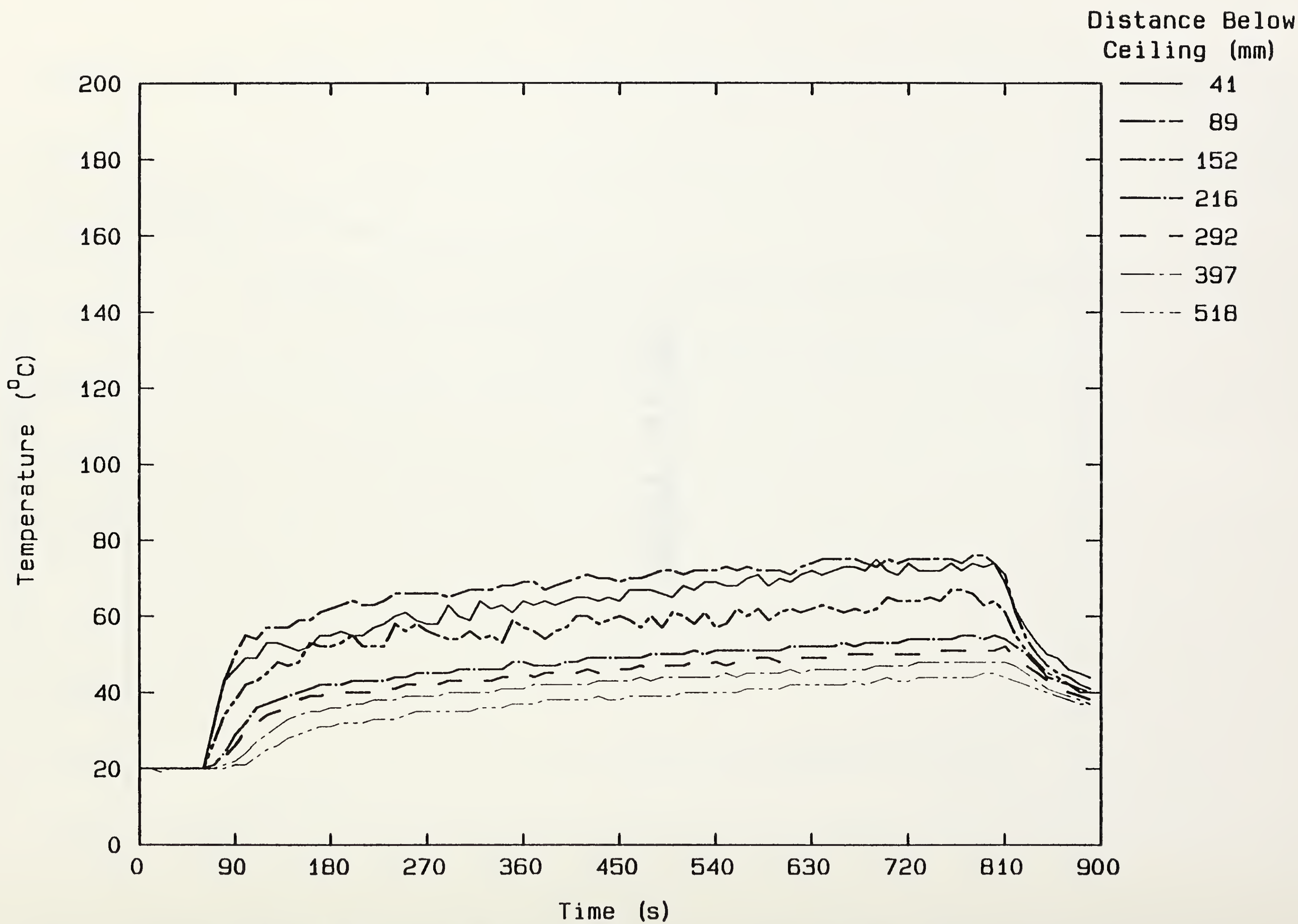

Figure 49. Test G1503 Vertical temperature profile at position A

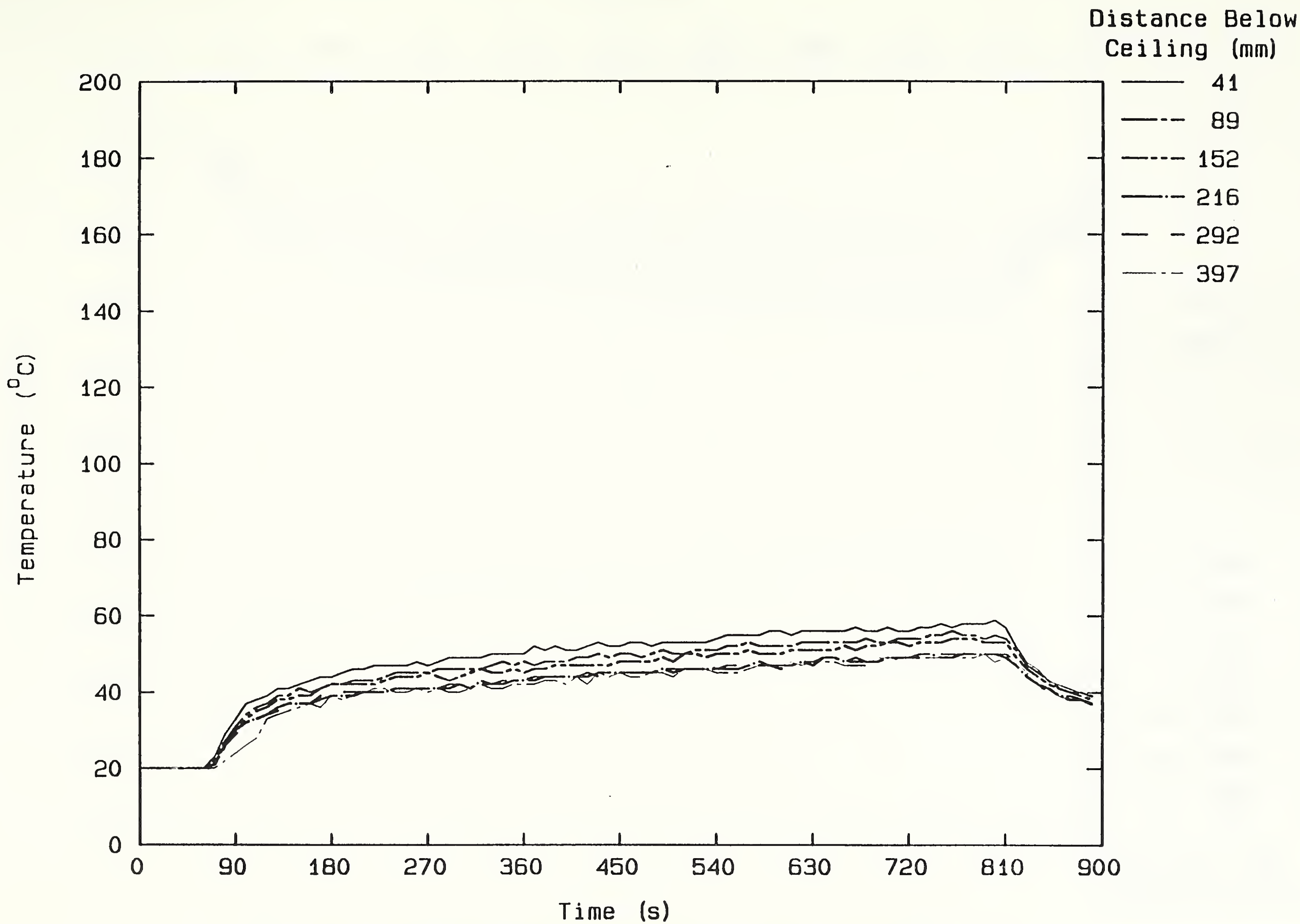

Figure 50. Test G1503 Vertical temperature profile at position B

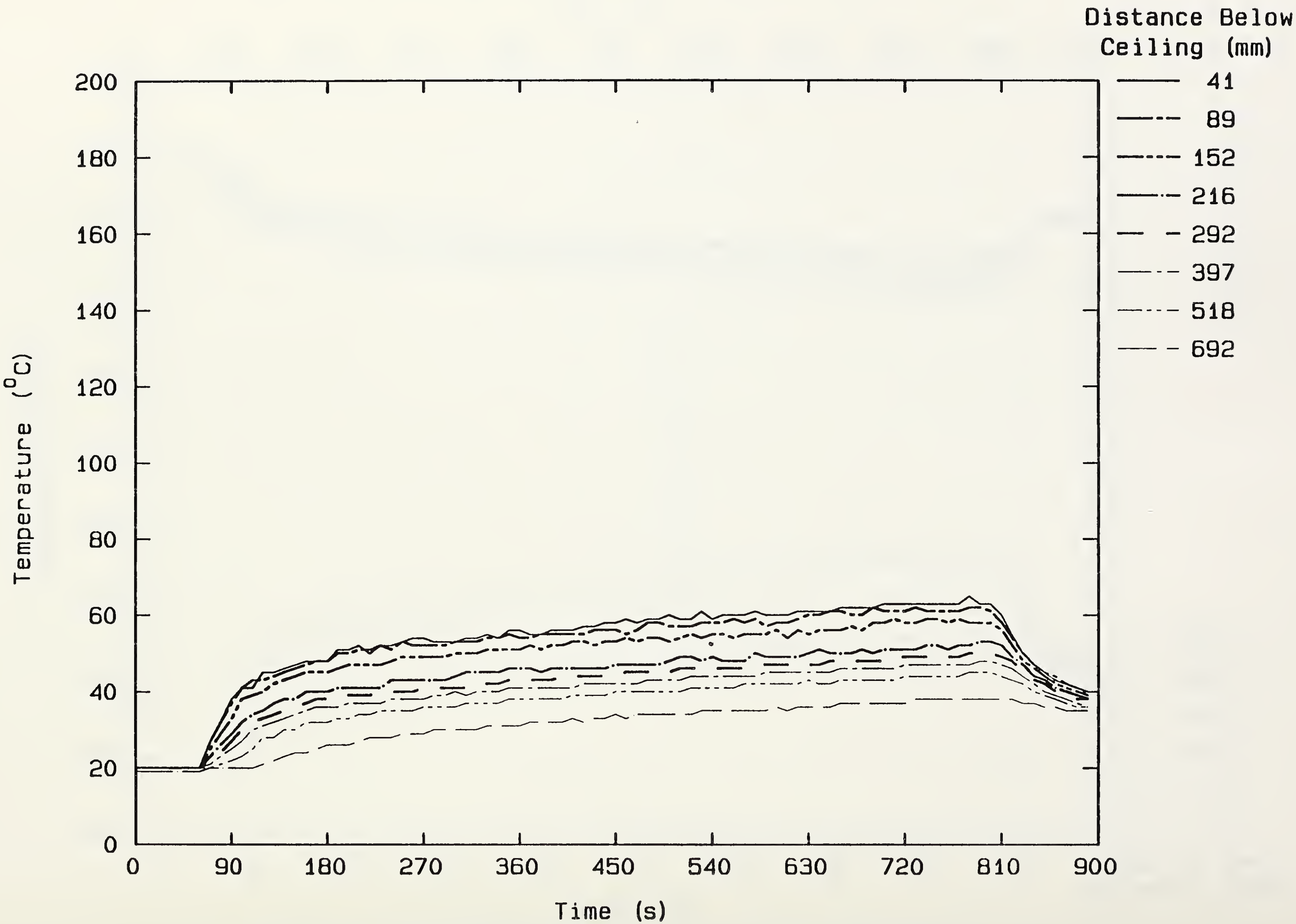

Figure 51. Test G1503 Vertical temperature profile at position C

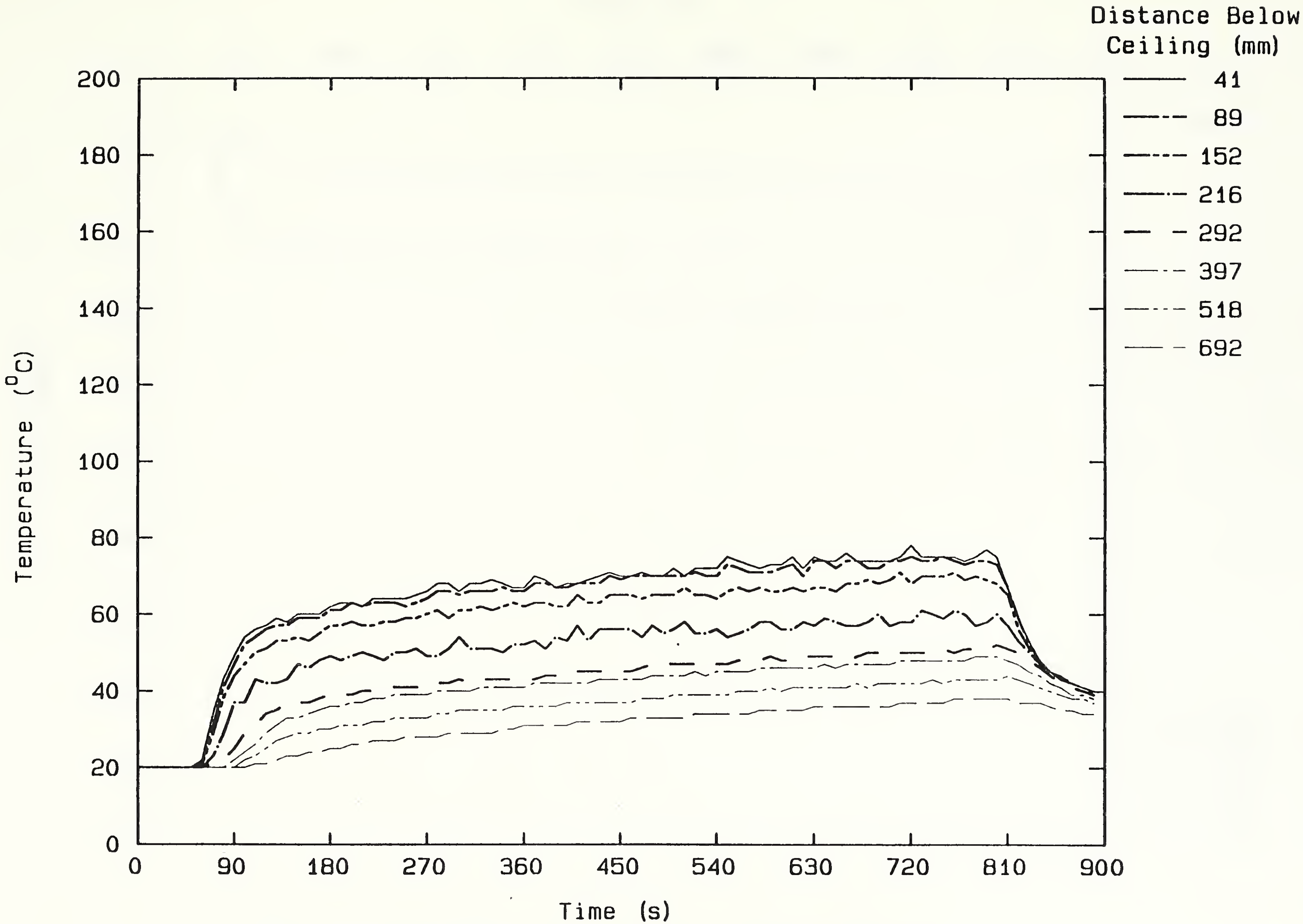

Figure 52. Test G1503 Vertical temperature profile at position D

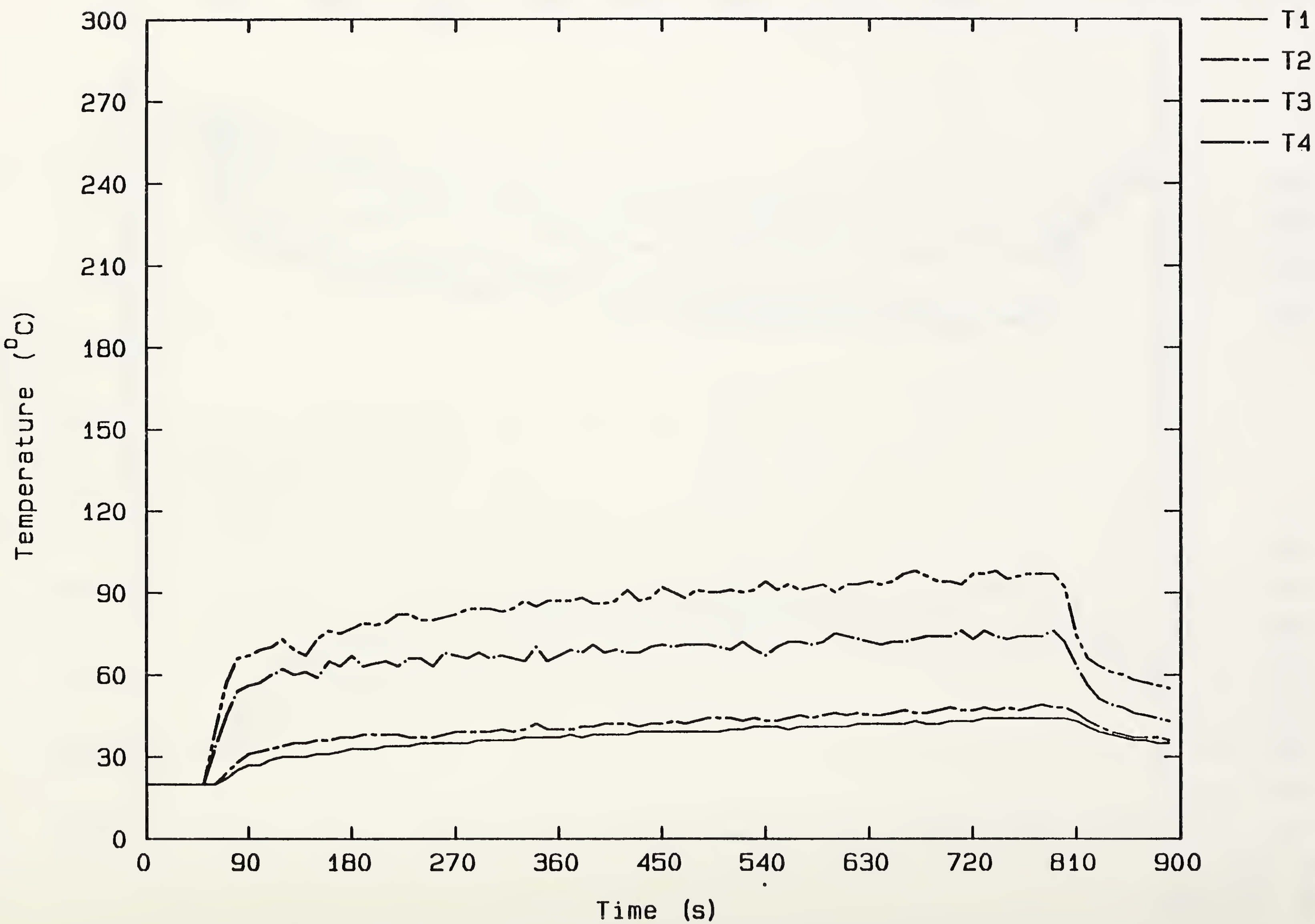

Figure 53. Test G1503 Ceiling interior surface temperature: T1 - T4

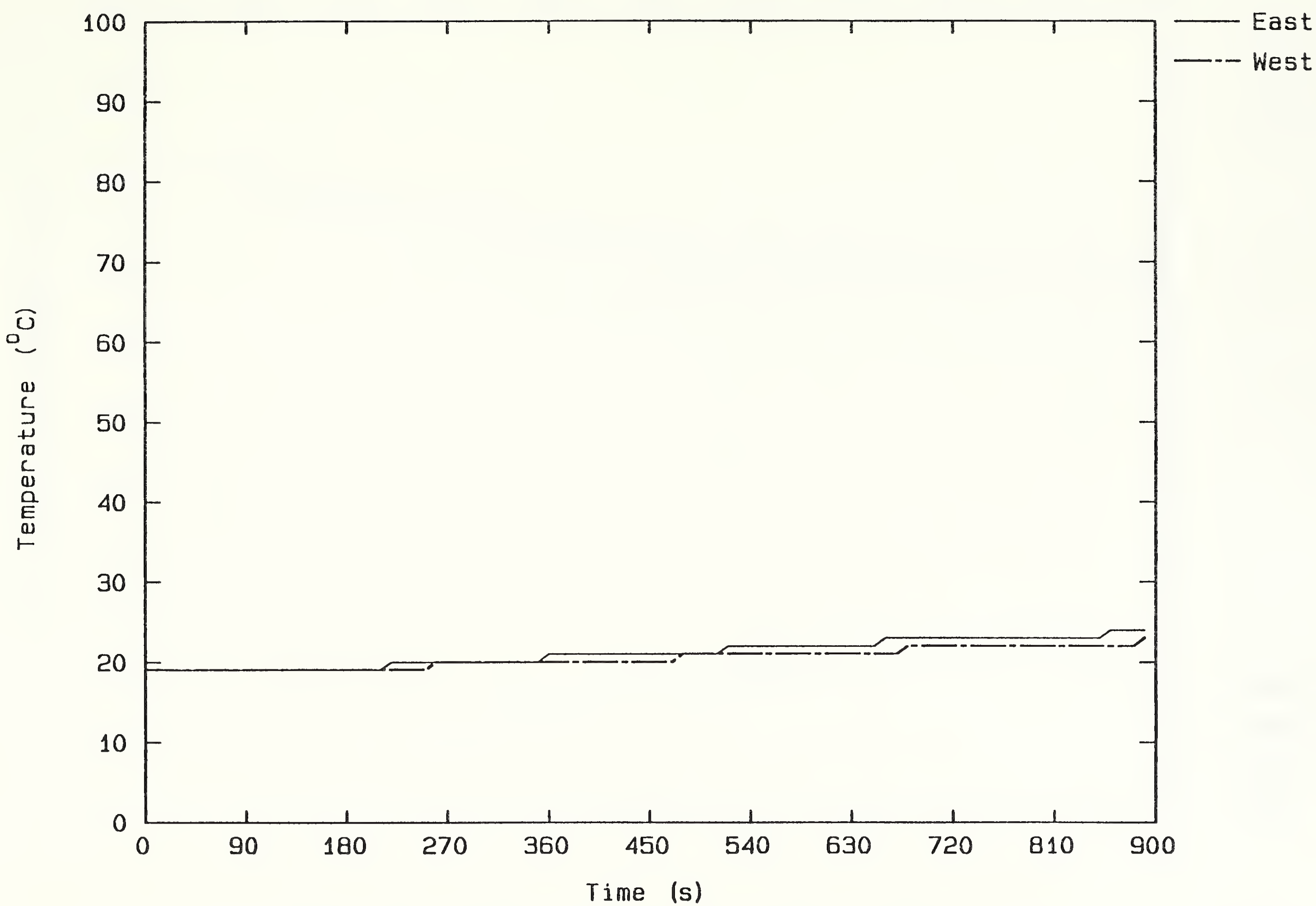

Figure 54. Test G1503 Exhaust temperature: east and west

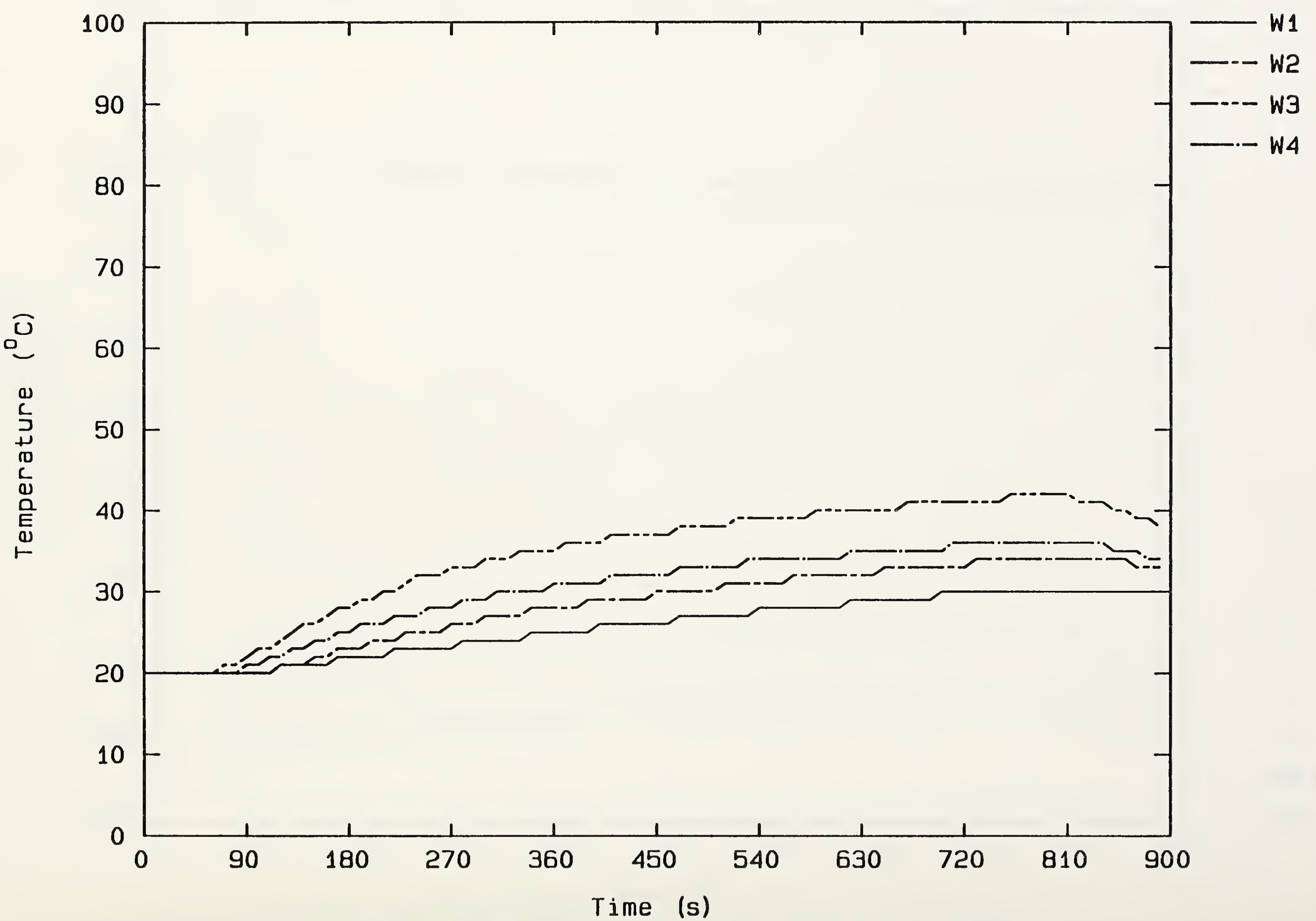

Figure 55. Test G1503 Wall interior surface temperature: W1 - W4

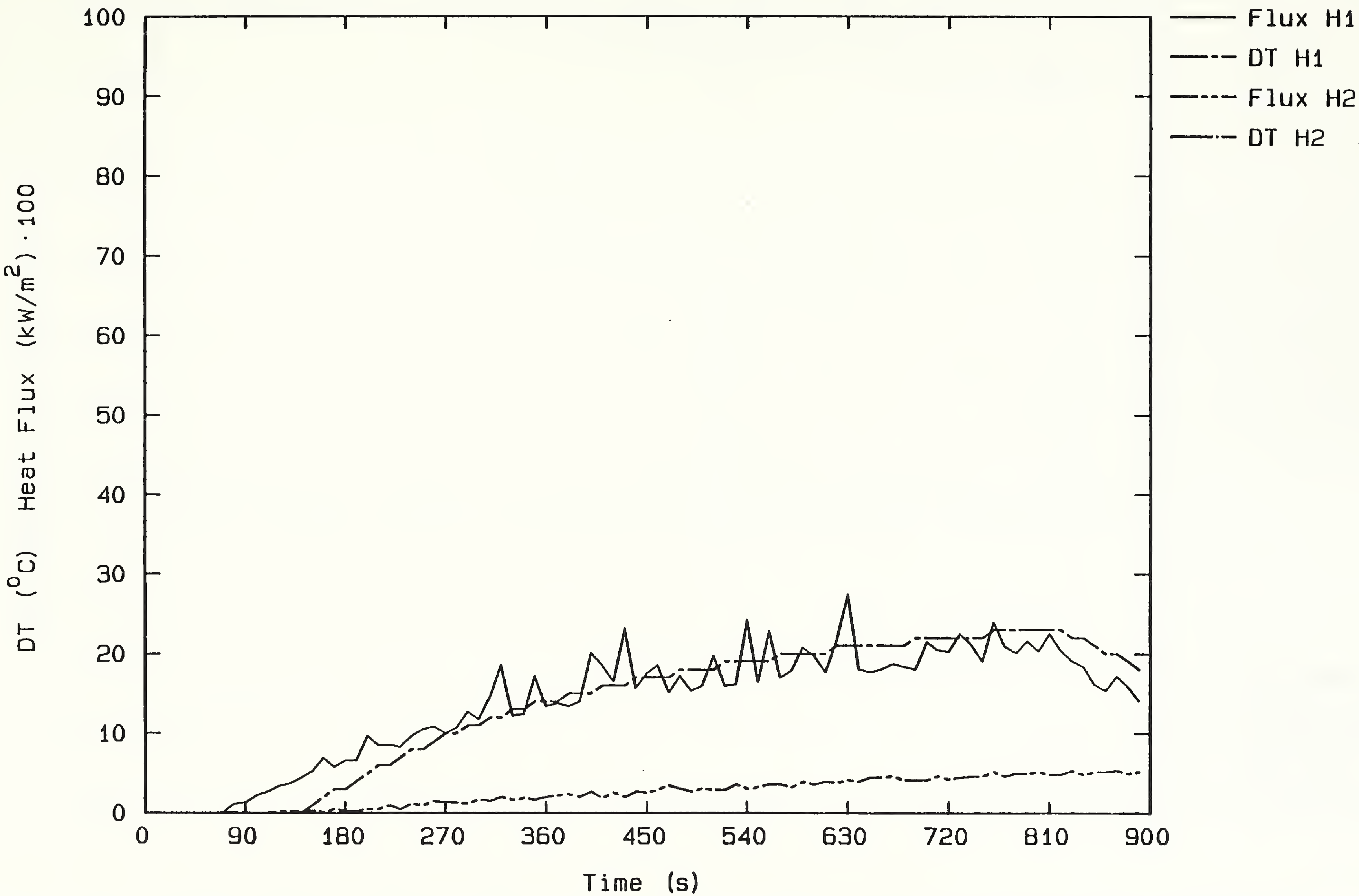

Figure 56. Test G1503 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

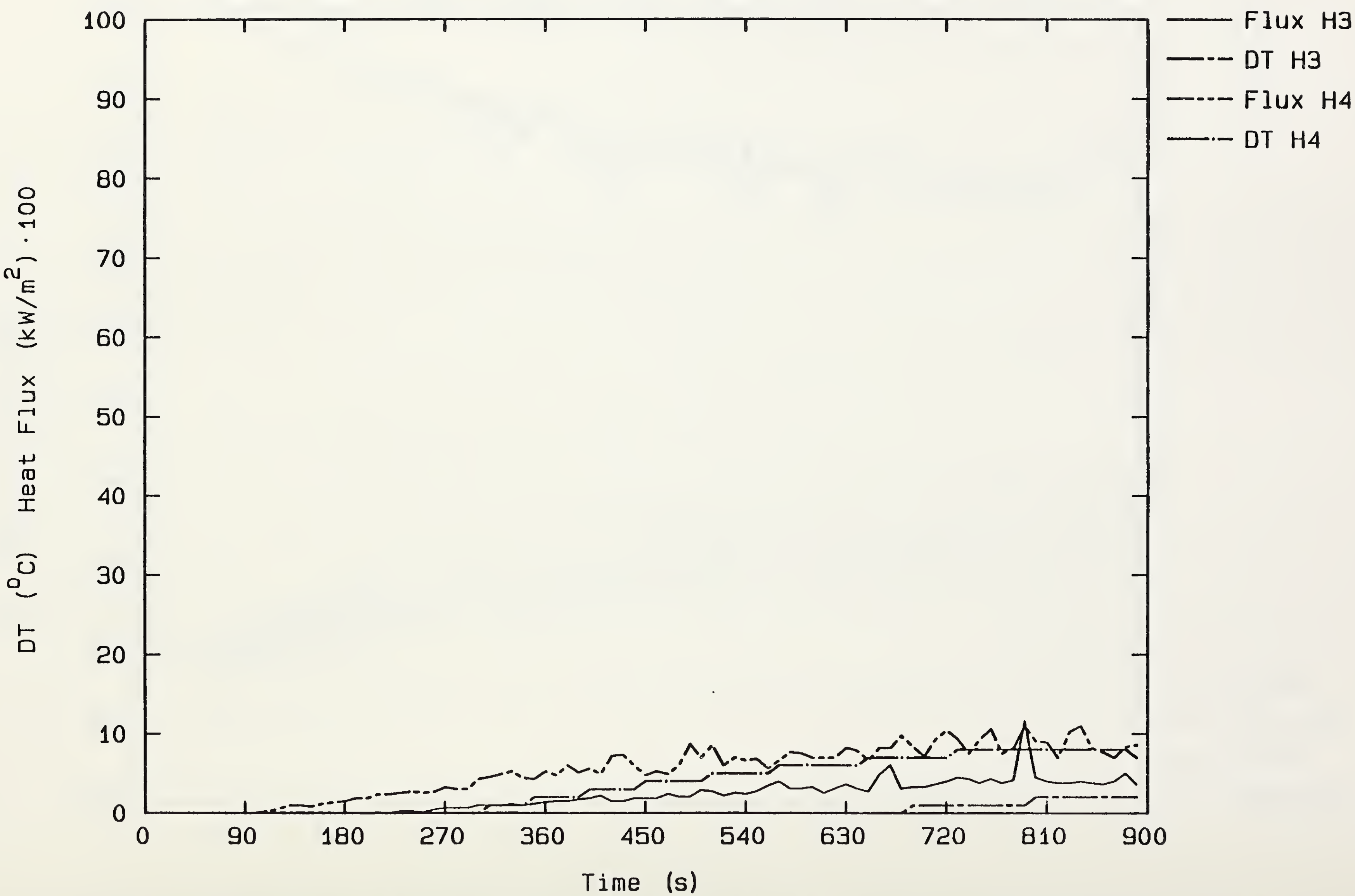

Figure 57. Test G1503 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

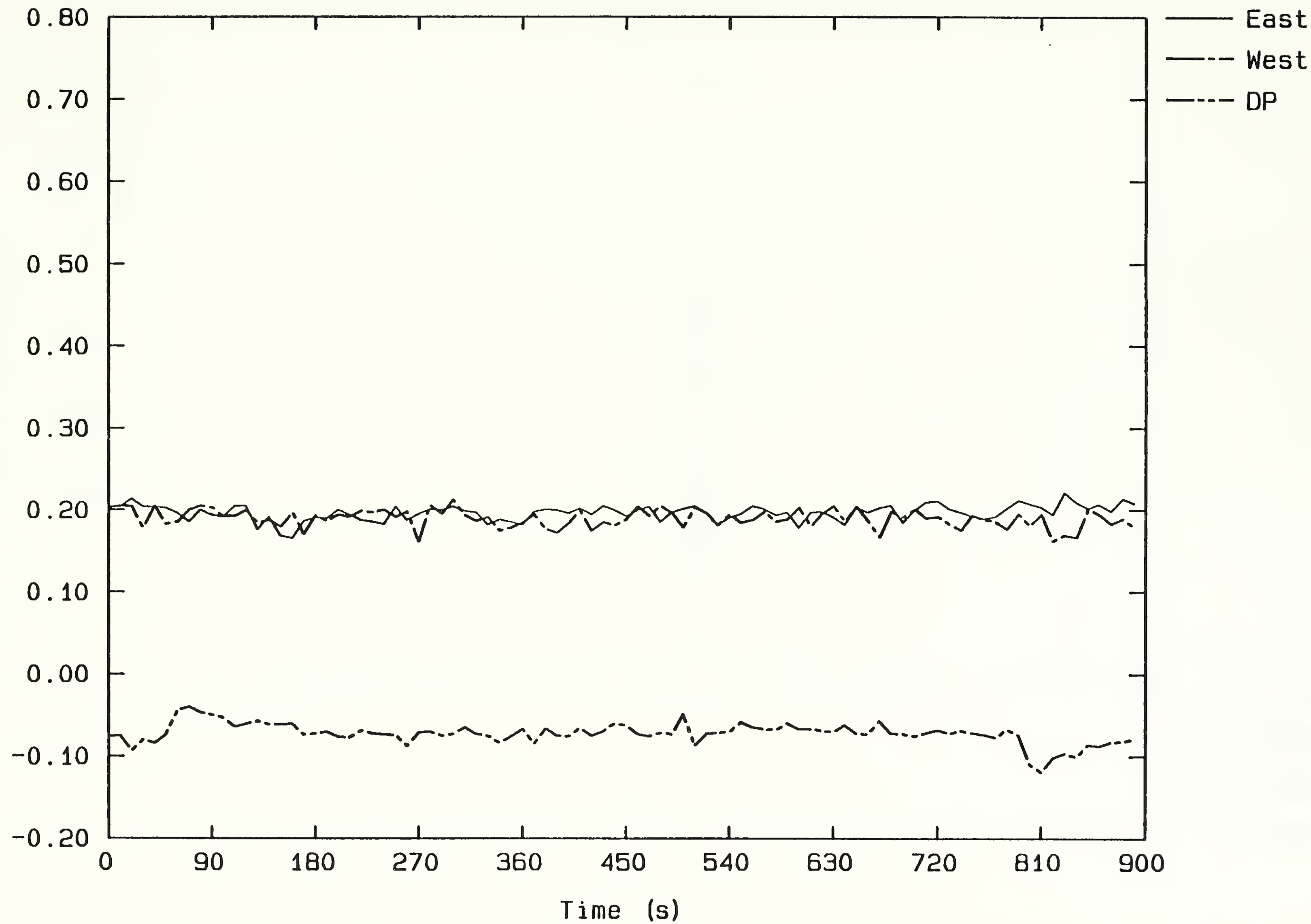

Figure 58. Test G1503 Cabin differential pressure and inlet flows, east and west

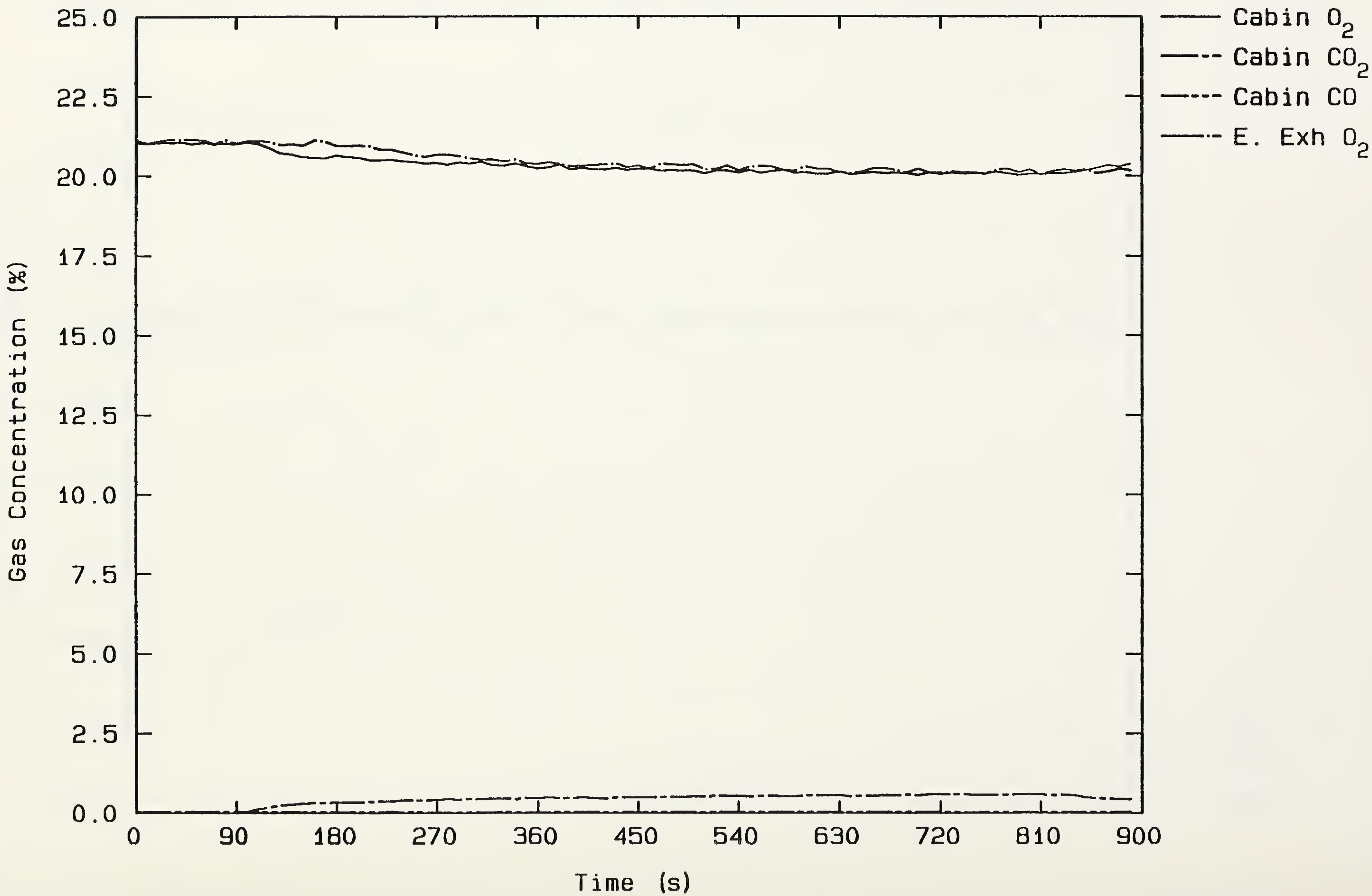

Figure 59. Test G1503 Cabin and exhaust gas concentrations

TEST G2903

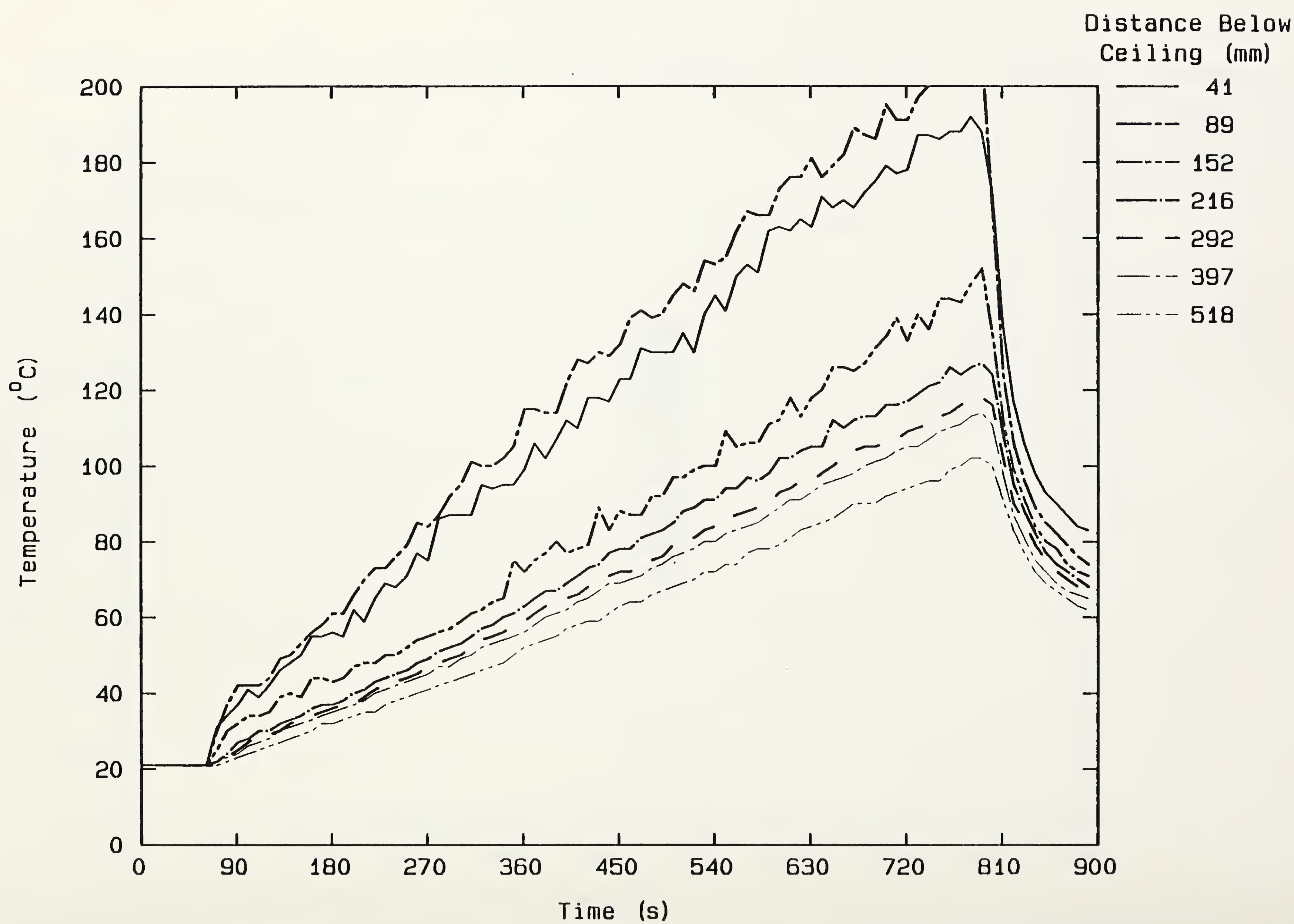

Figure 60. Test G2903 Vertical temperature profile at position A

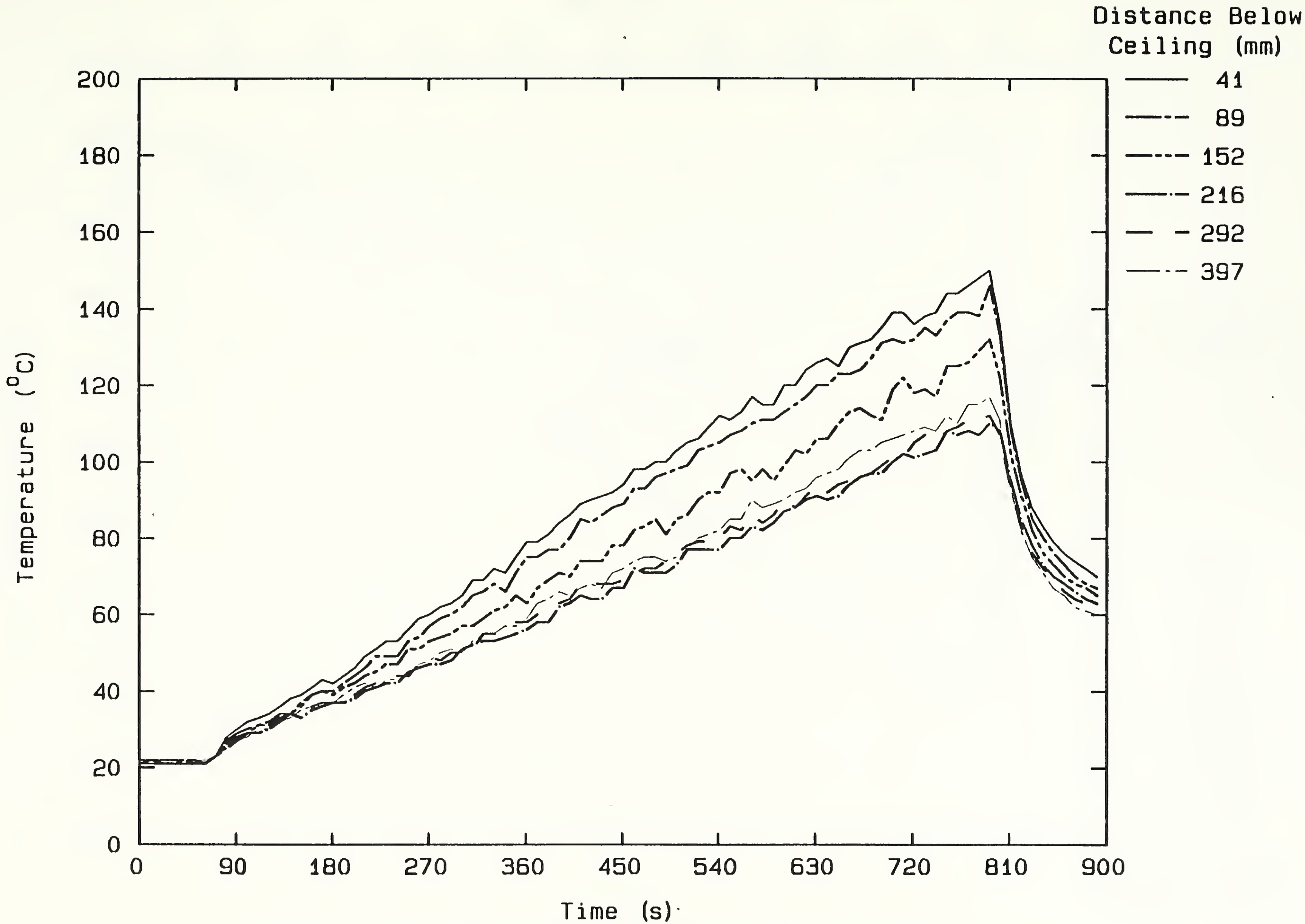

Figure 61. Test G2903 Vertical temperature profile at position B

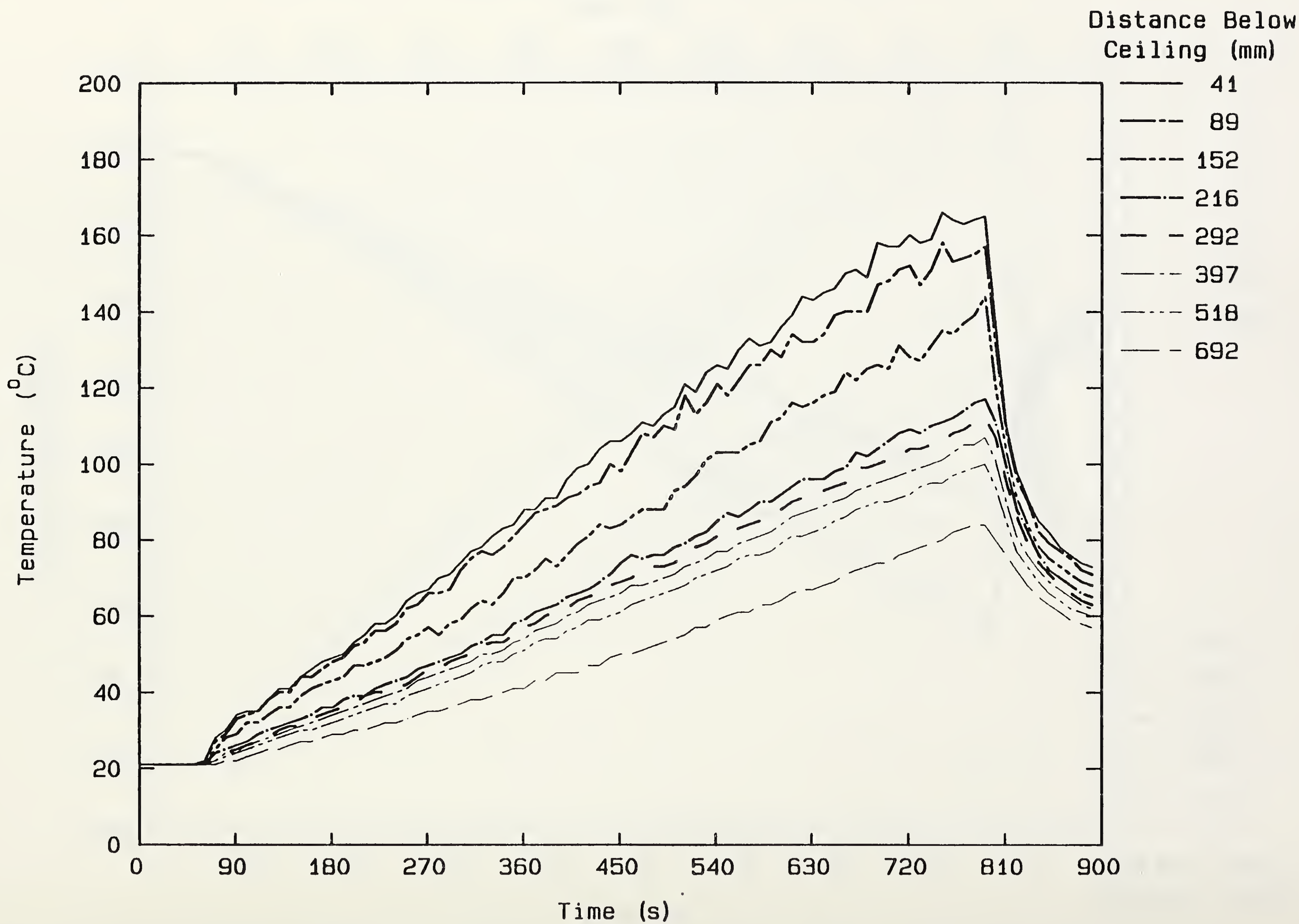

Figure 62. Test G2903 Vertical temperature profile at position C

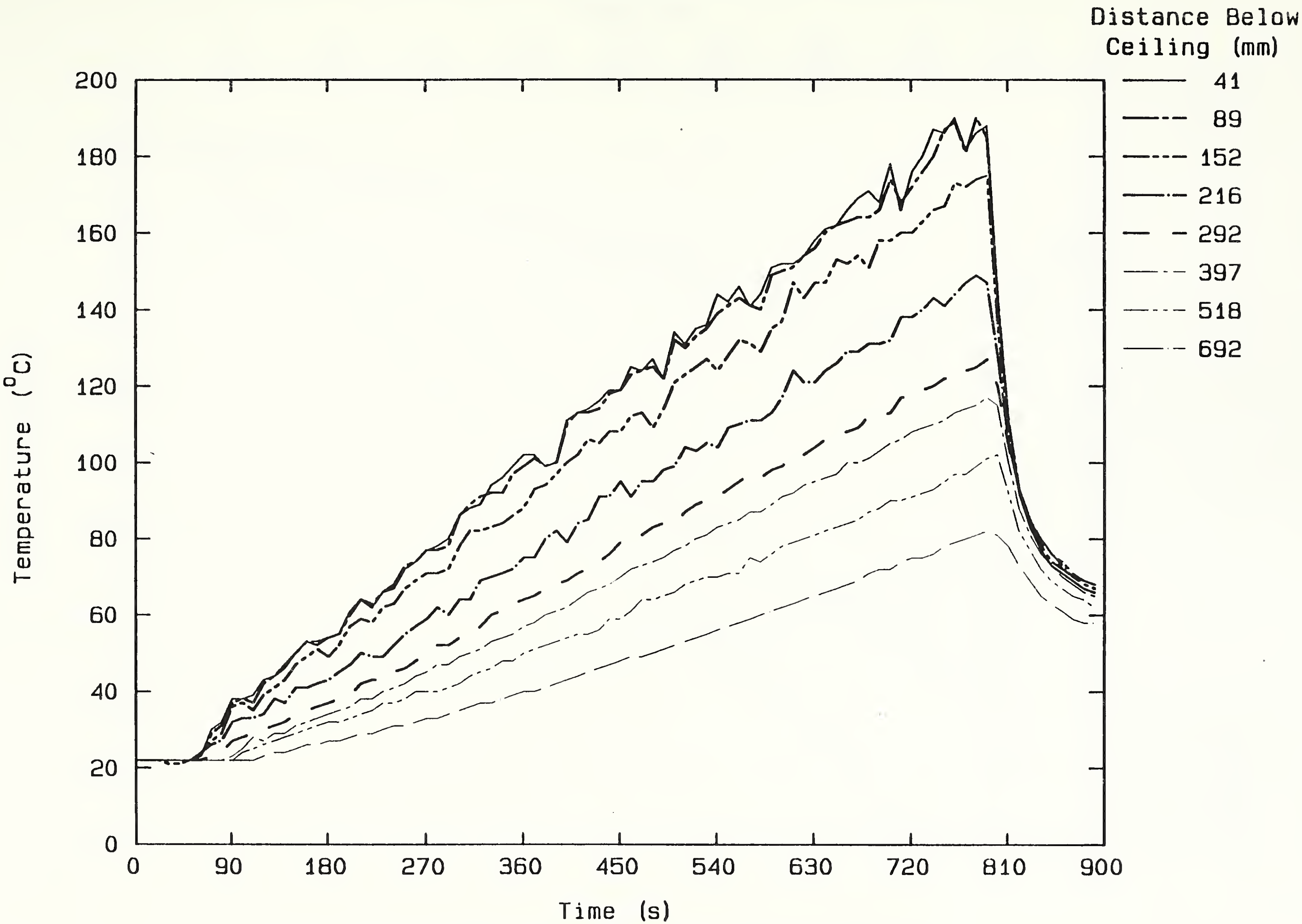

Figure 63. Test G2903 Vertical temperature profile at position D

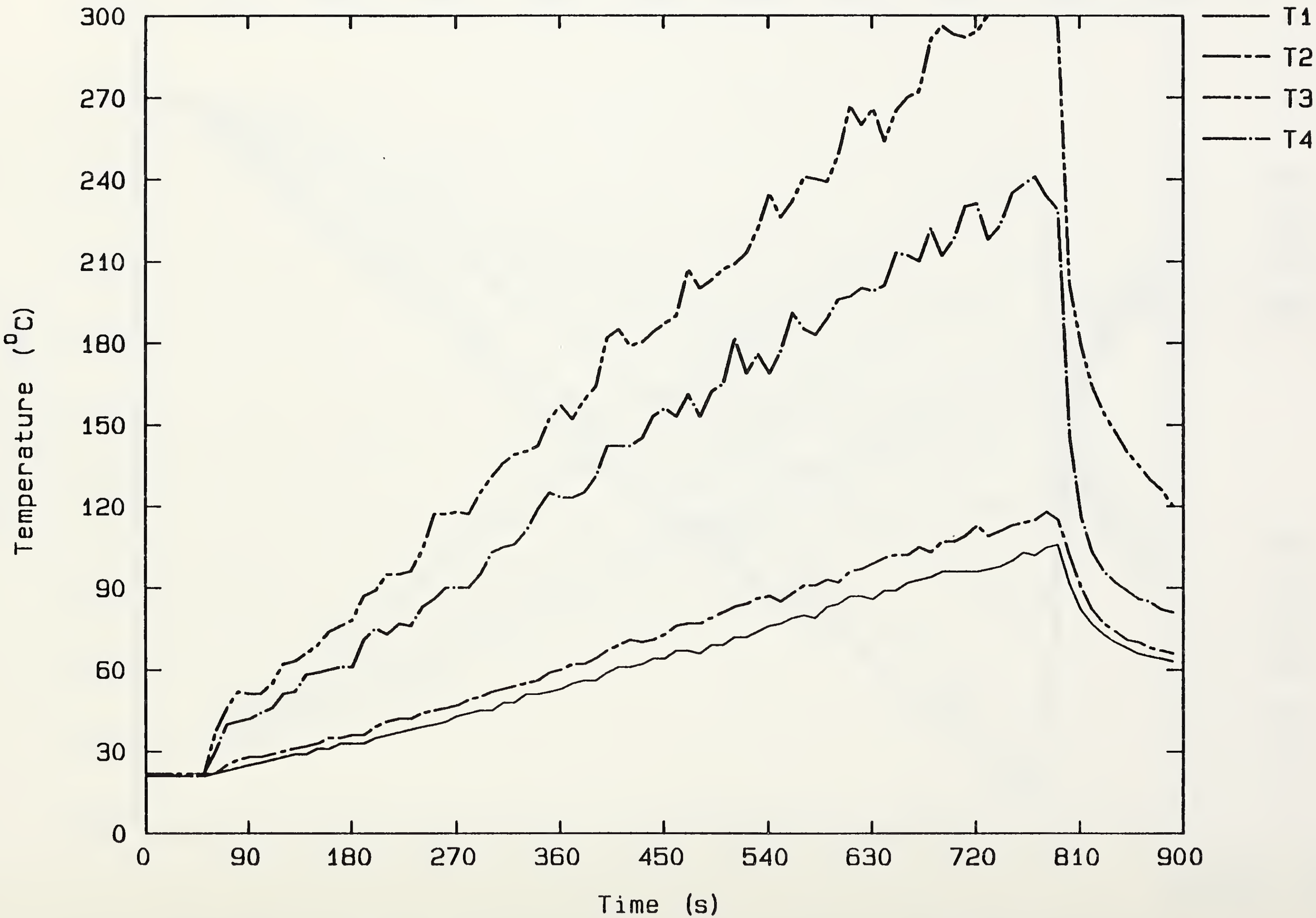

Figure 64. Test G2903 Ceiling interior surface temperature: T1 - T4

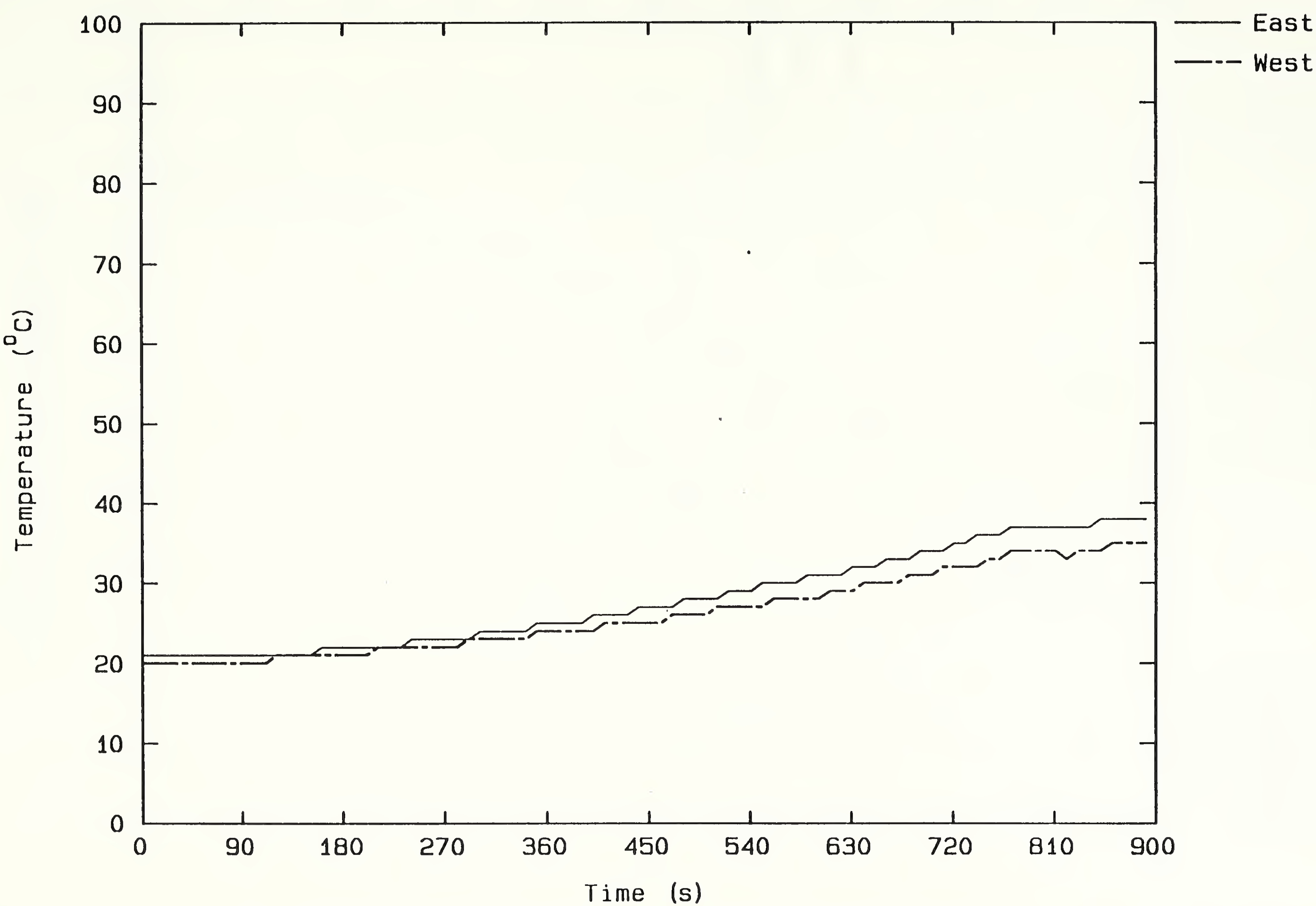

Figure 65. Test G2903 Exhaust temperature: east and west

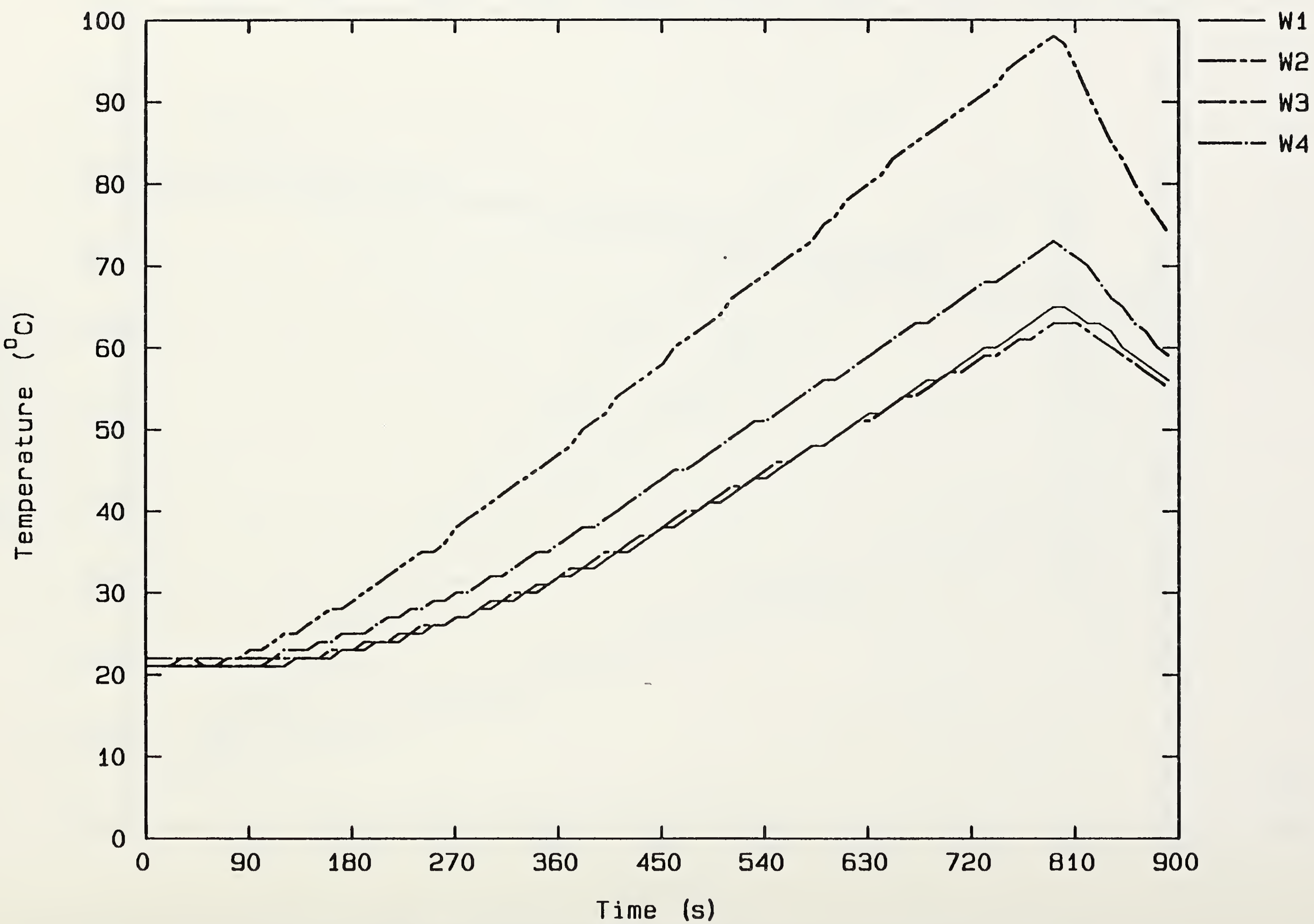

Figure 66. Test G2903 Wall interior surface temperature: W1 - W4

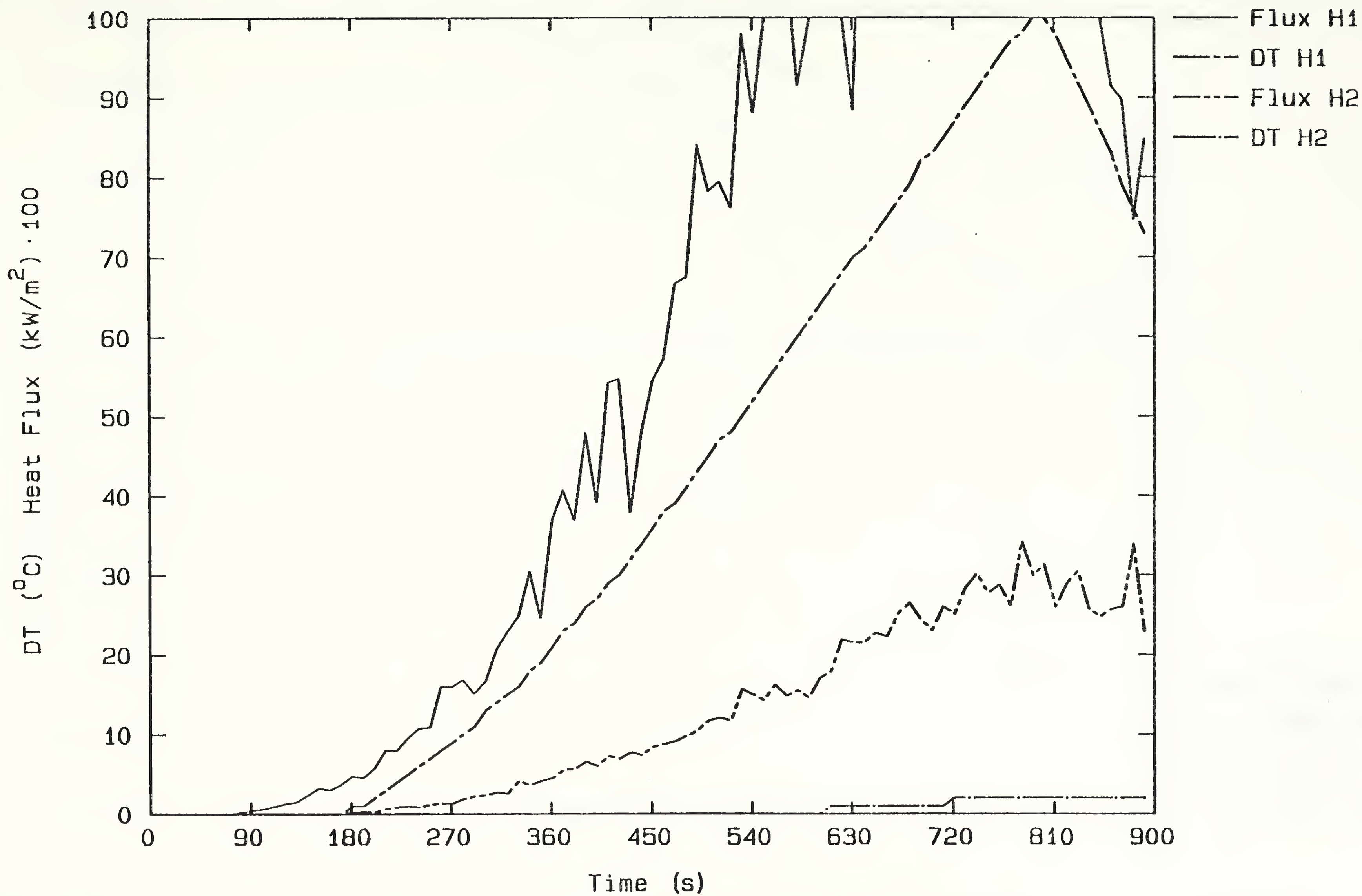

Figure 67. Test G2903 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

