Evaluation of Fire Containment of LD-3 Cargo Containers

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16. Abstract

Ten tests were conducted in LD-3 cargo containers of various construction. The types of containers tested were: rigid fiberglass with both fiberglass and neoprene/nylon doors, aluminum with both vinyl and aluminum doors, and high density polyethylene with an aluminum door. The materials were compliant with existing FAA flammability requirements contained in FAR 25.855(b-3). Fires were ignited inside these containers and the temperature on the ceiling of the containers and the oxygen concentration was recorded. It is concluded from this study that the existing flammability requirements for cargo compartment containers are not adequate to insure that accidental fires will be controlled in all cases.

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EXECUTIVE SUMMARY

This study was an outgrowth of previous fire testing conducted in a 640-cubic foot simulated class D cargo compartment. That study concluded that fires can reach dangerous proportions in any size compartment and that a good fire barrier liner can contain those fires. The purpose of this study was to evaluate the ability of currently used LD-3 cargo containers to contain test fires.

Ten test were conducted in containers of various construction. Fires were ignited inside these containers in boxes filled with newspaper and packing foam. The temperature and oxygen concentration inside the containers were recorded along with video coverage of the tests. Test fires were not contained in two of the ten tests. In these tests, flexible door coverings of neoprene nylon and vinyl were used. These materials were tested and easily passed the flammability test requirements specified for cargo containers. There was little or no damage to the containers in the remaining eight tests.

The major conclusion of this study is that the current flammability requirements specified in FAR 25.855(b-3) do not insure that cargo containers will be able to control the types of fires simulated in this study in all cases.

INTRODUCTION

PURPOSE.

The purpose of this study is to present the results of an investigation to determine the fire containment characteristics of various aircraft cargo containers currently in use in large cargo compartments.

BACKGROUND.

This study addresses one of the tasks in the overall cargo compartment fire protection plan. The plan was undertaken following an onboard fire in a Saudia Arabian Airlines L-1011 on August 19, 1980. Although the airplane had landed safely, all 301 occupants died from the effects of the fire. The cause of the fire was unknown, but it was determined to have started in the aft C3 cargo compartment. This cargo compartment is certified as class D with a volume of 700 cubic feet. Class D compartments are limited in size to 2000 cubic feet and depend on oxygen starvation to contain any fire likely to occur. Previous testing was completed at the Federal Aviation Administration (FAA) Technical Center in a 640-cubic foot simulated class D, bulk-load cargo compartment. It was determined that a good fire barrier used as a lining material can contain a fire in this size compartment. Large class D compartments, those above 1000 cubic feet, are primarily used for containerized cargo. Testing was initiated to determine if the containers used in these large compartments would behave as small individual class D compartments by controlling the fire through oxygen starvation.

LD-3 containers were used in this study. This type of container is currently in use in cargo compartments on the Boeing 747 and 747SP, McDouglas DC-10, Lockheed L1011 and the Airbus Industries A300 and A31B. LD-3 containers are half width containers with an internal volume of 150 cubic feet. The material used in the construction of a cargo container depends on its intended use, such as refrigerated, carriage of live animals, heavy duty, etc. Not all materials and types of cargo containers were available for testing in this study. Figure 1 shows the shape and dimensions of an LD-3 container. Full-width containers are also used in some wide-body aircraft cargo compartments. These have an internal volume of up to 350 cubic feet and are constructed of similar materials.

TEST CONFIGURATION.

The types of containers tested were: rigid fiberglass with both fiberglass and neoprene nylon doors, aluminum with both aluminum and vinyl doors and Marlex (high density polyethylene) with an aluminum door. Cardboard boxes filled with polyurethane packing foam made up the fire load for all tests. The fire was ignited in one box half filled with crumpled newspapers and foam. The fire load filled approximately 70 percent of the volume of the containers. A grid of six thermocouples was installed along the top of the containers. The output of these thermocouples along with the output of a Beckman OM11-EA oxygen analyzer was recorded on a Data General Nova 3 mini-computer. Figures 2 and 3 show the instrumentation used in the container. The millivolt signals were later converted to engineering units and plotted. Two additional thermocouples were placed in the containers and used by project personnel to monitor the fire conditions during the tests. An outside view of the container during the tests was recorded on video tape. Table 1 provides a description of the container type used in the 10 tests in this study along with the basic damage results.

TABLE 1. SUMMARY OF CONTAINER TYPE AND DAMAGE RESULTS

Test Number	Container Type	Burn Time (Min.)	Container Damage
1	Rigid Fiberglass LD-3 With Fiberglass Door	18	No Damage
2	Rigid Fiberglass LD-3 With Neoprene/Nylon Door Covering	20	No Damage
3	Rigid Fiberglass LD-3 With Neoprene/Nylon Door Covering	40	No Damage
4	Rigid Fiberglass LD-3 With Neoprene/Nylon Door Covering	28	Container Completely Destroyed
5	Aluminum LD-3 With Vinyl Door Covering	8	Extensive Damage
6	Aluminum LD-3 With Aluminum Doors	30	No Damage
7	Aluminum LD-3 With Aluminum Doors	35	No Damage
8	Aluminum LD-3 With Aluminum Doors	18	No Damage
9	Aluminum LD-3 With Aluminum Doors And Two (2) 6"X18" Holes Cut In Side of Container	20	Minimal Damage
10	Marlex (High Density Polyethylene) LD-3 With Aluminum Door	30	Minimal Damage

RESULTS.

