The heat is on:
Don’t leave your chocolate candy, kids or pets in a parked car

The SAE International Interior Climate Control Standards Committee has conducted many engineering test programs evaluating the performance of mobile air conditioning systems when vehicles are subjected to hot weather temperatures and high sun load.

Many times the nightly TV news programs report the consequences of a child being left in a parked vehicle under similar conditions.

There are many factors that cause a parked vehicle interior to become like an oven. These include, but are not limited to, the vehicle’s exterior and interior surface colors, the type, angle and size of the windows, and the size of the passenger compartment.

The extensive amount of glass used in vehicles today has a major impact on all vehicle interior surfaces that can be subjected to direct sunlight or the impact of temperatures caused by indirect solar load. Sun load is the major factor on elevating the vehicle interior temperature even on mild temperature days. Even on a cool 65°F day, the temperature at the breath level in some vehicles can reach 105°F in a closed vehicle. On hotter days, temperatures can reach over 150°F and this information has been known for over 50 years.

Heat stroke in an adult person, as reported by some, can occur when body temperature exceeds 104°F. Children can reach dangerous body temperatures at a much faster rate. A person remaining in a parked vehicle, with windows opened or closed, without an operating A/C system can result in their potential exposure to dangerously high body temperatures.

Even when making short stops, at the store or other destinations, interior vehicle conditions may reach 110°F in a matter of minutes. This time can be as short as 6 minutes on an 85°F day with high sun load. Even with the front windows open 2 inches, the interior can warm faster than windows closed, depending on the vehicle travel time and direction of the sun entering the vehicle. Under the same conditions on an 85°F day with a 30 minute stop, the difference between front windows open two inches, windows closed and both front windows full open resulted in the breath level temperature being between 105 and 123°F (Figure and Table 1).

The information in figure 1 and table 1 compares the parked vehicle with both front windows open 2 inches for 30 minutes, all windows closed for 30 minutes followed by two front windows full open for 30 minutes. With the ambient temperature, under full sun exposure, being in the 85°F range, the vehicle breath temperature is above 100°F.

As the data indicates, if the vehicle is parked in sunlight, the midday breath temperatures can be high. It should also be noted that the subject vehicle has all the advantages (white color, and film on windows)

to help reduce the effects of the sun increasing the heat input to the vehicle. Vehicles with dark exterior and interior colors and large window areas can have significantly hotter temperature conditions.