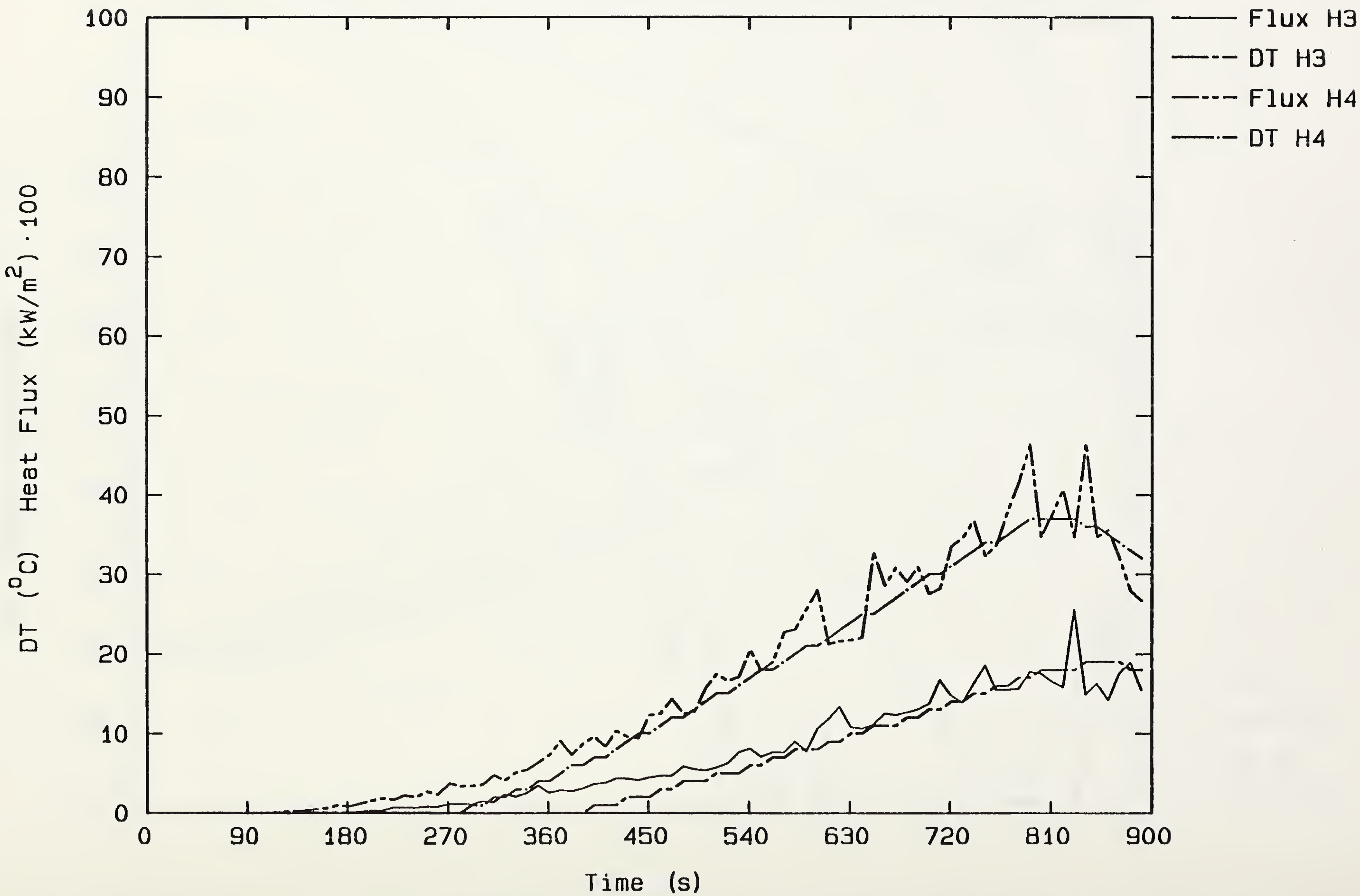

Figure 68. Test G2903 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

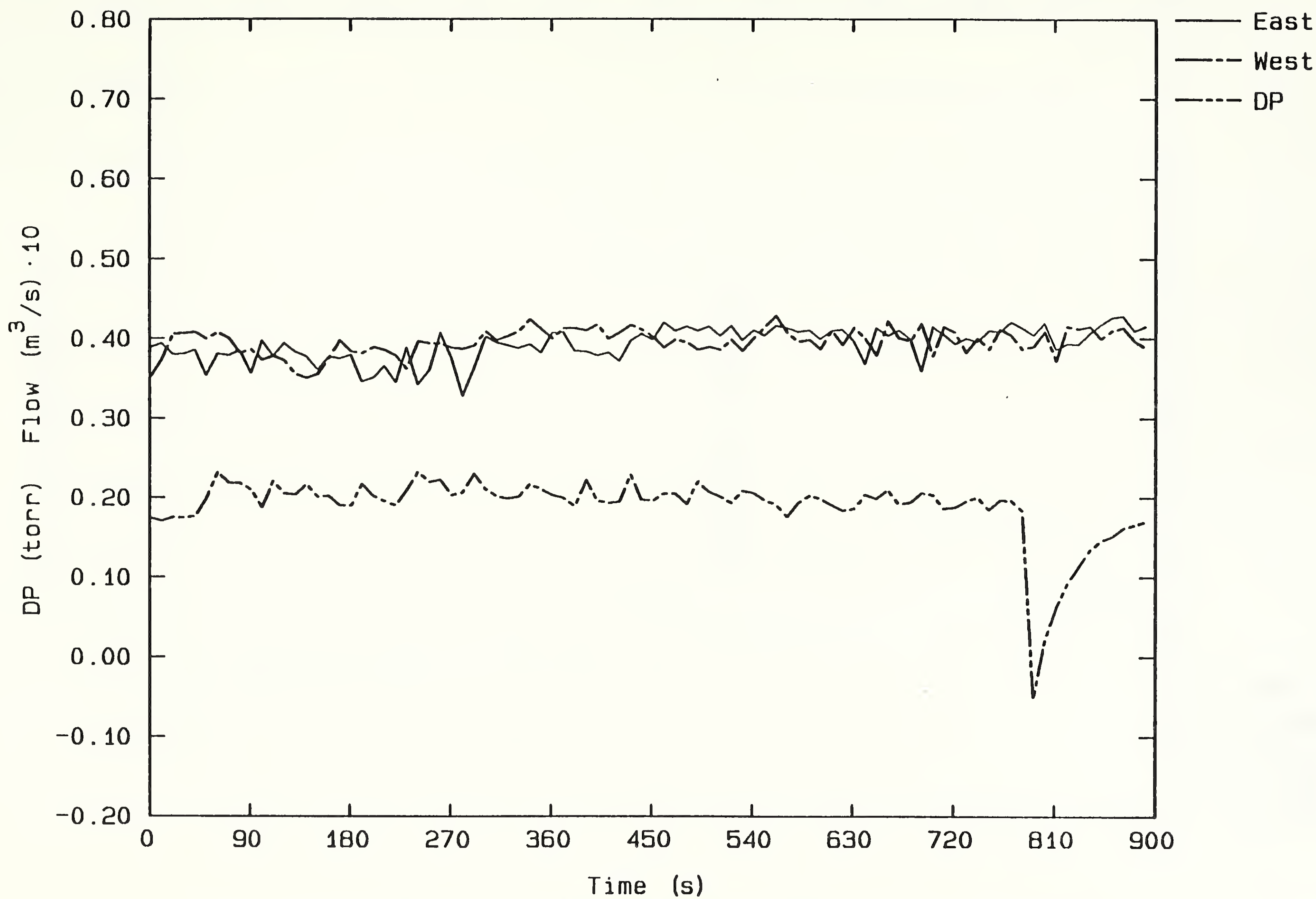

Figure 69. Test G2903 Cabin differential pressure and inlet flows, east and west

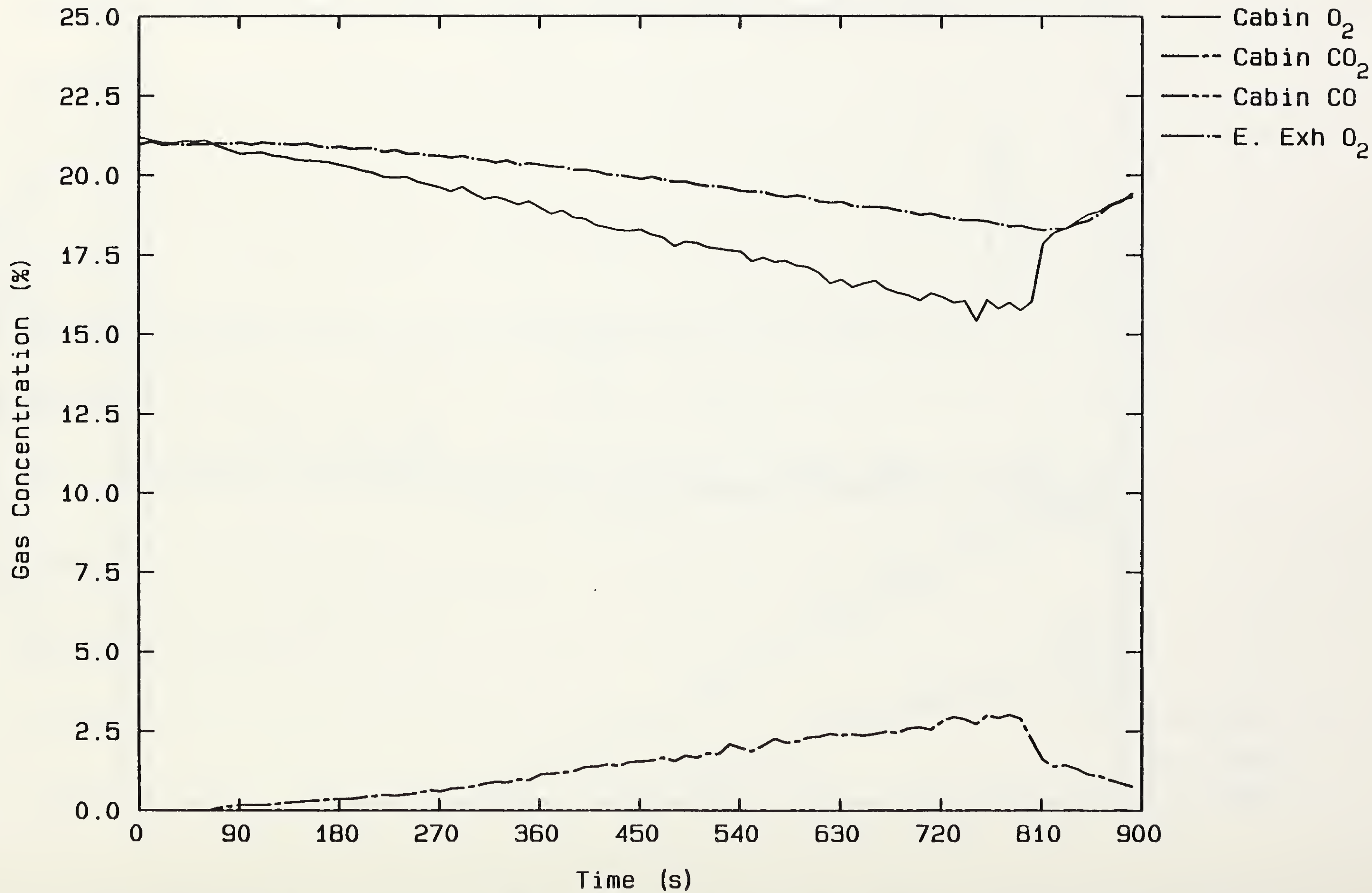

Figure 70. Test G2903 Cabin and exhaust gas concentrations

TEST G0205

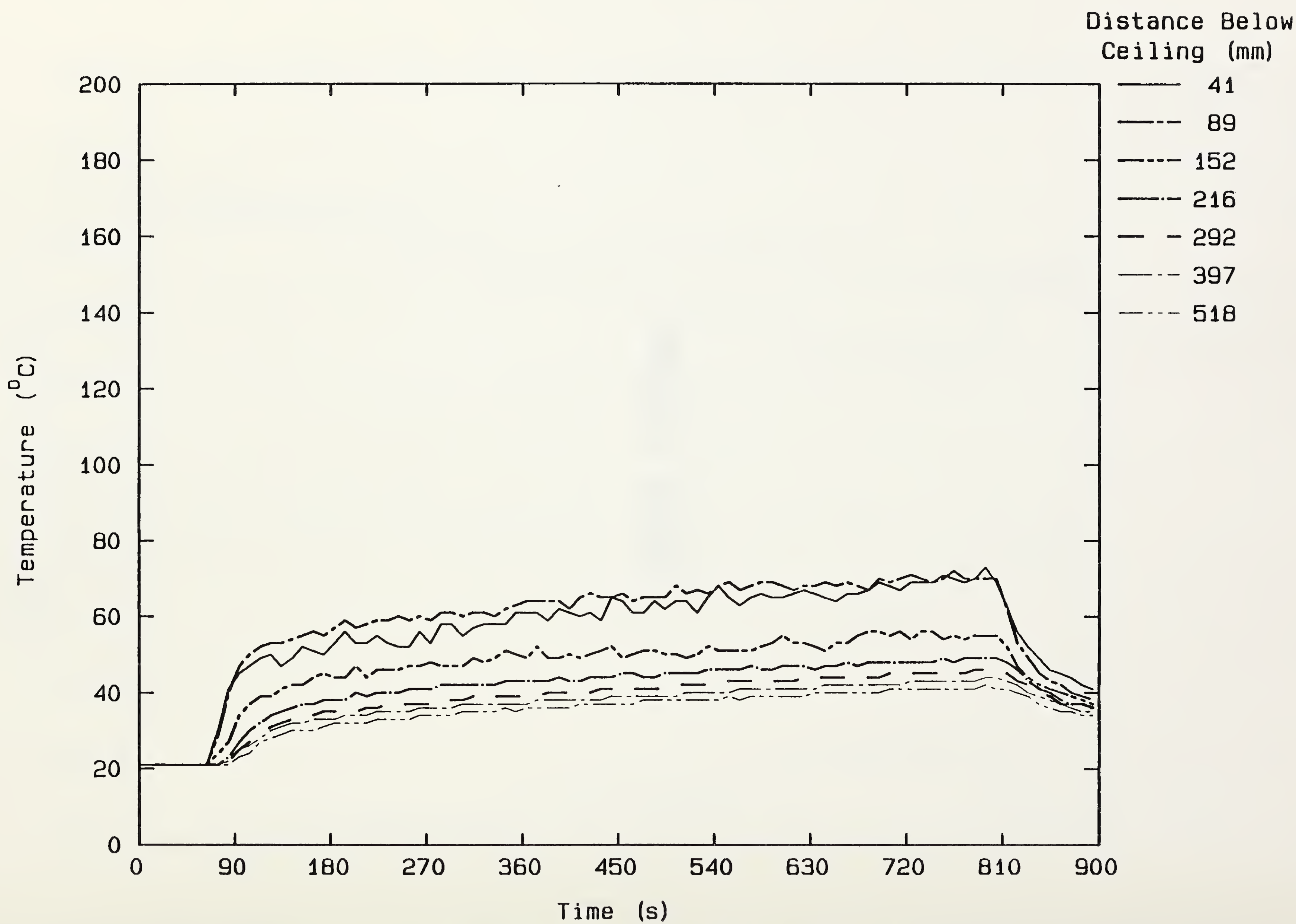

Figure 71. Test G0205 Vertical temperature profile at position A

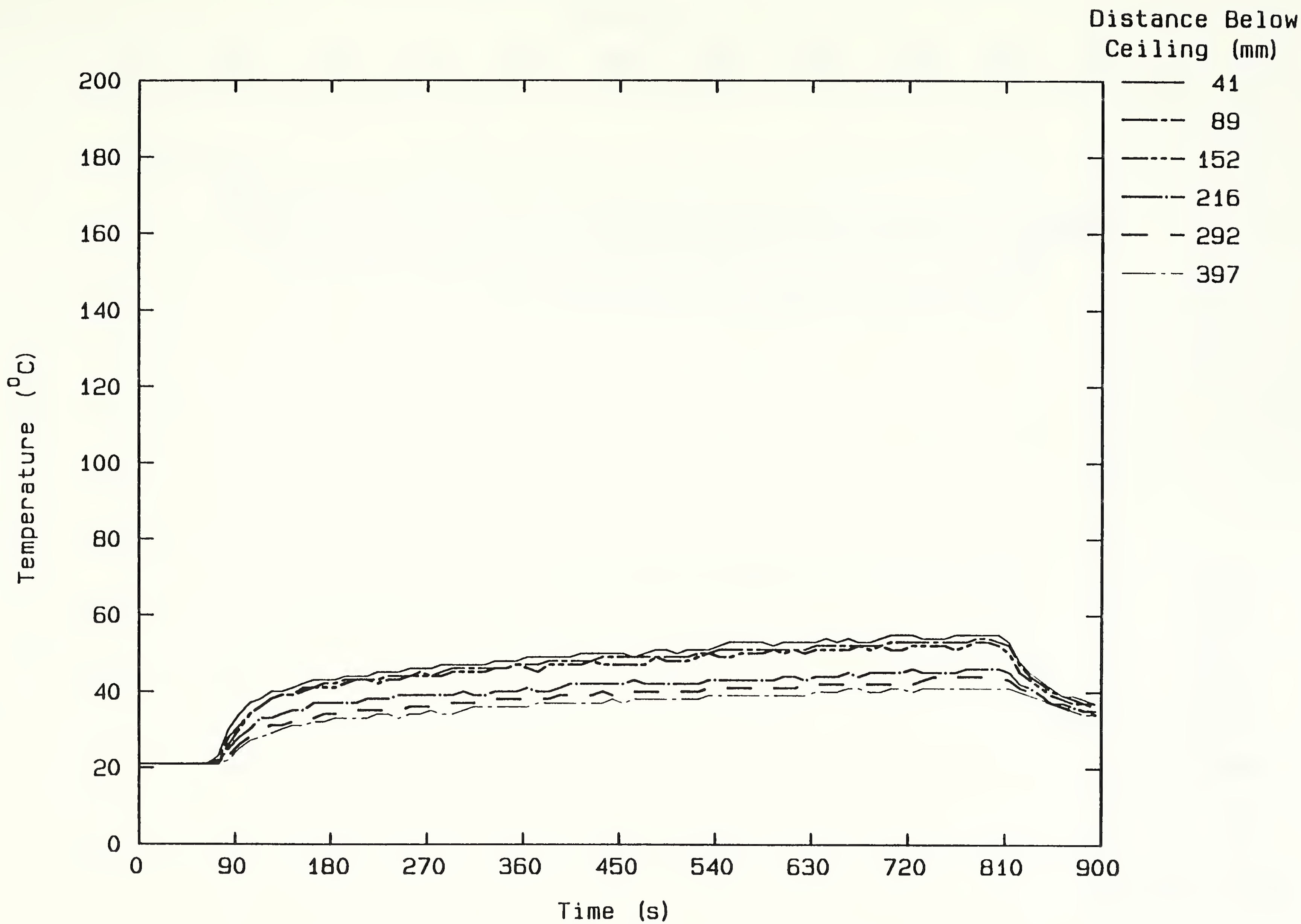

Figure 72. Test G0205 Vertical temperature profile at position B

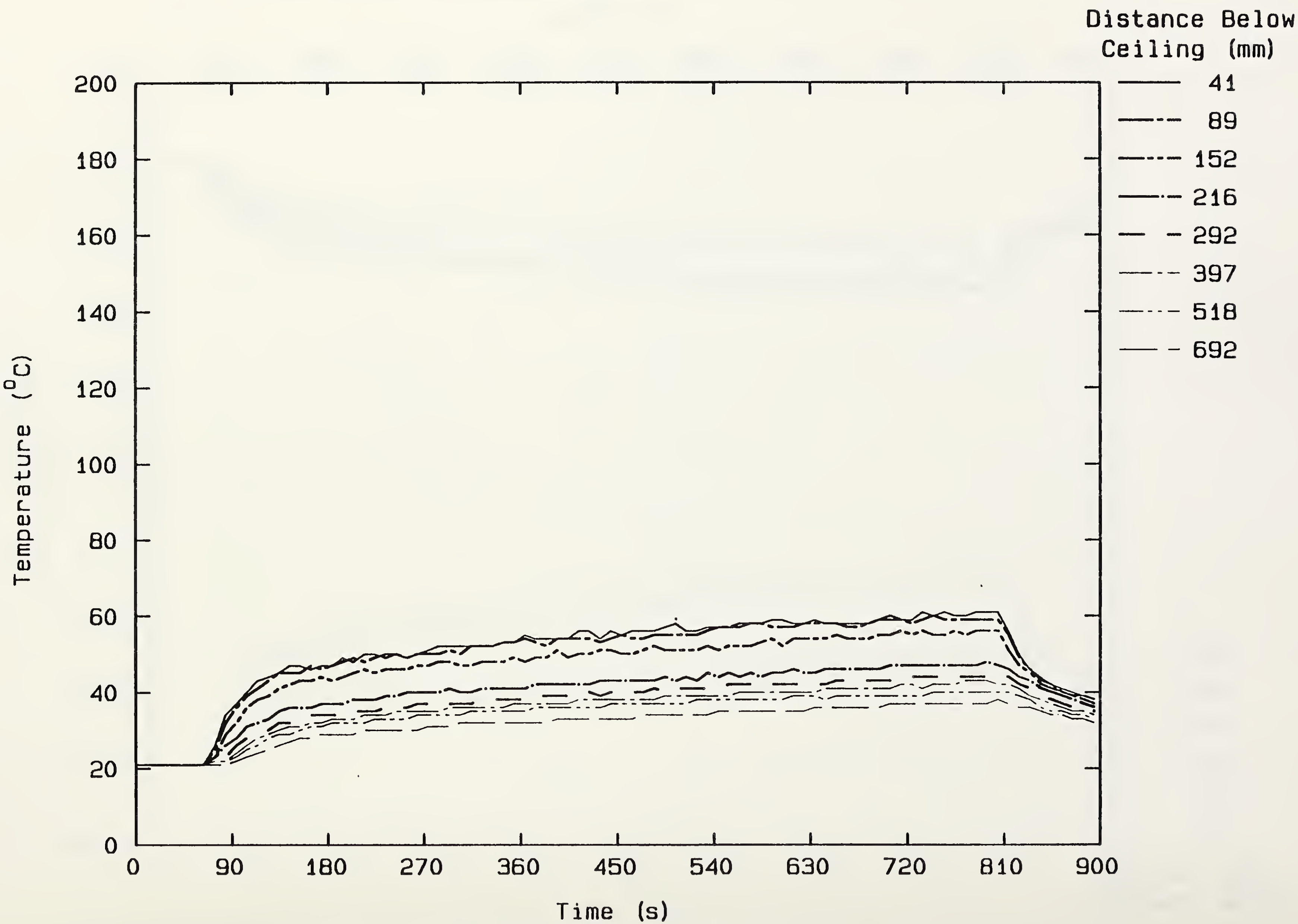

Figure 73. Test G0205 Vertical temperature profile at position C

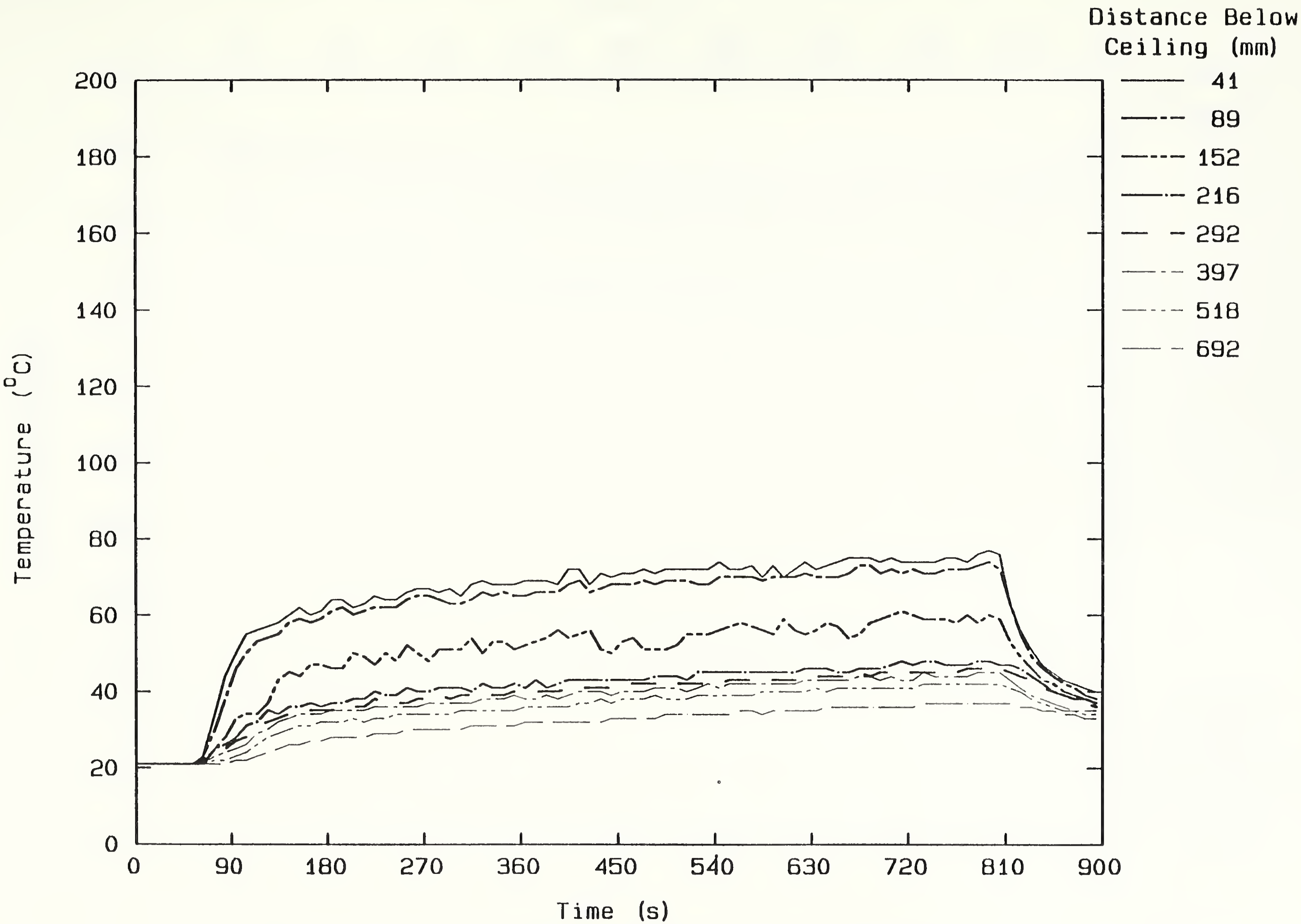

Figure 74. Test G0205 Vertical temperature profile at position D

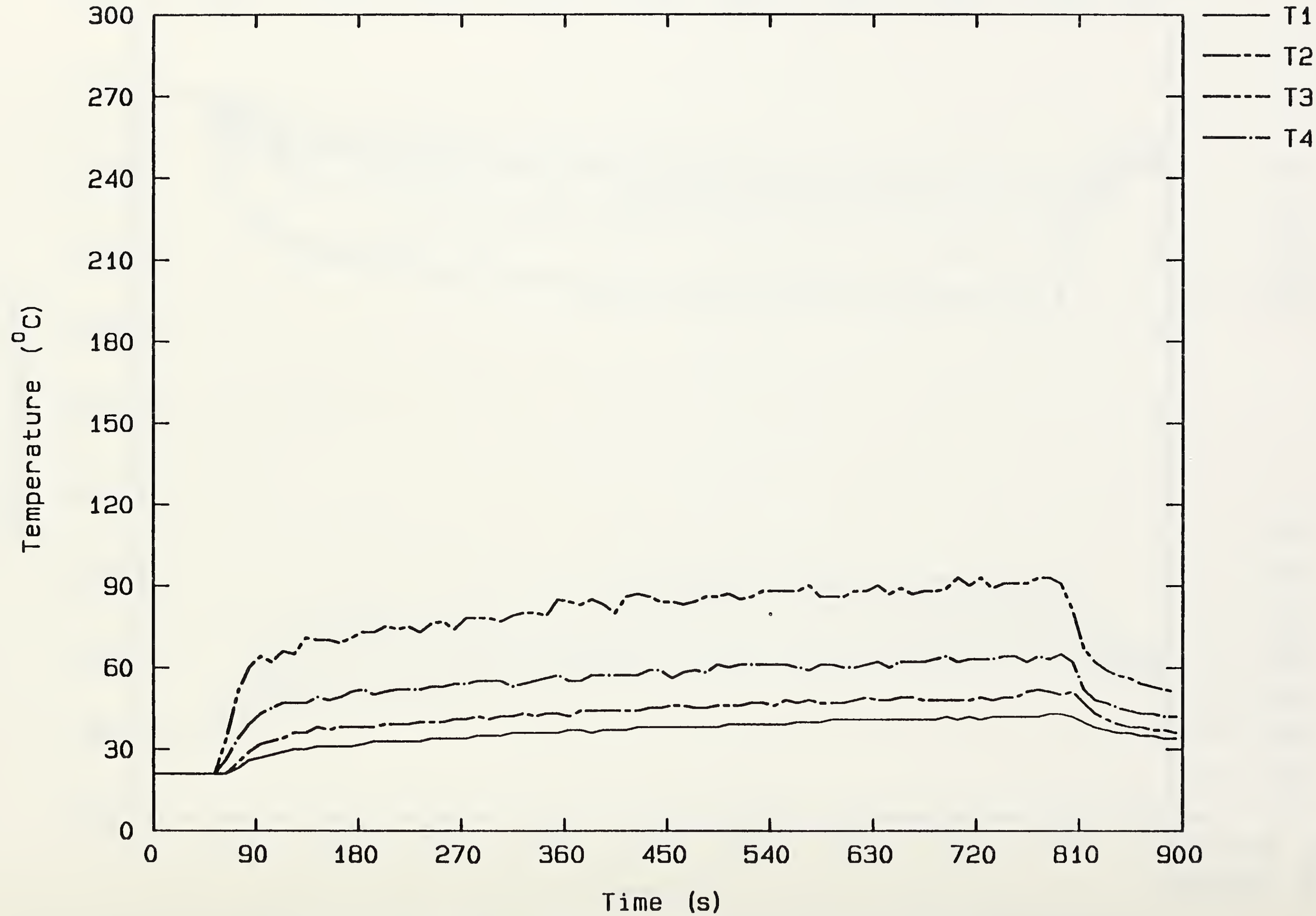

Figure 75. Test G0205 Ceiling interior surface temperature: T1 - T4

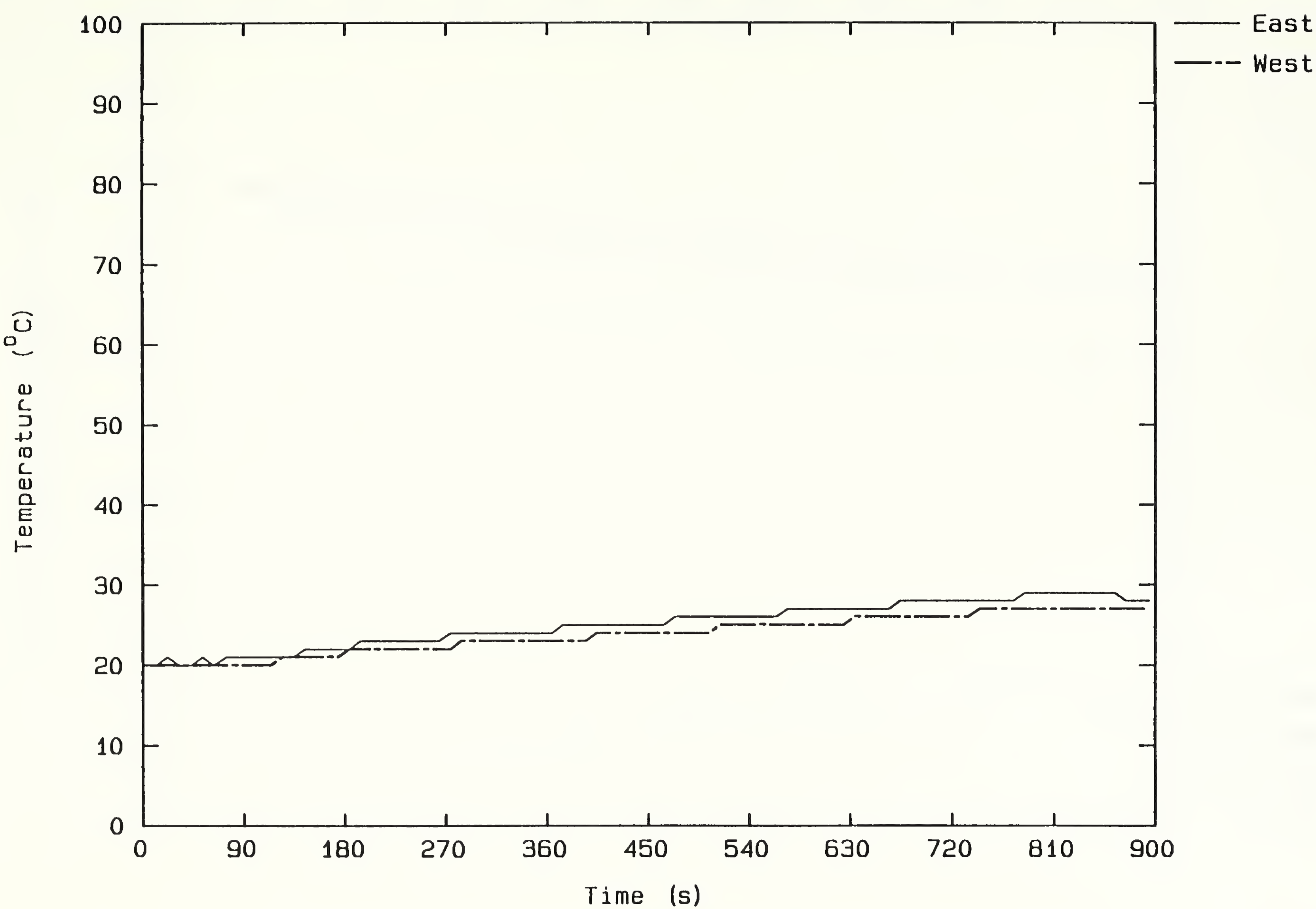

Figure 76. Test G0205 Exhaust temperature: east and west

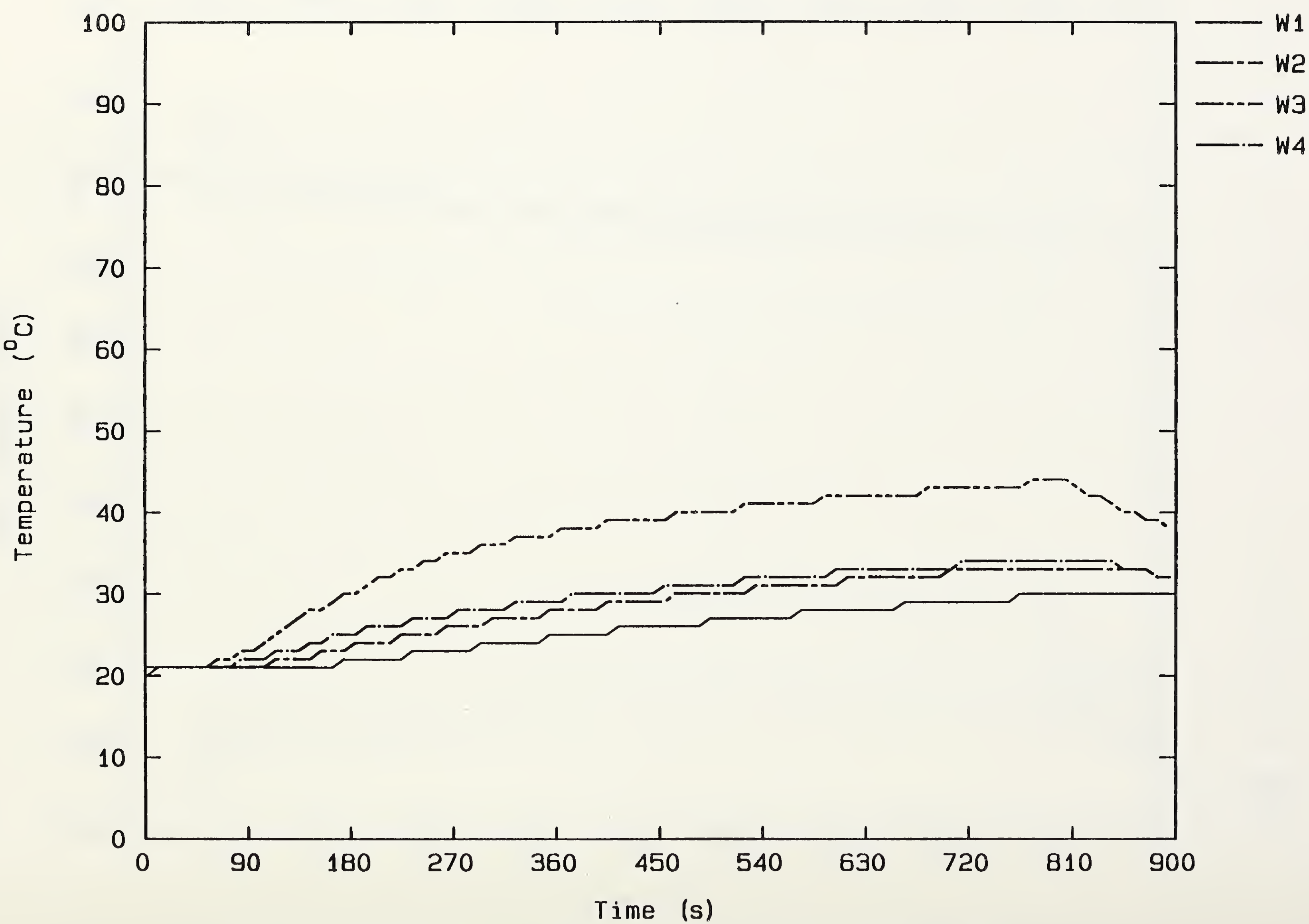

Figure 77. Test G0205 Wall interior surface temperature: W1 - W4

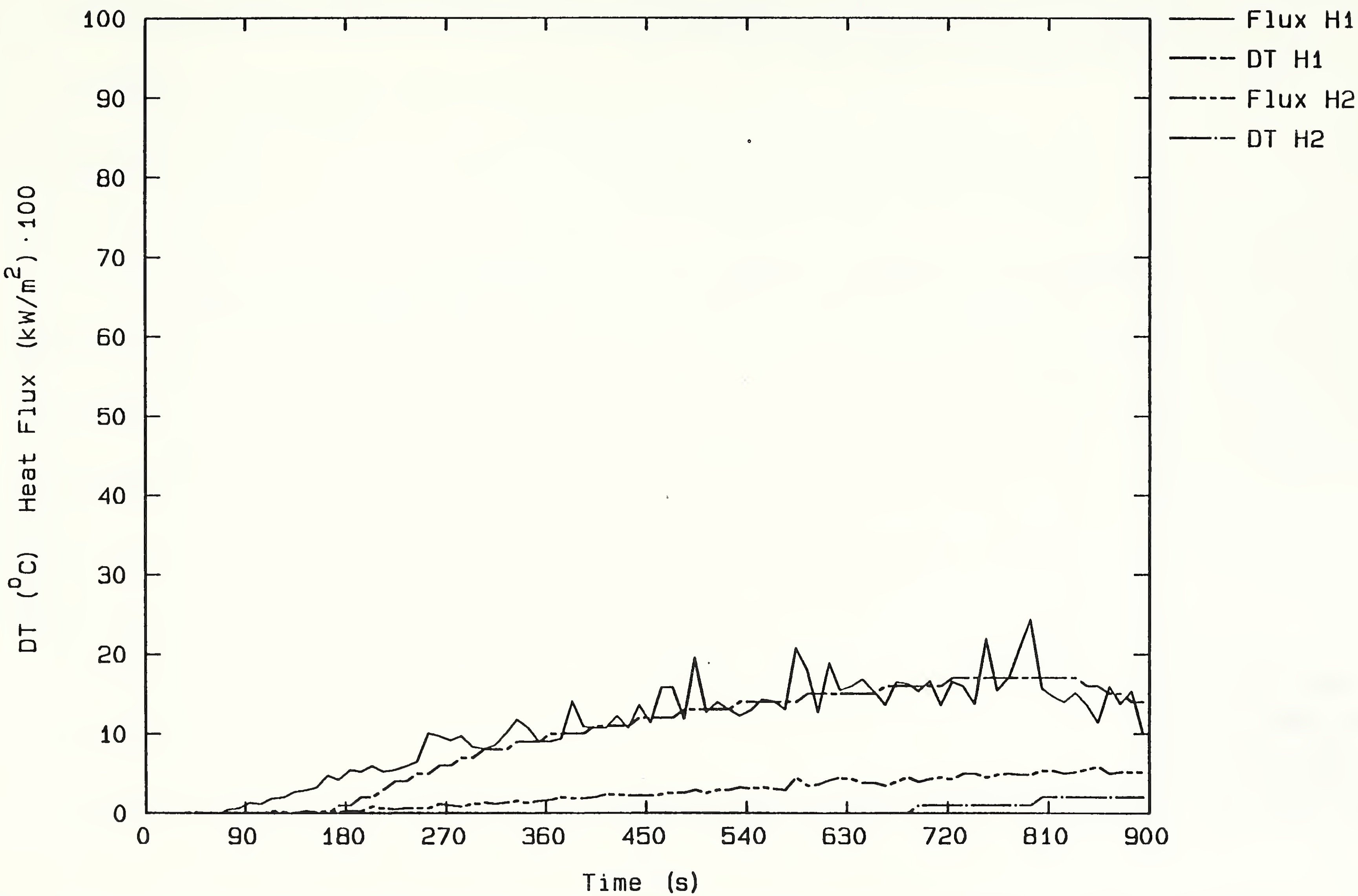

Figure 78. Test G0205 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

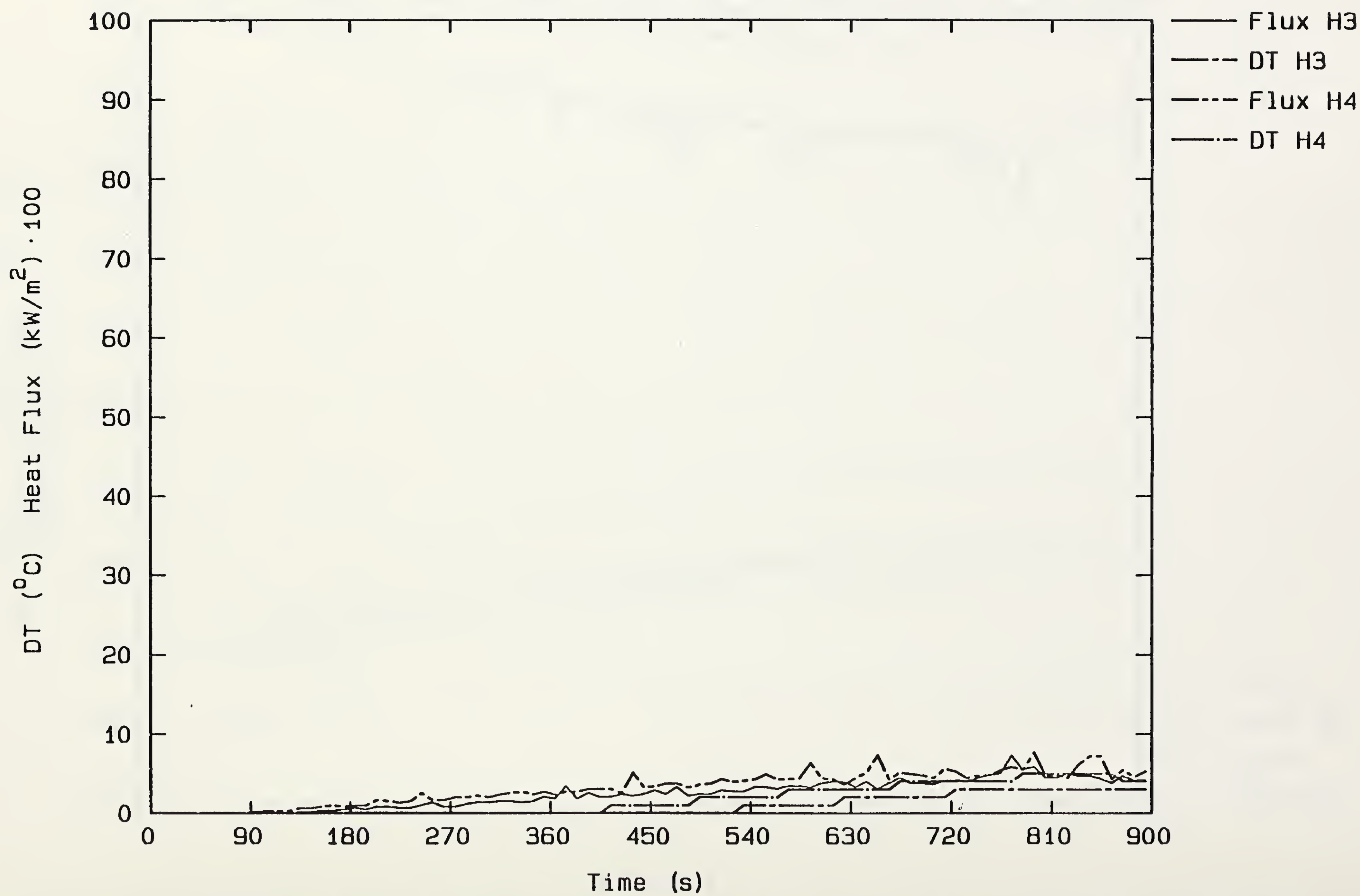

Figure 79. Test G0205 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

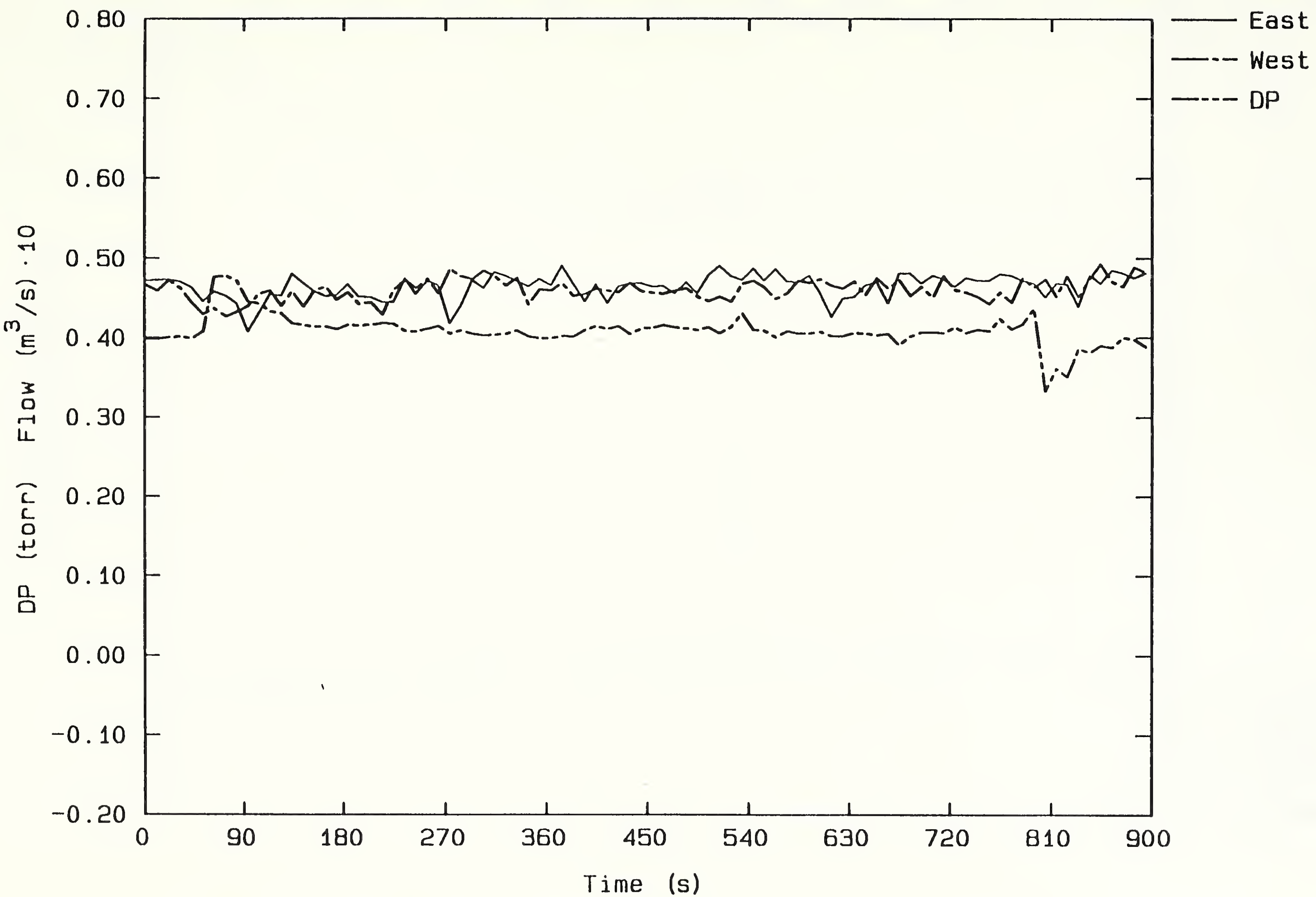

Figure 80. Test G0205 Cabin differential pressure and inlet flows, east and west

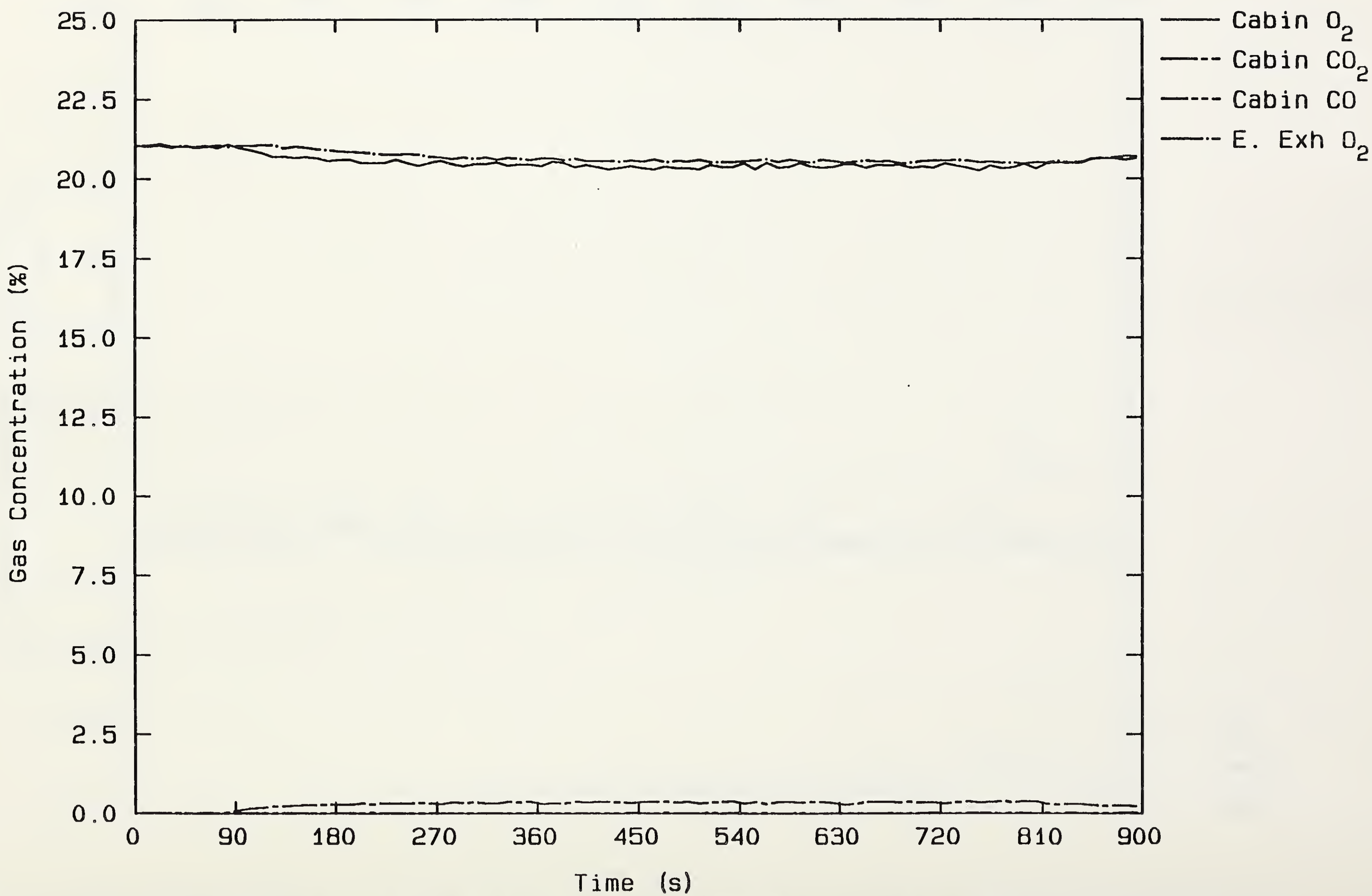

Figure 81. Test G0205 Cabin and exhaust gas concentrations

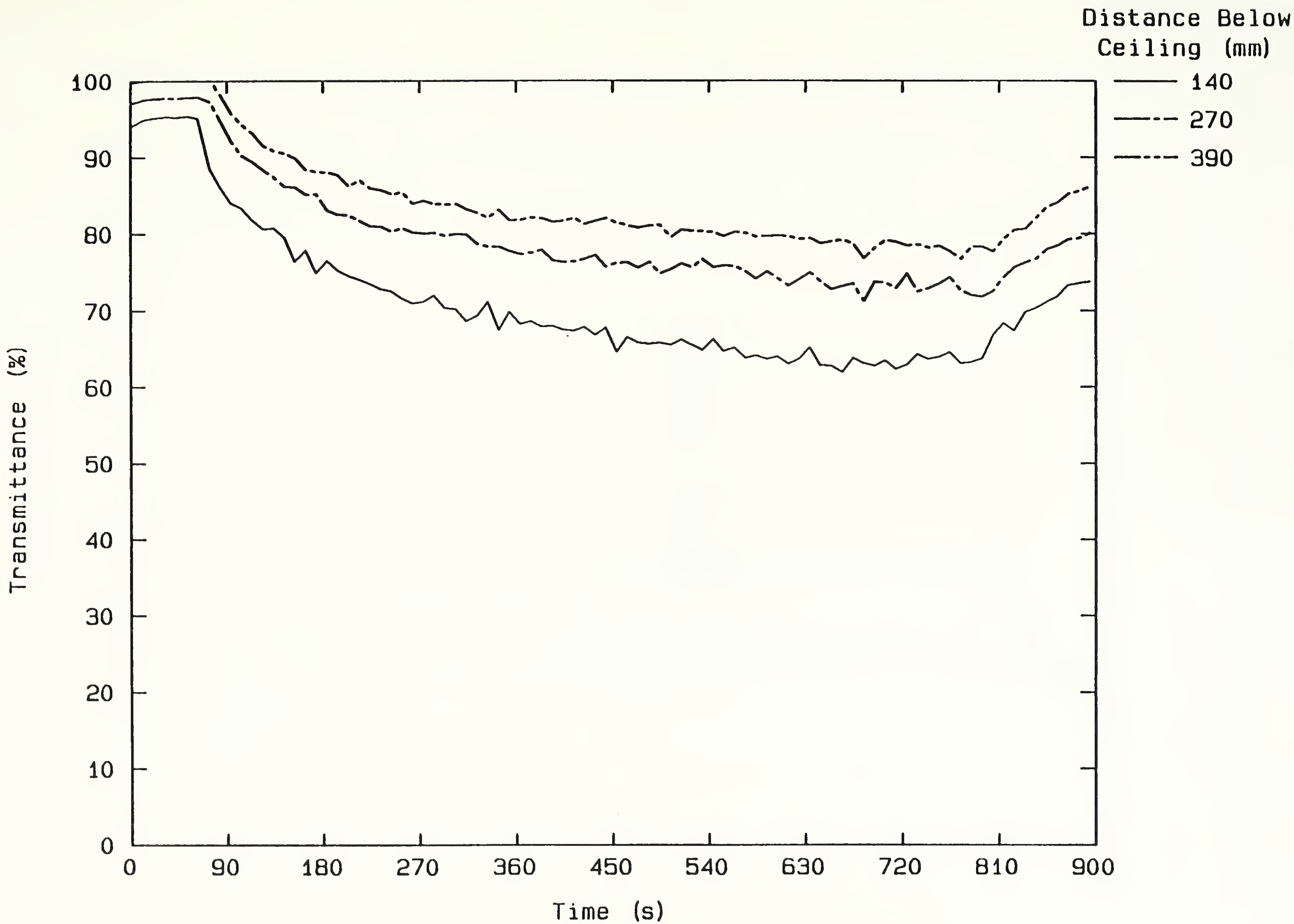

Figure 82. Test G0205 Cabin light attenuation by smoke

TEST G0605

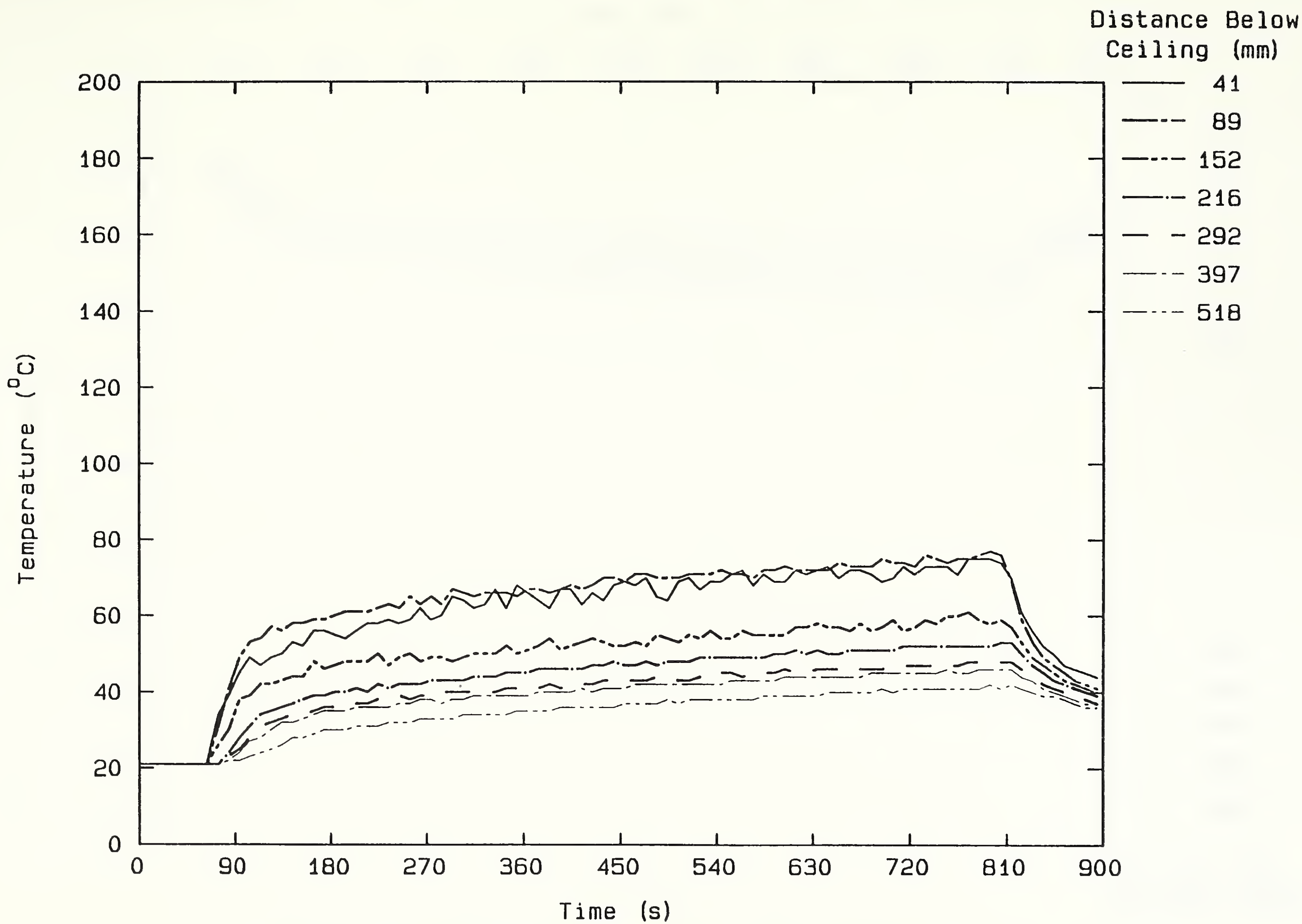

Figure 83. Test G0605 Vertical temperature profile at position A

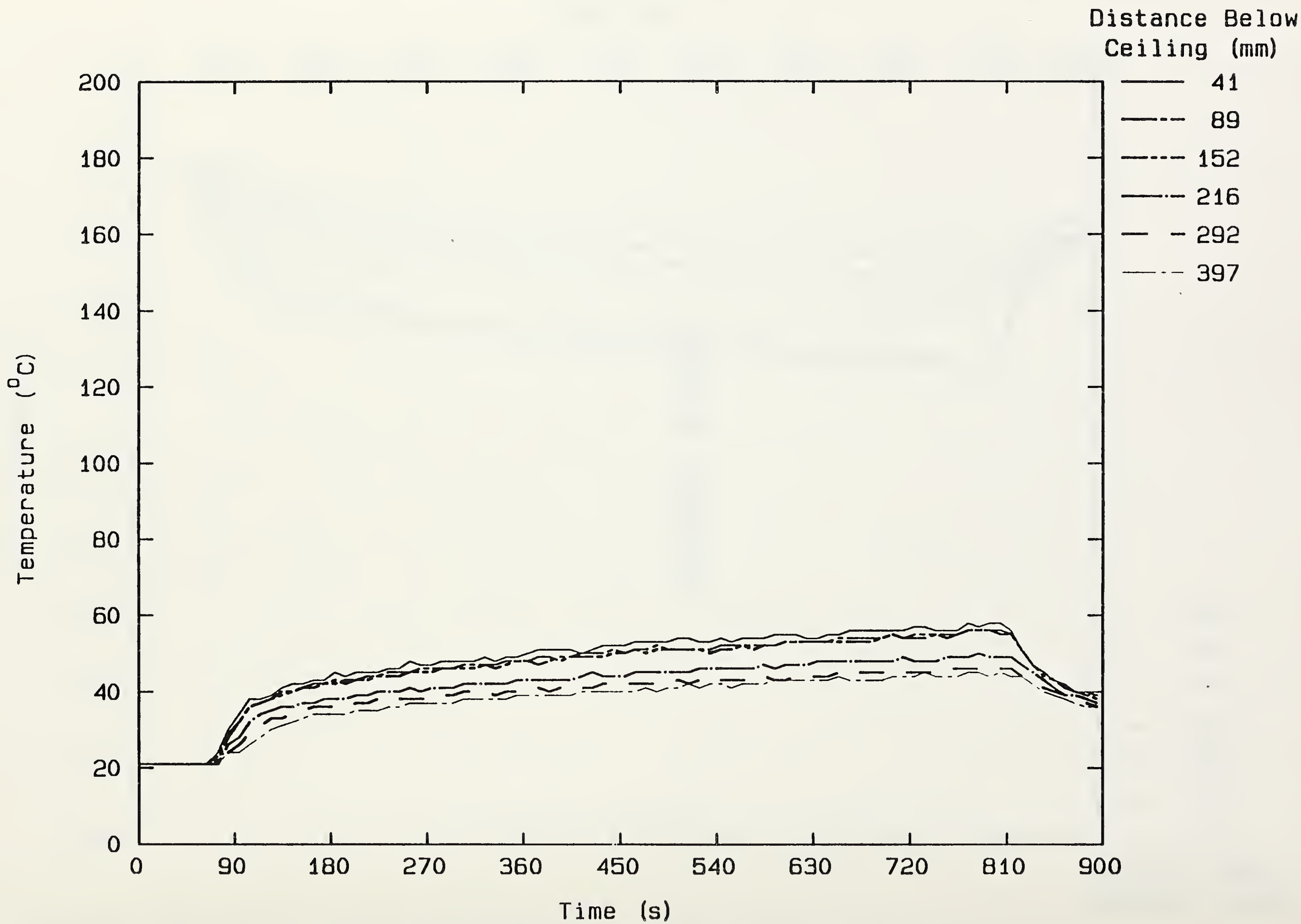

Figure 84. Test G0605 Vertical temperature profile at position B

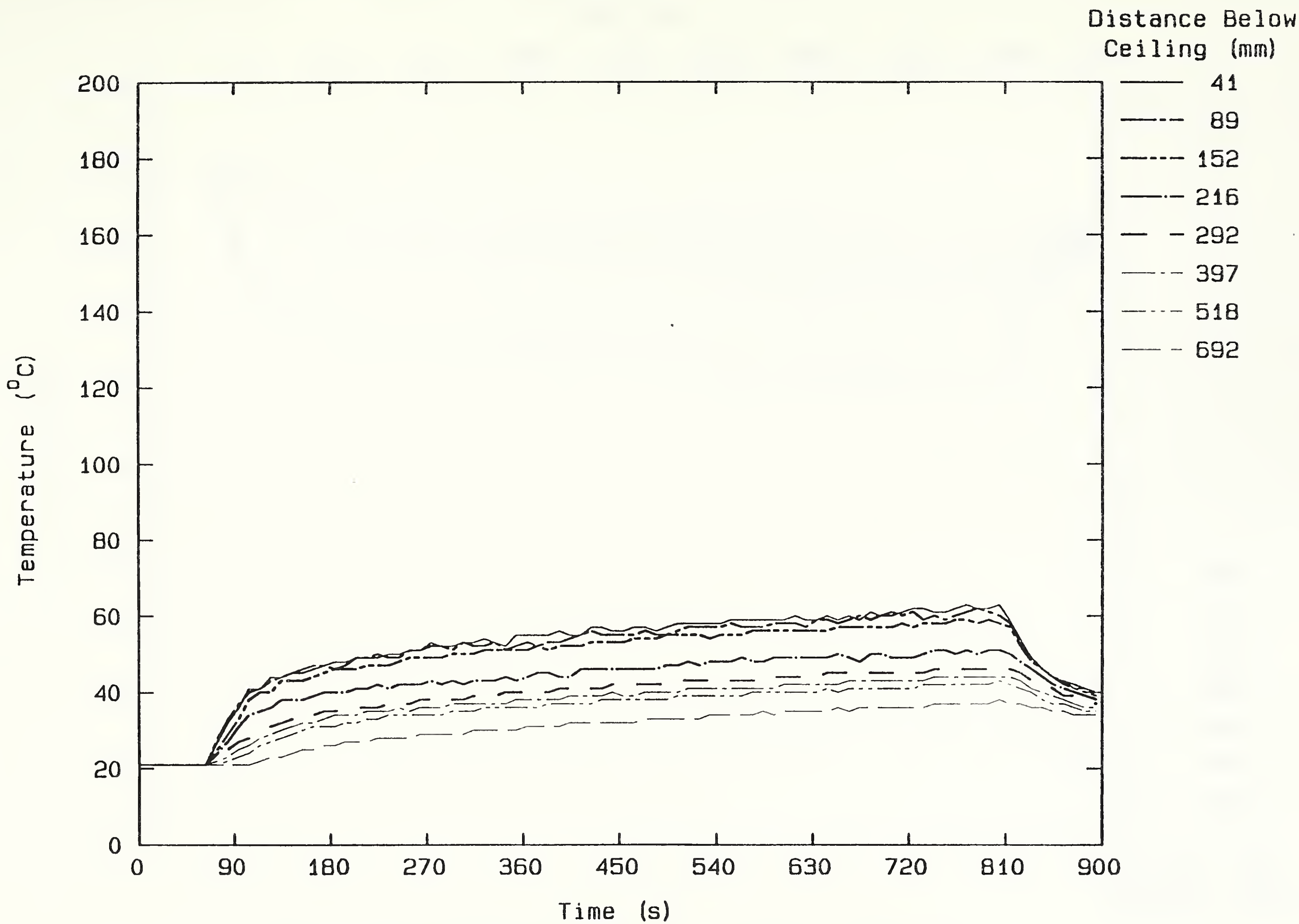

Figure 85. Test G0605 Vertical temperature profile at position C

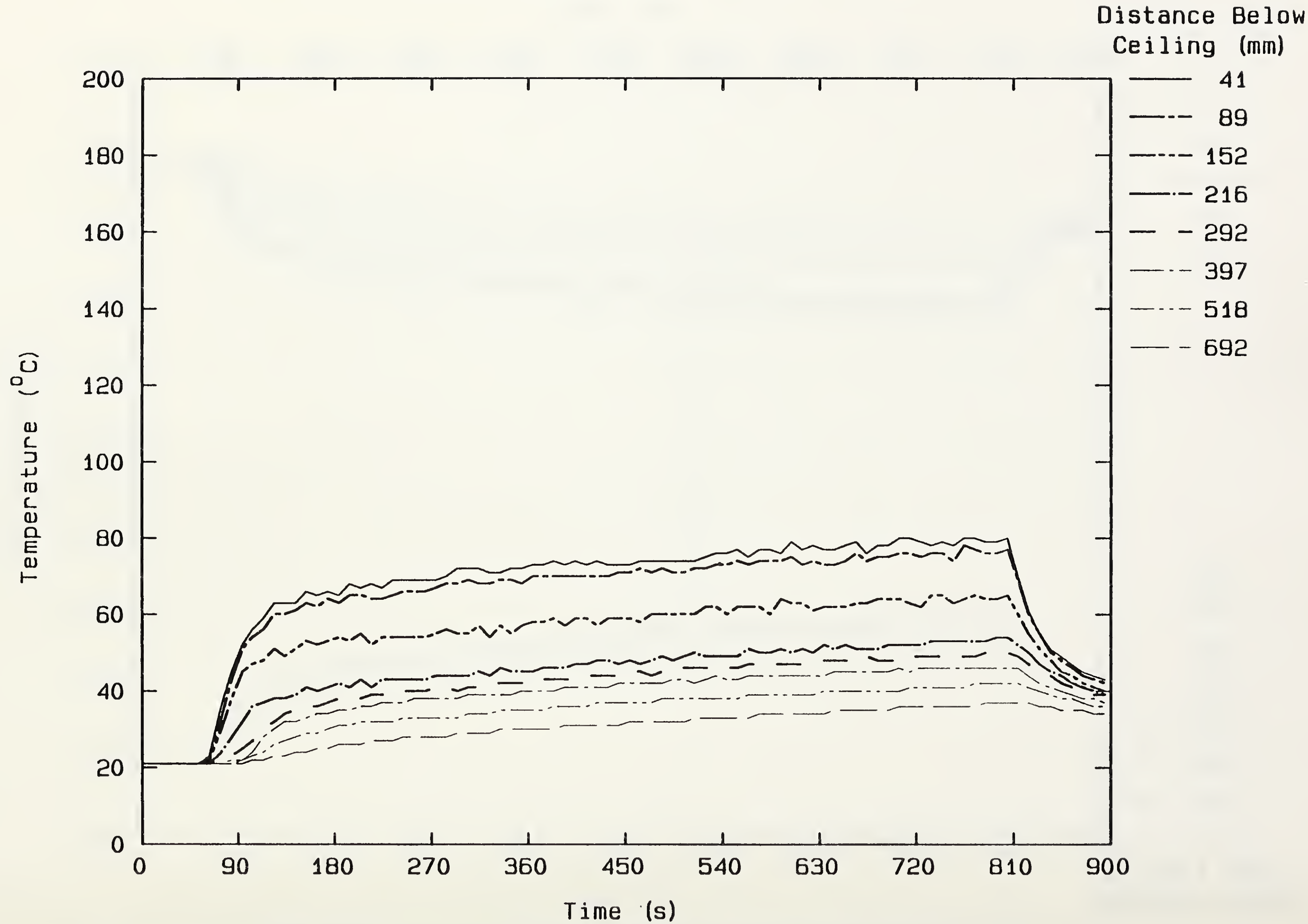

