

# HUB ALERT™

## Heat Sensing Labels

REPORT NUMBER 11-15-C0165B Revision 1

### **“Temperature Activation Test on HUB ALERT™ Heat Sensing Labels”**

NOTE TO READER:

The attached report prepared by Exova Canada for Spectra Products Inc. details the independent testing undertaken to confirm the surface temperature of sample hub/hubcaps at which the HUB ALERT™ heat sensing labels activated.

In the test environment, given the short time span required for the testing and the oil stationary rather than circulating, the internal hub/hubcap oil was heated to very high temperature levels in order to activate the HUB ALERT™ sensors on the test surfaces in the shortest time possible. Actual internal hub/hubcap oil temperatures during equipment operation would be considerably lower to activate the HUB ALERT™ sensors.

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## Temperature Activation Test on HUB ALERT™ Heat Sensing Labels

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## 1.0 INTRODUCTION

Spectra Products Inc. submitted forty (40) HUB ALERT™ heat sensing labels for performance testing in accordance with customer-supplied test protocol. We were informed that such labels are applied to the wheel hubs and hub caps of trucks, trailers and buses in order to provide an early warning temperature alert for wheel hub oil. Specifically, the label will turn black permanently if the temperature reaches 250°F (121°C) in order to alert the driver that further inspection is required (wheel end manufacturers recommend a detailed inspection if temperatures reach 250°F in order to address potential seal and bearing problems).

The received test samples were assigned an Exova sample number and cross referenced to Spectra Product's description as listed:

<u>Exova Sample No.</u>	<u>Description</u>
11-15-0165-1 to 40	Forty (40) HUB ALERT™ heat sensing labels #16914 SWISS CelsiDot® Label dimension: 19 mm x 25 mm

We were instructed to evaluate the heat sensing labels in terms of Pressure Washing Resistance (Adhesion Effectiveness) and Temperature Activation. This report contains the results from the Temperature Activation test.

Also submitted for testing were the following items:

- One aluminum hub cap (STEMCO HUB-SEAL 2, Longview, Texas, 4009).
- One plastic hub cap (International 3531209C91, U.S. Pat. 5,505, 525).
- One steel hub and hub cap (6-X-1350 FOM B110-9).
- Metal fixture for mounting the steel hub and hub cap horizontally and a 1500 W, 120 V heating element (FITSALL™) heating element to fit into the oil-filled hub cap (see Appendix A, Figure 1A and Figure 2A).
- Fixture for mounting the plastic and aluminum hub cap horizontally and a 120 V heating element to fit into the oil-filled hub cap (see Appendix A, Figure 3A and Figure 4A).
- Four 1 quart bottles of Delo® SAE 80W-90 gear lubricant ESI.

## 2.0 TEST EQUIPMENT

- THERMOTRON F-94CHMV environmental chamber, MII No. A14571 (Calibrated)
- FLUKE 572 IR thermometer, MII No. B011644 (For Reference Only)
- FLUKE Hydra Series II data acquisition system, MII No. A13654 (Calibrated)
- Thermocouple, type K, MII No. A14571 (Calibrated)

## 3.0 PROCEDURES

The accuracy of the FLUKE 572 IR thermometer was verified as follows. A steel weight with a mass of approximately 8 lb. was placed into a THERMOTRON F-94CHMV environmental chamber and the tip of the type K thermocouple was attached to the weight with aluminum adhesive tape. The chamber was set a temperature of 80°C and maintained at that temperature overnight.

Subsequently, the surface temperature of the metal weight was read with the IR thermometer through a port hole located in the side of the chamber and a temperature reading was also taken via the thermocouple. The above procedure was repeated with the chamber set at 105°C and 130°C.

The results were as follows:

<u>Temperature, °C (Type K thermocouple)</u>	<u>Temperature, °C (IR thermometer)</u>
79.8	78.9
104.8	105.6
130.5	129.7

Three (3) sets of Temperature Activation tests were performed, as follows:

1. Temperature activation of HUB ALERT™ heat sensing labels attached to the steel hub and hub cap.
2. Temperature activation of HUB ALERT™ heat sensing labels attached to the plastic hub and hub cap.
3. Temperature activation of HUB ALERT™ heat sensing labels attached to the aluminum hub and hub cap.

A Spectra Products representative was present to witness the testing.

Prior to testing, HUB ALERT™ heat sensing labels were manually applied to the hub / hub caps on surfaces pre-cleaned with a de-greaser and/or sandpaper, as required. The labels were applied as follows:

Steel Hub and Hub Cap

- 3 labels manually applied to the side of the hub surface and 2 labels to the surface of the hub cap (Exova sample no. 11-15-0165-28 to 32).

Plastic Hub Cap

- 3 labels manually applied to the side surface of the hub cap and 2 labels to the end surface of the hub cap (Exova sample no. 11-15-0165-33 to 37).