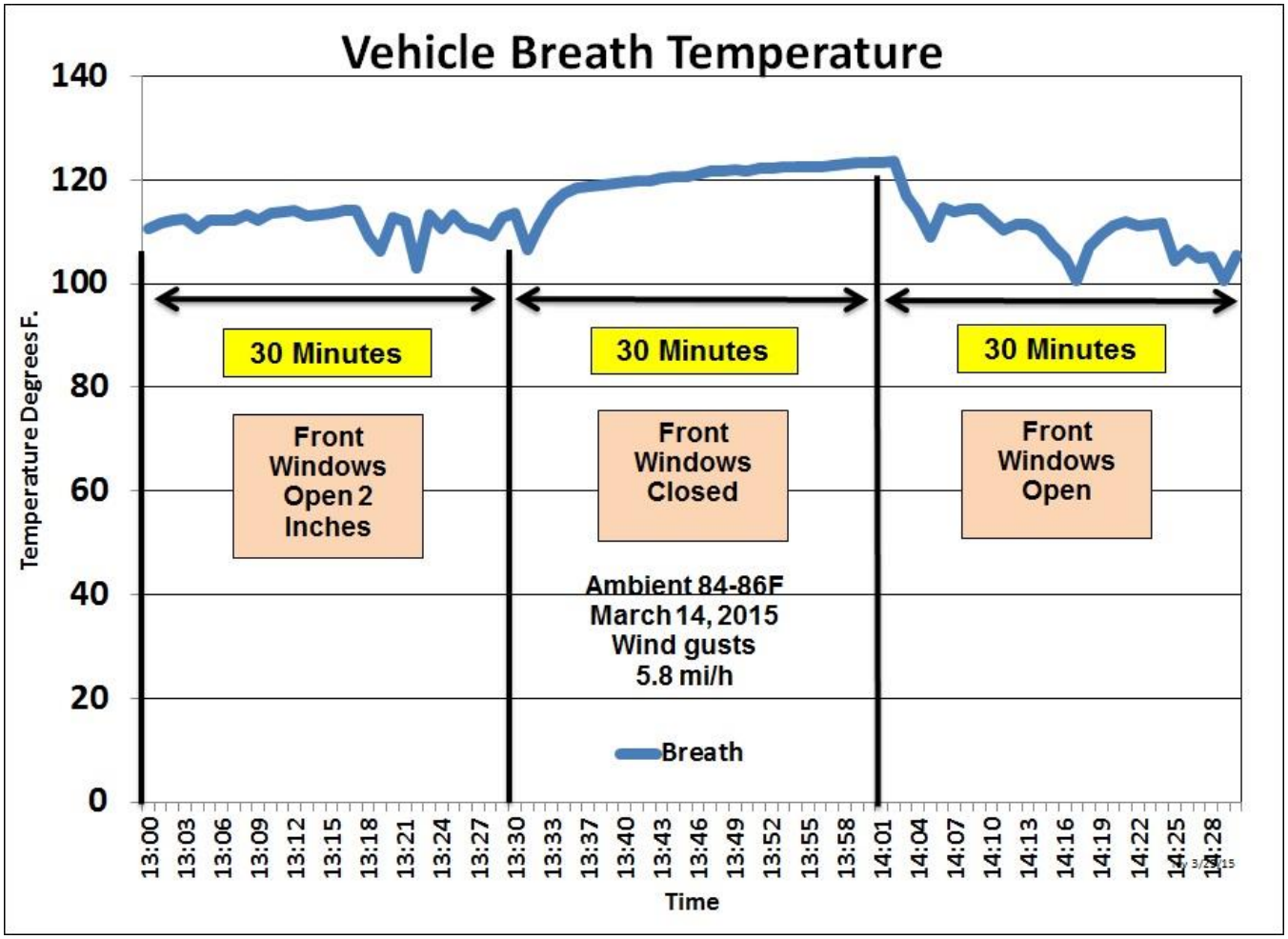


Figure 1*:* Window positions, full sun

Table 1: Ambient 84-86°F (28-30°C), full sun
Window effect over 30 min period, parked vehicle

	Avg. 30 min. Temp	Start	End period

	Breath Level Temperature °F	Breath Level Temperature °F	Breath Level Temperature °F
Front open 2"	**111.6**	**110.7**	**113.5**
Windows closed	**117.9**	**113.5**	**123.4**
Front full open	**113.9**	**123.4**	**105.4**

Study of vehicle breath temperatures during a typical day trip schedule

Exposure, in mild weather, 83 to 85°F (28-29°C), resulting in vehicle interior breath temperatures of 100 to 115°F (37-46°C) can occur in a closed vehicle in a short period of time. Temperatures in this range are most important to consider from a health and safety standpoint, as well as higher vehicle interior temperatures which can occur. Since many customers use their vehicle for short trips of driving and parking, temperatures during these short stops are very important. In figures 2, 3, 4 and table 2, the results of breath warm-up rate in the 4 door sedan, exterior color white, gray interior and tinted glass with added window film are shown. The travel day profile was conducted with all windows closed the entire day. Reaching this 100 to 115°F detrimental breath level temperature range for an individual, can even occur on cooler temperature days.

