



Study of Excessive Temperatures in Enclosed Vehicles

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Jan Null, CCM ^{1,2}

Also see: [Fact Sheet](#) & [2003 Hyperthermia Fatalities \(Children in Vehicles\)](#)

BACKGROUND

Every year dozens of children tragically die due to hyperthermia (heat stroke) after being left unattended in cars, trucks and vans. Over the past five years in the United States 160 deaths of this type have been documented ([Kids and Cars](#) and [4 R Kids Sake™](#), 2003). Hundreds of other children left in similar situations suffer great bodily harm and these numbers do not include similar consequences to infirm adults or animals.

OBJECTIVE

This study quantifies vehicle temperatures and temperature changes with time under a variety of meteorological circumstances.

STUDY DESIGN

Temperature sensors were placed two types of vehicles on sunny days with ambient temperatures ranging from 70 F (21C) to 100 F (38C). The initial interior temperature was regulated to equal the ambient temperature. The vehicles were in full sun but the sensors in the vehicles were not subject to direct sunlight and were not in direct contact with any interior surface. Except as noted in the results, the trials were conducted in a mid-sized dark blue sedan with medium gray interior and all of the windows were fully closed. Using wireless temperature sensors the ambient outside and the inside vehicle temperatures were sampled every five minutes for at least one hour. A secondary vehicle (a white mini-van with light gray interior) was used for some tests. Neither vehicle had tinted windows.

TRIAL SUMMARY

Between May 16, 2002 and Aug 8, 2002 twenty-one trials were conducted on 15 days. Table 1 summarizes the ambient and inside vehicle temperatures on the primary test vehicle with the windows fully closed. Table 2 compares the temperature in the primary test vehicle on two occasions when the windows were fully closed and then when they were "cracked" open approximately 1.5 inches (3.8 cm). Table 3 is a summary of two additional test cases using the primary vehicle and the secondary vehicle.

Table 1. Temperatures F (C), Primary Test Vehicle, Windows Closed

Date	Ambient Temp	10 min		20 min		30 min		60 min	
		Temp.	Temp Rise	Temp.	Temp Rise	Temp.	Temp Rise	Temp.	Temp Rise
6/7/2002	72 (22.2C)	93 (33.9C)	21 (11.7C)	105 (40.6C)	33 (18.3C)	110 (43.3C)	38 (21.1C)	119 (48.3C)	47 (26.1C)
5/16/2002	73 (22.8C)	90 (32.2C)	17 (9.4C)	99 (37.2C)	26 (14.4C)	104 (40.0C)	31 (17.2C)	112 (44.4C)	39 (21.7C)
6/17/2002	74 (23.3C)	95 (35.0C)	21 (11.7C)	104 (40.0C)	30 (16.7C)	110 (43.3C)	36 (20.0C)	125 (51.7C)	51 (28.3C)
6/7/2002	75 (23.9C)	87 (30.6C)	12 (6.7C)	104 (40.0C)	29 (16.1C)	111 (43.9C)	36 (20.0C)	120 (48.9C)	45 (25.0C)
6/6/2002	77 (25.0C)	96 (35.6C)	19 (10.6C)	106 (41.1C)	29 (16.1C)	110 (43.3C)	33 (18.3C)	122 (50.0C)	45 (25.0C)
6/24/2002	78 (25.6C)	95 (35.0C)	17 (9.4C)	105 (40.6C)	27 (15.0C)	107 (41.7C)	29 (16.1C)	117 (47.2C)	39 (21.7C)
6/25/2002	78 (25.6C)	95 (35.0C)	17 (9.7C)	102 (38.9C)	24 (13.3C)	106 (41.1C)	28 (15.6C)	117 (47.2C)	39 (21.7C)
5/30/2002	81 (27.2)	98 (36.7C)	17 (9.4C)	108 (42.2C)	27 (15.0C)	113 (45.0C)	32 (17.8C)	114 (45.6C)	33 (18.3C)
5/24/2002	82 (27.8C)	109 (42.8C)	27 (15.0C)	119 (48.3C)	37 (20.6C)	119 (48.3C)	37 (20.6C)	130 (54.4C)	48 (26.7C)
6/4/2002	82 (27.8C)	107 (41.7C)	25 (13.9C)	116 (46.7C)	34 (18.9C)	121 (49.4C)	39 (21.7C)	132 (55.6C)	50 (27.8C)