A rigid fiberglass LD-3 with fiberglass doors was used in test 1. The test fire burned rapidly for approximately 6 minutes before oxygen depletion reduced the flaming combustion to a smoldering state. The fire continued to smolder for the remainder of the test. There was no damage to the container. This same container was used in tests 2, 3, and 4. The fiberglass door was replaced with a neoprene nylon cover. This material was part of an evacuation slide and not normally used as a door covering. It was tested in accordance with the requirements of FAR 25.855(b-3) and easily passed. Tests 2 and 3 resulted in conditions similar to test 1. As oxygen was consumed, the fire was reduced to a smoldering state. Test 4 began with conditions similar to the previous tests, however, after 28 minutes the smoldering fire melted the neoprene nylon door covering. Once this occured, fresh air was entrained and the fire flared up and completely destroyed the fiberglass container. The fire load and ignition location were the same for tests 2, 3, and 4. However, in test 4, the fire apparently burned closer to the door covering, exposing it to more radiant heat. There was enough radiant heat in test 4 to melt through the covering while in tests 2 and 3 there was not. An aluminum LD-3 with vinyl door coverings on both the front and back doors was used for test 5. The fire penetrated the front door covering in 5 minutes and burned rapidly until extinguished at approximately 7 minutes. Both front and back vinyl covering were burned away and the aluminum ceiling was warped, although not burned through. The vinyl material was tested as above and easily passed the requirements of FAR 25.855(b-3). An aluminum container with aluminum doors was used in tests 6 through 9. Tests 6, 7, and 8 produced the same initial flareup followed by a smoldering fire as seen in the earlier tests. There was no damage to the container. This same container was tested again in test 9. Two holes measuring 6 by 18 inches were cut into the sides of the container. This was done to simulate the type of container used to carry live animals. The fire burned hotter than in previous tests but not with sufficient intensity to melt the aluminum container. The boxes in this container were almost entirely consumed but the damage to the container was not substantial. A container constructed of high density polyethylene with one aluminum door was used in test 10. After the initial flareup, the fire was reduced and smoldered for the remainder of the tests. There was minimal damage to the container. Figures 4 through 10 are plots of the highest temperature measured on the ceiling of the container versus time. Figure 11 shows the oxygen concentration inside the container versus time.

As can be seen in table 1, two test fires were not contained and became out of control. This occurred when the fire penetrated the flexible door covering of the container and provided sufficient oxygen for continued flaming combustion. The fact that eight of ten test fires were successfully contained, shows that accidental fires in cargo containers can be controlled provided that fire resistant materials are used. Large class D cargo compartments of approximately 1000 cubic feet or greater are used primarily for containerized cargo. It is unclear if these large compartments, with a relatively large quantity of available oxygen, would be able to effectively control a fire through oxygen starvation. To insure the containment of accidental fires in these large compartments, the cargo containers used should be constructed of fire resistant materials. The horizontal burn test specified in FAR 25.855(b-3) does not insure that cargo containers will be able to control the type of fires simulated in this study in all cases.

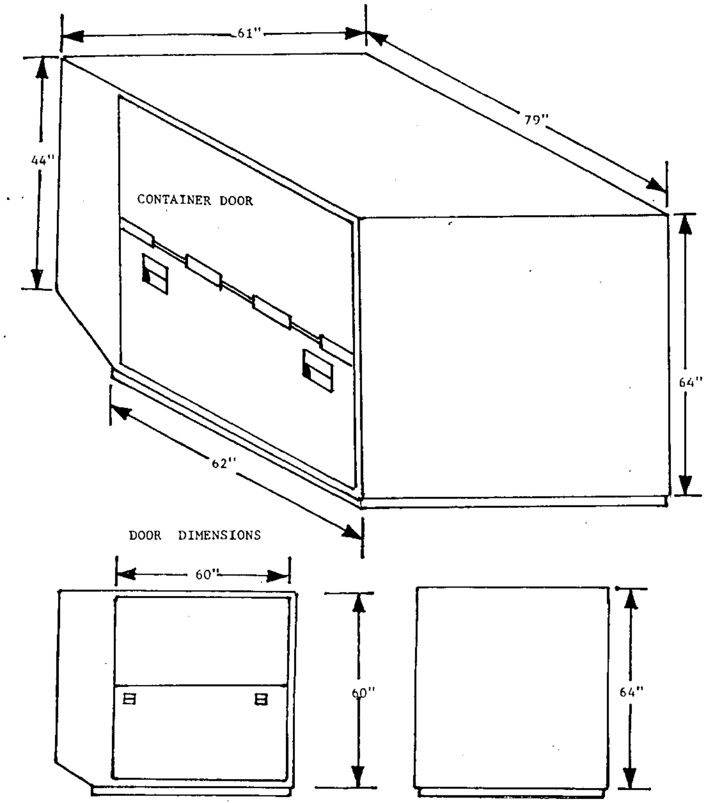

FIGURE 1. LD-3 CARGO CONTAINER DIMENSIONS

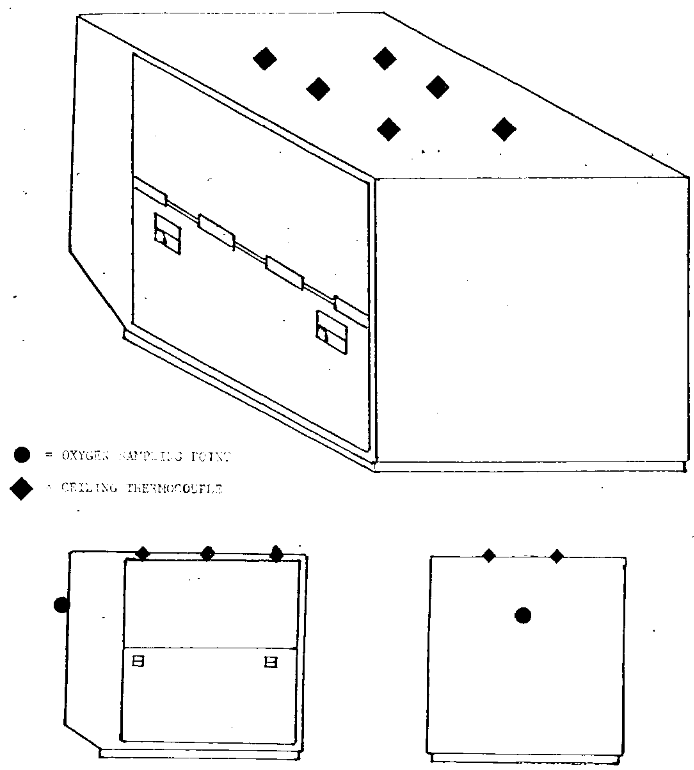

FIGURE 2. INSTRUMENTATION LOCATION - (INTERIOR OF CONTAINER)