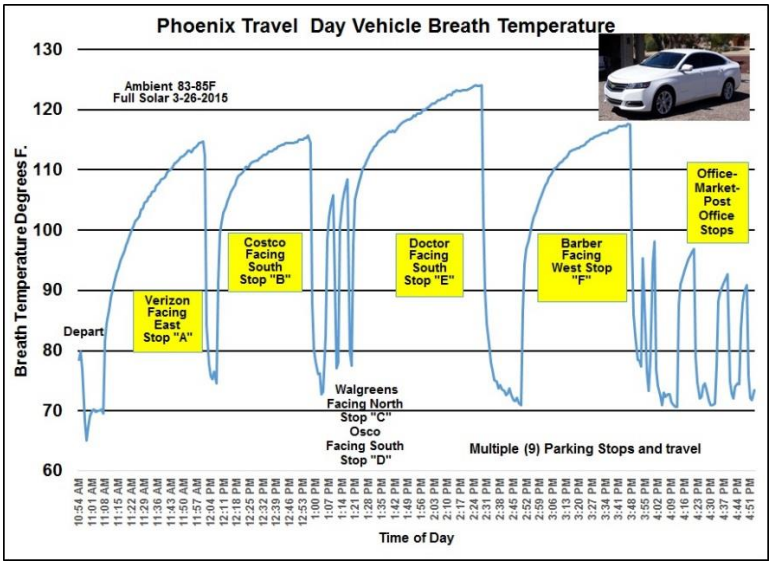
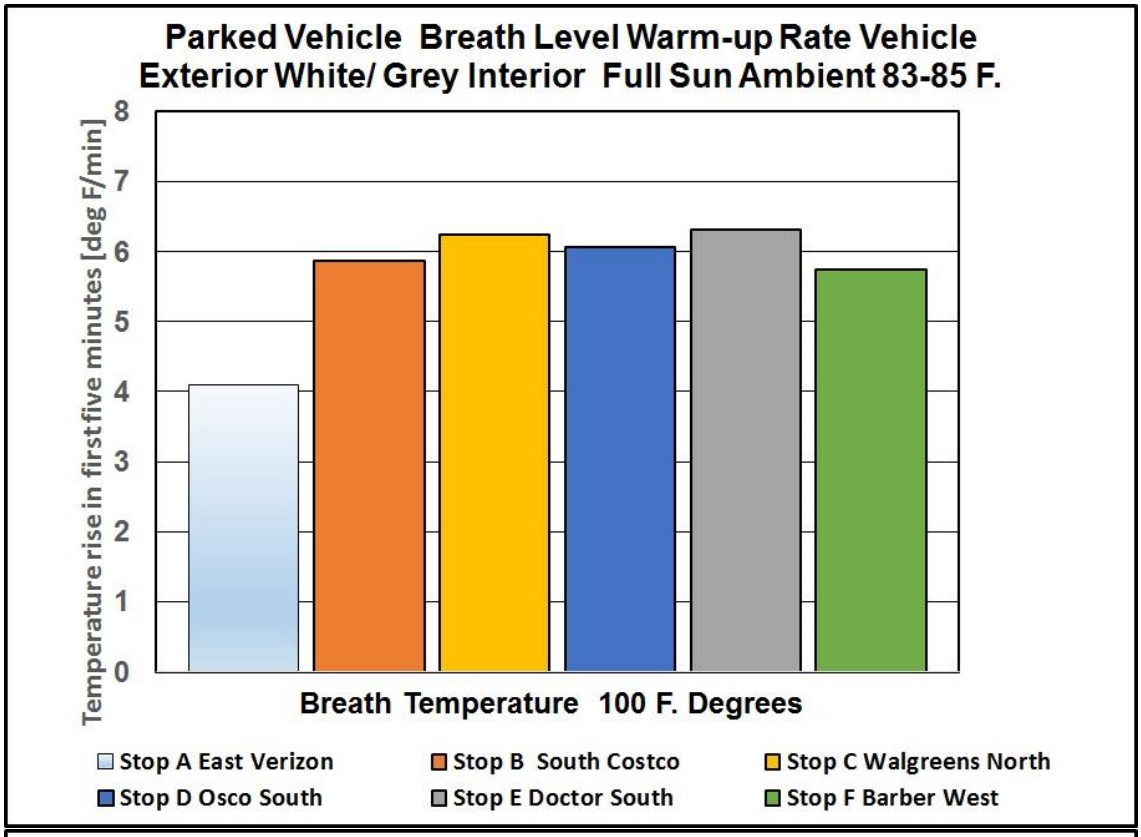
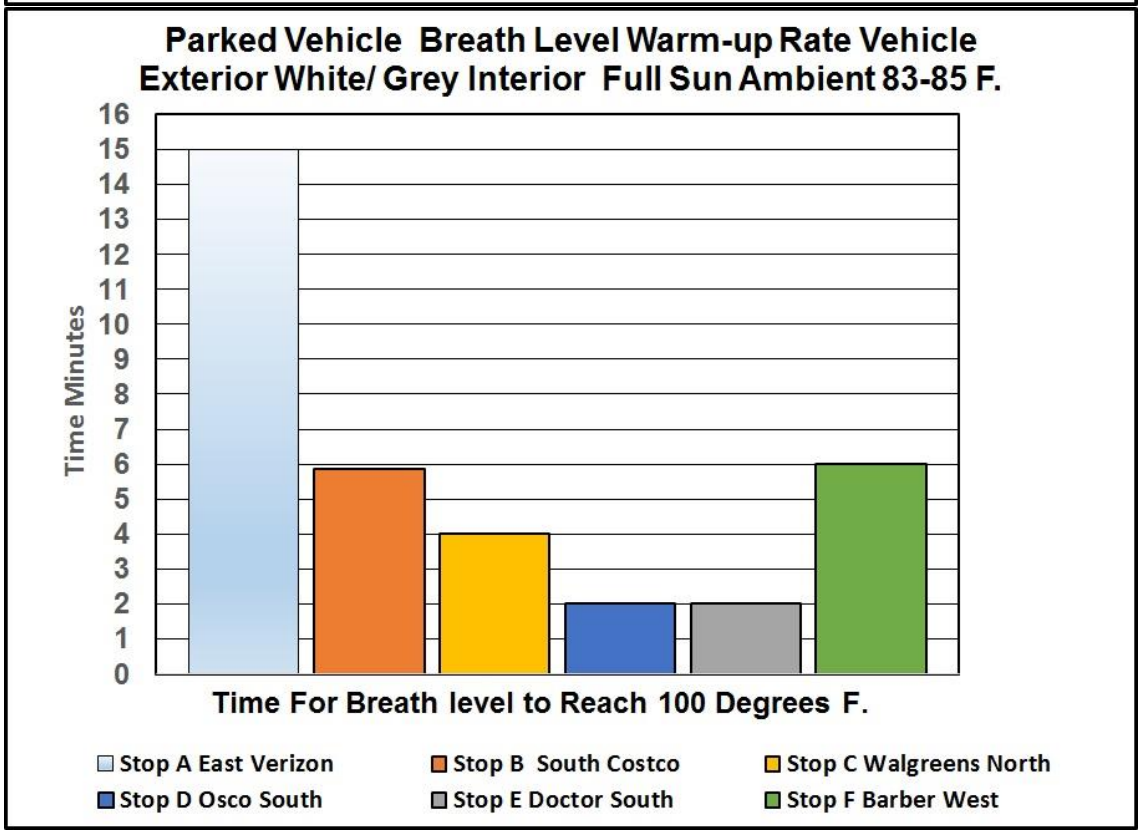


Figure 2: In 2014 vehicle, breath level temperature rise during vehicle day drive. Ambient 85°F (28°C), 9 stops and park





