ISO Solar Loading Background

Joint ISO/TC 22-ISO/TC 146/SC6/WG 13

June 8, 2016

Mark Polster

Presentation Overview

- This presentation is a comprehensive review of the background and data that went in to the definition of heating radiator in ISO 12219-1, 4.2. Heating radiator
  - Infrared radiator, halogen radiator or other radiators (simulating sun light) (wave length <300 nm shall be filtered out). The heating radiators used shall be powered to create a radiation density at the reference measurement point in the middle of the roof surface of the test vehicle of 350 W/m² to 450 W/m² (400 W/m² ±50 W/m²).
  - The heating area shall cover at least the area of the test vehicle cabin and an additional 0,5 m more to each side of the lower part of the glazing (footprint) (see Figure 1). The heating radiators are positioned at the roof with a shining angle of 90 ° to the heating area. There are no heating radiators shining from the side. The heating area shall be calibrated in squares of 25 cm x 25 cm with a radiation density of 400 W/m² ±50 W/m². The required radiation density shall be available directly after the lamps are switched-on (within a few min).
  - The irradiation shall be measured in accordance with ISO 9060.

Background

- Formation of the ISO Working Group (WG) began in 2007 in response for a need to create a harmonized vehicle method, ISO 12219-1.
- ISO/TC22-ISO/TC146/SC6 WG13
  - TC22: Road Vehicles
  - TC146: Air Quality
  - SC6: Indoor Air
  - WG13: Joint working group for vehicle level VOC test procedures
- The first meeting was in Berlin, Germany and there have been a total of 8 meetings.
- The 9th meeting is in Burlington, Vermont (US) September 28, 2016.
- To date there are over 277 committee documents and 9 test methods at various stages.

ISO Committee Members

- Members include 10 countries and 32 representatives
  - US, UK, Germany, Japan, Korea, France, Belgium, Italy, Russia, Switzerland

Automotive	**Research Institutes and Universities**	**Test Laboratories**
Ford (US)	The University of Tokyo (Japan)	BRE (UK)
Toyota (Japan)	Waseda University (Japan)	Markes (UK)
Honda (Japan)	Kyushu University (Japan)	TUV Nord (Germany)
Isuzu (Japan)	Society of Automotive Engineers of Japan (Japan)	Fraunhofer (Germany)
GM (Germany)	Research Centre for Automotive Testing and Refinement (Russia)	Kaneka (Korea)
Kia (Germany)	Korea Institute of Construction Technology (Korea)	
Hyundai (Germany)	Korea Institute of Industrial Technology (Korea)	
VW (Germany)	Kongju National University (Korea)	
Fiat (Italy)	Kangwon National University (South Korea)	

Original ISO 12219-1 Draft

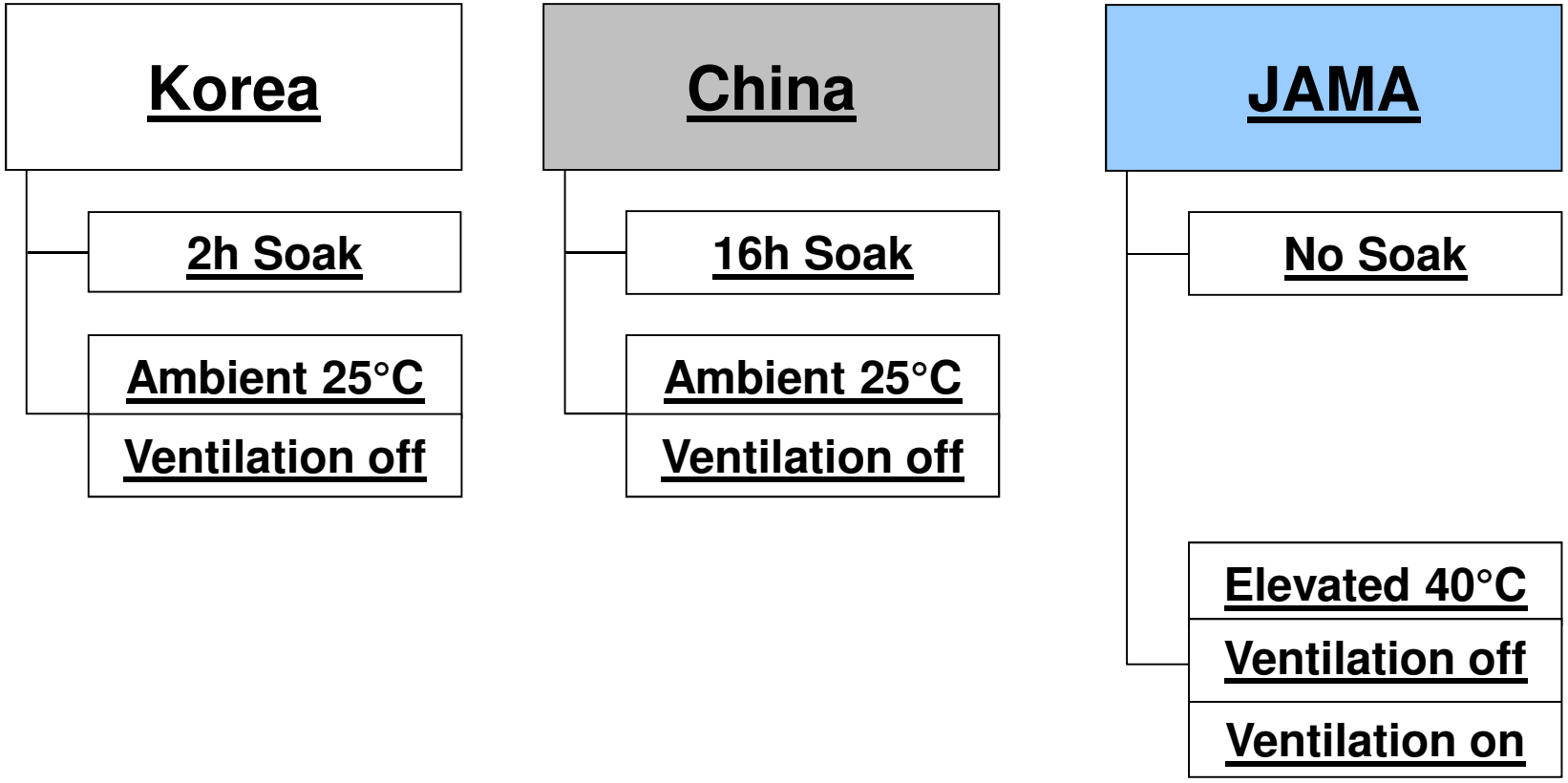
- The original ISO proposal was to maintain a constant temperature within the vehicle like the JAMA method.
- The JAMA method did not include an ambient mode but the Korean and China method did.
- The JAMA method only required the measurement of Formaldehyde during the elevated “parking mode.”
- There were other methods considered, see next slide.

VIAQ Procedures back in 2008

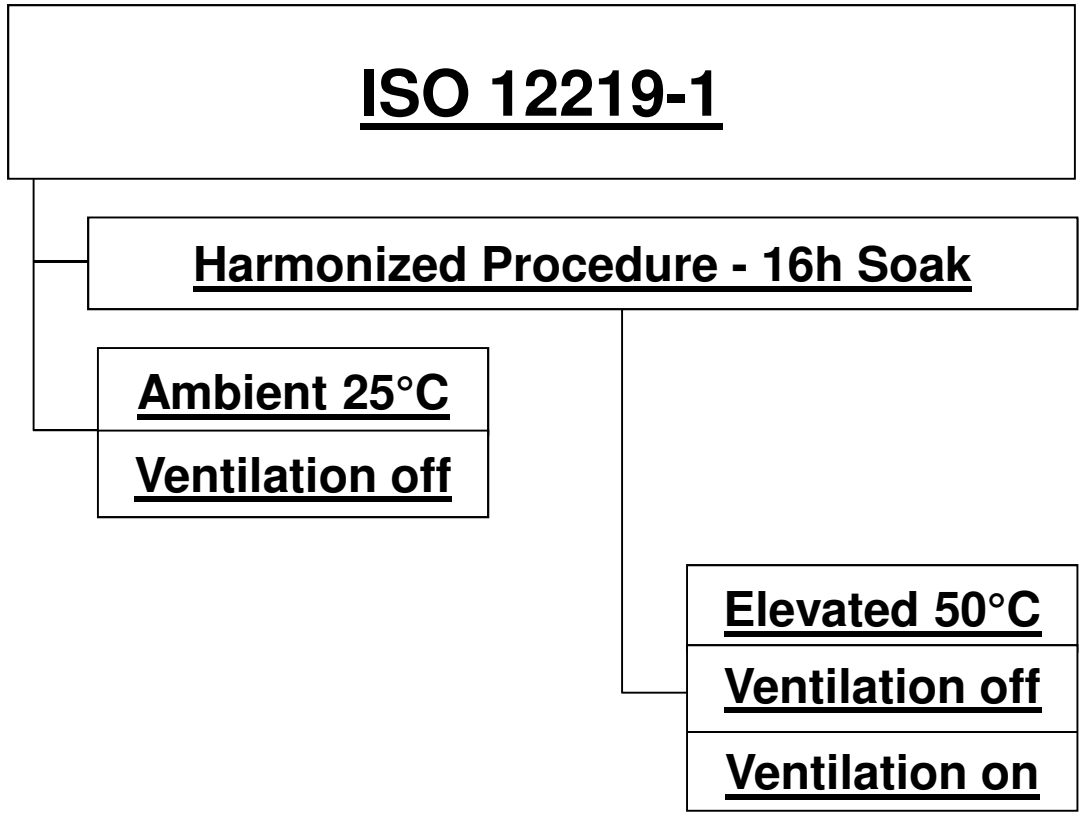
Test Conditions	Regulations		Voluntary/Recommended Guidelines		
Criteria	HJ China HJ/T (Draft)	Russian Federation Russia GOST R 51206-04	JAMA JAMA	Japanese Automobile Standards JASO M361 (Draft)	© KAIDA Korea MOTC Not. (Draft)
VOC's & Aldehydes	Vehicle Level 25°C ± 1°C for 16hrs; 15 types of aldehyde-ketone constituents (specific VOCs undefined)	Vehicle Level Ambient; Engine idle & vehicle stationary and at 50 km/h or max veh speed. CO, NO_x, VOCs, form. limits.	Vehicle Level 40°C ± 2°C for 4.5hrs; 9 VOC's measured; closed and engine & A/C on mode	Component Level 65°C ± 1°C for 2hrs; 10L sampling bag; targets 4 VOCs and 2 Ald following hot soak	Vehicle Level 25°C ± 2°C for 12 hours; 6 VOC's restricted (stage 1:Form., tol, e-benz, & styrene; stage 2:benz & xyl).
Planned Effective Date	2010; China may consider adopting ISO in place of HJ.	Mandatory 1/1/06. Pollutant content in cabin resulting from fuel combustion in the engine and evap of fuel, etc.	New models of PC to be sold from fiscal 2007 must satisfy the VOC limits.	Deadline: March 2008	Stage 1 eff 7/1/09; Stage 2 eff 7/1/10. KAMA is asking to delay introduction until ISO standard is completed (~ 2012).

Test Conditions	ISO International Standard	3rd Party Cert.
Criteria	ISO International Organization for Standardization ISO TC 146/SC 6 N (Draft)	TÜV TÜV Rheinland Group TUeV
VOC's & Aldehydes	Vehicle Level Ambient (23± 2°C) and elevated cabin air (50±2°C); Surface Temp. (65±2°C) for 3hrs. VOC limits not defined	Vehicle Level 21°C ± 2°C for > 8hrs; includes road driving test. Targets 4 VOCs, 2 Ald, & 11 classes of compounds
Planned Effective Date	Working draft completed 6/12/07	Updated 5/07 TUV has indicated willingness to adopt ISO.

VIAQ Procedures back in 2008



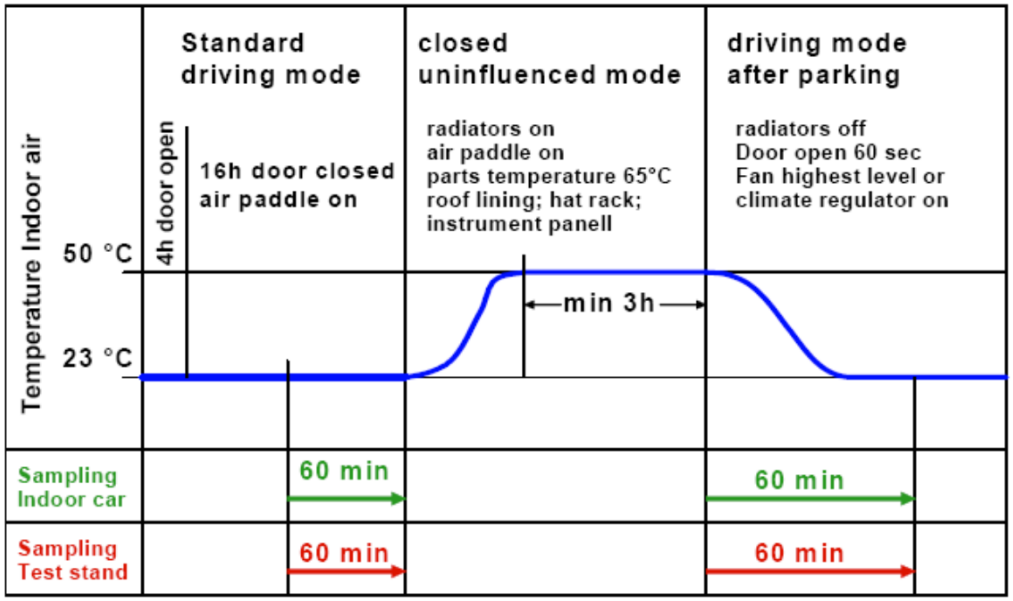
Harmonization of VIAQ Procedures back in 2008



Overview of the Draft ISO 12219-1 Procedure

- Preconditioning
  - Vent vehicle for 4 hours with doors and windows open

- Test
  - Standard driving mode
    - ✓ Soak 15 hrs; sample 1hr

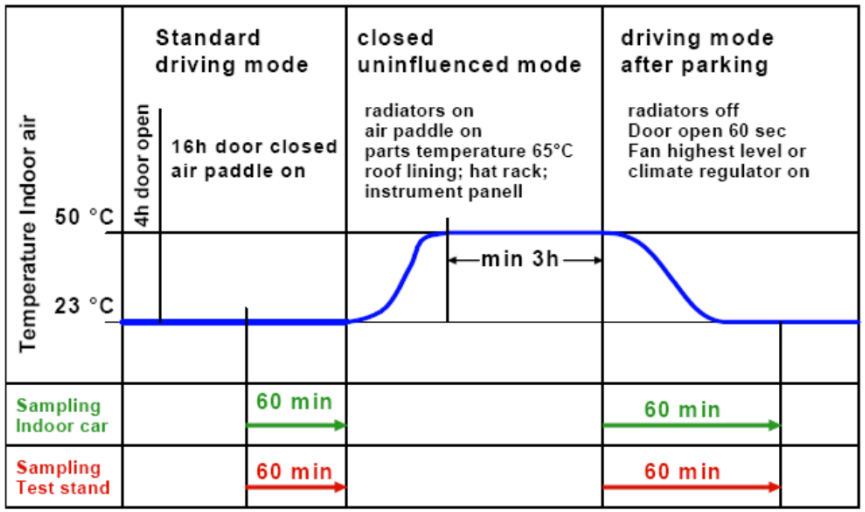


- Closed uninfluenced mode
  - Control cabin air to 50°C ± 2°C
  - Control hat rack, IP, headliner to 65°C ± 2°C
  - Hold temperatures for 3hrs
  - Radiators are positioned on top and sides of vehicle.
- Driving mode after parking
  - Lights off, A/C on 23°C; sample 1hr

First Meeting - Resolution 3

Unattended driving mode at 40°C accepted for HCHO sampling only

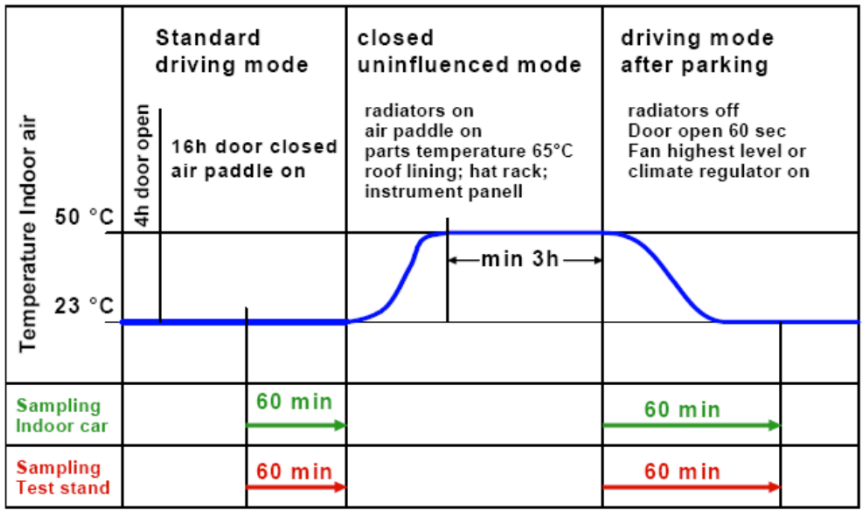
- Position
  - Closed mode only for HCHO
  - Values are high – 10 times
  - Low cost to include and satisfies JAMA
- Test Plan
  - Assess variability
  - Assess levels at 40 °C vs. 50°C



First Meeting - Resolution 6

Real life data – component temperature profiles

- Position
  - Draft is unrealistic
    - 65°C at headliner, IP, and hat rack; and 50°C at center of vehicle is unrepresentative



- Test Plan
  - Gather real life data
    - Different locations
    - Vehicle size (mass)
    - Angle of glass
    - Glass emissivity
  - Note need for real life conditions
  - Study constant uniform solar load centered over vehicle.