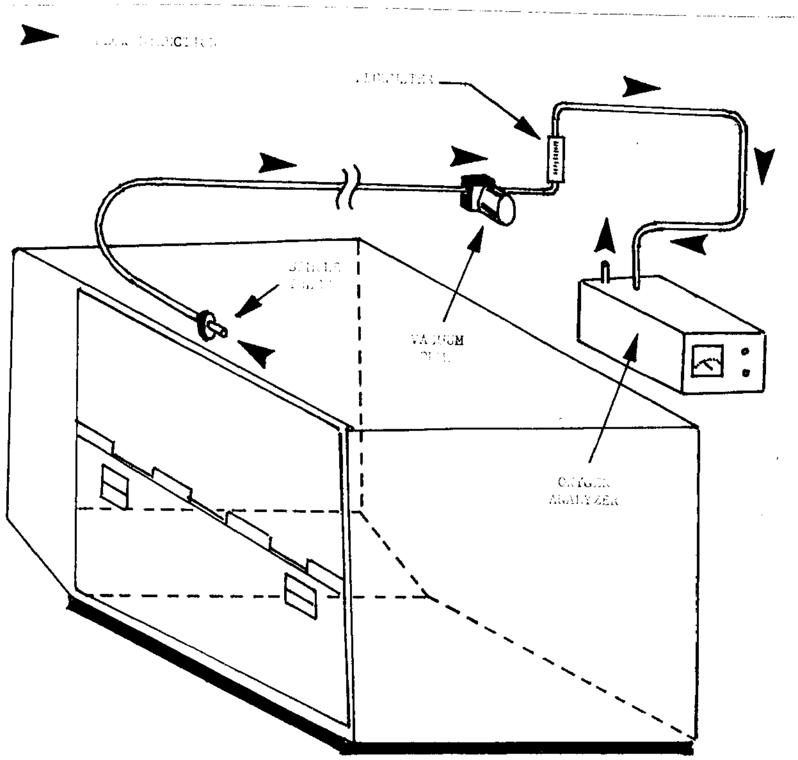

FIGURE 3. OXYGEN CONCENTRATION MEASURING SYSTEM

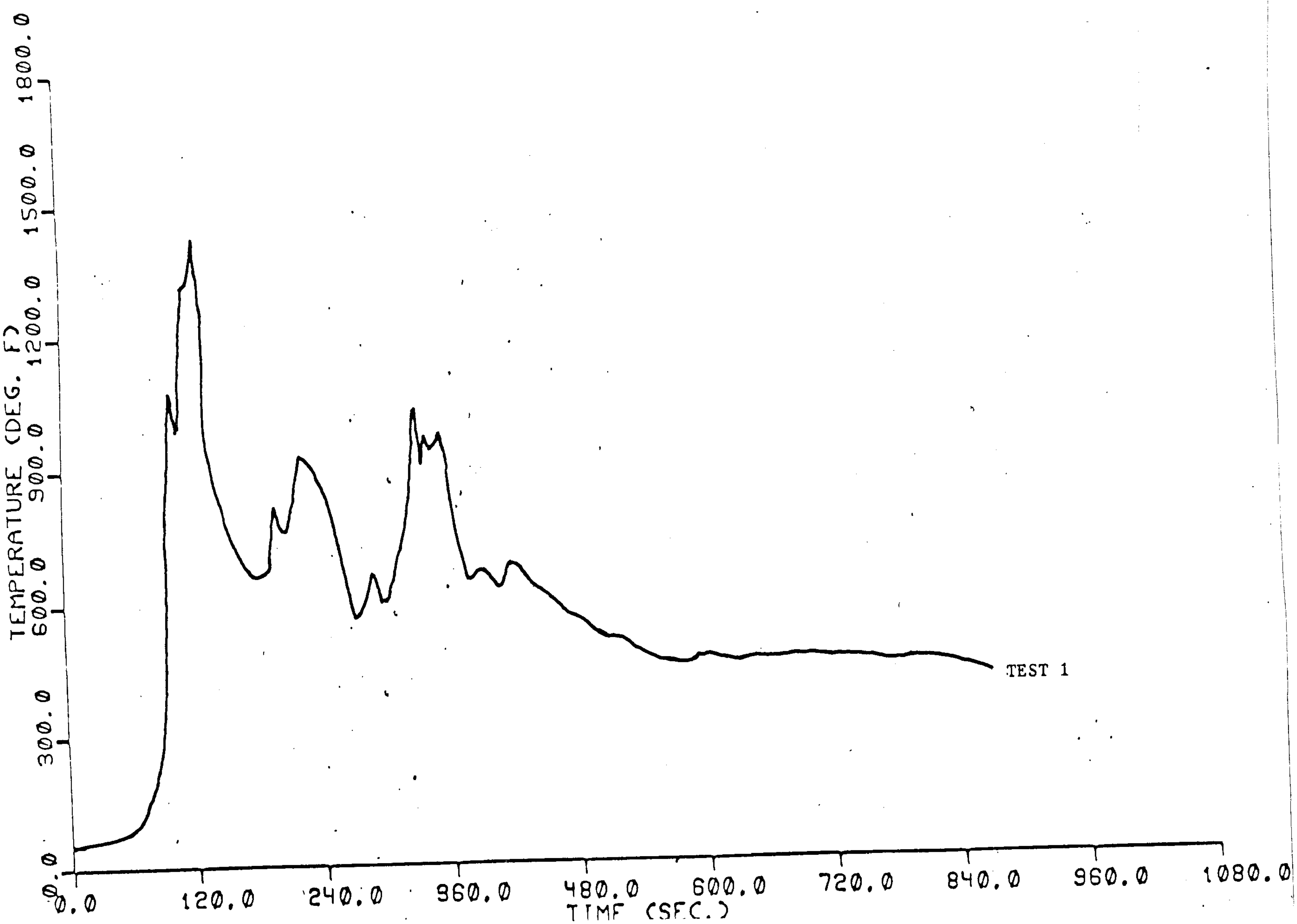

FIGURE 4. LD-3 CONTAINER