Figure 86. Test G0605 Vertical temperature profile at position D

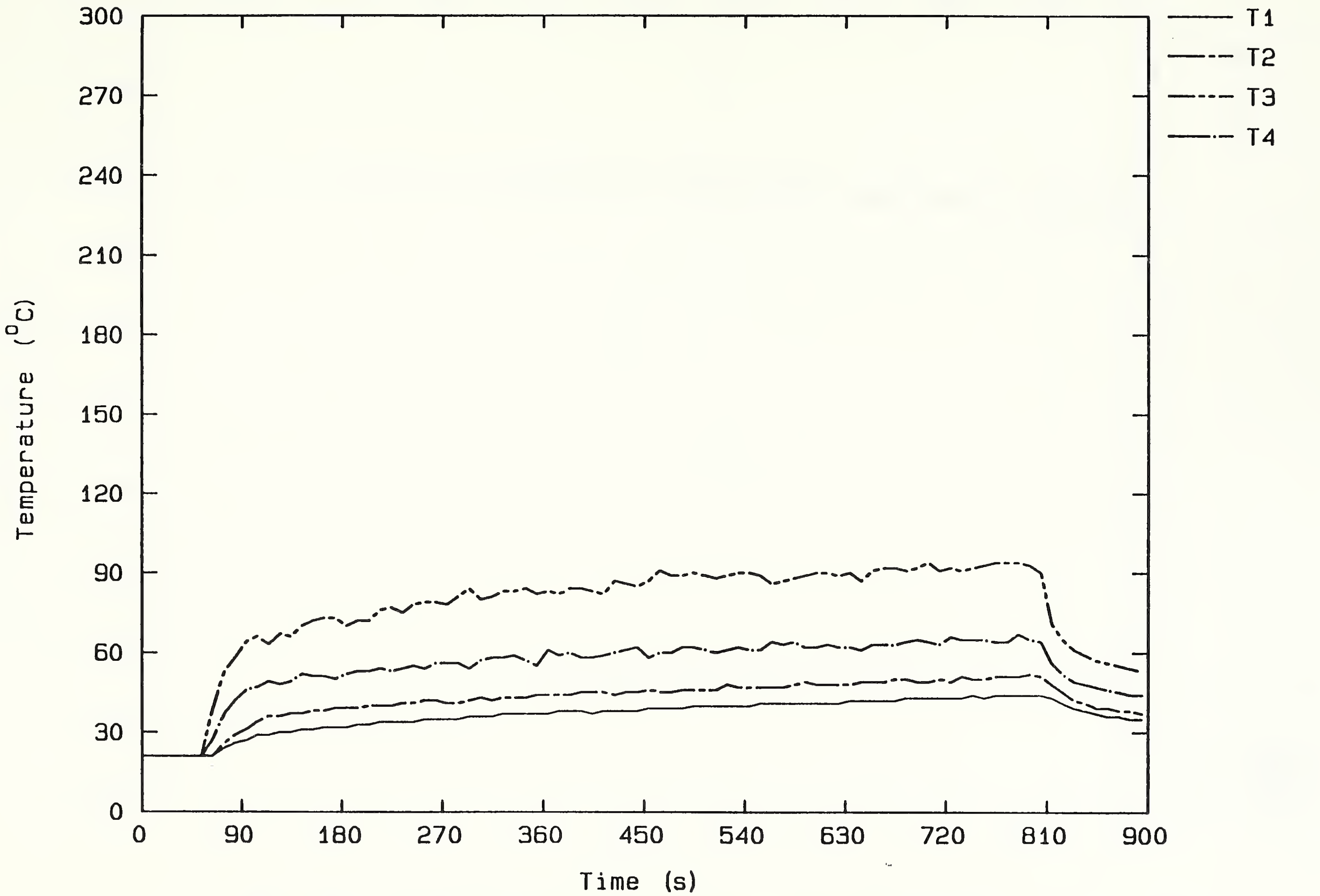

Figure 87. Test G0605 Ceiling interior surface temperature: T1 - T4

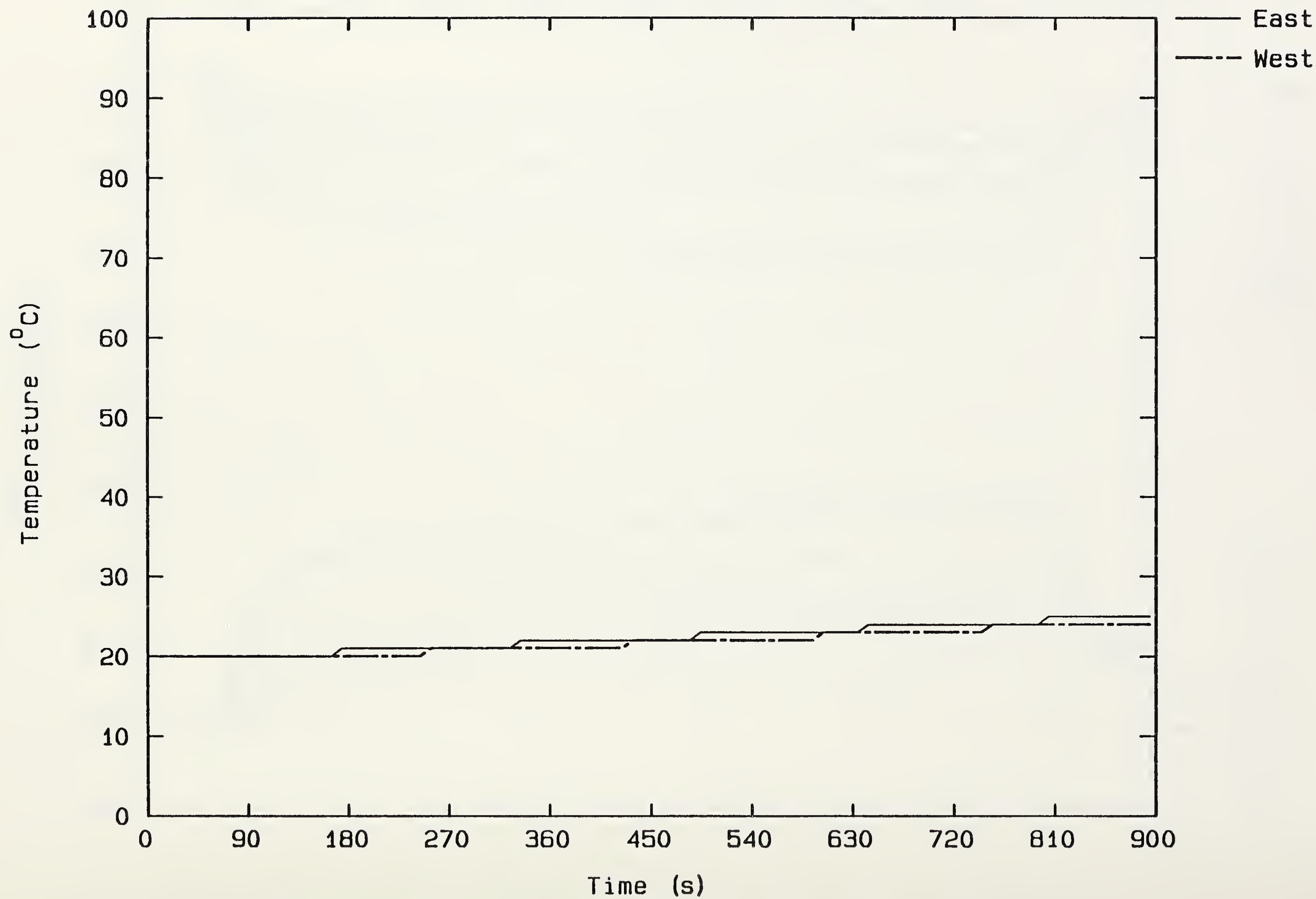

Figure 88. Test G0605 Exhaust temperature: east and west

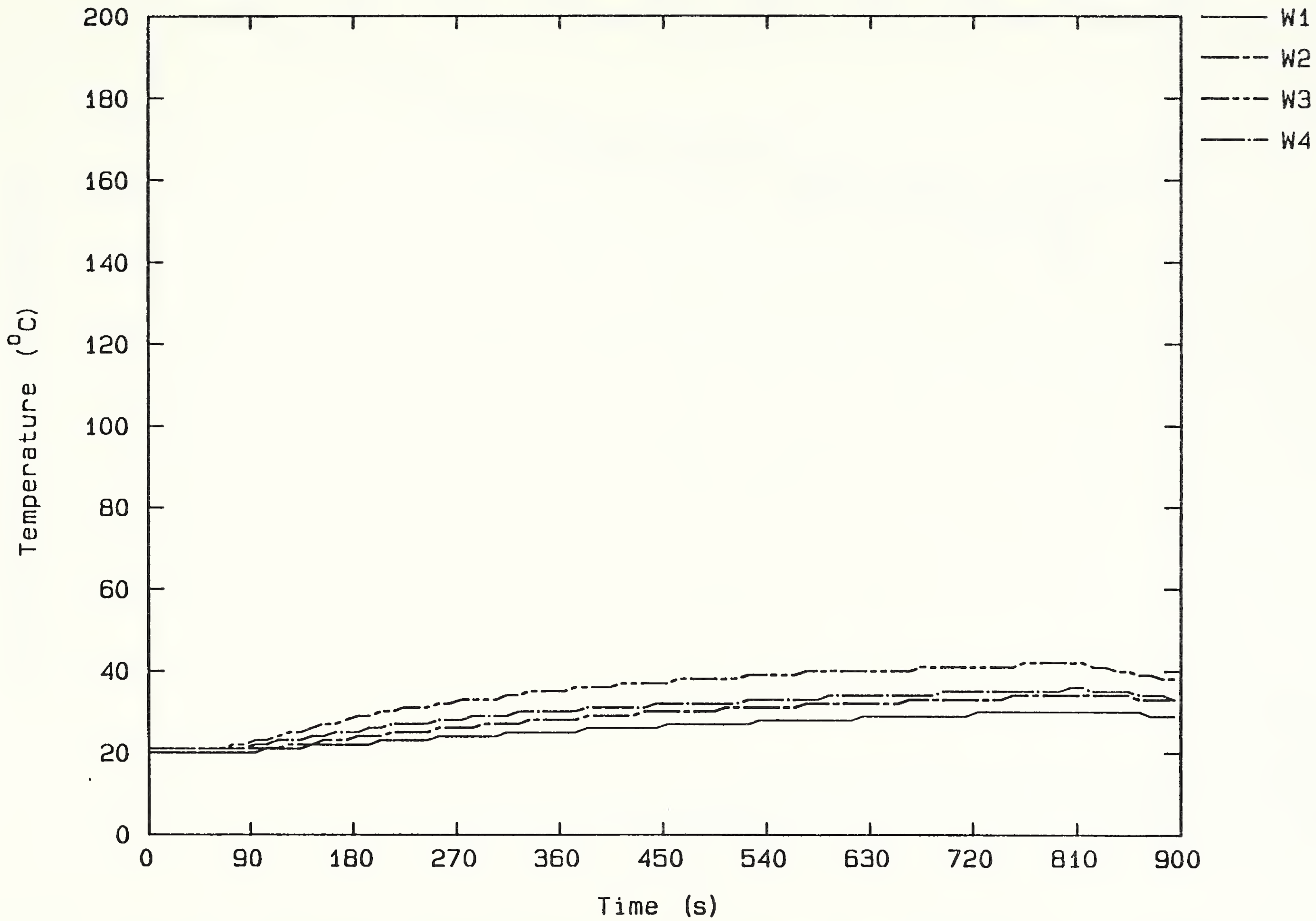

Figure 89. Test G0605 Wall interior surface temperature: W1 - W4

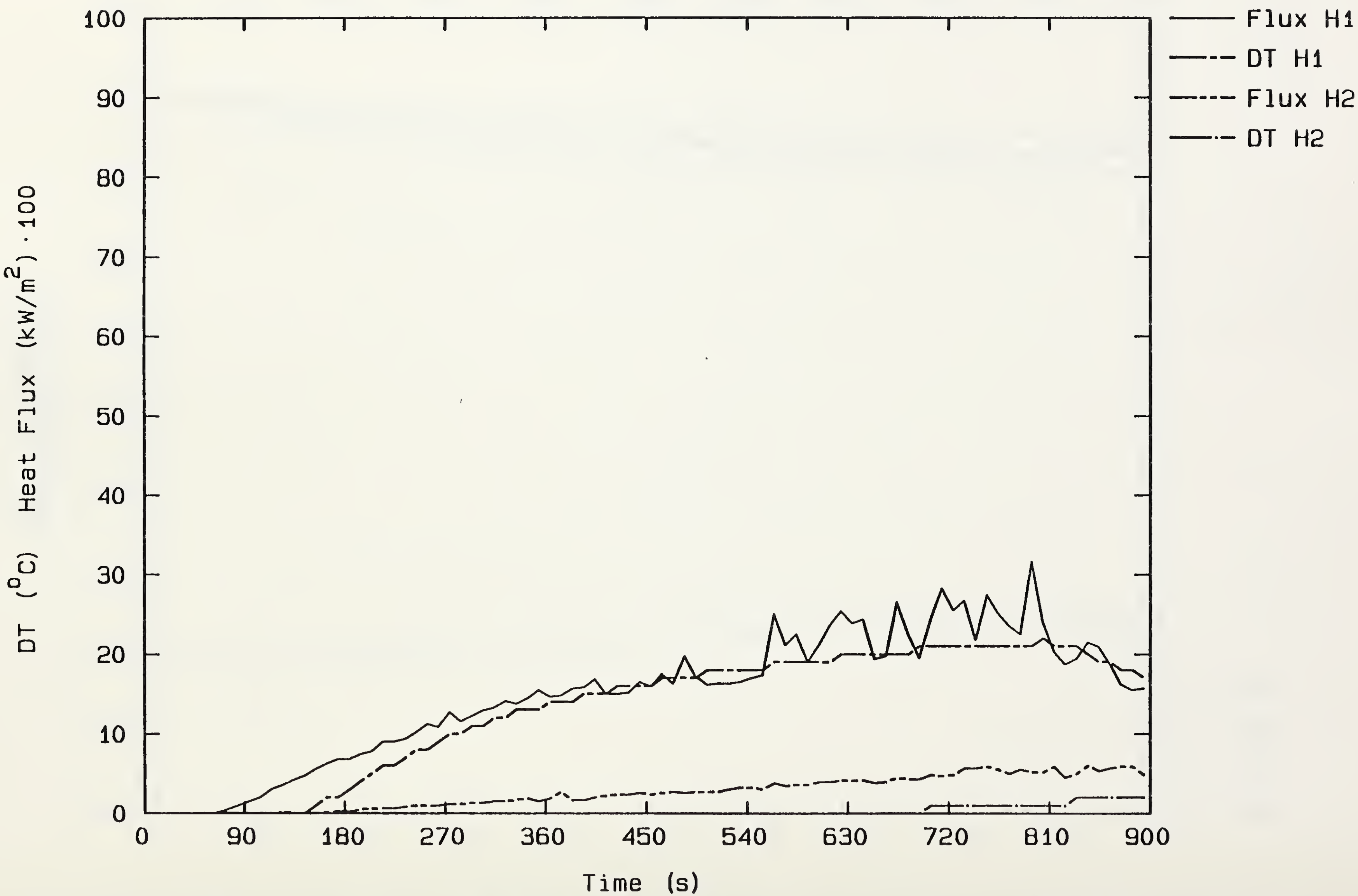

Figure 90. Test G0605 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

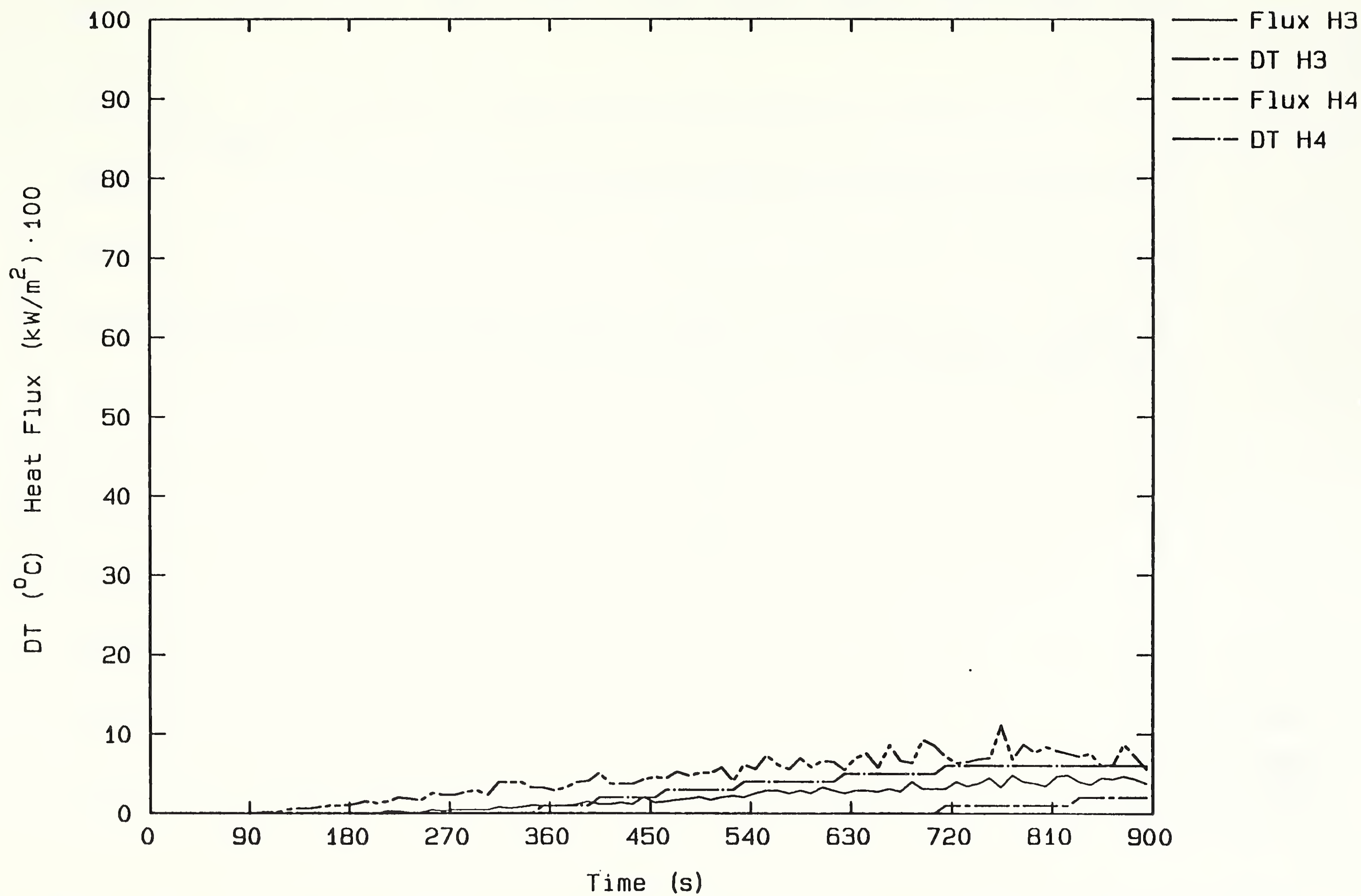

Figure 91. Test G0605 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

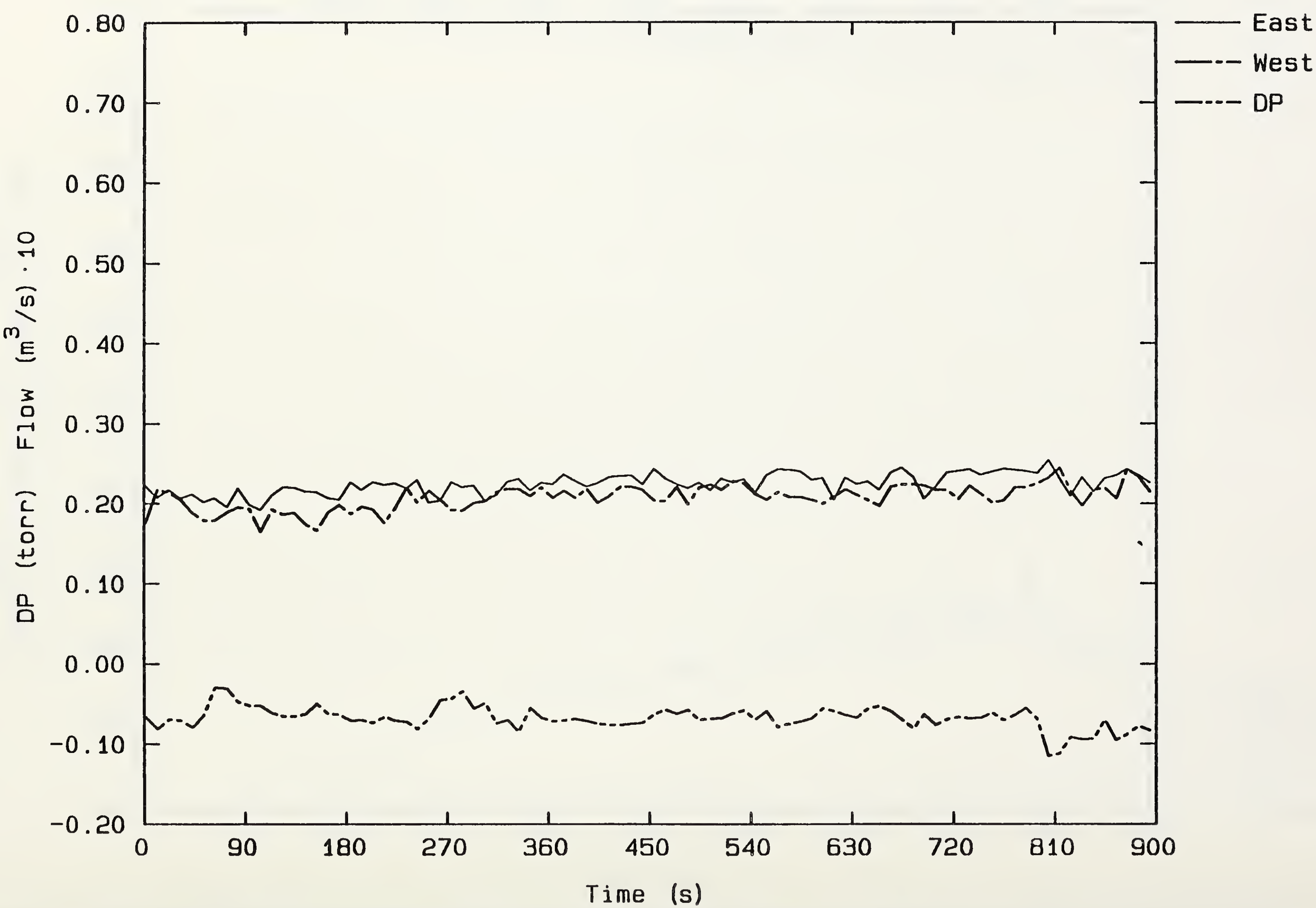

Figure 92. Test G0605 Cabin differential pressure and inlet flows, east and west

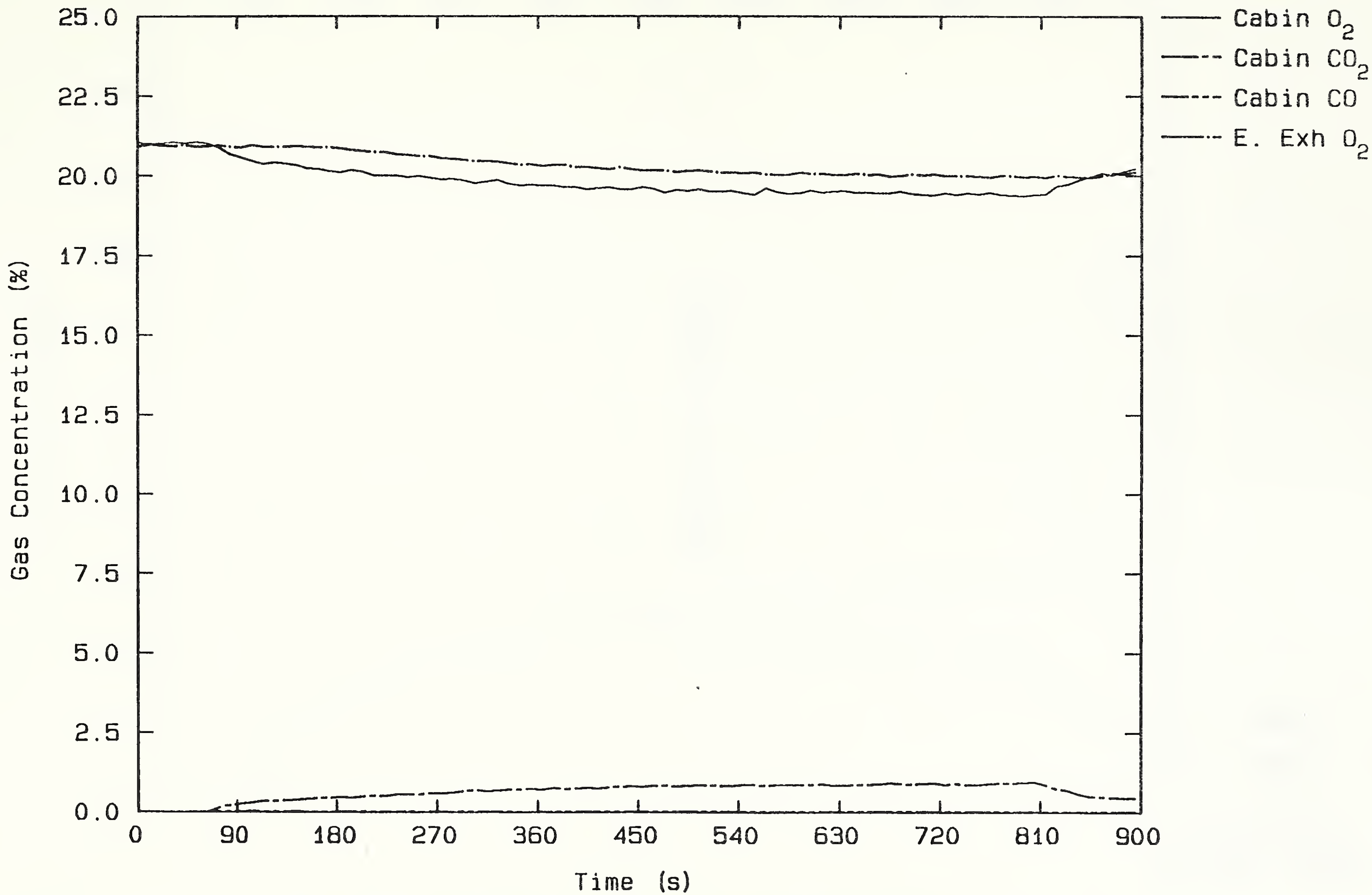

Figure 93. Test G0605 Cabin and exhaust gas concentrations

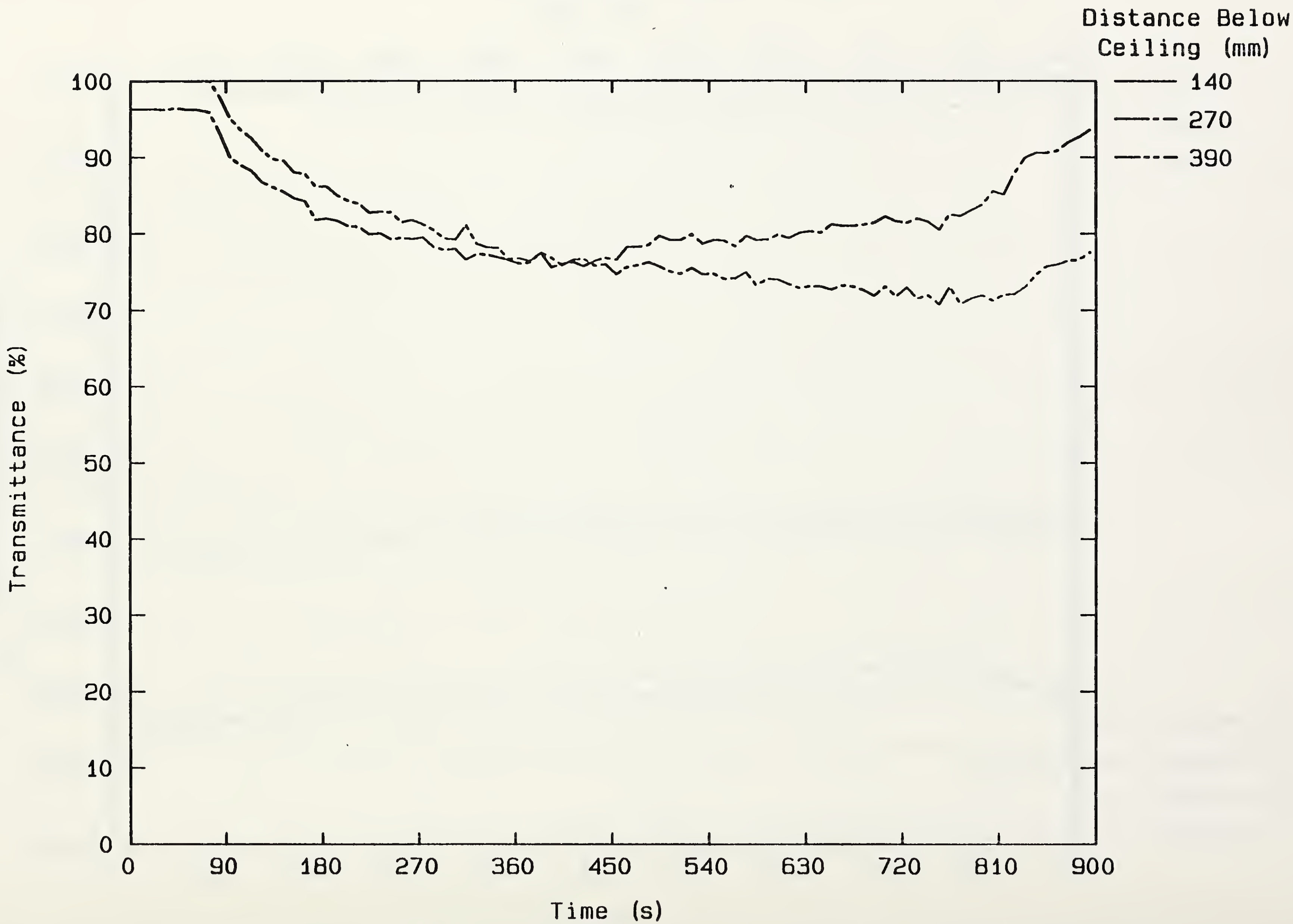

Figure 94. Test G0605 Cabin light attenuation by smoke

TEST G2305

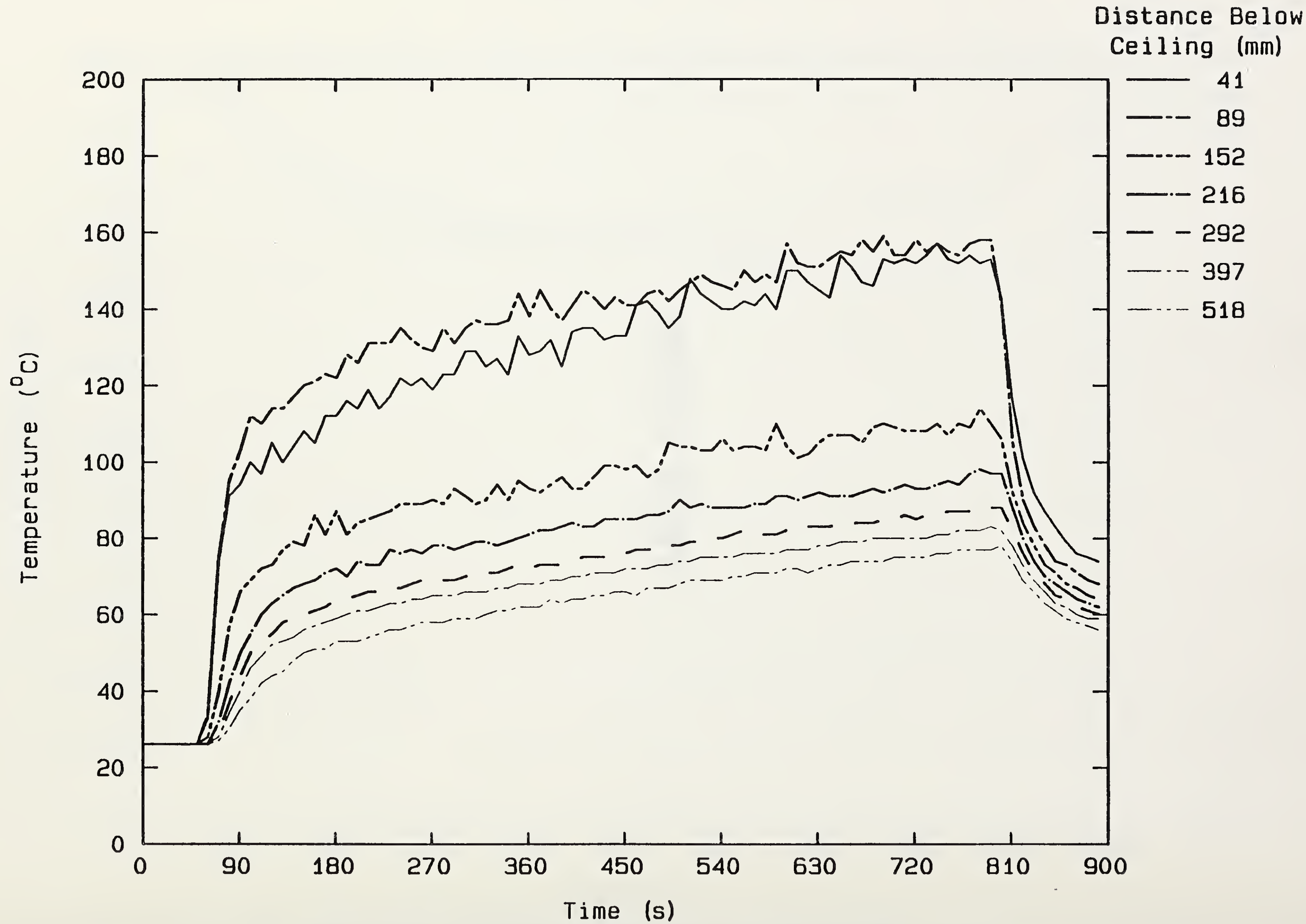

Figure 95. Test G2305 Vertical temperature profile at position A

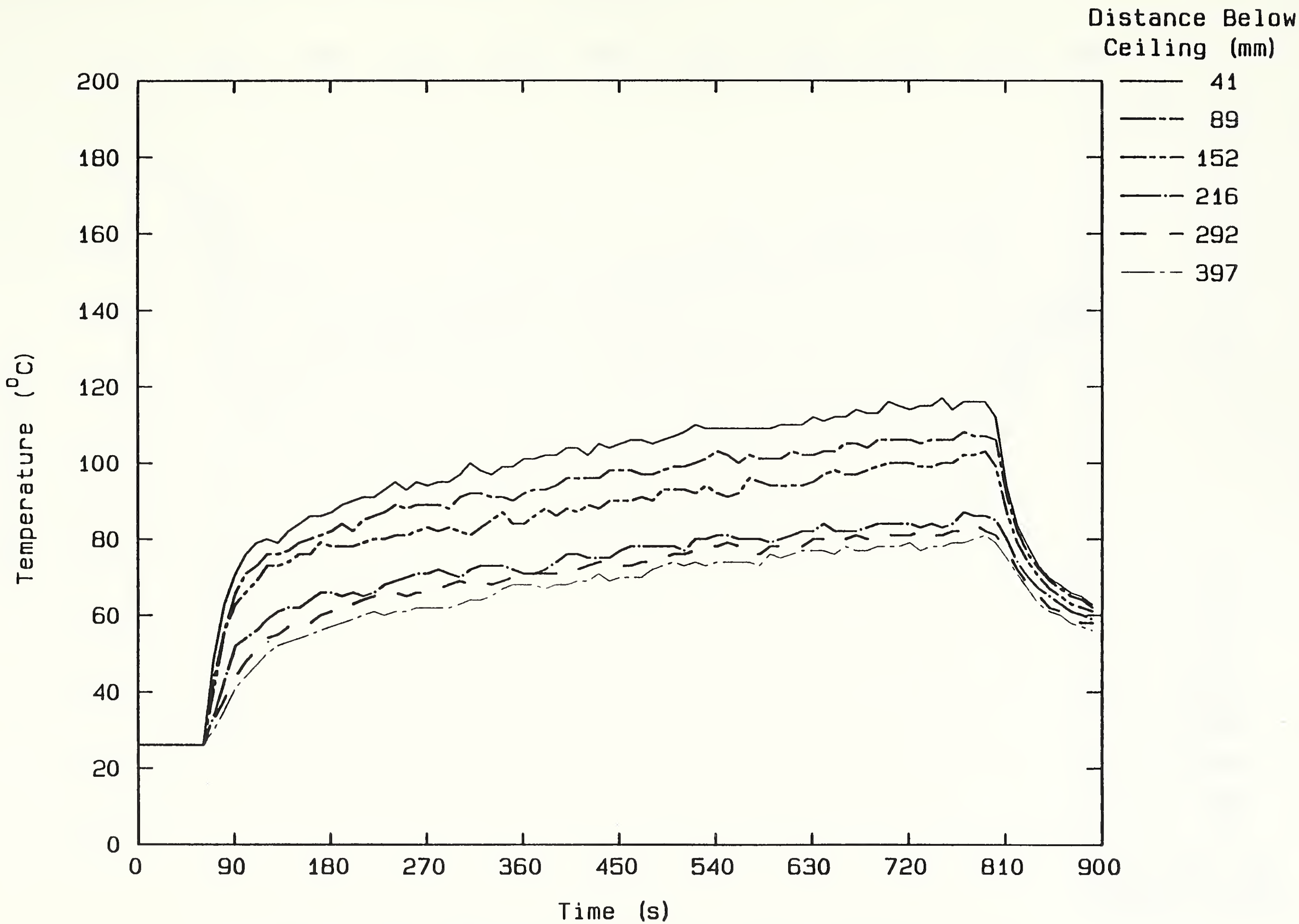

Figure 96. Test G2305 Vertical temperature profile at position B

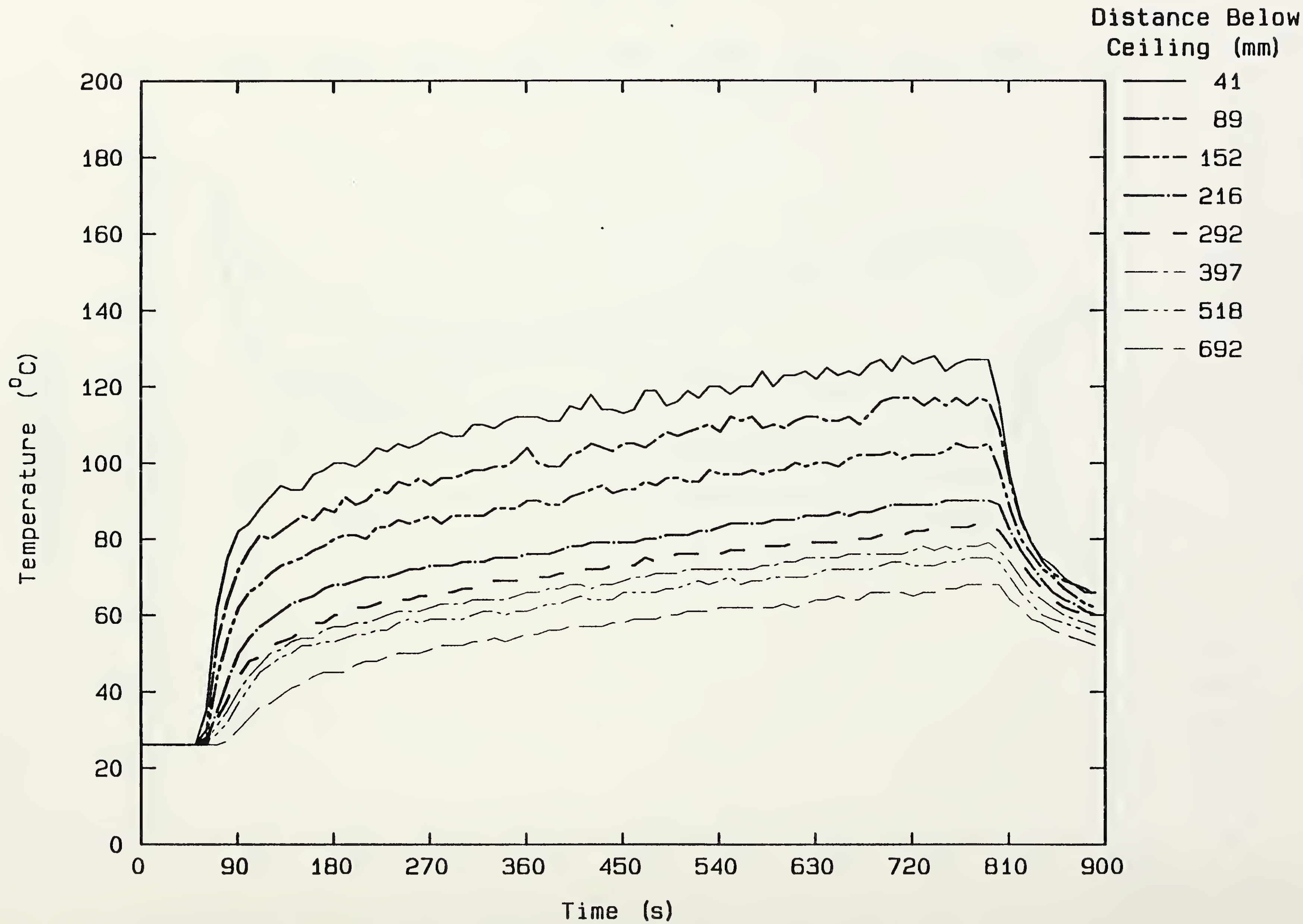

Figure 97. Test G2305 Vertical temperature profile at position C

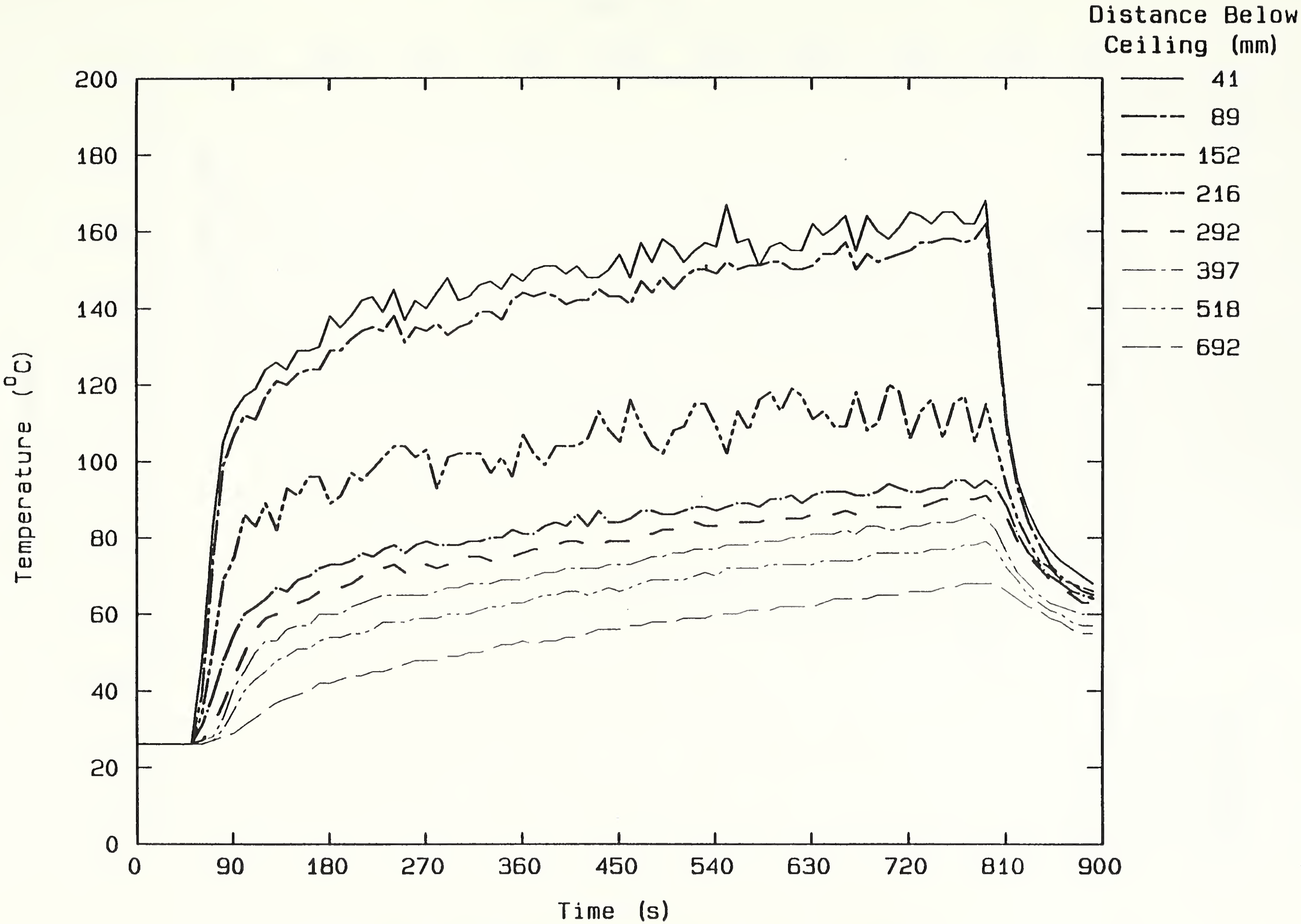

Figure 98. Test G2305 Vertical temperature profile at position D

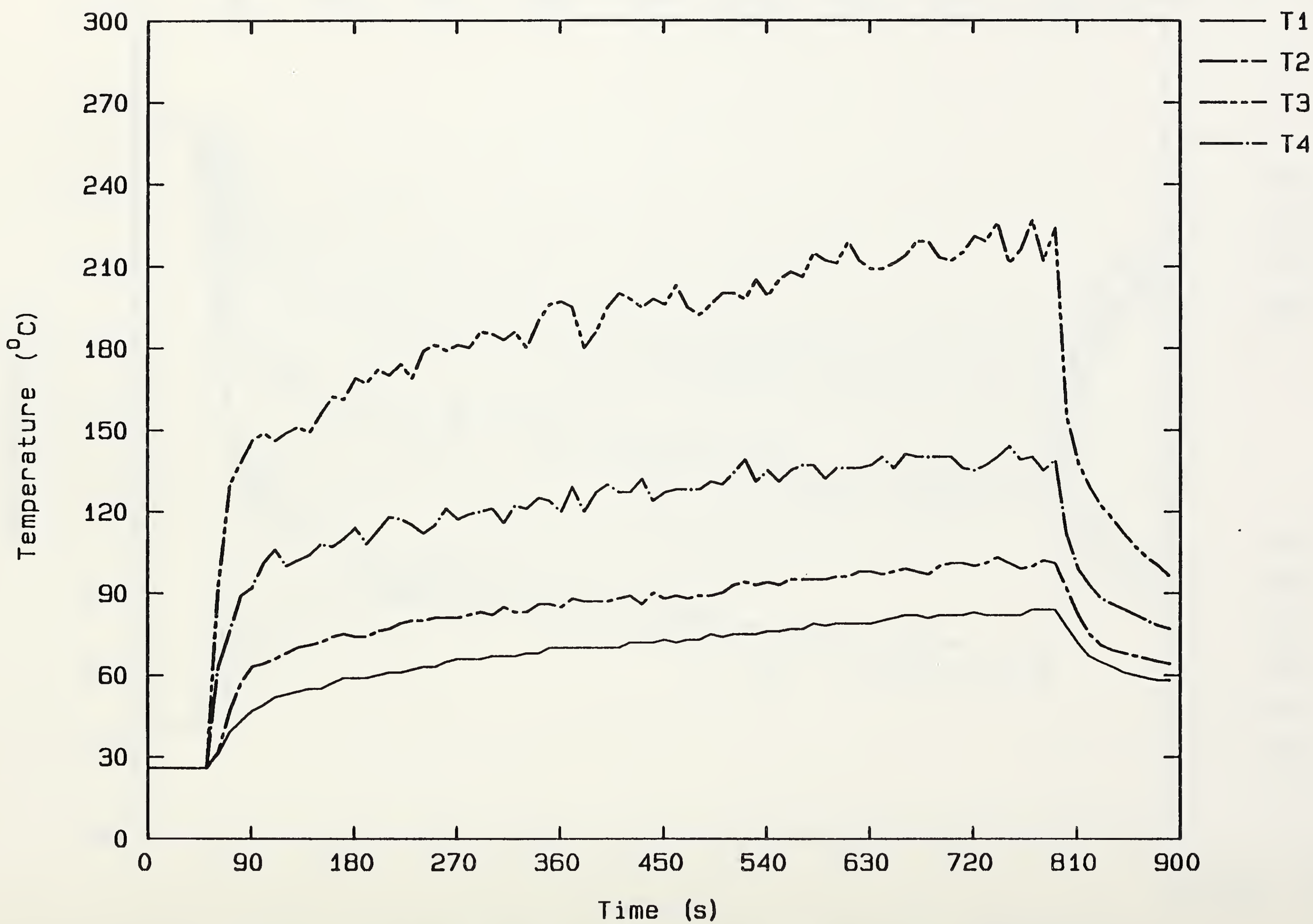

Figure 99. Test G2305 Ceiling interior surface temperature: T1 - T4

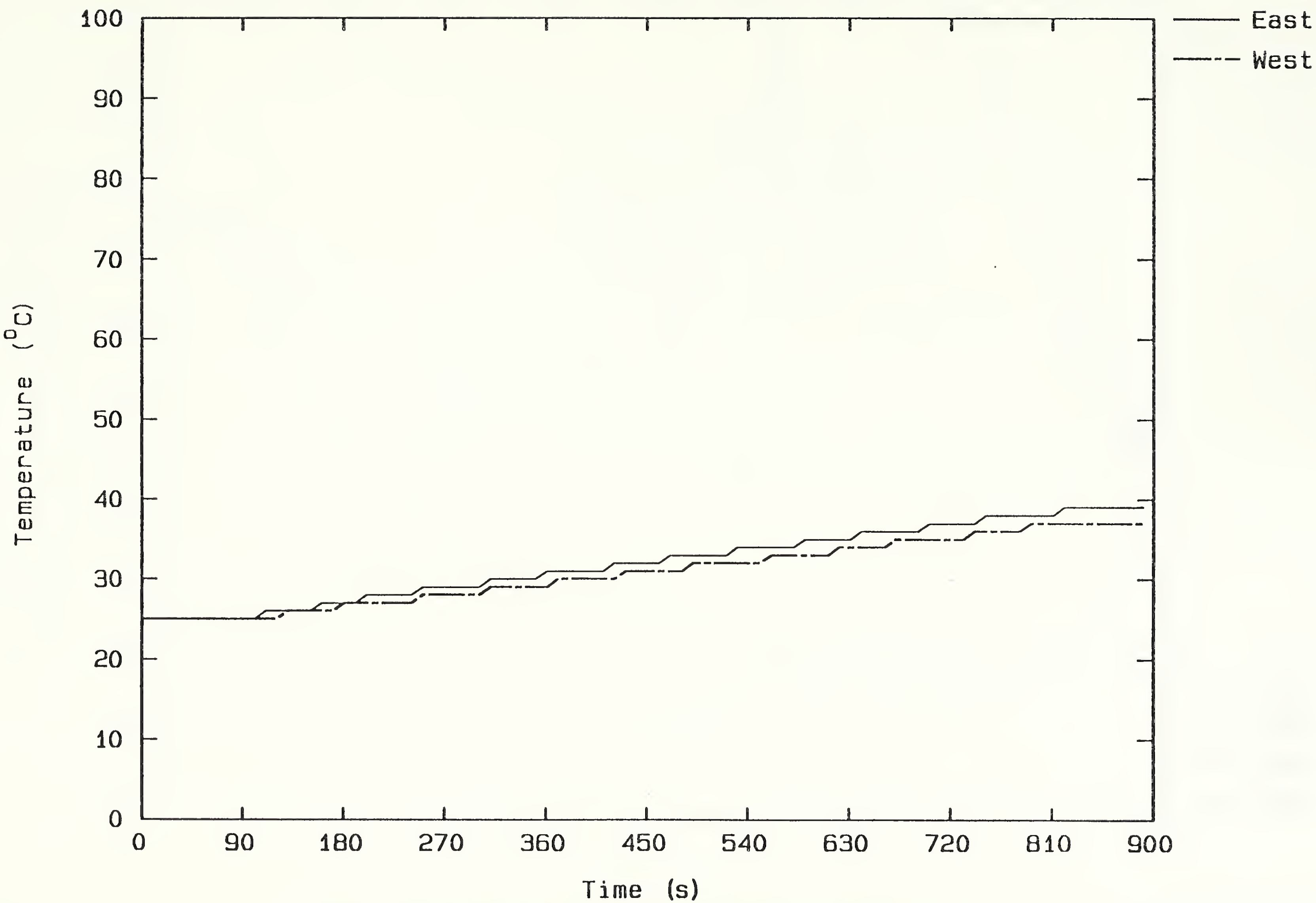

Figure 100. Test G2305 Exhaust temperature: east and west

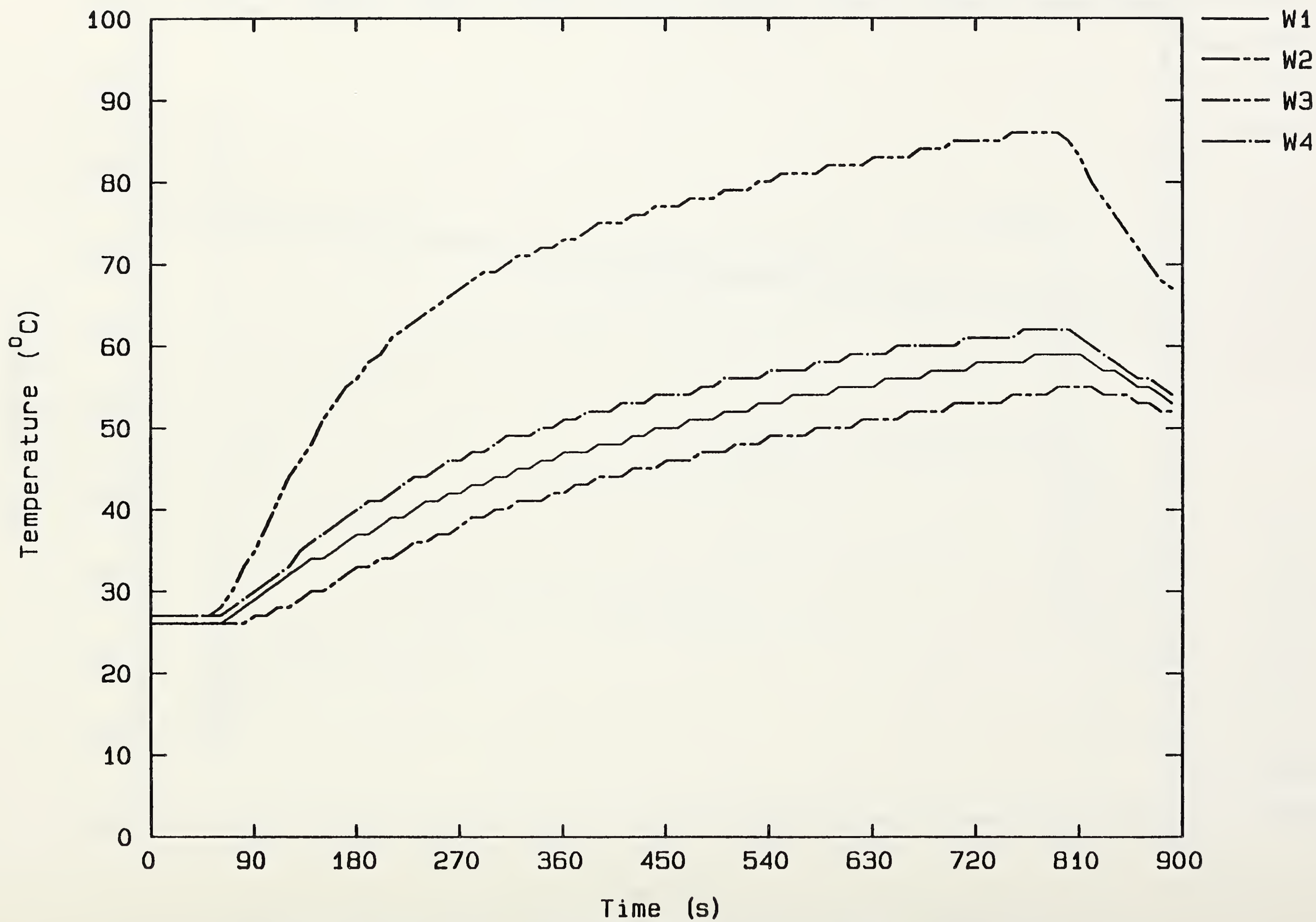

Figure 101. Test G2305 Wall interior surface temperature: W1 - W4

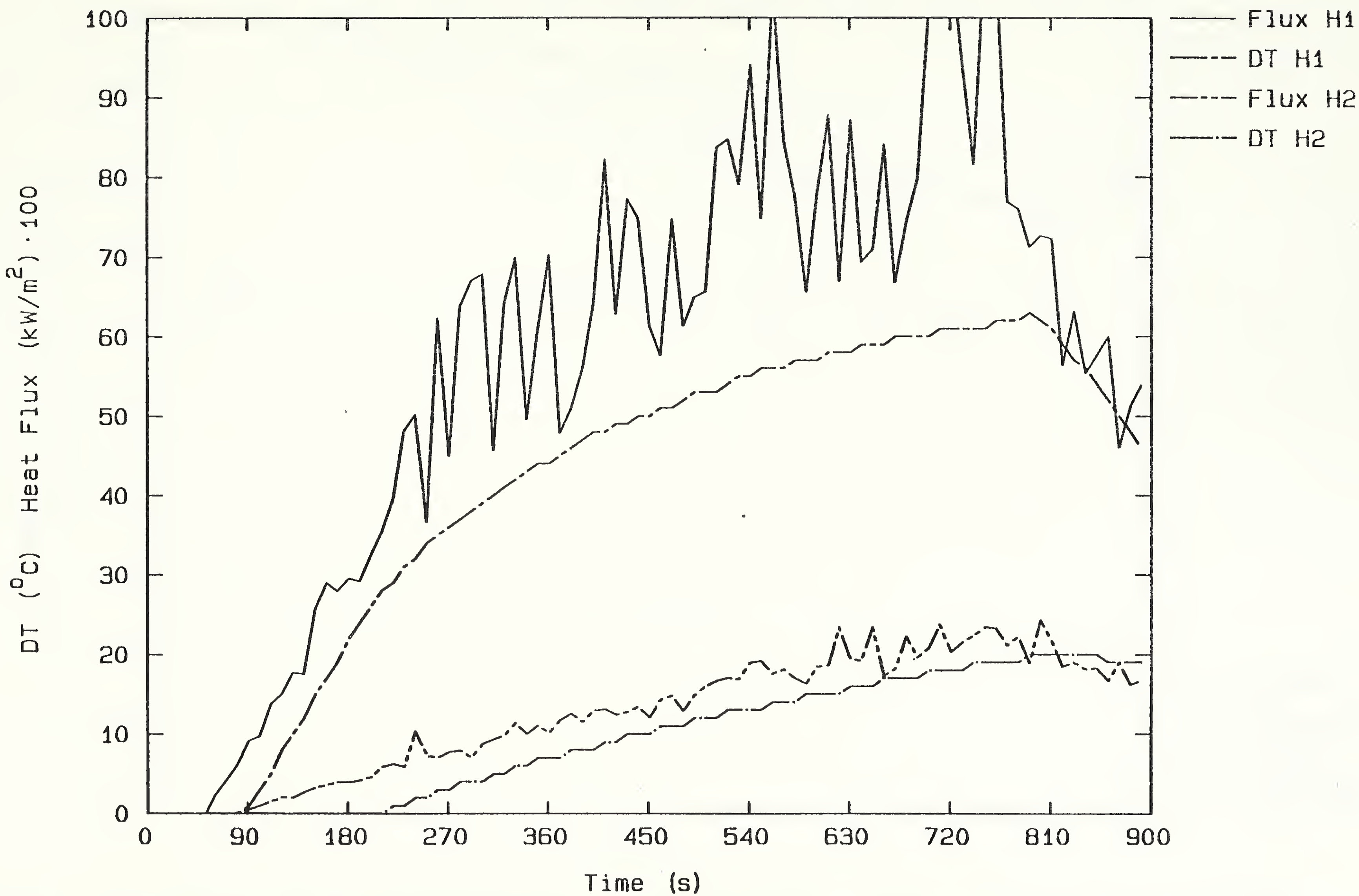

Figure 102. Test G2305 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

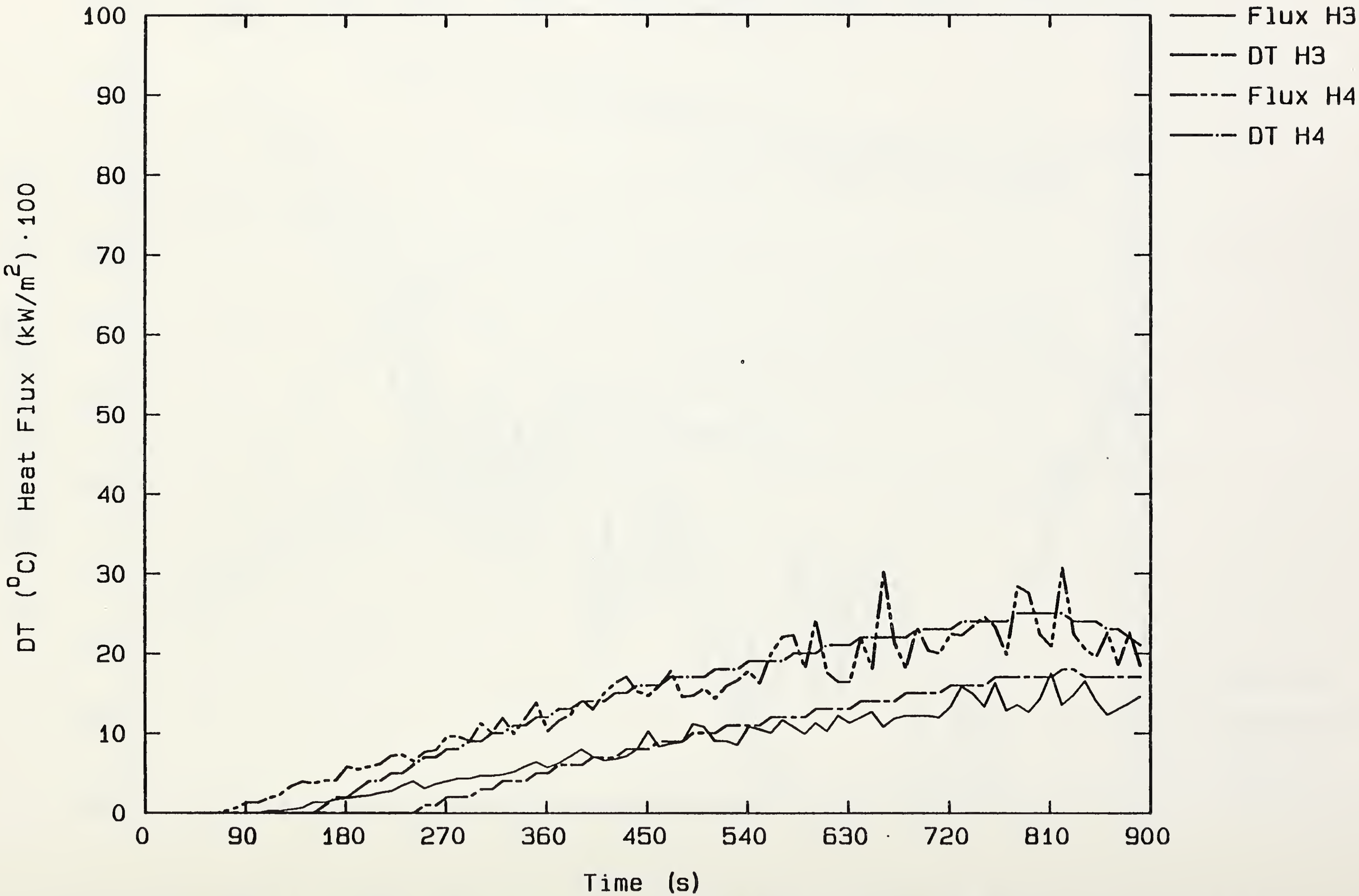

Figure 103. Test G2305 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

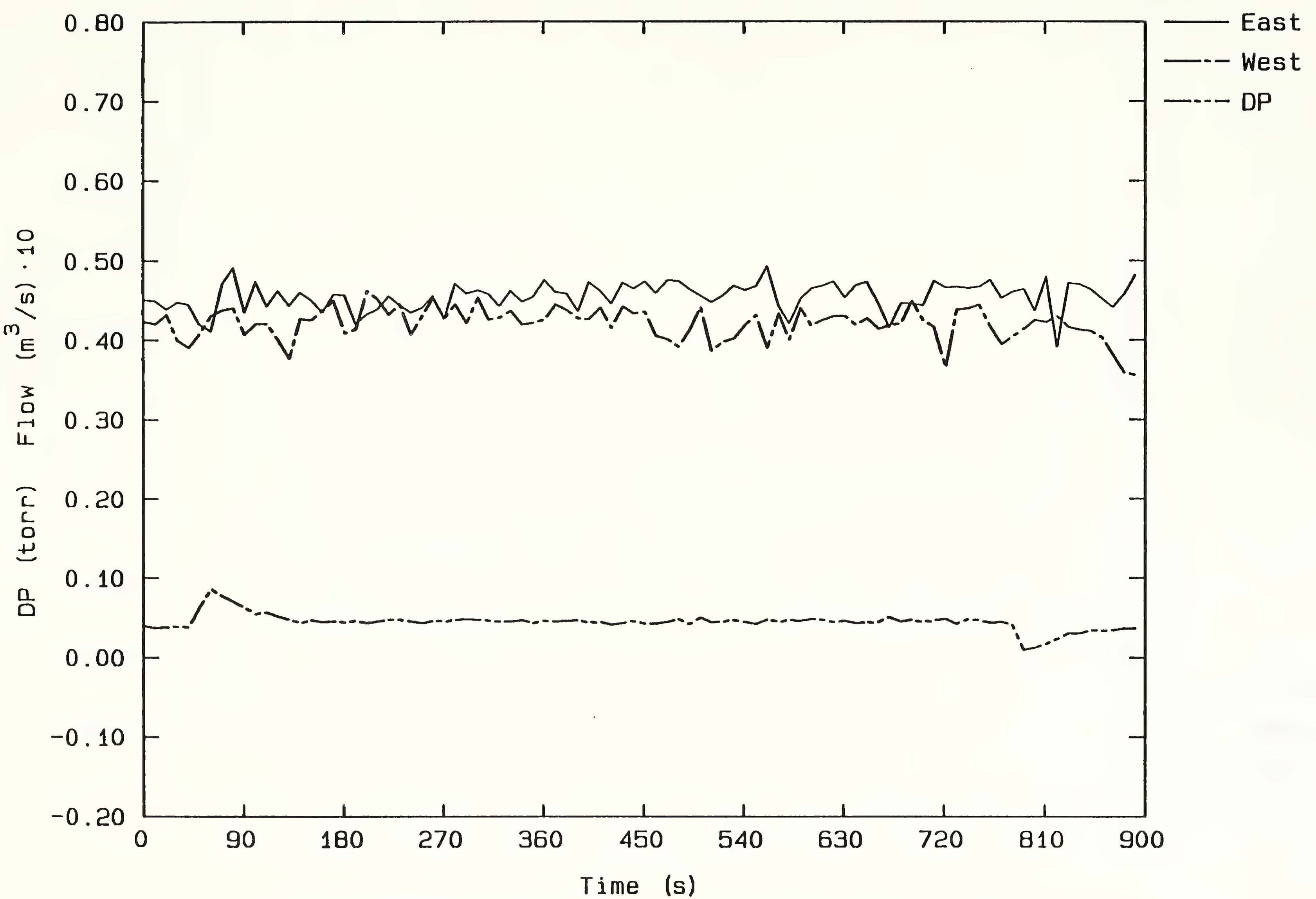

Figure 104. Test G2305 Cabin differential pressure and inlet flows, east and west

