CENTER FOR INFRASTRUCTURE ENGINEERING STUDIES

DETERMINATION OF THE TEMPERATURE - DISTORTION CHARACTERISTICS OF THE COMPOSITE STEAM MANHOLE COVER F95 UNDER SUSTAINED LOA

FINAL REPORT

by

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May 3, 2006

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RESEARCH INVESTIGATION CIES 06 - XXX

FINAL REPORT

DETERMINATION OF THE TEMPERATURE – DISTORTION CHARACTERISTICS OF THE COMPOSITE STEAM MANHOLE COVER F95 UNDER SUSTAINED LOAD

PREPARED FOR

FIBRELITE

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TABLE OF CONTENTS

LIST OF FIGURES

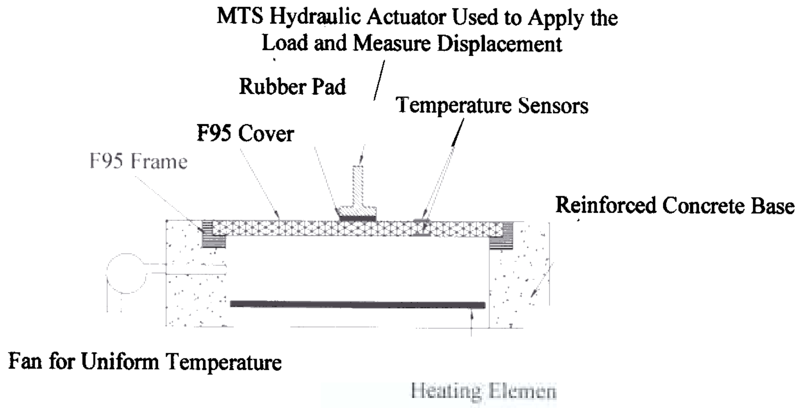
LIST OF TABLES

1. OBJECTIVES

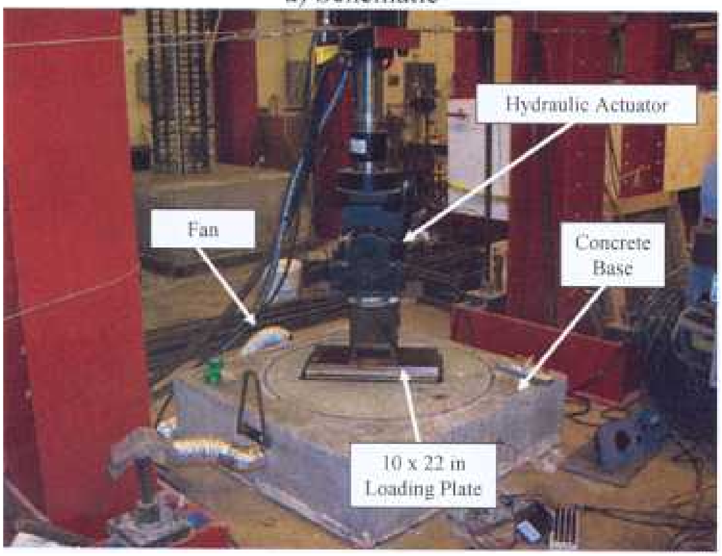
The scope of this project is the evaluation of the performance, under a concentrated load and high temperature, of the composite steam manhole cover and frame F-95 produced by Fibrelite.

2. TEST INSTRUMENTATION AND PROCEDURES

Figure 1-a shows a schematic of the test setup. The load was applied using a MTS hydraulic actuator, operable in load control, which was programmed to apply the desired load—time history. The temperature sensor on the bottom of the cover detects when the element reaches the desired temperature and automatically enables the MTS to apply the load. The additional sensor at the top of the manhole allows determining the performance of the element in terms of thermal insulation.



a) Schematic

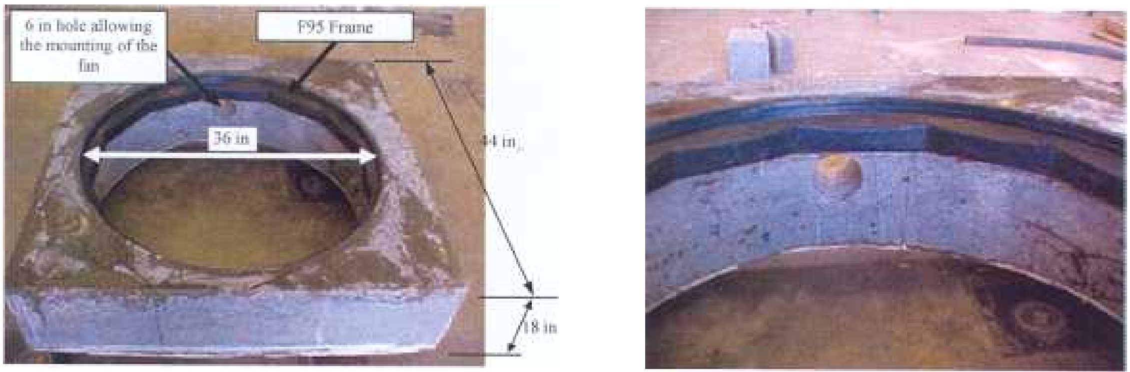


b) Photograph

Figure 1 – Test Setup

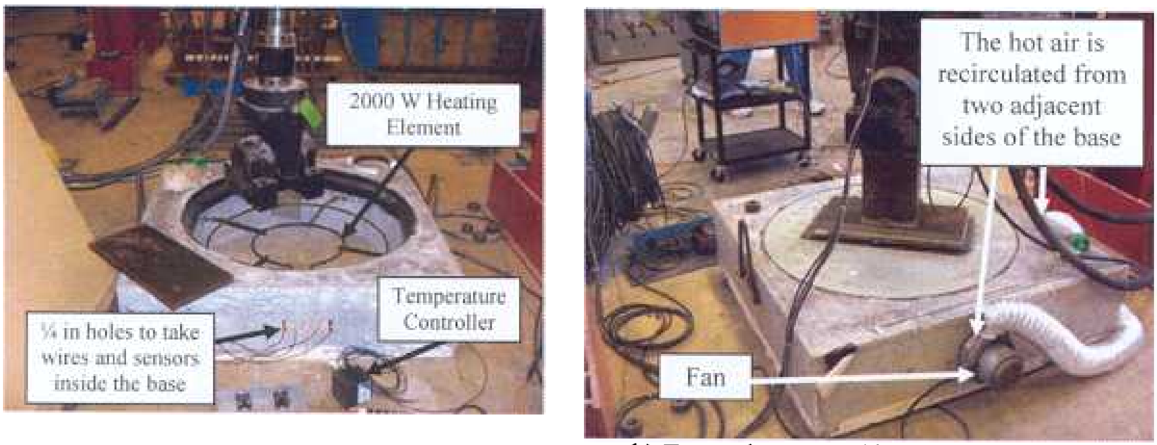
The concrete base consisted of a 48 in (122 cm) square cross-section with a 36 in (91 cm) central circular opening for the seating of the manhole cover over its support frame. The height of the concrete base was 18 in (46 cm). To allow a perfect fit of the manhole cover with the concrete base, the F95 frame was used as part of the form while pouring the concrete base (See Figure 2).