First Meeting - Resolution 7

Study temperature profile of the vehicle during heating in chamber
Lamp orientation, Exterior/Interior/Component temp, Lamp profile

- Position
  - Study the use of SCO3 site
    - No additional cost for some labs
    - Good at simulating sun
  - ISO Site
    - Low added cost
    - Fair at simulating sun
    - Allow different light sources per a specification
- Test Plan
  - Record orientation, profile, temperatures
    - SCO3 site
    - ISO site
    - Different vehicles

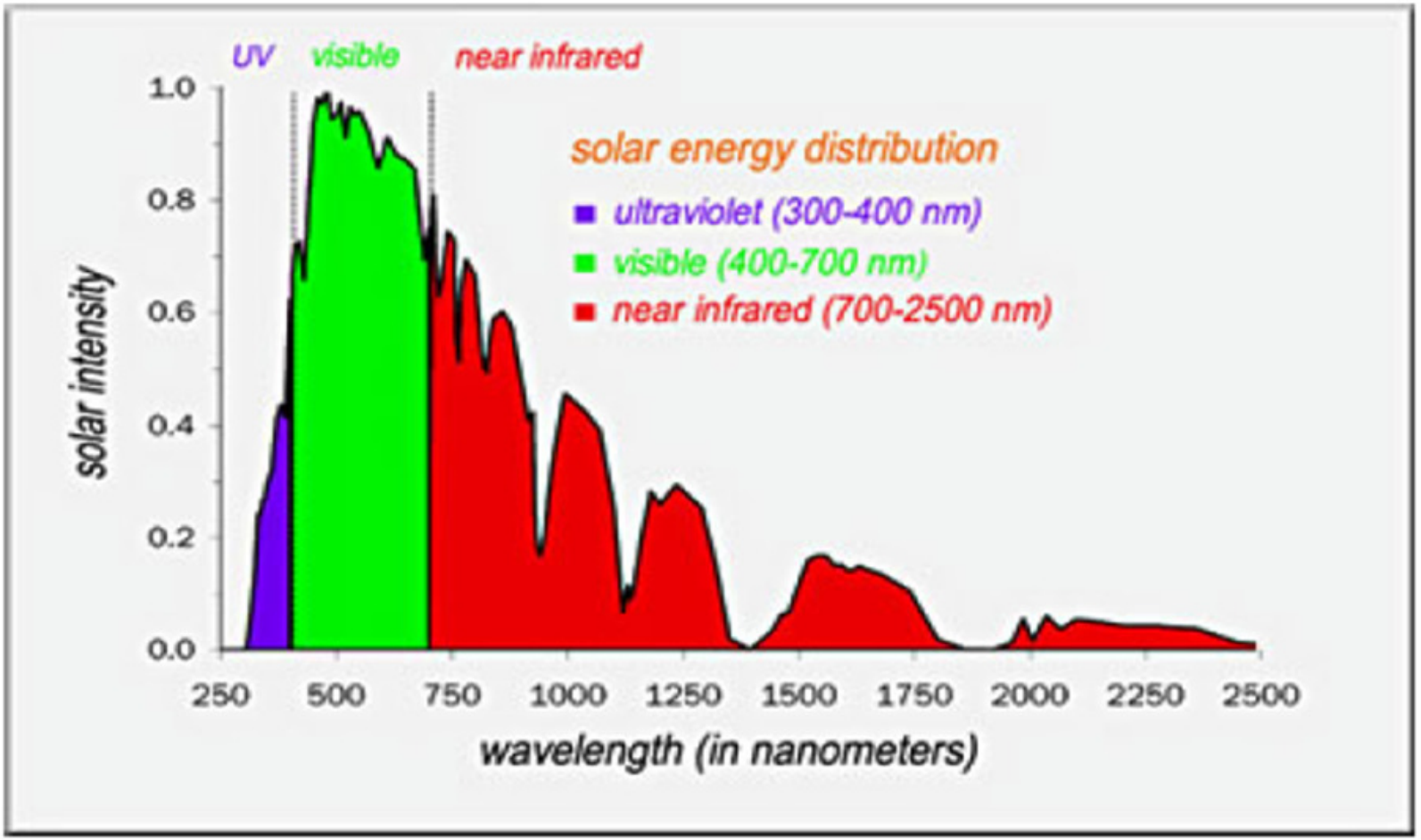
First meeting summary

- After the first meeting the WG agreed to investigate the heating method
  - ❑ Investigate different methods to apply a solar load to the vehicle like the sun.
  - ❑ Investigate different global locations for solar load
  - ❑ Investigate different vehicle sizes and angle of glass
  - ❑ Investigate different glass emissivity
  - ❑ Investigate different light technologies, first ISO 12219-1 method used halogen lights.
  - ❑ Start with reviewing other methods that apply a solar load to vehicles.

Indicial review of methods that currently apply solar loads

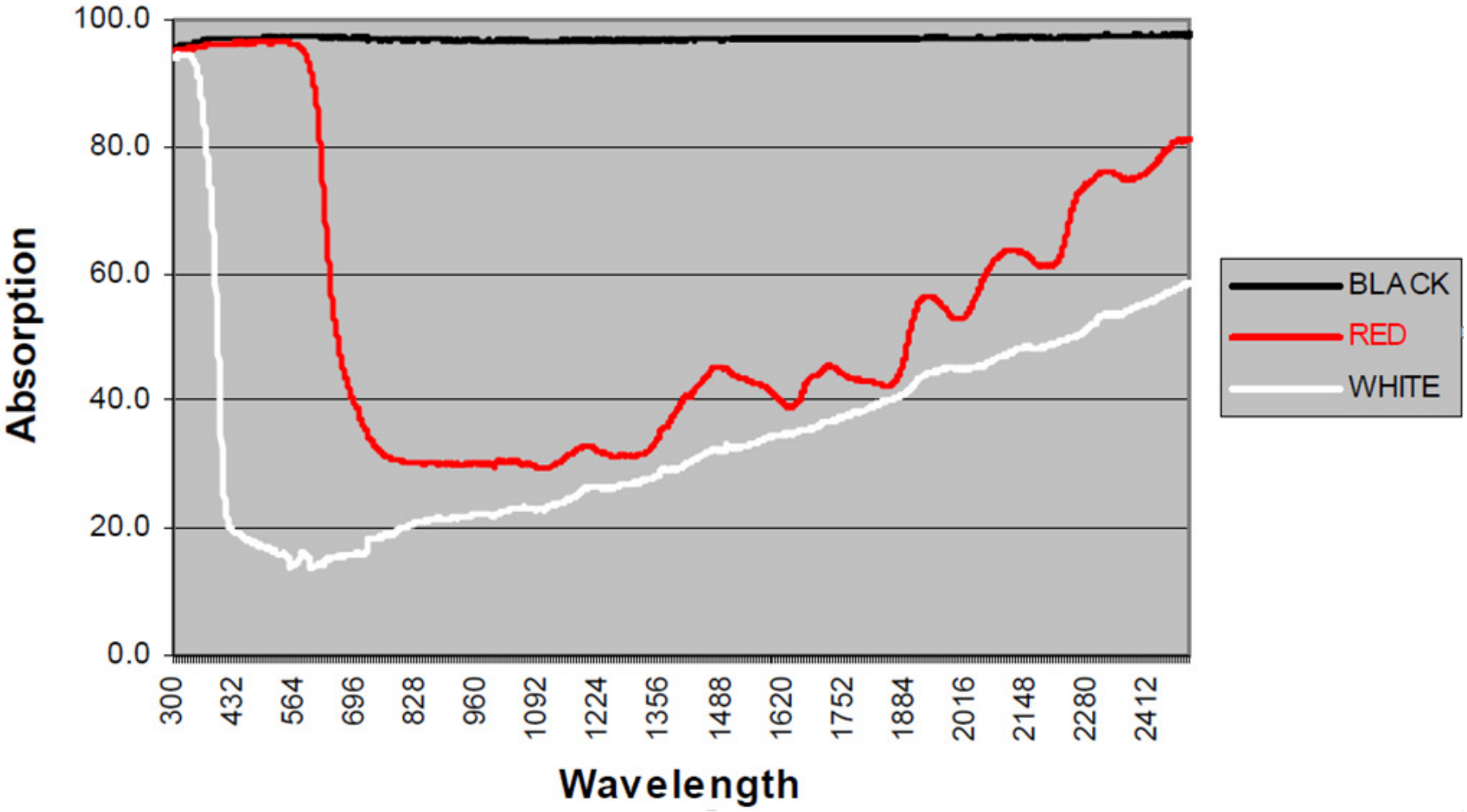
- A US EPA test method for vehicle air conditioning in the US was looked at for solar load definitions.
- SCOC test method included a general approach is to apply a solar load in watts/meter square.
- Review other methods and collect data for:
  - ❑ Type of lights
  - ❑ Level of the solar load
  - ❑ Duration of the load.

Solar Energy Distribution

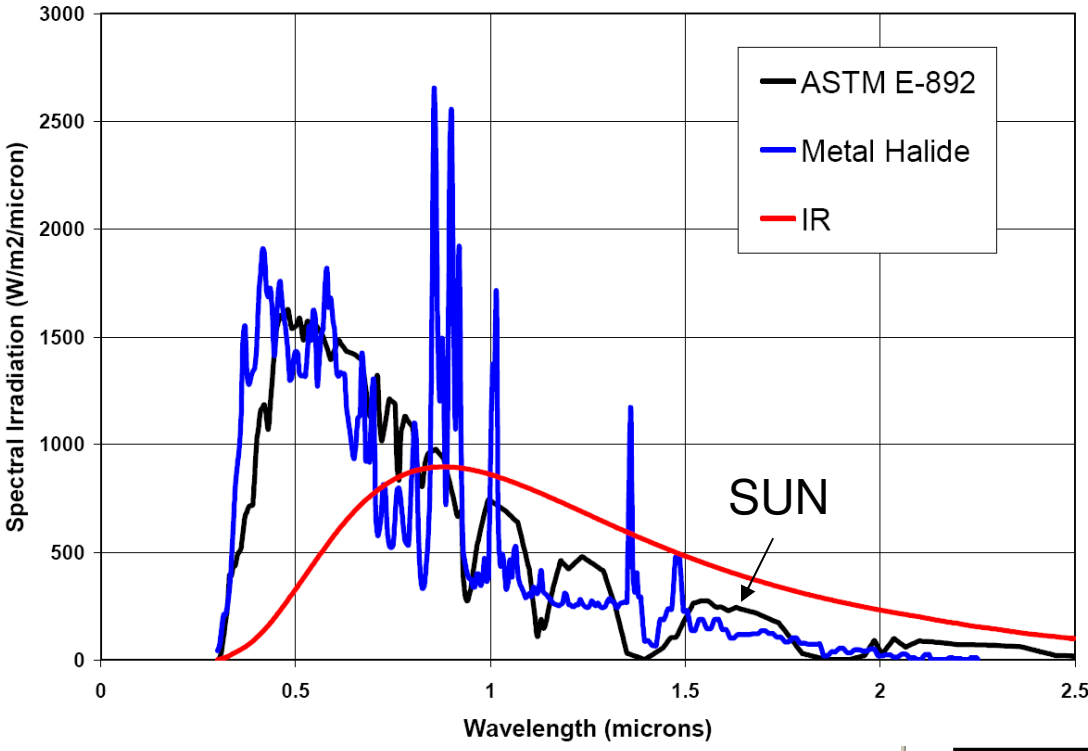


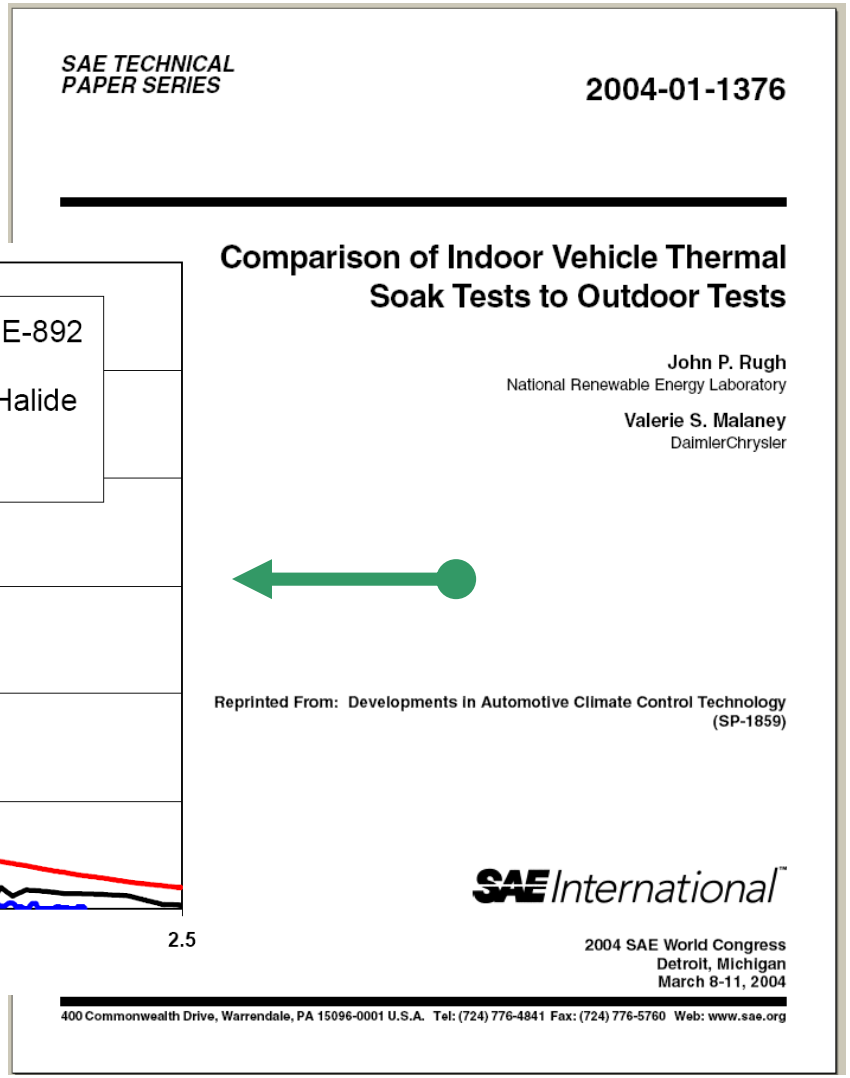
Source: http://www.lbl.gov/Science-Articles/Archive/sb/Aug-2004/3_coolroofs-2.html

Spectral Adsorption vs. Color



Sun and Solar Loading





SAE TECHNICAL PAPER SERIES

2004-01-1376

Comparison of Indoor Vehicle Thermal Soak Tests to Outdoor Tests

John P. Rugh
National Renewable Energy Laboratory

Valerie S. Malaney
DaimlerChrysler

Reprinted From: Developments in Automotive Climate Control Technology (SP-1859)