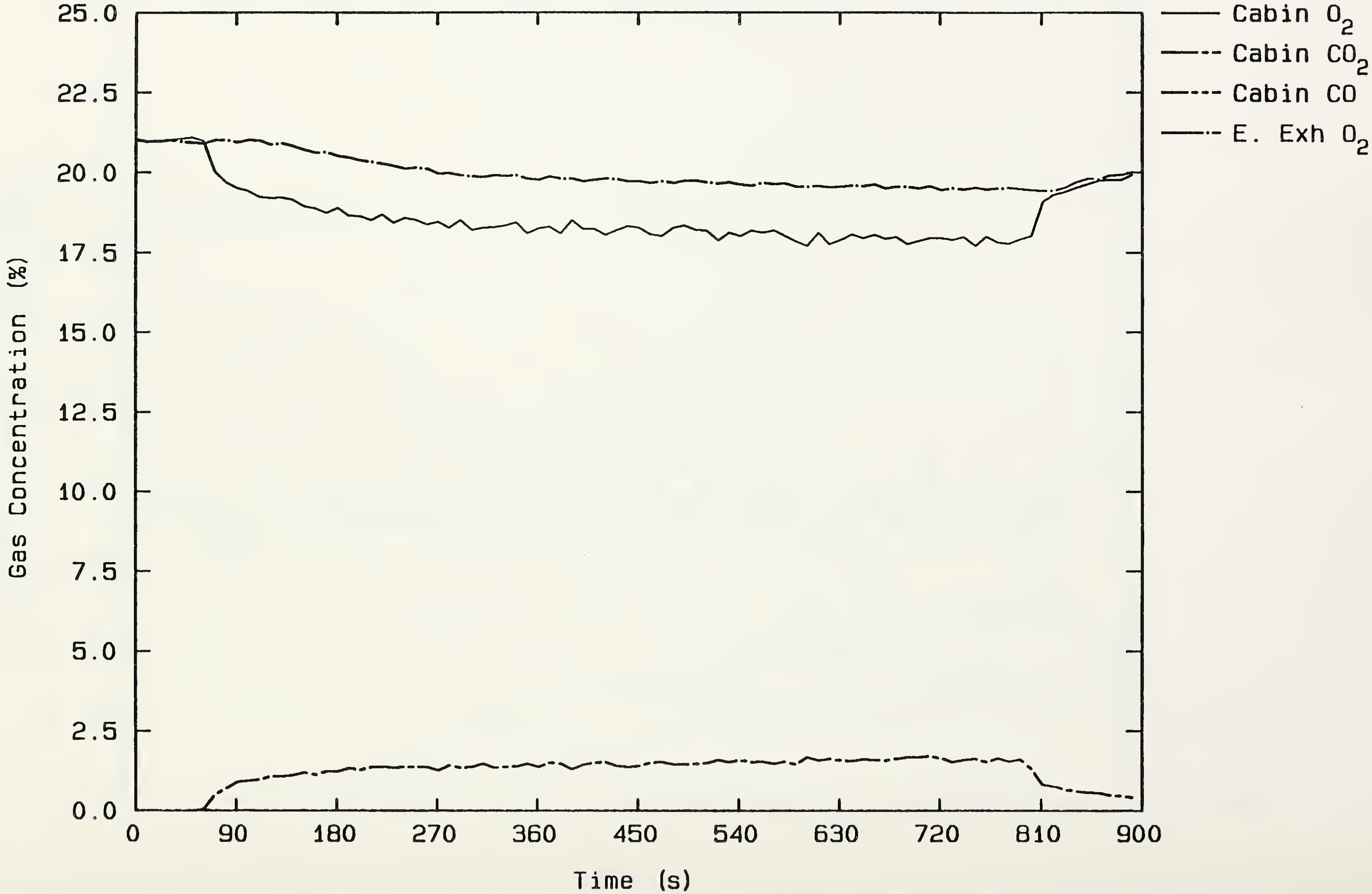

Figure 105. Test G2305 Cabin and exhaust gas concentrations

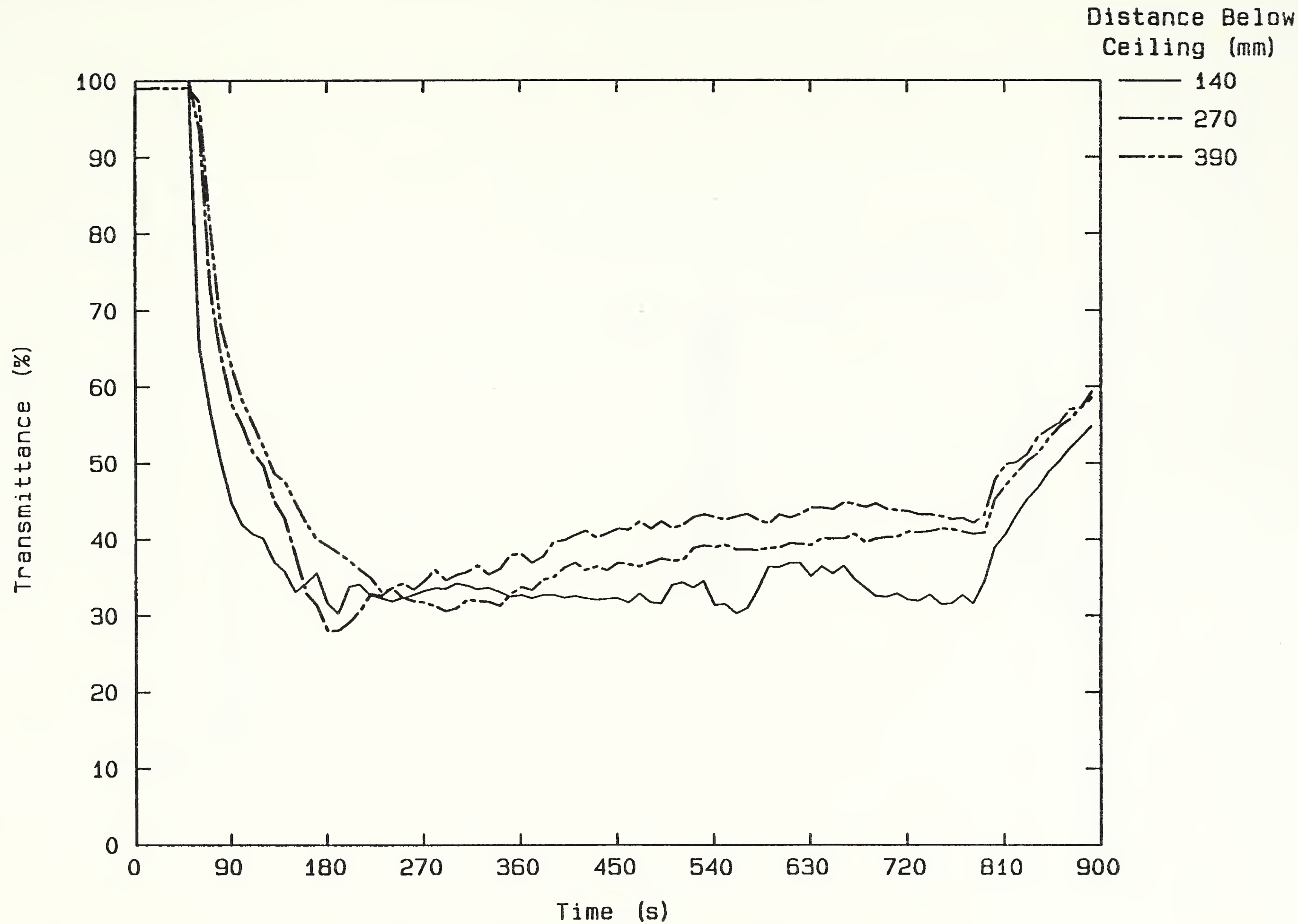

Figure 106. Test G2305 Cabin light attenuation by smoke

TEST G2405

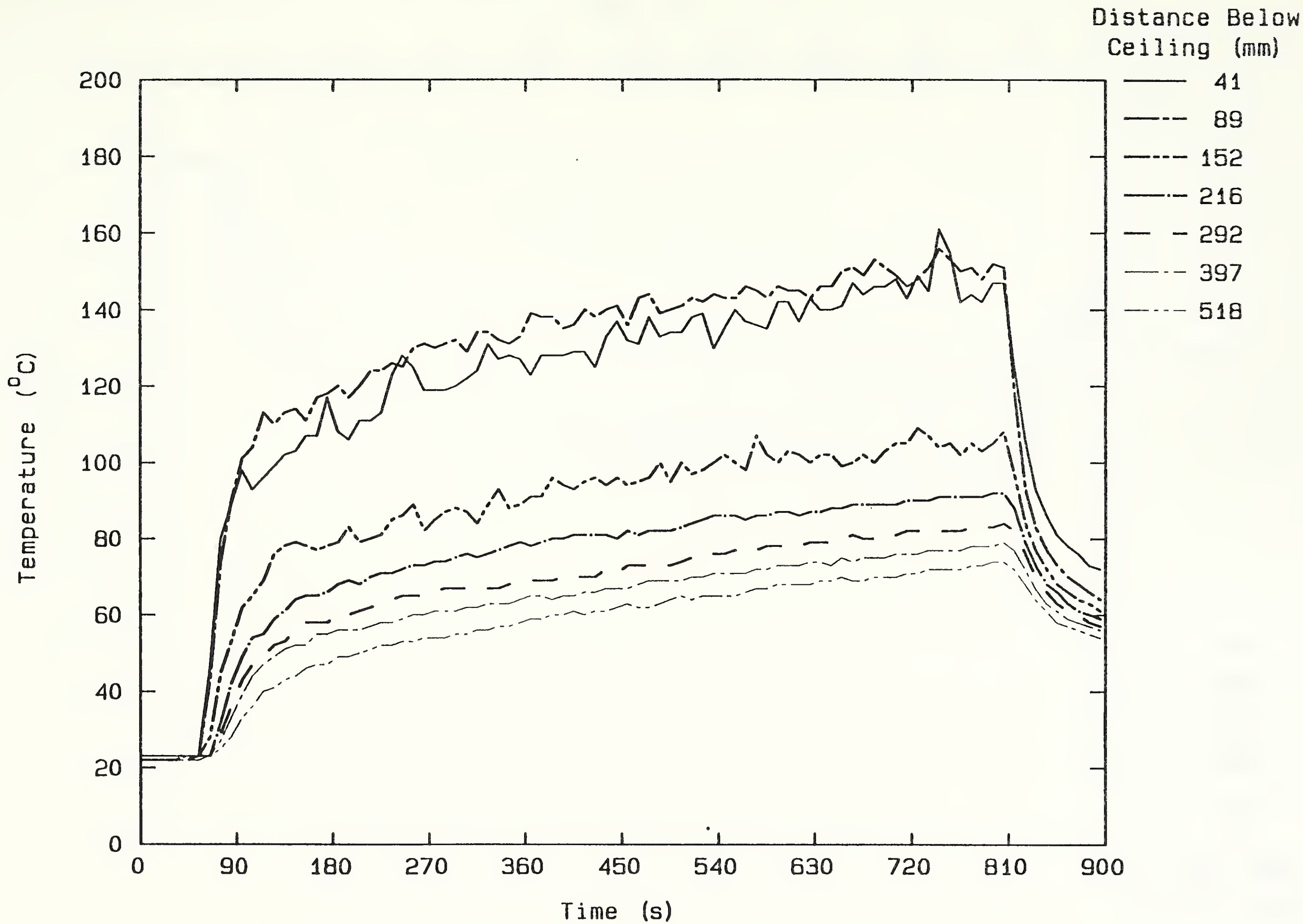

Figure 107. Test G2405 Vertical temperature profile at position A

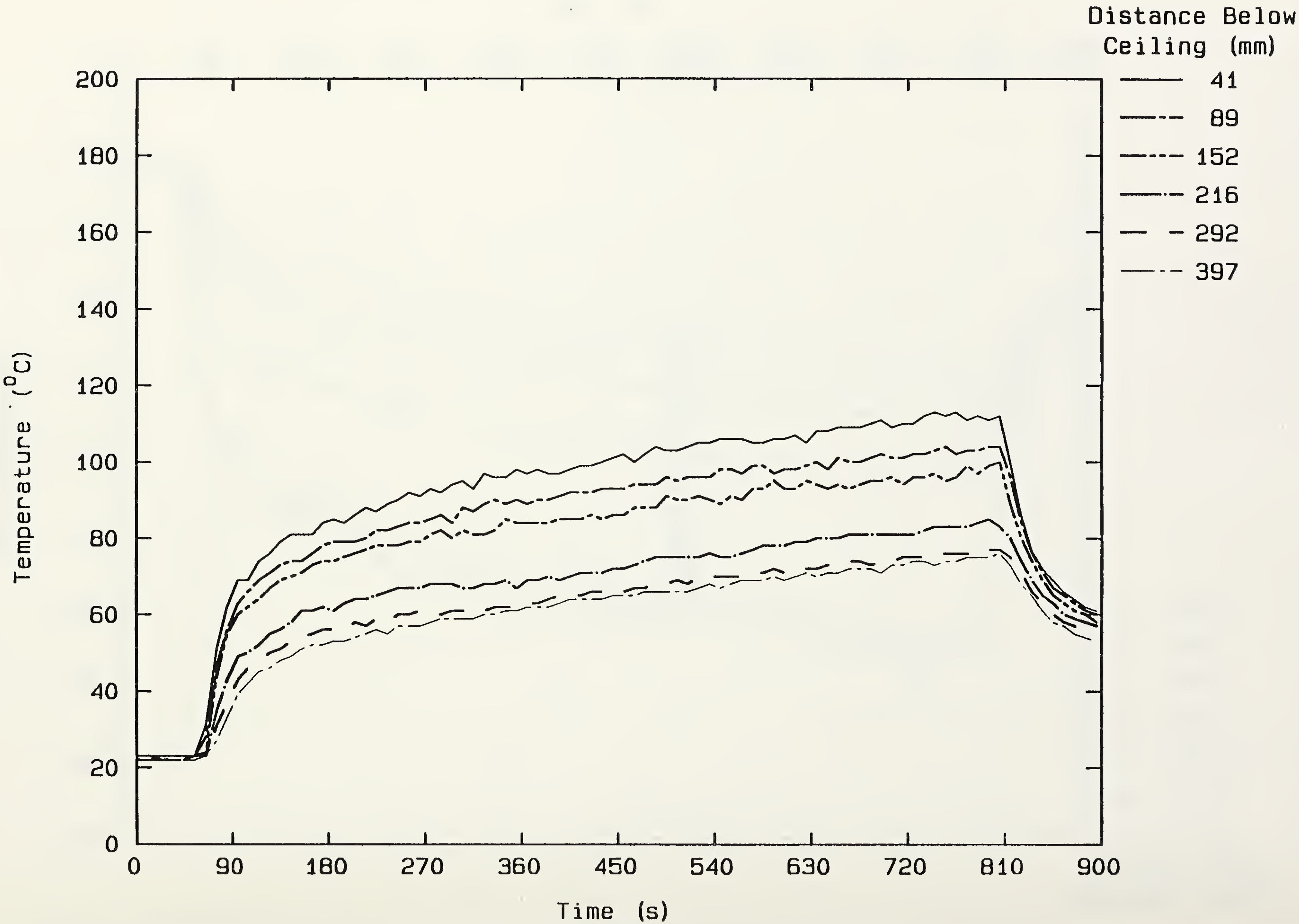

Figure 108. Test G2405 Vertical temperature profile at position B

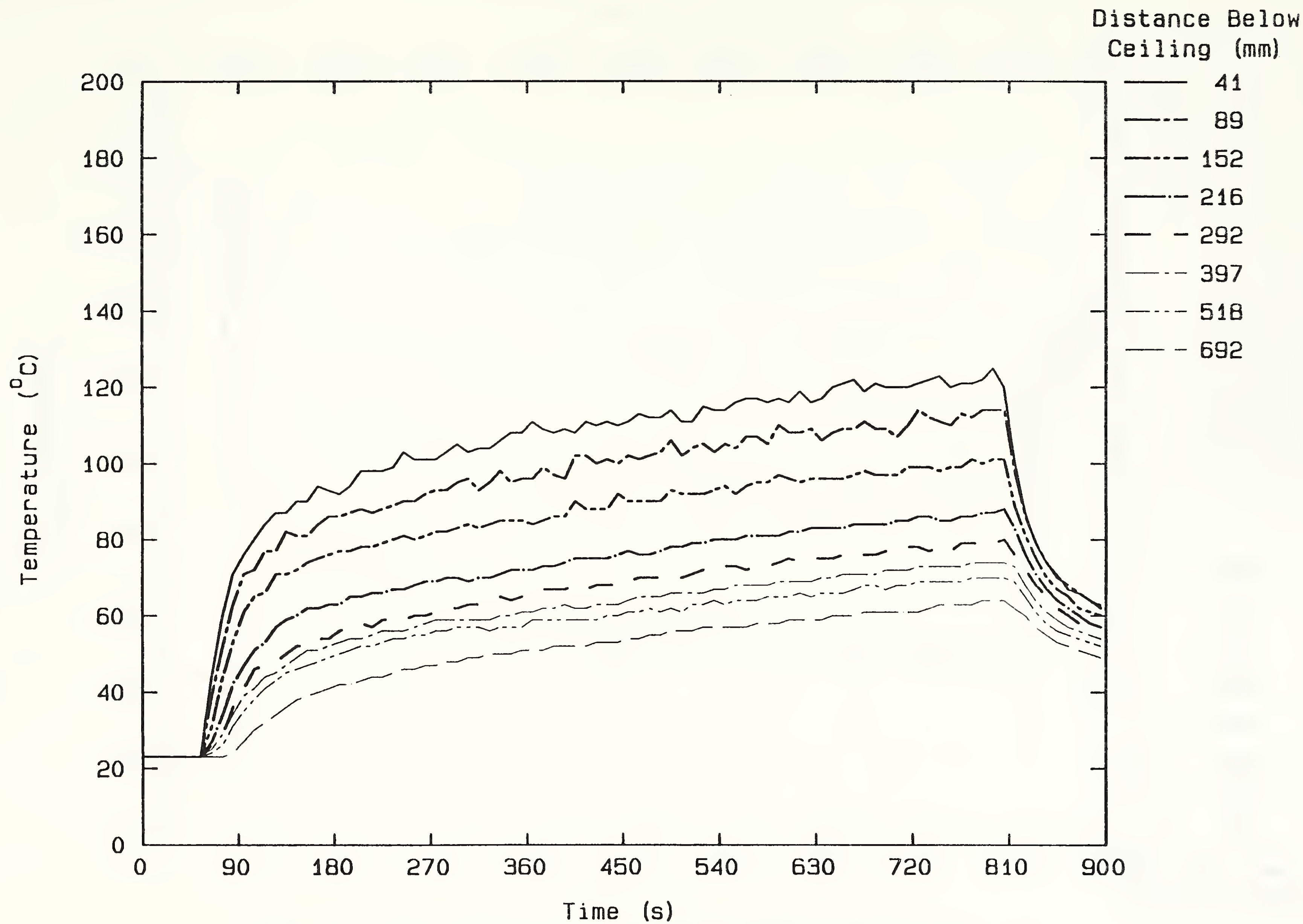

Figure 109. Test G2405 Vertical temperature profile at position C

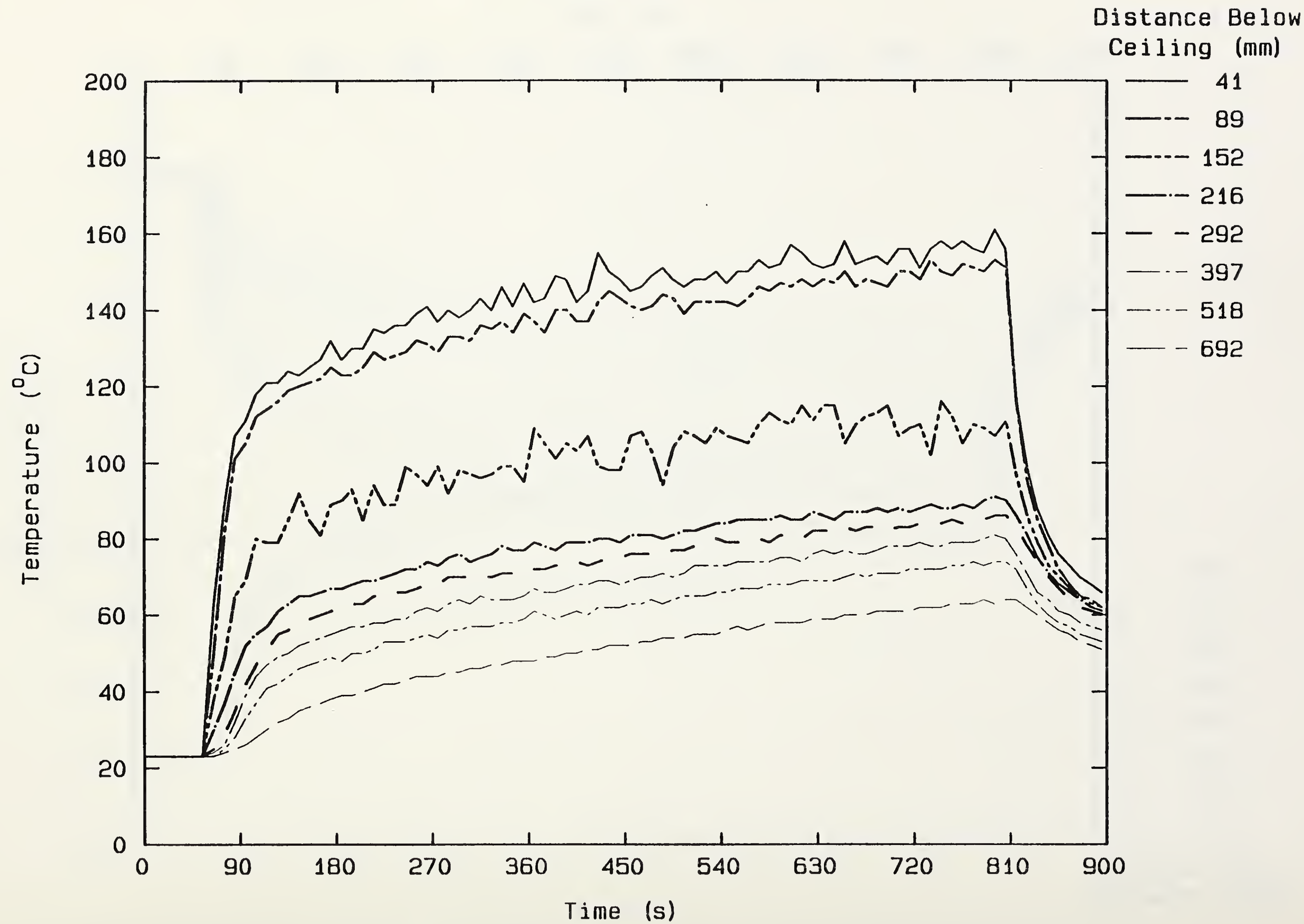

Figure 110. Test G2405 Vertical temperature profile at position D

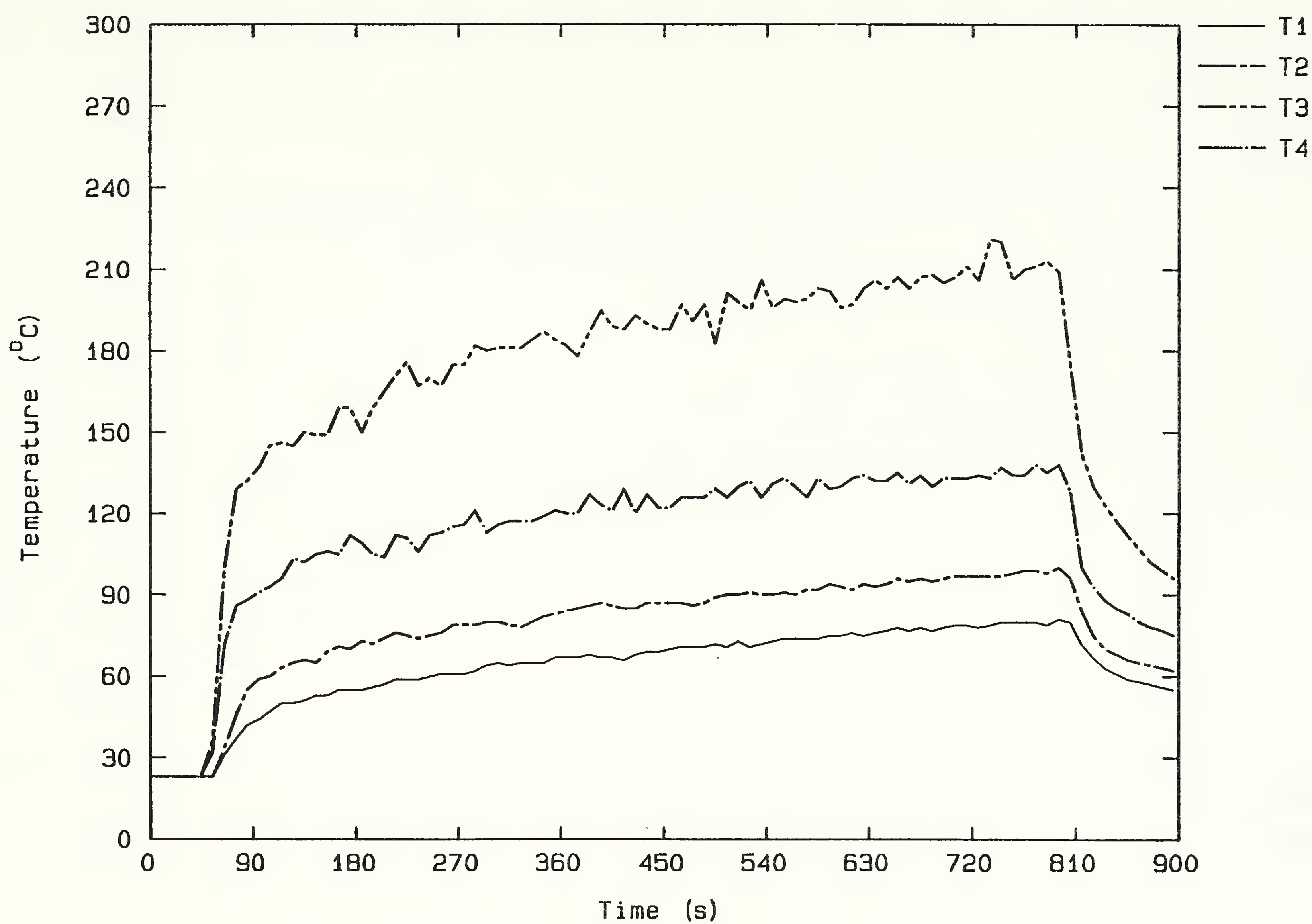

Figure 111. Test G2405 Ceiling interior surface temperature: T1 - T4

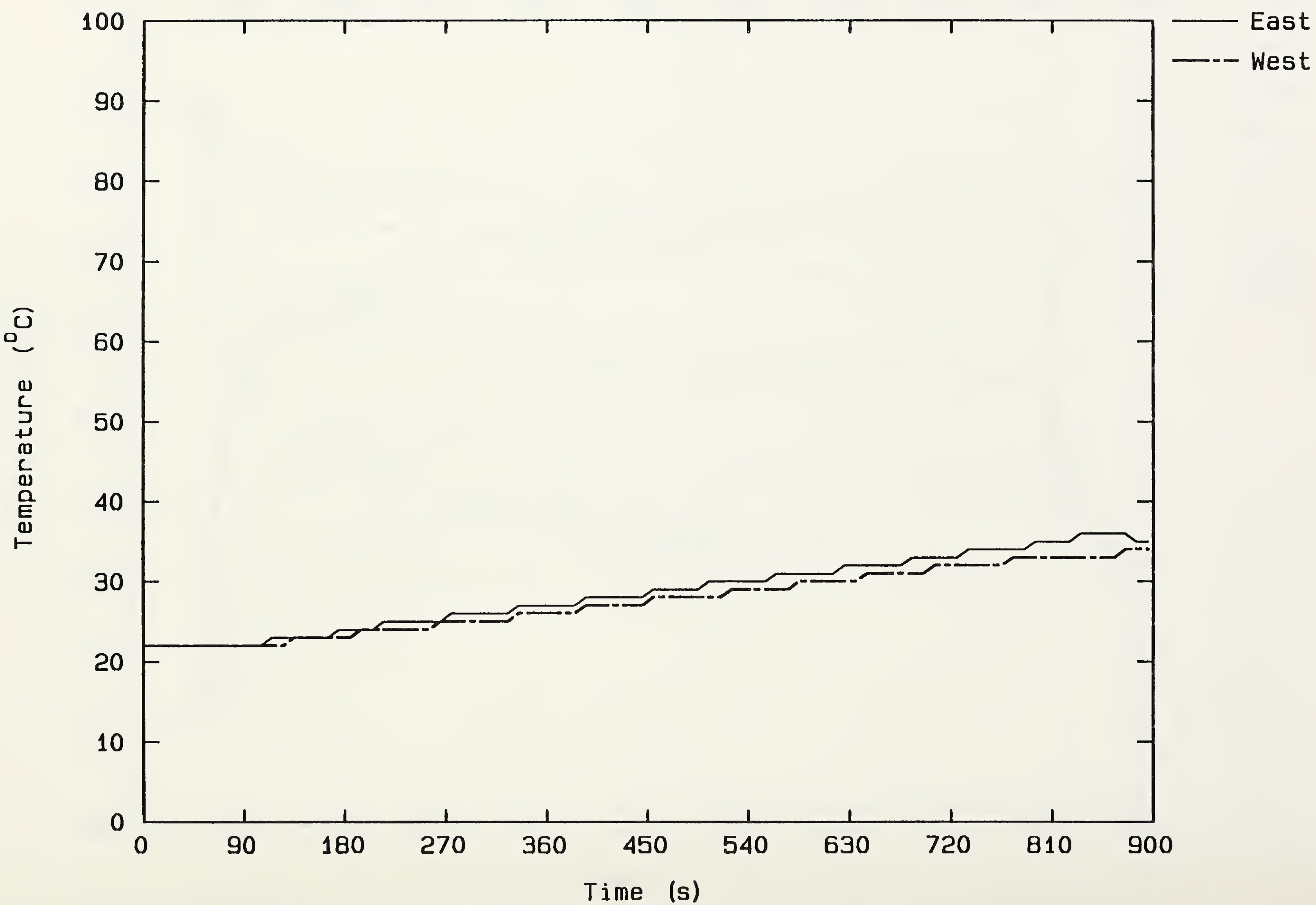

Figure 112. Test G2405 Exhaust temperature: east and west

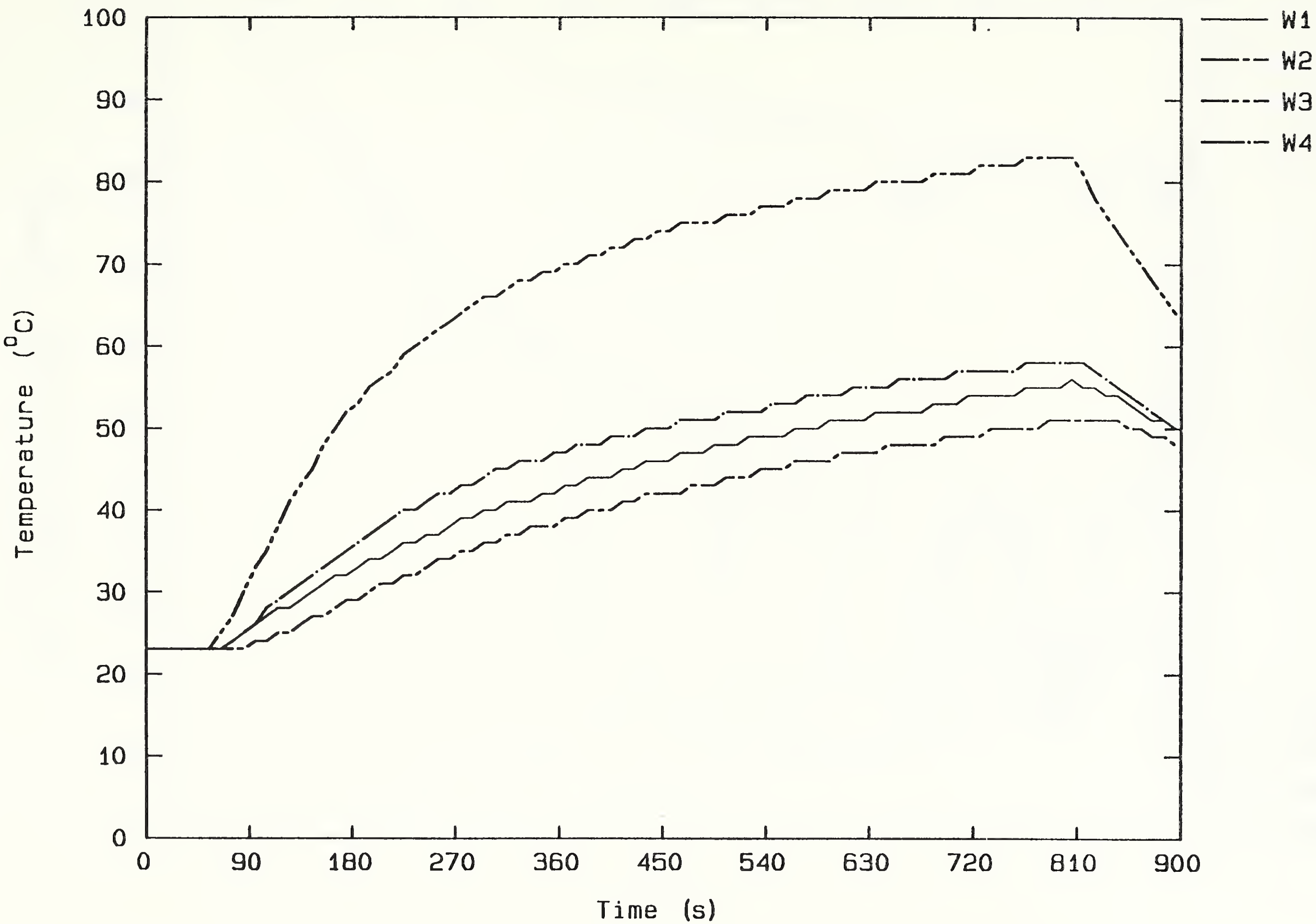

Figure 113. Test G2405 Wall interior surface temperature: W1 - W4

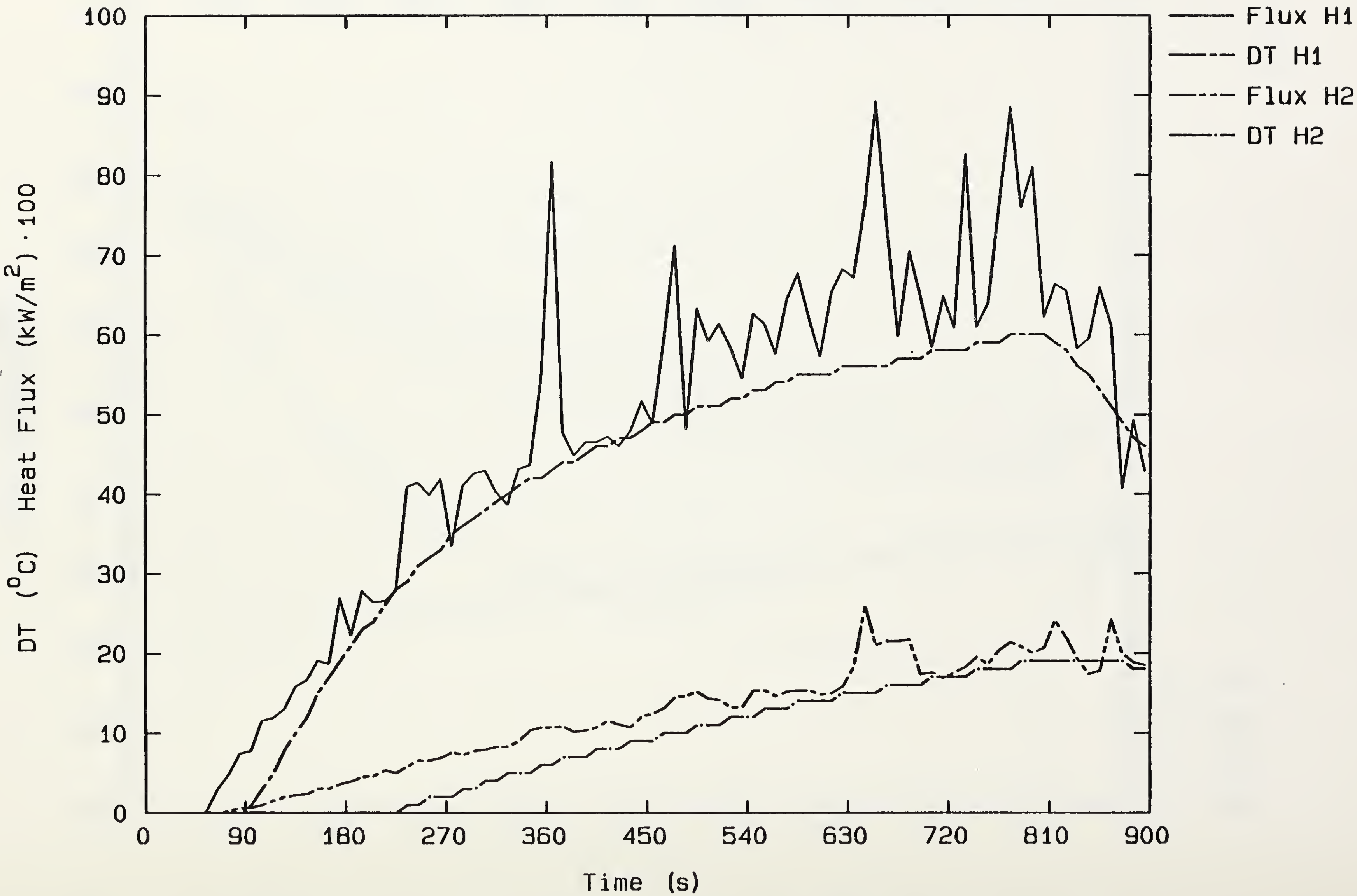

Figure 114. Test G2405 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

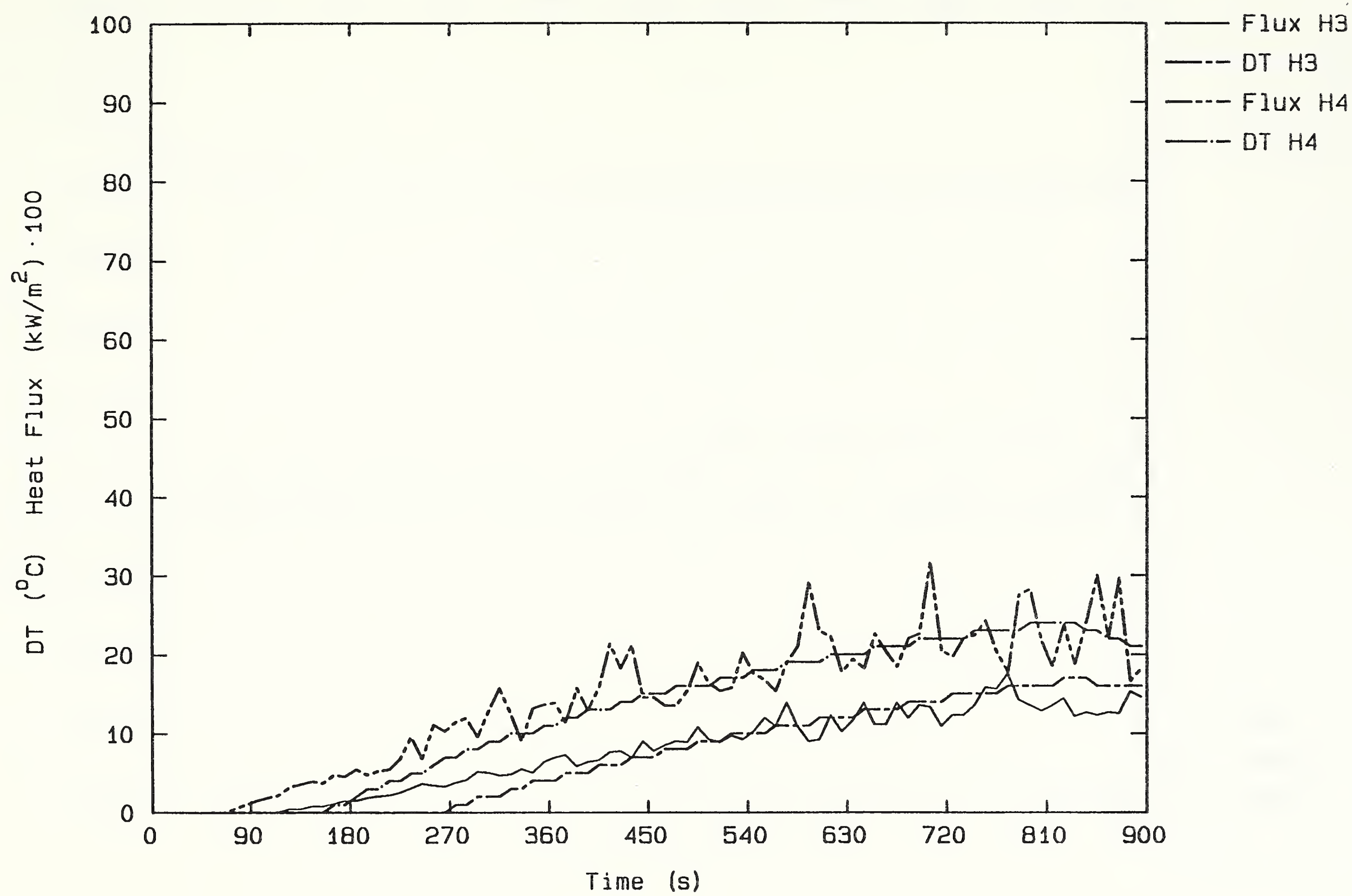

Figure 115. Test G2405 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

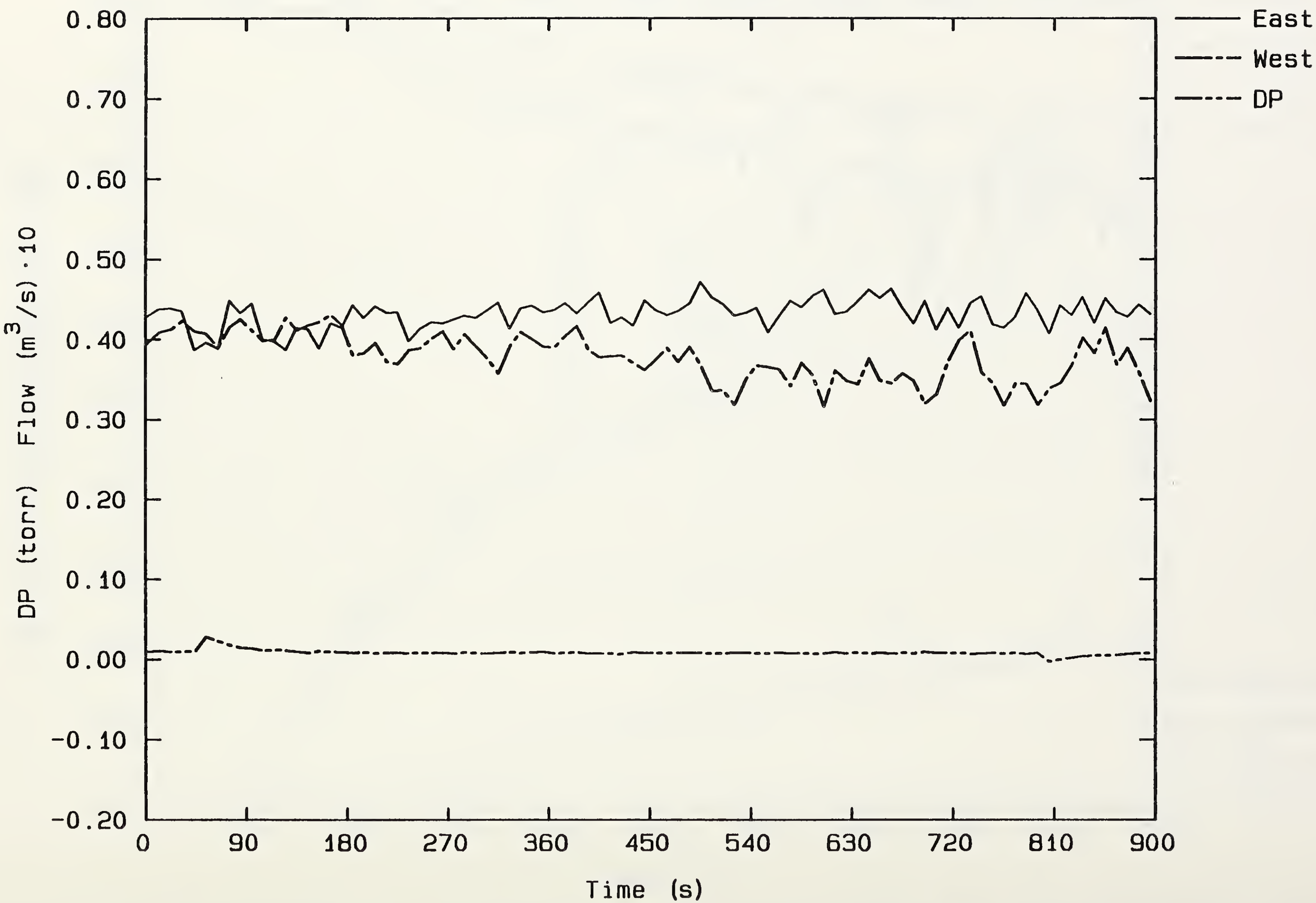

Figure 116. Test G2405 Cabin differential pressure and inlet flows, east and west