TEST CEILING TEMPERATURE PROFILE TEST 1

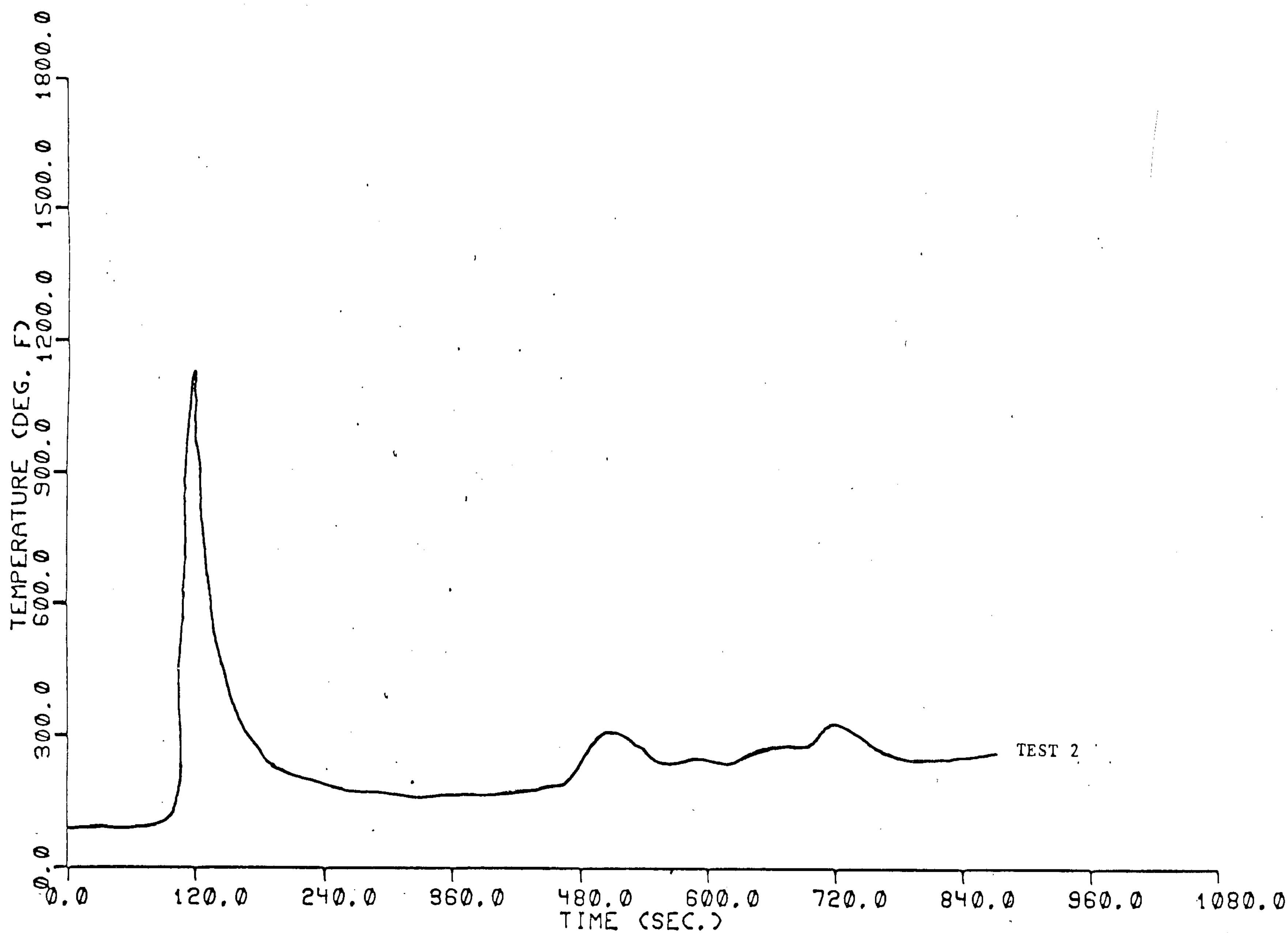

FIGURE 5. LD-3 CONTAINER TEST CEILING TEMPERATURE PROFILE TEST 2