In addition to providing the support for the manhole cover, the concrete base was also intended to become the heating chamber during the performance of the test, with heating generated by the serpentine shown in Figure 3-b. The uniformity of the temperature inside the concrete base was guaranteed by re-circulating hot air with a fan mounted between two adjacent sides of the base as showed in Figure 3-b.



a) Heating element b) Close-up

Figure 2 – Base Details



a) Heating element b) Fan to have a uniform distribution of temperatures

Figure 3 – Test Setup Details

Figure 4 shows the temperature-time history to which the F95 cover was subjected. When the temperature of the underside of the cover reached the temperature (T_i) variable between 200°F and 400°F in increments of 50°F and held for 30 minutes, the hydraulic actuator applied a load of 20 *kip* (89 kN) for 30 seconds and then removed it as schematically shown in Figure 5. At the time the load was applied, the deflection of the manhole center was recorded. An additional load cycle at room temperature was performed before starting the temperature treatment and at the end of the temperature treatment to verify whether any degradation of mechanical properties occurred. Therefore, a total of seven load cycles per specimen were applied.

During the test, the cover temperature for top and bottom and the ambient temperature were recorded to draw a temperature/deflection graph.

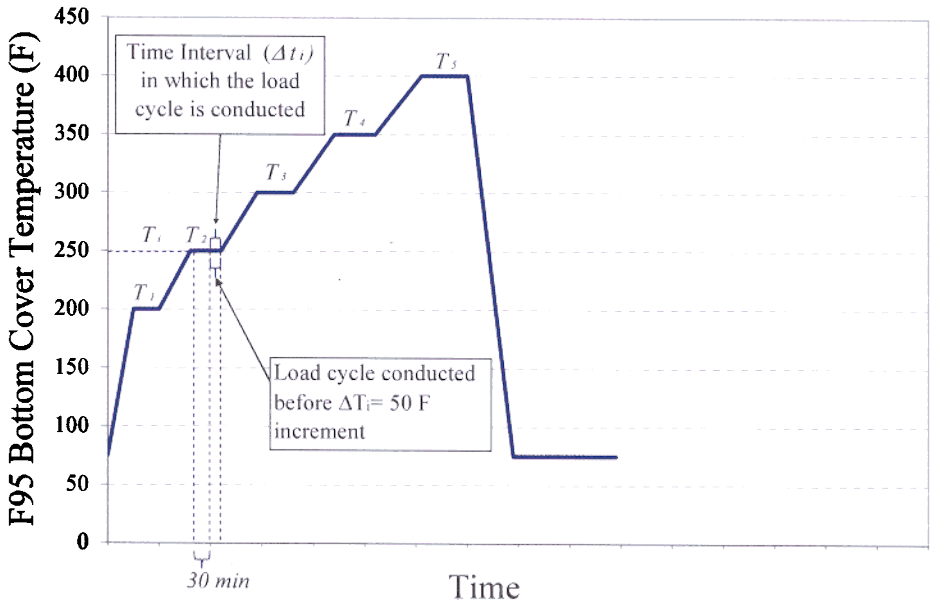


Figure 4 – Temperature–Time History

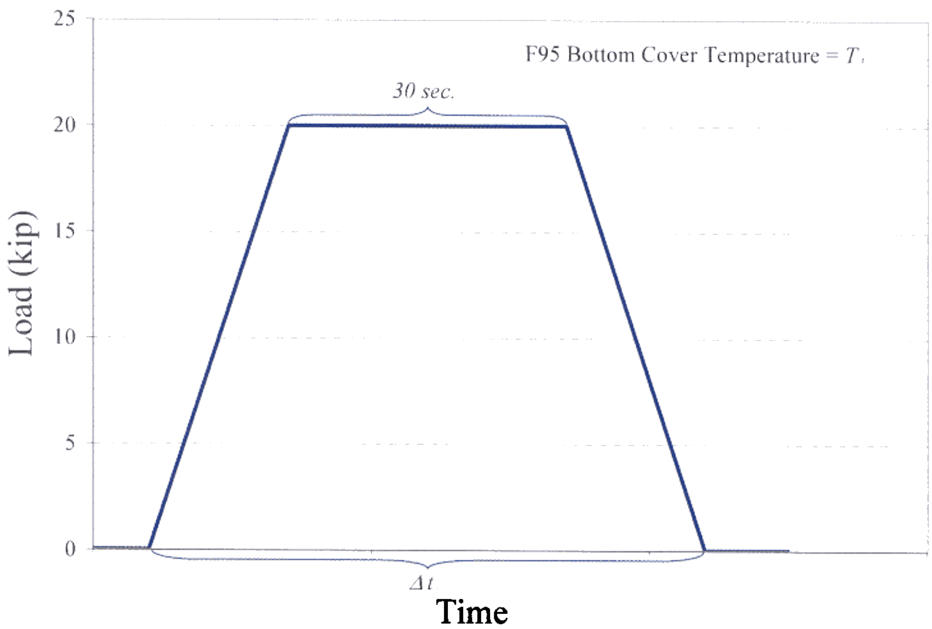


Figure 5 – Load–Time Individual Cycle

As requested by Fibrelite, the load was applied on a 10 x 22 in (254 x 559 mm) square foot print, in load control, at a rate 225 $\frac{lbf}{s}$ $\left(1\ \frac{kN}{s}\right)$ up to a maximum load of 20 *kip* (89 kN). To allow for proper distribution, a piece of 1-in (25.4-mm) thick plywood and a rubber pad were placed between the loading steel plate and cover top surface (see Figure 1).

3. TEST RESULTS AND DISCUSSION

As requested by Fibrelite, a total of 6 manhole covers were tested. A data acquisition system recorded signals at a rate of 0.1 Hz for specimens 1 to 4 and at 1 Hz for specimens 5 and 6 from all devices. Load vs. deflection curves and the temperature-time history were displayed in real time on the computer monitor (See Figure 6).

Figure 6 – Data Acquisition System

Figure 7 to Figure 12 show the temperature-time history for the six specimens, while Figure 13 to Figure 18 present the corresponding load-deflection curves. The experimental results are very consistent, demonstrating the repeatability of the test setup and the specimens.