Aluminum Hub Cap

- 3 labels manually applied to the side of the aluminum hub cap (Exova sample no. 11-15-0165-38 to 40)

**3.1 Temperature Activation of HUB ALERT™ Labels Affixed to the Steel Hub and Hub Cap**

The temperature activation test procedure for the steel hub and hub cap was as follows:

1. Place hub and hubcap with gasket affixed into the holding fixture and secure.
2. Fill hub with 2 L of the oil provided and previously stored at room temperature.
3. Insert the heating element into the oil.
4. Insert the tip a type K thermocouple connected to a *FLUKE* data acquisition system into the oil bath and commence data logging of the oil temperature at 1-minute intervals.
5. Take initial surface temperature readings of the HUB ALERT™ heat sensing labels attached to the steel hub / hubcap surfaces with the *FLUKE 572* IR thermometer by centering the 3 red dots inside the white circles of the labels.
6. Attach the heating element to a powerstat and heat the oil to a temperature of 107°C (225°F).
7. Record the surface temperature of the the HUB ALERT™ heat sensing labels with the IR thermometer.
8. Heat the oil to 121°C (250°F).

9. Record the surface temperature of the HUB ALERT™ heat sensing labels with the IR thermometer.
10. Maintain the oil temperature at 121°C (250°F) for 30 minutes while monitoring the surface temperature of the HUB ALERT™ heat sensing labels.
11. If the surface temperature of the HUB ALERT™ heat sensing labels does not reach activation temperature (121°C, 250°F), raise the oil temperature by increasing the setting on the powerstat.
12. Monitor the surface temperatures of the HUB ALERT™ heat sensing labels and record the temperatures at which the individual labels begin to activate.

A photograph of the test set-up is provided in Appendix A, Figure 5A.

### 3.2 Temperature Activation of HUB ALERT™ Labels Affixed to the Plastic and the Aluminum Hub Cap

The temperature activation test procedure for the plastic hub cap and the aluminum hub cap was as follows:

1. Place hubcap into the holding fixture and secure.
2. Fill hub with 250 mL of the oil provided and previously stored at room temperature.
3. Insert the heating element into the oil.
4. Insert the tip a type K thermocouple connected to a *FLUKE* data acquisition system into the oil bath and commence data logging of the oil temperature at 1-minute intervals.
5. Take initial surface temperature readings of the HUB ALERT™ heat sensing labels attached to the plastic hub cap surfaces with the *FLUKE* 572 IR thermometer by centering the 3 red dots inside the white circles of the labels.
6. Attach the heating element to a powerstat and heat the oil to a temperature of 107°C (225°F).
7. Record the surface temperature of the the HUB ALERT™ heat sensing labels with the IR thermometer.
8. Heat the oil to 121°C (250°F).
9. Record the surface temperature of the HUB ALERT™ heat sensing labels with the IR thermometer.
10. Maintain the oil temperature at 121°C (250°F) for 30 minutes while monitoring the surface temperature of the HUB ALERT™ heat sensing labels.
11. If the surface temperature of the HUB ALERT™ heat sensing labels does not reach activation temperature (121°C, 250°F), raise the oil temperature by increasing the setting on the powerstat.
12. Monitor the surface temperatures of the HUB ALERT™ heat sensing labels and record the temperatures at which the individual labels begin to activate.

A photograph of the test set-up for the plastic hub cap is provided in Appendix A, Figure 6A while a photograph of the test set-up for the aluminum hub cap is provided in Appendix A, Figure 7A.

## 4.0 RESULTS

### 4.1 Temperature Activation of HUB ALERT™ Labels Affixed to the Steel Hub and Hub Cap

Five HUB ALERT™ heat sensing labels were attached, three to the side of the hub surface and two to the surface of the hub cap (see Appendix A, Figure 8A and 9A, respectively).

Temperature readings taken on the labels indicated that the hub surface heated up at a slow rate. Hence the oil temperature was raised gradually to 140°C (284°F) and it was maintained at that temperature for approximately 20 minutes. At this point the following temperatures were recorded for the labels:

<u>Label ID (Exova Sample No.)</u>	<u>Location</u>	<u>Temperature (°C)</u>
11-15-0165-28	Side	77 (171°F)
11-15-0165-29	Side	78 (172°F)
11-15-0165-30	Side	80 (176°F)
11-15-0165-31	Hub Cap	60 (140°F)
11-15-0165-32	Hub Cap	61 (142°F)

Within approximately 90 minutes for start of the test, the oil temperature was gradually increased to 190°C (374°F) and the following temperatures were recorded for the labels:

<u>Label ID (Exova Sample No.)</u>	<u>Location</u>	<u>Temperature (°C)</u>
11-15-0165-28	Side	98 (208°F)
11-15-0165-29	Side	99 (210°F)
11-15-0165-30	Side	103 (217°F)
11-15-0165-31	Hub Cap	83 (181°F)
11-15-0165-32	Hub Cap	84 (183°F)

Within the next 20 minutes the oil temperature was further increased to 230°C (446°F), at which point the labels affixed to the side of the hub started to activate, as observed by a gradual darkening of the white dots at the centre of the labels. This culminated with the dots turning black (final activation). Initial activation and final activation temperatures were as follows:

<u>Label ID</u>	<u>Initial Activation Temp. (°C)</u>	<u>Final Activation Temperature (°C)</u>
11-15-0165-28	116 (241°F)	119 (246°F)
11-15-0165-29	117 (243°F)	122 (252°F)
11-15-0165-30	117 (243°F)	119 (246°F)