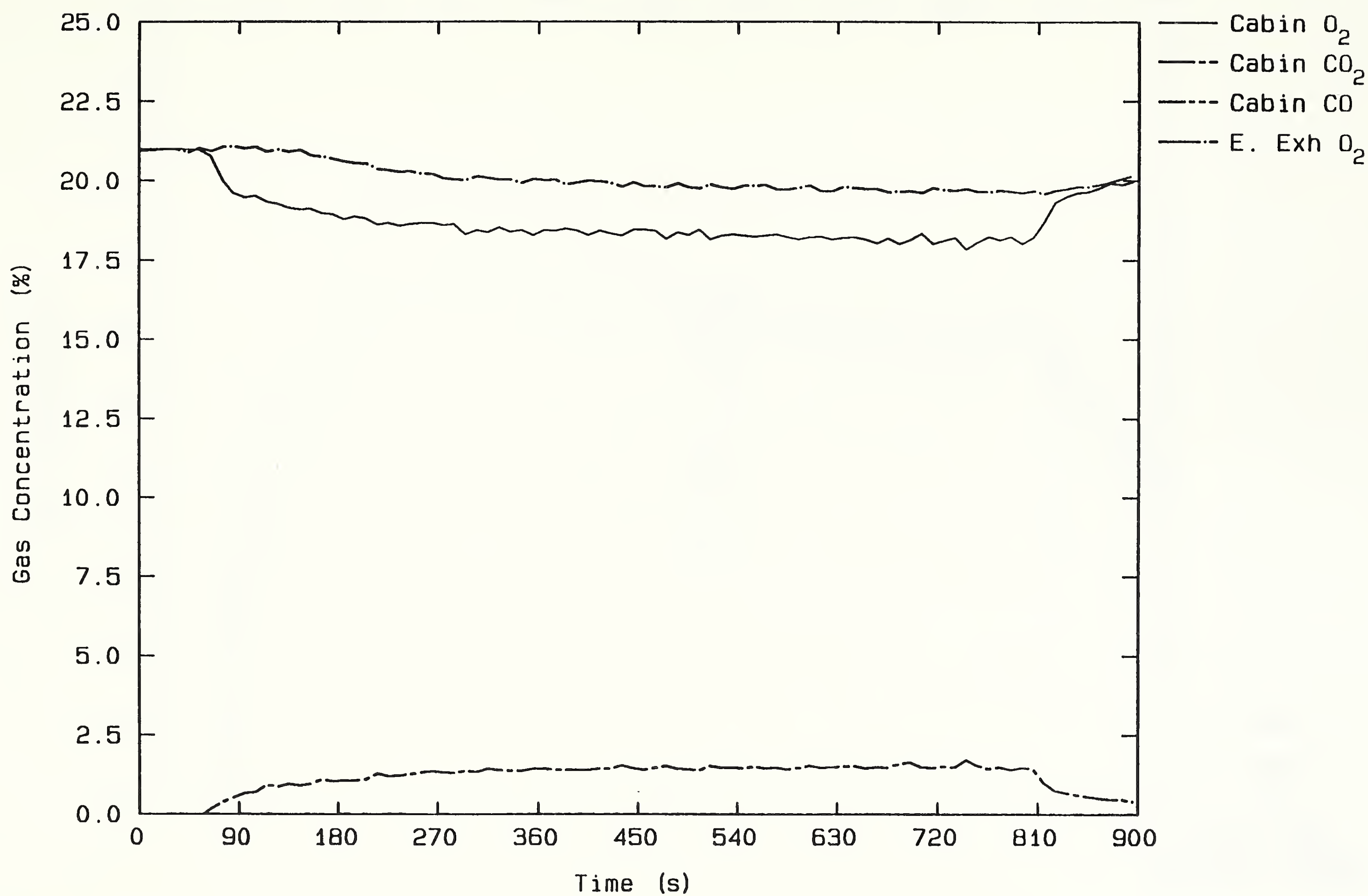

Figure 117. Test G2405 Cabin and exhaust gas concentrations

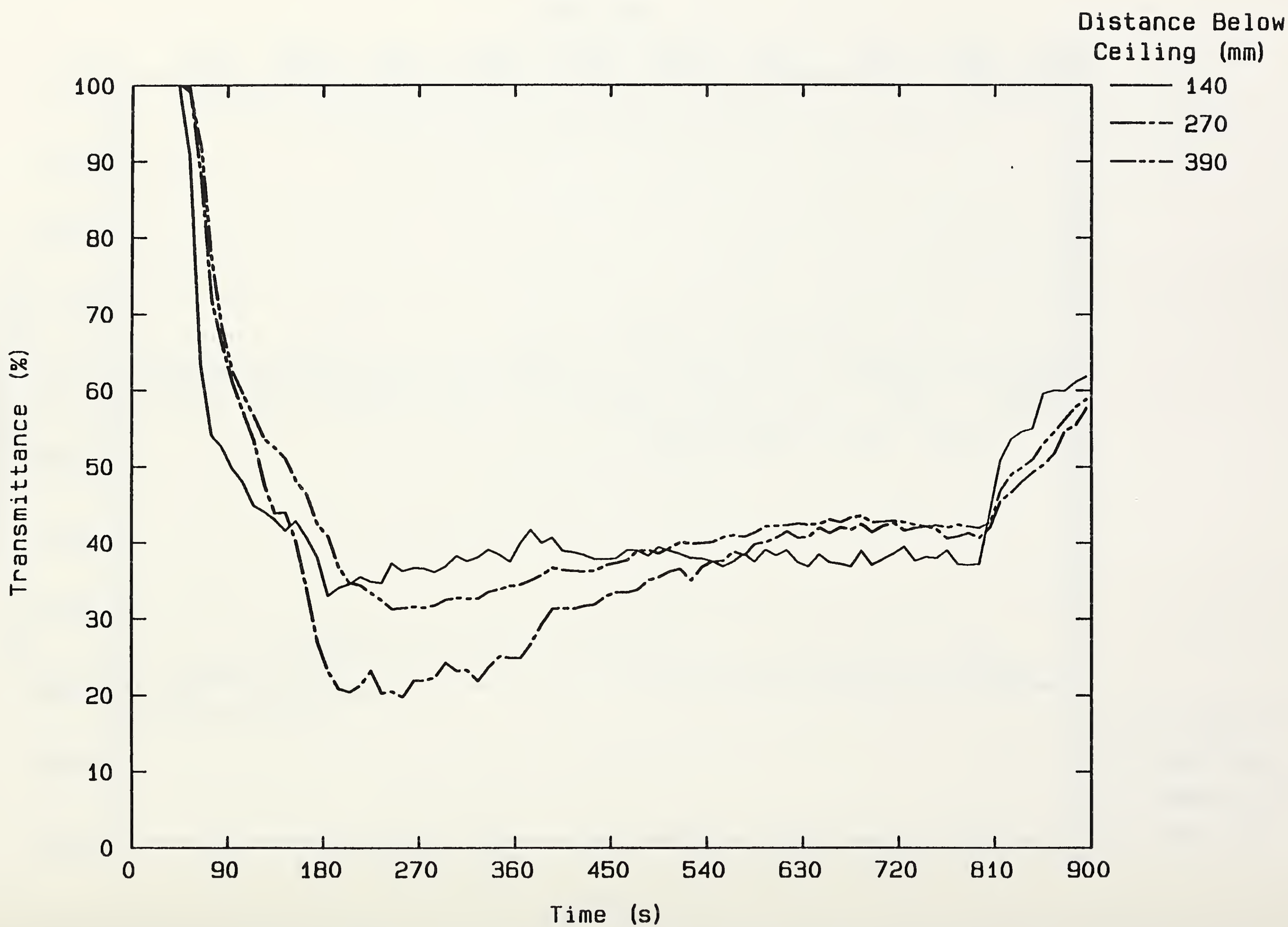

Figure 118. Test G2405 Cabin light attenuation by smoke

TEST G0106

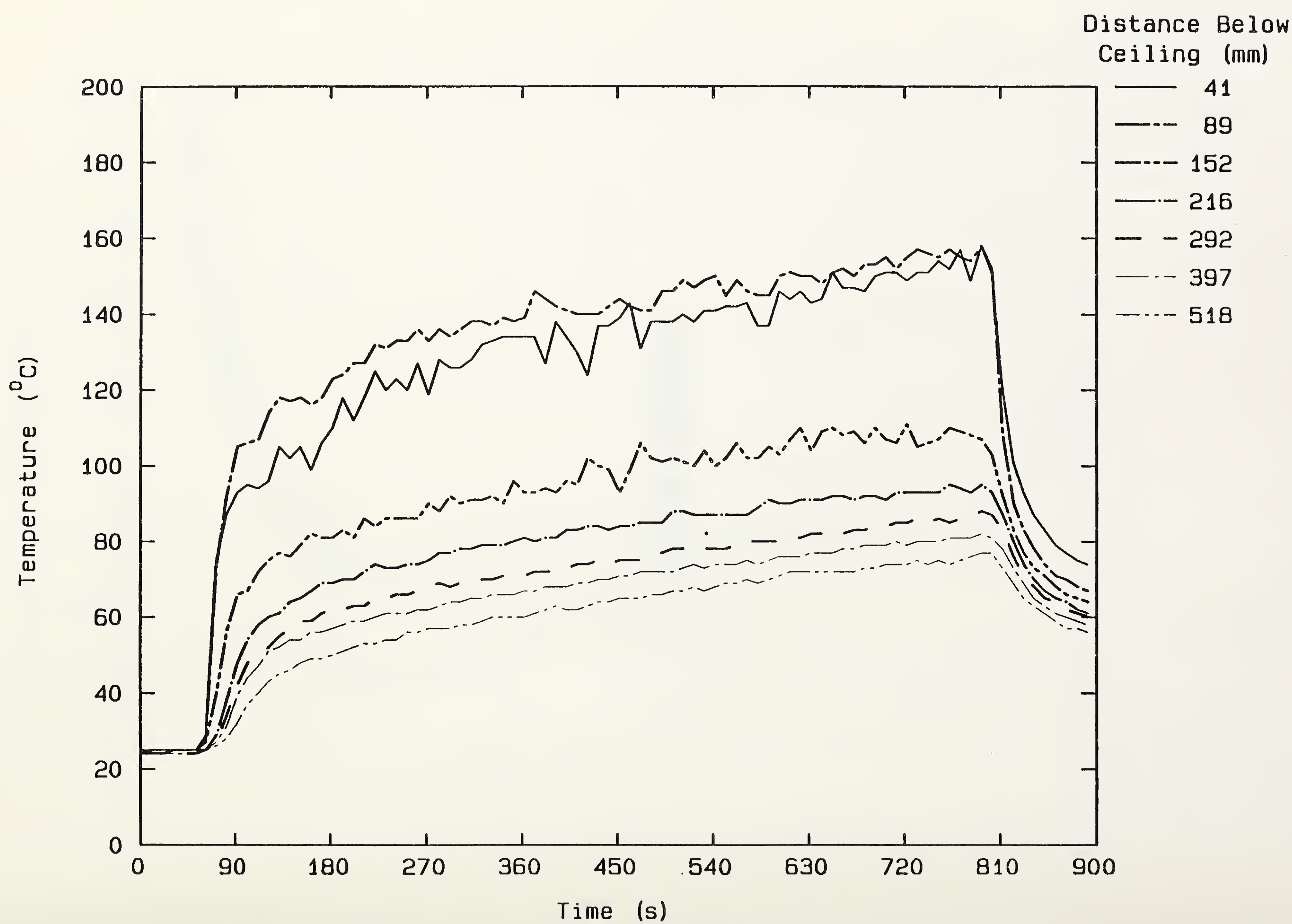

Figure 119. Test G0106 Vertical temperature profile at position A

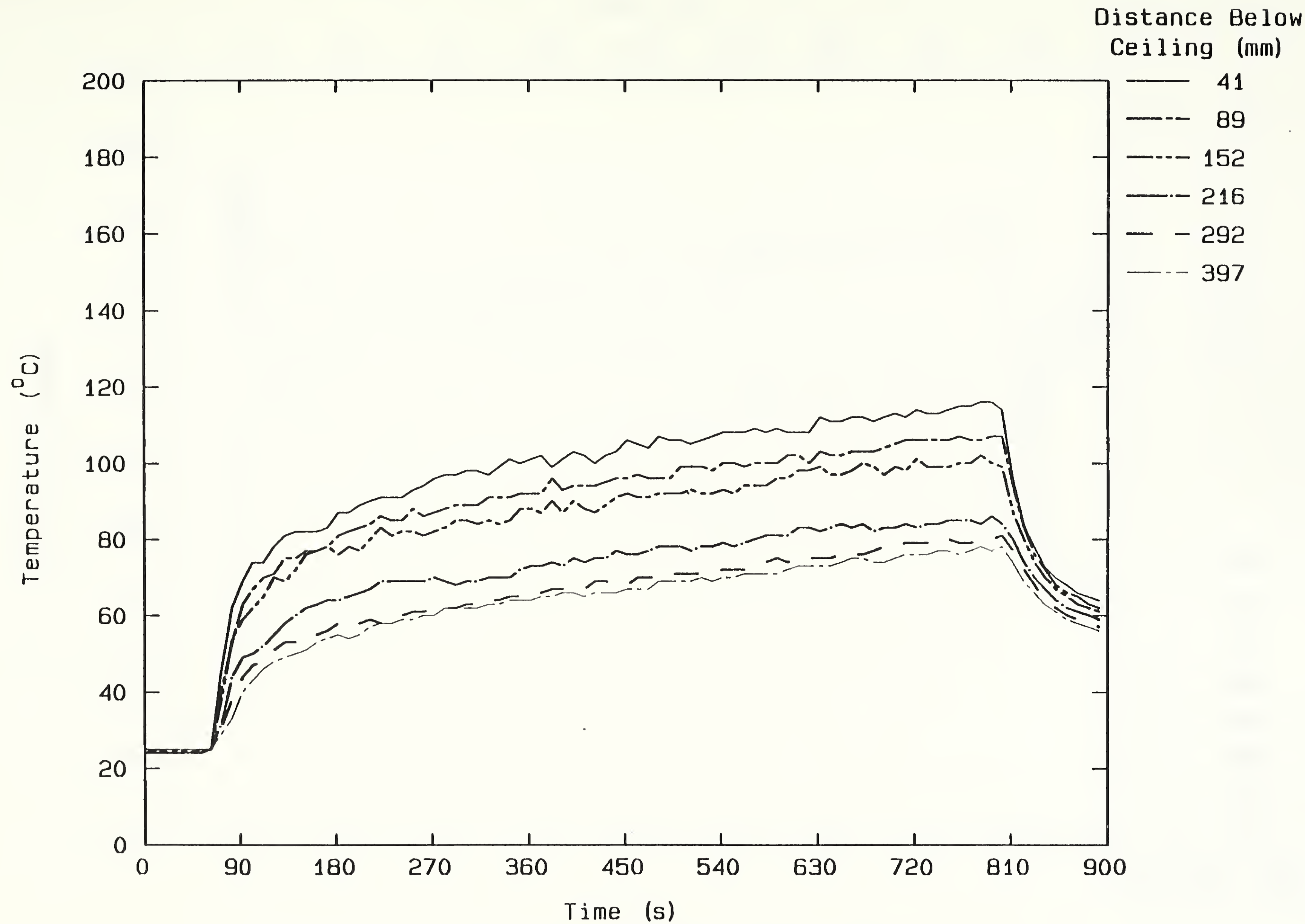

Figure 120. Test G0106 Vertical temperature profile at position B

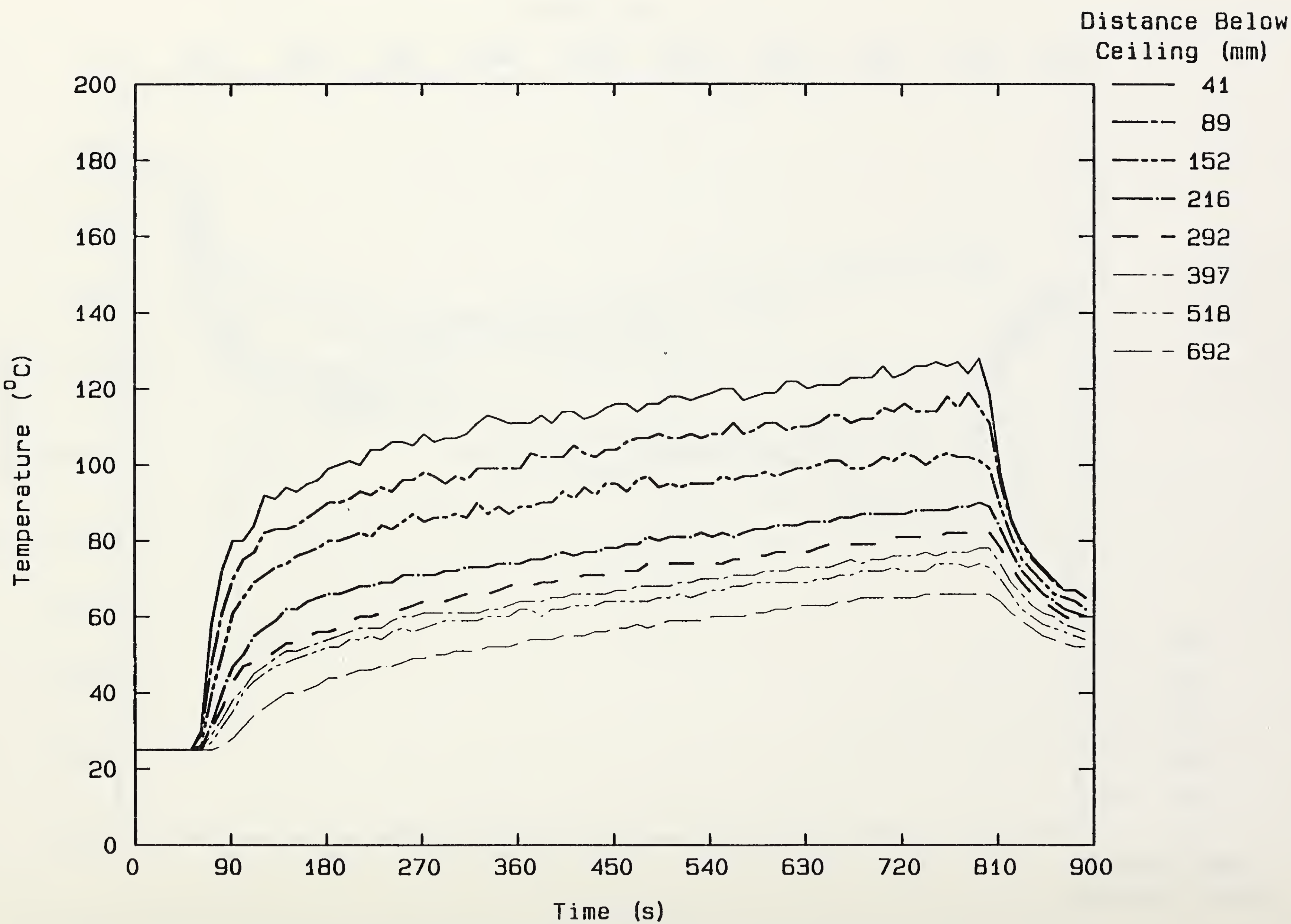

Figure 121. Test G0106 Vertical temperature profile at position C

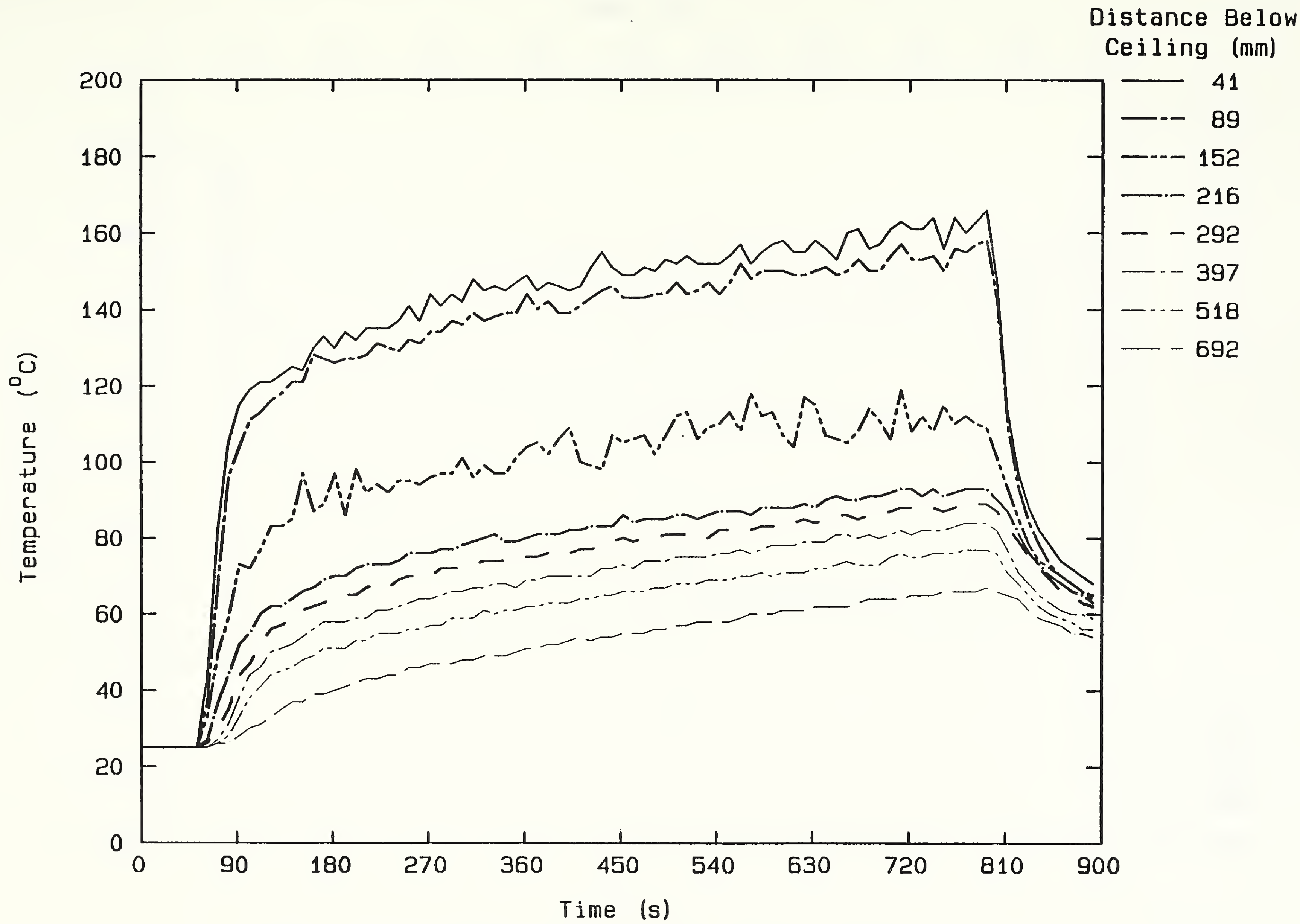

Figure 122. Test G0106 Vertical temperature profile at position D

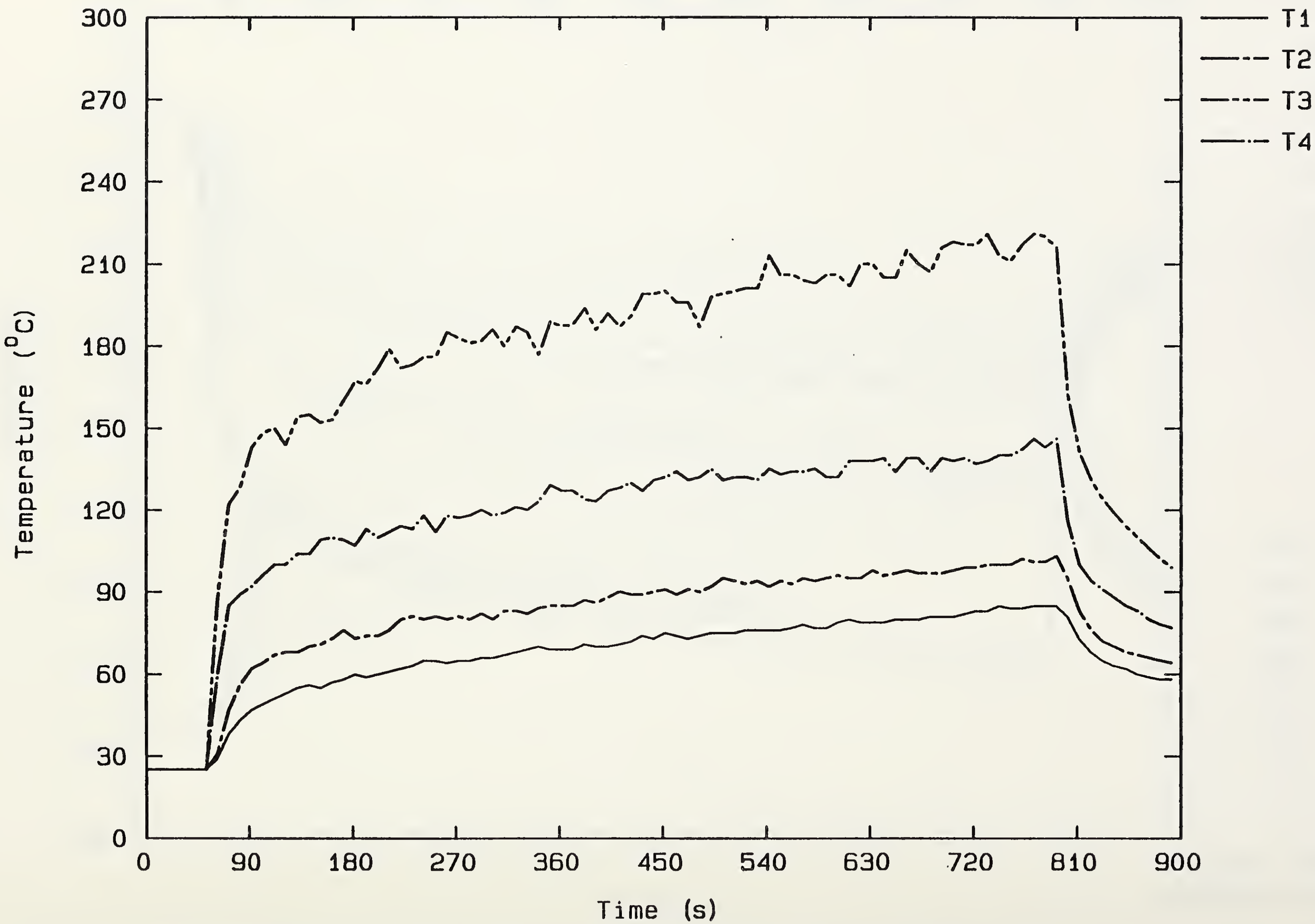

Figure 123. Test G0106 Ceiling interior surface temperature: T1 - T4

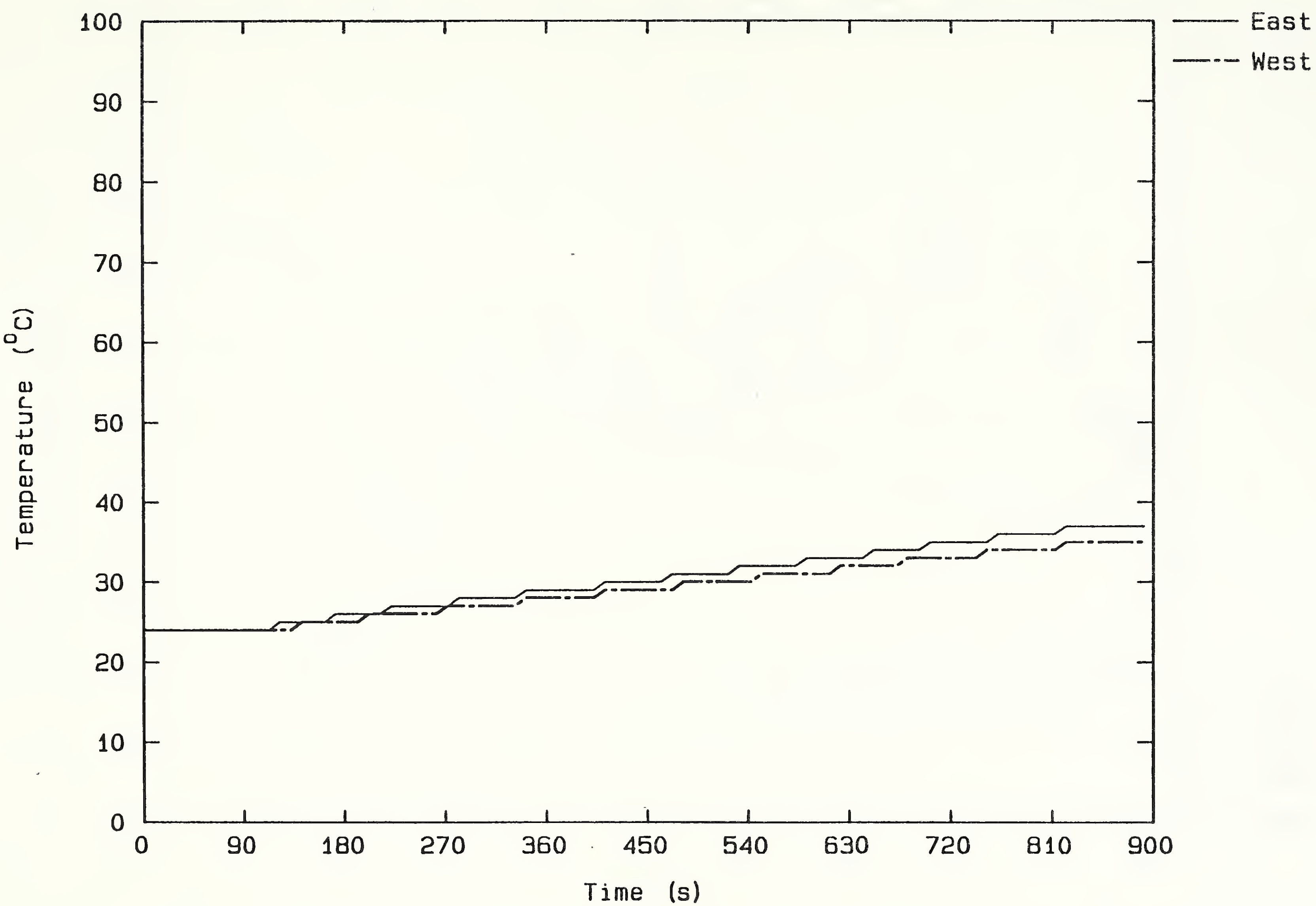

Figure 124. Test G0106 Exhaust temperature: east and west

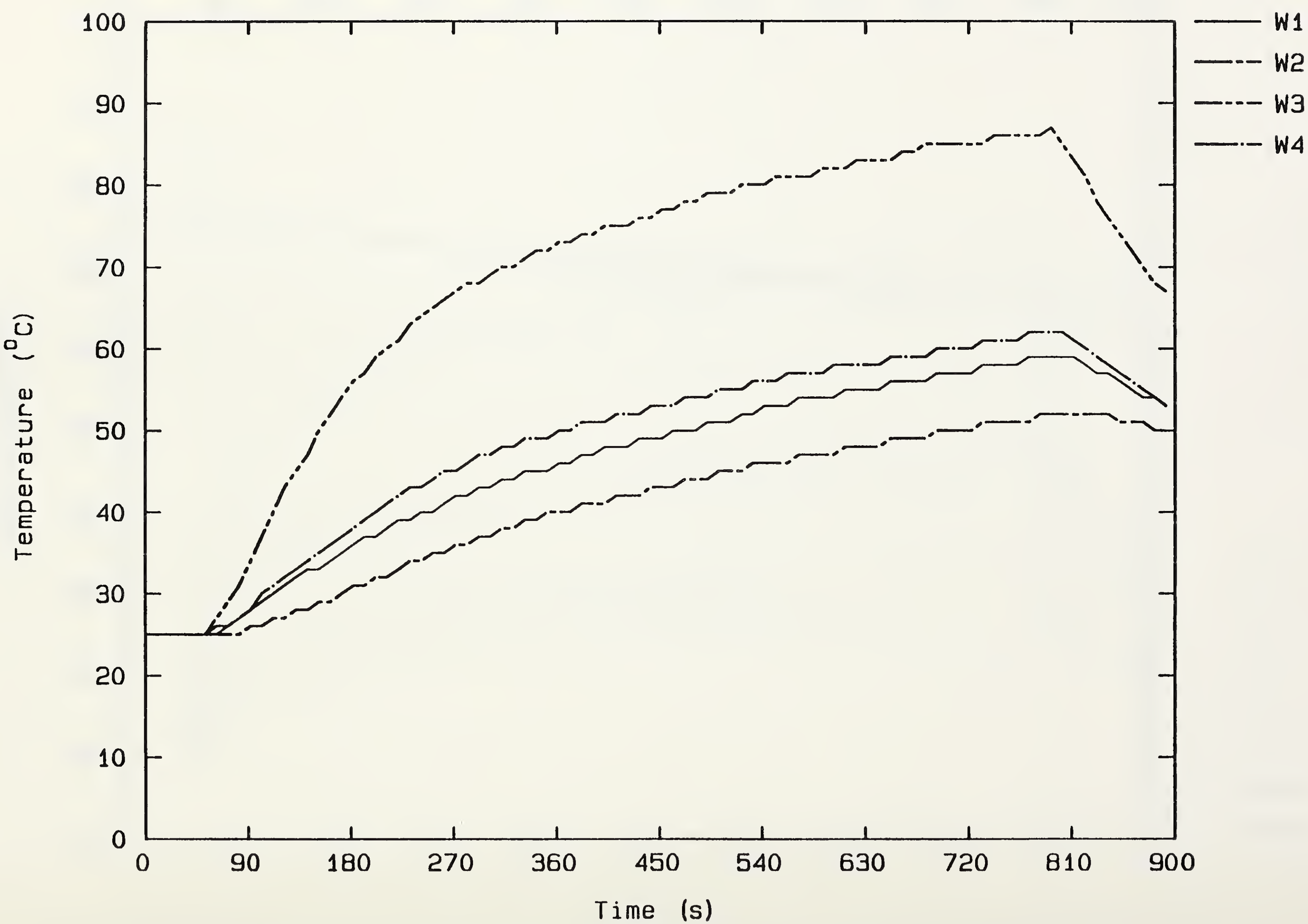

Figure 125. Test G0106 Wall interior surface temperature: W1 - W4

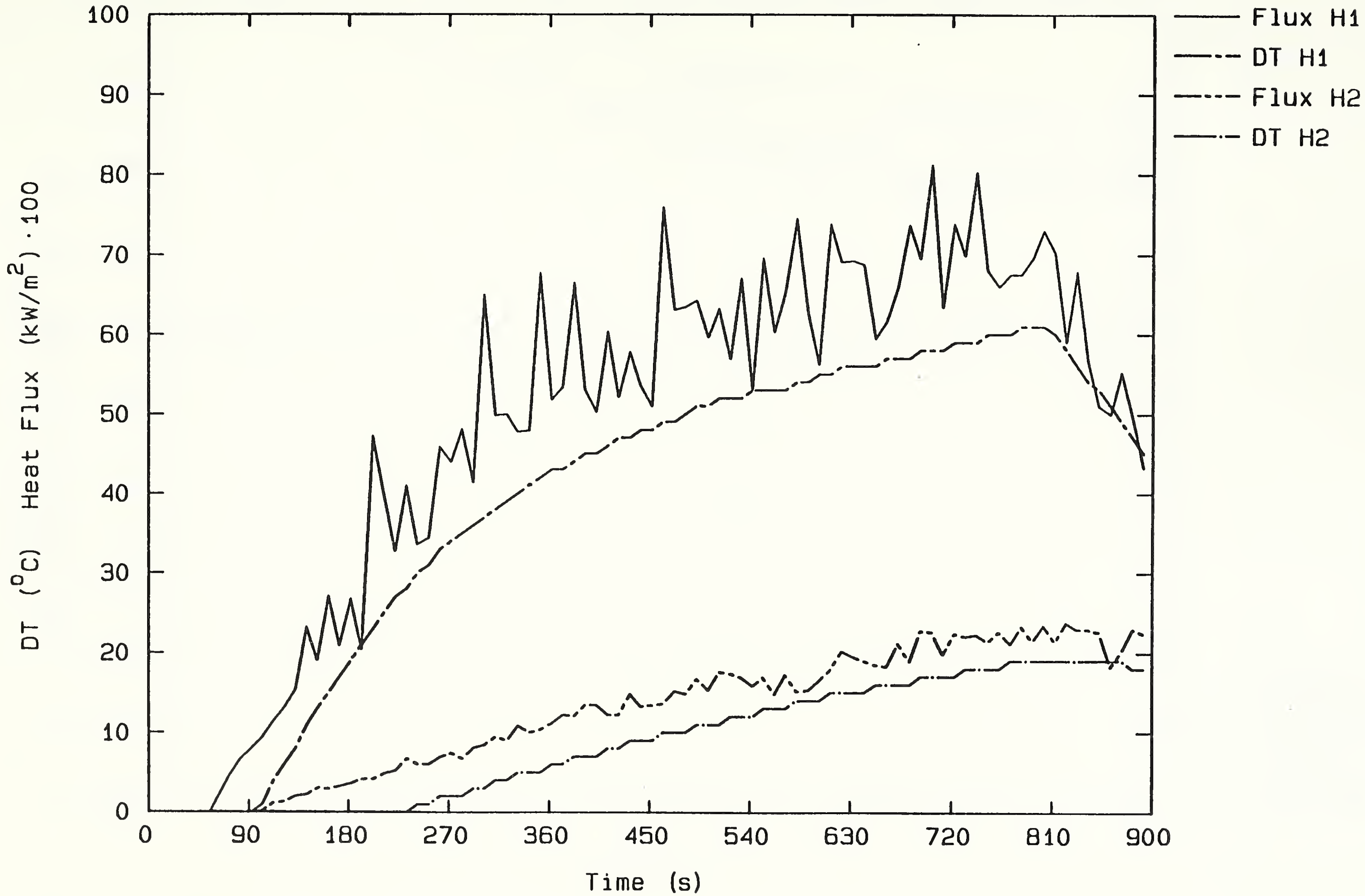

Figure 126. Test G0106 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

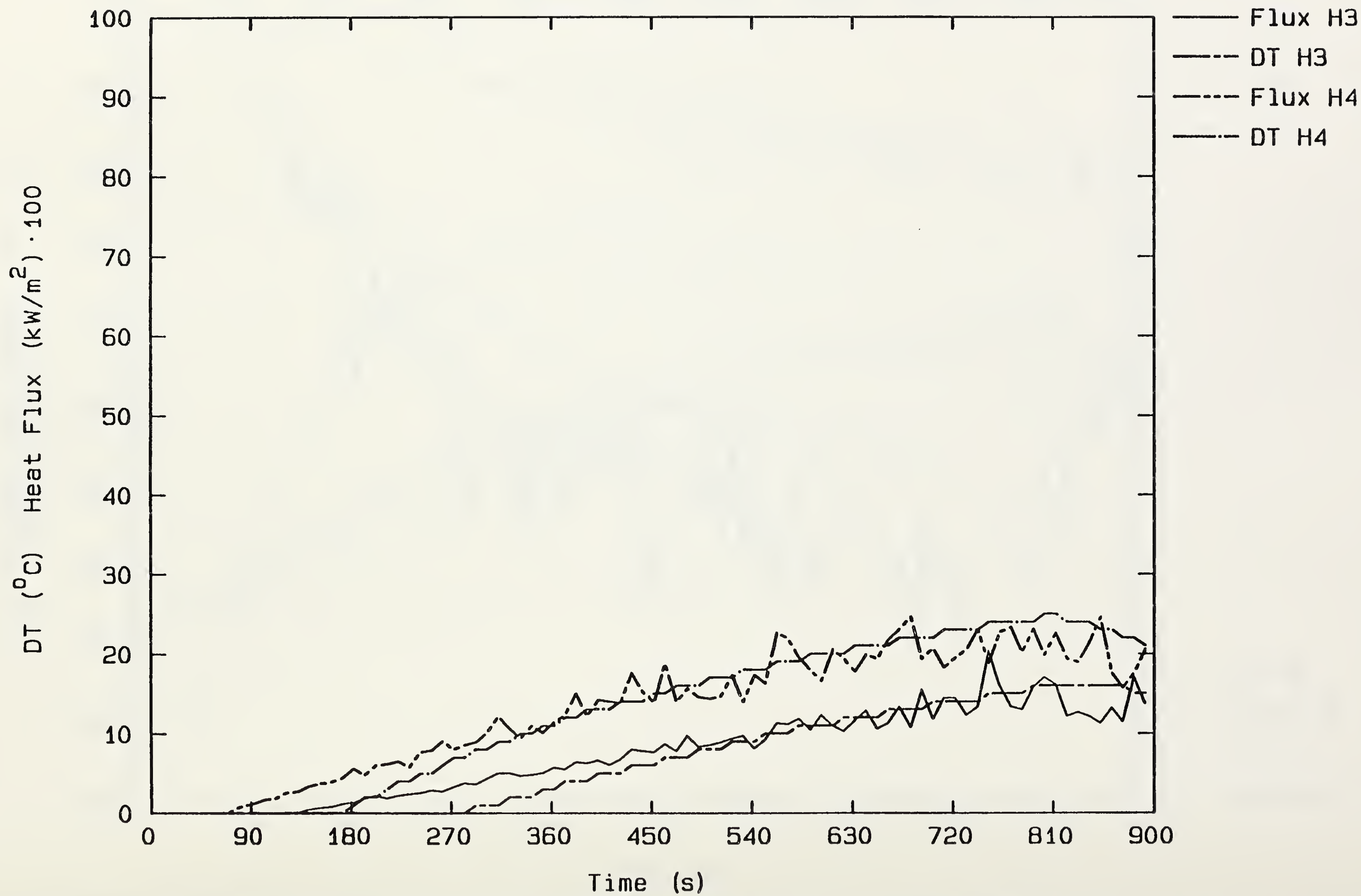

Figure 127. Test G0106 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

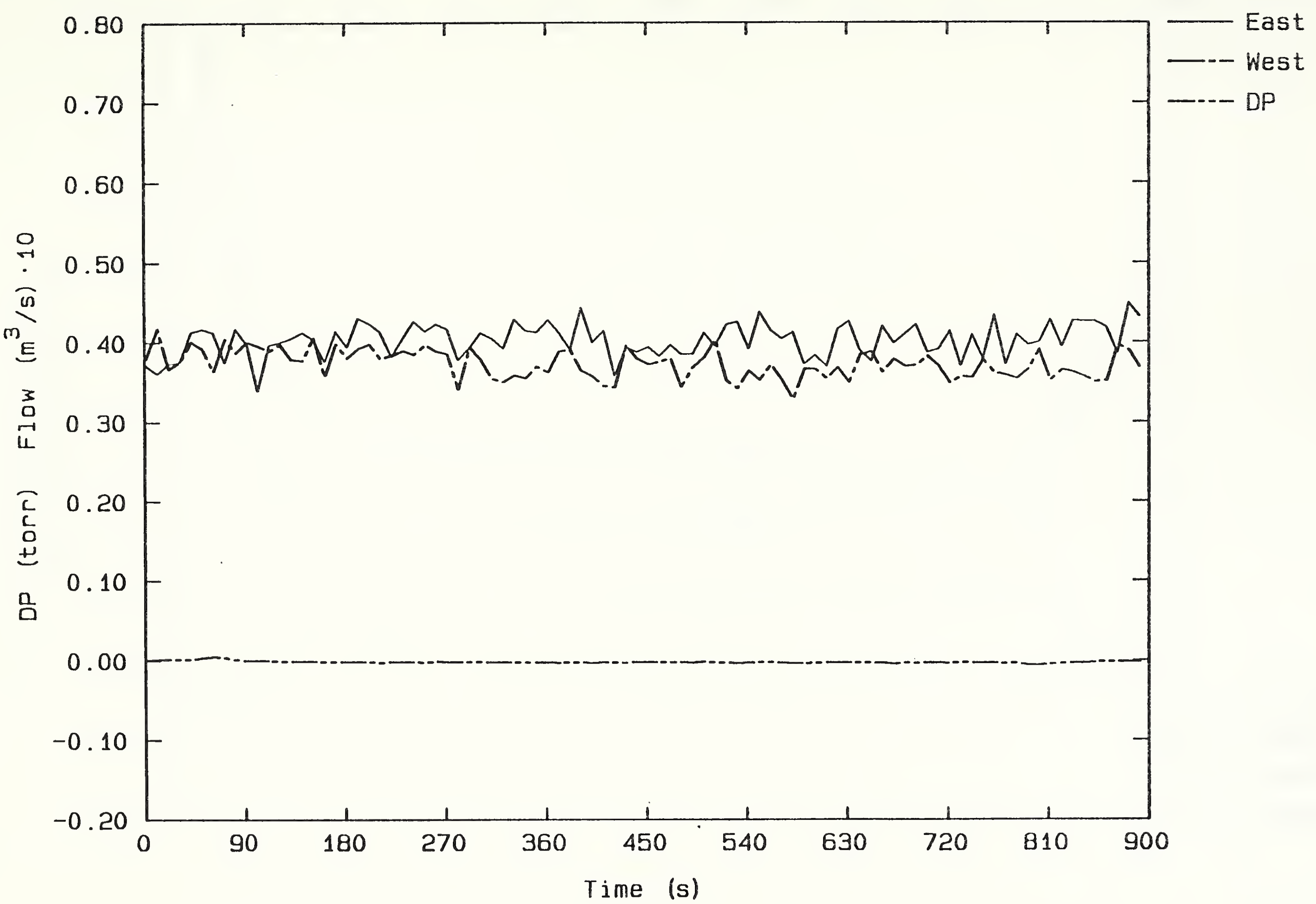

Figure 128. Test G0106 Cabin differential pressure and inlet flows, east and west