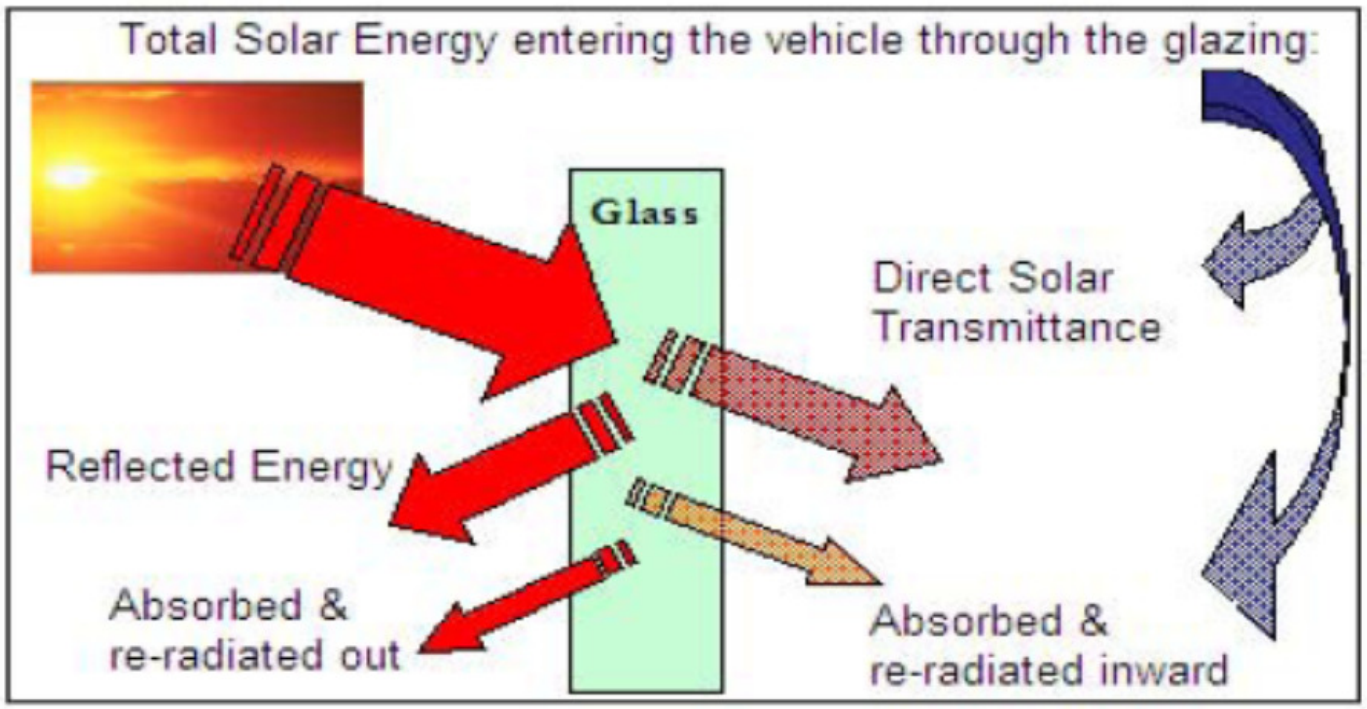
SAE International

2004 SAE World Congress
Detroit, Michigan
March 8-11, 2004

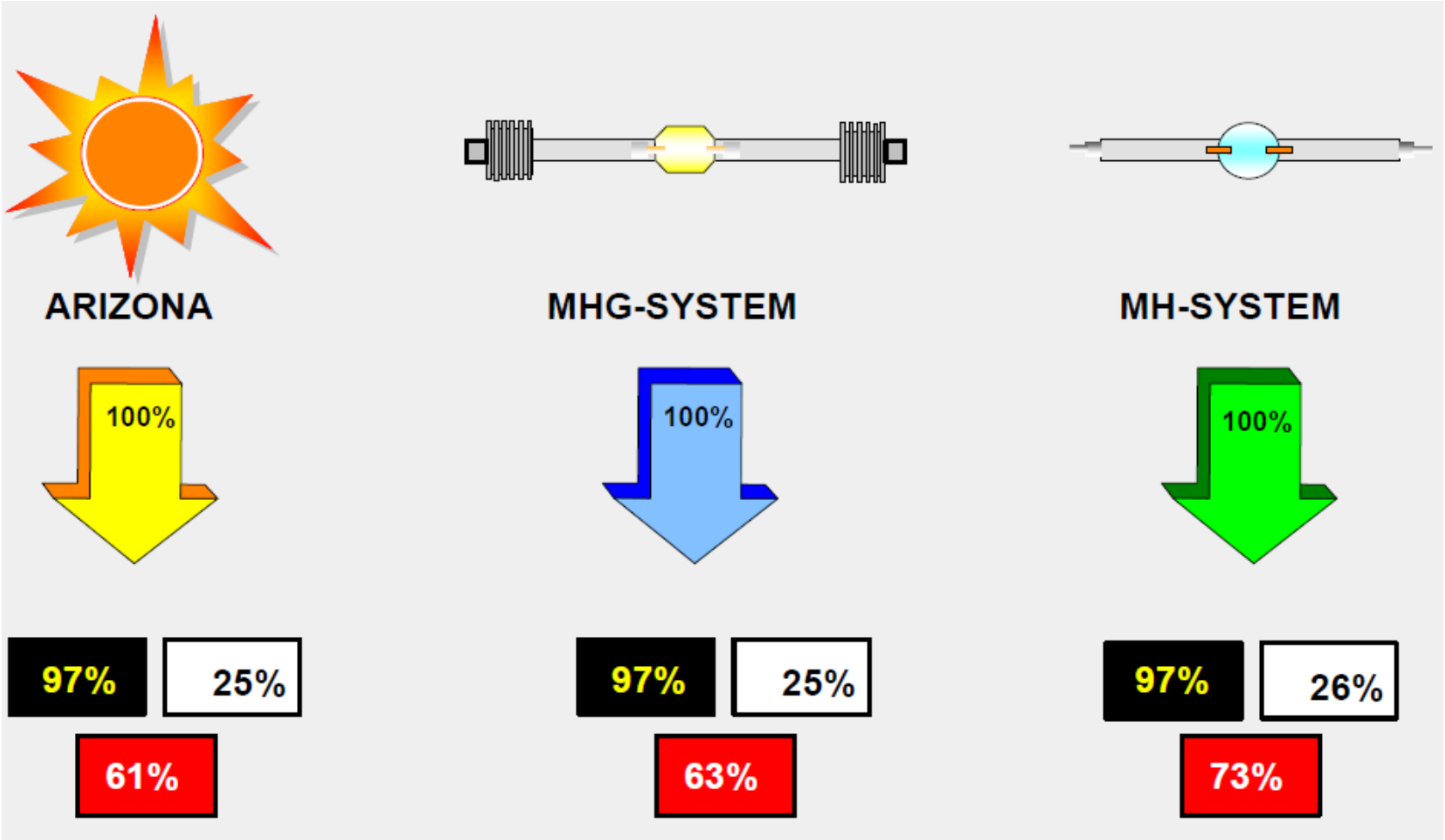
400 Commonwealth Drive, Warrendale, PA 15096-0001 U.S.A. Tel: (724) 776-4841 Fax: (724) 776-5760 Web: www.sae.org

- Paper states, “Solar lamps are used to simulate the sun”