6/6/2002	84 (28.9C)	103 (39.4C)	19 (10.6C)	111 (43.9C)	27 (15.0C)	116 (46.7C)	32 (17.8C)	127 (52.8C)	43 (23.9C)
6/30/2002	87 (30.6C)	101 (38.3C)	14 (7.8C)	105 (40.6C)	18 (10.0C)	107 (41.7C)	20 (11.1C)	119 (48.3C)	32 (17.8C)
6/10/2002	88 (31.1C)	105 (40.6C)	17 (9.4C)	117 (47.2C)	29 (16.1C)	125 (51.7C)	37 (20.6C)	137 (58.3C)	49 (27.2C)
7/1/2002	91 (32.8C)	117 (47.2C)	26 (14.4C)	124 (51.1C)	33 (18.3C)	129 (53.9C)	38 (21.1C)	138 (58.9C)	47 (26.1C)
6/5/2002	93 (33.9C)	106 (41.1C)	13 (7.2C)	114 (40.0C)	21 (11.7C)	119 (48.3C)	26 (14.4C)	137 (58.3C)	44 (24.4C)
7/9/2002	96 (35.6C)	113 (45.0C)	17 (9.4C)	128 (53.3C)	32 (17.8C)	132 (55.6C)	36 (20.0C)	140 (60.0C)	44 (24.4C)

Table 2. Temperatures F (C), Primary Test Vehicle, Windows "Cracked"

Date	Ambient	10 min		20 min		30 min		60 min		Comments
	Temperature	Temp.	Temp Rise	Temp.	Temp Rise	Temp.	Temp Rise	Temp.	Temp Rise	
7/1/2002	91 (32.8C)	117 (47.2C)	26 (14.4C)	124 (51.1C)	33 (18.3C)	129 (53.9C)	38 (21.1C)	138 (58.9C)	47 (26.1C)	Fully closed
7/1/2002	92 (33.3C)	108 (42.2C)	16 (8.9C)	113 (45.0C)	21 (11.7C)	118 (47.8C)	26 (14.4C)	136 (57.8C)	44 (24.4C)	"Cracked"
7/9/2002	96 (35.6C)	113 (45.0C)	17 (9.4C)	128 (53.3C)	32 (17.8C)	132 (55.6C)	36 (20.0C)	140 (60.0C)	44 (24.4C)	Fully closed
7/9/2002	94 (34.4C)	110 (43.3C)	16 (8.9C)	112 (44.4C)	18 (10.0C)	116 (46.7C)	22 (12.2C)	124 (51.1C)	30 (16.7C)	"Cracked"

Table 3. Temperatures F (C), Primary Test Vehicle and Secondary Vehicle

Date	Ambient	10 min		20 min		30 min		60 min		Comments
	Temp	Temp.	Temp Rise	Temp.	Temp Rise	Temp.	Temp Rise	Temp.	Temp Rise	
5/30/2002	81 (27.2C)	98 (36.7C)	17 (9.4C)	108 (42.2C)	27 (15.0C)	113 (45.0C)	32 (17.8C)	114 (40.0C)	33 (18.3C)	Primary
5/30/2002	81 (27.2C)	91 (32.8C)	10 (5.6C)	100 (37.8C)	19 (10.6C)	105 (40.6C)	24 (13.3C)	113 (45.0C)	32 (17.8C)	Secondary
6/17/2002	74 (23.3C)	95 (35.0C)	21 (11.7C)	104 (40.0C)	30 (16.7C)	110 (43.3C)	36 (20.0C)	125 (51.7C)	51 (28.3C)	Primary
6/17/2002	74 (23.3C)	83 (28.3C)	9 (5.0C)	91 (32.8C)	17 (9.4C)	99 (37.2C)	25 (13.9C)	109 (42.8C)	35 (19.5C)	Secondary

METHODS AND PROCEDURES

Vehicle selection. The primary test vehicle was a [2000 Honda Accord](#). The exterior color is dark blue and the interior is a medium gray. The windows are not tinted. The secondary vehicle in the study is a 1997 Honda Odyssey minivan which is white in color with a light gray interior and without tinted windows.

Measurements. Ambient temperatures were recorded with a Davis Instruments Vantage Pro Sensor Suite. Wireless temperature sensors were placed in the test vehicles which transmitted to and were archived in the Vantage Pro base station. The temperature sensors had a resolution of 1 F (0.6C) and an accuracy of +/- 1 F (0.6C). All readings were taken out of direct sunlight.

Experimental procedures. Trials were conducted on a number of cloud-free days with varying ambient temperatures. The vehicles were parked facing at approximately a 45 degree angle away from the sun to minimize direct sunlight through the windshield.