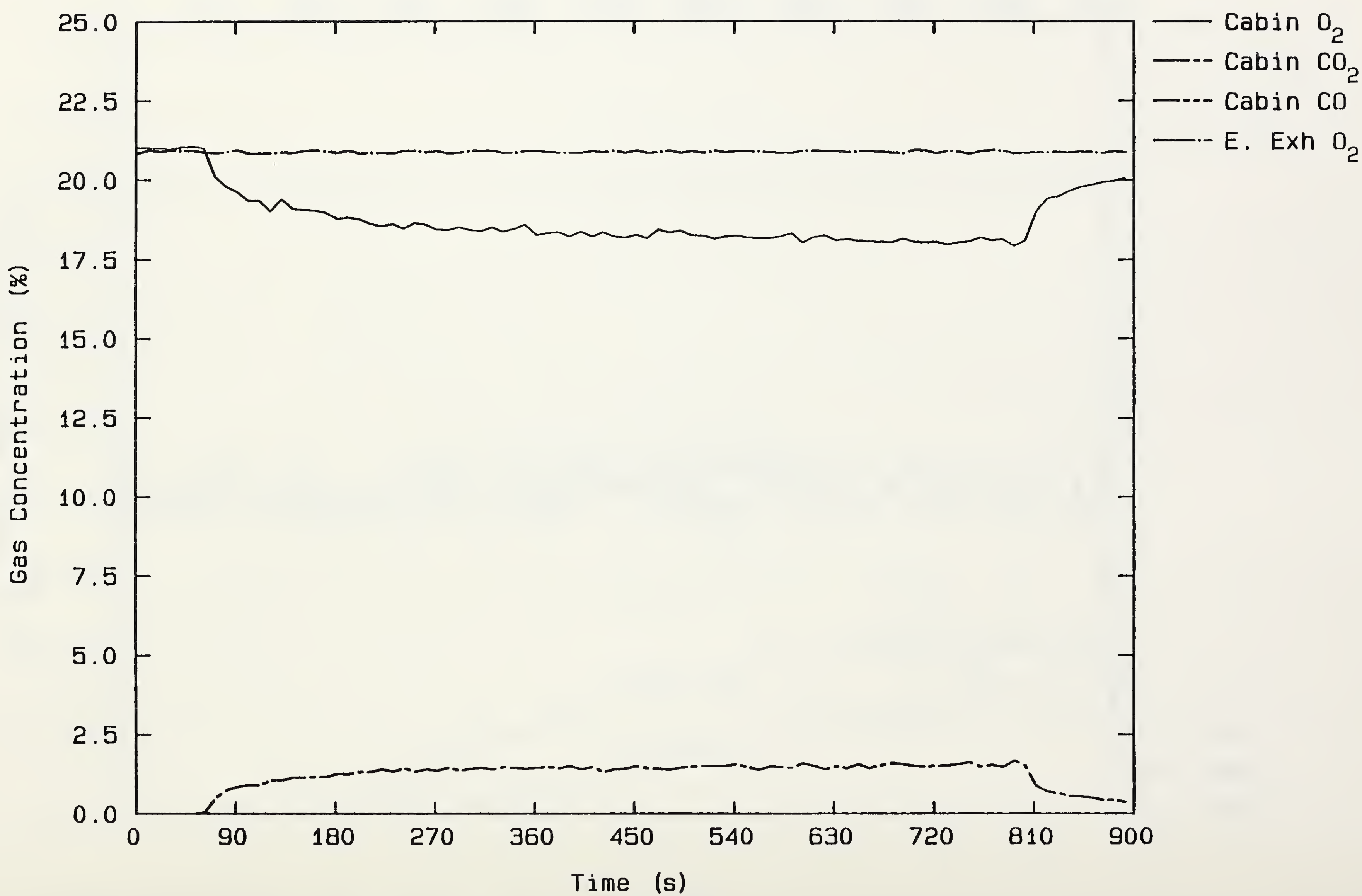

Figure 129. Test G0106 Cabin and exhaust gas concentrations

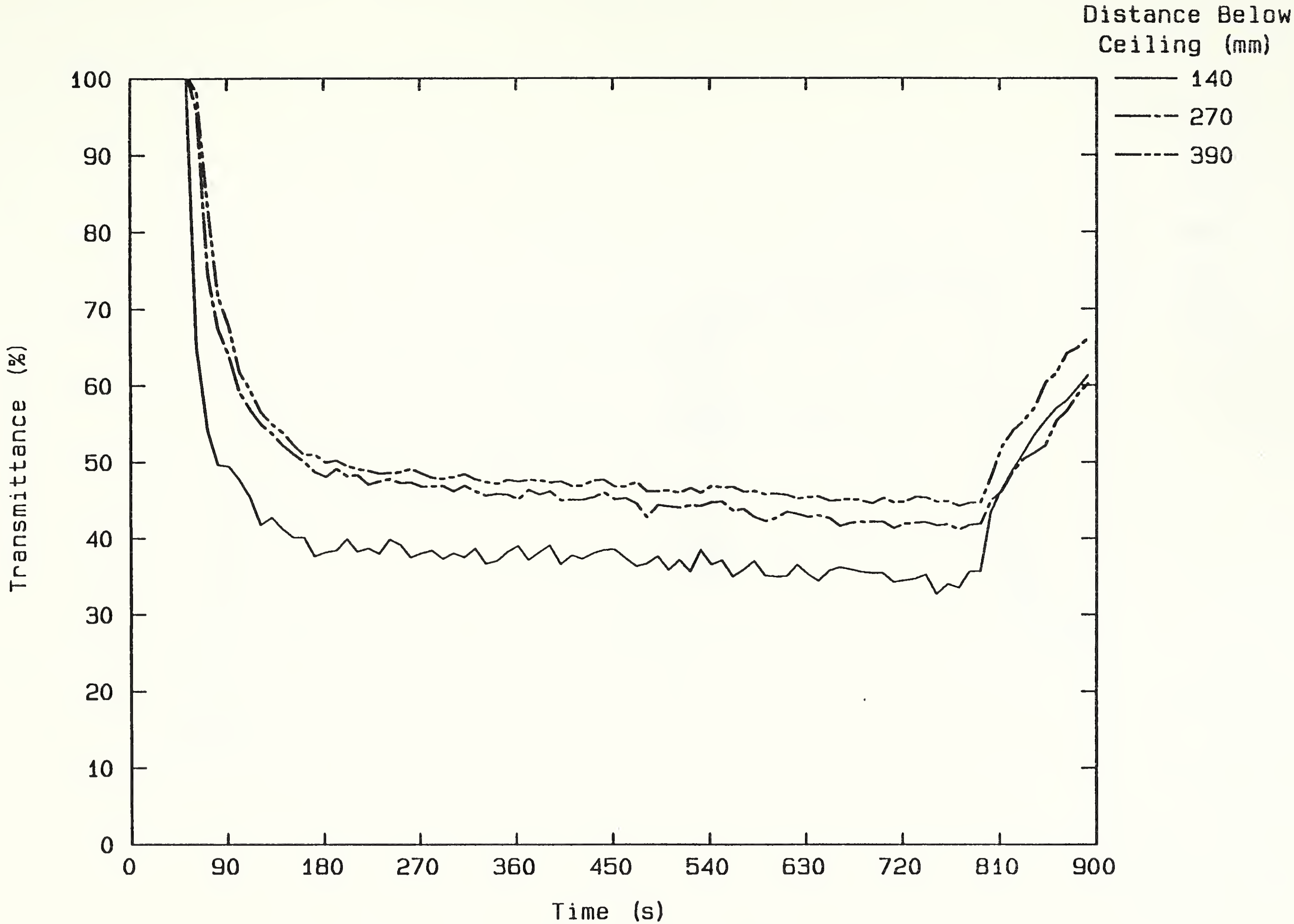

Figure 130. Test G0106 Cabin light attenuation by smoke

TEST G1406

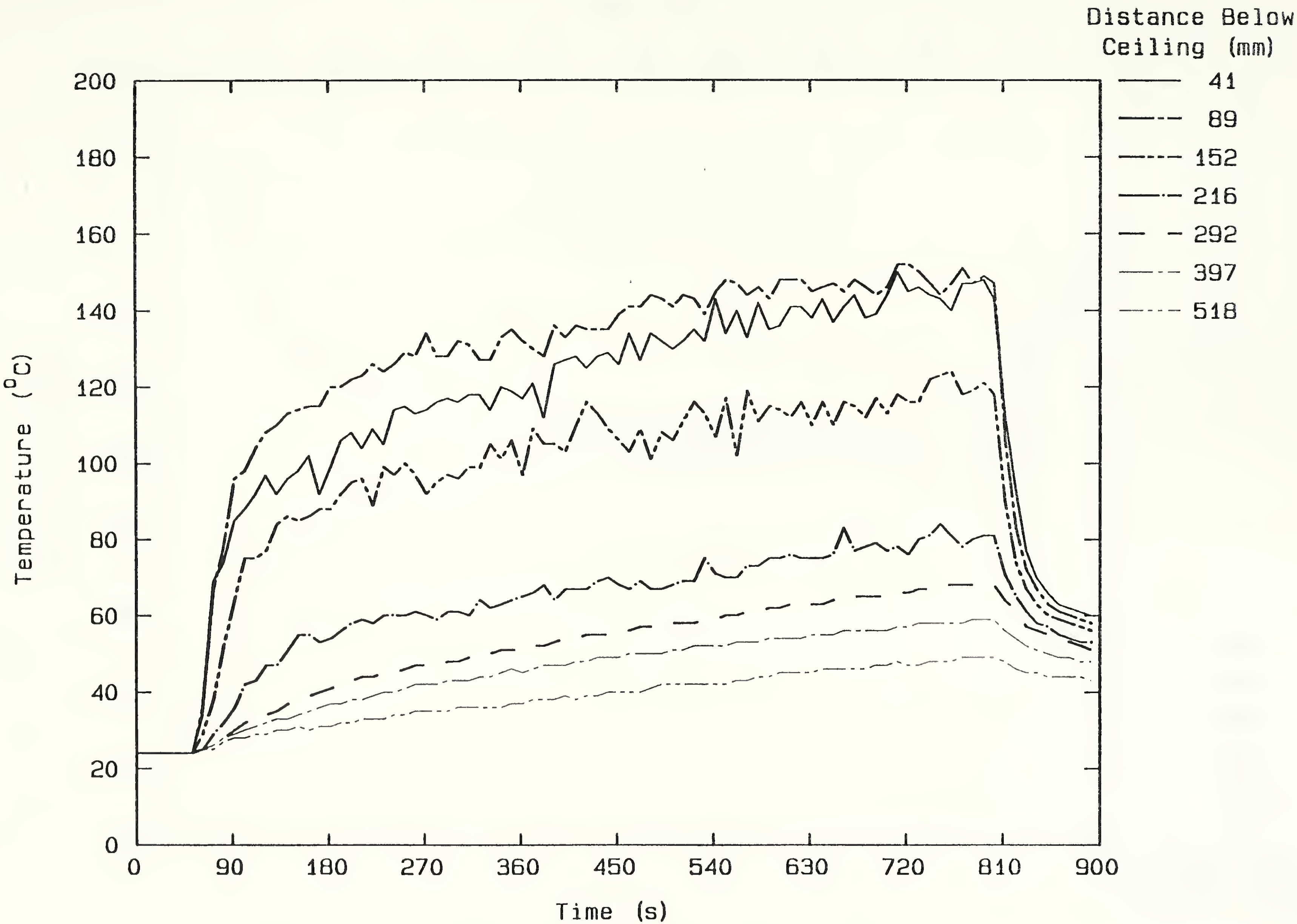

Figure 131. Test G1406 Vertical temperature profile at position A

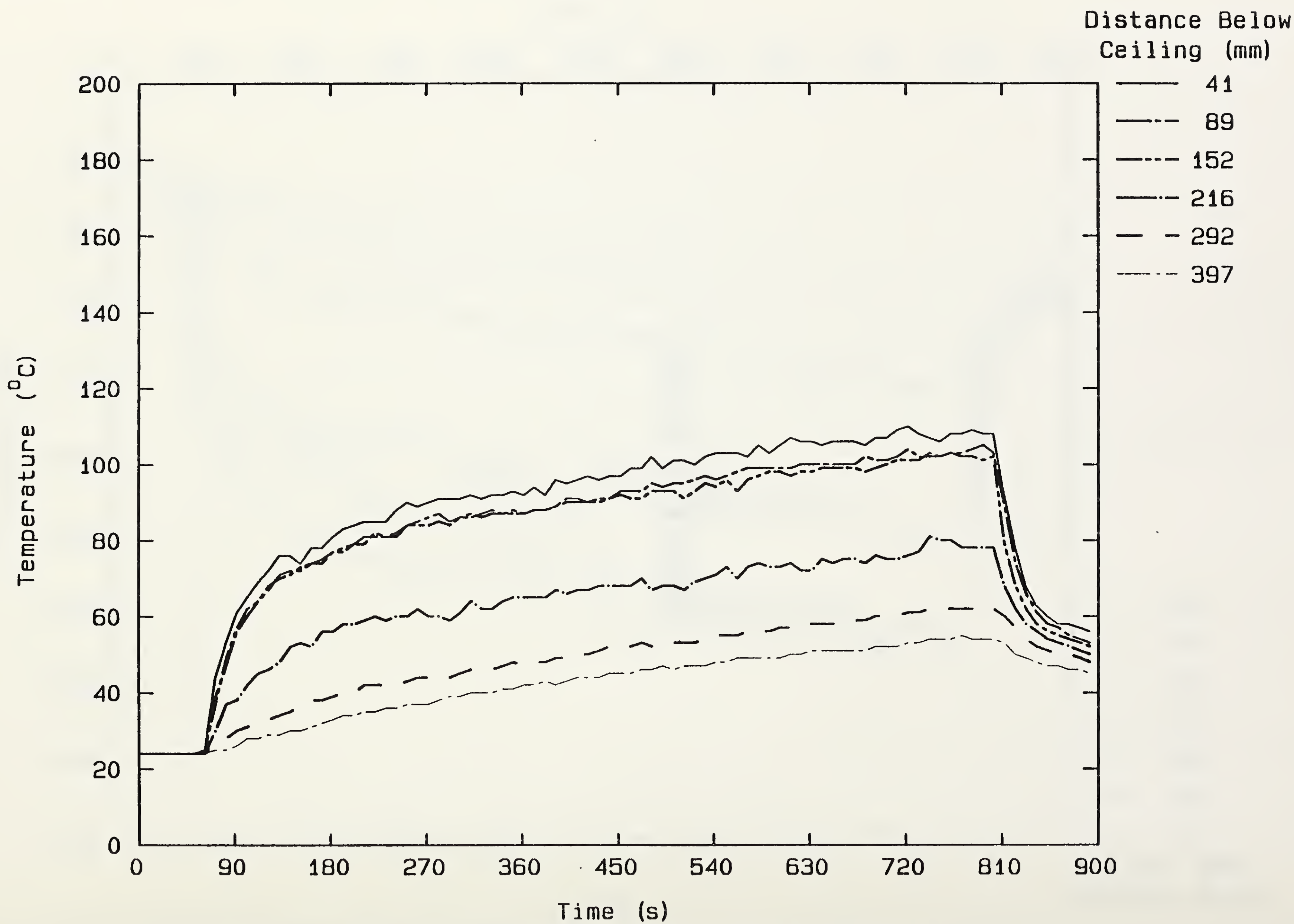

Figure 132. Test G1406 Vertical temperature profile at position B

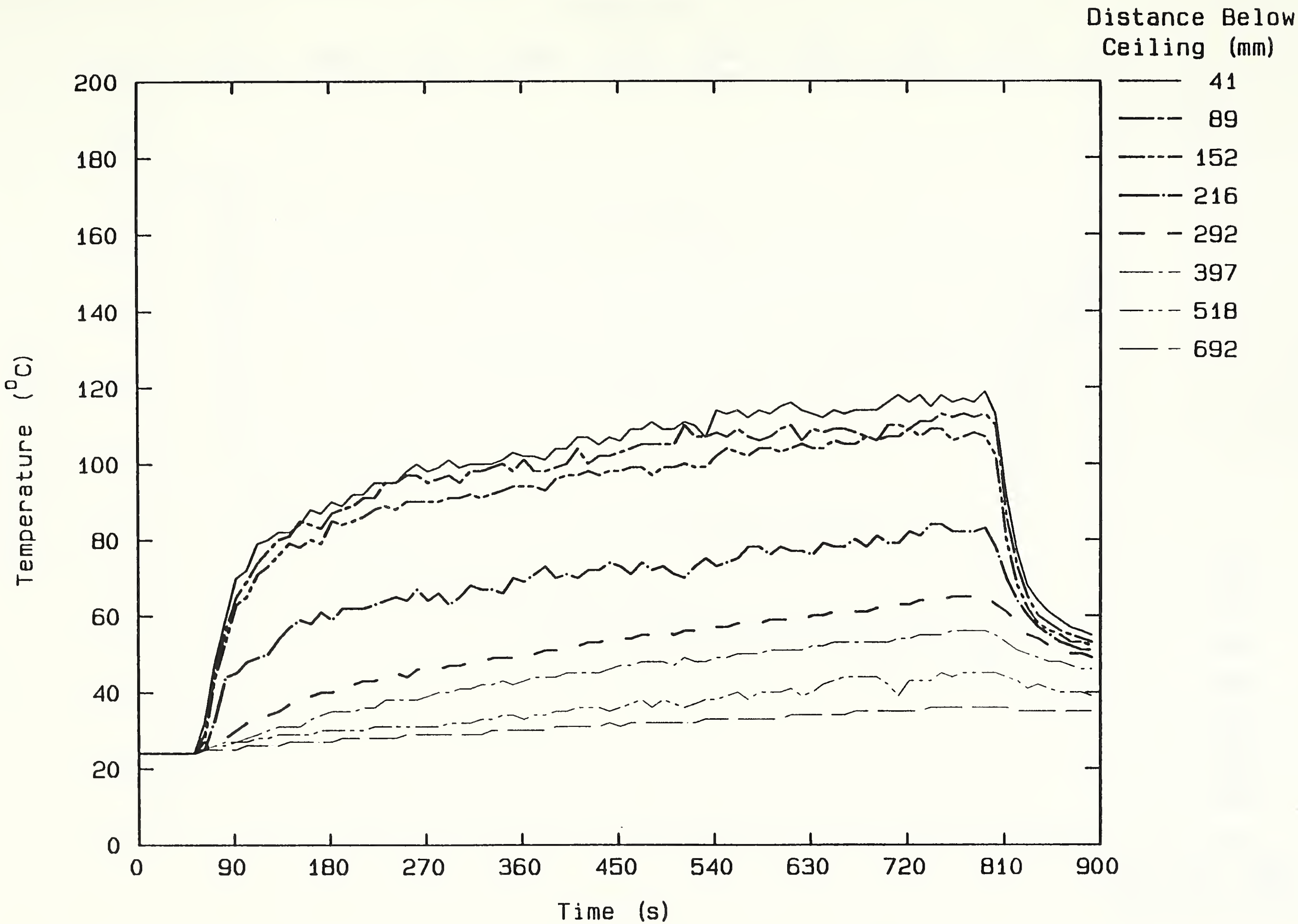

Figure 133. Test G1406 Vertical temperature profile at position C

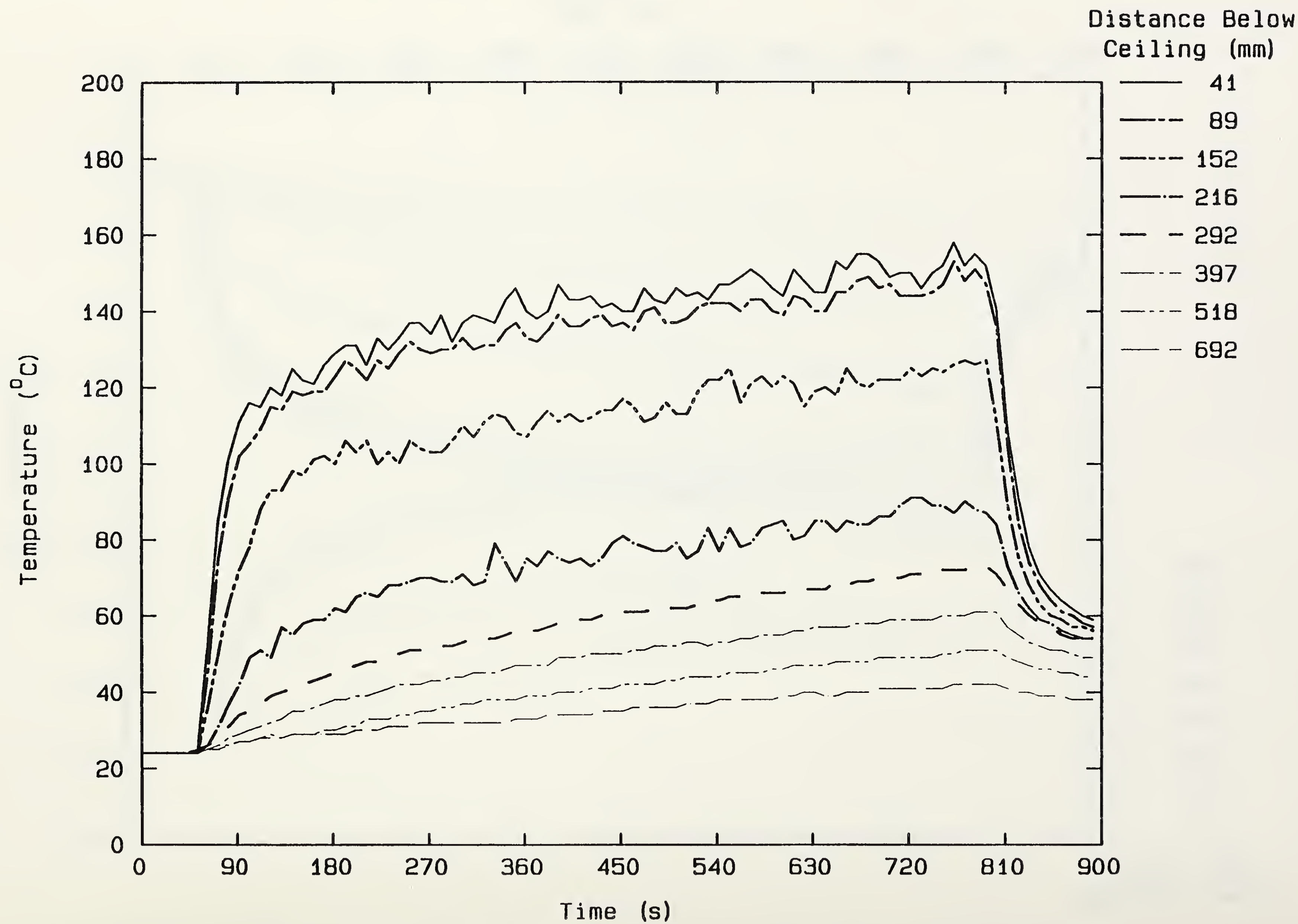

Figure 134. Test G1406 Vertical temperature profile at position D

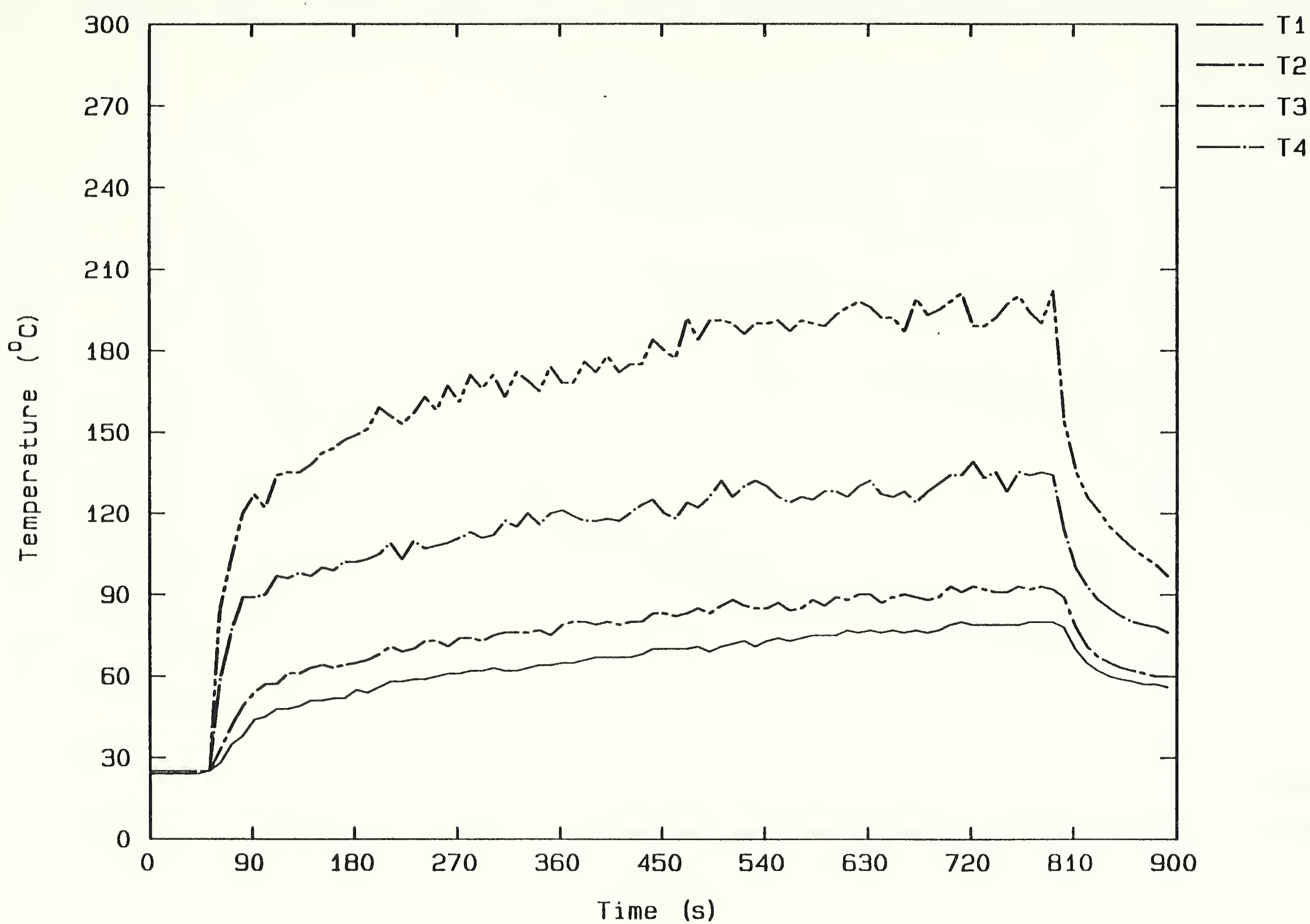

Figure 135. Test G1406 Ceiling interior surface temperature: T1 - T4

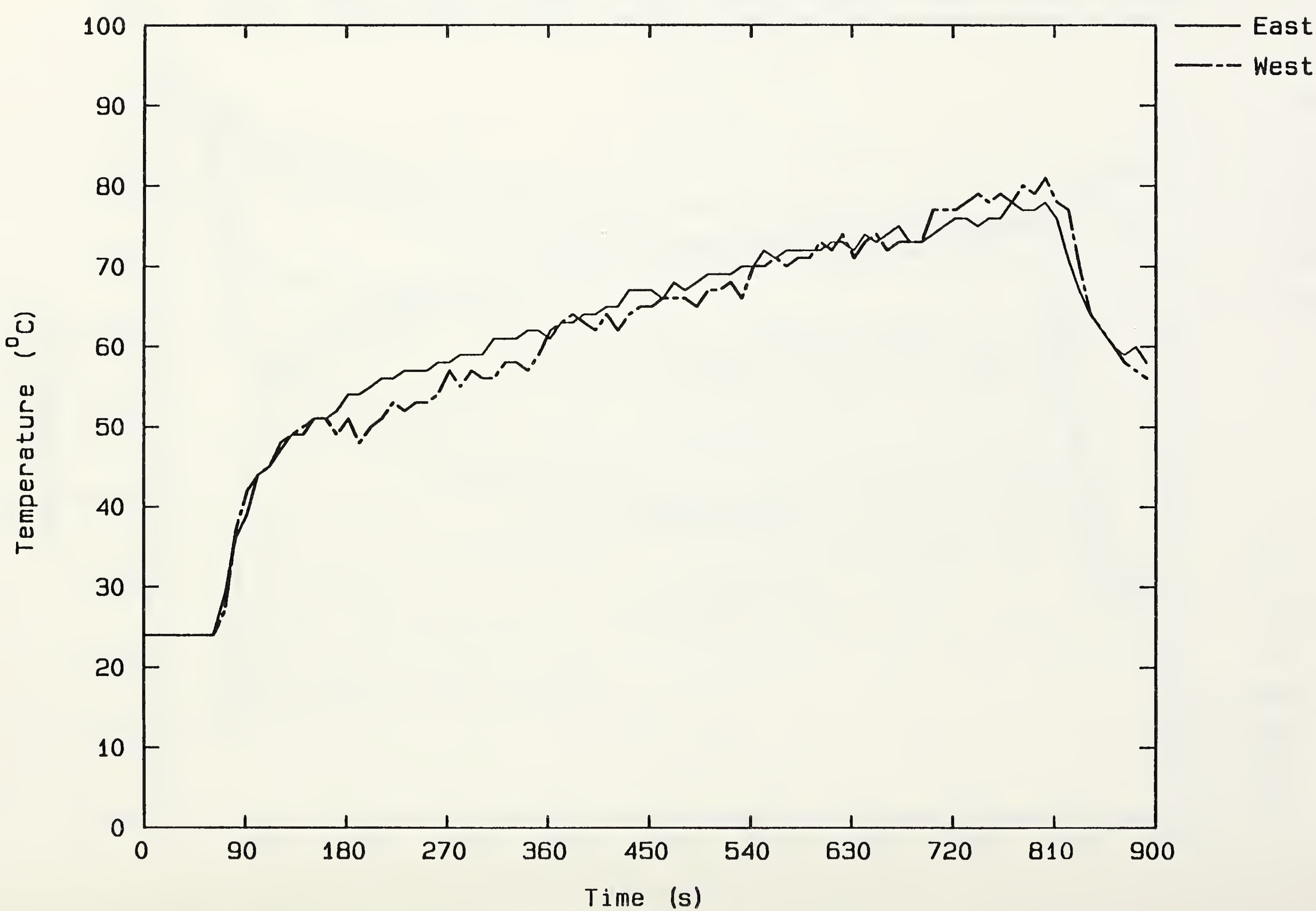

Figure 136. Test G1406 Exhaust temperature: east and west

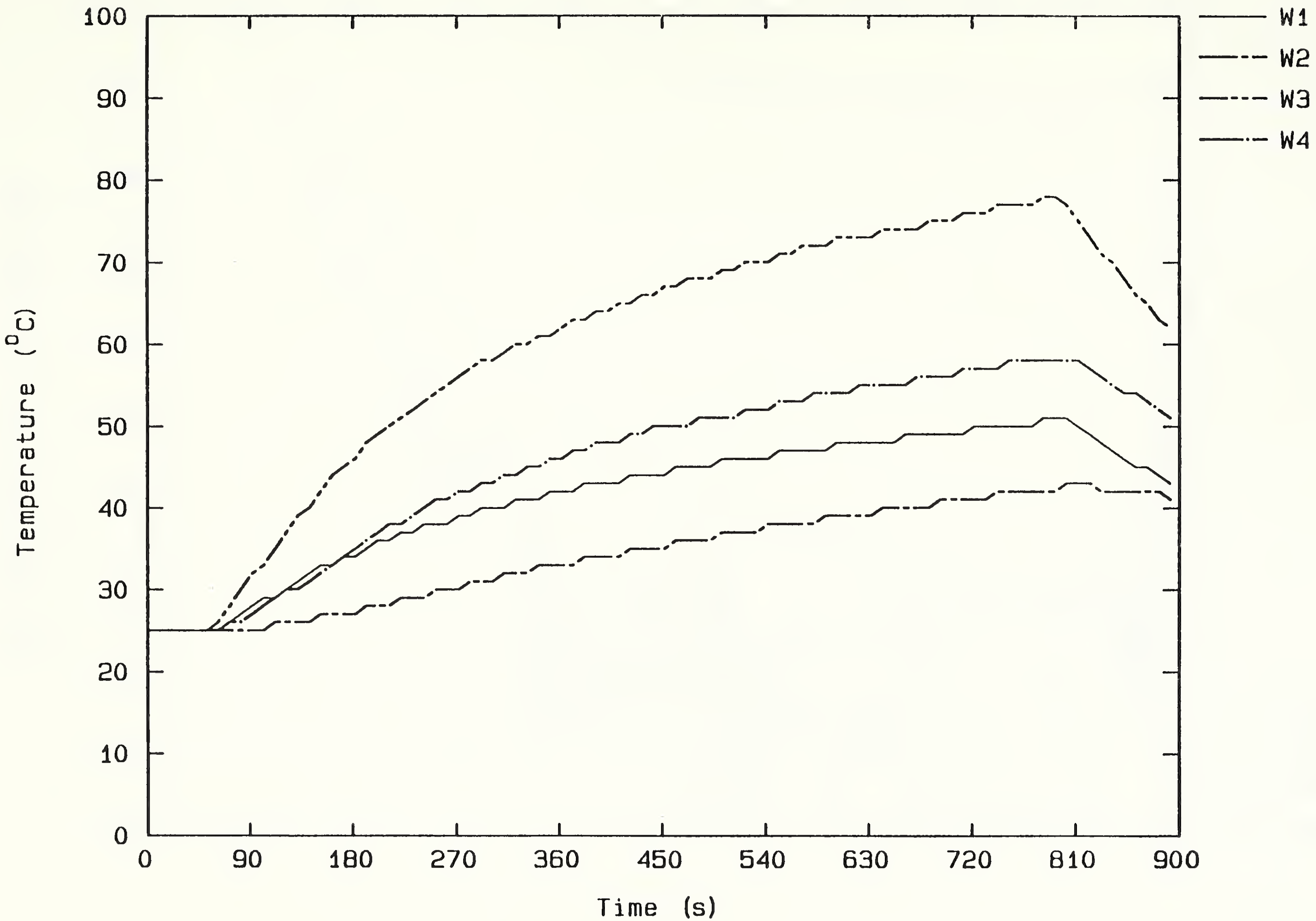

Figure 137. Test G1406 Wall interior surface temperature: W1 - W4

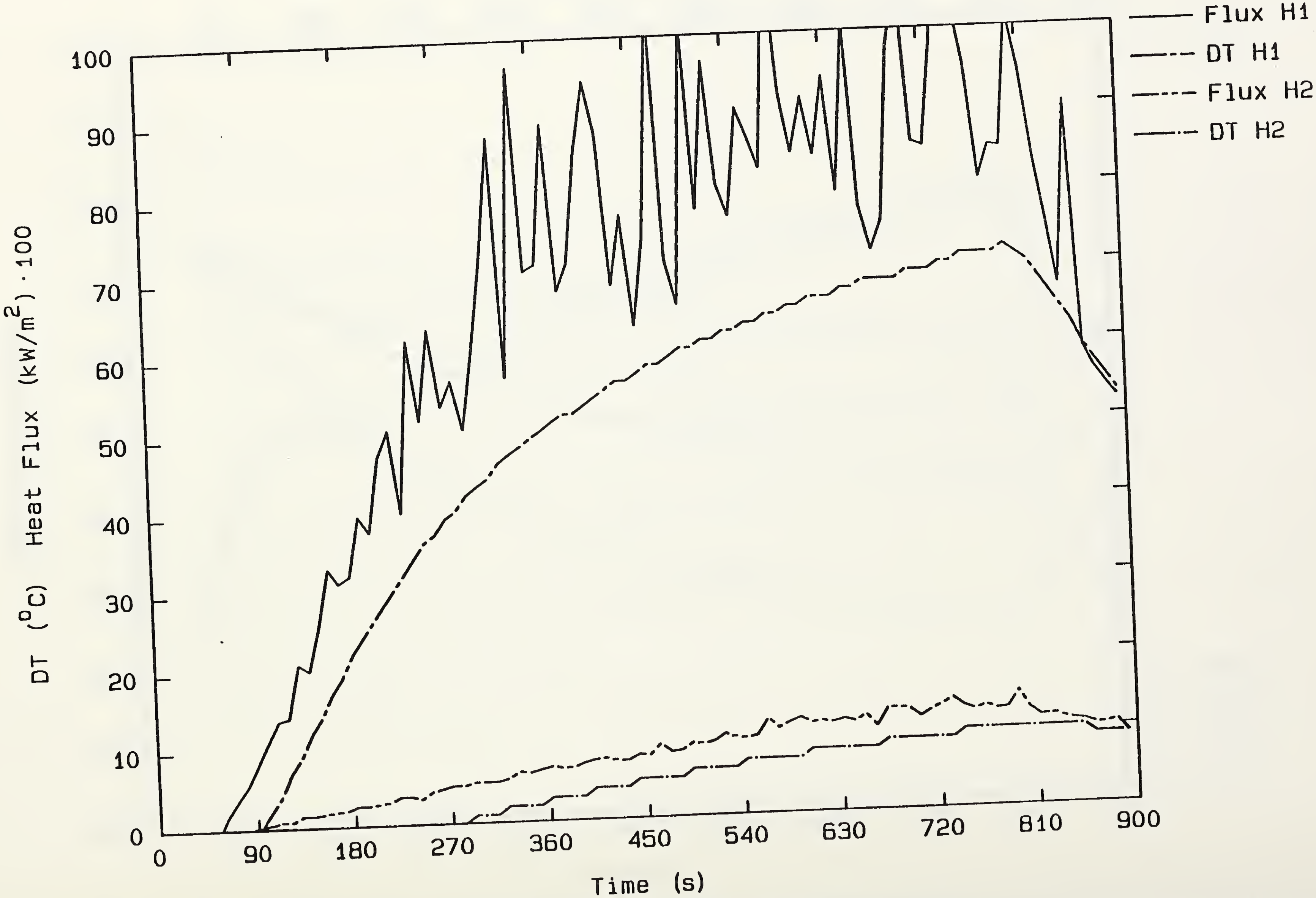

Figure 138. Test G1406 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

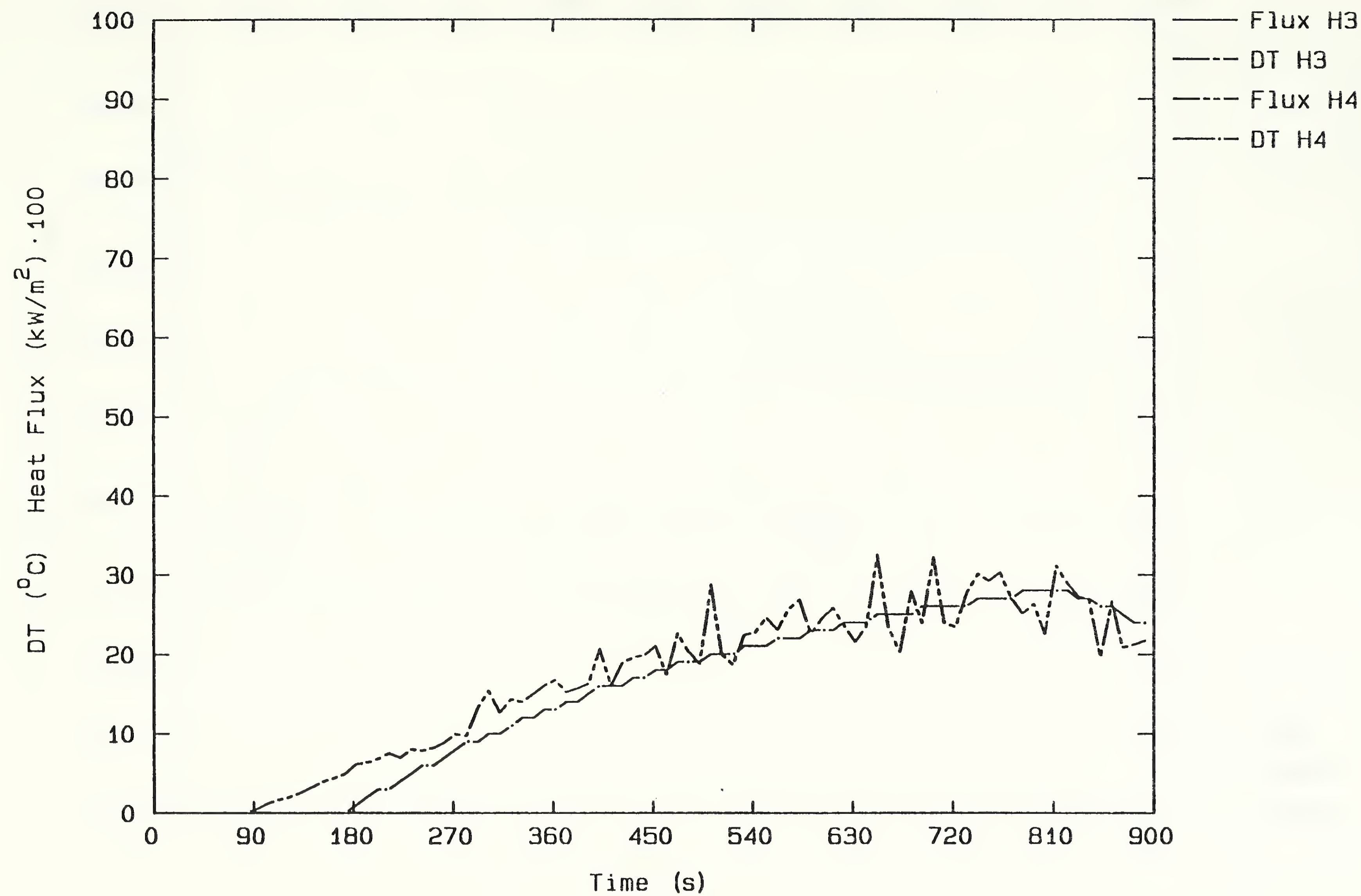

Figure 139. Test G1406 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

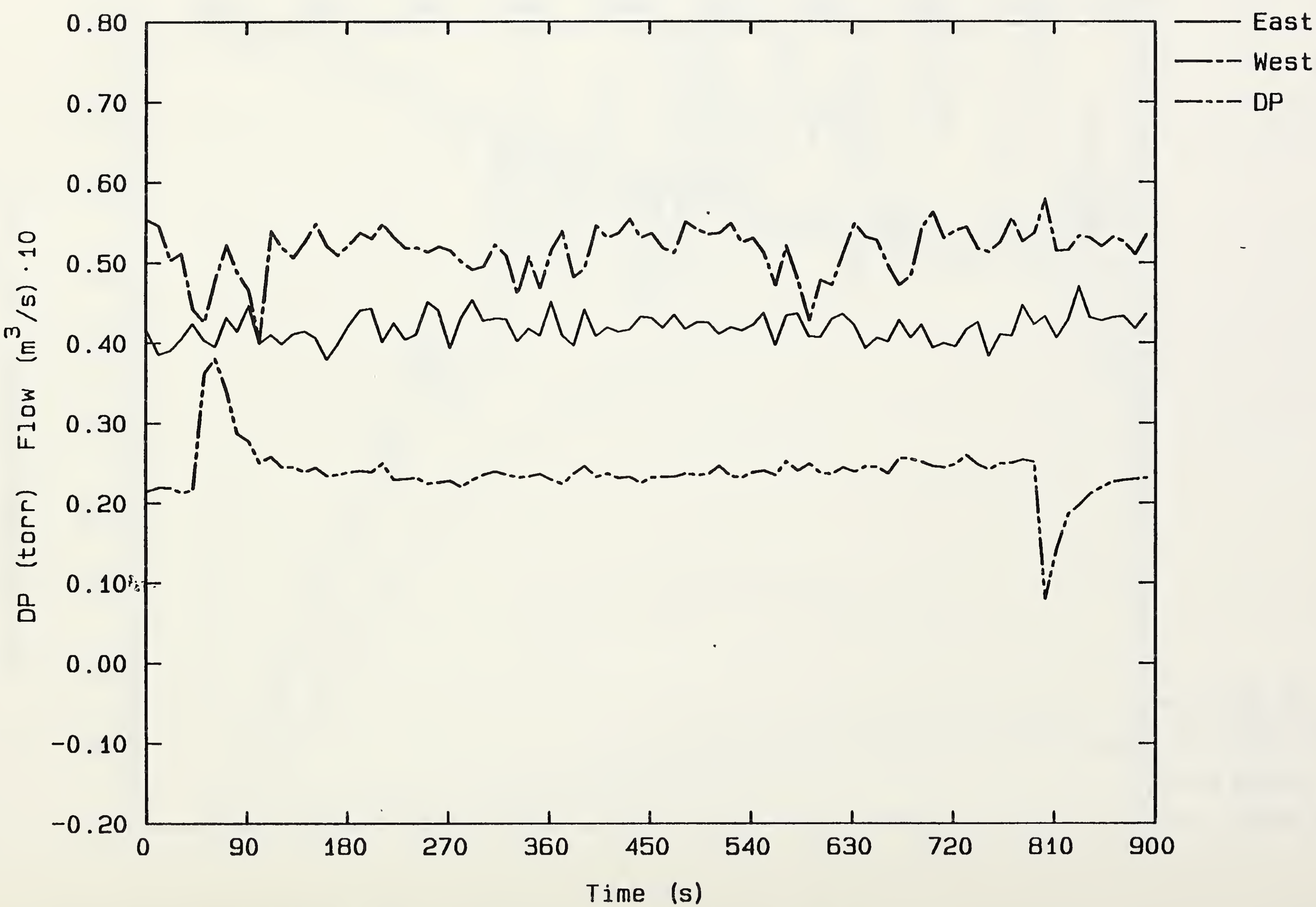

Figure 140. Test G1406 Cabin differential pressure and inlet flows, east and west