Figures 3 & 4: Breath warm-up rates

Table 2: Breath temperature rise rate

Time of day	11:07	12:07	13:03	13:11	13:19	14:49	15:57–17:19
Stop Full Sun Temperature 83-85°F	A Verizon	B Costco	C Walgreens	D Osco	E Doctor	F Barber	7-8-9
Stop Breath Temperature °F	69.5	74.5	72.7	77.0	77.5	71.0	73.3
Time from stop to 100°F	15 min.	3 min.	4 min.	2 min.	2 min.	6 min.	Late in day did not reach
Time from Stop to 110°F	36 min.	15 min.			6min.	18 min.	Late in day did not reach
Time from Stop to 115°F	53 min.	45 min.			15 min.	37 min.	Late in day did not reach

SAE International and Sun Test Engineering conducted testing that has resulted in a collection of 81 different vehicles during the summer in Phoenix, Arizona from 1989 to 2008. The vehicles had many different exterior, interior colors and different type and size windows. The interior breath level temperatures are the results of a one-hour (closed vehicle) soak with ambient temperatures over 100°F F (38°C). Figures 5-6, and table 3 summarize the results of these tests. Other temperature studies have been conducted adding to information at a variety of vehicle soak conditions.

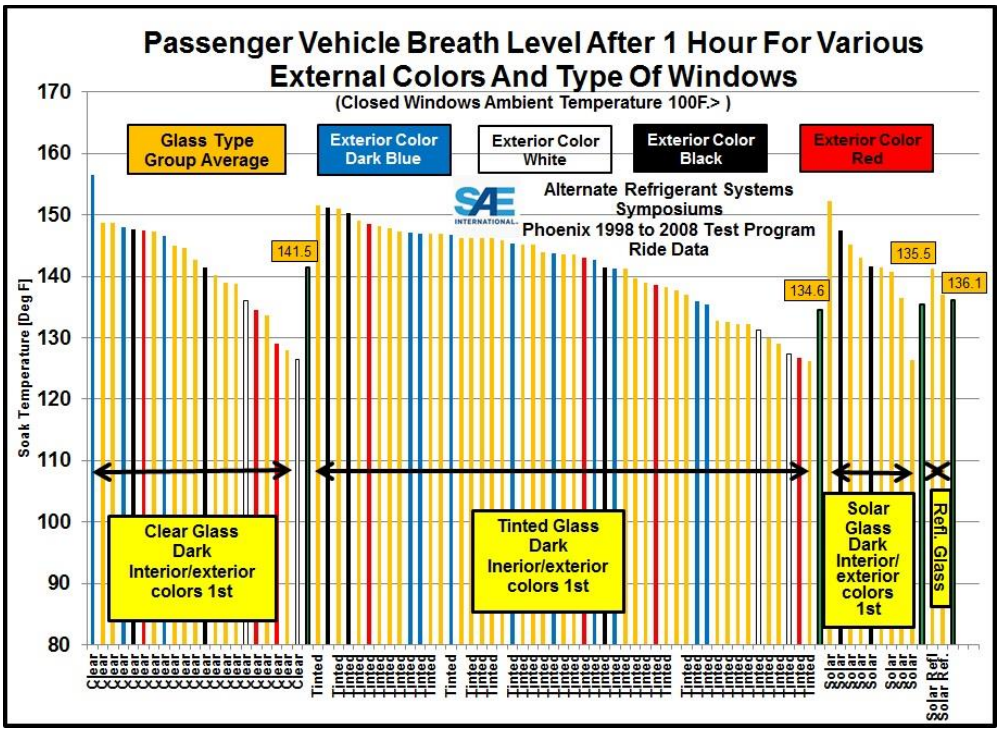


Figure 5: SAE 81 vehicles, closed vehicle 1 hour soak

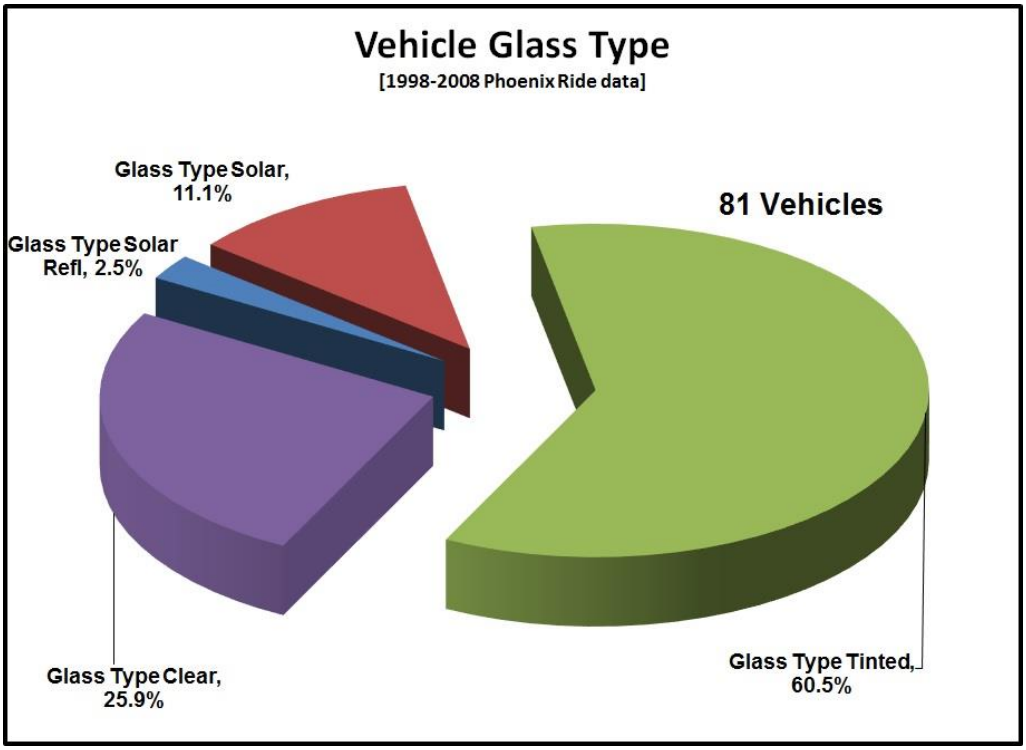


Figure 6: SAE 81 vehicle glass type; various colors and type of windows

Table 3: SAE 81 vehicle 1 hour ambient 100°F > (38°C)
Breath temperature soak range 126 – 156°F (52-68°C)

Breath Temp. Degrees F°					Fleet Average F°	Fleet Average C°
Glass Type	Solar Refl.	Solar	Tinted	Clear		
Highest	141.2	152.2	151.5	156.5	150.4	65.5
Lowest	137	126.4	126.2	126.4	129.0	53.3
Average	136.1	135.5	134.6	141.5	136.9	58.1

When comparing the vehicle soak temperatures of the 81 vehicles, tested over 10 years, it becomes evident that many factors of vehicle color, vehicle glass type and area have a major bearing upon how hot the in-vehicle temperatures become (figures 5-6 and table 3). This makes it difficult to predict how hot the interior surfaces and air might become under given environmental conditions.

SAE Technical paper 860591 "Occupant comfort in a black exterior/interior 1985 sports vehicle in an all-day (102°F ambient)" reported temperatures at the top of the steering wheel (in direct sun) reaching 200°F (93°C) and the breath level temperature reaching 170°F (76°C). The amount of glass and the angle of glass in vehicles today could result in even more extreme interior temperatures. To improve vehicle fuel economy, windshield designs have changed. The lower front edge is moved forward changing the angle of the windshield. This results in an increase of the instrument panel surface and increased exposure to the sun. To minimize the reflection of this surface in the driver's vison area, the instrument panel is usually dark in color. This results in increased heat input on sunny days since the dark colors adsorb the sun rays and the surface becomes hotter than lighter colors might get.