In order for the labels affixed to hub cap to activate the oil temperature was further increased to 250°C (482°F). The labels activated at the following temperatures:

<u>Label ID</u>	<u>Initial Activation Temp. (°C)</u>	<u>Final Activation Temperature (°C)</u>
11-15-0165-31	116 (241°F)	119 (246°F)
11-15-0165-32	117 (243°F)	122 (252°F)

Partial temperature activation of the HUB ALERT™ labels affixed to the side of the hub (Exova sample numbers 11-15-0165-29 and 30) is shown in Appendix A, Figure 10A and full temperature activation of the same labels is shown in Appendix A, Figure 11A. Partial temperature activation of the HUB ALERT™ labels affixed to the surface of the hub cap (Exova sample numbers 11-15-0165-31 and 32) is shown in Appendix A, Figure 12A. The oil temperature data for the test is presented graphically in Appendix B, Figure 1B.

#### 4.2 Temperature Activation of HUB ALERT™ Labels Affixed to the Plastic Hub Cap

Three HUB ALERT™ heat sensing labels were affixed to the side surface of the hub cap and two to the end surface of the hub cap (see Appendix A, Figure 13A). As instructed by the client, the labels were attached to an area of the side that was not in proximity to the internal heating element.

The oil temperature was raised gradually to 121°C (250°F) and held at that temperature for 30 minutes. The following temperature readings were taken on the labels:

<u>Label ID (Exova Sample No.)</u>	<u>Location</u>	<u>Temperature, °C (°F)</u>
11-15-0165-33	Side	85 (185°F)
11-15-0165-34	Side	81 (178°F)
11-15-0165-35	Side	80 (176°F)
11-15-0165-36	End	45 (113°F)
11-15-0165-37	End	46 (115°F)

Surface temperature readings were also taken at the top of the hub's side as well as at the bottom of the side and the following temperatures were recorded: 90°C (194°F) at the top and 76°C (169°F) at the bottom. This confirmed the presence of a pronounced temperature gradient.

The oil temperature was gradually increased up to 170°C (338°F). When the oil temperature was at 160°C (320°F), the following temperatures were recorded for the labels:

<u>Label ID (Exova Sample No.)</u>	<u>Location</u>	<u>Temperature (°C)</u>
11-15-0165-33	Side	105 (221°F)
11-15-0165-34	Side	102 (216°F)
11-15-0165-35	Side	99 (210°F)
11-15-0165-36	End	49 (120°F)
11-15-0165-37	End	49 (120°F)

Due to the hub cap's temperature gradient, only the upper halves of the labels applied to the side of the hub cap activated. The label identified with Exova sample no. 11-15-0165-33 activated first (see Appendix A, Figure 14A), followed by the other two labels applied to the side of the hub cap (see Appendix A, Figure 15A and Figure 16A). Since only the upper half of each label had activated, temperature readings were taken in these areas, as follows:

<u>Label ID</u>	<u>Activation Temperature (°C)</u>
11-15-0165-33	119 (246°F)
11-15-0165-34	118 (244°F)
11-15-0165-35	118 (244°F)

Surface temperature readings were again taken at the top of the hub's side as well as at the bottom of the side and the following temperatures were recorded: 138°C (280°F) at the top and 75°C (167°F) at the bottom. At this point it was decided to terminate the test. Additional temperature readings were taken on the labels applied to the end surface of the hub cap and both labels recorded a temperature of 55°C (131°F).

The oil temperature data for the test is presented graphically in Appendix B, Figure 2B.

**4.3 Temperature Activation of HUB ALERT™ Labels Affixed to the Aluminum Hub Cap**

Three HUB ALERT™ heat sensing labels were attached to the side surface of the hub cap (see Appendix A, Figure 17A and Figure 18A). As instructed by the client, the labels were attached to an area of the side that was not in proximity to the internal heating element.

The oil temperature was raised to 130°C (266°F) and held at that temperature for 15 minutes. Temperature readings taken on the labels, as follows:

<u>Label ID (Exova Sample No.)</u>	<u>Location</u>	<u>Temperature, °C (°F)</u>
11-15-0165-38	Side	95 (203°F)
11-15-0165-39	Side	95 (203°F)
11-15-0165-40	Side	93 (199°F)

Since the powerstat had malfunctioned the power to the heater was subsequently controlled by manually interrupting the voltage supplied to the heater. In this fashion the oil temperature was further raised to approximately 160°C (320°F). At this point the labels started to activate. Initial activation and final activation temperatures were as follows:

<u>Label ID</u>	<u>Initial Activation Temp. (°C)</u>	<u>Final Activation Temperature (°C)</u>
11-15-0165-38	117 (243°F)	119 (246°F)
11-15-0165-39	117 (243°F)	119 (246°F)
11-15-0165-40	118 (244°F)	120 (248°F)

Partial and complete temperature activation of the HUB ALERT™ label identified with Exova sample numbers 11-15-0165-39 is shown in Appendix A, Figure 19A and Figure 20A, respectfully. Complete temperature activation of the label identified with Exova sample numbers 11-15-0165-40 is shown in Appendix A, Figure 21A.

The oil temperature data for the test is presented graphically in Appendix B, Figure 3B.