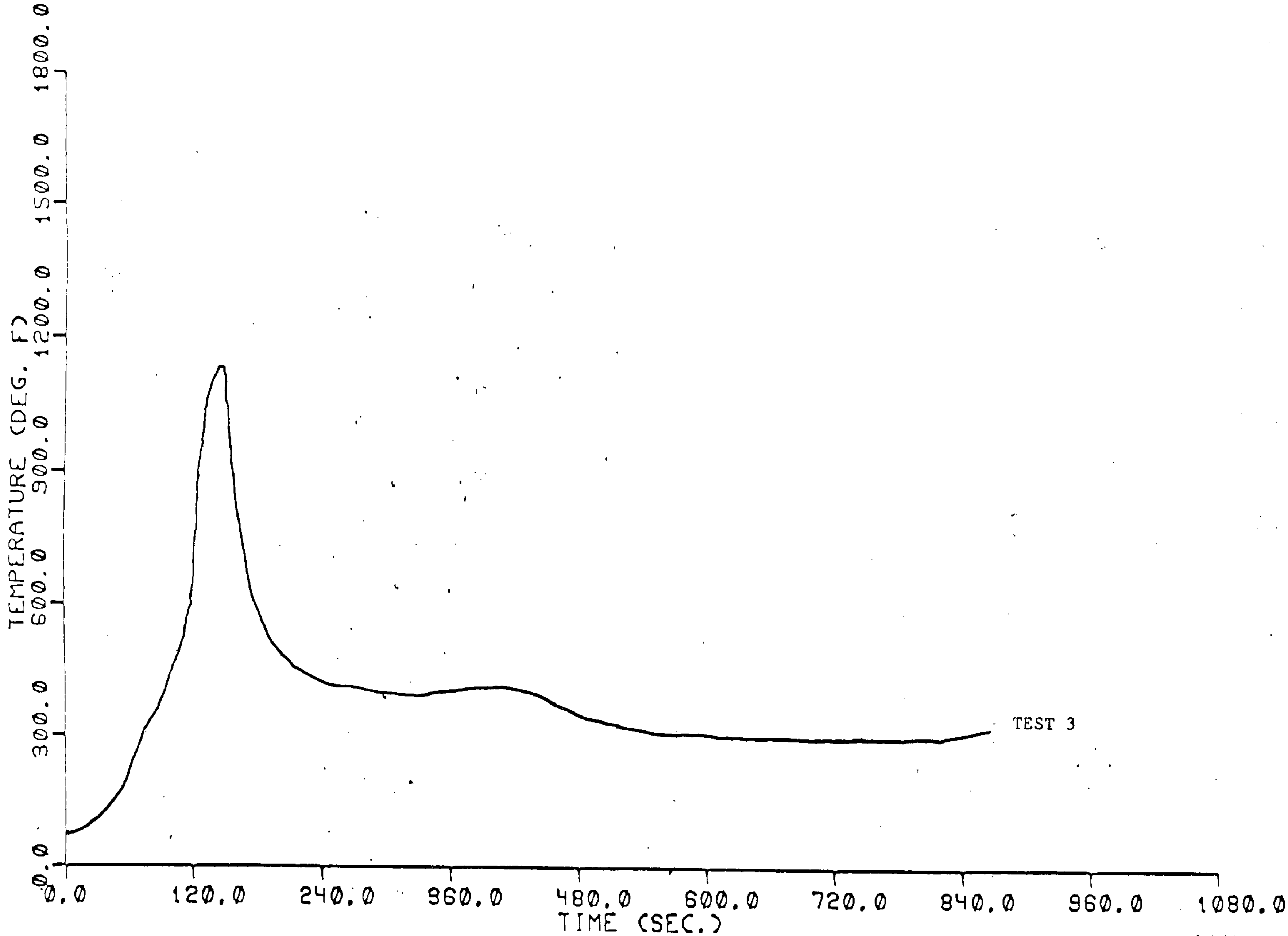

FIGURE 6. LD-3 CONTAINER TEST CEILING TEMPERATURE PROFILE TEST 3

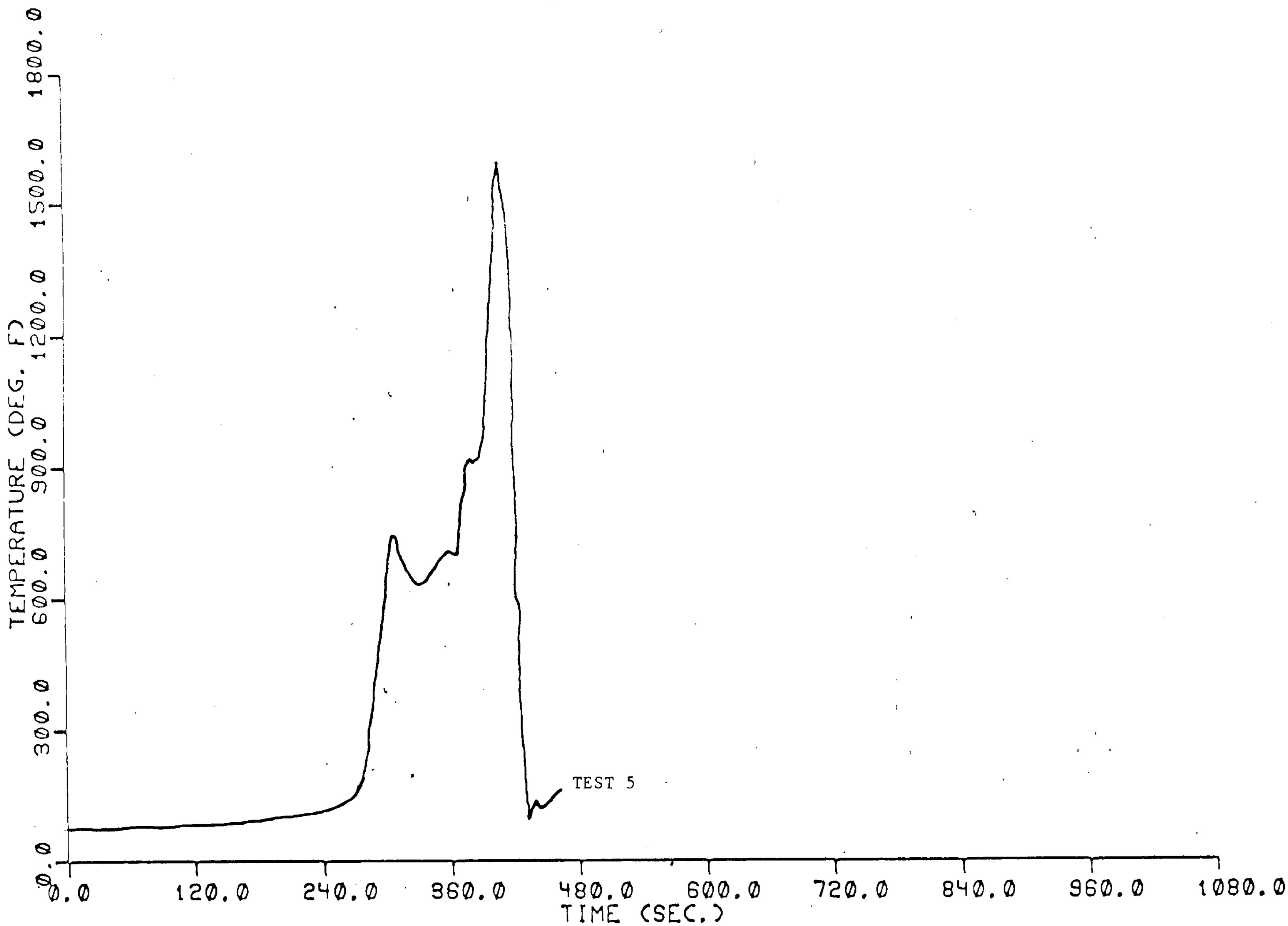