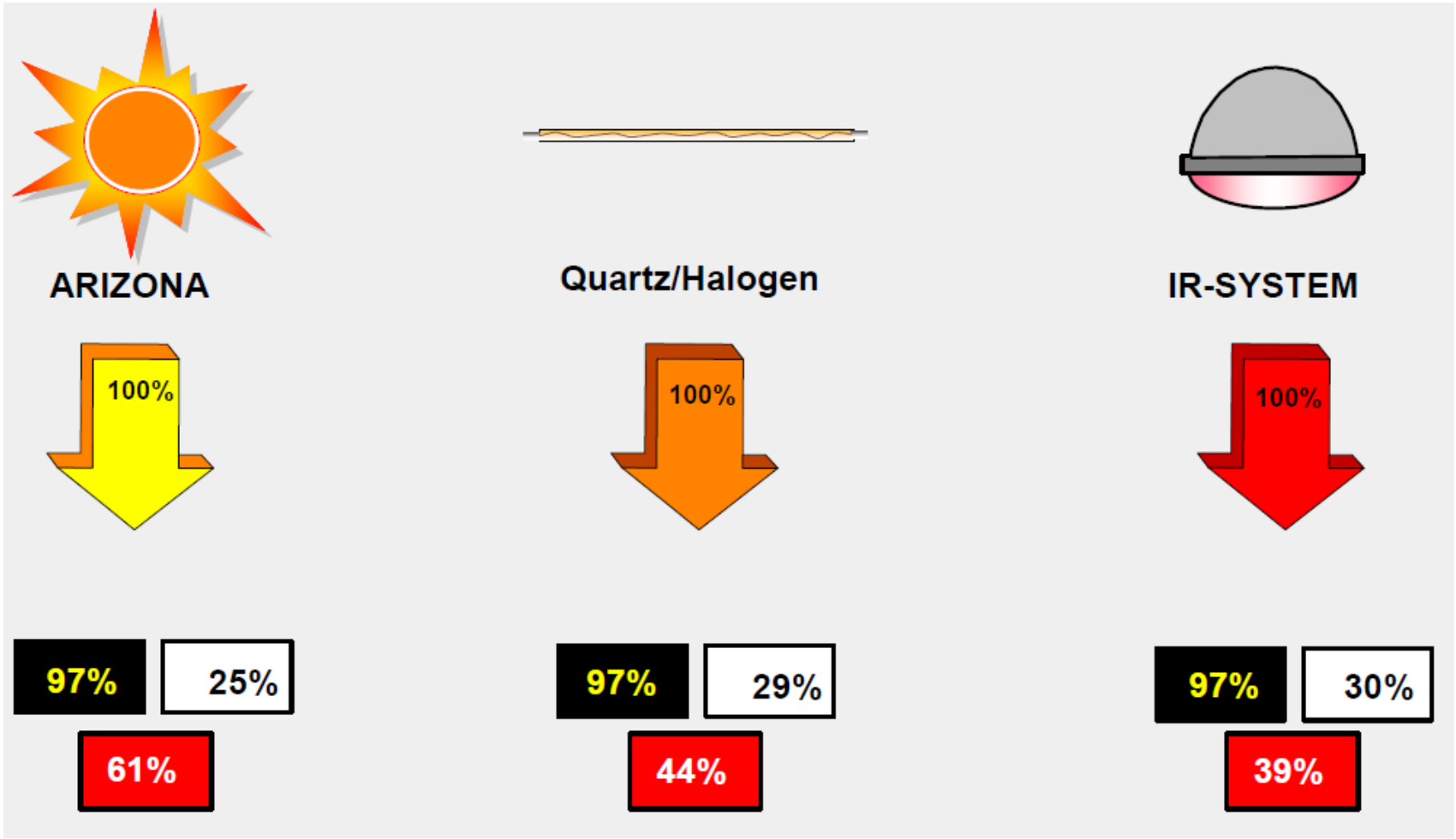
Solar Energy Penetration



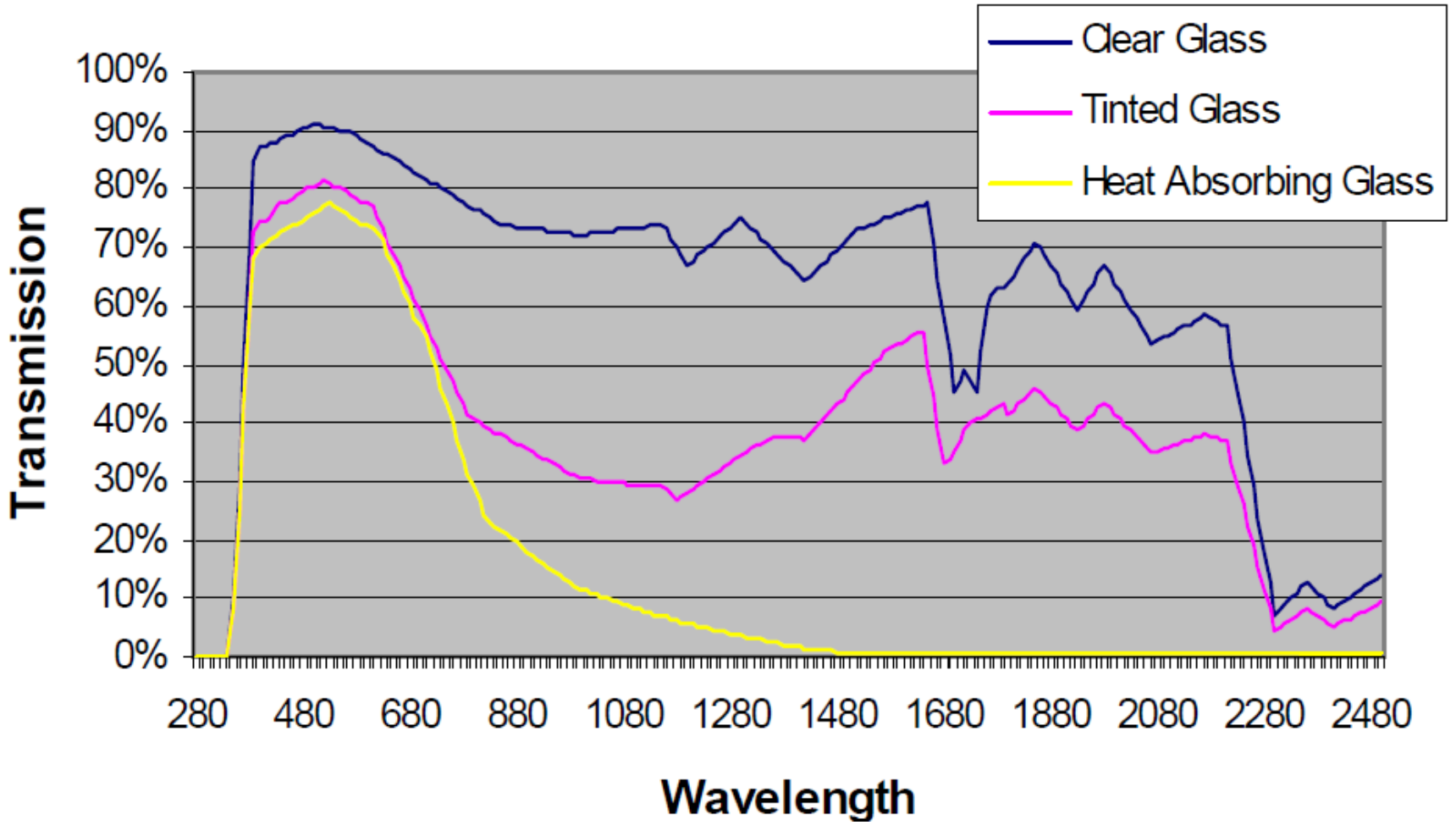
Total of Absorbed Radiation - 1 of 2



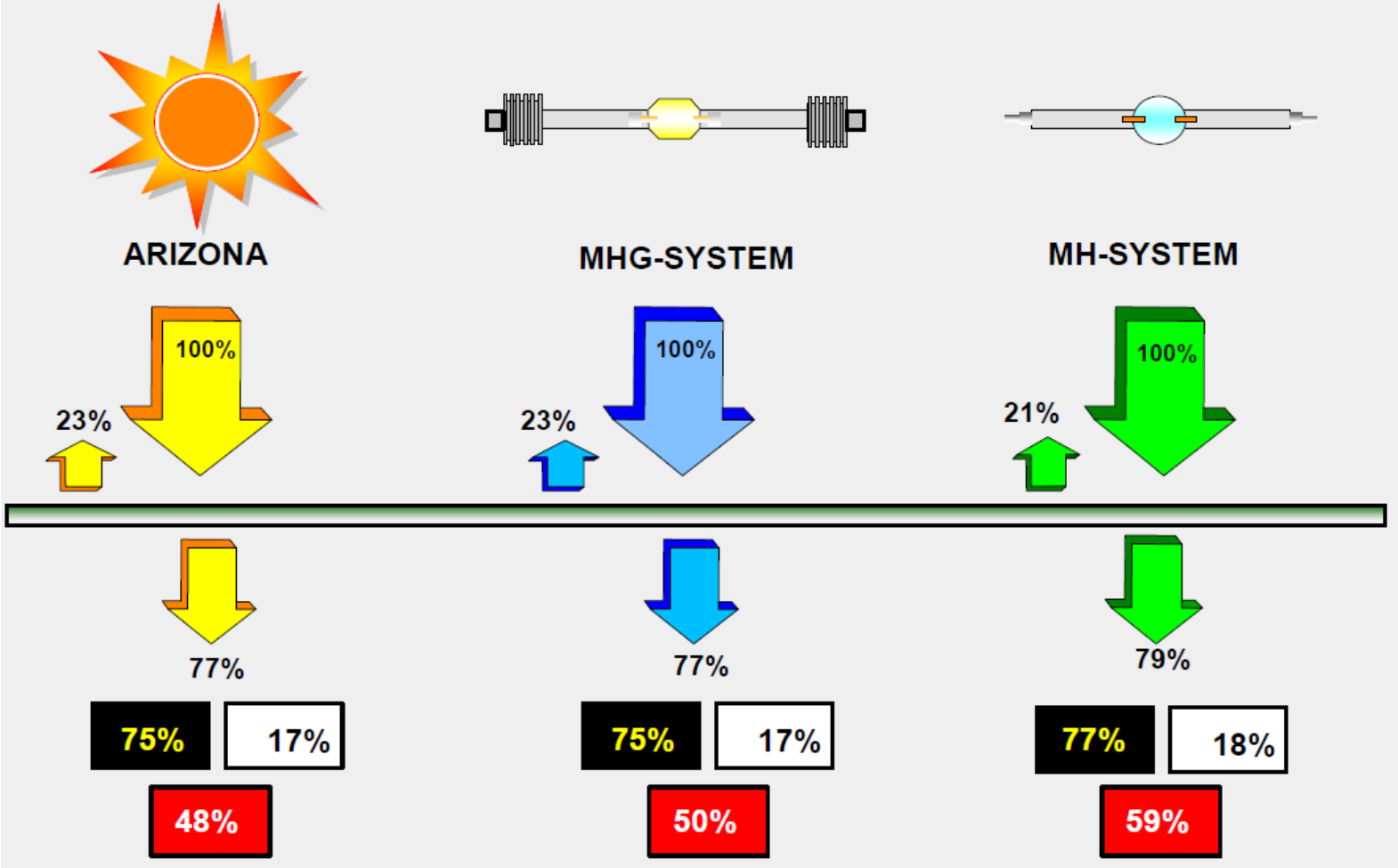
Total of Absorbed Radiation - 2 of 2



Spectral Transmission of Automotive Glass



Total of Absorbed Radiation Through Clear Glass



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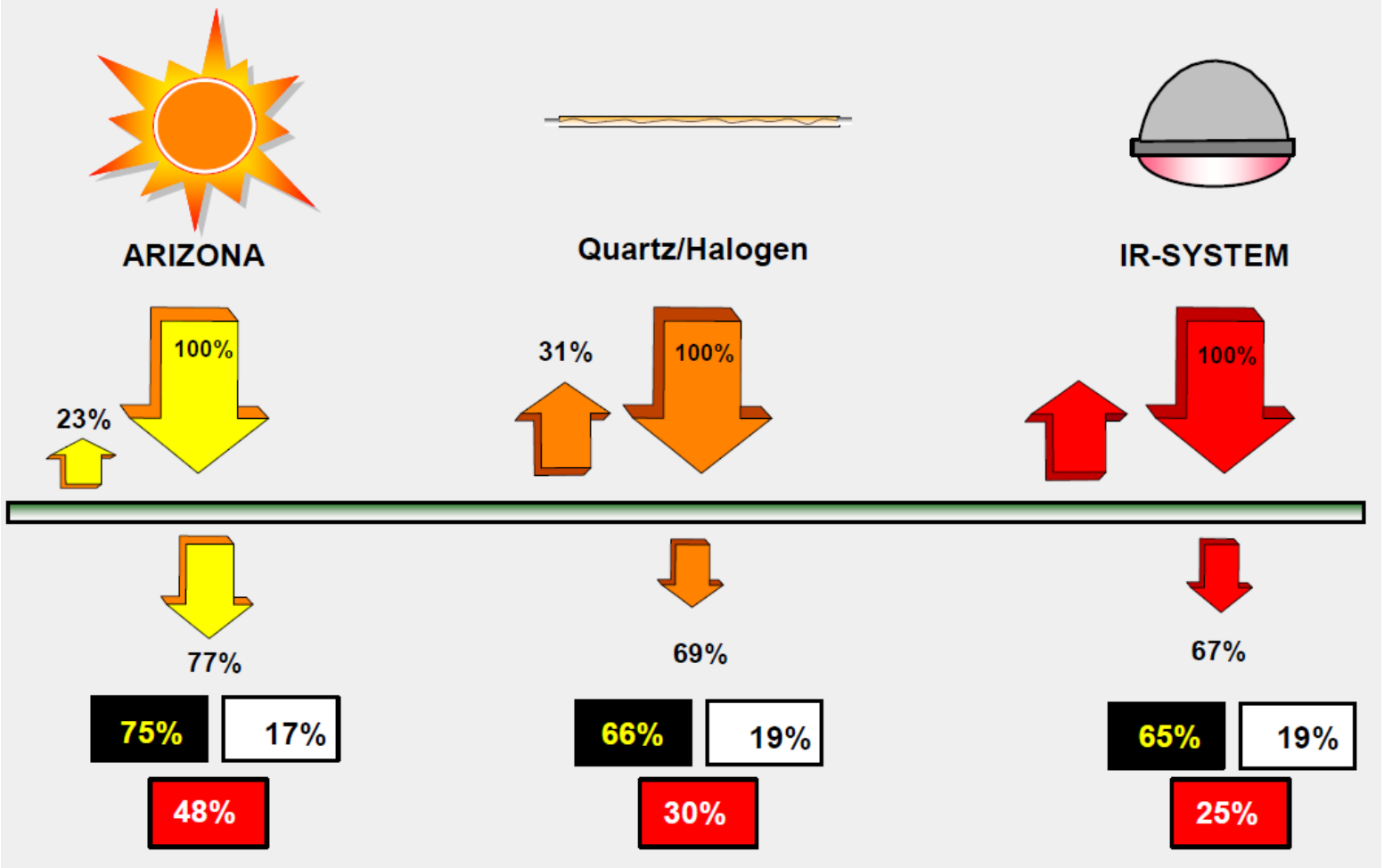
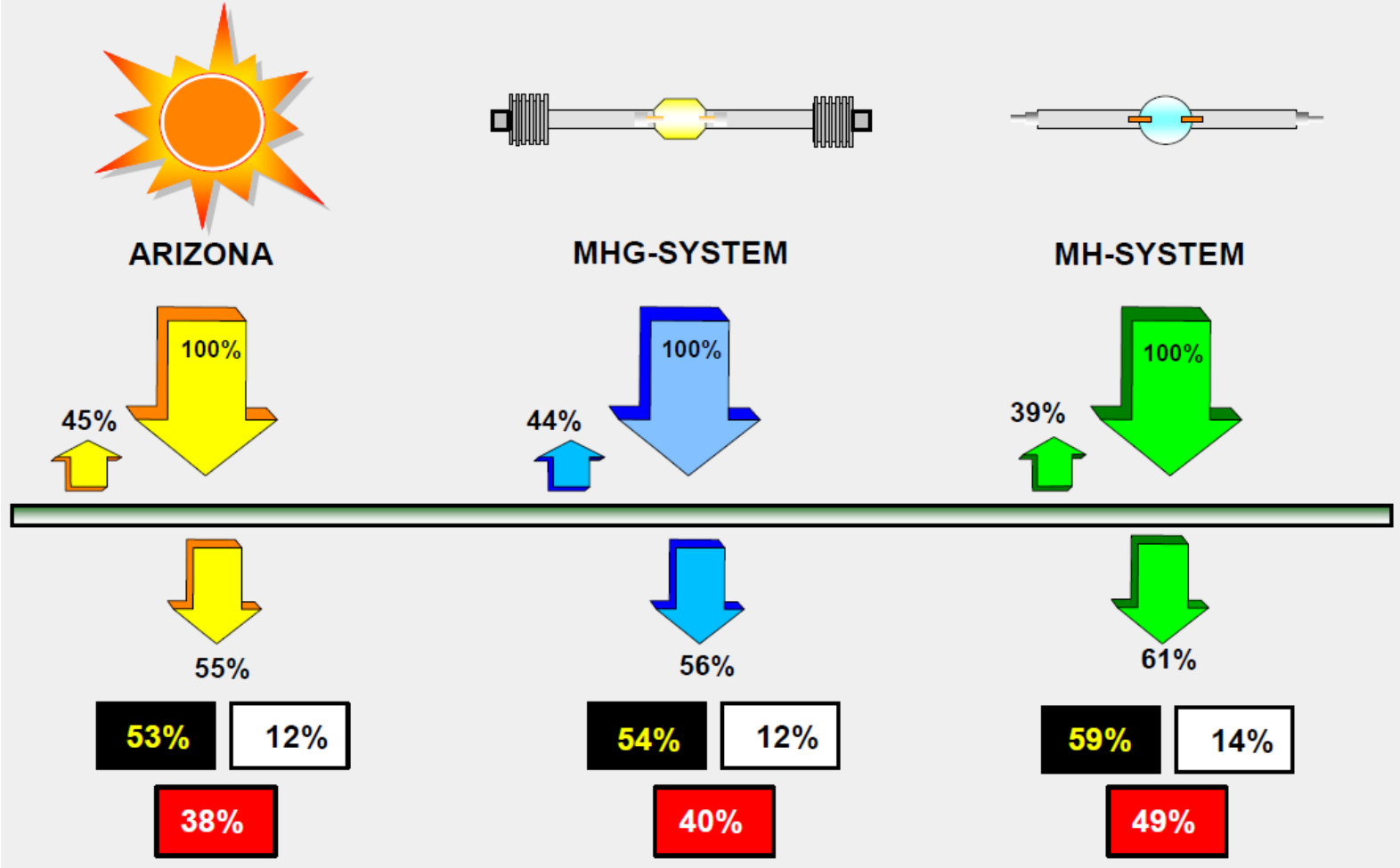
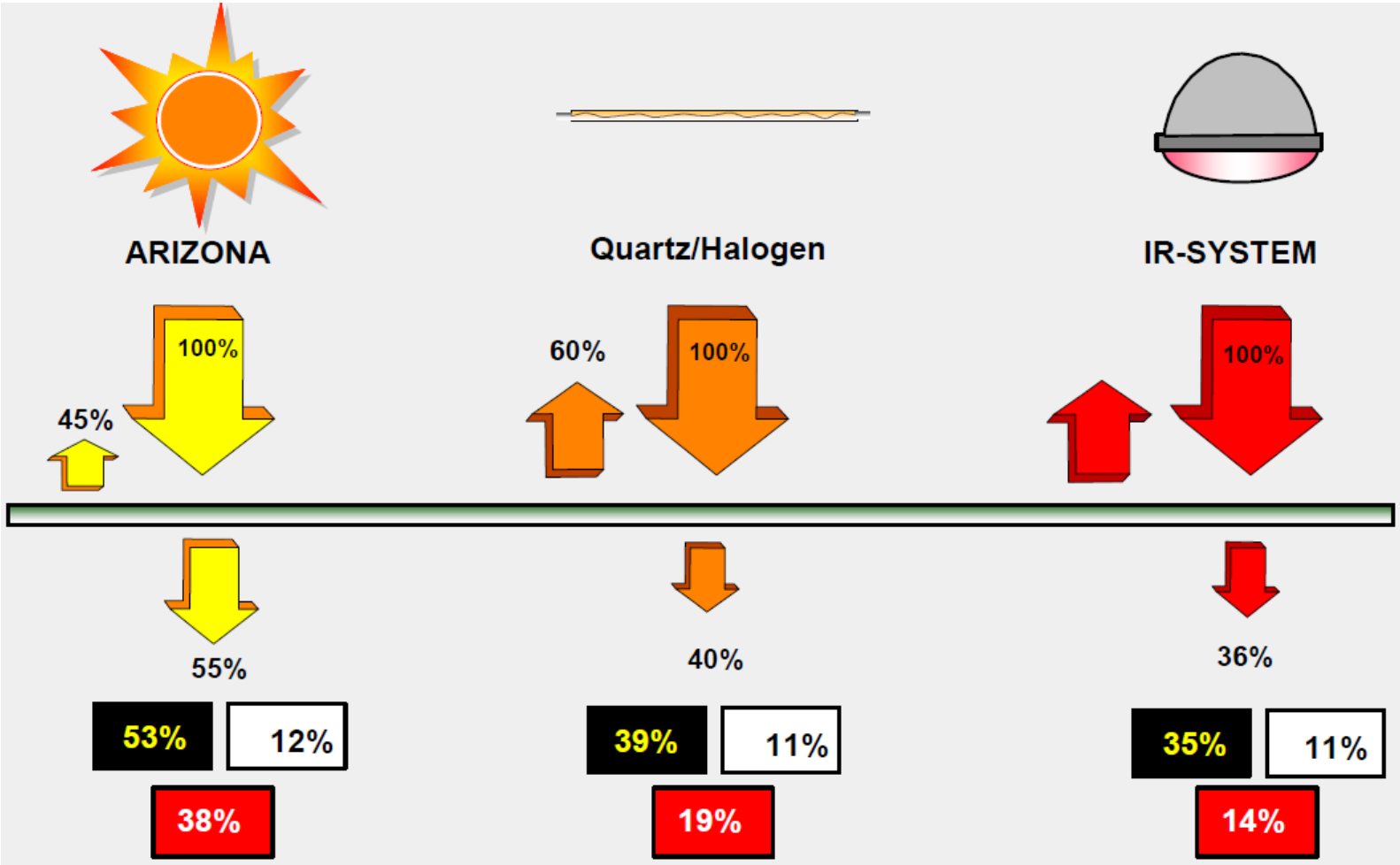


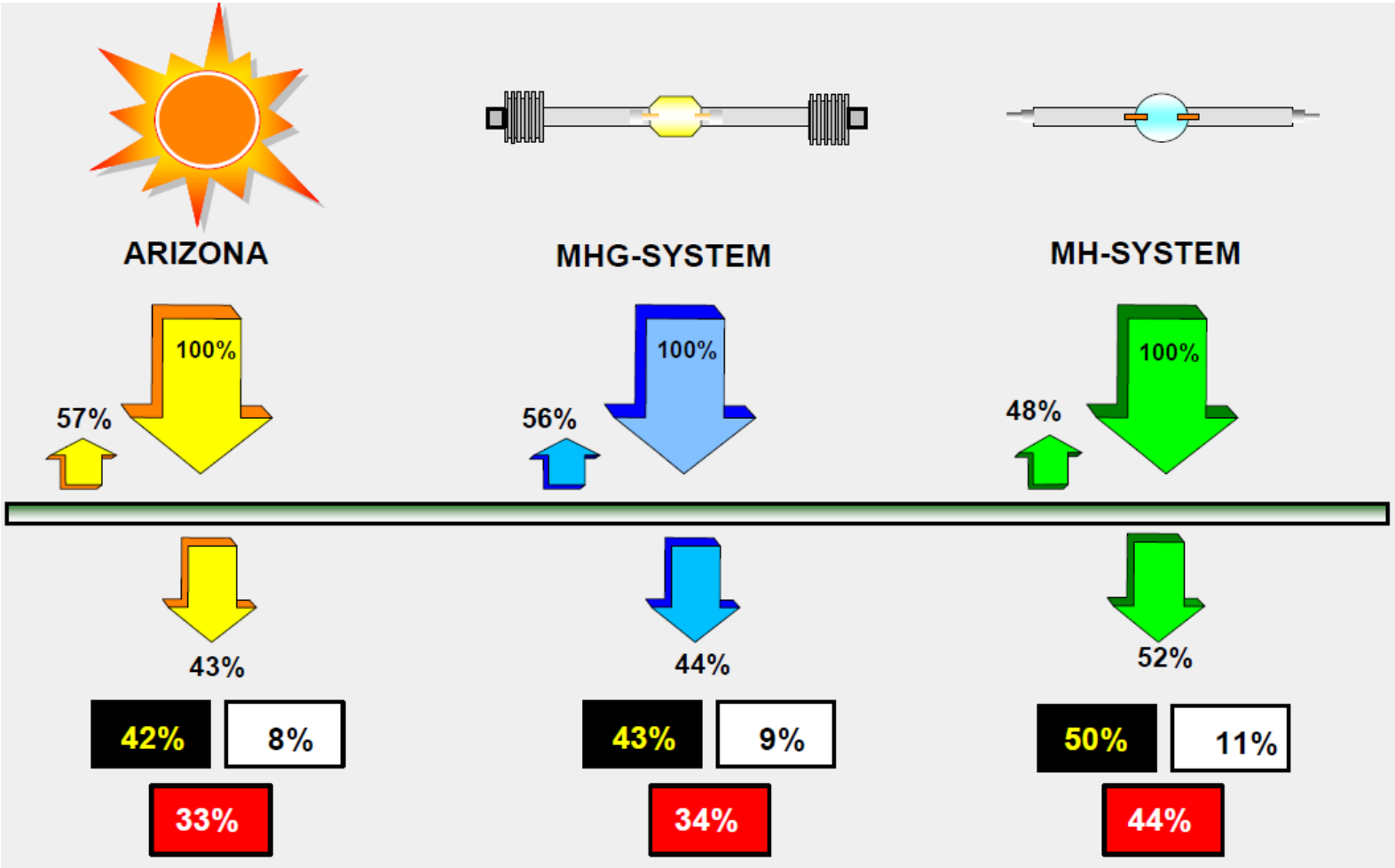
Total of Absorbed Radiation Through Tinted Glass



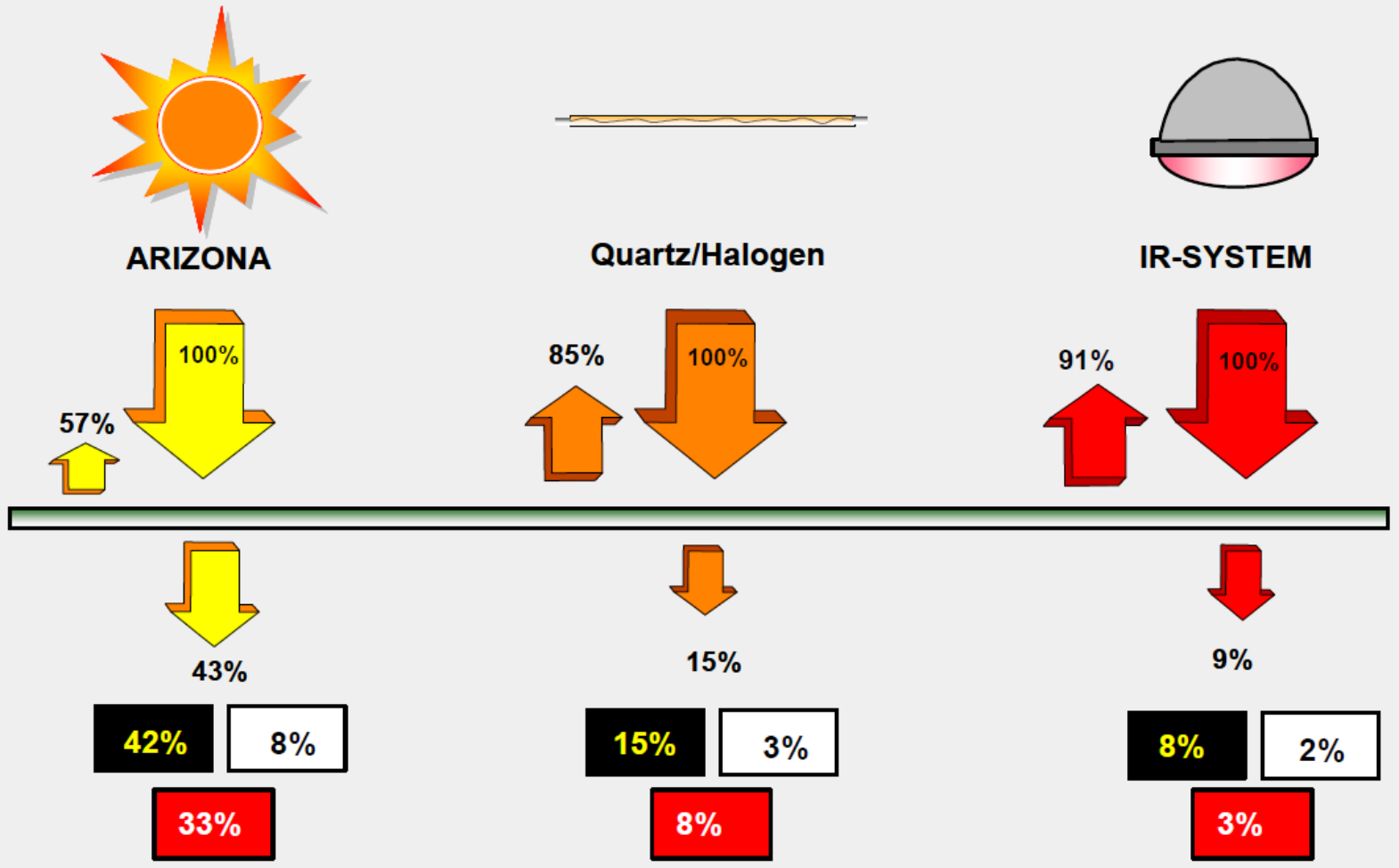
Total of Absorbed Radiation Through Tinted Glass