Results

In the sixteen cases with the windows fully closed, the average temperature rise was 19 F (10.6C) in the first 10 minutes. After 20 minutes the average rise was 29 F (16.1C). At the 30 minute mark the average rise was 33 F (18.3C). The average rise after 60 minutes was 43 F (24C) degrees. In trials that exceeded 60 minutes the interior vehicle readings stabilized. (see Figures 1 & 2)

Figure 1.

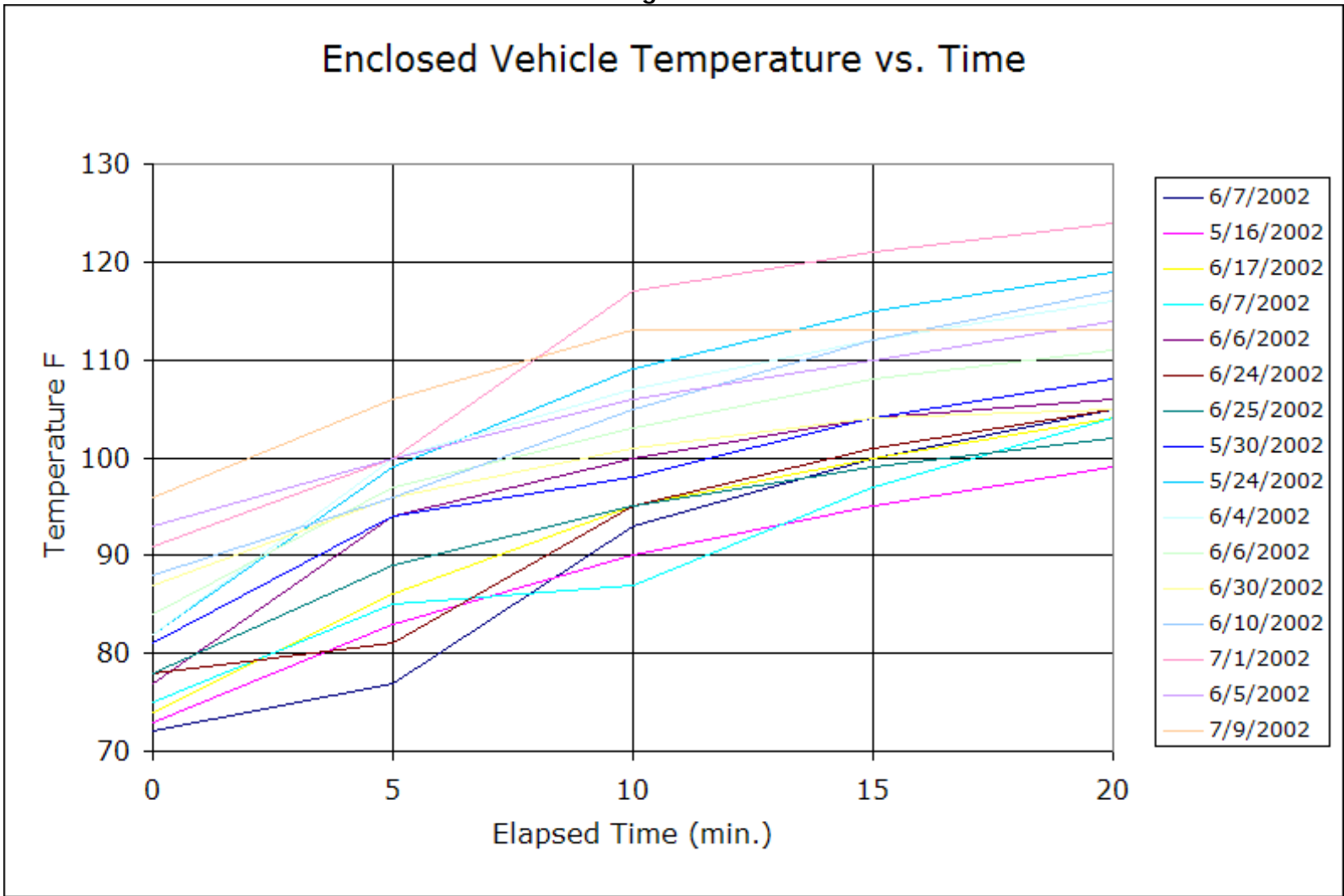
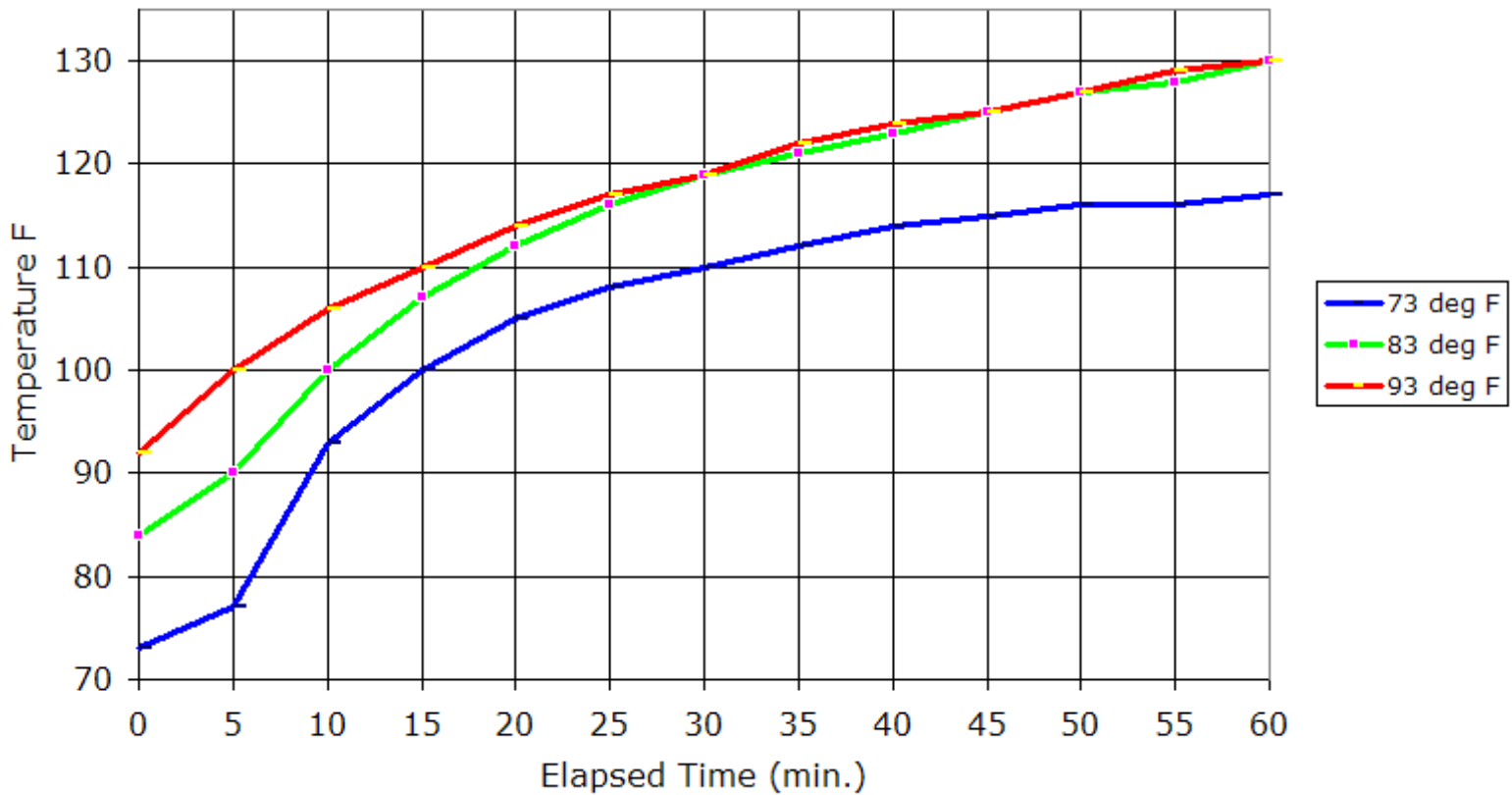