**4.0 DISCUSSION**

HUB ALERT™ heat sensing labels were affixed to an oil-filled steel hub and hub cap, an oil-filled plastic hub cap, and an oil-filled aluminum hub cap. The oil was then gradually heated until the heat sensing labels activated. The activation temperatures of the labels were measured by means of an IR thermometer.

Regarding the labels affixed to the steel hub and hub cap, the HUB ALERT™ heat sensing labels activated within the following temperature ranges:

- Initial Activation Temperature: 116°C to 117°C (241°F to 243°F)
- Final Activation Temperature: 119°C to 122°C (246°F to 252°F)



Regarding the labels affixed to the aluminum cap, the HUB ALERT™ heat sensing labels activated within the following temperature ranges:

- Initial Activation Temperature: 117°C to 118°C (243°F to 244°F)
- Final Activation Temperature: 119°C to 120°C (246°F to 248°F)

The temperature of the plastic hub cap varied considerably from top to bottom and only the upper halves of the labels applied to the side of the hub cap activated. The HUB ALERT™ heat sensing labels activated within the following temperature ranges:

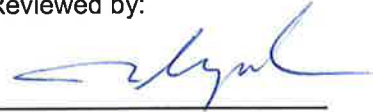
- Final Activation Temperature: 118°C to 119°C (244°F to 246°F)

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**Appendix A**

Photographs

(11 Pages)



Figure 1A : The steel hub / hub cap affixed to the test fixture provided



Figure 2A : The heating element for insertion into the oil-filled hub



Figure 3A : The plastic hub cap affixed to the test fixture provided



Figure 4A : The heating element for insertion into the oil-filled hub cap (plastic and aluminum hub caps)



Figure 5A : Temperature activation test set-up for the steel hub and hub cap



Figure 6A : Temperature activation test set-up for the plastic hub cap

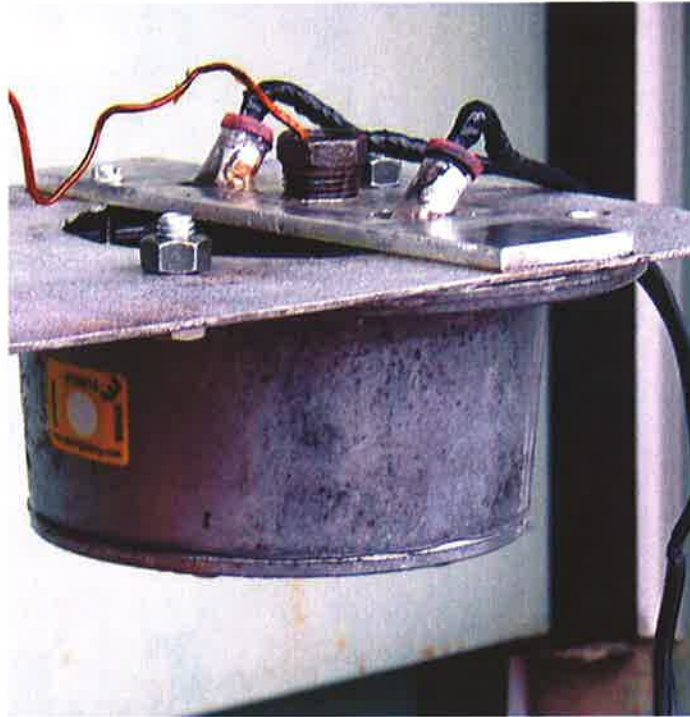


Figure 7A : Temperature activation test set-up for the aluminum hub cap



Figure 8A : Labels attached to the side of the steel hub



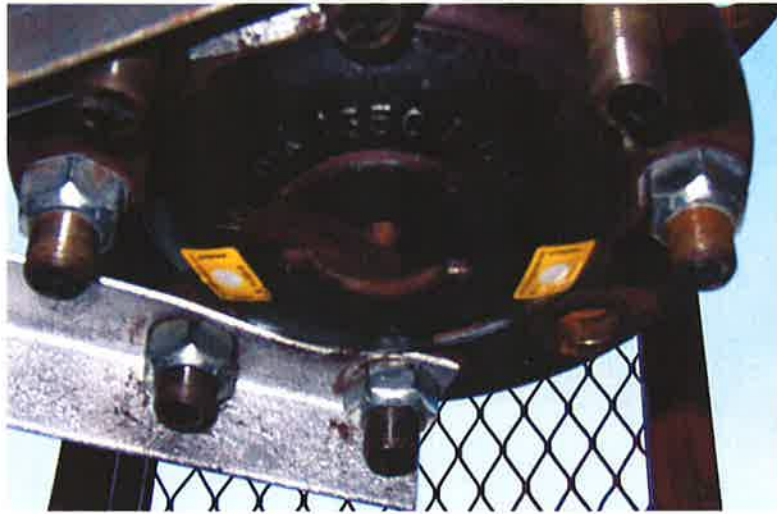


Figure 9A : Labels attached to the surface of the steel hub hub cap



Figure 10A : Steel hub with labels – Partial temperature activation of HUB ALERT™ heat sensing labels  
(Exova sample numbers 11-15-0165-29 and 30, labels applied to side of hub)