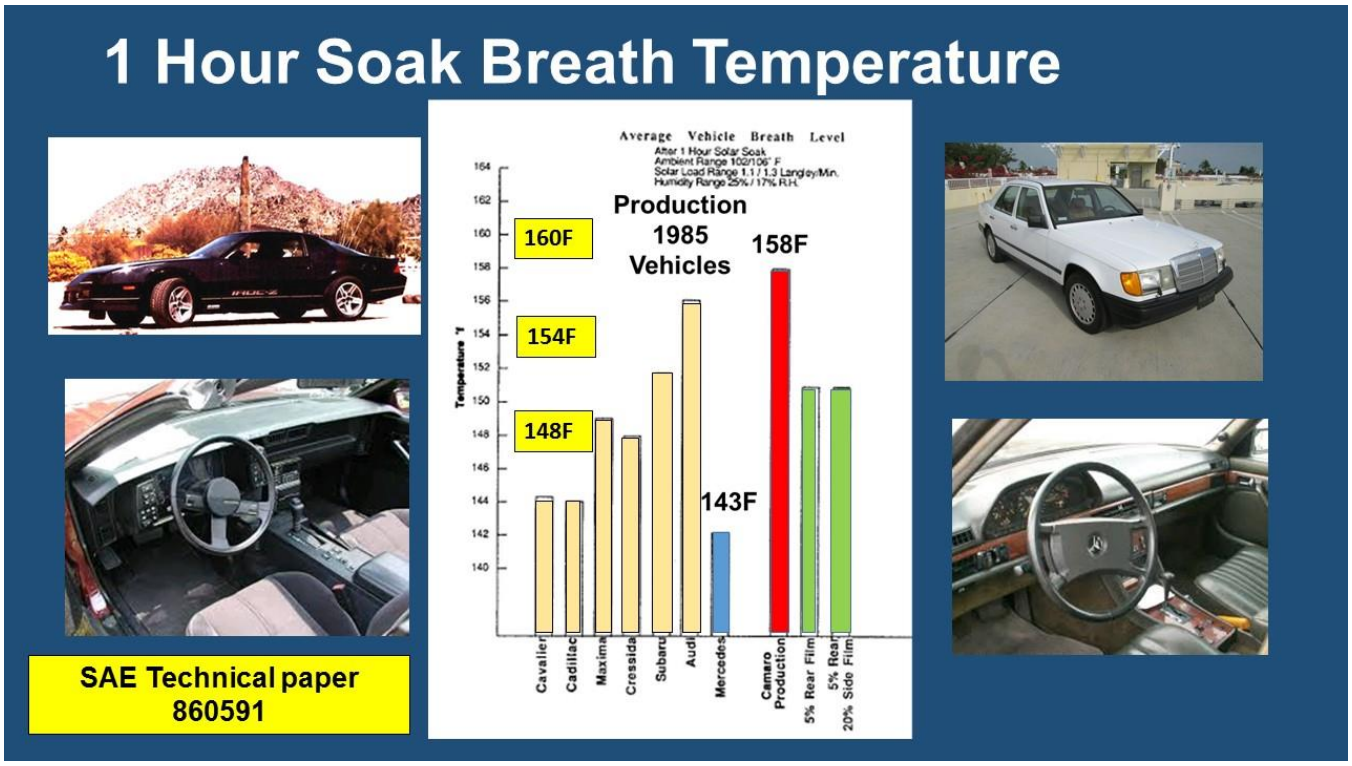


Figure 7

As indicated in figure 7, the soak breath temperature was 143°F compared to 158°F for a 4 door sedan and the 2 door sport coupe, due to amount of window, instrument panel surface areas and colors.

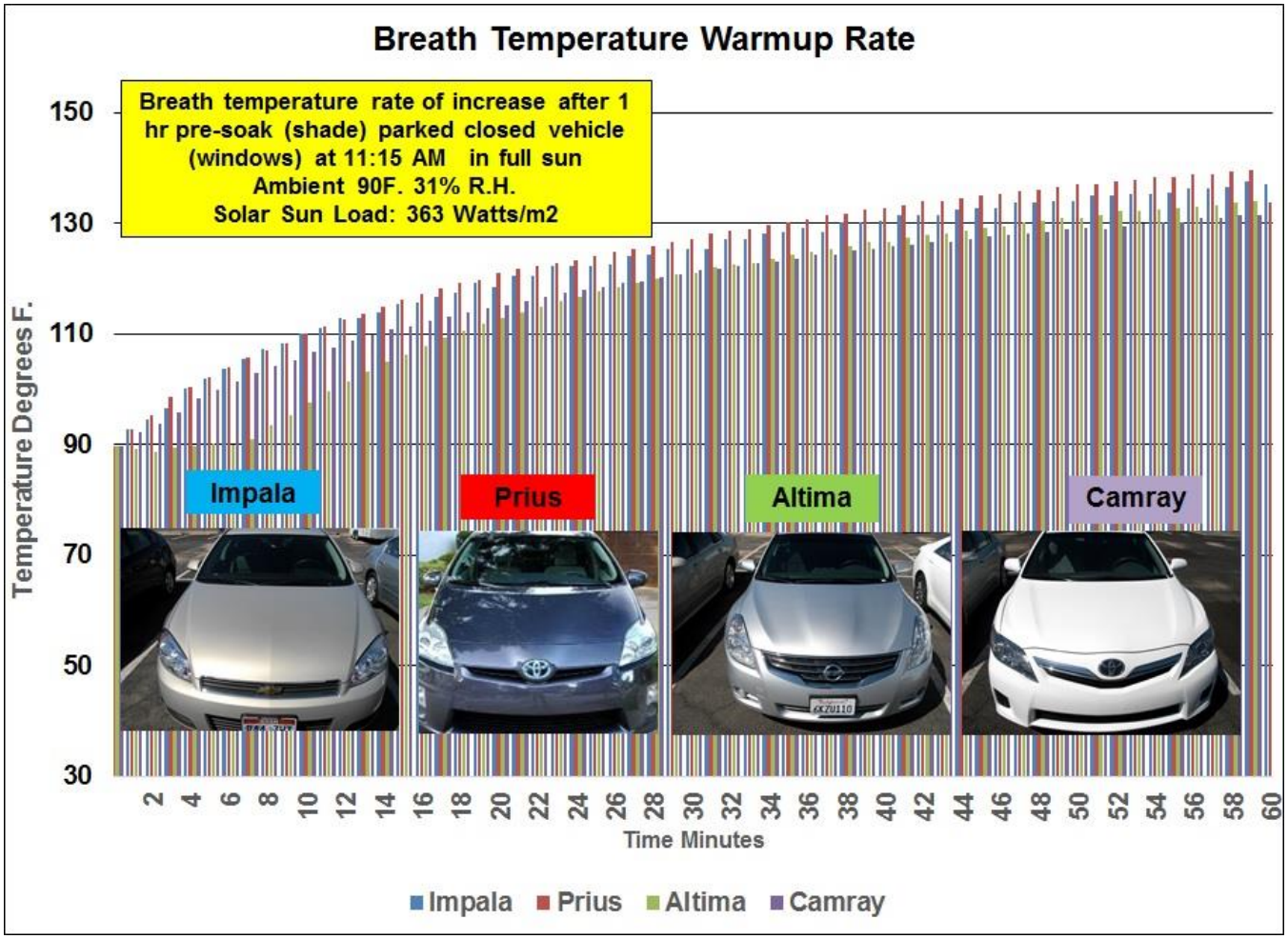


Figure 8: SAE 2011 4 vehicle 1 hour soak ambient 90°F (32°C)
Breath range 131-139°F (55-59°C)

The interior air temperatures when exposed to direct sun can reach temperatures well above the ambient temperature weather conditions. As indicated in Figure 8 the 2010 and 2011 model year (4 vehicles) reached breath level temperatures on a 90° day (32°C) in 1 hour of 131 -139°F (55-59°C).