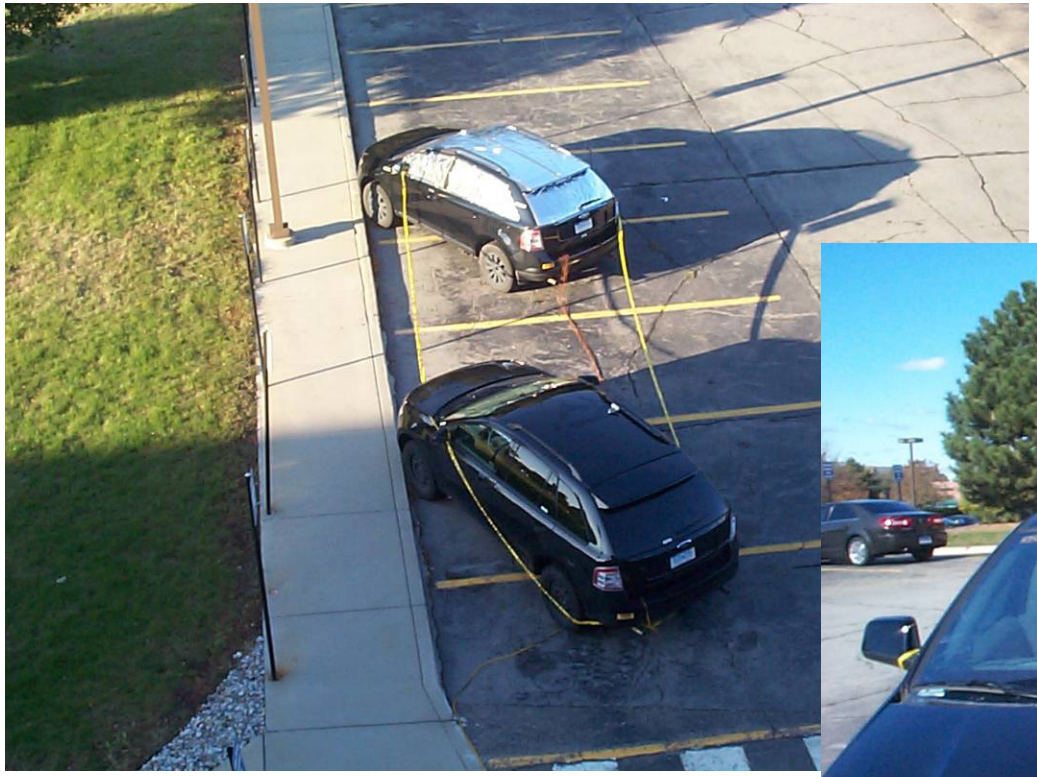
Total of Absorbed Radiation Through Thermal Glass

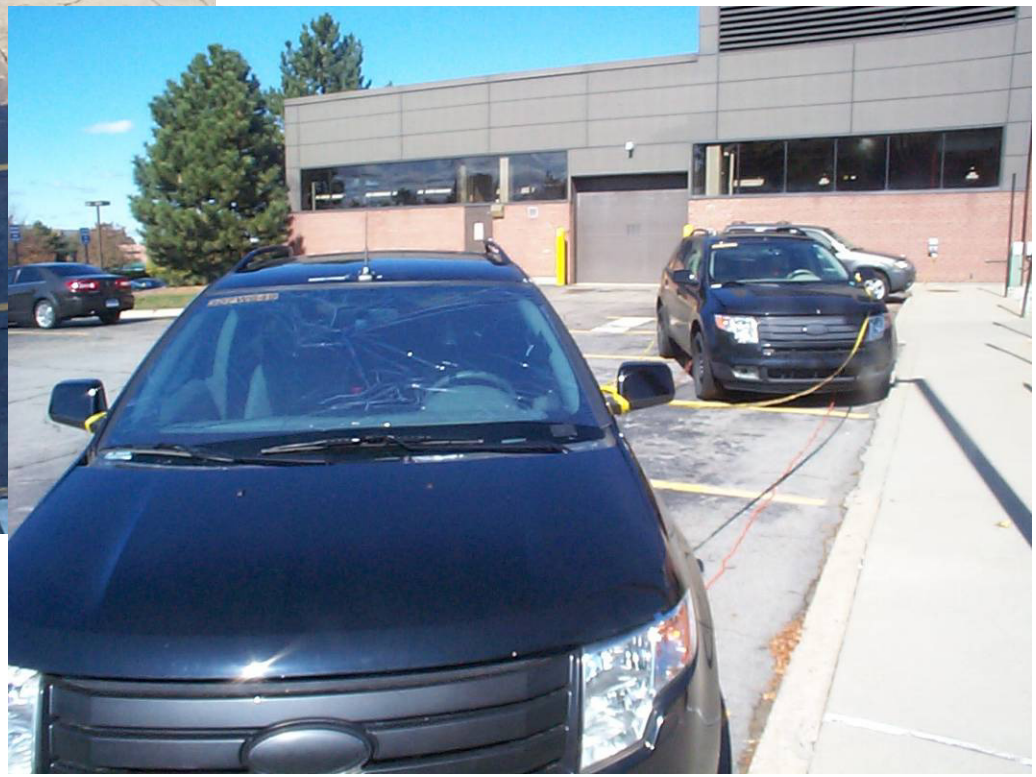


Total of Absorbed Radiation Through Thermal Glass

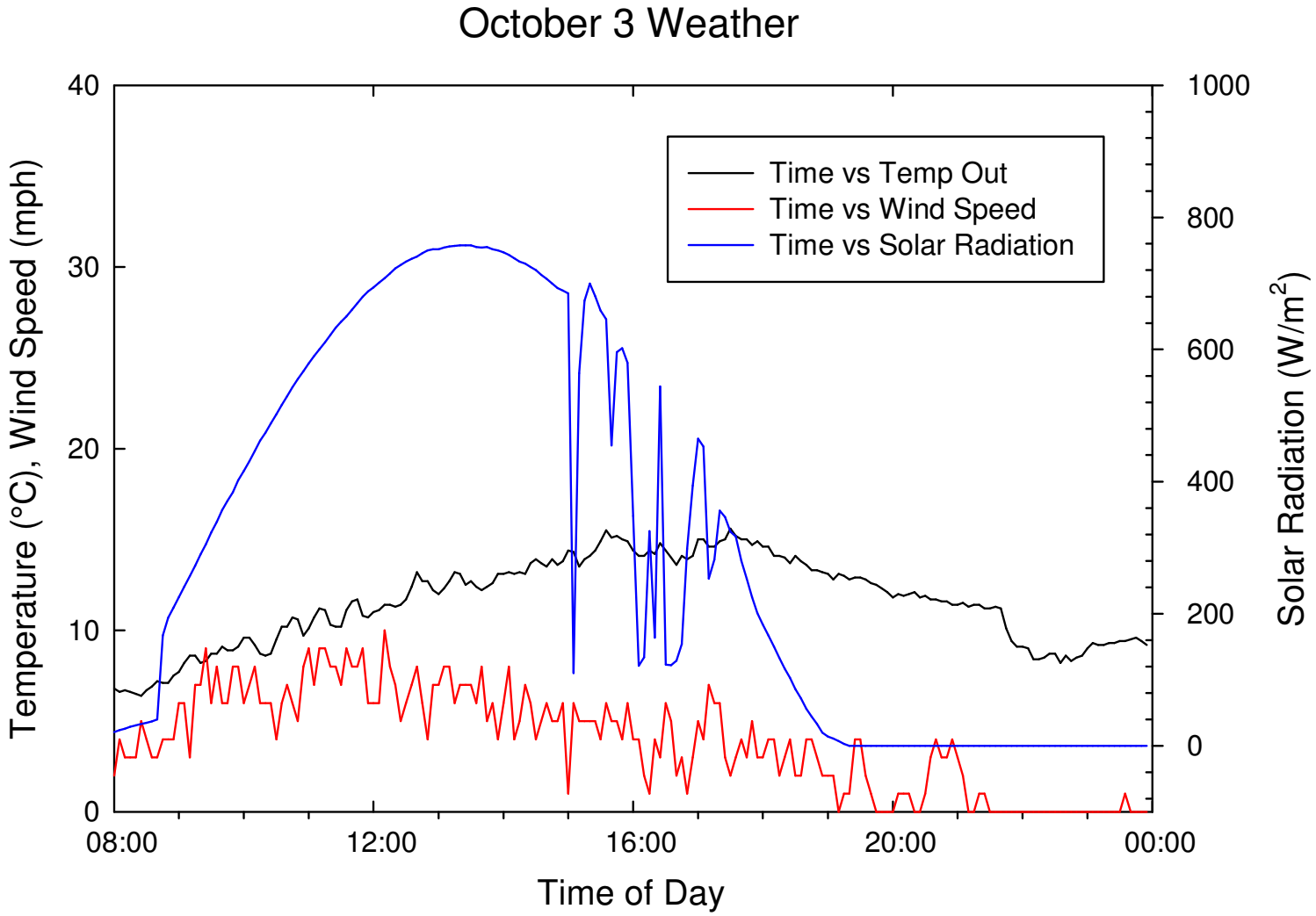


Ford Edge with Different Glass Technologies - October 3,4,&5 2009 at Ford RIC

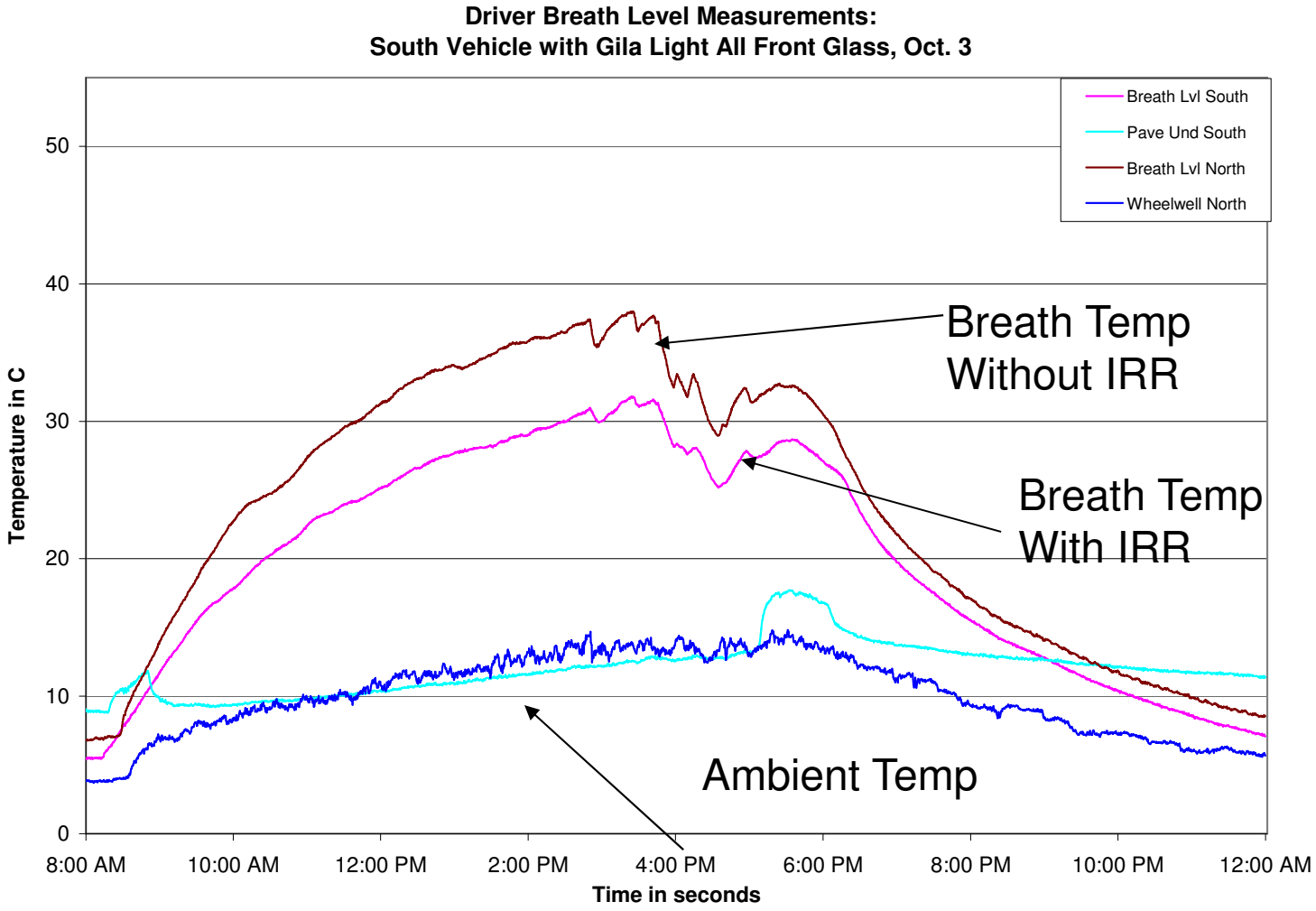




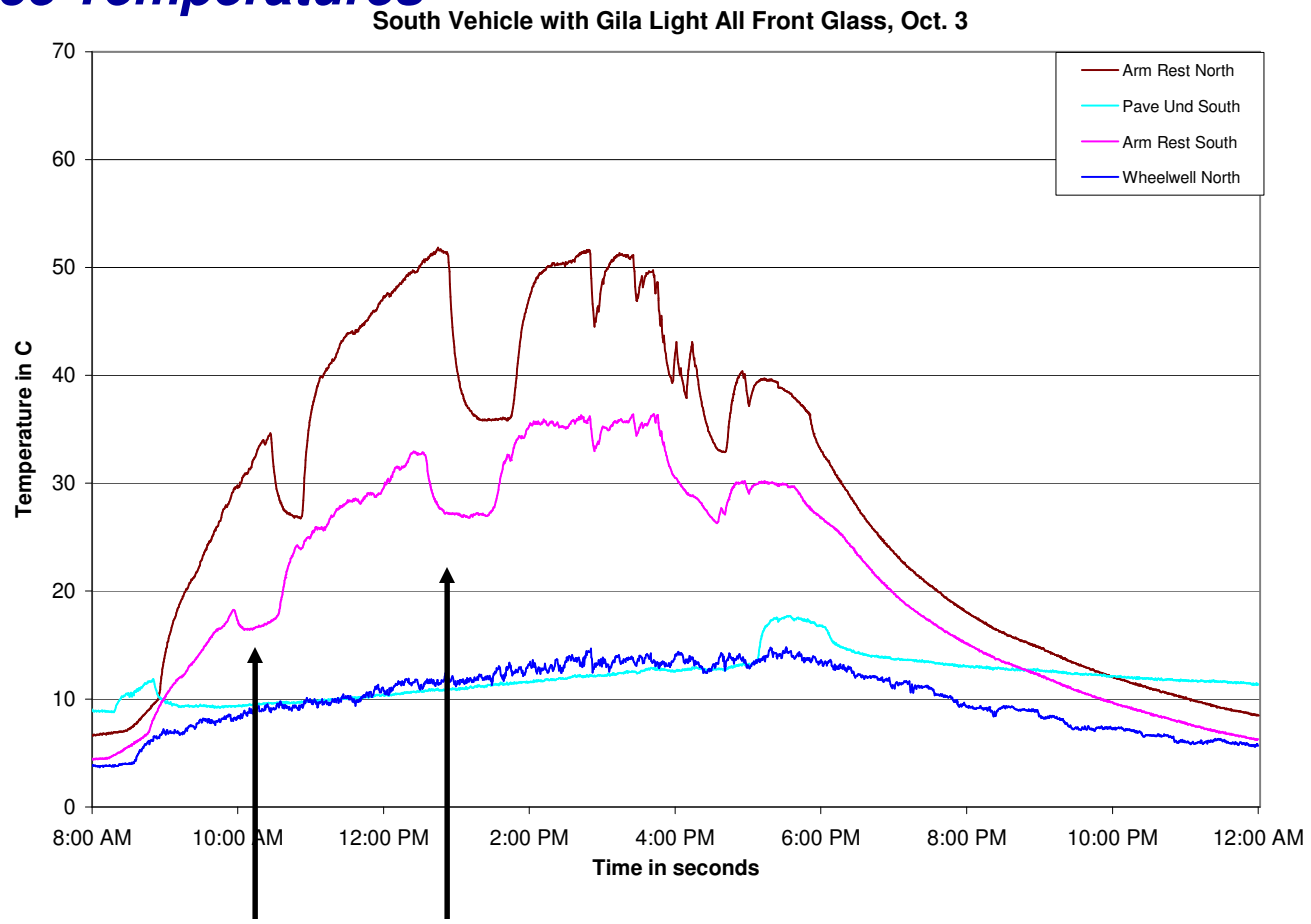
IRR Film on Glass
- Effect of Intermittent Afternoon Clouds