The temperature-time graphs show the remarkable insulating properties of the manholes; in fact, the maximum temperature reached at the top of the elements was only 110°F after the temperature at the bottom was kept at 400°F for 30 minutes.

The load-deflection curves are not very accurate in the load range up to 5 *kip* because of the non-linearity of the load cell mounted on the hydraulic actuator for low load values.

The load deflection diagrams show a change of the mechanical properties (stiffness of the composite material) when subject to increasing temperature (See also Table 1). However, no permanent damage was recorded since the load-deflection diagrams before and after the thermal treatment overlap.

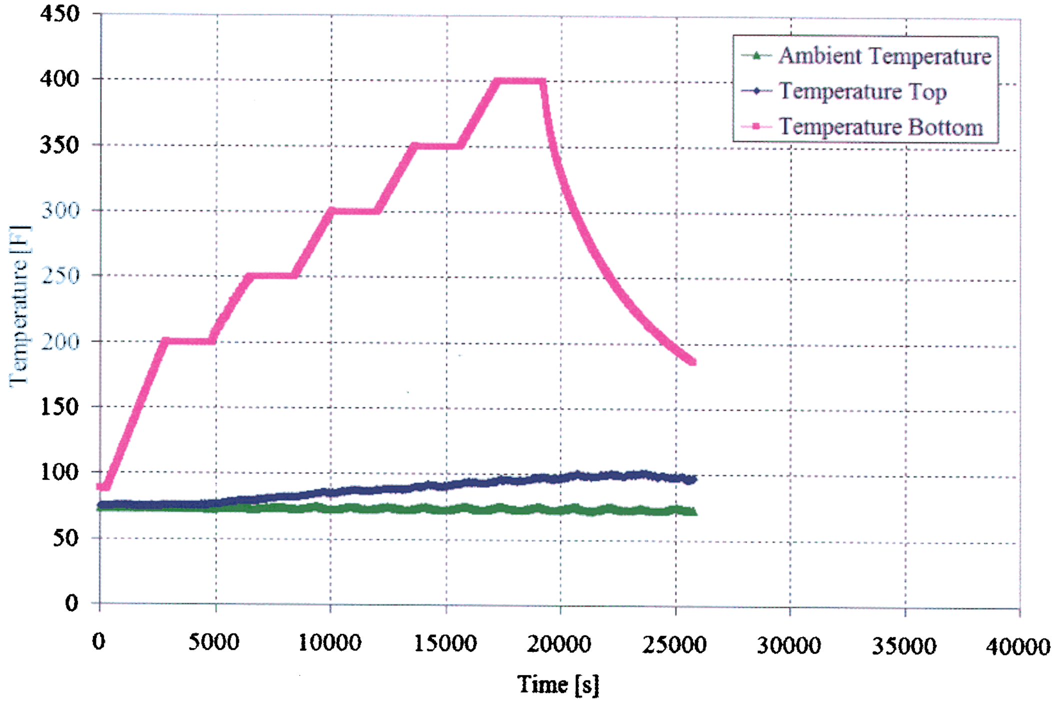


Figure 7 – Temperature–Time History Specimen 1

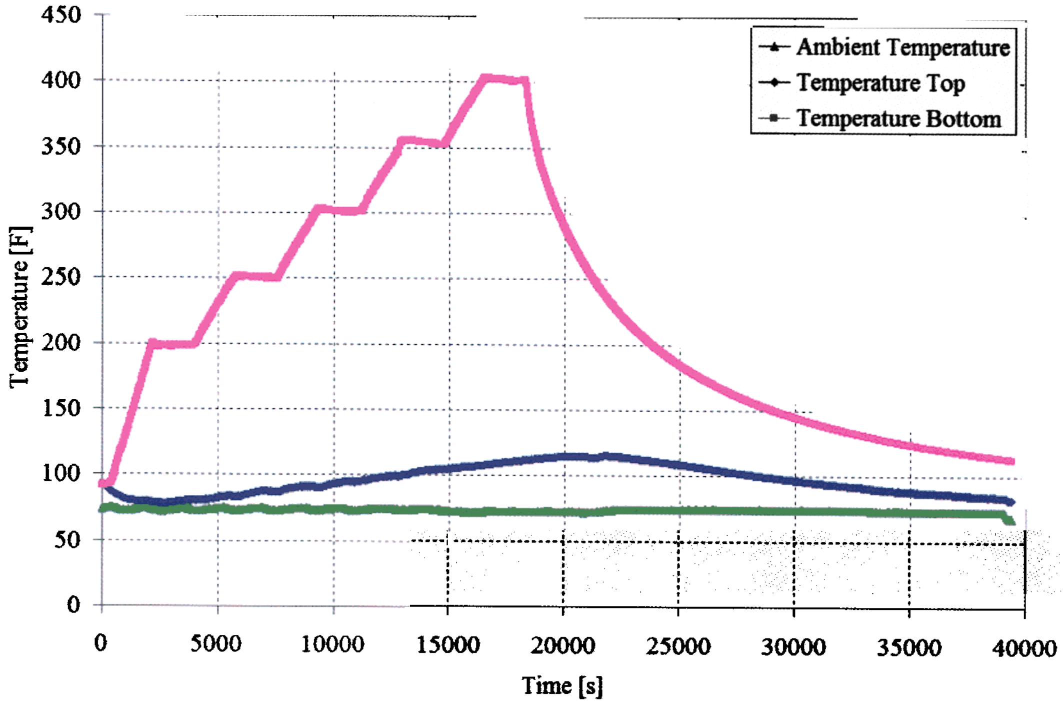


Figure 8 – Temperature–Time History Specimen 2

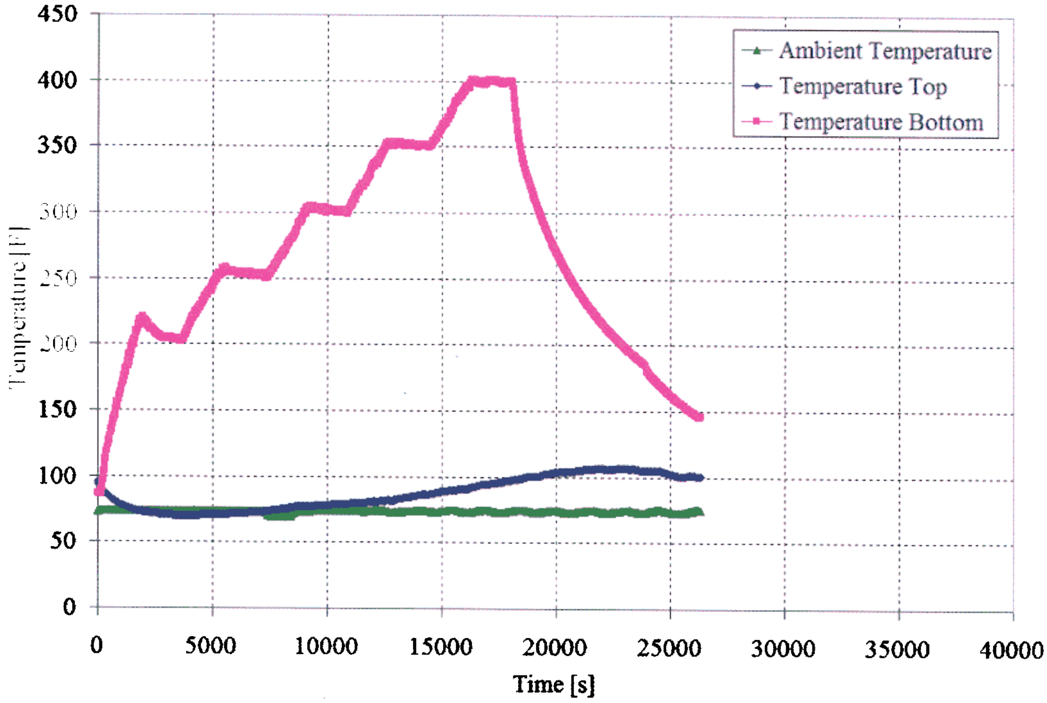


Figure 9 – Temperature–Time History Specimen 3