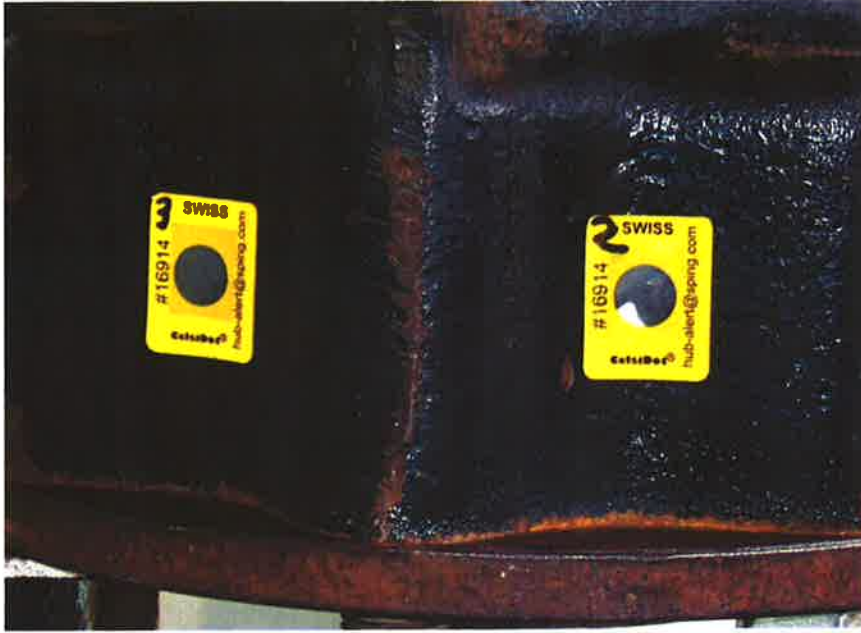


Figure 11A : Steel hub with labels – Full temperature activation of HUB ALERT™ heat sensing labels (Exova sample numbers 11-15-0165-29 and 30), labels applied to side of hub

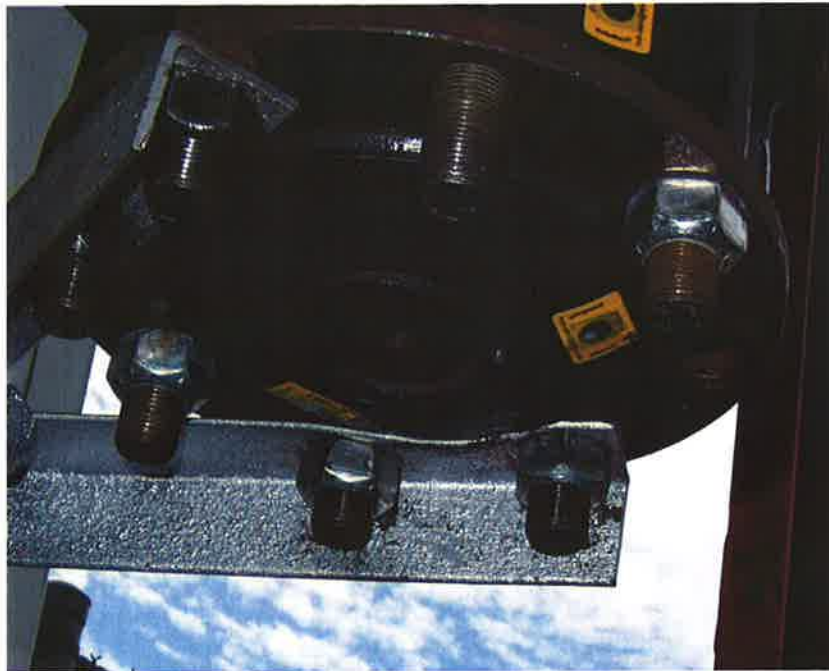


Figure 12A : Steel hub with labels – Partial temperature activation of HUB ALERT™ heat sensing labels (Exova sample numbers 11-15-0165-31 and 32), labels applied to the surface of the hub cap





Figure 13A : Temperature activation test set-up for plastic hub cap



Figure 14A : Plastic hub cap, showing partial temperature activation of HUB ALERT™ heat sensing label  
(Exova sample numbers 11-15-0165-33, labels applied to side of hub cap)