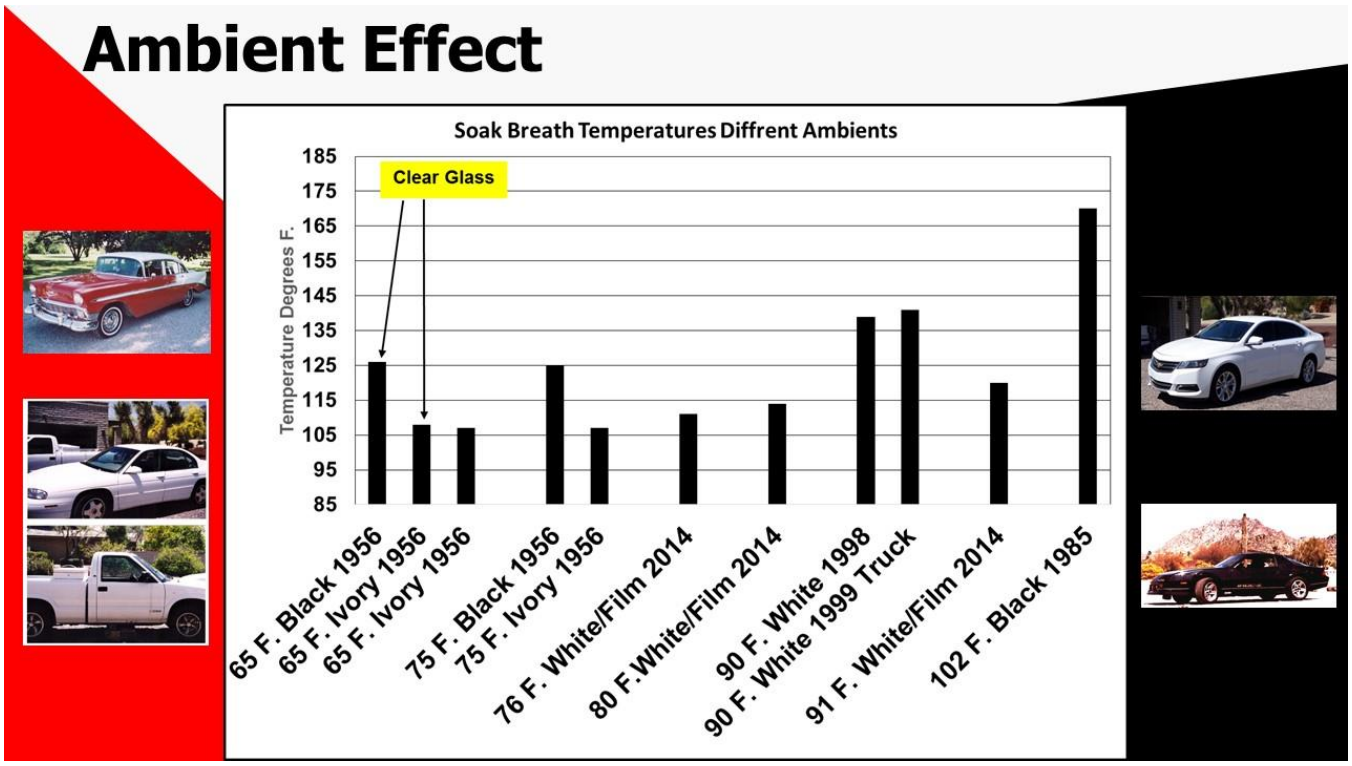


Figure 9

As indicated in figure 9, the breath temperature with full sun, closed vehicle can be 105°F on a 65°F day. Different vehicle types (2 door truck, 2 door sport vehicle and 4 door sedans) are shown with breath level soak air temperatures.