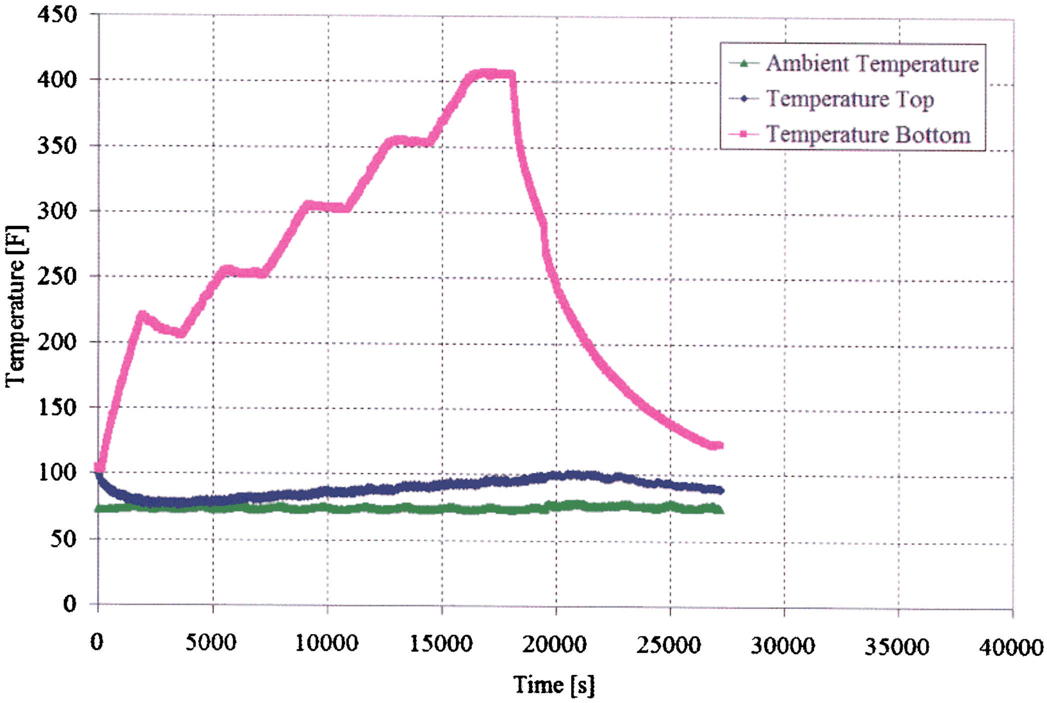


Figure 10 – Temperature–Time History Specimen 6

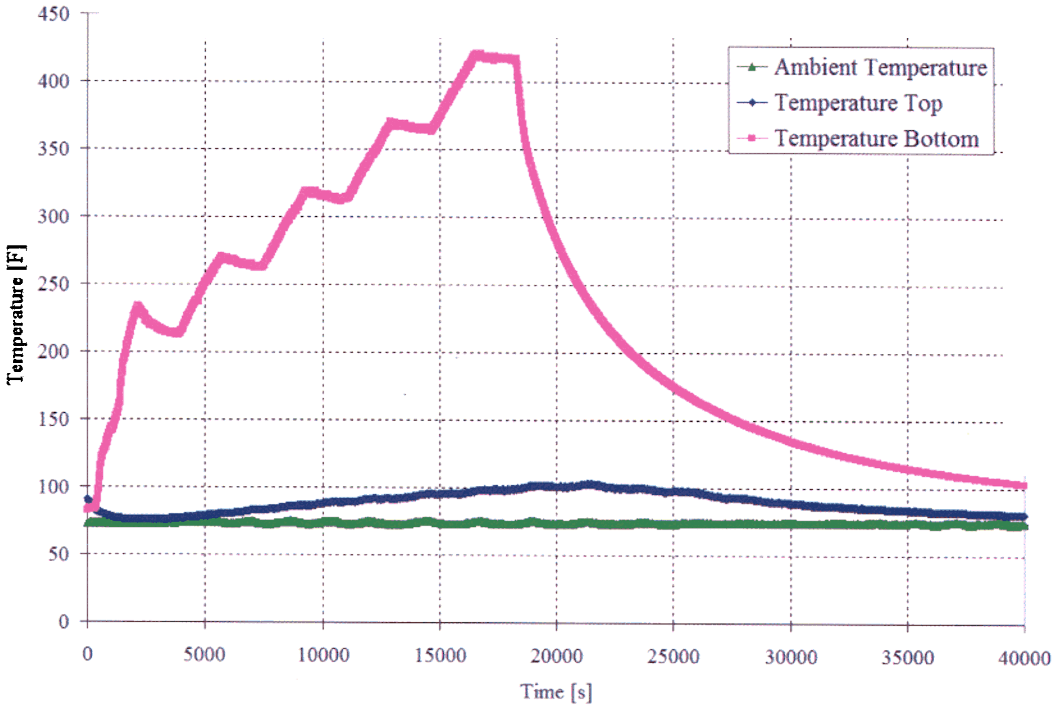


Figure – Temperature–Time History Specimen 5

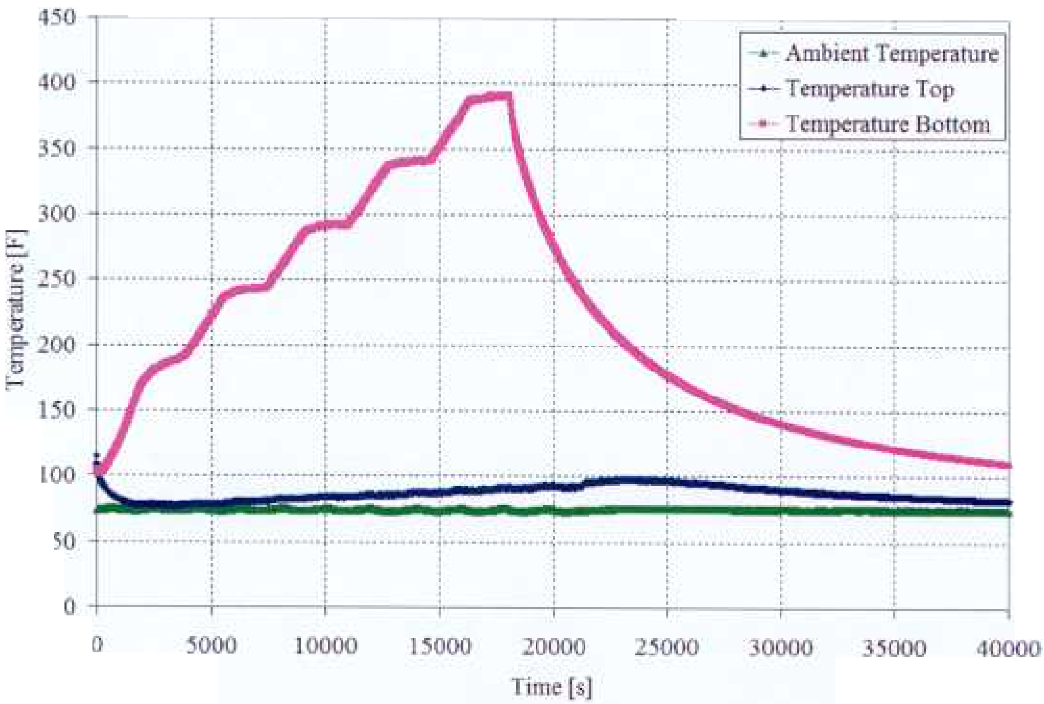


Figure 12 – Temperature–Time History Specimen 6

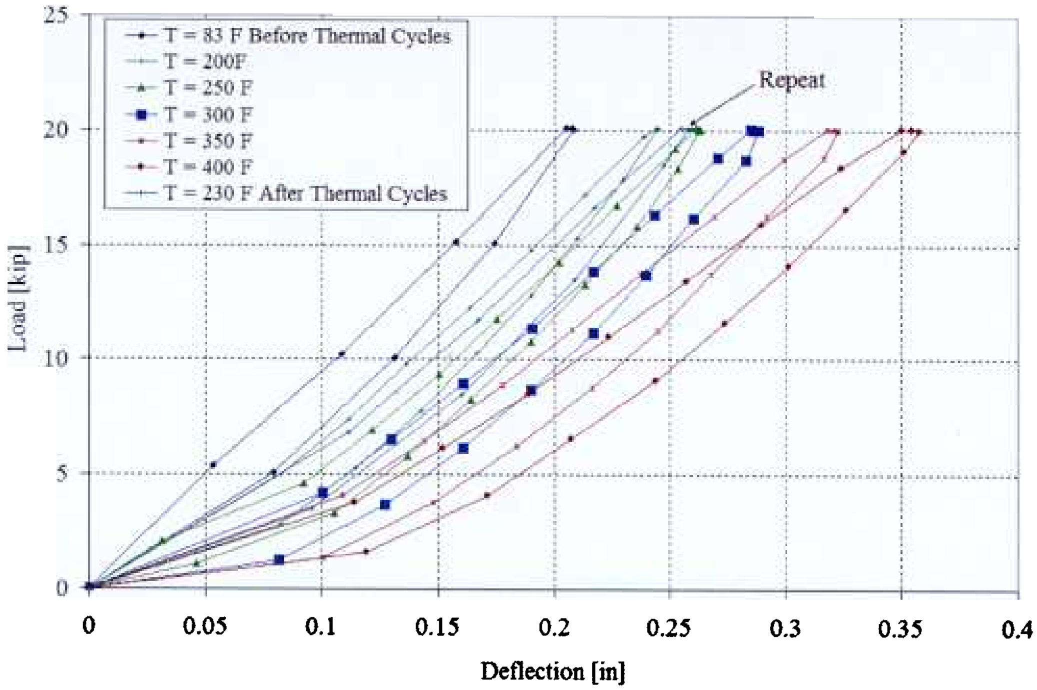


Figure 13 – Load –Deflection Graph Specimen 1 (1 *kip* = 4.45 kN, in = 25.4 mm)

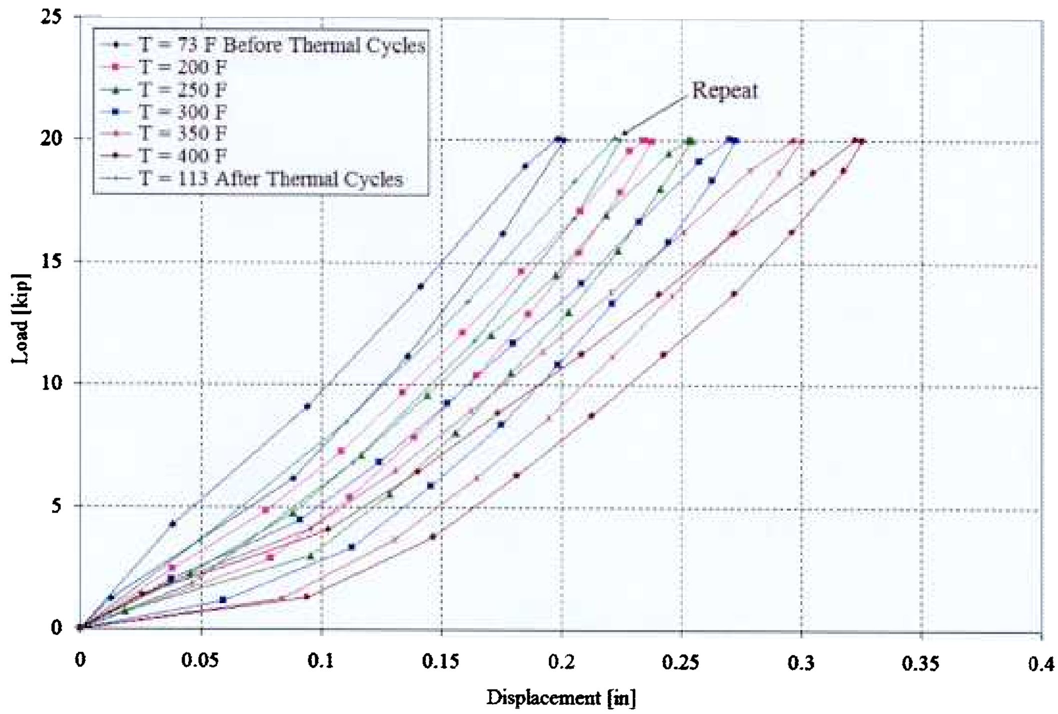


Figure 14 – Load –Deflection Graph Specimen 2 (1 *kip* = 4.45 kN, 1 in = 25.4 mm)