IRR Film on Glass
- Effect of Intermittent Afternoon Clouds on Breath Temp



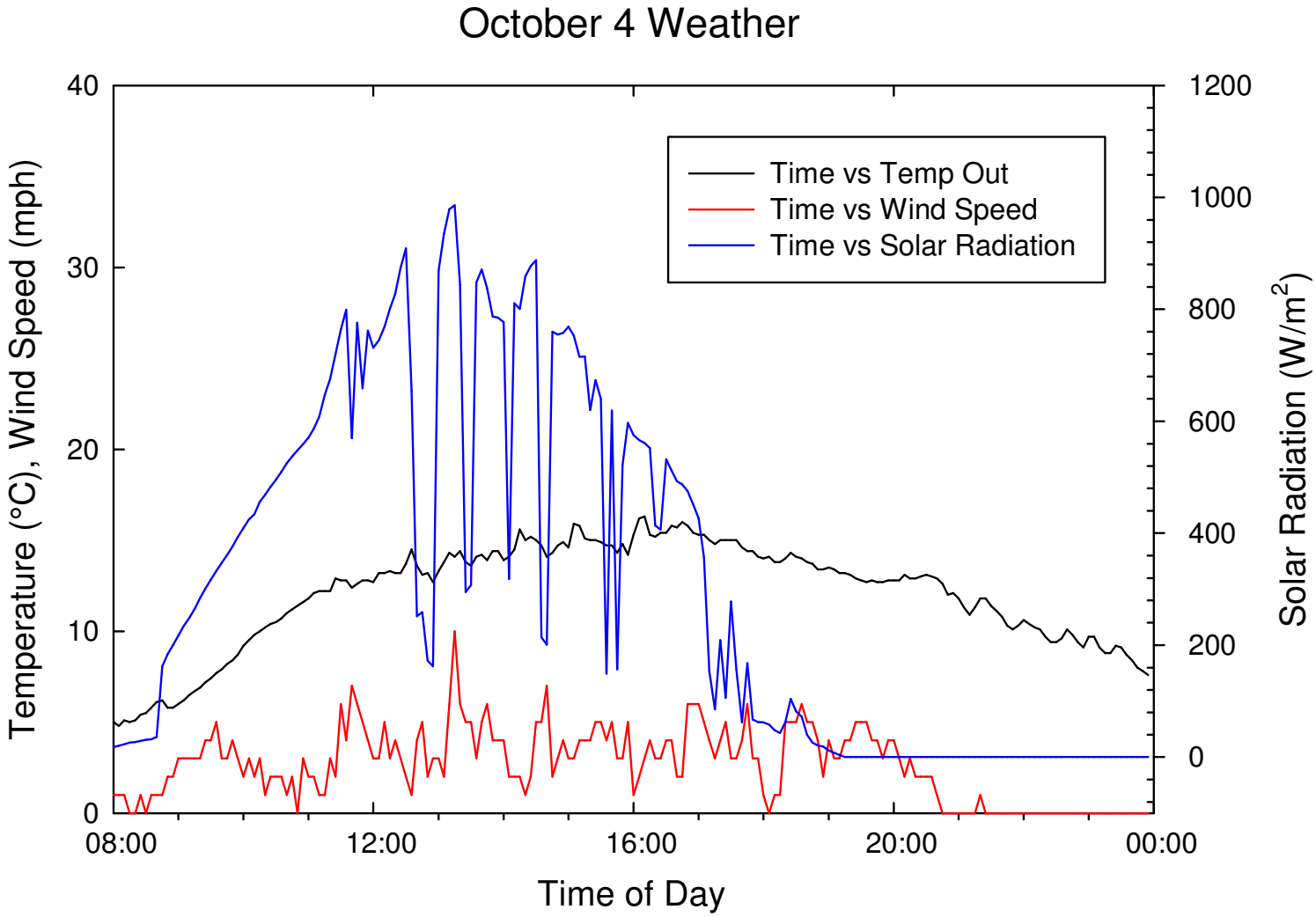
IRR Film on Glass
- Effect of Surface Temperatures



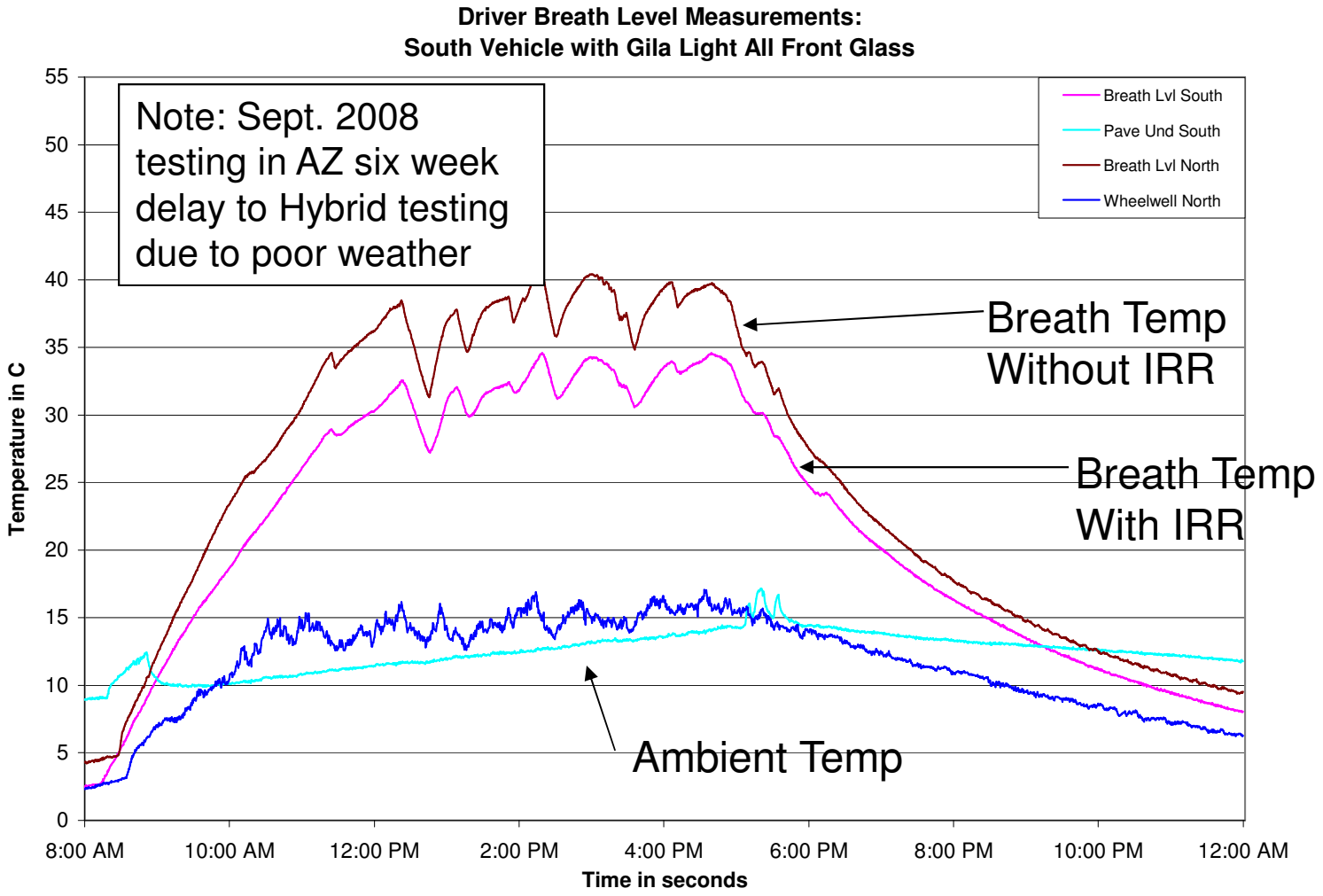
Vehicle Pillars Block Solar Load but does not change breath temperature

*see previous slide

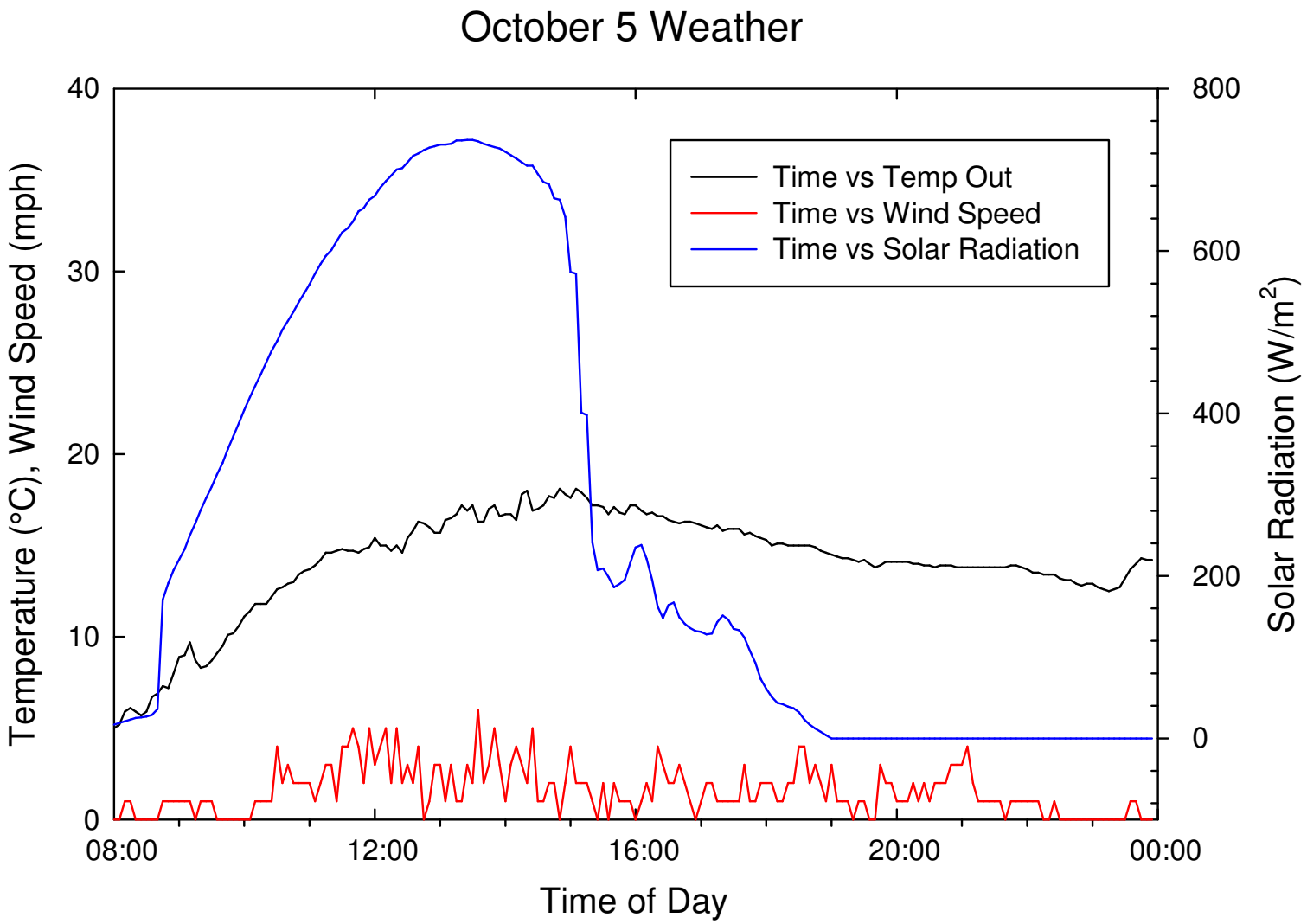
IRR Film on Glass
- Effect of Many Afternoon Clouds



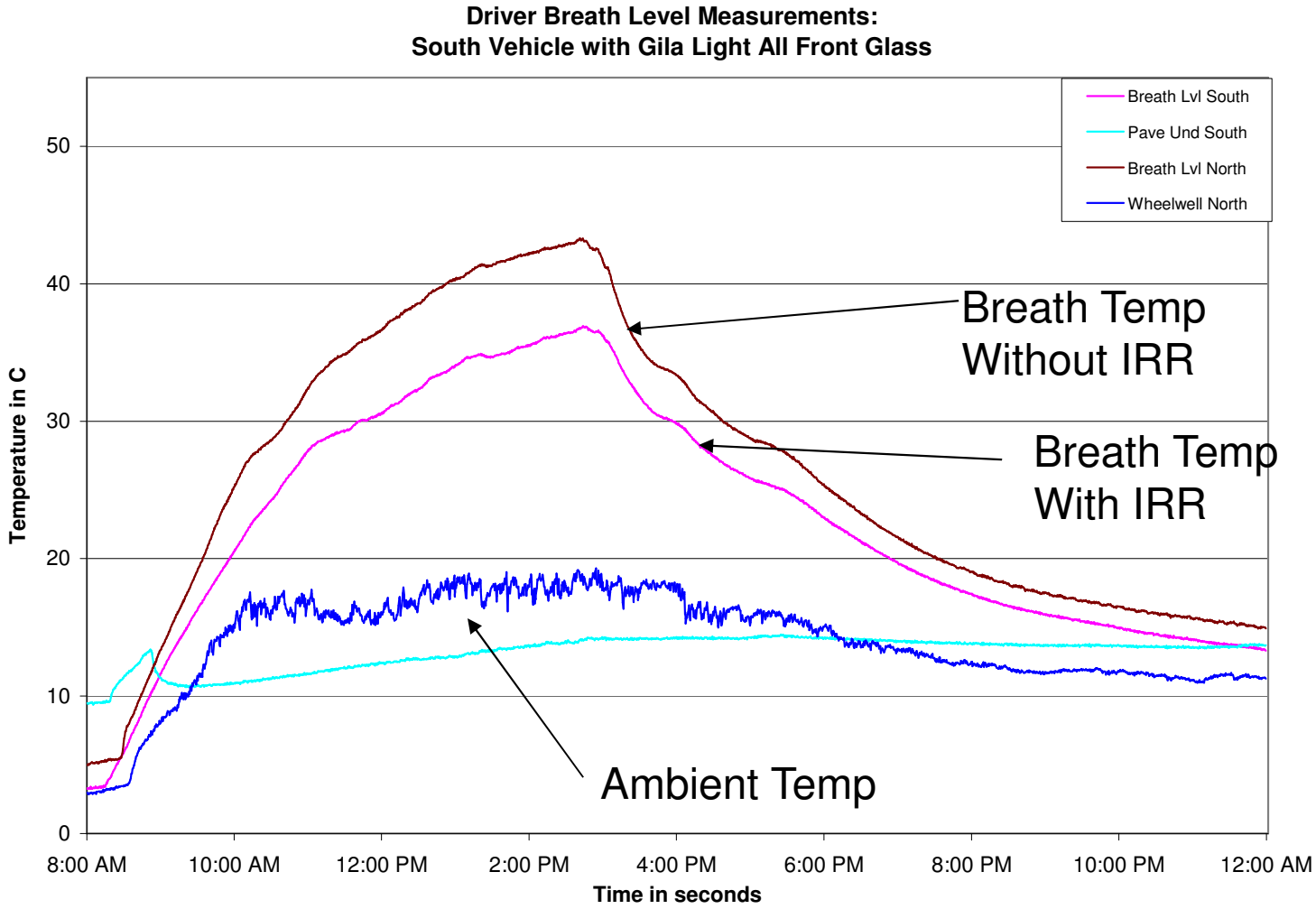
IRR Film on Glass
- Effect of Many Afternoon Clouds



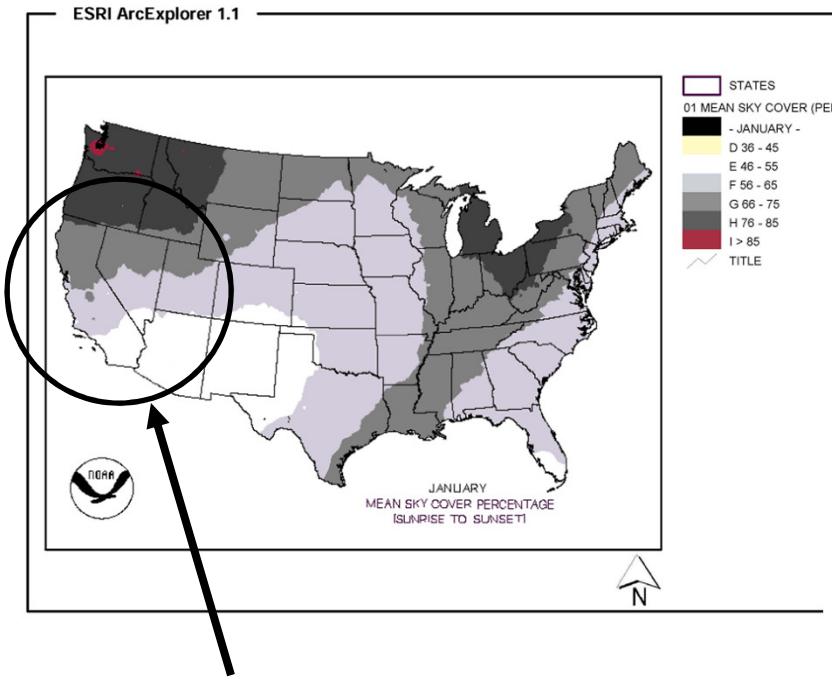
IRR Film on Glass
- Effect of No Clouds until Late Afternoon



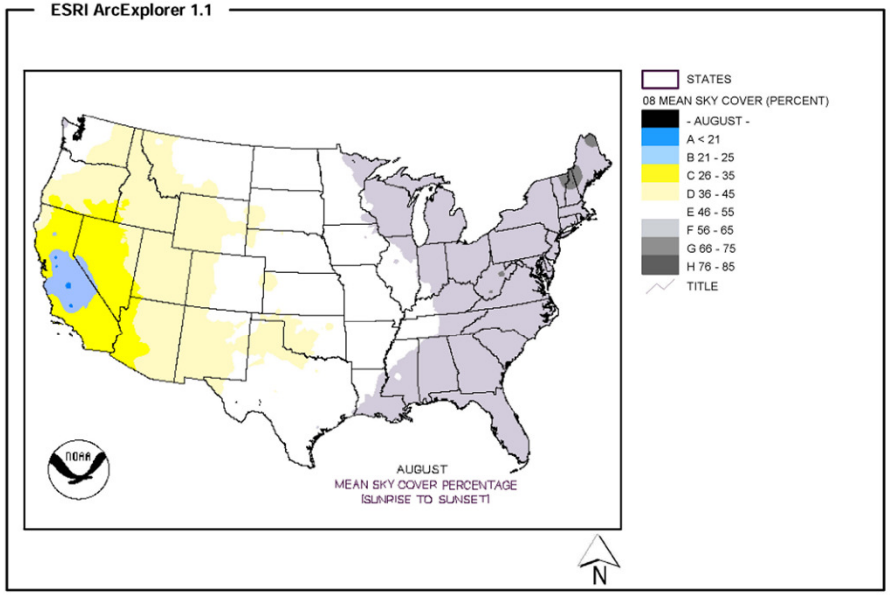
IRR Film on Glass
- Effect of No Clouds until Late Afternoon



Mean Sky Cover (MSC)
- Varies Greatly Based on Location and Time of Year



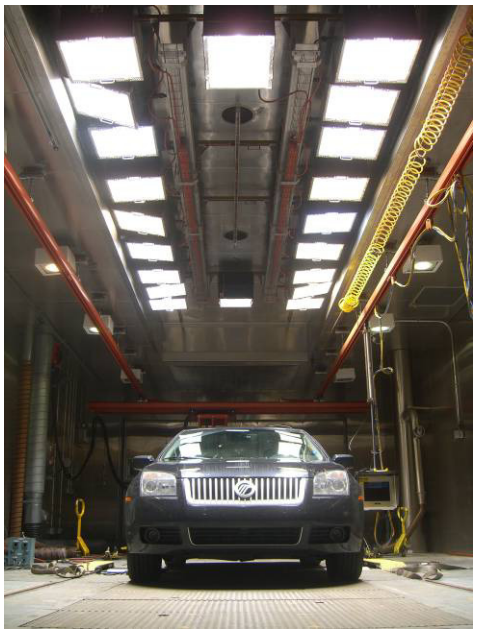
Note: No US location
as less than 46% MSC



Conclusions on Outdoor Solar Loads and glass technology

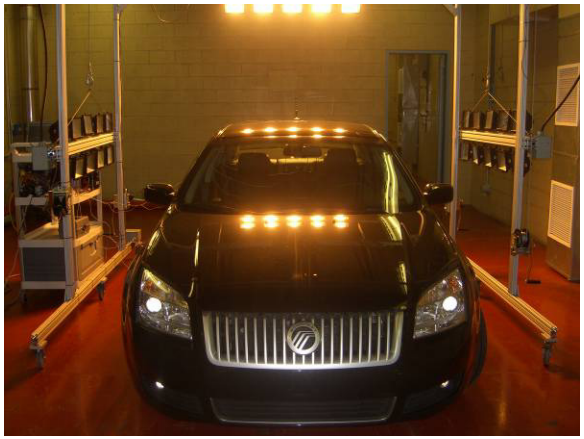
- Interior temperature were impacted by glass technologies
- Solar load changes and varies greatly with:
  - Geographic location
  - Clouds
  - Vehicle direction
  - Solar path
  - Time of day/calendar day
  - Sudden wind gusts.