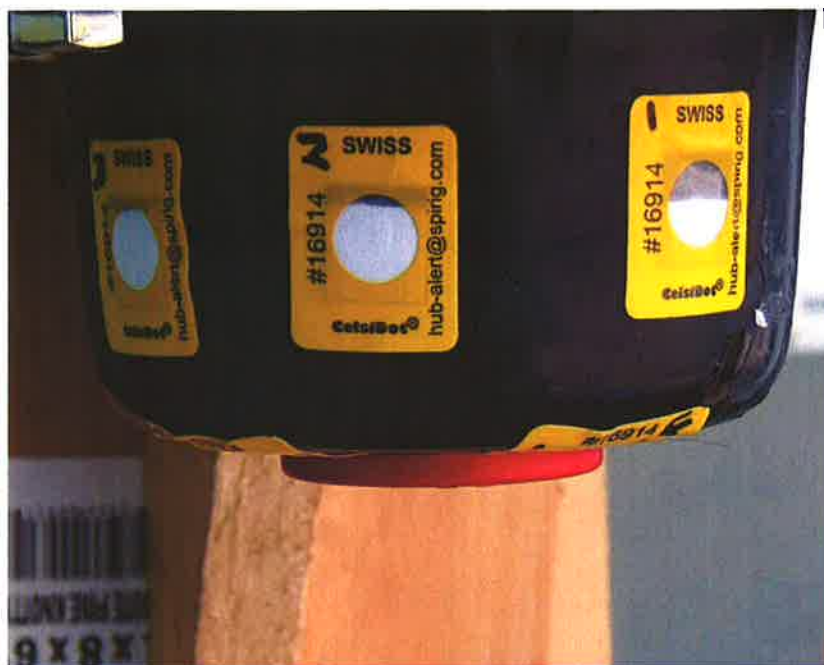


Figure 15A : Plastic hub cap, showing partial temperature activation of HUB ALERT™ heat sensing labels (Exova sample numbers 11-15-0165-33 to 35 labels applied to side of hub cap)



Figure 16A : Plastic hub cap, showing partial temperature activation of HUB ALERT™ heat sensing labels (Exova sample numbers 11-15-0165-33 to 35 labels applied to side of hub cap)

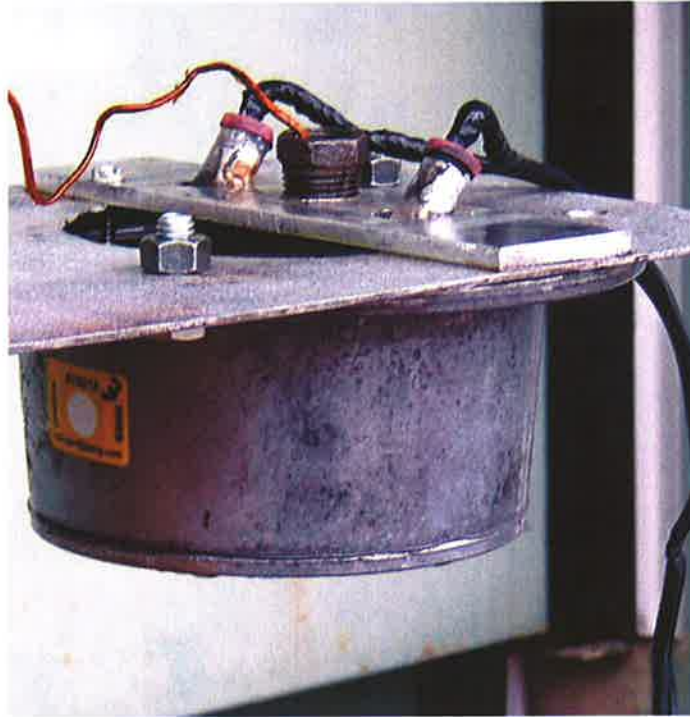


Figure 17A : Temperature activation test set-up for plastic hub cap



Figure 18A : Temperature activation test set-up for plastic hub cap



Figure 19A : Aluminum hub cap, showing partial temperature activation of HUB ALERT™ heat sensing label (Exova sample numbers 11-15-0165-39)



Figure 20A : Aluminum hub cap, showing complete temperature activation of HUB ALERT™ heat sensing label (Exova sample numbers 11-15-0165-39)



Figure 21A : Aluminum hub cap, showing complete temperature activation of HUB ALERT™ heat sensing label (Exova sample numbers 11-15-0165-40)



**Appendix B**

Figure 1B to Figure 3B

(3 Pages)