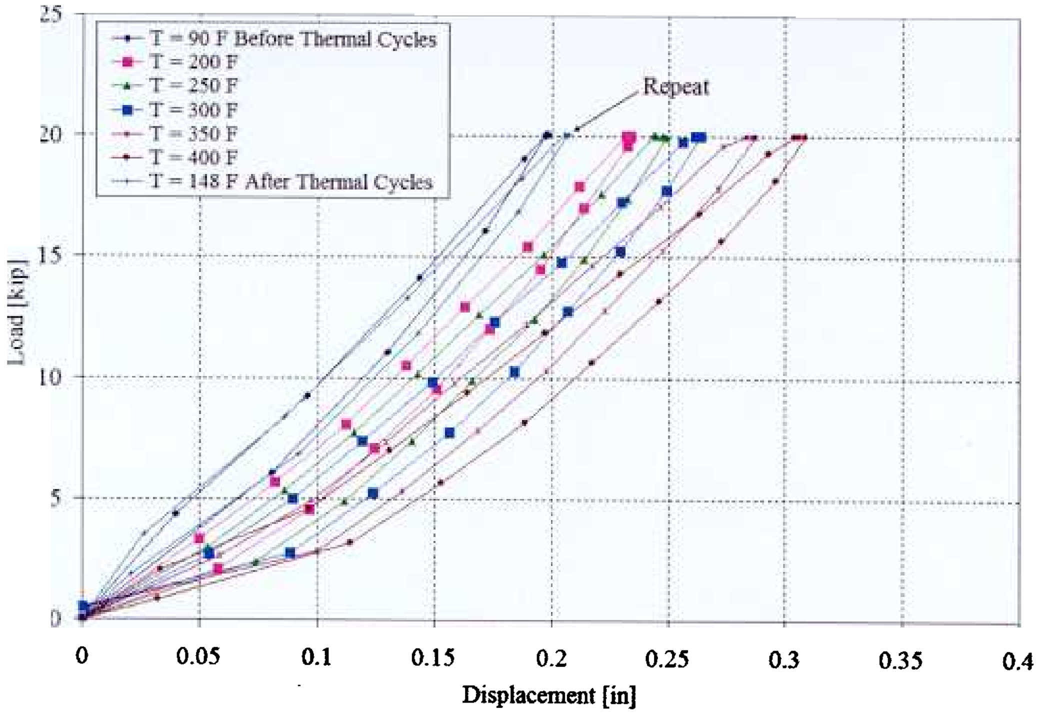


Figure 15 – Load –Deflection Graph Specimen 3 (1 *kip* = 4.45 kN, in = 25.4 mm)

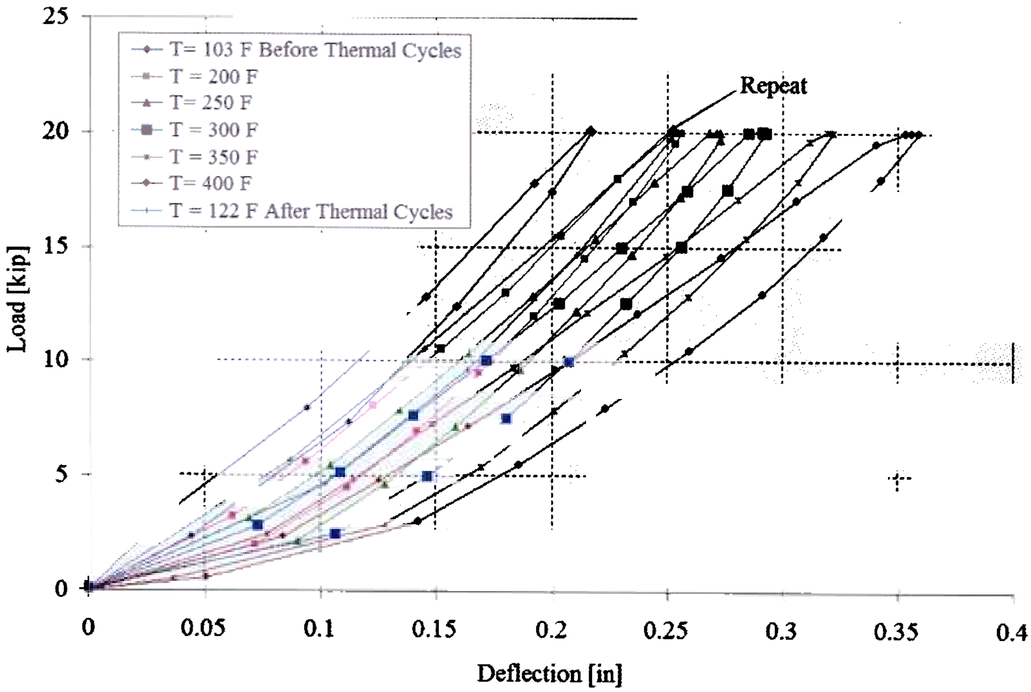


Figure 16 – Load –Deflection Graph Specimen 4 (1 *kip* = 4.45 kN, 1 in = 25.4 mm)