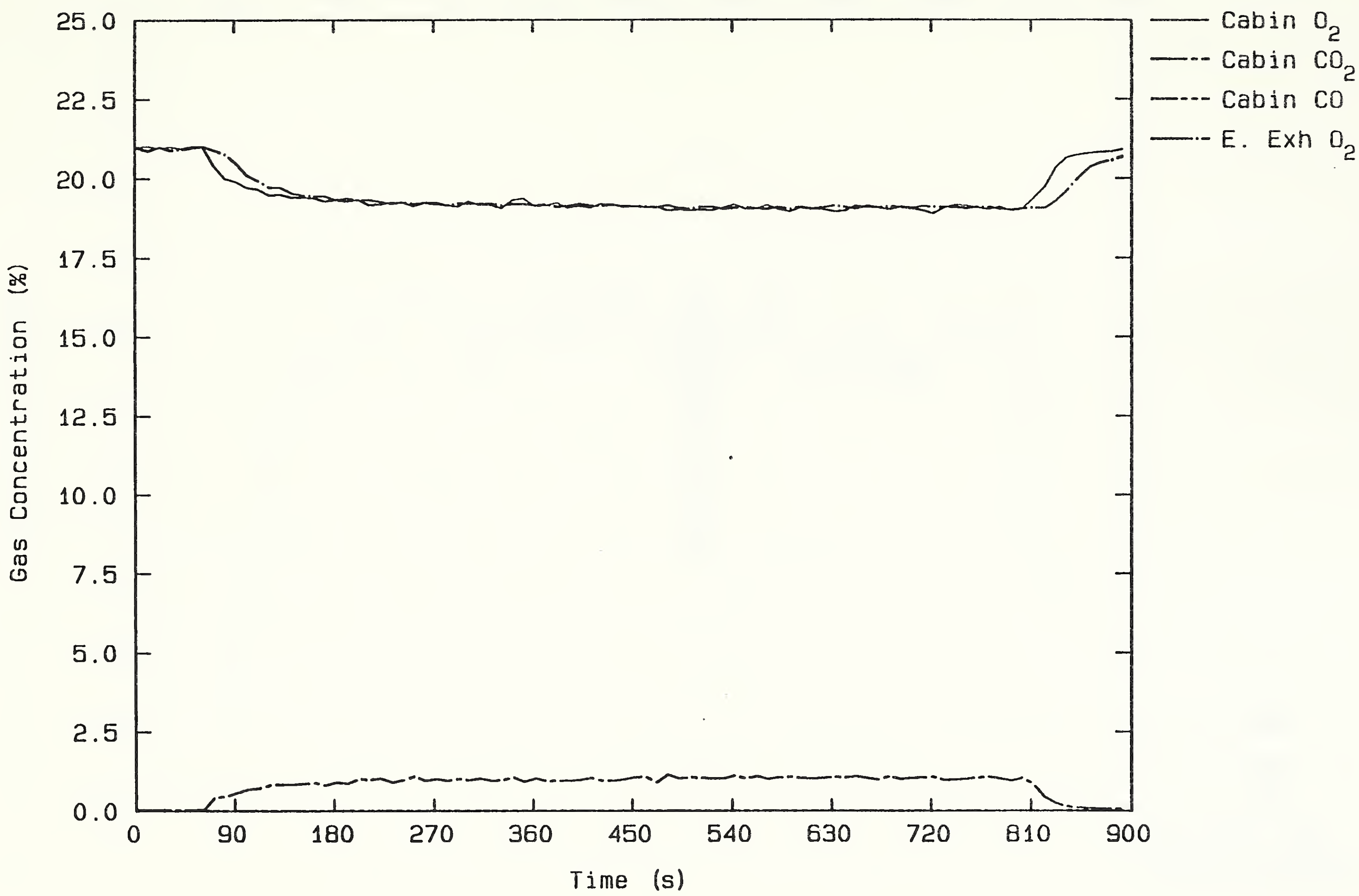

Figure 141. Test G1406 Cabin and exhaust gas concentrations

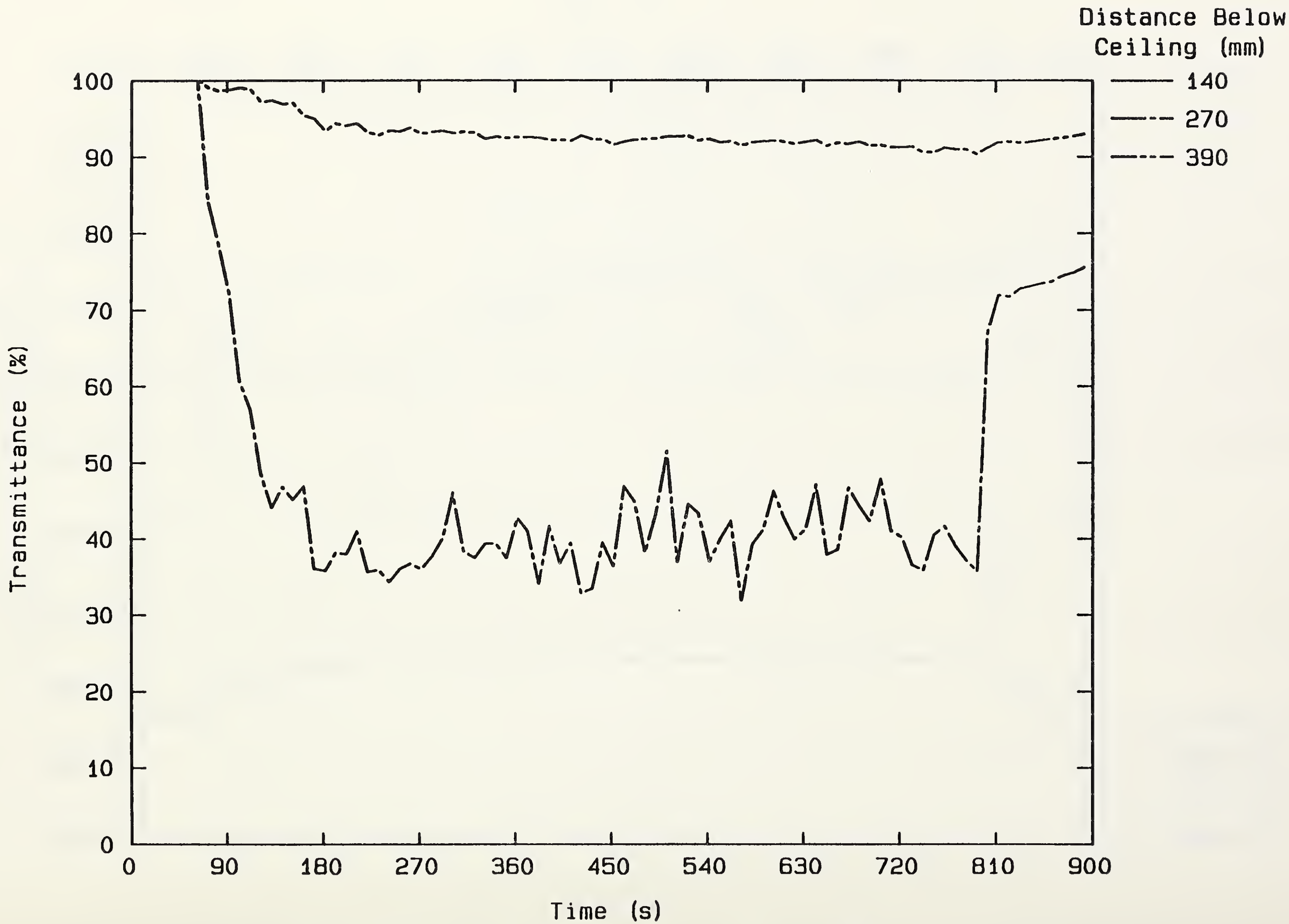

Figure 142. Test G1406 Cabin light attenuation by smoke

TEST G1506

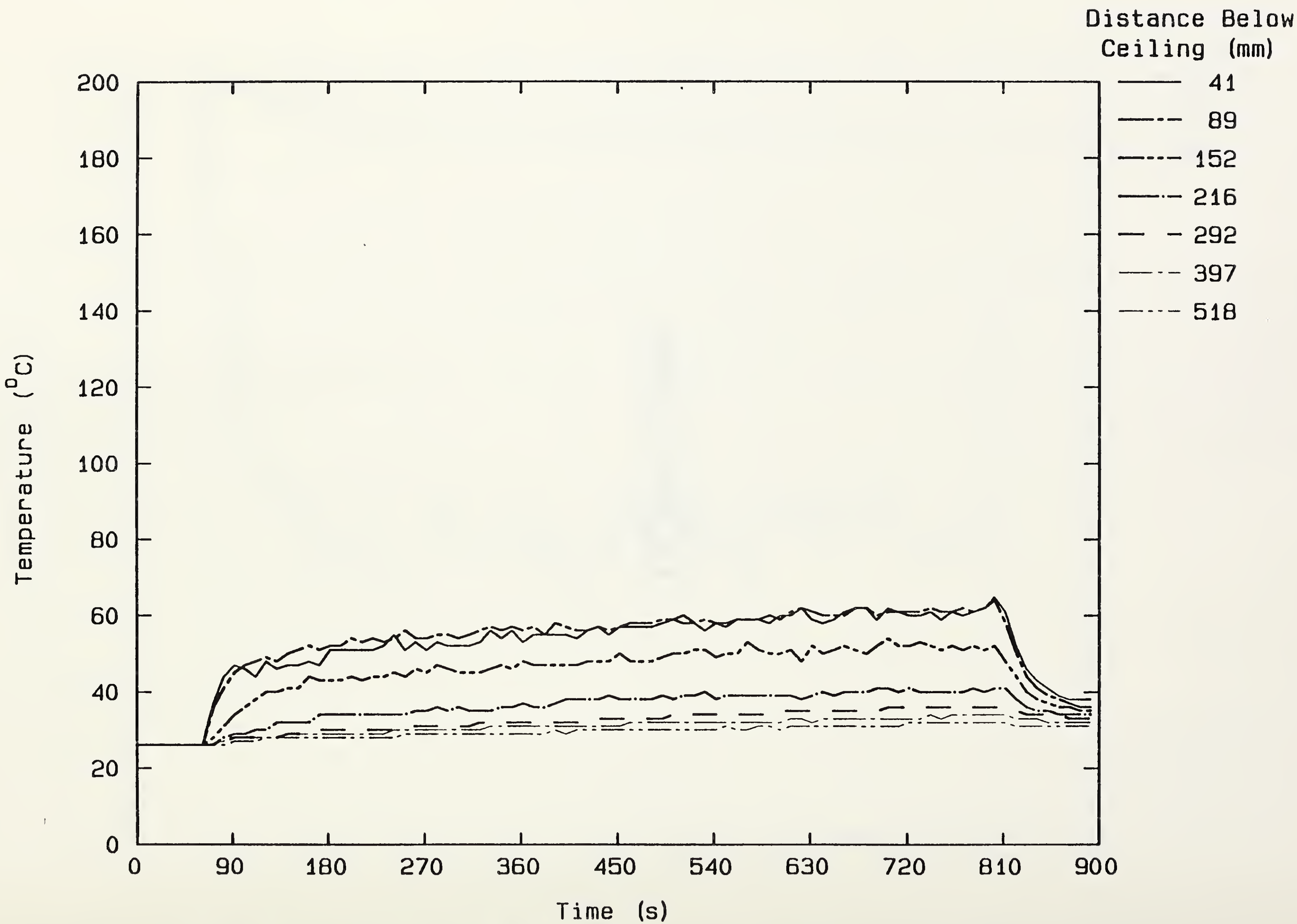

Figure 143. Test G1506 Vertical temperature profile at position A

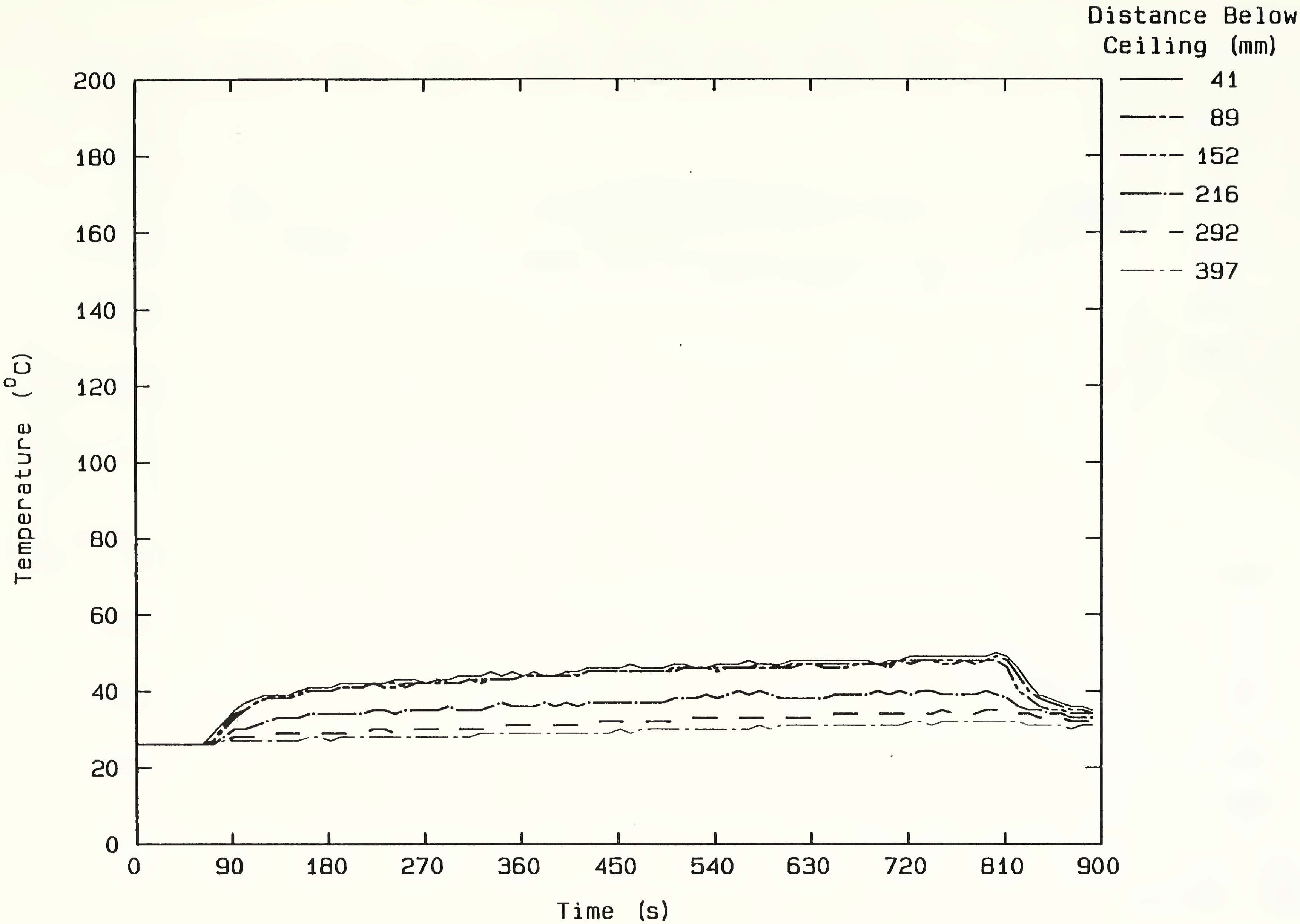

Figure 144. Test G1506 Vertical temperature profile at position B

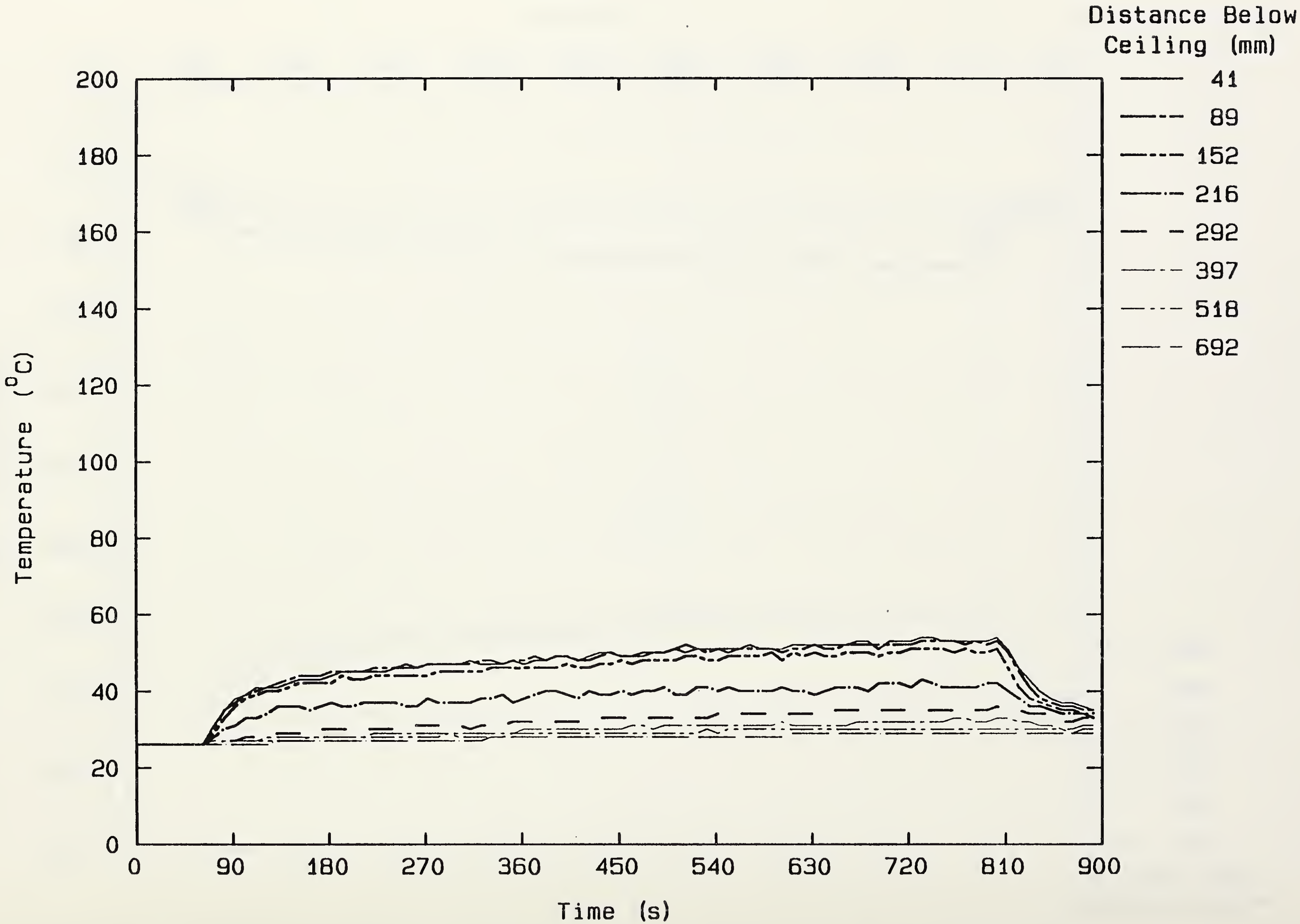

Figure 145. Test G1506 Vertical temperature profile at position C

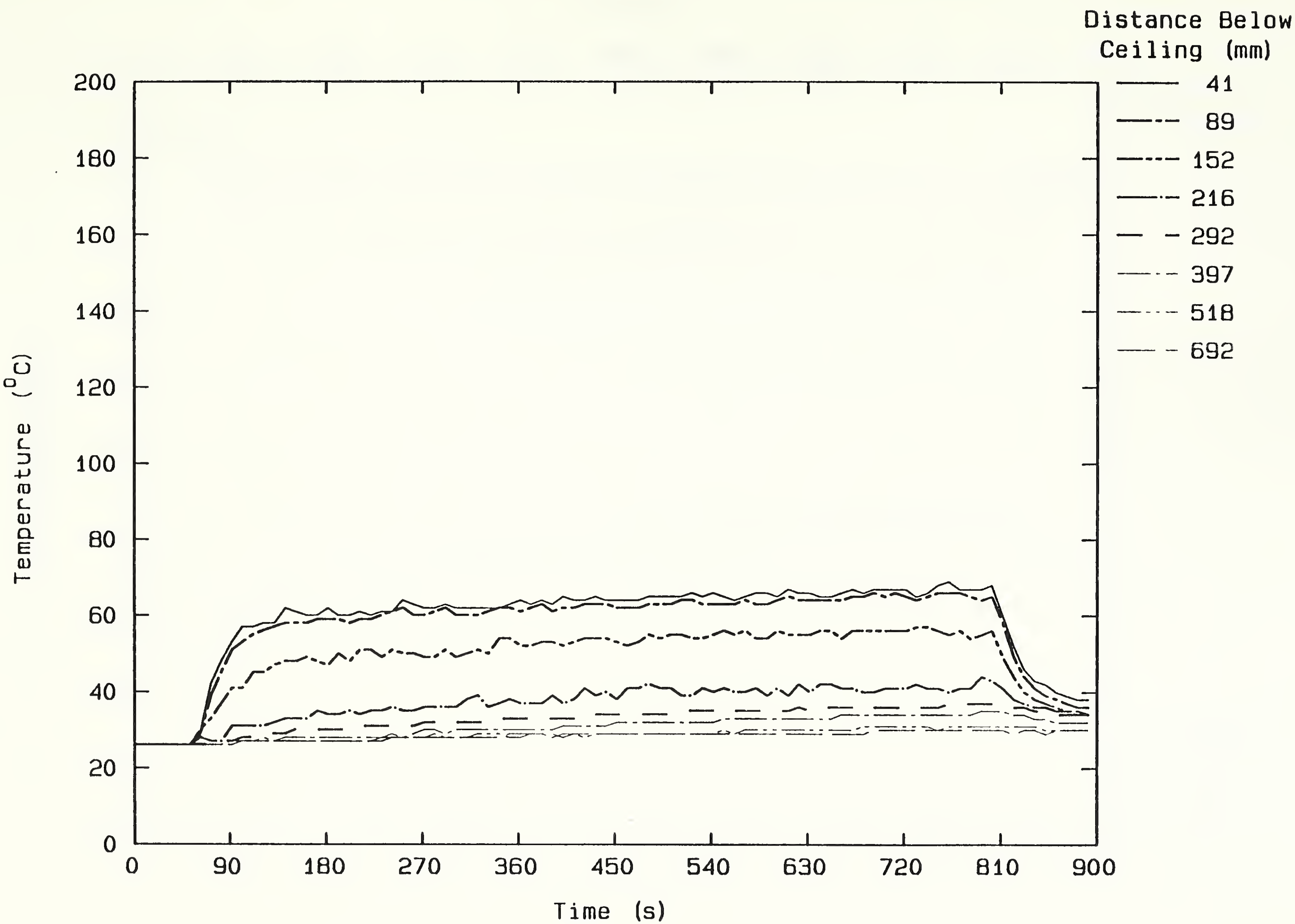

Figure 146. Test G1506 Vertical temperature profile at position D

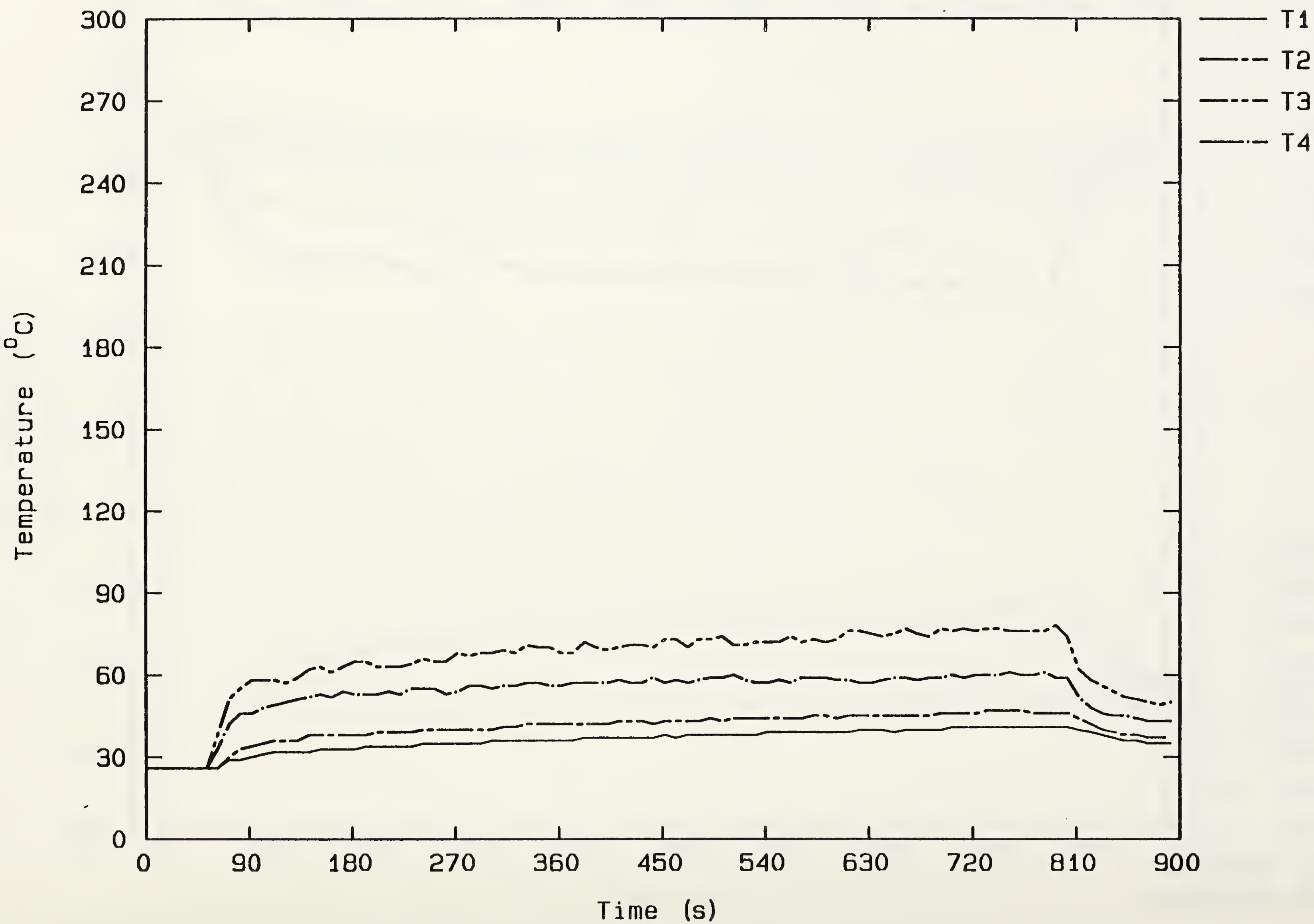

Figure 147. Test G1506 Ceiling interior surface temperature: T1 - T4

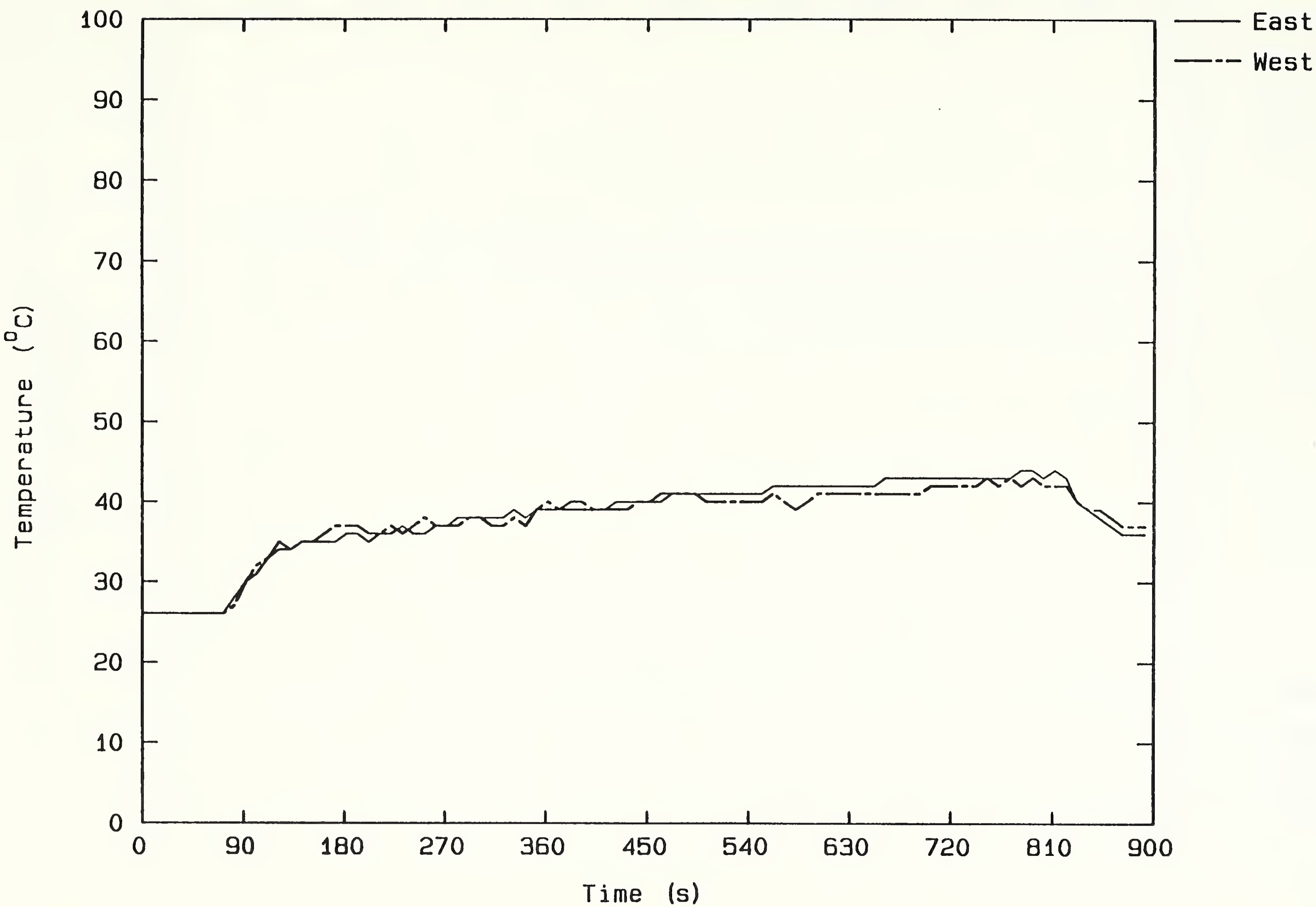

Figure 148. Test G1506 Exhaust temperature: east and west

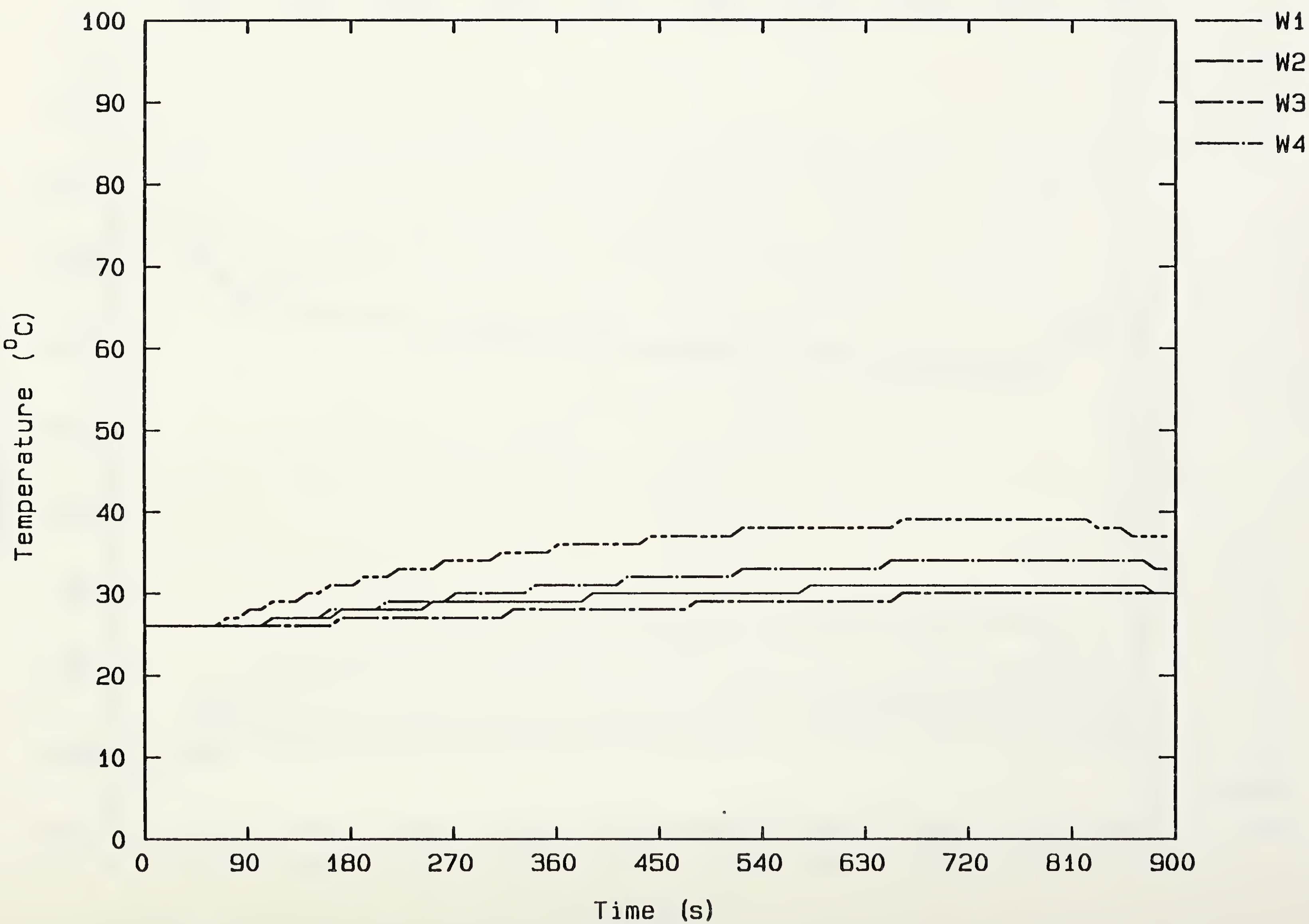

Figure 149. Test G1506 Wall interior surface temperature: W1 - W4

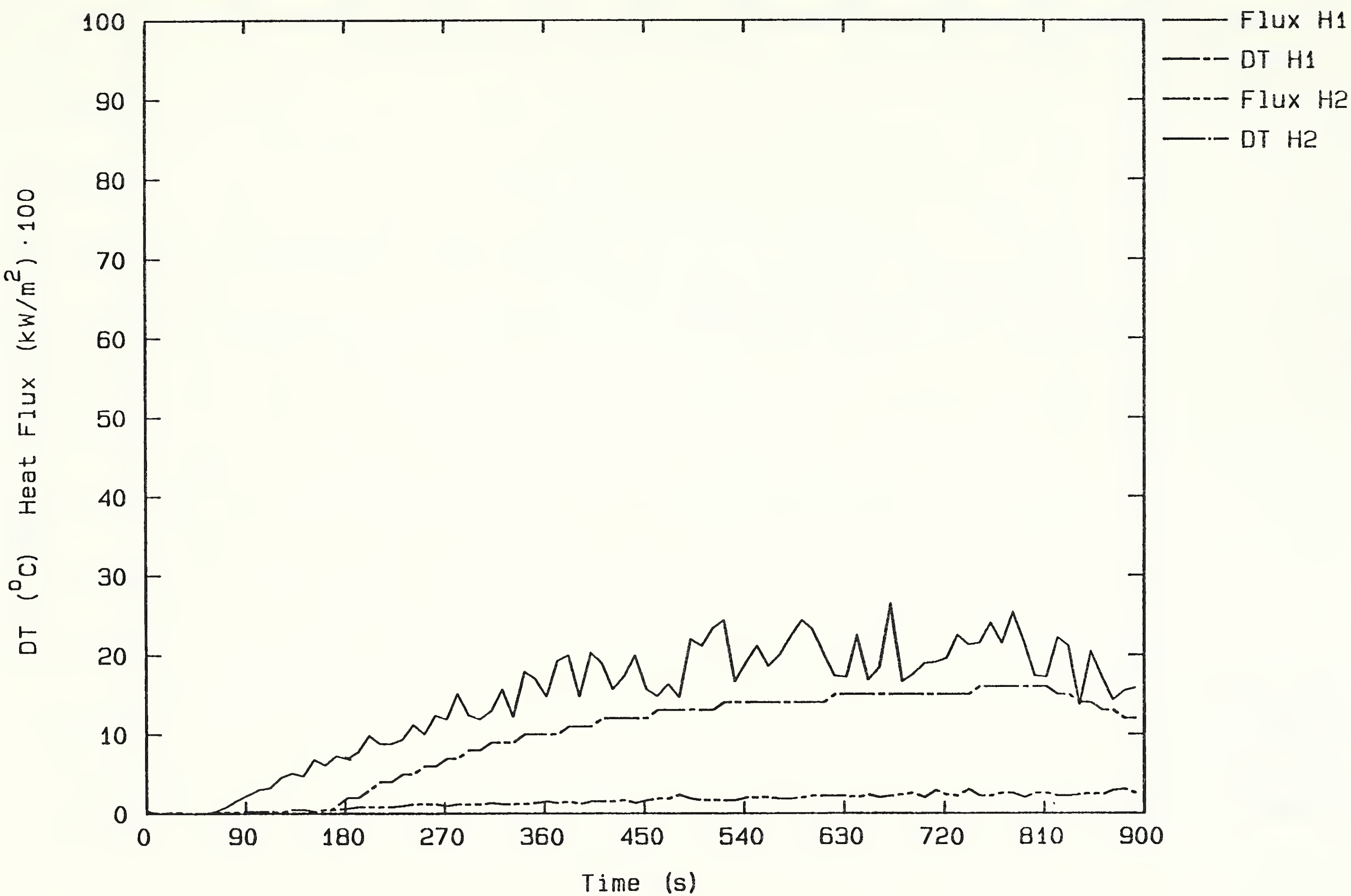

Figure 150. Test G1506 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

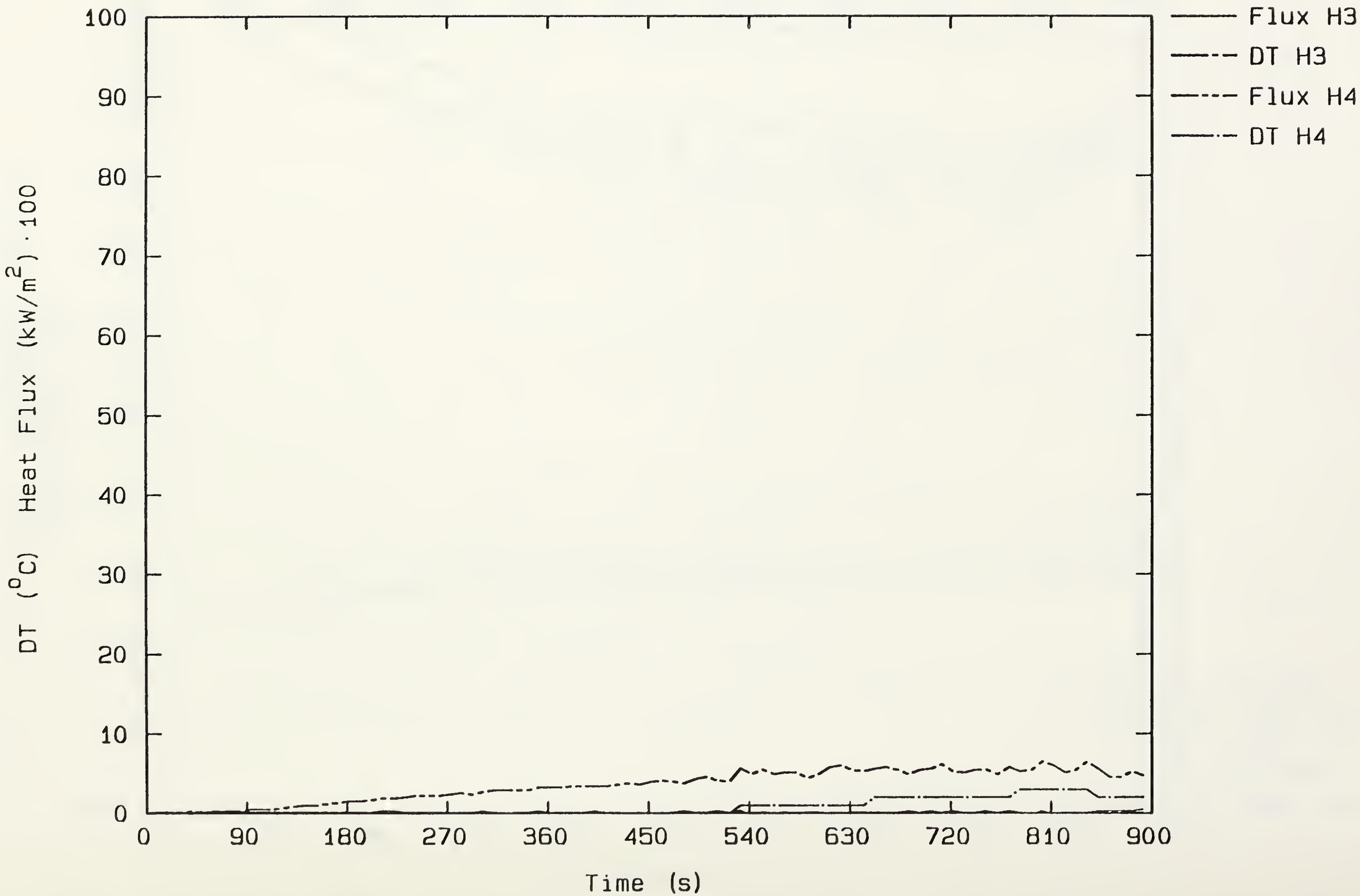

Figure 151. Test G1506 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

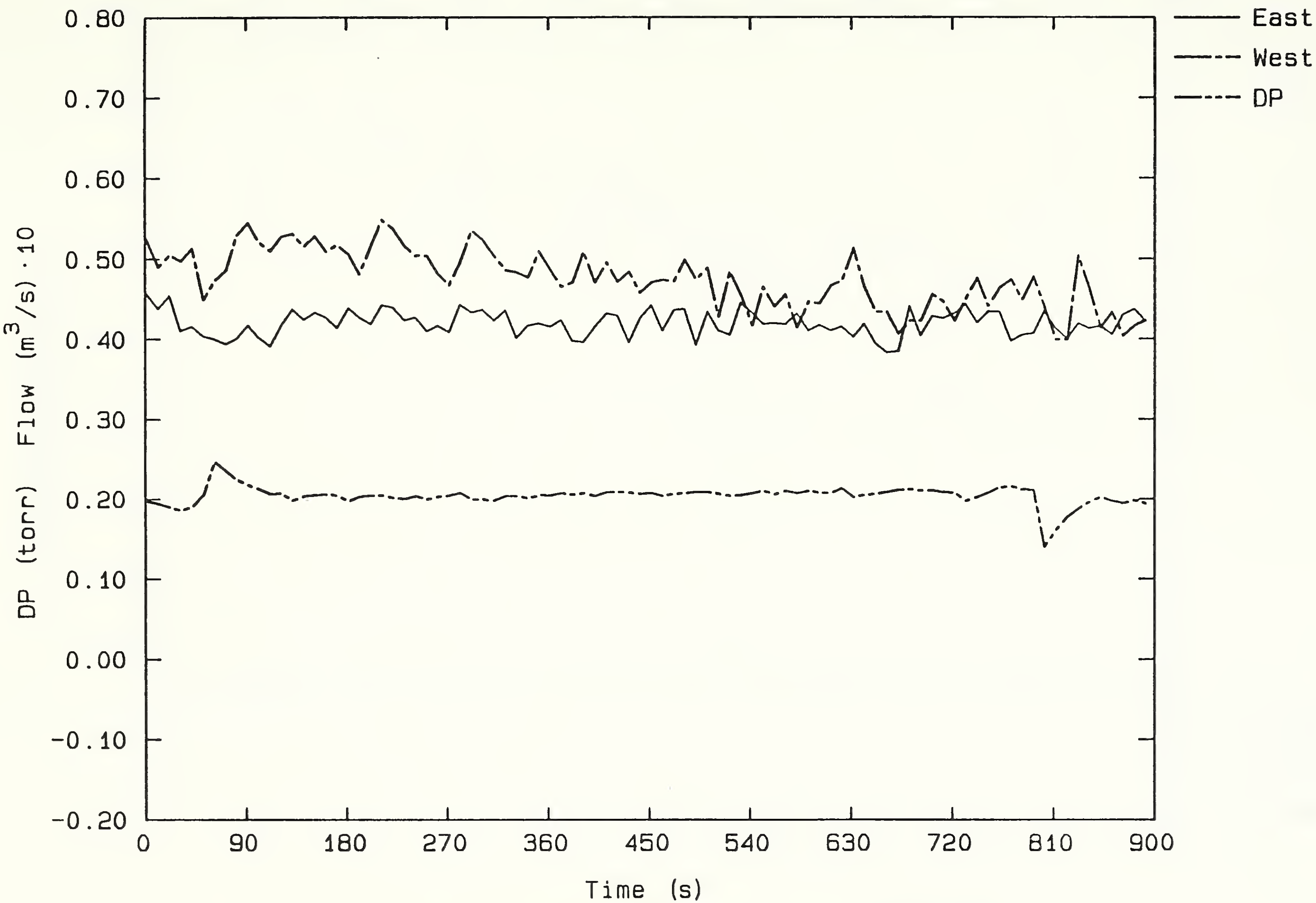

Figure 152. Test G1506 Cabin differential pressure and inlet flows, east and west

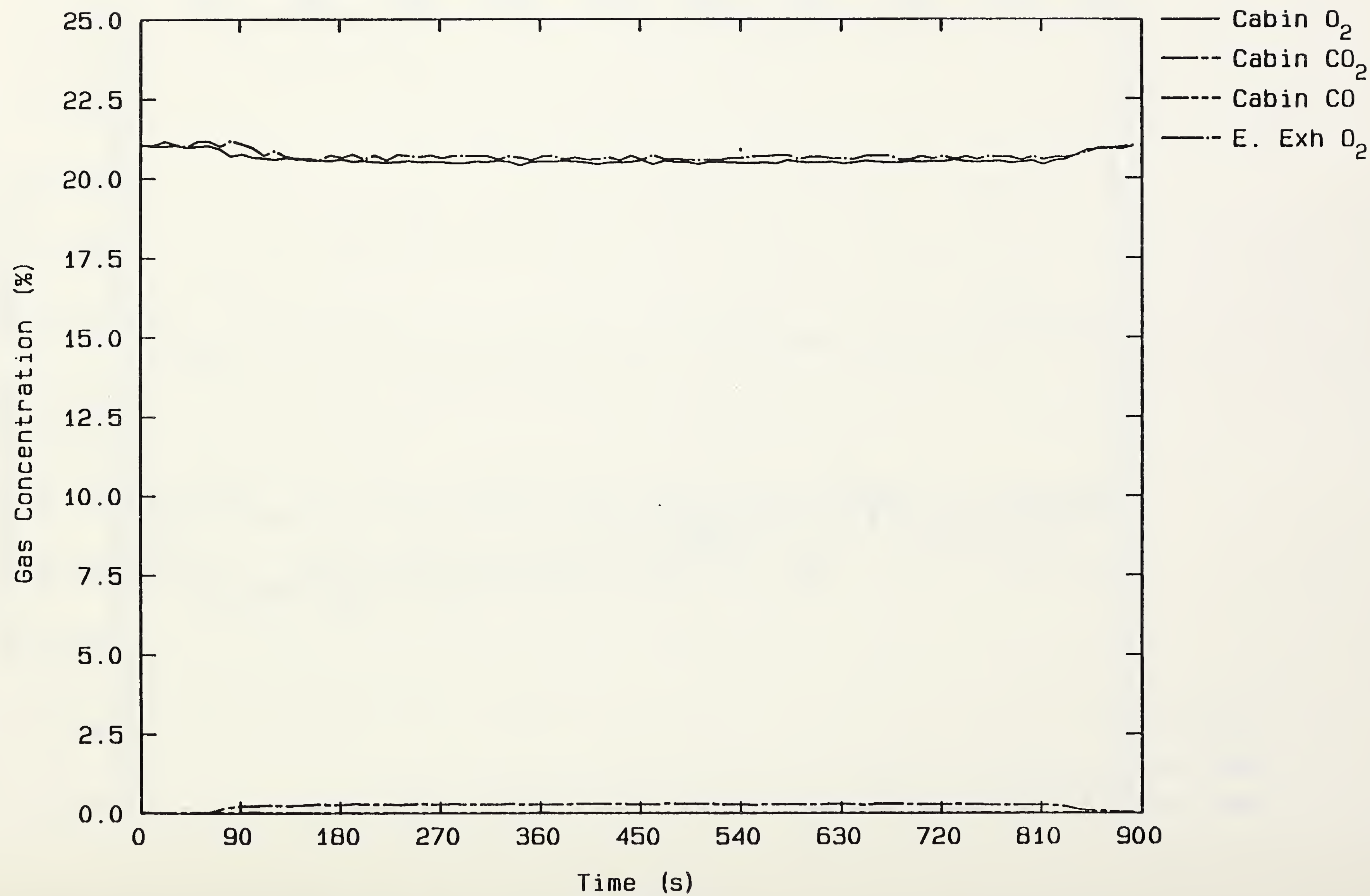

Figure 153. Test G1506 Cabin and exhaust gas concentrations

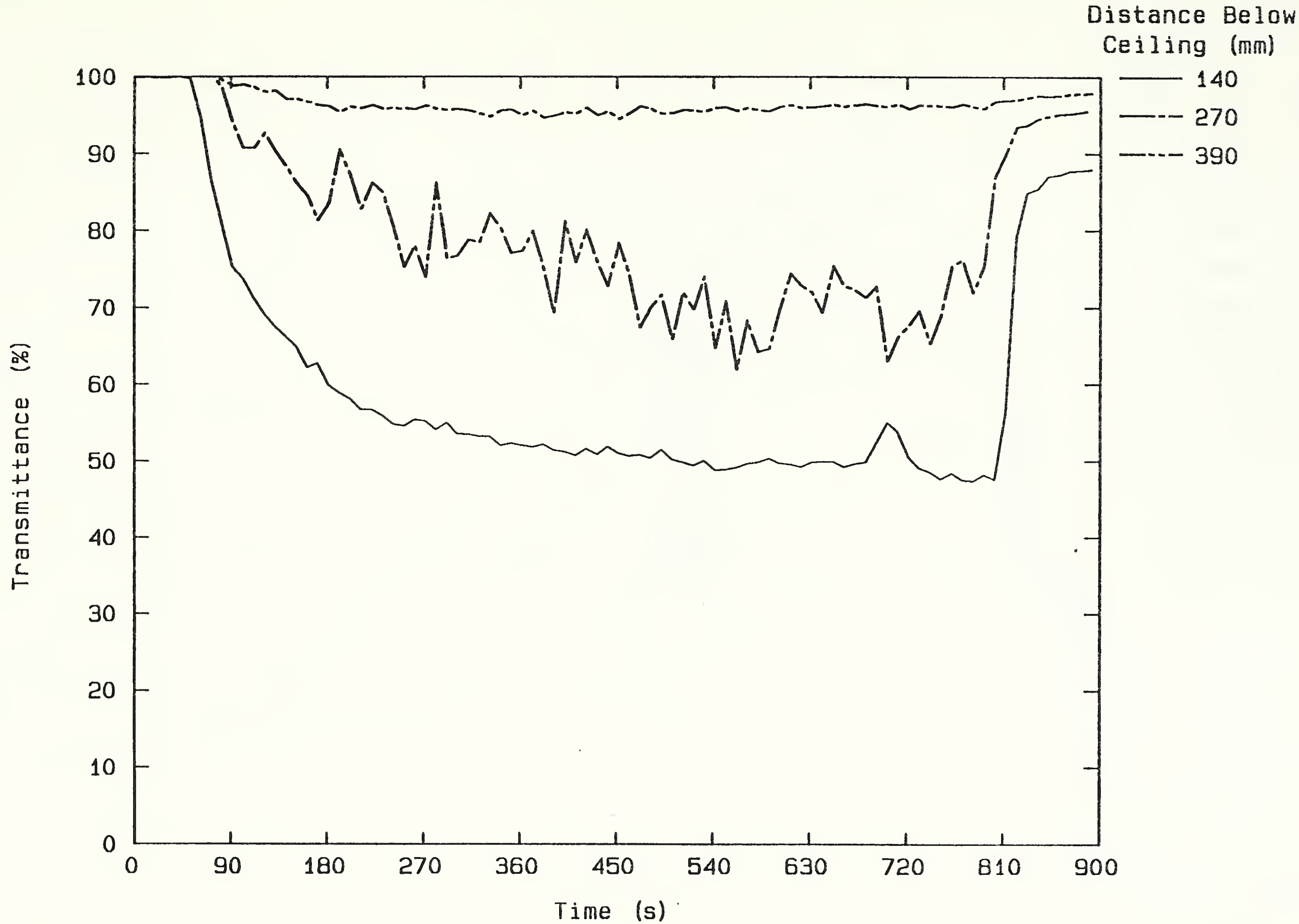

Figure 154. Test G1506 Cabin light attenuation by smoke

TEST G1706

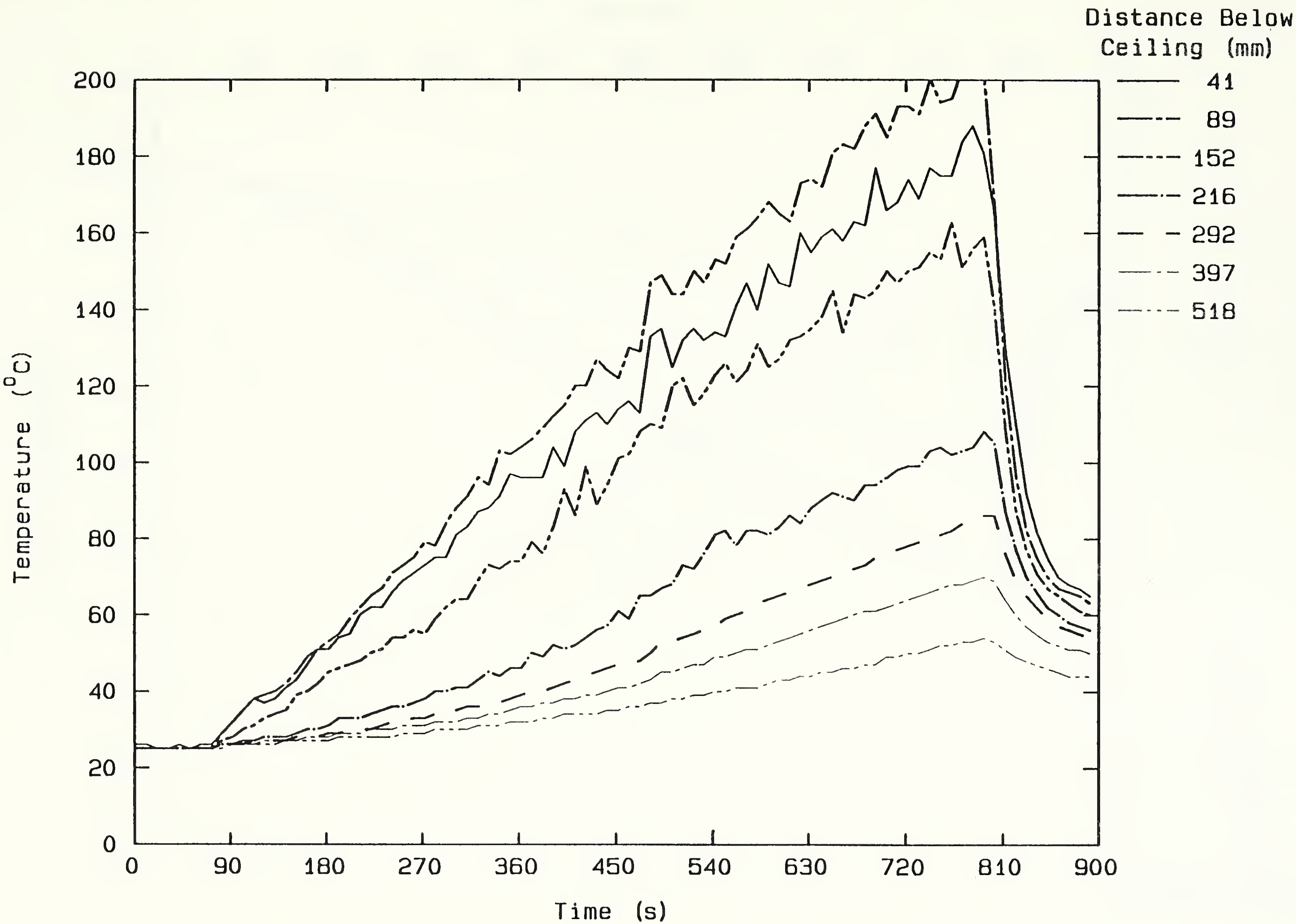

Figure 155. Test G1706 Vertical temperature profile at position A

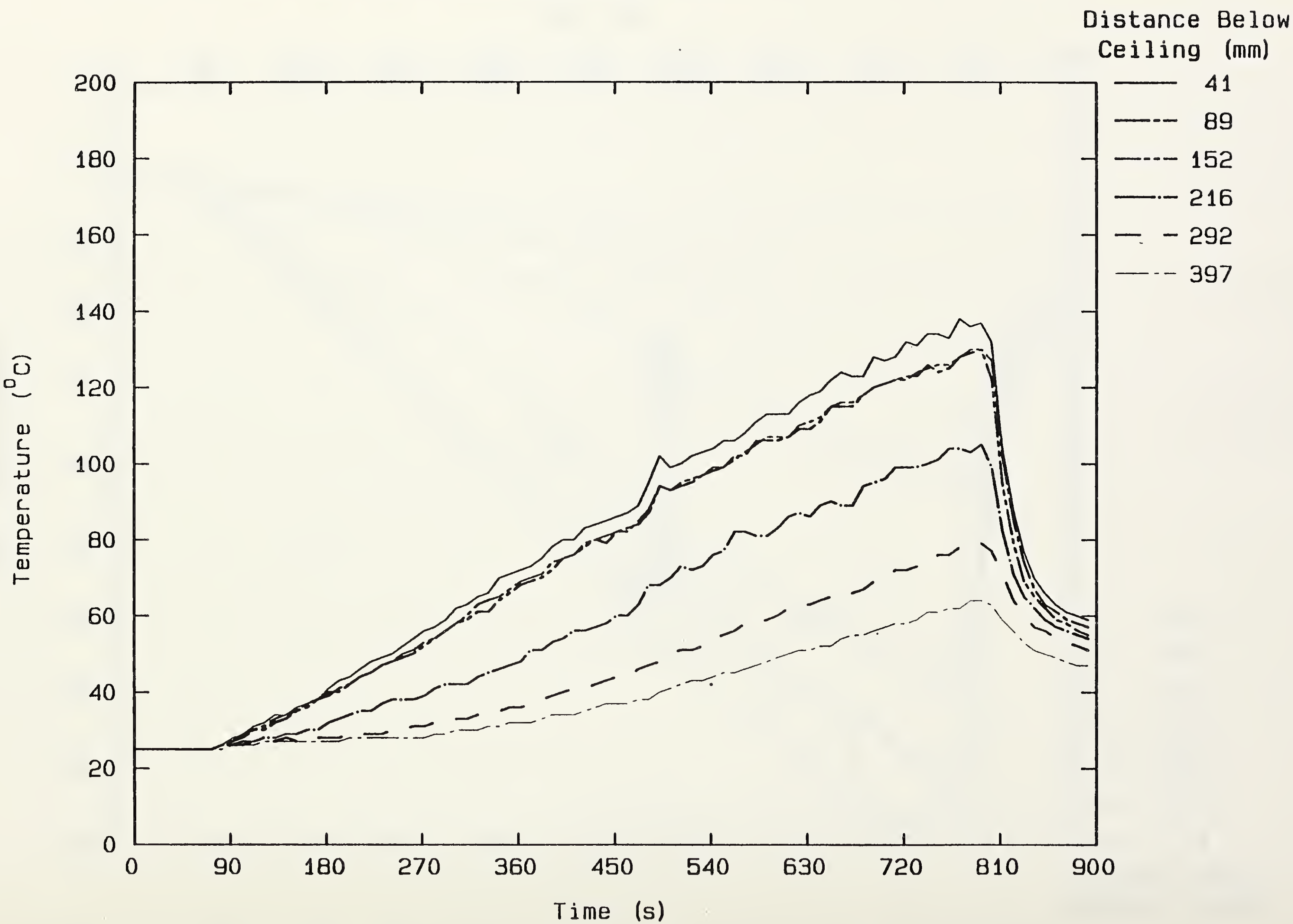

Figure 156. Test G1706 Vertical temperature profile at position B

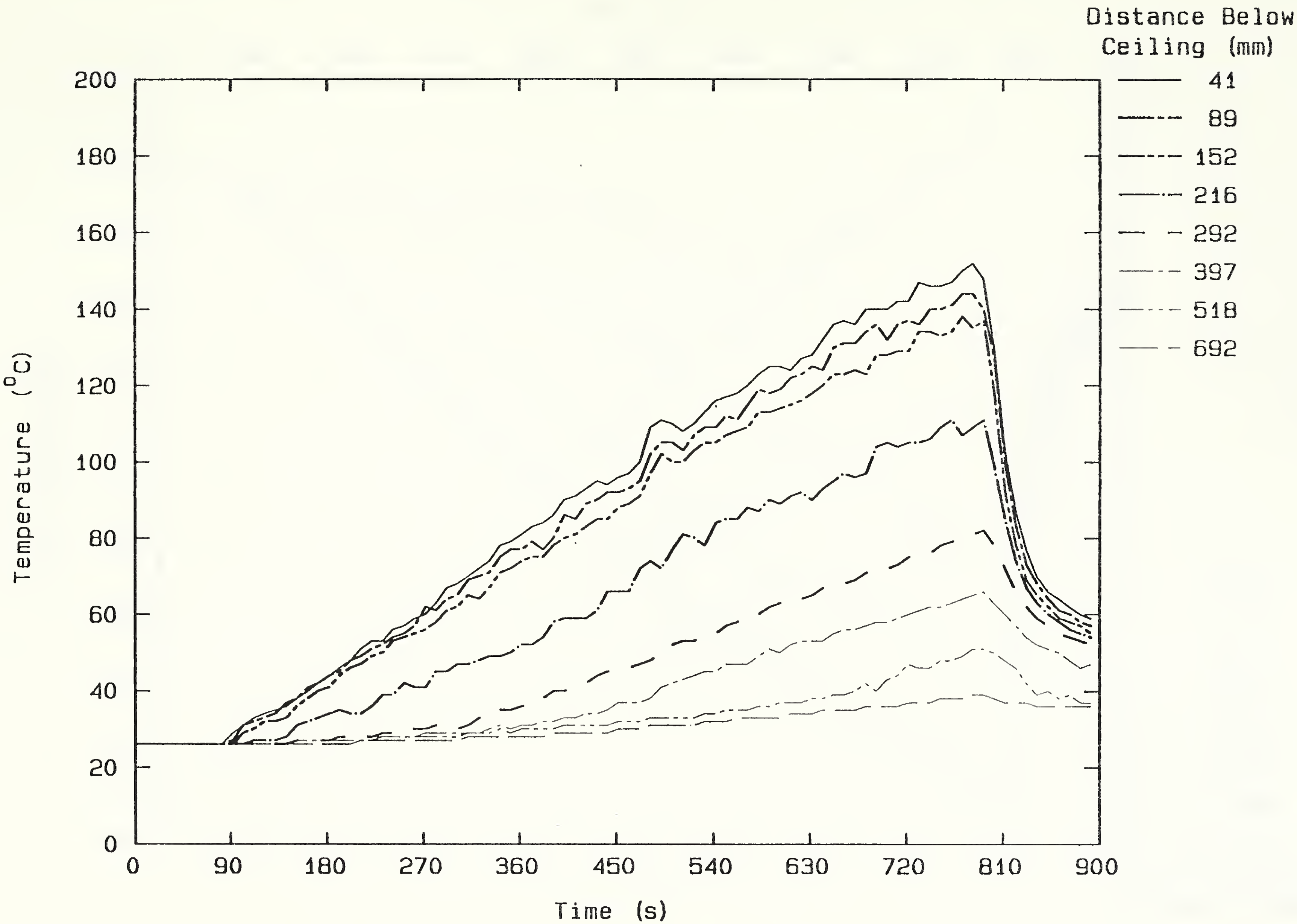

Figure 157. Test G1706 Vertical temperature profile at position C

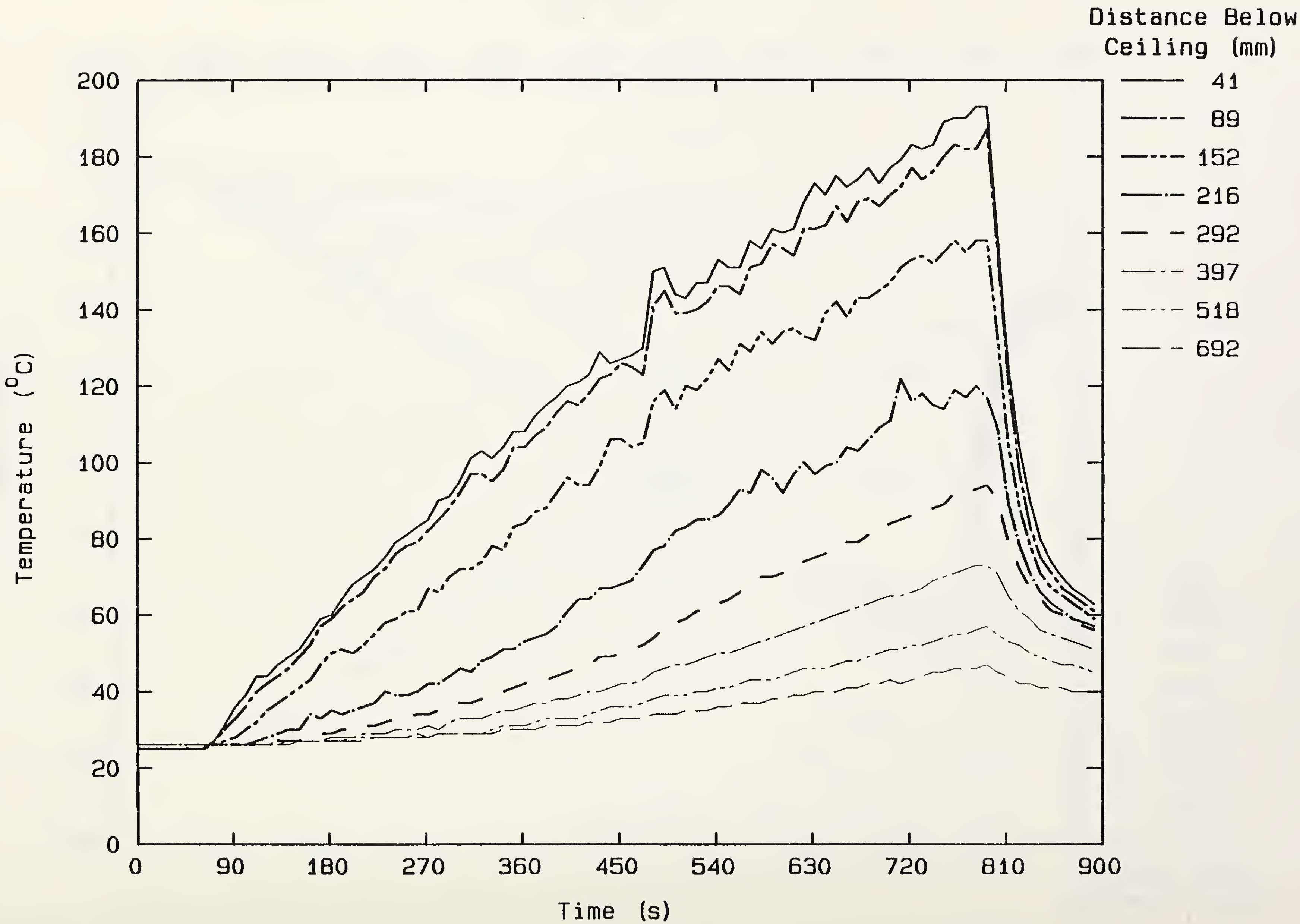

Figure 158. Test G1706 Vertical temperature profile at position D

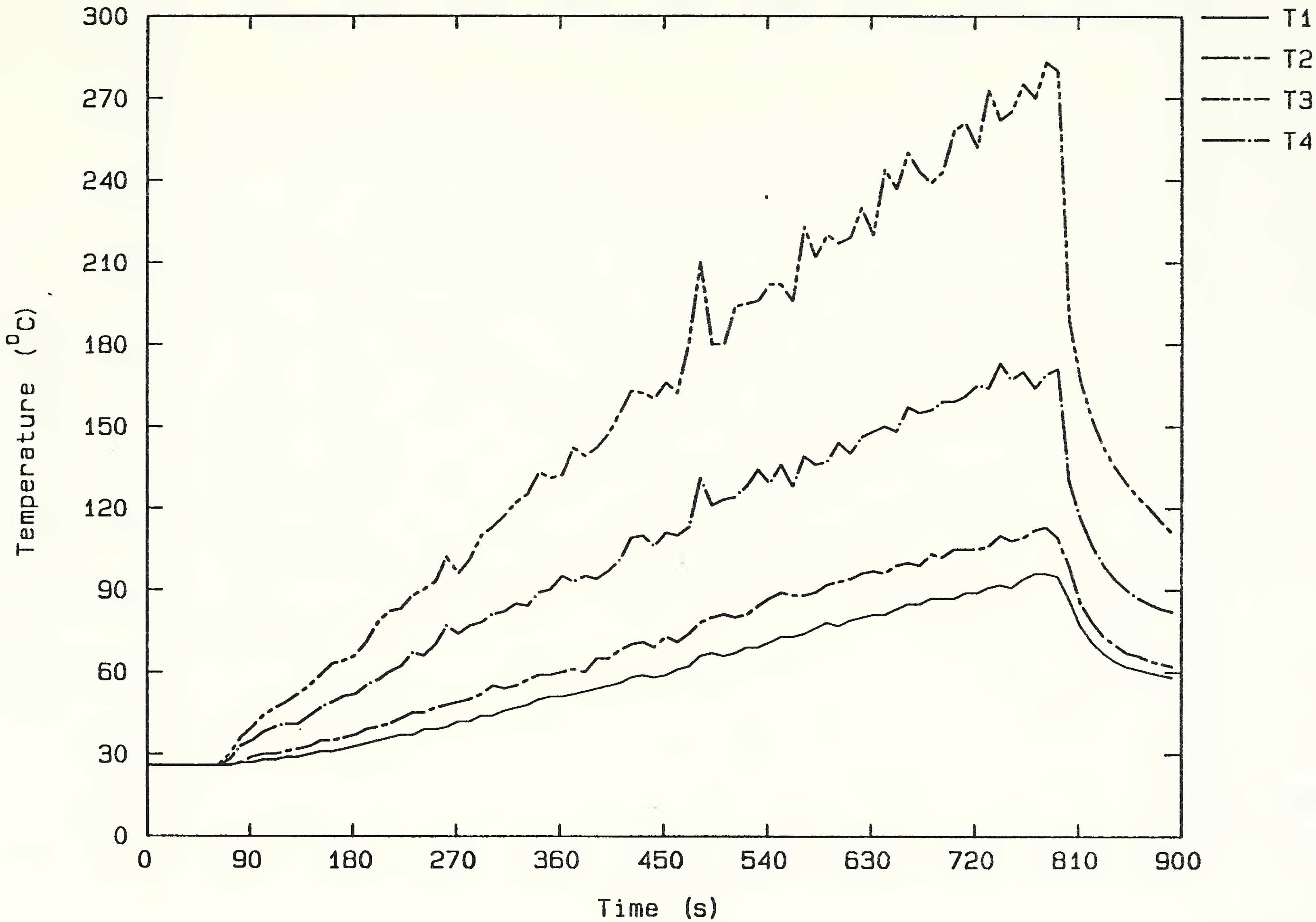

Figure 159. Test G1706 Ceiling interior surface temperature: T1 - T4

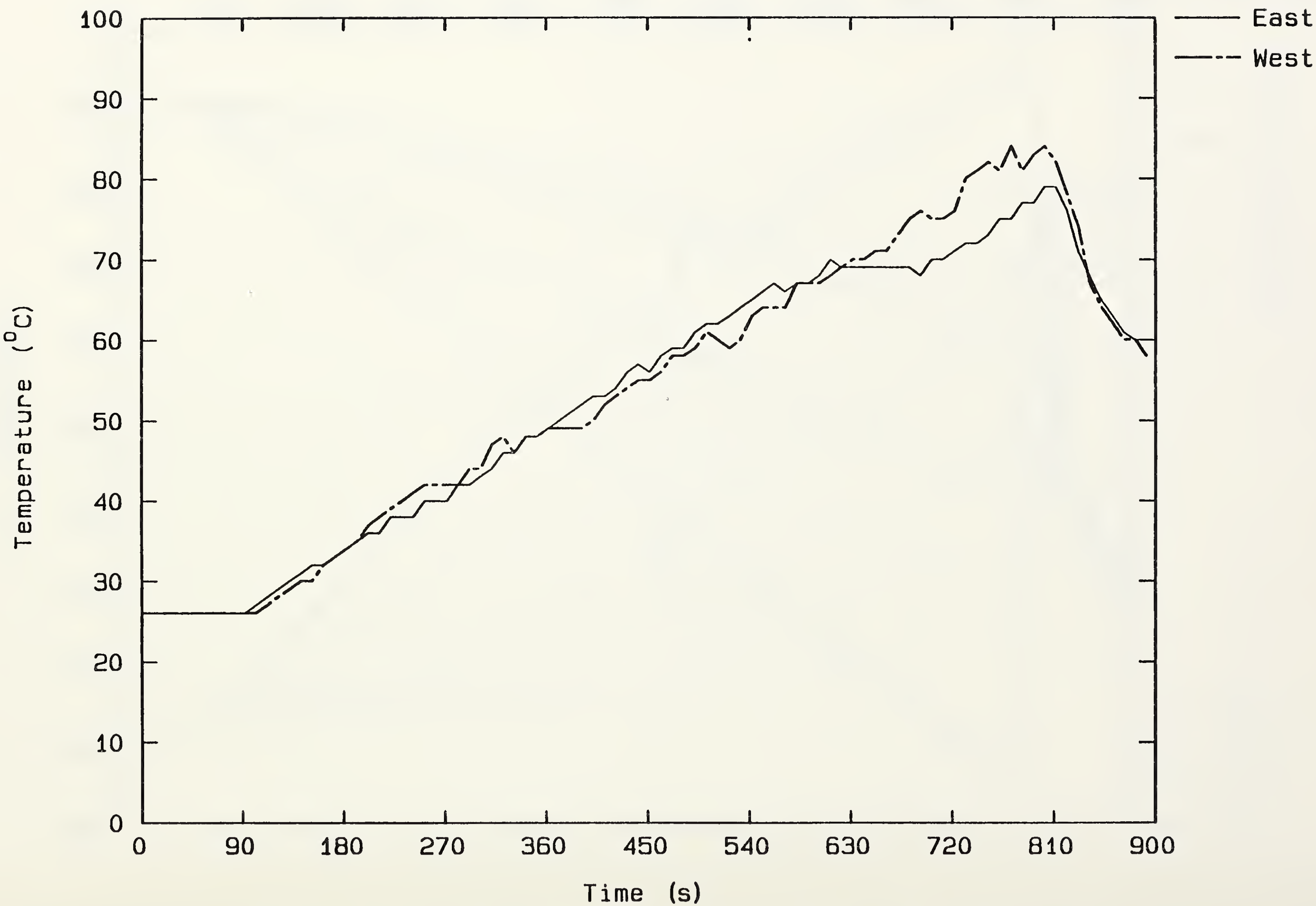

Figure 160. Test G1706 Exhaust temperature: east and west

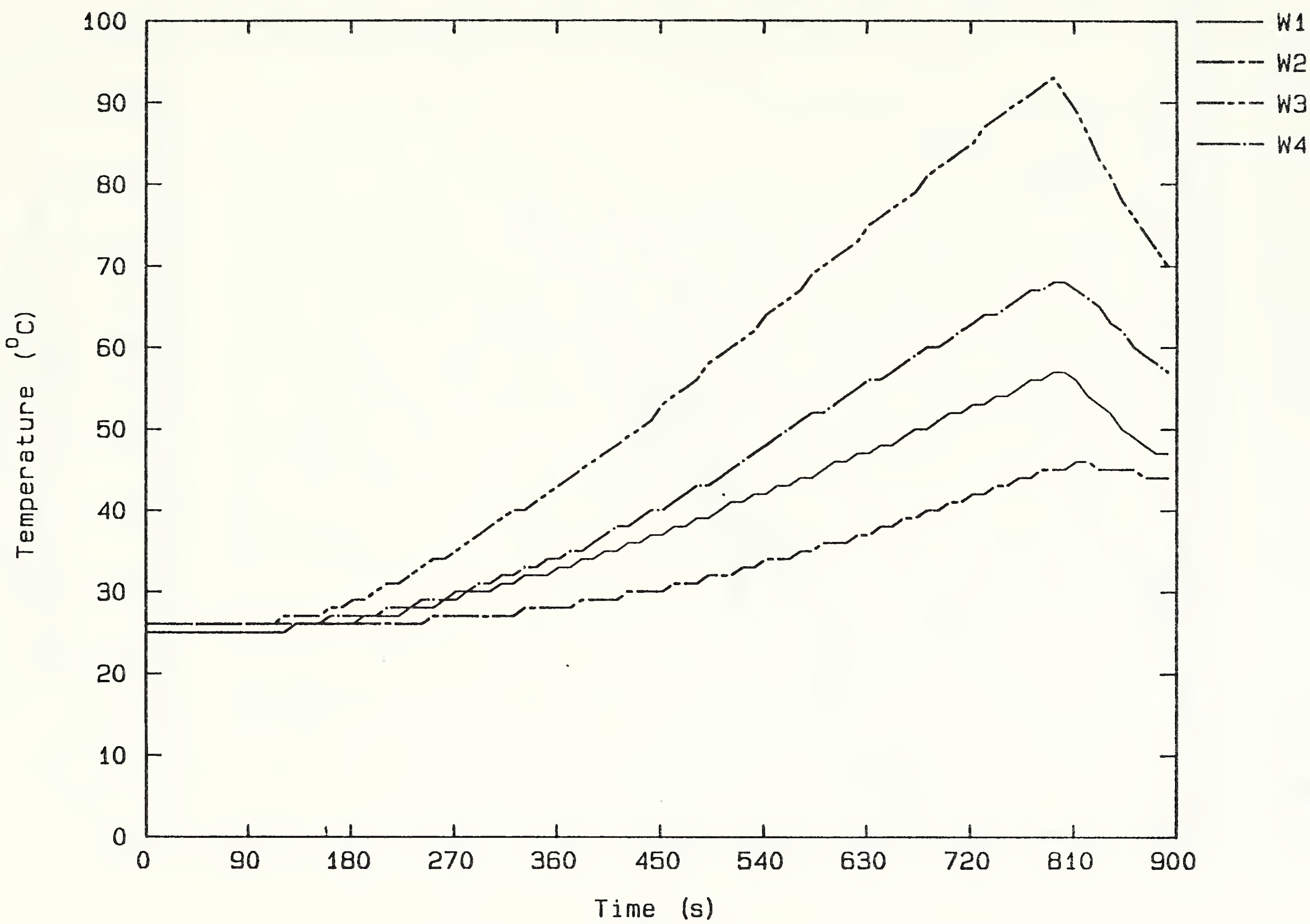

Figure 161. Test G1706 Wall interior surface temperature: W1 - W4

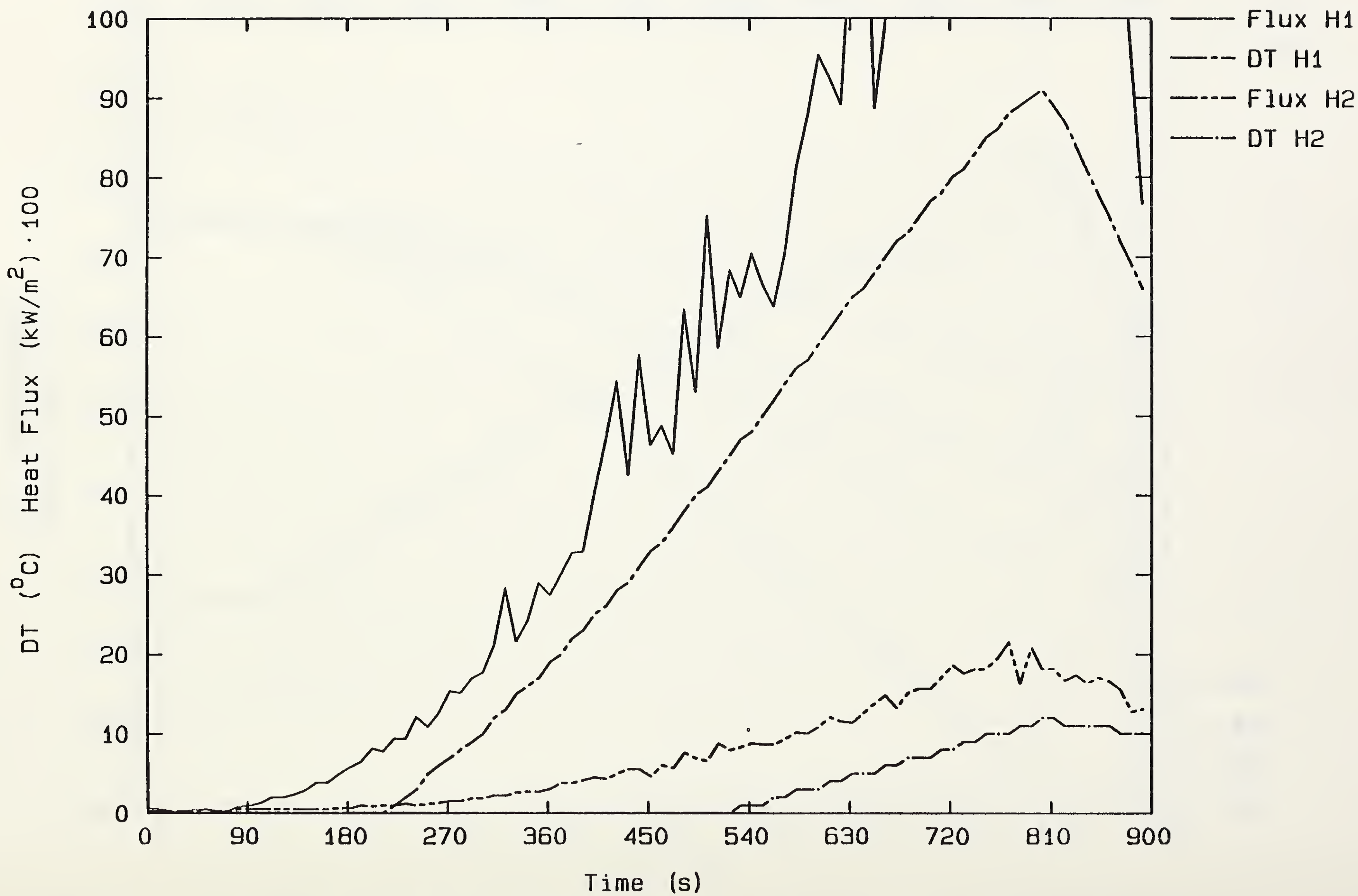

Figure 162. Test G1706 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

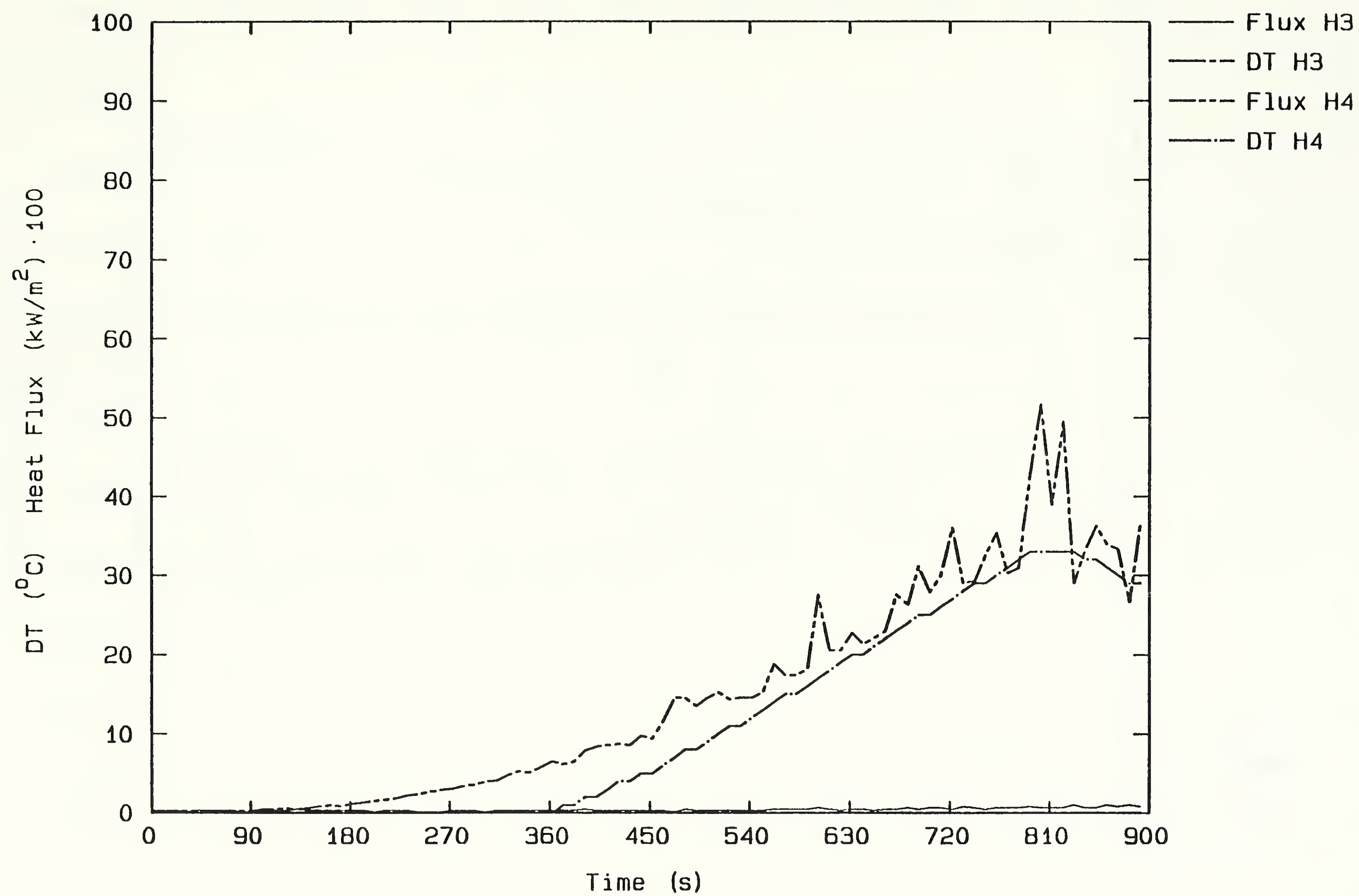

Figure 163. Test G1706 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

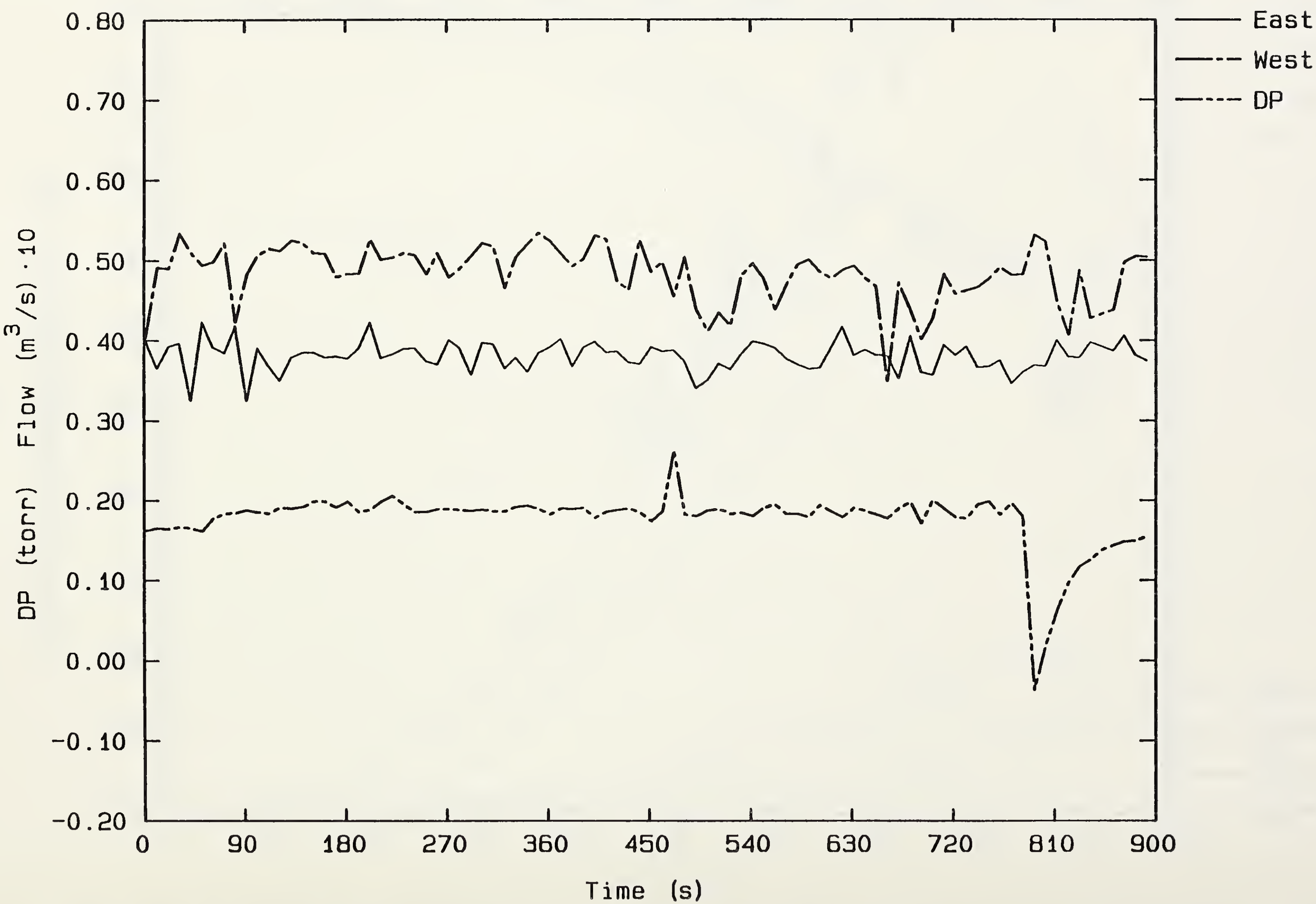

Figure 164. Test G1706 Cabin differential pressure and inlet flows, east and west