### Temperature Activation Test: Oil Temperature for the Steel Hub and Hub Cap

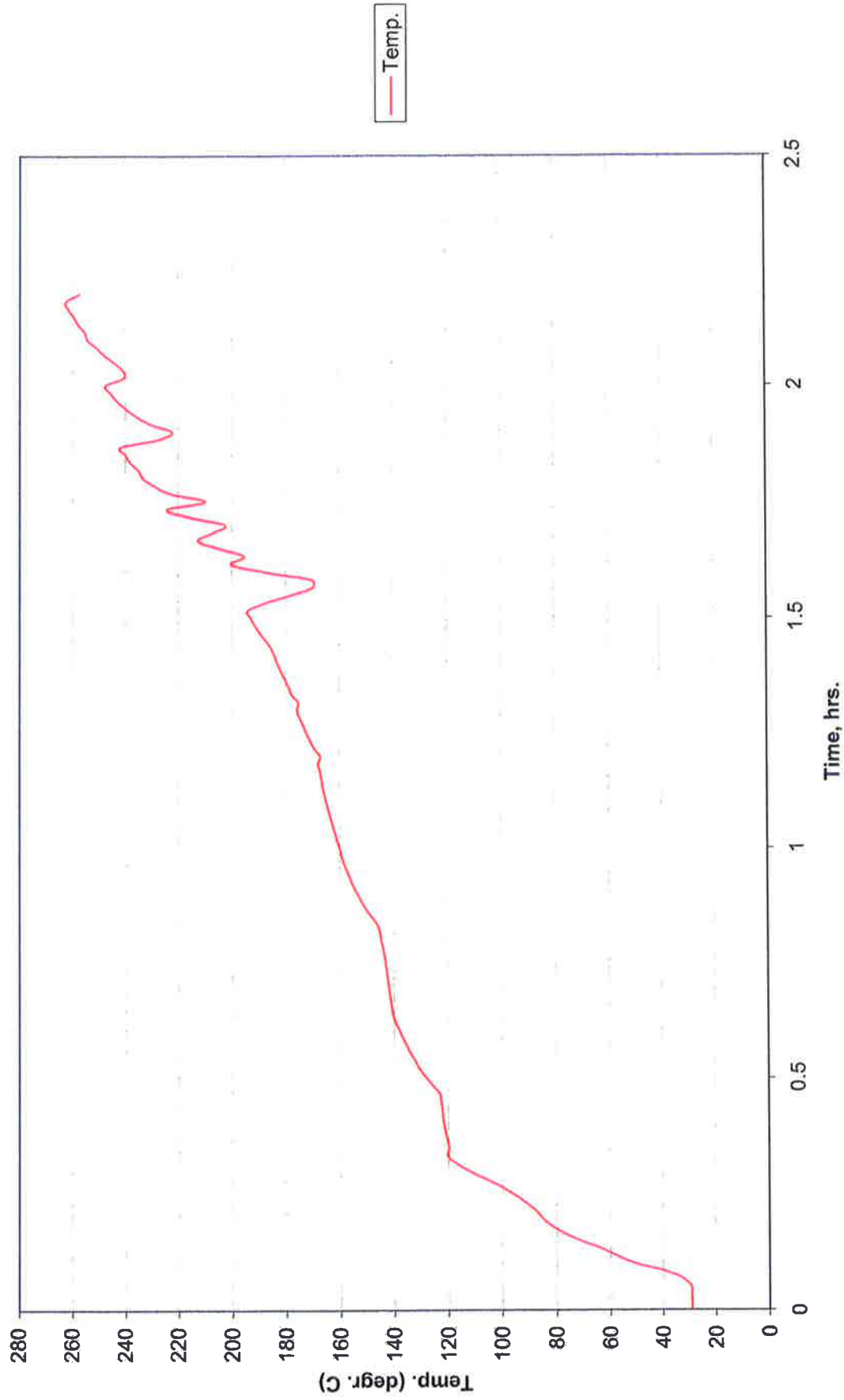


FIGURE 1B

### Temperature Activation Test: Oil Temperature for the