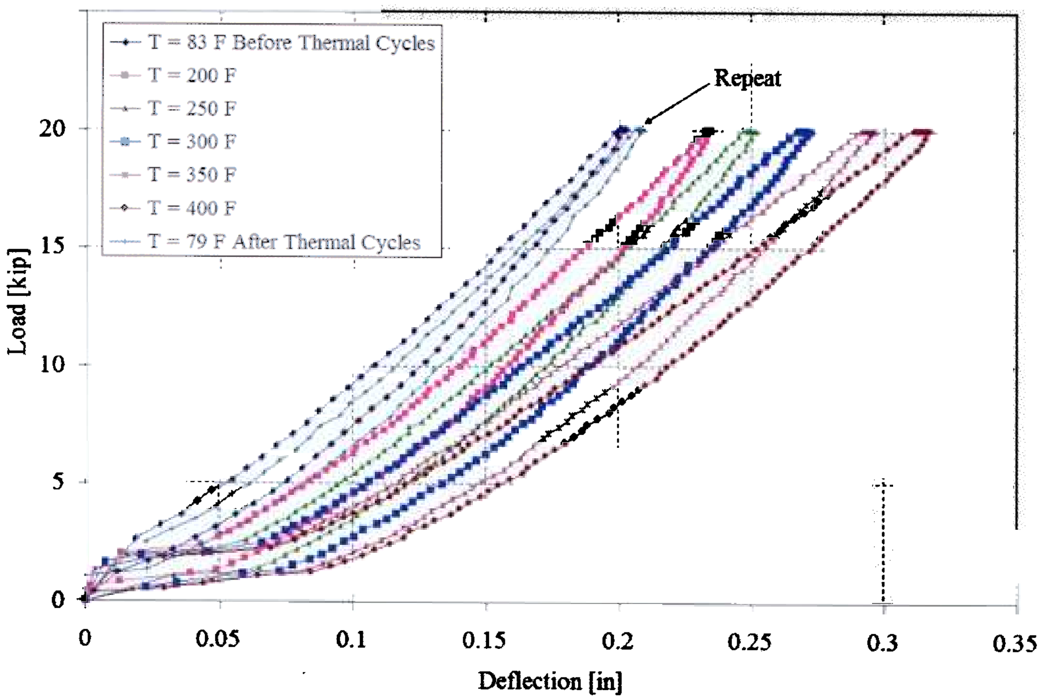


Figure 17 – Load –Deflection Graph Specimen 5 (1 *kip* = 4.45 kN, in = 25.4 mm)

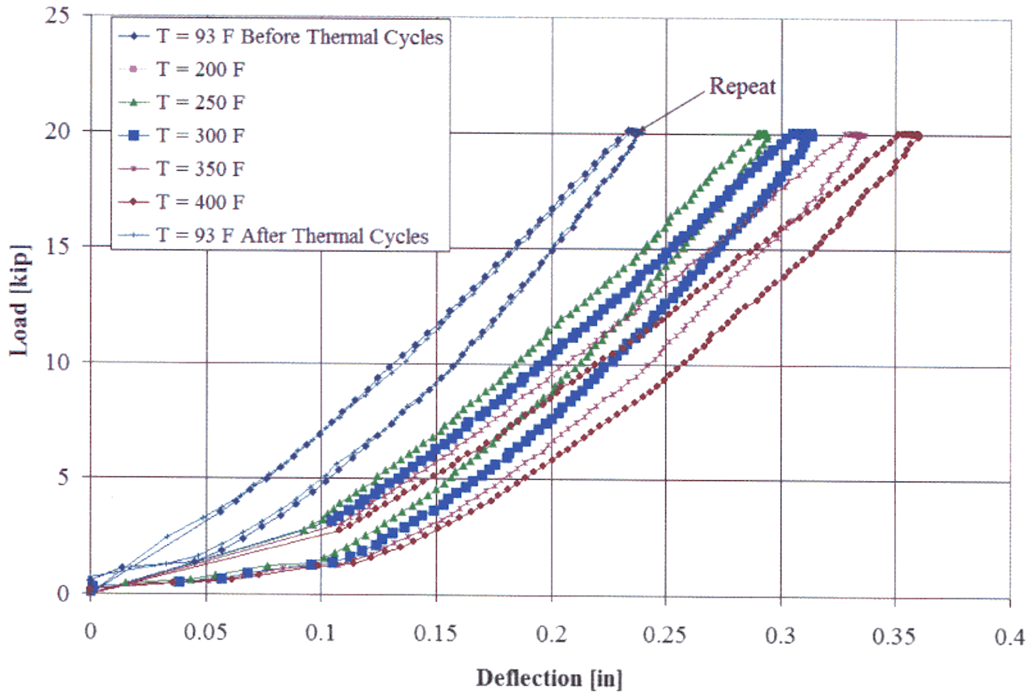


Figure 18 – Load –Deflection Graph Specimen 6 (1 *kip* = 4.45 kN, 1 in = 25.4 mm)

Table – Summary of Results

Specimen	Maximum Deflection [in]						
	T = 73 F	T = 200 F	T = 250 F	T = 300 F	T = 350 F	T = 400 F	Repeat (T)
1	0.208	0.245	0.262	0.288	0.323	0.357	0.259 (230 F)
2	0.201	0.238	0.254	0.272	0.300	0.326	0.224 (113 F)
3	0.199	0.234	0.249	0.264	0.287	0.308	0.207 (148 F)
4	0.218	0.235	0.273	0.293	0.322	0.356	0.254 (122 F)
5	0.202	0.235	0.251	0.272	0.296	0.317	0.209 (79 F)
6	0.231	0.274	0.294	0.314	0.336	0.360	0.239 (93 F)
Average [in]	0.210	0.243	0.264	0.284	0.311	0.337	N/A
S. Deviation [in]	0.012	0.016	0.017	0.018	0.019	0.023	N/A
Covariance %	5.7	6.6	6.4	6.3	6.1	6.8	N/A

No additional theoretical analyses were performed on the manholes since Fibrelite did not require it.

4. CONCLUSIONS

An experimental campaign aiming at determining the temperature – distortion characteristics of the composite steam manhole cover F95 under sustained load was conducted. This manhole is manufactured by Fibrelite.

A completely automated system comprising a MTS hydraulic actuator operated in load control, and a temperature controller programmed to apply the desired load—time history was assembled for this experimental campaign. Temperature sensors placed on the topside and underside of the manhole cover allowed monitoring the temperature distribution through the experiment. After conducting the first load test at room temperature, the specimen was tested again when the temperature of the underside of the cover reached 200°F. Load tests were repeated at increments of 50°F till a temperature of 400°F. A seventh and final load test was conducted at the completion of the heat treatment at about room temperature. For each of the seven load tests performed on an individual specimen, the hydraulic actuator applied a load of 20 *kip* (89 kN) for 30 seconds and then removed it

Based on the experimental investigation, the following conclusions can be drawn:

1. Even when the temperature on the bottom face reached 400°F, the maximum temperature recorded on the opposite side (top of the manhole) was only 110°F, demonstrating the good performances of the specimen in terms of thermal insulation.
2. As expected, a reduction in the mechanical properties (stiffness of the composite material) was recorded when subjecting the composite manholes to increasing temperatures. On average, the maximum deflection at 400°F was 60 percent higher than the deflection recorded at room temperature (73°F)
3. No permanent damage of the manholes was recorded after the thermal treatment and corresponding load tests. In other words, the original stiffness of the composite material was recovered upon cooling.
4. The six manholes tested showed a high level of performance repeatability as demonstrated by the covariance that ranged from 5.7 percent to 6.8 percent.

APPENDIX A

COMPOSITE STEAM MANHOLE COVER F95: MANUFACTURER SPECIFICATIONS

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Order against product code only.