Effects of soak temperatures with open windows

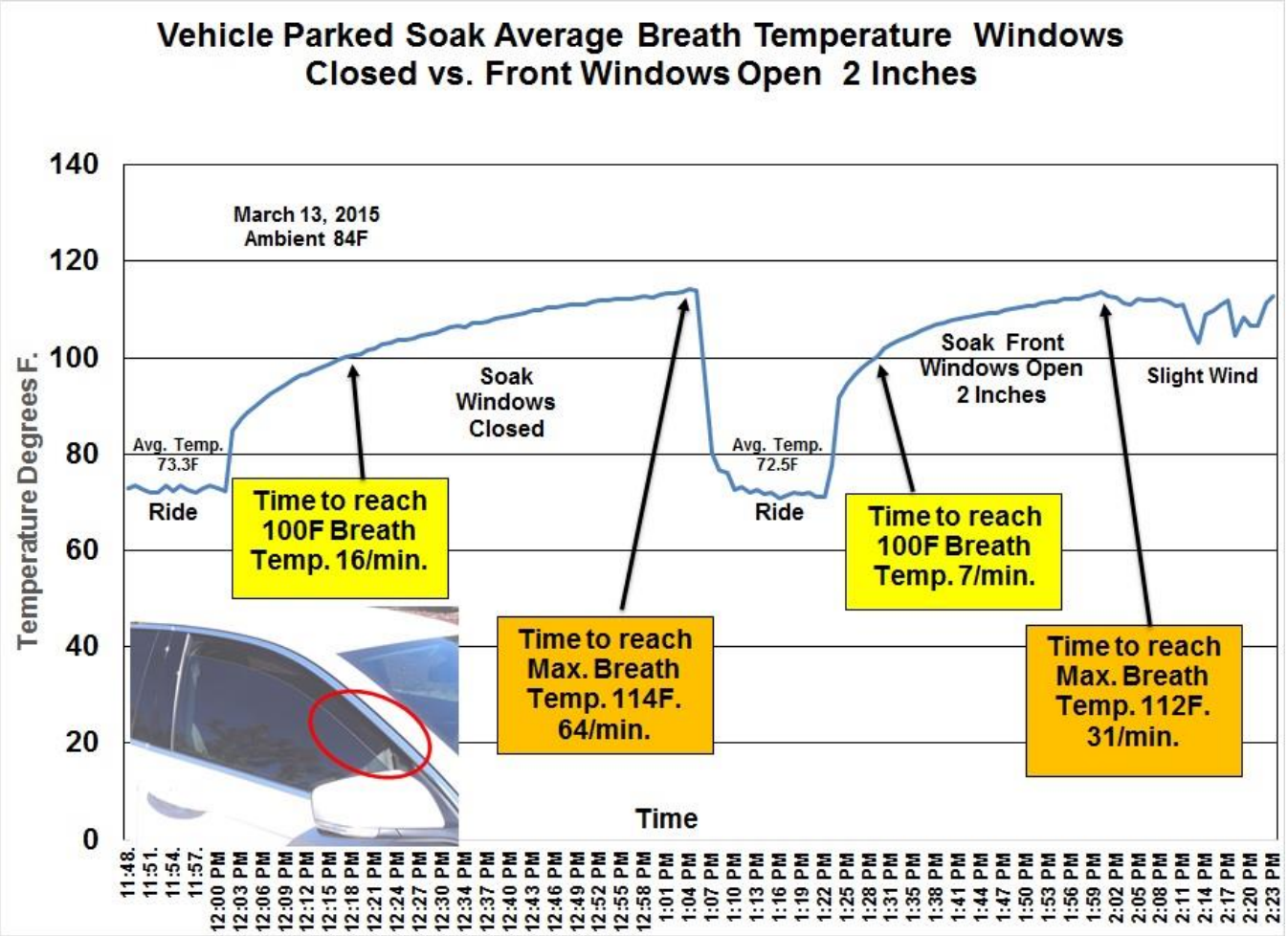


Figure 10: Rides, windows closed vs. front open 2 inches

When parking a vehicle with closed or some form of open windows on a sunny day, it is important to understand what happens to the breath air temperature of the vehicle interior. With the vehicle interior cooled down from a pre-city traffic drive and then parked, the interior breath temperature increased faster with the left and right front windows open two inches. (This result will be influenced by the wind direction and velocity.) Opening the windows allows outside warm air to enter the passenger car and warm up the interior. With the vehicle's windows open, this warm up time can vary depending upon if it is a windy day (figure 10 and table 4).

Table 4 Summary of windows open vs closed

Time of day	12:00	13:23	% Change Front windows open 2"
Stop Parked Full Sun Temperature 84°F light wind	Windows Closed	Front Windows Open 2 Inches after stop	

Stop Breath Temperature °F after pre-ride	**73.3**	**72.5**	
Time from stop to 100°F	**16 min.**	**7 min.**	**43% faster**
Time from stop to 110°F	**45 min.**	**25 min.**	**55% faster**
Time from stop to max. temperature	**64 min. 114°F**	**31 min. 112°F**	**48% faster**

Heat stroke

Heat stroke is the most serious heat-related illness. As indicated by some, it occurs when the body becomes unable to control its temperature: the body's temperature rises rapidly, the body loses its ability to sweat, and it is unable to cool down. Body temperatures rise to 106°F or higher within 10 to 15 minutes. Heat stroke can cause death or permanent disability if emergency treatment is not provided. *(http://www.bt.cdc.gov/disasters/extremeheat/elderlyheat.asp)*

Chocolate candy from Amazon.com

"Good" chocolate melts at around 34°C (94°F). This is what most chocolate manufacturers aim for and requires predominance of grade 5 fat crystals in the chocolate.

This melting point is no accident. A large part of chocolate design is to allow the chocolate to survive usual room temperatures but still melt in the mouth.

Technical papers and reference

SAE International Web Site

For the SAE CRP reports and some of the ARSS presentations: http://www.sae.org/standardsdev/tsb/cooperative/altrefrig.htm
For the majority of the AARS, ARSS and ARSES presentations: http://www.sae.org/events/aars/presentations/

MACS Worldwide Web Site

http://www.macsw.org/imis15/MACS

SAE Technical Papers:

Thermal and Solar Effects on Vehicle Components 830073
Occupant Comfort Requirements for Automotive Air Conditioning Systems 860591
Designing Mobile Air-conditioning Systems to Provide Occupant Comfort 2000-01-1237

Additional Information:

"Heatstroke Deaths of Children in Vehicles by Jan Null, CCM Department of Earth & Climate Sciences San Francisco State University Updated August 1, 2014"
[www.ggweather.com/heat/?m]

"National Center for Biotechnology Information, U.S. National Library of Medicine
http://www.ncbi.nlm.nih.gov/pubmed/25332172

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