Different Solar Testing Sites



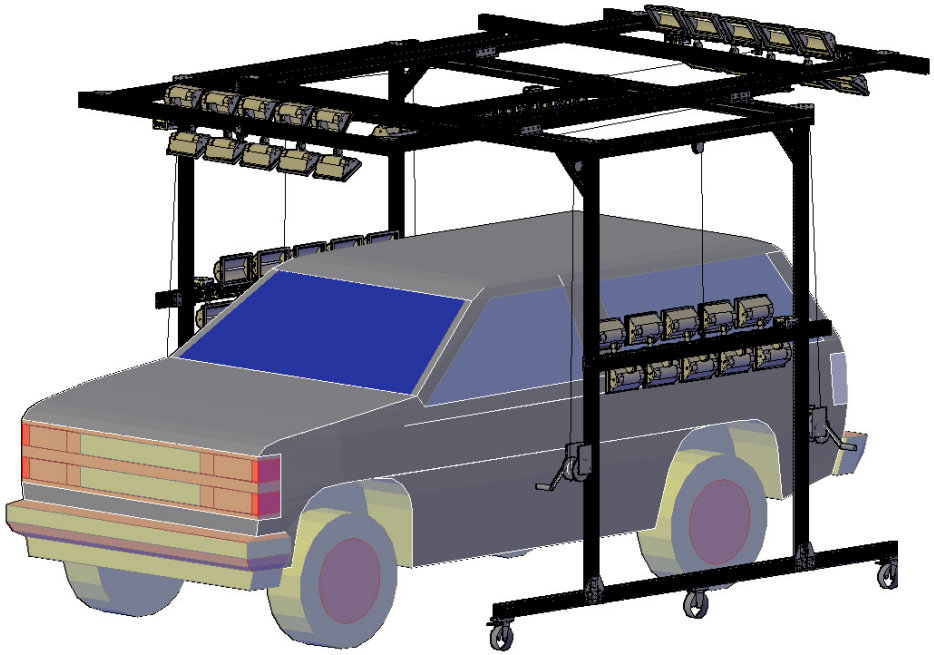
Metal Halide

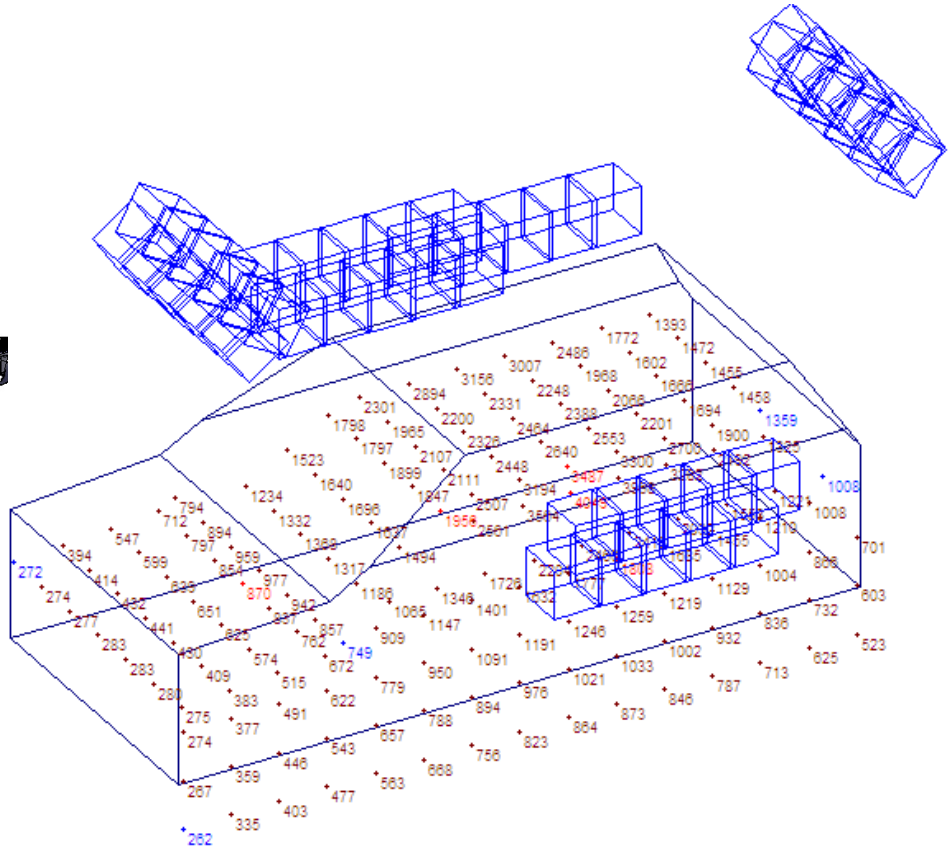
Outdoor



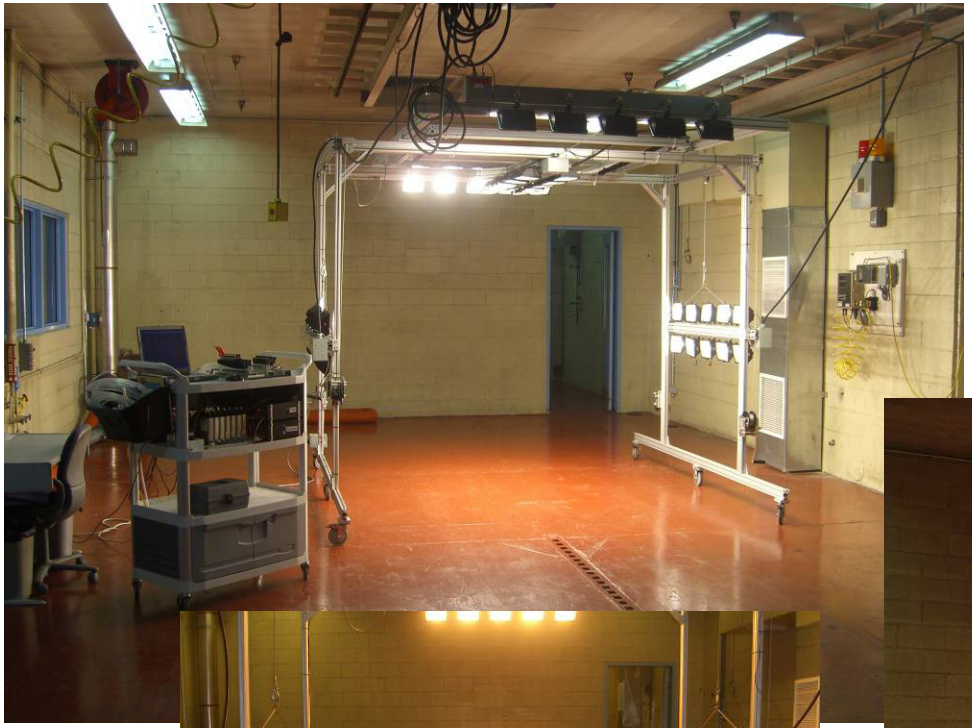
Halogen

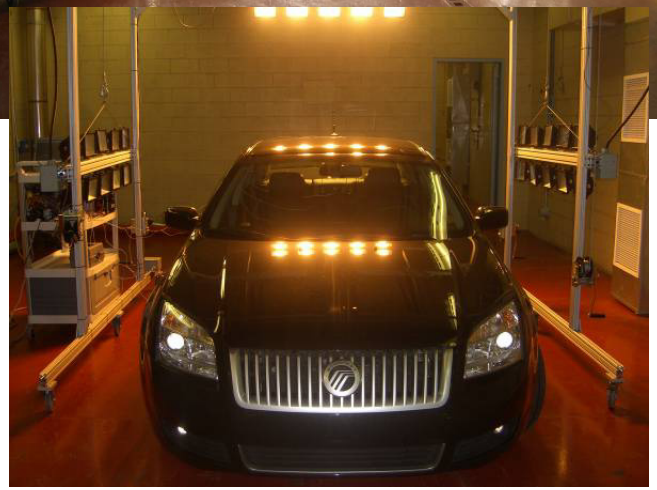
Response to ISO VOC draft site design

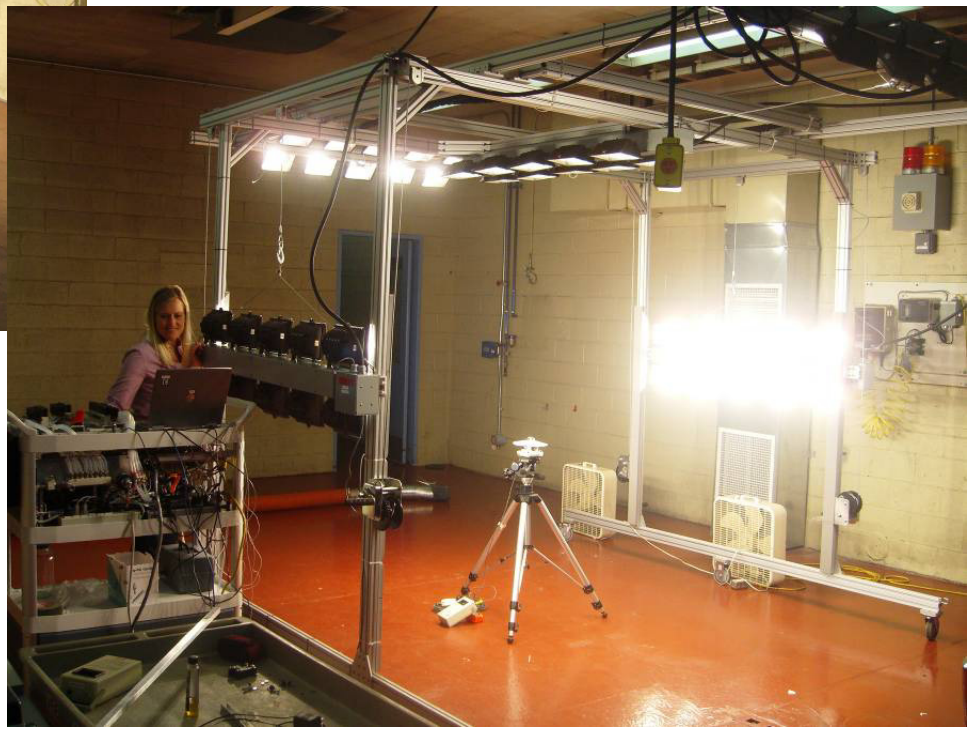




ISO Interior Air Quality Test Site







EPA Solar Loading Procedure – SC03
Federal Code of Register

- **§ 86.161–00 Air conditioning environmental test facility ambient requirements.**

- The goal of an air conditioning test facility is to simulate the impact of an ambient heat load on the power requirements of the vehicle's air conditioning compressor while operating on a specific driving cycle.

SC03 Solar Load represents <u>WORST CASE</u> for US.

This emissions test was designed to find defeat devises related to AC usage <u>not</u> A/C efficiency.

Continued…

(3) Radiant energy specifications. (i) Simulated solar radiant energy intensity is determined as an average of the two points measured at: (A) Centerline of the test vehicle at the base of the windshield. (B) Centerline of the vehicle at the base of the rear window (truck and van location defined as bottom of vertical window or where an optional window would be located). (ii) The radiant energy intensity set point is **850 +-45 watts/square meter.** (iii) The definition of an acceptable spectral distribution is contained in the following table:

DEFINITION OF THE SPECTRAL DISTRIBUTION

Band width (nanometers)	Percent of total spectrum	
	Lower limit (percent)	Upper limit (percent)
<320	0	0
320–400	0	7
400–780	45	55
>780	35	53

(iv) The angle of incidence of radiant energy is defined as 90 degrees from the test cell floor.

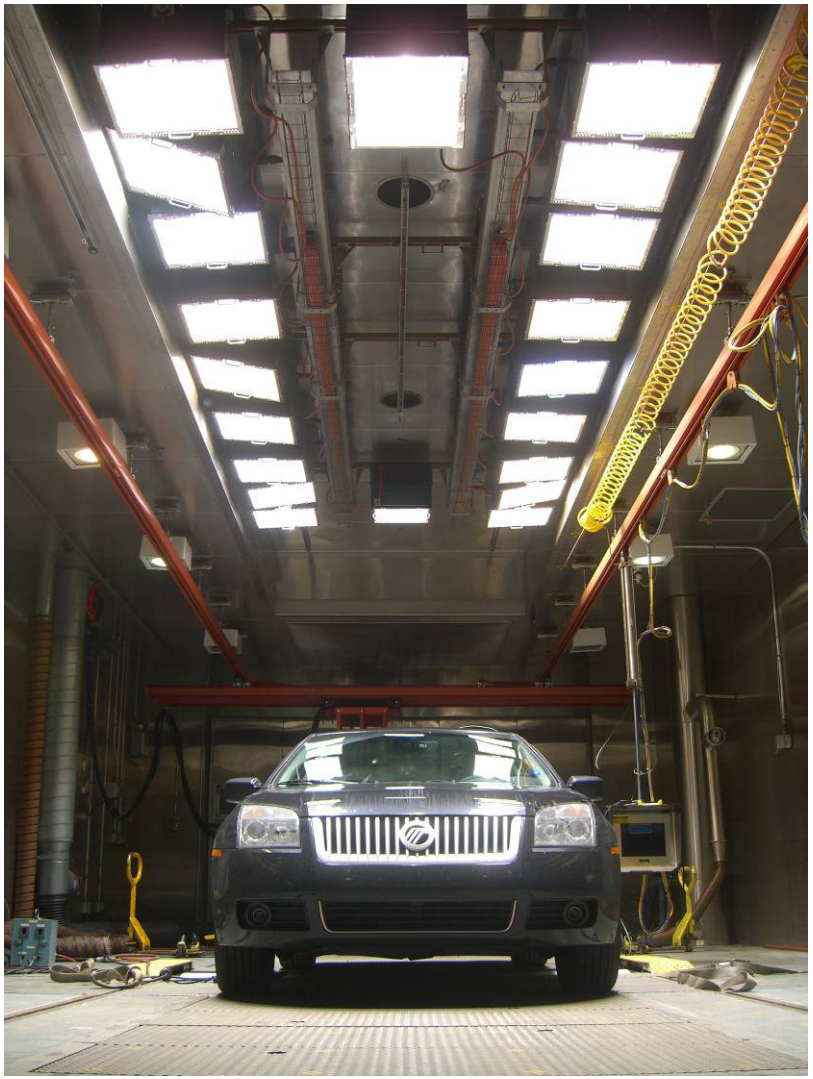
Continued…

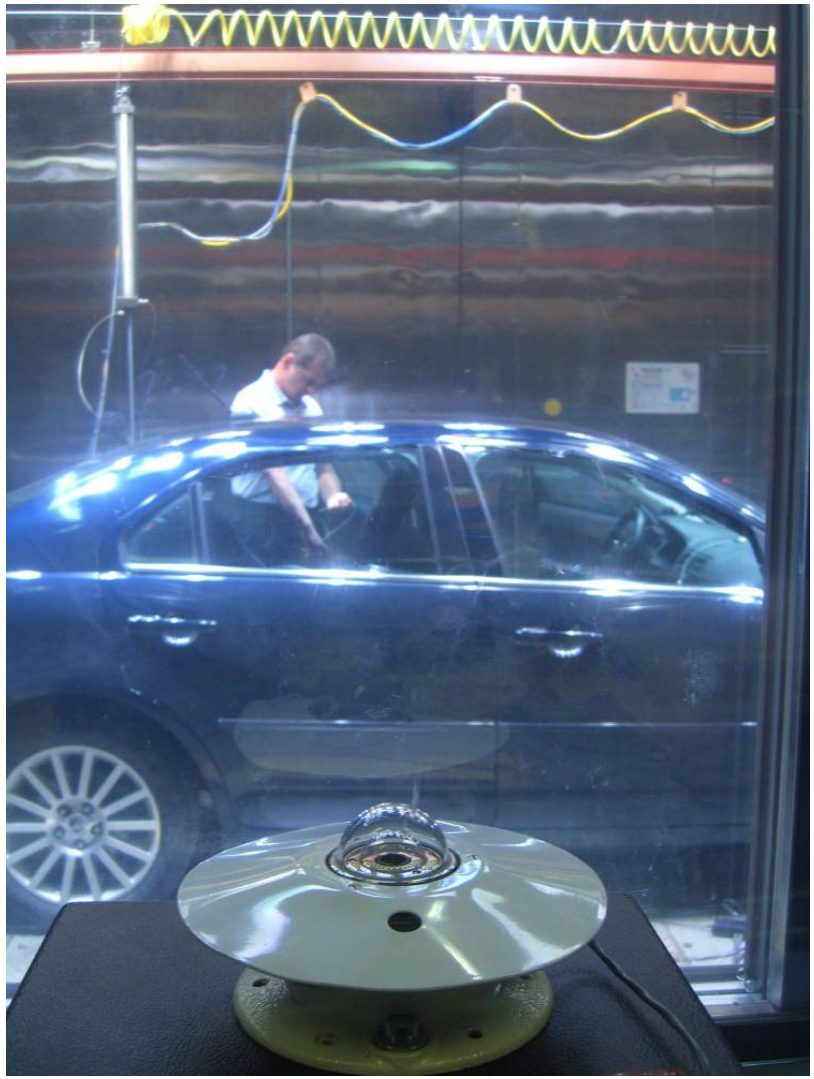
(d) *Solar heat loading.*

(1)(i) Acceptable types of radiant energy emitters that may be used for simulating solar heat load are: **(A) Metal halide; (B) Quartz halogen with dichroic mirrors; and (C) Sodium iodide. (ii)** The Administrator will approve other types of radiant energy emitters if the manufacturer can show they satisfy the requirements of this section.