Figure 2.

Enclosed Vehicle Temperature vs. Time (3 cases)

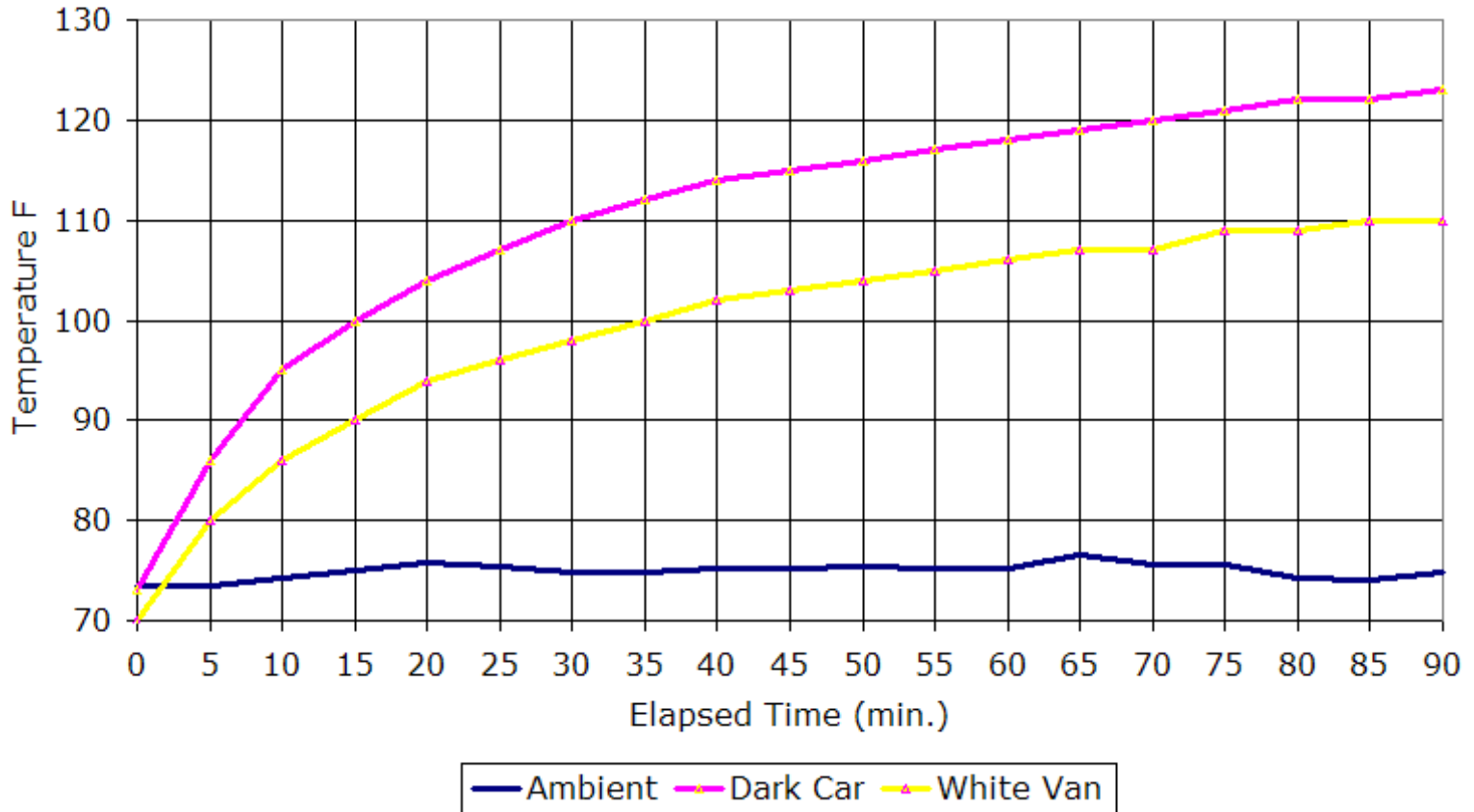


On the two occasions with the windows "cracked" open the average 10 minute rise was 16 F (8.9C), then 20 F (11.2C) after 20 minutes, 24 F (13.3C) after 30 minutes and the 60 minutes average rise of 37 F (20.1C).

An additional two trials were conducted with simultaneous readings in the primary test vehicle and the secondary vehicle. (see Figure 3) The average 10 minute rise in the primary test vehicle was 19 F (10.6C) compared to 10 F (5.6C) in the secondary vehicle. After 20 minutes the respective average rises were 29 F (16.1C) and 18 F (10.0C), and after 30 minutes they were 34 F (18.9C) and 24 F (13.3C). The average one hour rises were 42 F (23.3C) and 34 F (18.9C) respectively.

Figure 3.

Enclosed Vehicle Temperature vs. Time (Primary & Secondary)



ADDITIONAL RESEARCH

This investigation sought to determine the rate and extent of temperature rises in enclosed vehicles using only a single parameter, temperature, for evaluation. Additional work should be done to examine any influence of relative humidity upon the change in the vehicle's interior temperature.

Further studies should also be undertaken to delineate the effect of other factors on a vehicle's interior temperature. These variables include vehicles of different exterior and interior colors and materials as well as window tinting and window coverings.

In addition to children further studies should look at the effects of heat stress on adults and also pets.

CONCLUSIONS

When temperatures exceed 80 F (26.7C) potentially lethal temperatures of 105 F (40.6C) plus can be reached in less than 20 minutes and when they exceed 88 F (31.1C) lethal readings can be reached in 10 minutes or less. Only minor mitigation achieved by "cracking" the windows or having a vehicle of larger size or a lighter color.

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¹ Certified Consulting Meteorologist, Golden Gate Weather Services (phone: 510-657-2246)

² Adjunct Professor, Department of Geosciences, San Francisco State University