Plastic Hub Cap

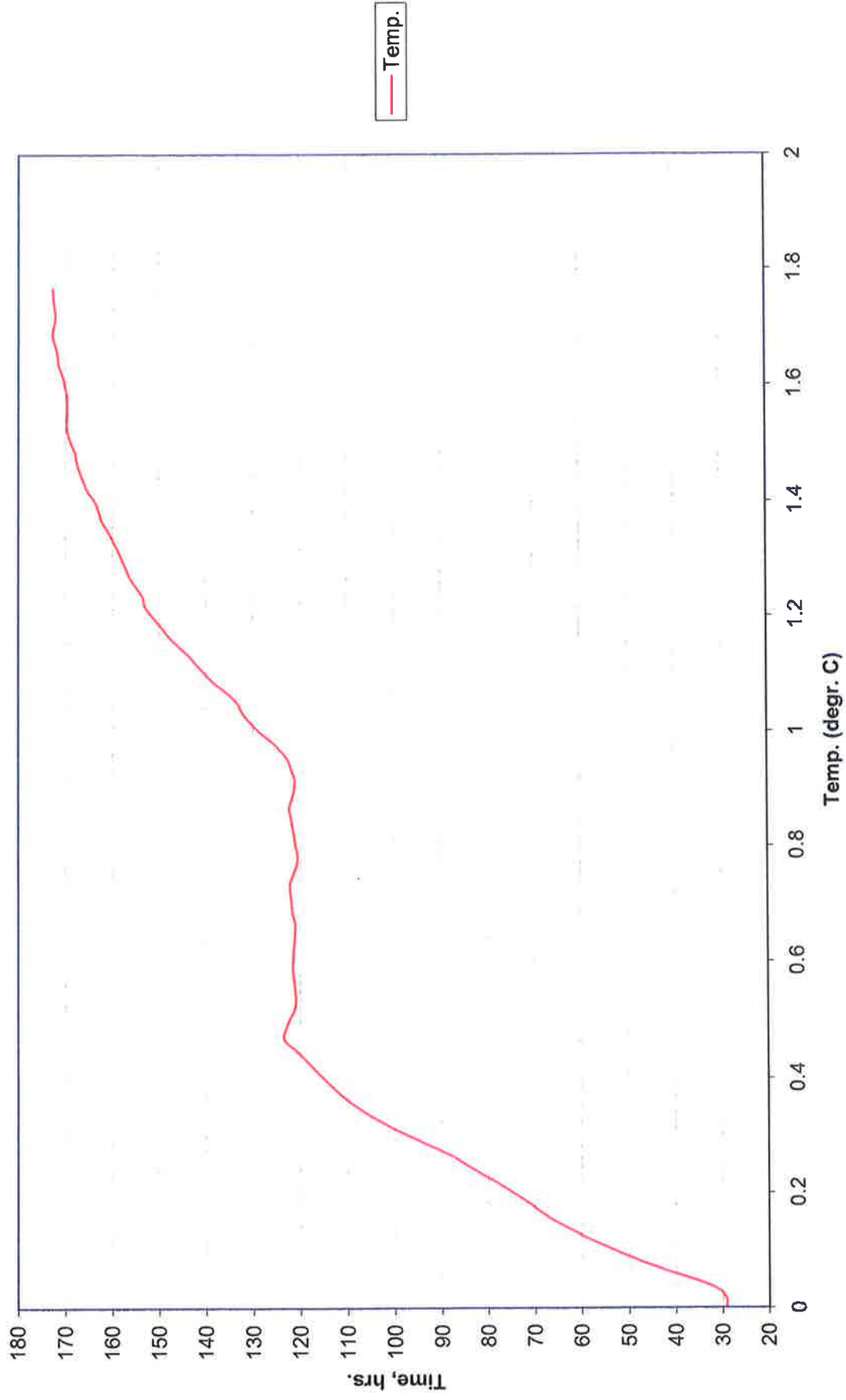


FIGURE 2B



### Temperature Activation Test: Oil Temperature for the Aluminum Hub

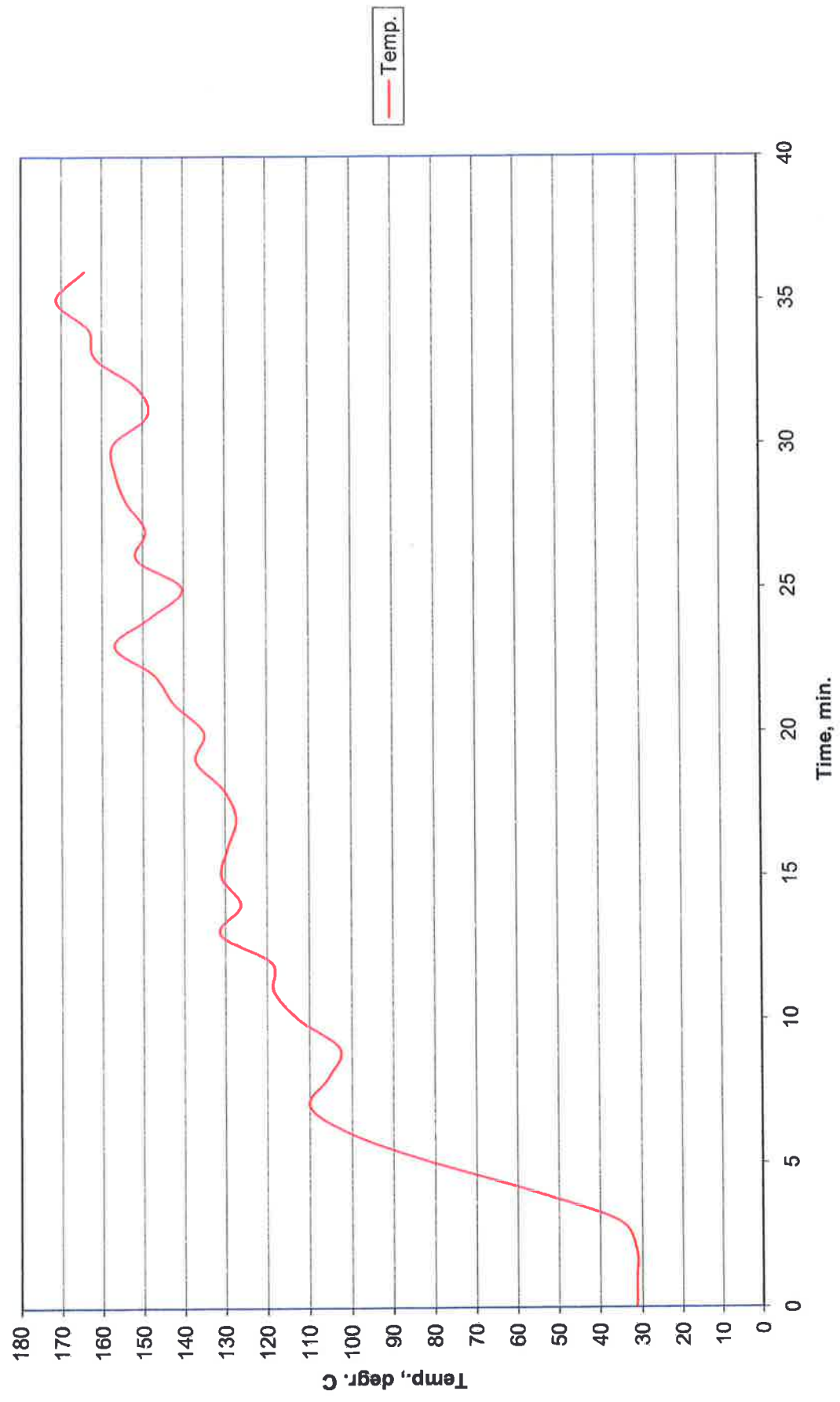


FIGURE 3B