FIGURE 7. LD-3 CONTAINER TEST CEILING TEMPERATURE PROFILE TEST 5

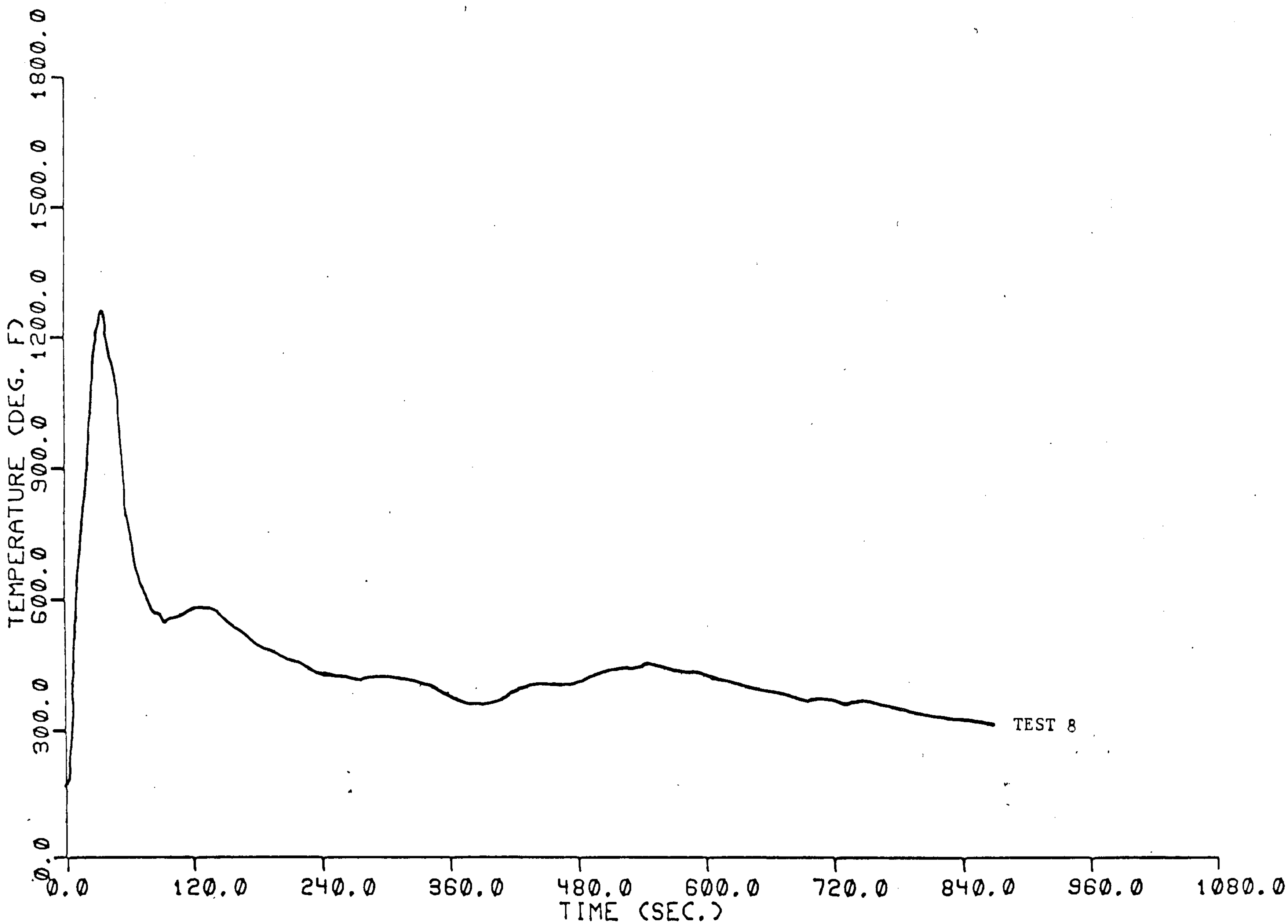

FIGURE 8. LD-3 CONTAINER TEST CEILING TEMPERATURE PROFILE TEST 8