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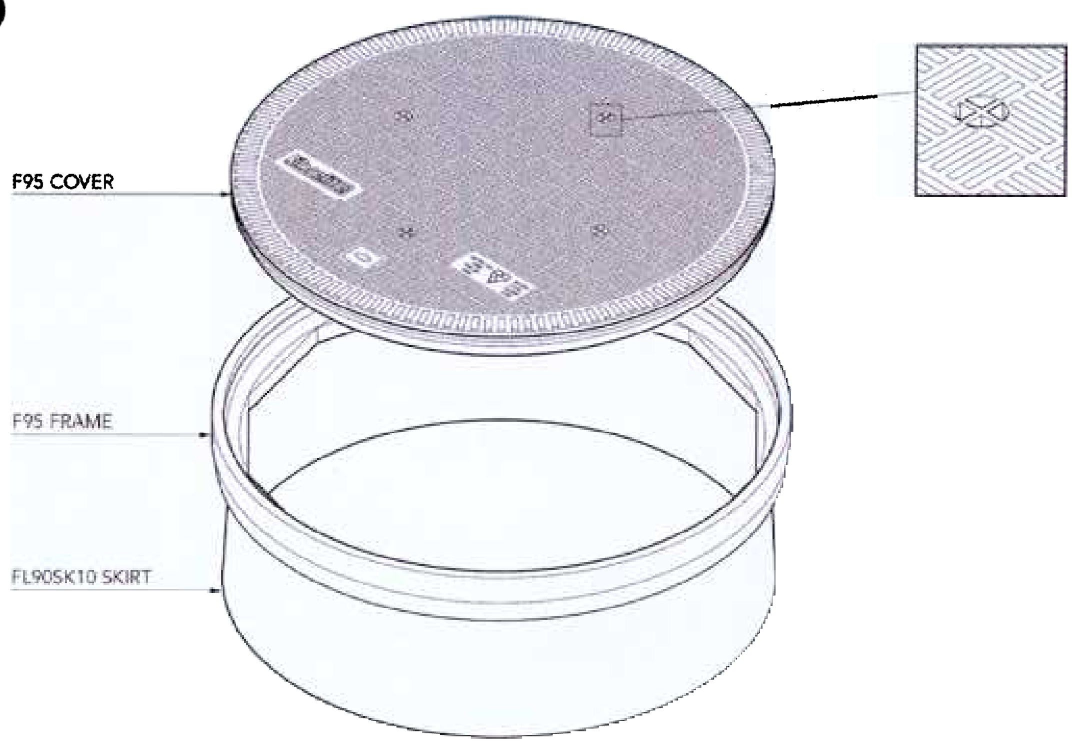

Notes: BS EN 124 1994 PAS 26 1998 MODEL FL90 CLASS C250	Category:	**ACCESS COVER AND FRAME**	
	Product Description:	F95 - 36" diameter composite cover and frame with LG2 Gun Metal key housing for steam applications	
For reference puposes only. This drawing is not a specification.	Drawing No.: **US12950**	Product Code: **F95**	
	Date: **April 2005**	Revisons:	

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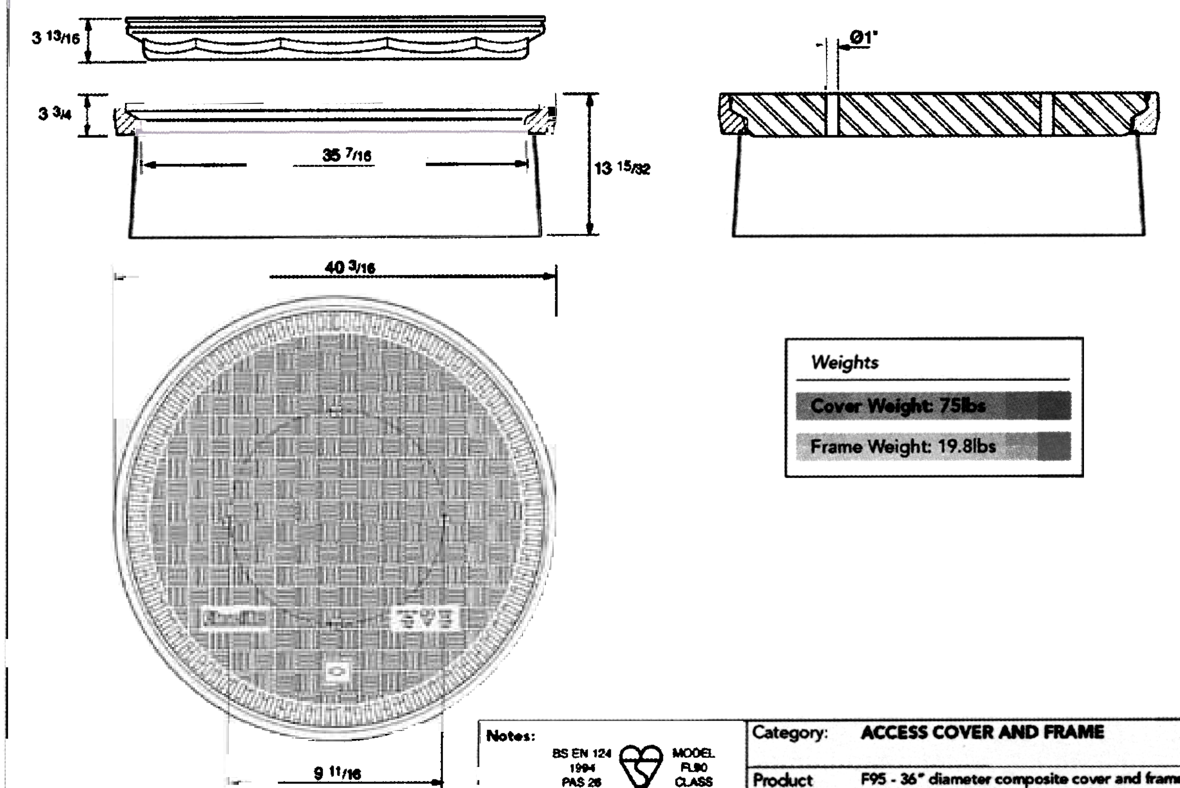

Weights

Cover Weight: 75lbs

Frame Weight: 19.8lbs

Notes:

BS EN 124 1994 PAS 26 1998

MODEL FL90 CLASS C250

For reference puposes only.
This drawing is not a specification.

Category:	**ACCESS COVER AND FRAME**
Product Description:	**F95 - 36" diameter composite cover and frame with LG2 Gun Metal key housing for steam applications**
Drawing No.: **US12951**	Product Code: **F95**
Date: **April 2005**	Revisons:

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