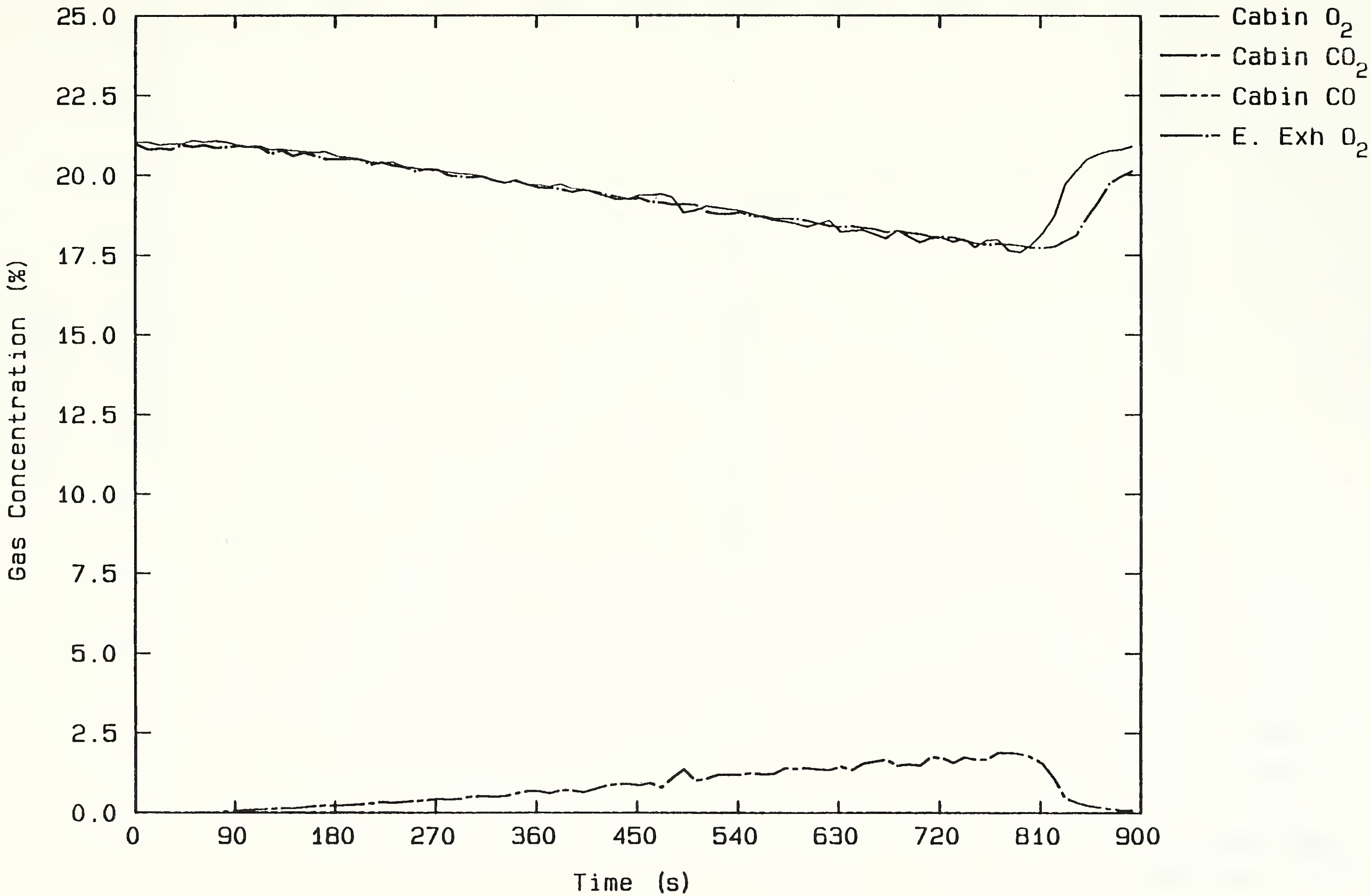

Figure 165. Test G1706 Cabin and exhaust gas concentrations

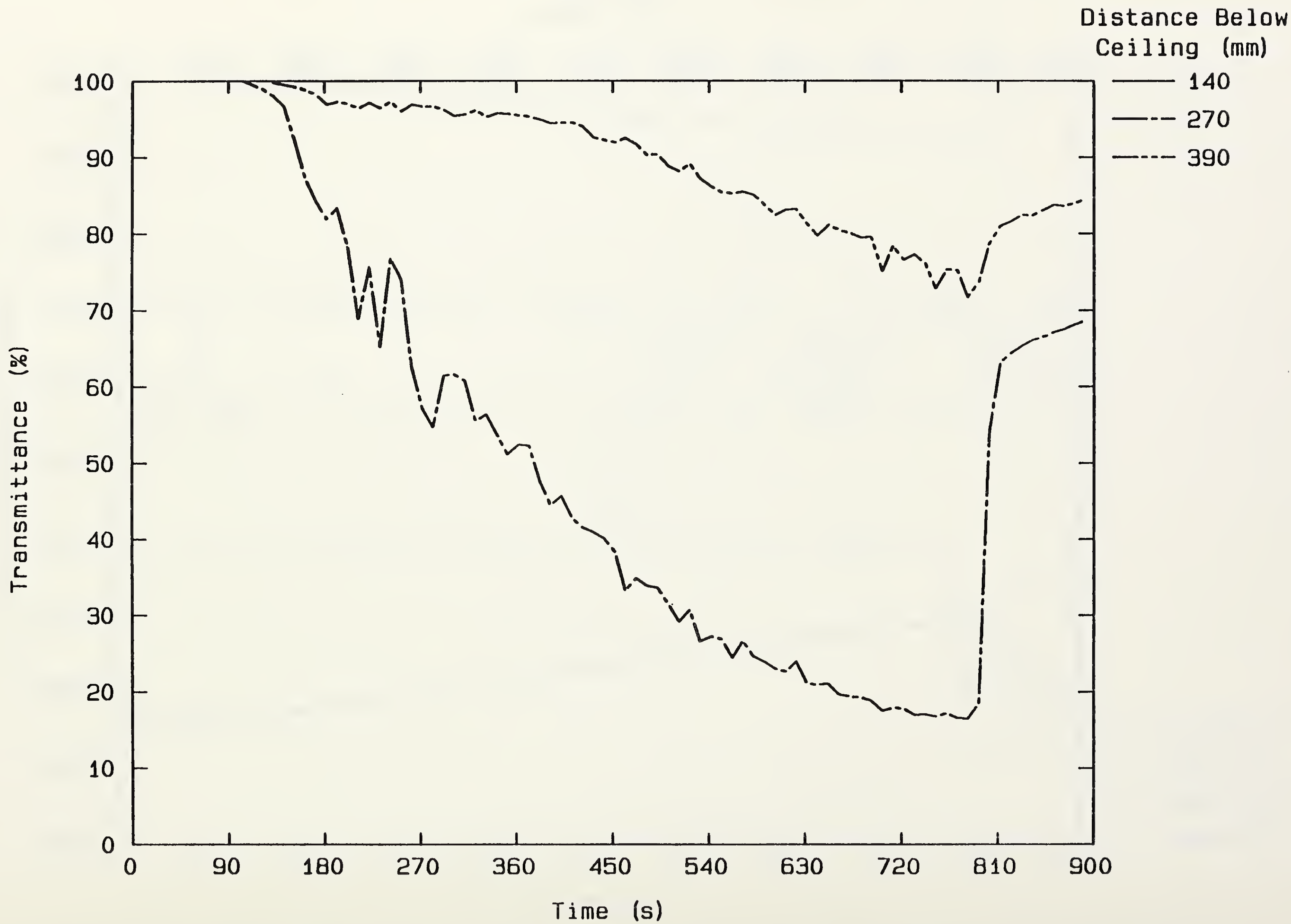

Figure 166. Test G1706 Cabin light attenuation by smoke

TEST G2206

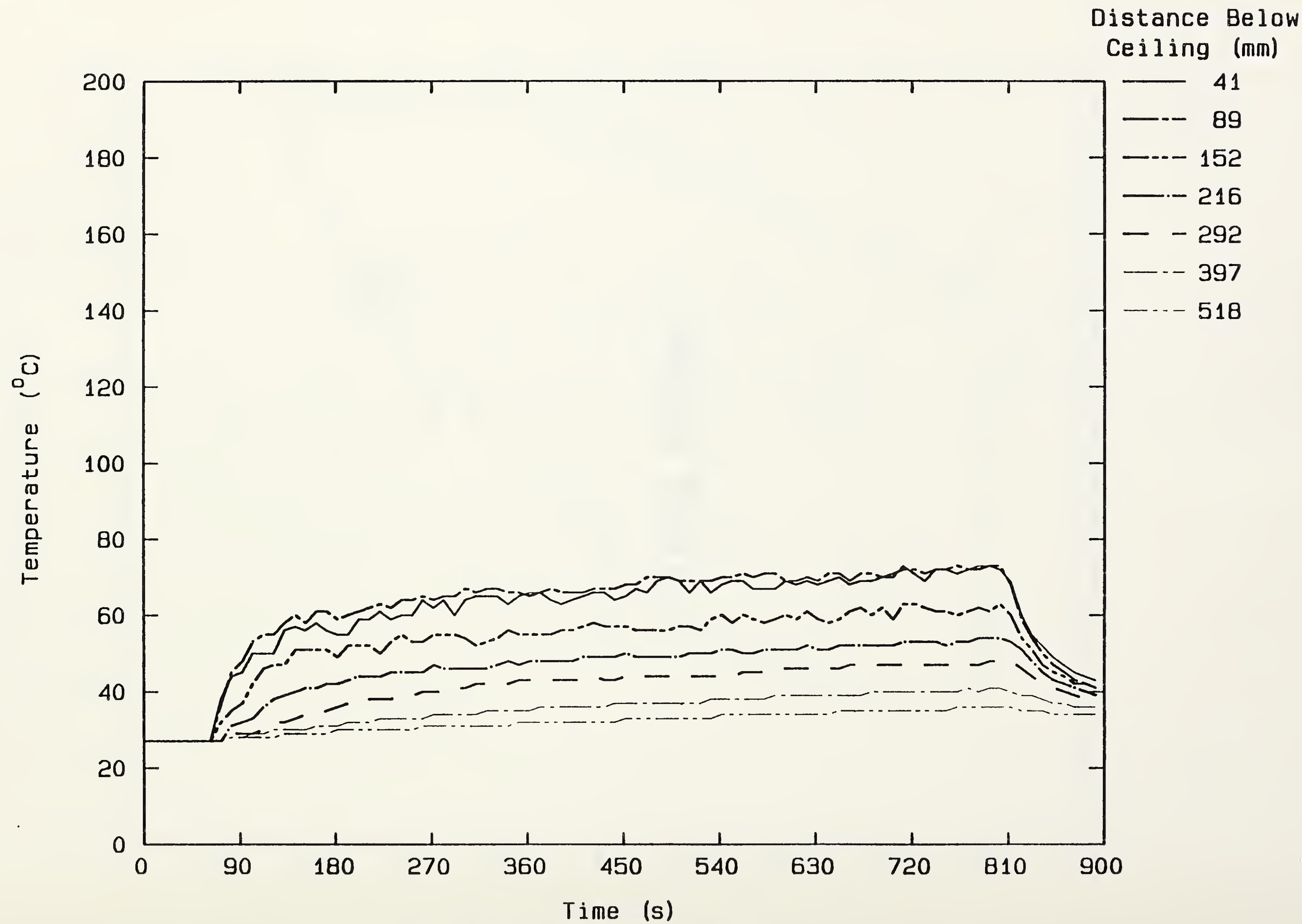

Figure 167. Test G2206 Vertical temperature profile at position A

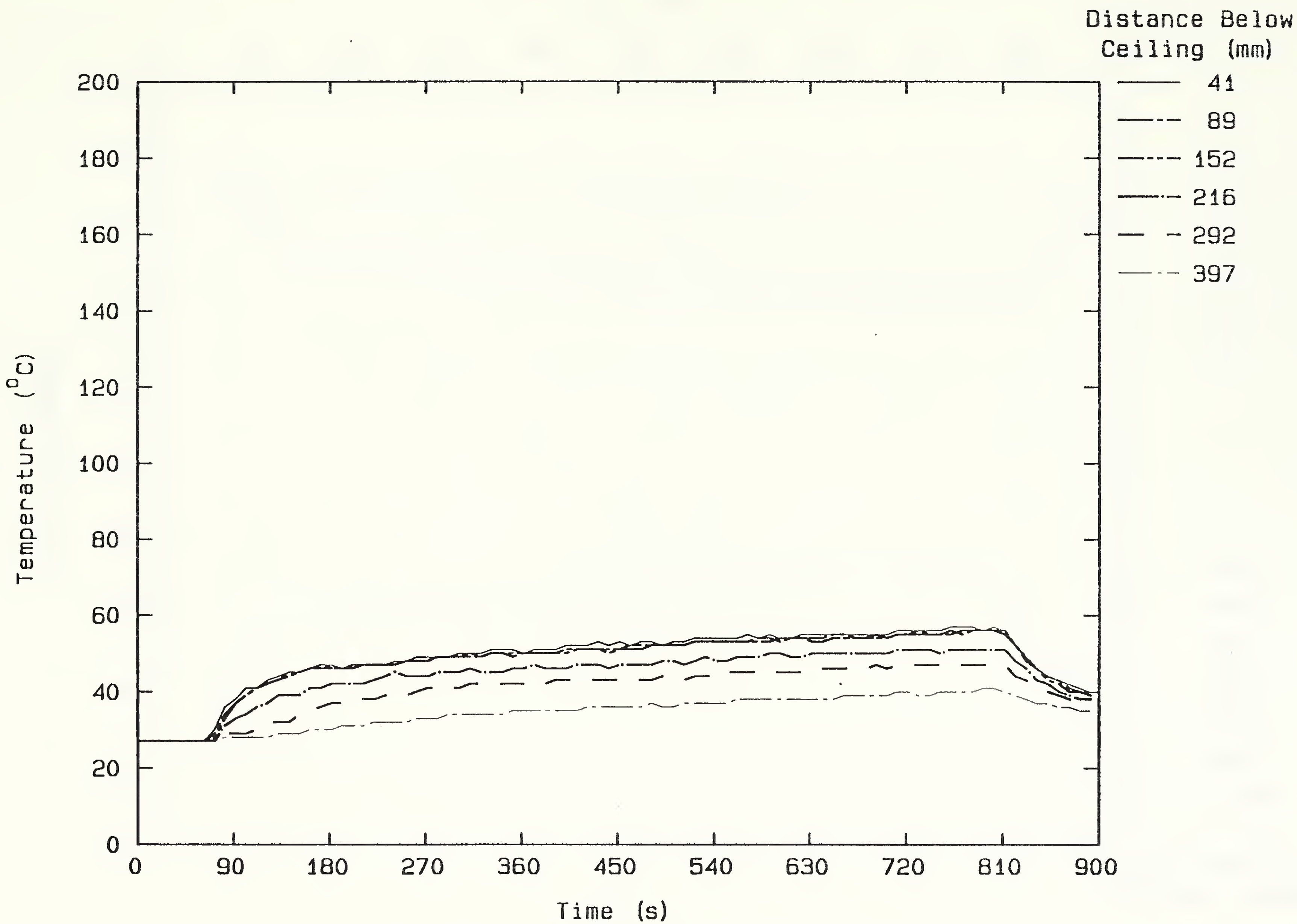

Figure 168. Test G2206 Vertical temperature profile at position B

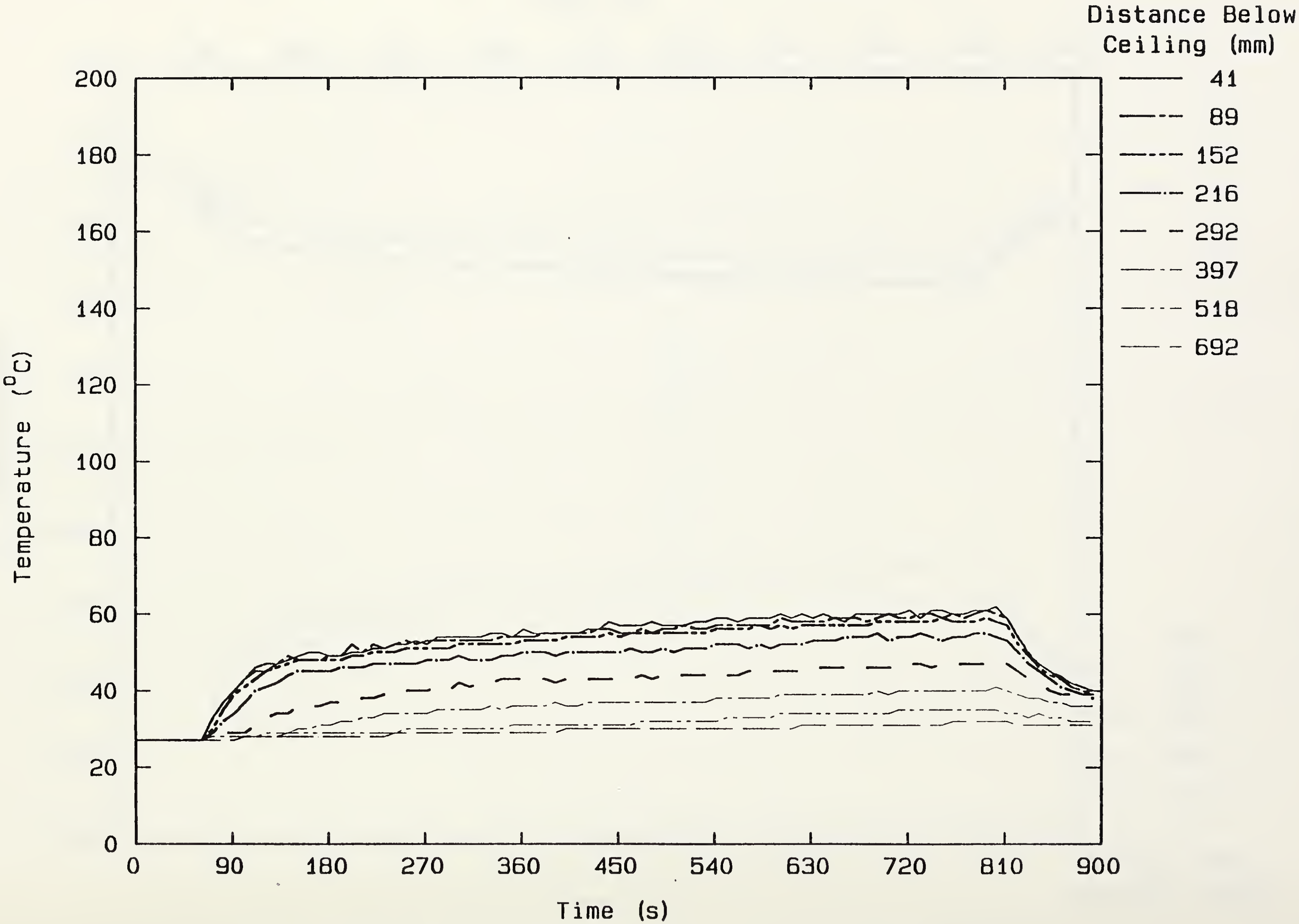

Figure 169. Test G2206 Vertical temperature profile at position C

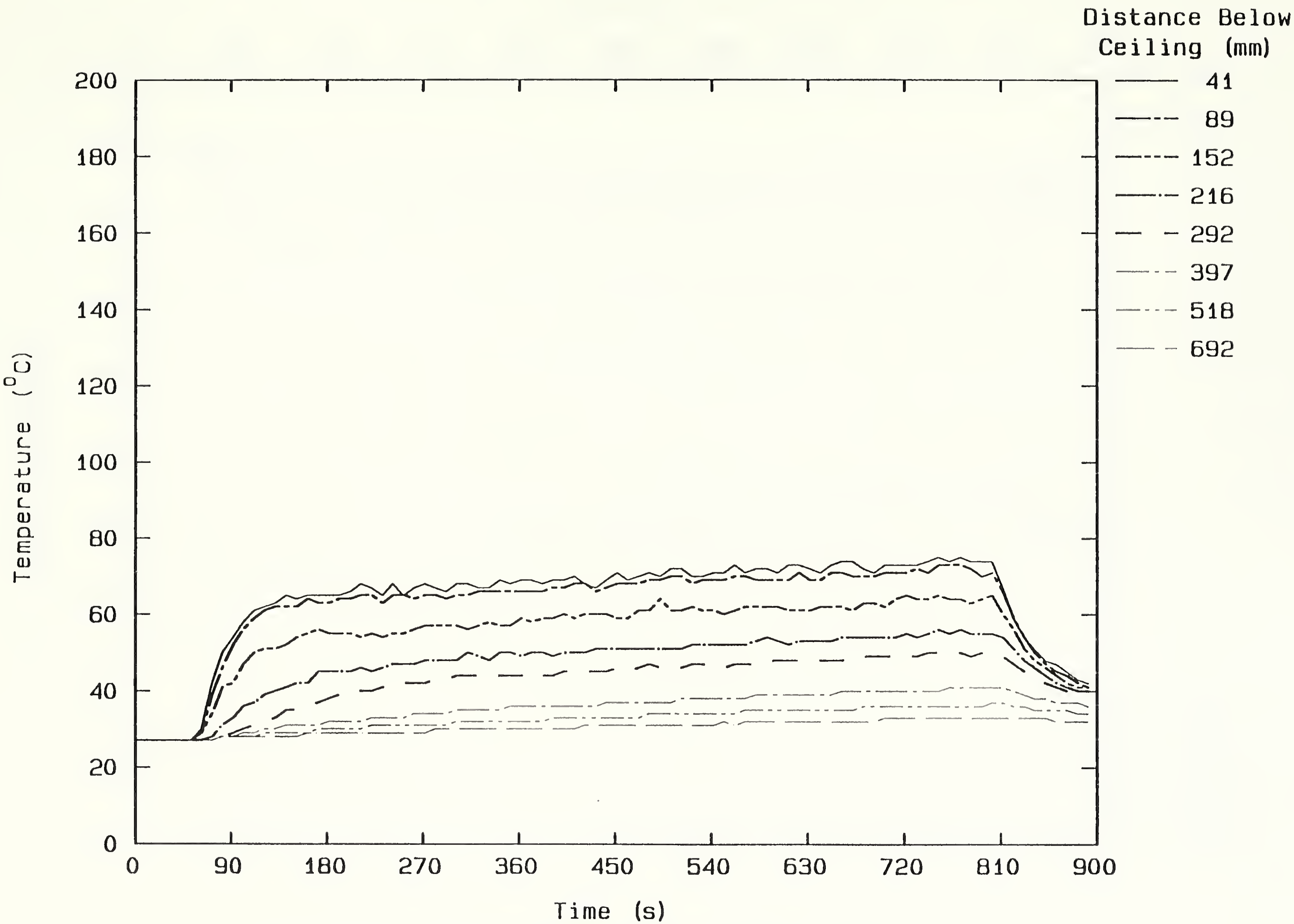

Figure 170. Test G2206 Vertical temperature profile at position D

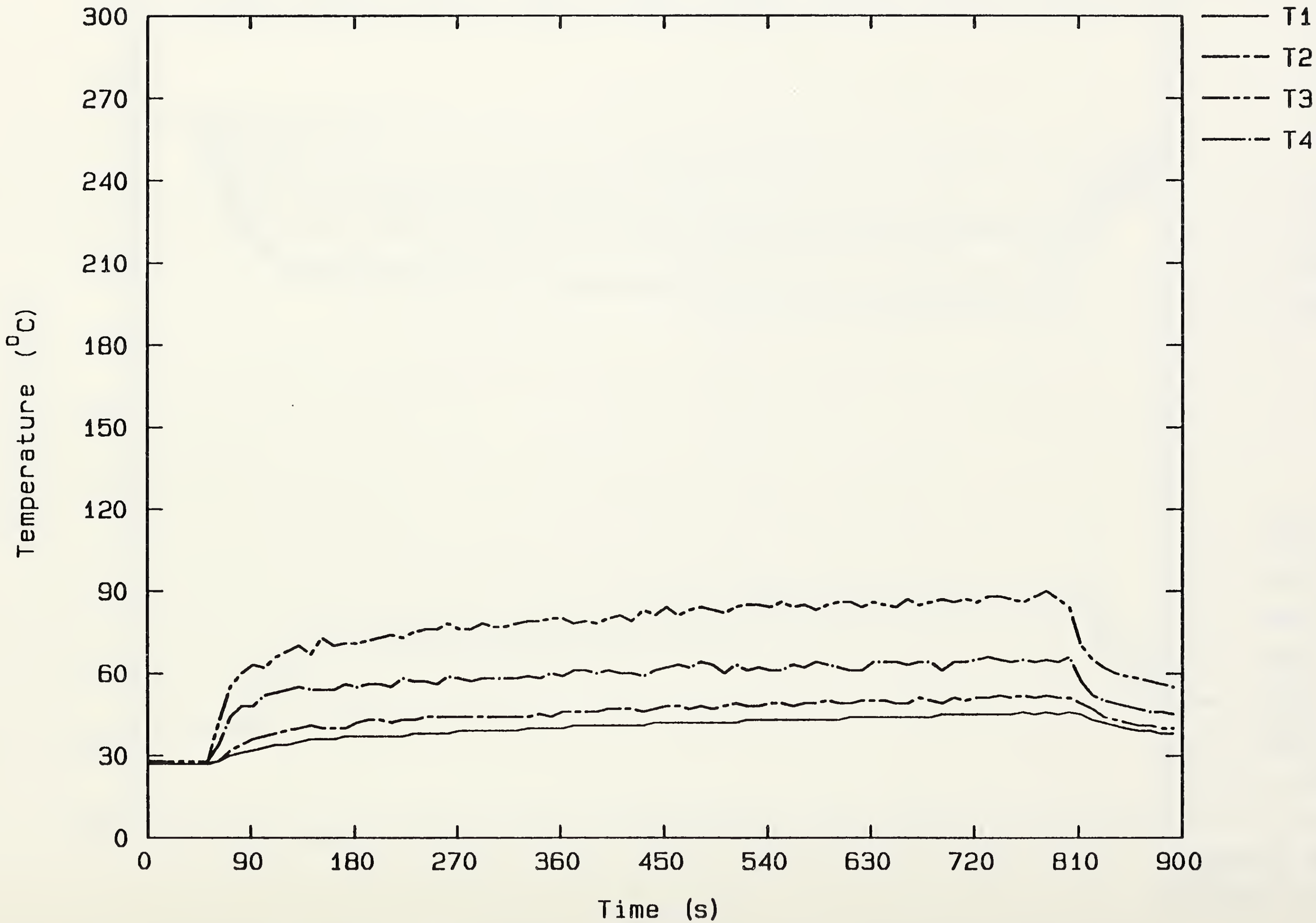

Figure 171. Test G2206 Ceiling interior surface temperature: T1 - T4

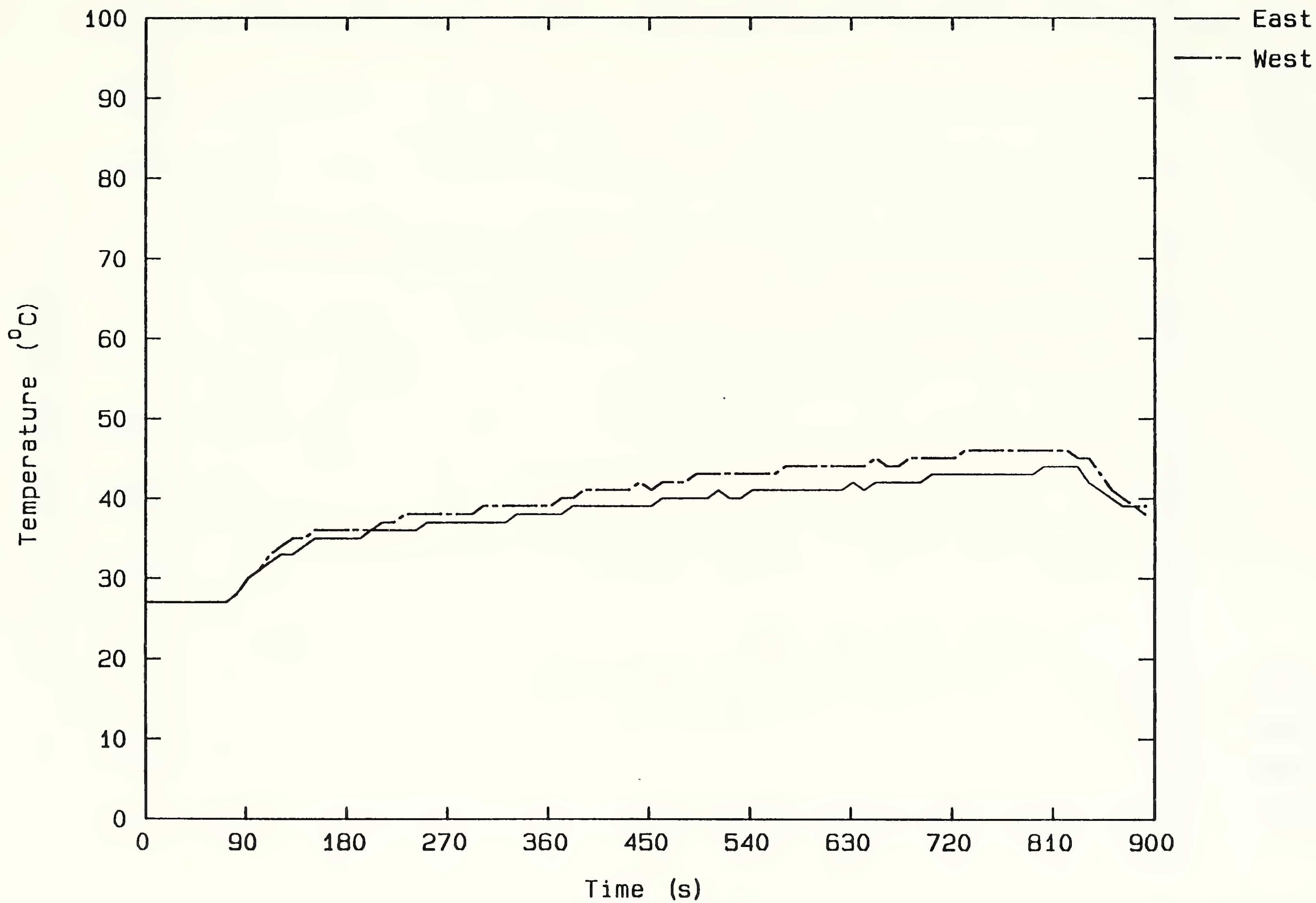

Figure 172. Test G2206 Exhaust temperature: east and west

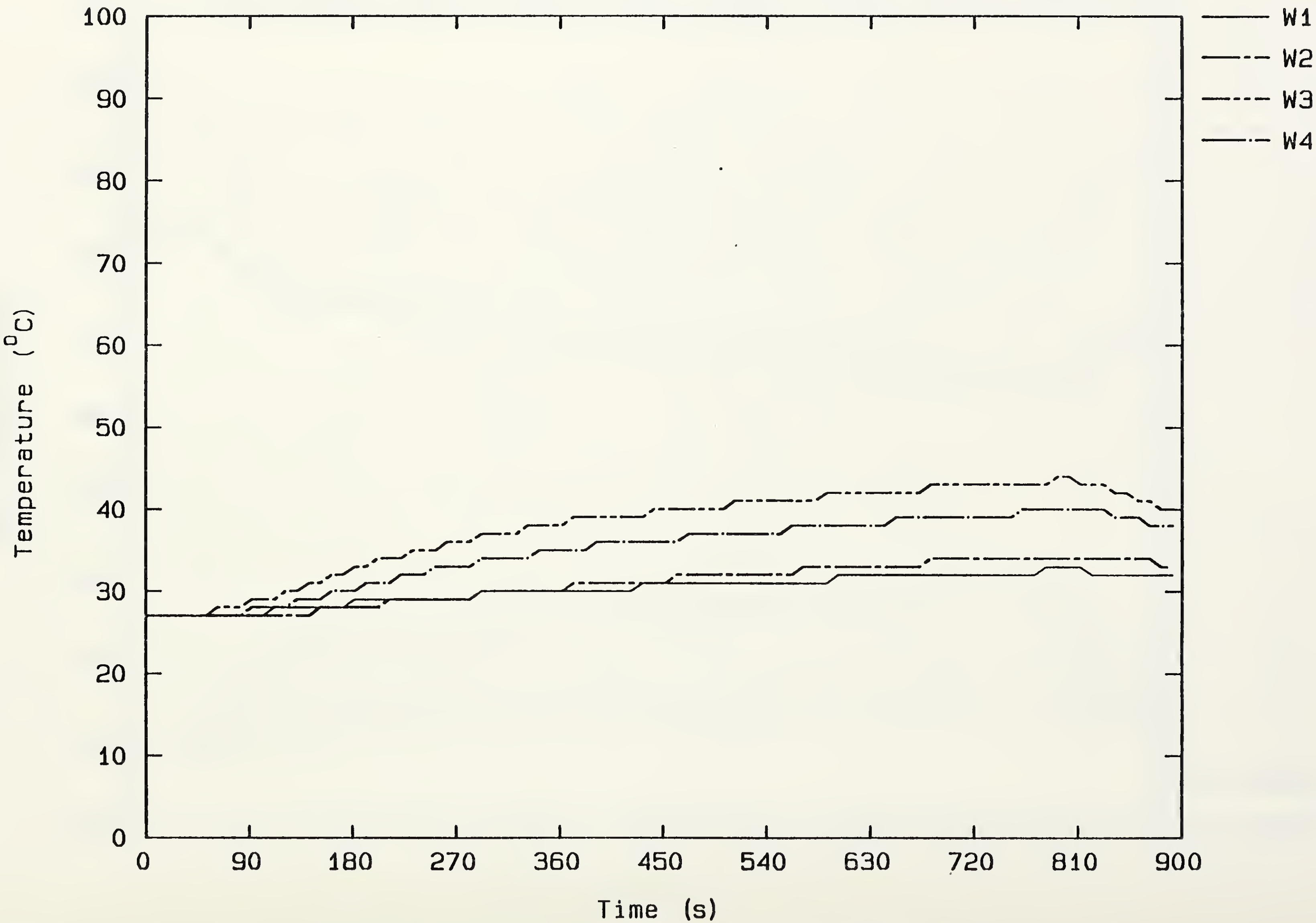

Figure 173. Test G2206 Wall interior surface temperature: W1 - W4

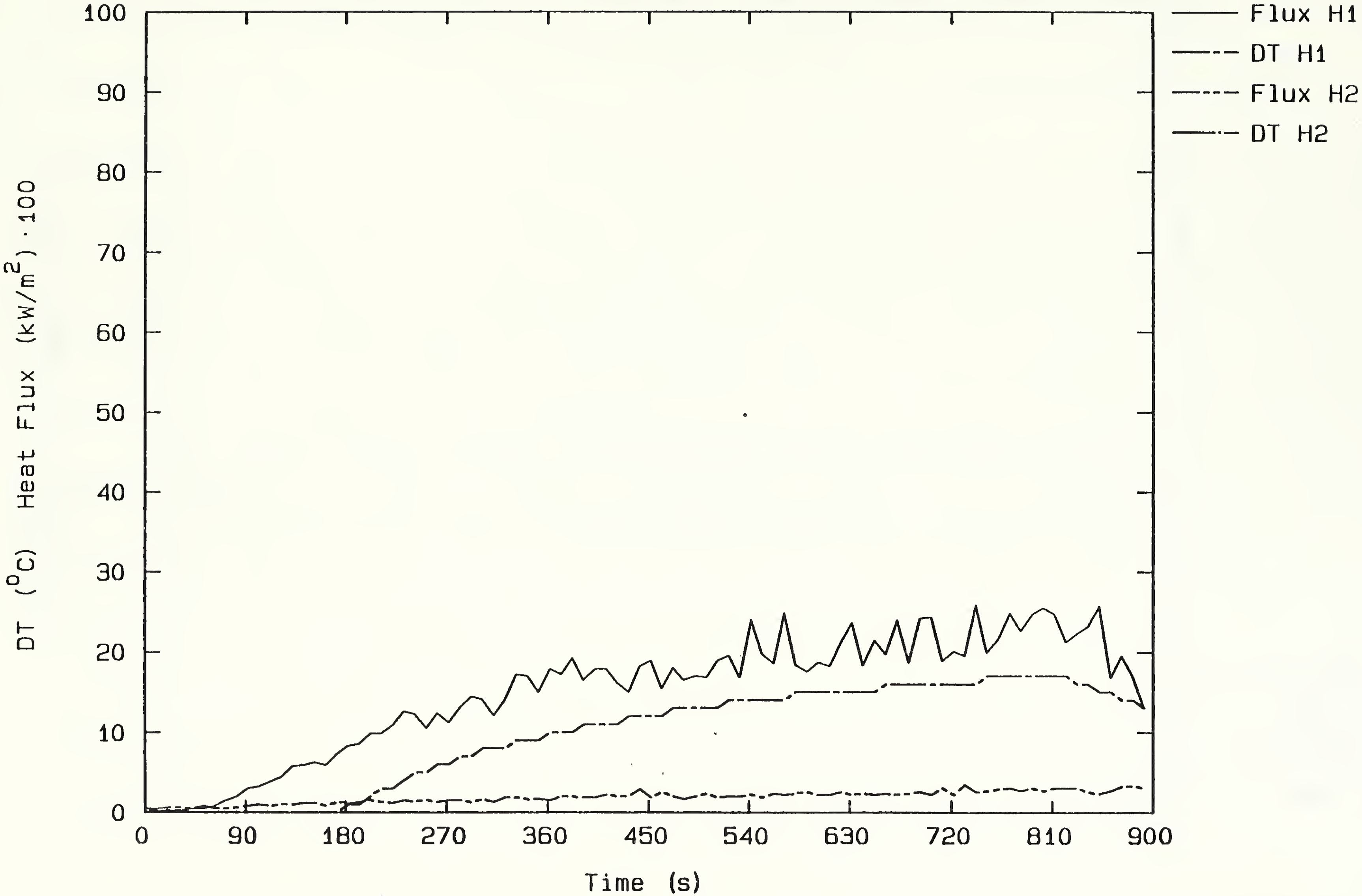

Figure 174. Test G2206 Heat flux through exterior wall and exterior wall surface temperature rise: H1, DT H1, H2, DT H2

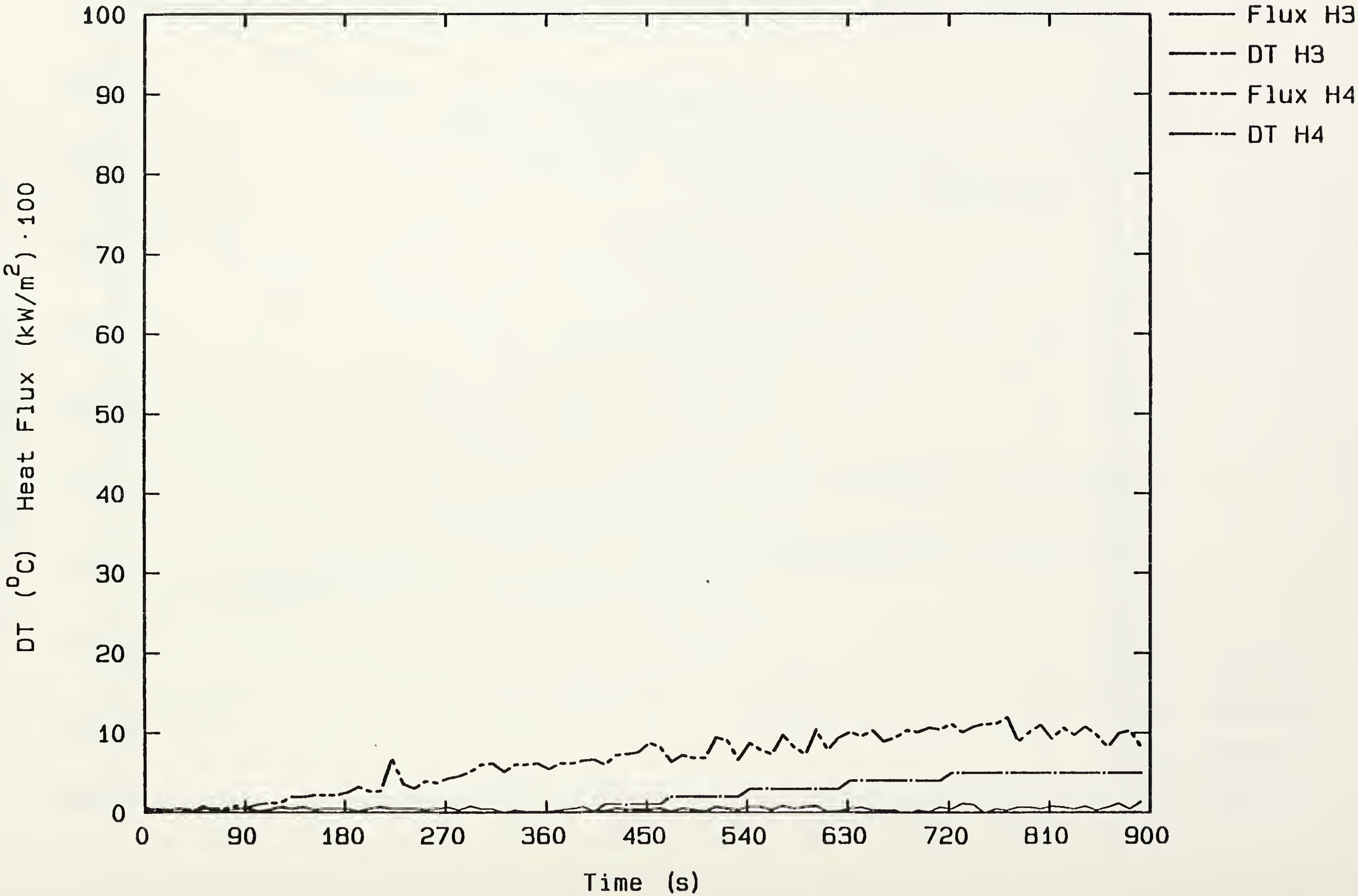

Figure 175. Test G2206 Heat flux through exterior wall and exterior wall surface temperature rise: H3, DT H3, H4, DT H4

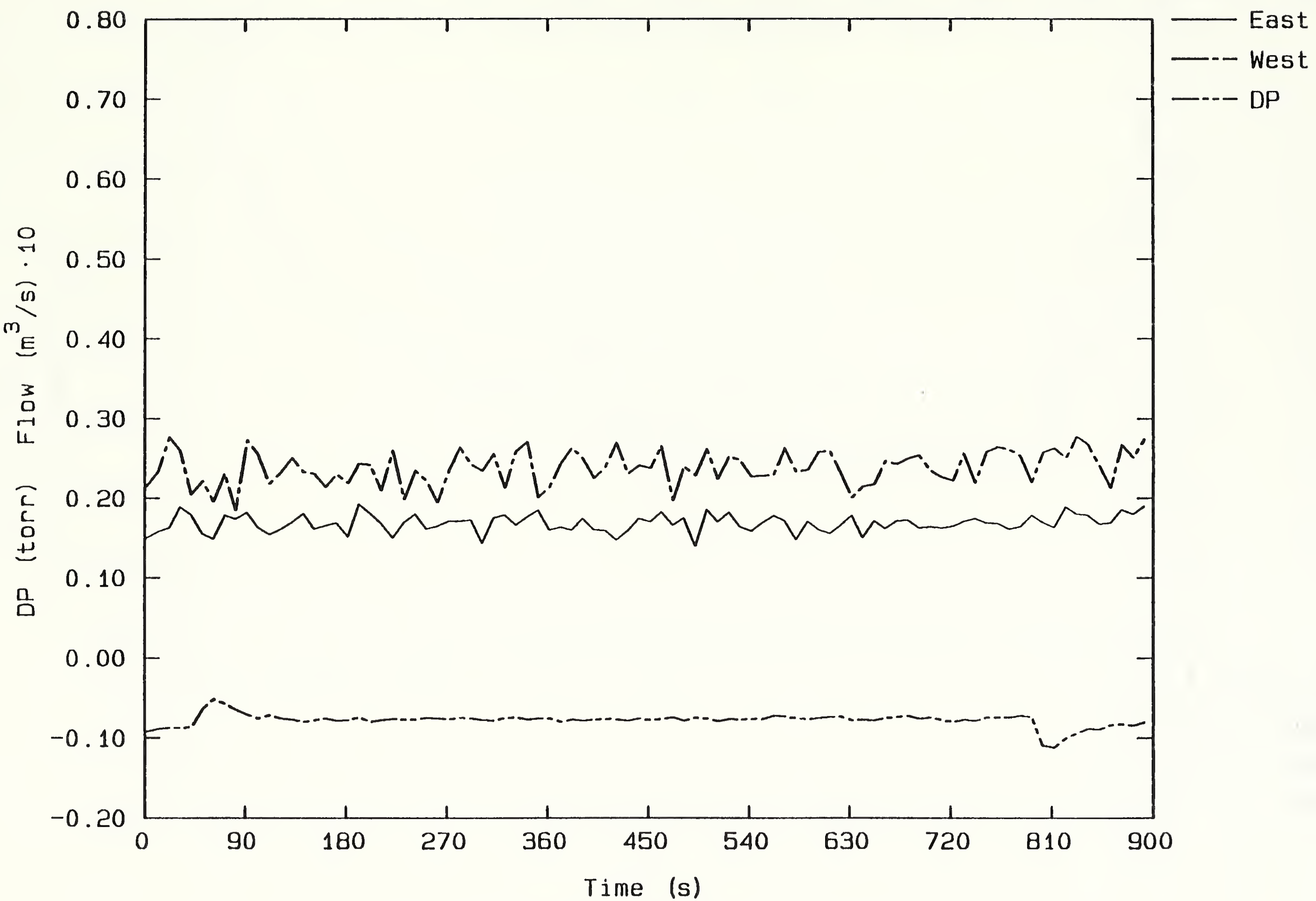

Figure 176. Test G2206 Cabin differential pressure and inlet flows, east and west

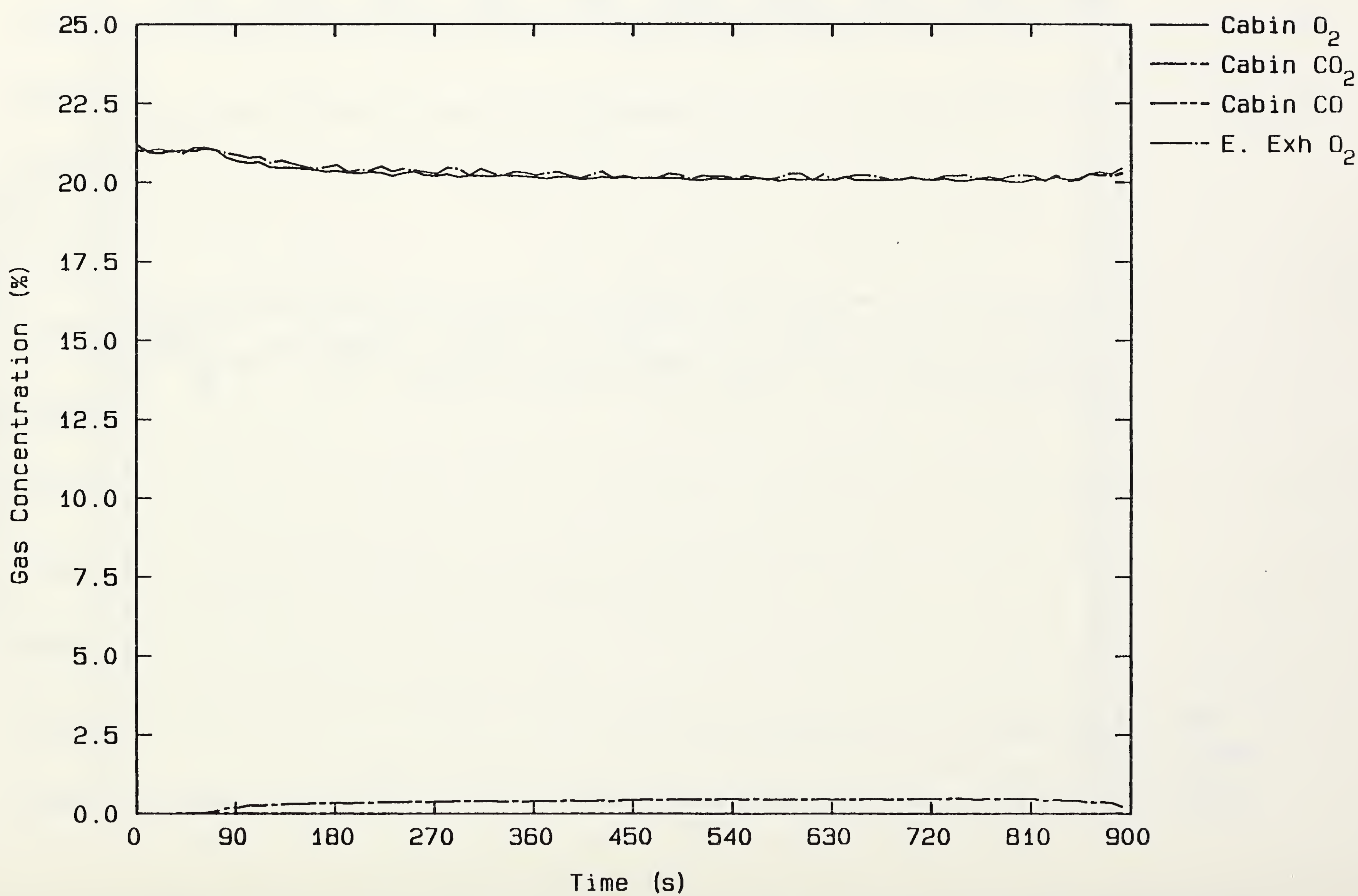

Figure 177. Test G2206 Cabin and exhaust gas concentrations

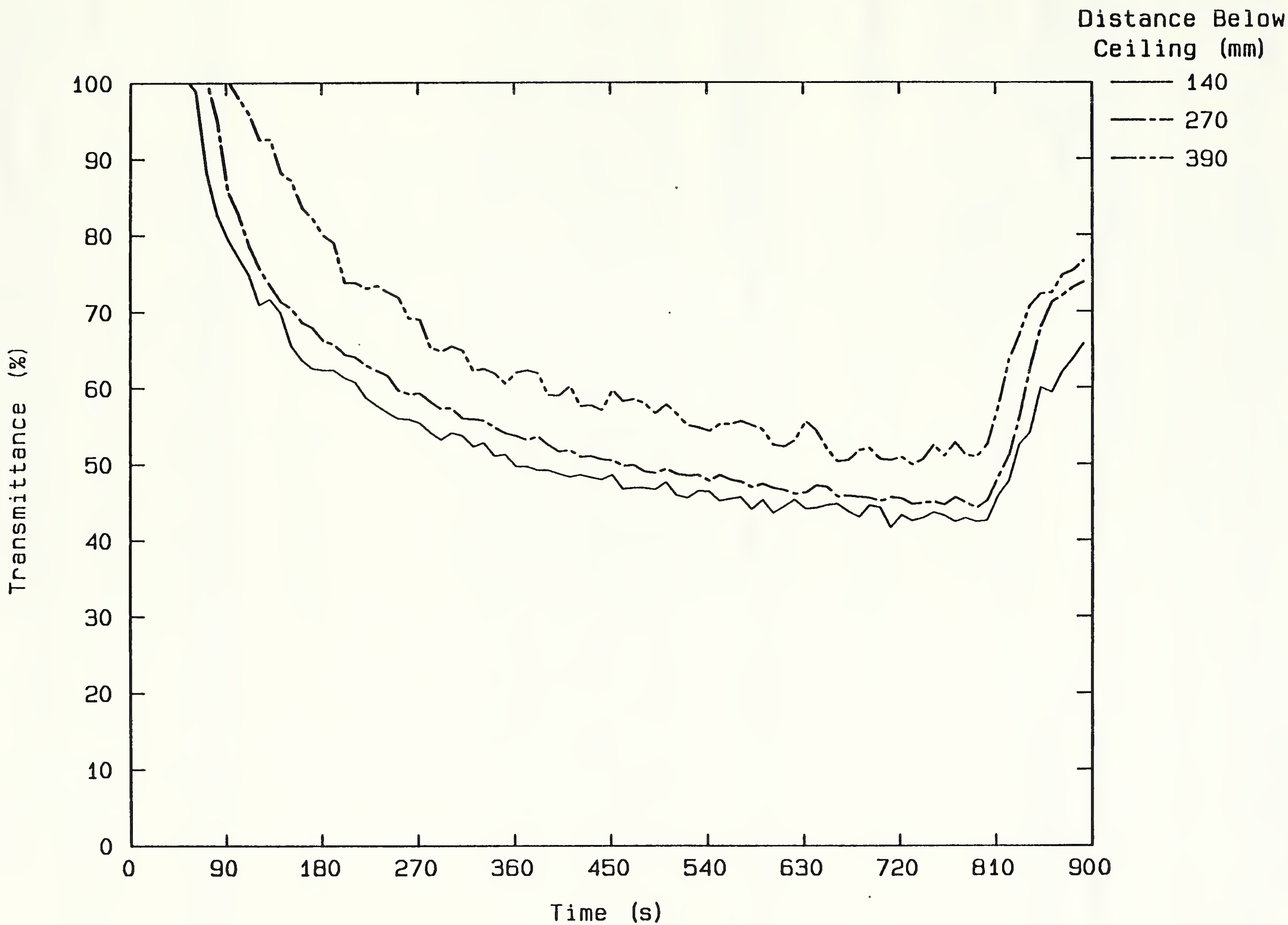

Figure 178. Test G2206 Cabin light attenuation by smoke

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11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

This report contains 15 complete sets of test data from a series of experiments performed in a reduced scale simulated aircraft cabin for the determination of the effects of ventilation on the environment created by an interior fire. Measurements reported include gas temperature and gas species concentrations in both the cabin and the ventilation exhaust, light attenuation by smoke, and heat transfer to the walls and ceilings. Experimental parameters include the effects of fire size, ventilation rate, and ceiling vent position (central or near wall), the direction of ventilation (inlet at the ceiling, exhaust at the floor and inlet at the floor, exhaust at the ceiling), and also the effects of open exhaust hatches in the wall near the ceiling.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)
aircraft fires; compartment fires; fire growth; fire tests; room fires; toxicity; ventilation

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