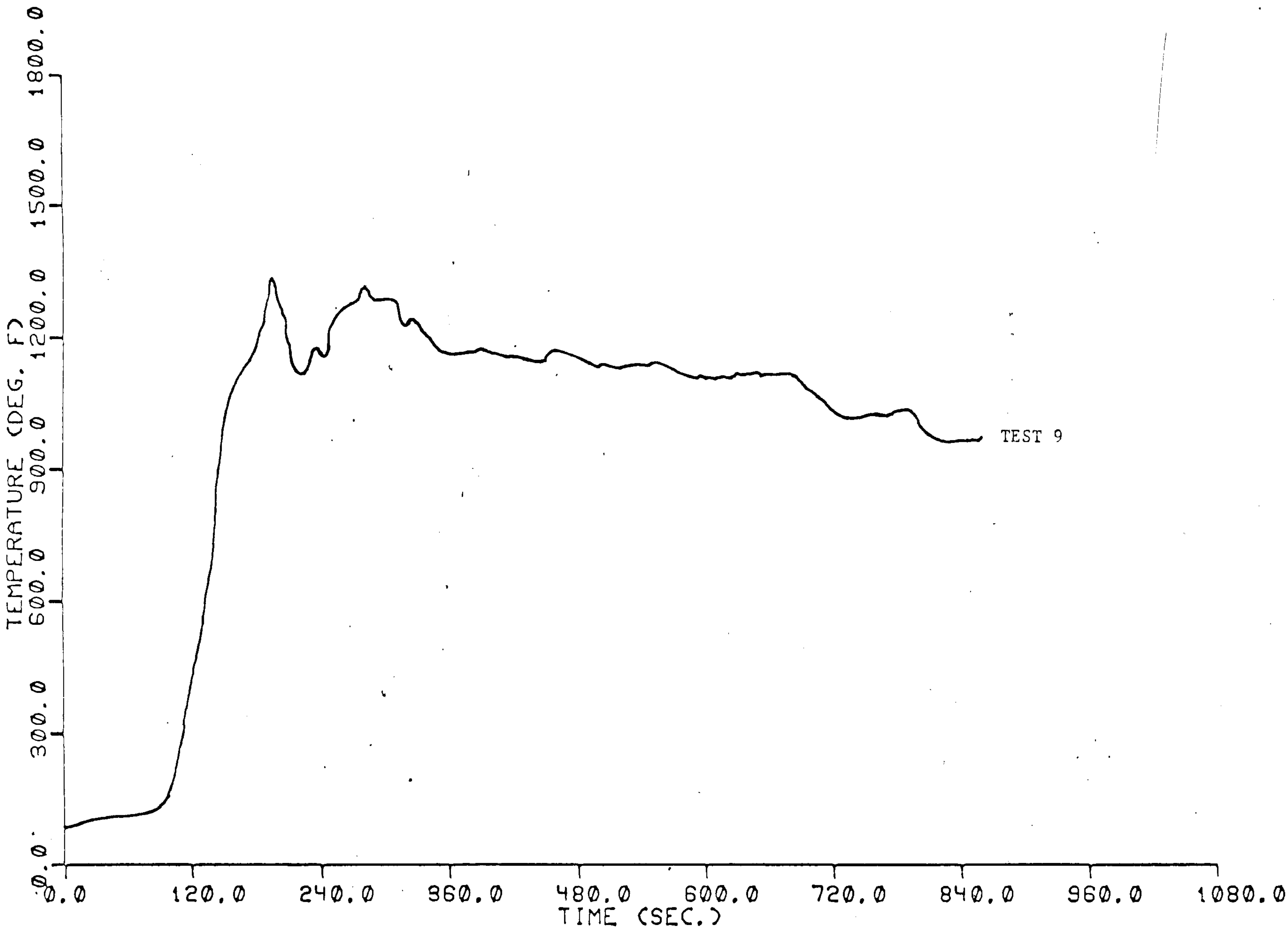

FIGURE 9. LD-3 CONTAINER TEST CEILING TEMPERATURE PROFILE TEST 9

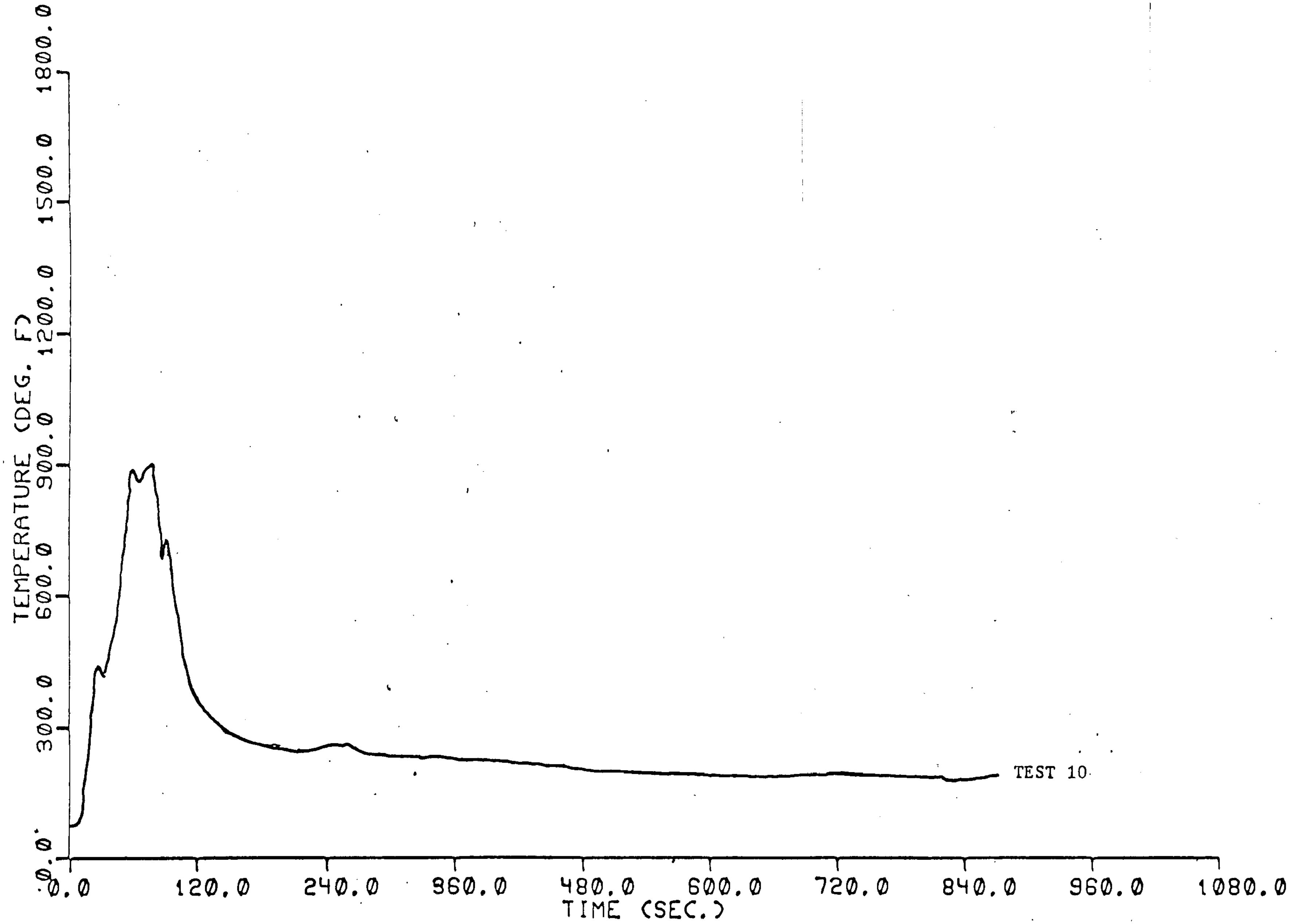

FIGURE 10. LD-3 CONTAINER TEST CEILING TEMPERATURE PROFILE TEST 10

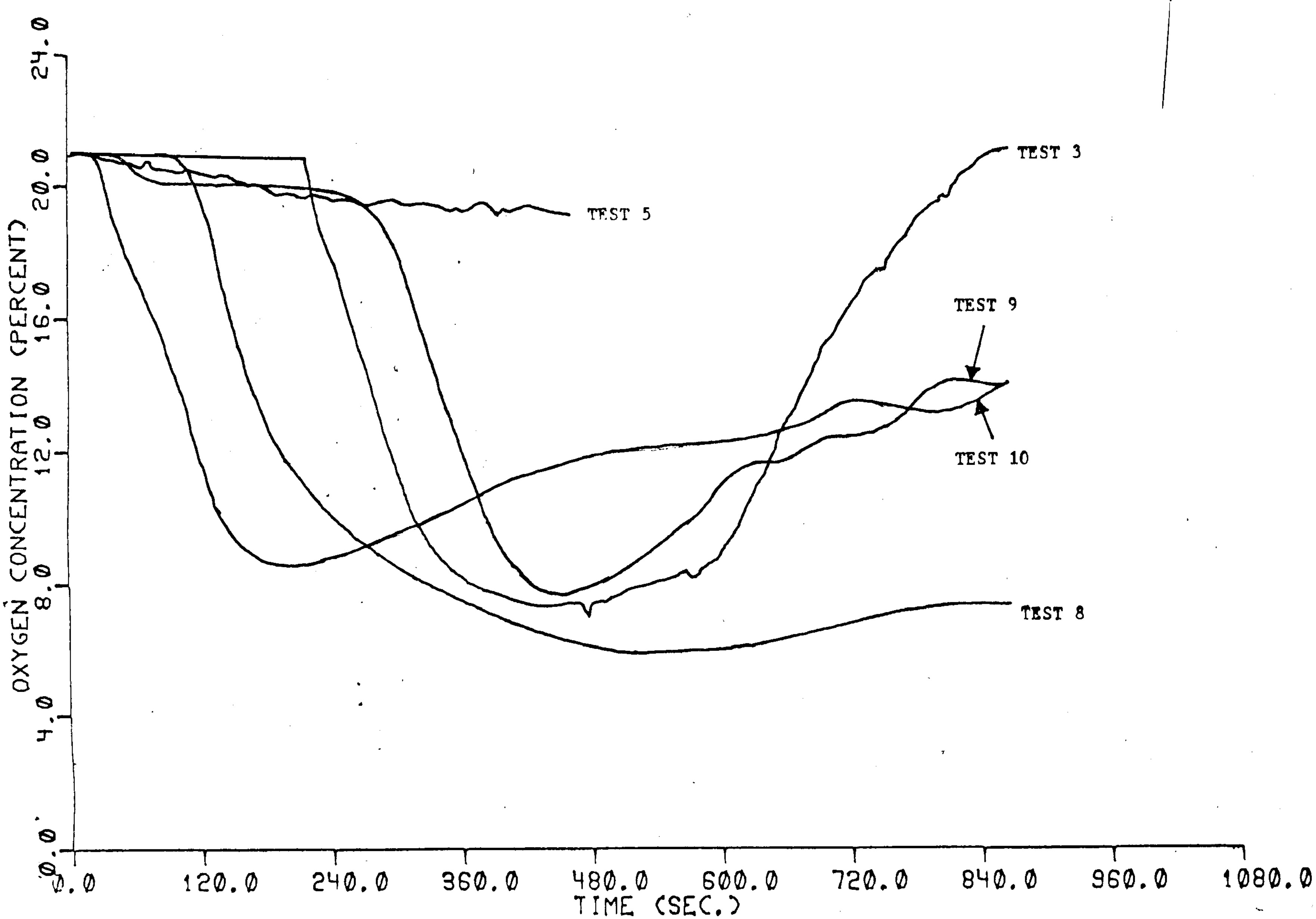

FIGURE 11. LD-3 CONTAINER TESTS OXYGEN CONCENTRATION