(2) The height of the minimal cell size will dictate the type of radiant energy source that will satisfy the spectral distribution and uniformity definitions of this section. (v) The requirements for measuring the uniformity of radiant energy are: (A) The radiant energy uniformity tolerance is +-15 percent of the radiant energy intensity set point of 850 watts/ square meter. (B) The uniformity of radiant energy intensity is measured at each point of a 0.5 meter grid over the entire footprint of the test vehicle at the elevation of one meter including the footprint edges. (C) Radiant energy uniformity must be checked at least every 500 hours of emitter usage or every six months depending on which covers the shorter time period; and every time major changes in the solar simulation hardware occur. (vi) The radiant energy intensity measurement instrument specifications (minimum) are: (A) Sensitivity of 9 microvolts per watt/square meter; (B) Response time of 1 second; (C) Linearity of +-0.5 percent; and (D) Cosine of +-1 percent from normalization 0–70 degree zenith angle.

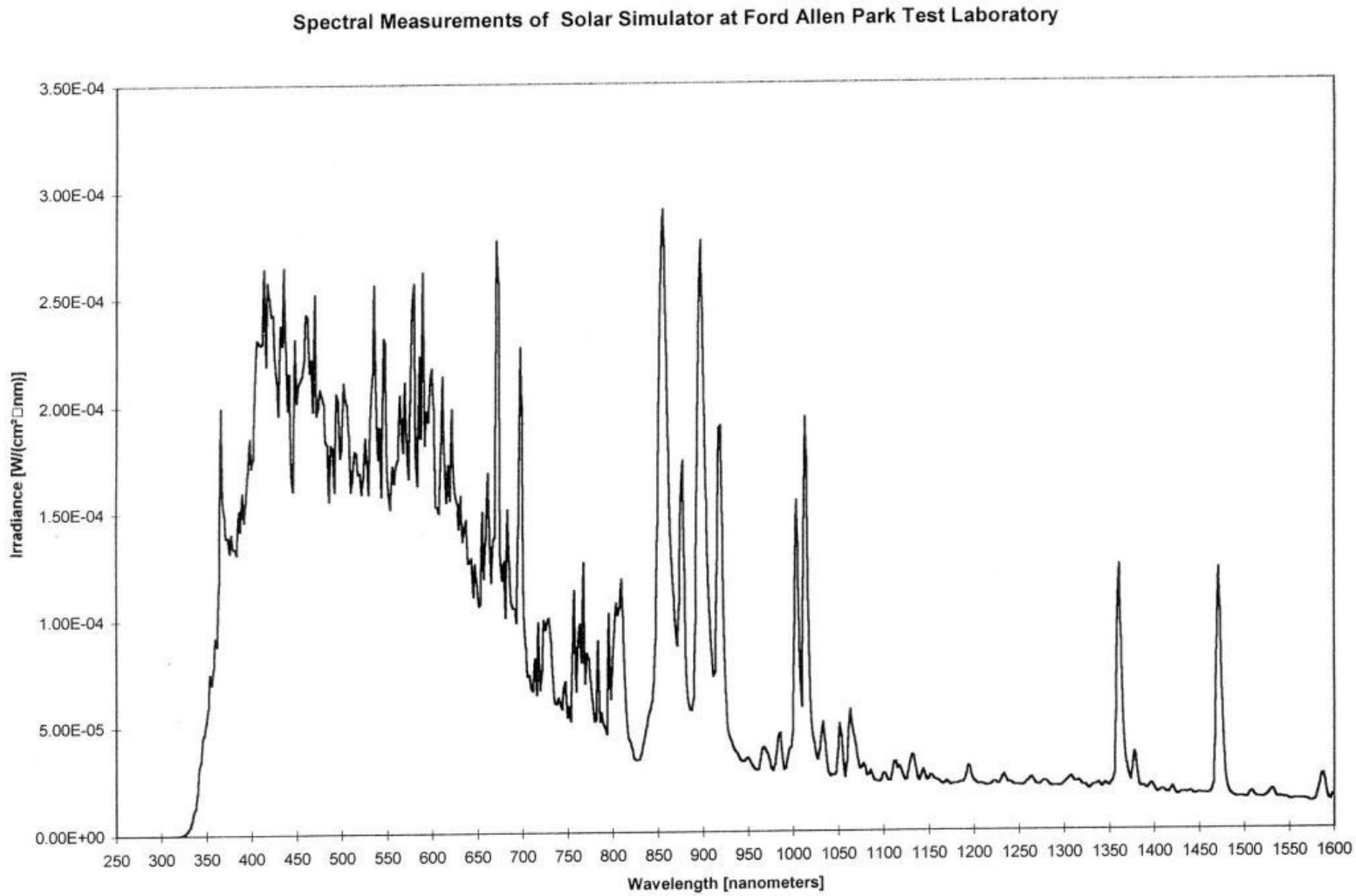
SCO3 Site with Metal Halide Lights and Pyranometer





Ford SC03 Site

- As measured at APTL SC03 Site



Eppley Precision Spectral Pyranometer (PSP)

- This radiometer measures sun and sky irradiance in the range of wavelengths 0.285 to 2.8 microns, including most of the solar spectrum. The PSP is intended to weight the energy flux in all wavelengths equally. It is a “hemispheric receiver” intended to approximate the cosine response for oblique rays.

  - Specifications:
  - Sensitivity approximately 9 microvolts per W/m2. Thus an irradiance of 1000W/m2 will produce a DC potential of 9 millivolts.
  - Impedance is approximately 650 Ohms. Thus, if current is drawn from the PSP, the output voltage will drop.
  - Temperature dependence is 1% over -20 to +40C
  - Linearity is plus or minus 0.5% from 0 to 2800 W/m2
  - Response time is 1 second (for a 1/e relaxation)
  - Cosine response: 1% for 0 to70 degrees from zenith; 3% from 70 to 80 degrees
  - Size 5.75 inches diameter; 3.75 inched high
  - Weight 7 pounds

Solar Uniformity on SC03 Site

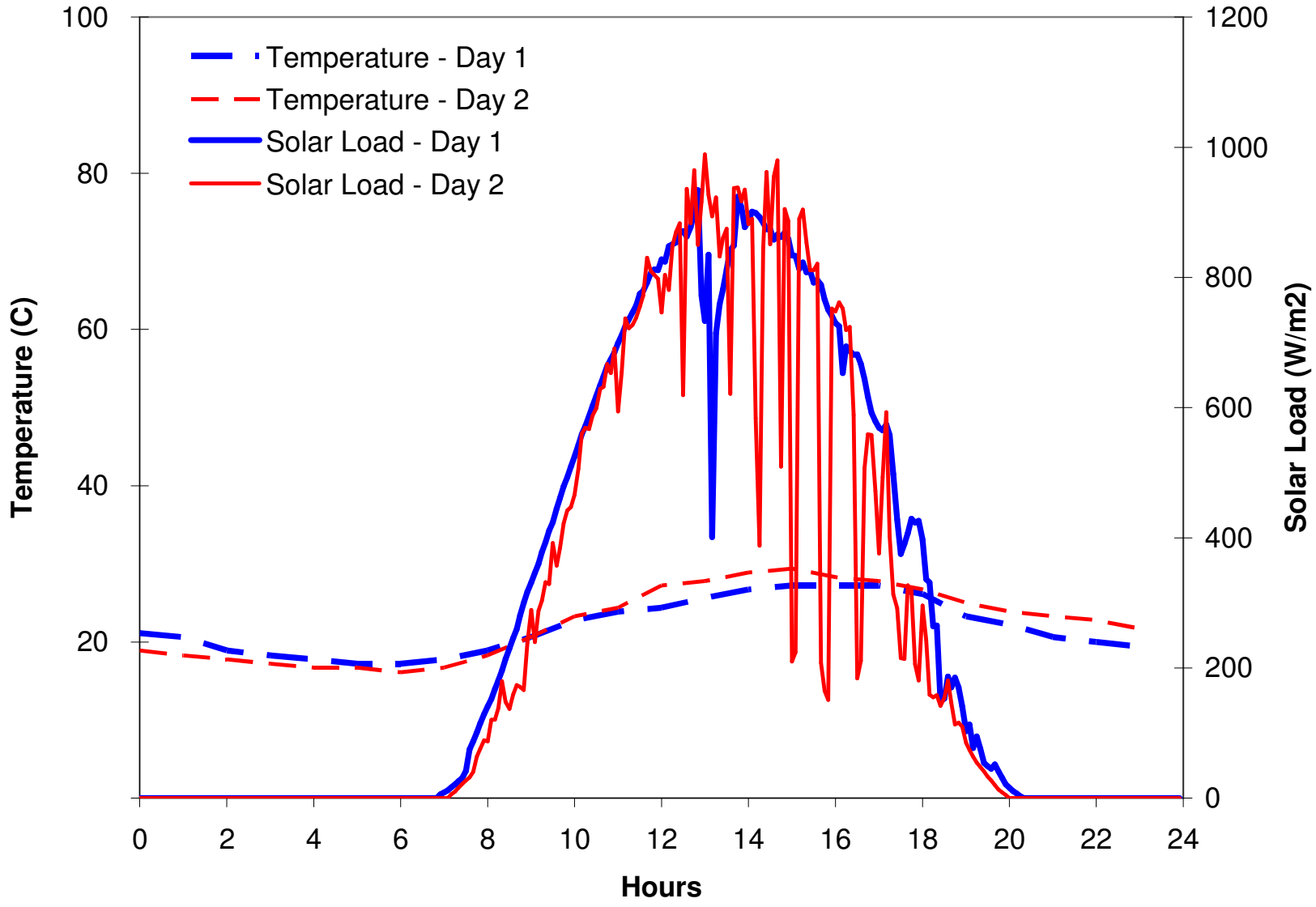
SITE 78 SOLAR UNIFORMITY VERIFICATION DATA

DATE:	2/1/2008	(run hours: on E1)			Before	2468	After	2756	Run Hours		288		
OBSERVER:	B. Hefferon / Cass Kemp/ Jeff Smith								Inaccuracy:				
INSTRUMENT:	Mfr & Model:	psp			T-No.:		33413F3		Calibration Due:		Jul-08		
AMBIENT:	Temp:	72							Humidity:		43.1		
Solar Intensity Data (W/m^2)										Intensity:	92%		
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
0.0	719	785	848	897	868	837	814	804	831	852	838	819	740
0.5	721	788	831	880	889	878	868	863	862	881	864	748	752
1.0	699	750	763	812	811	825	823	812	805	800	815	789	790
1.5	745	784	803	850	838	831	812	800	802	818	781	774	697
2.0	800	859	891	921	880	859	835	824	832	862	826	792	708
2.5	741	800	843	861	792	767	747	749	773	802	782	742	692
Minimum Intensity			692	-14.4%					Average Intensity			808.8	
Maximum Intensity			921	13.9%					Standard Deviation			51.5	
Percent Difference from Average Intensity													
c	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
0.0	-11.1%	-2.9%	4.8%	10.9%	7.3%	3.5%	0.6%	-0.6%	2.7%	5.3%	3.6%	1.3%	-8.5%
0.5	-10.9%	-2.6%	2.7%	8.8%	9.9%	8.6%	7.3%	6.7%	6.6%	8.9%	6.8%	-7.5%	-7.0%
1.0	-13.6%	-7.3%	-5.7%	0.4%	0.3%	2.0%	1.8%	0.4%	-0.5%	-1.1%	0.8%	-2.4%	-2.3%
1.5	-7.9%	-3.1%	-0.7%	5.1%	3.6%	2.7%	0.4%	-1.1%	-0.8%	1.1%	-3.4%	-4.3%	-13.8%
2.0	-1.1%	6.2%	10.2%	13.9%	8.8%	6.2%	3.2%	1.9%	2.9%	6.6%	2.1%	-2.1%	-12.5%
2.5	-8.4%	-1.1%	4.2%	6.5%	-2.1%	-5.2%	-7.6%	-7.4%	-4.4%	-0.8%	-3.3%	-8.3%	-14.4%
Minimum Difference			-14.4%		EPA Min Limit		-15%		Average Difference			0.0%	
Maximum Difference			13.9%		EPA Max Limit		15%		Standard Deviation			6.4%	

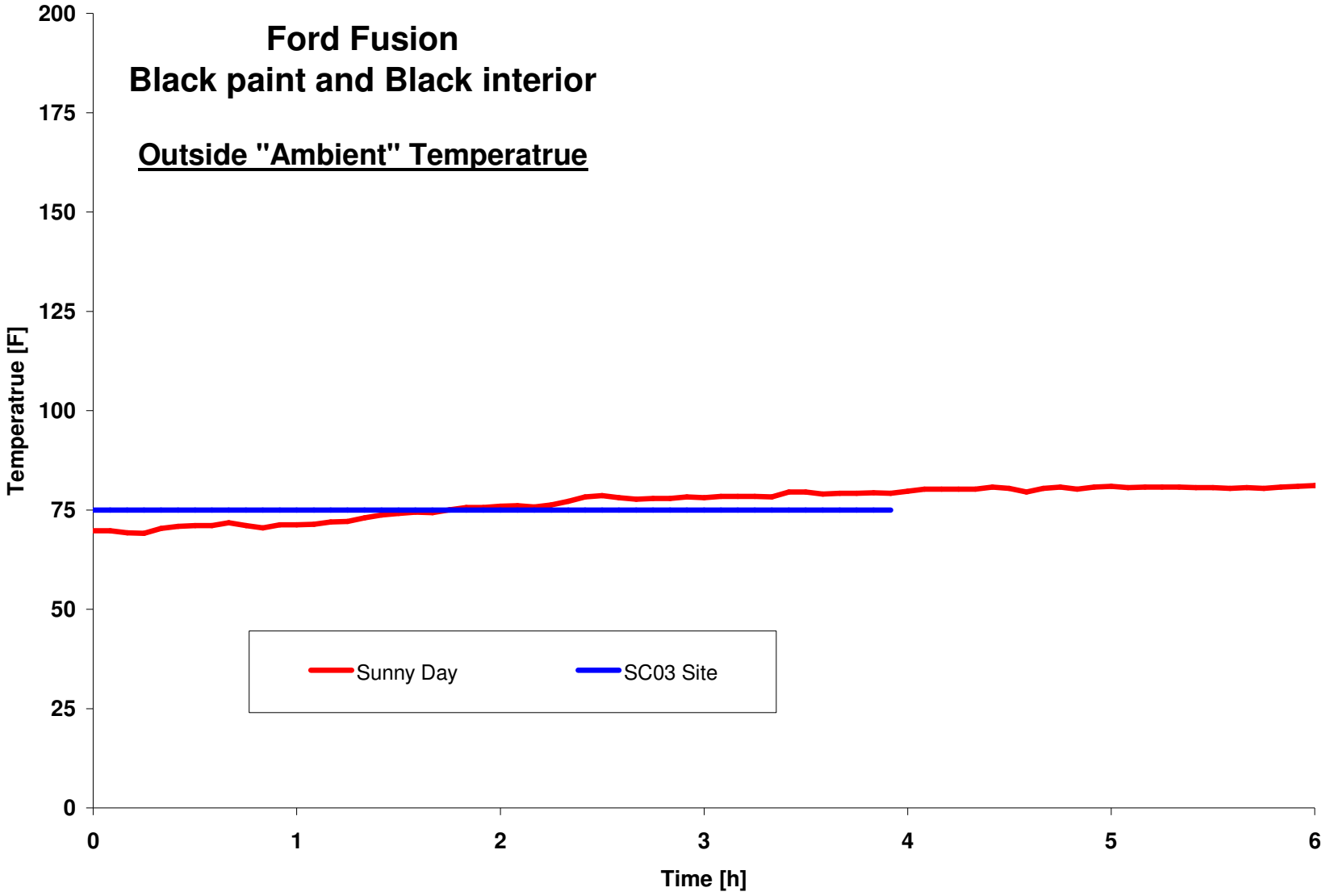
WG Progress

- The WG shared data for temperatures in the countries and regions they represented.
- With that was some test site and real world solar and temperature data.
- The WG also shared data on the effect the type of the light had on heating the vehicle, taking into account the type of glass technology on the vehicle.

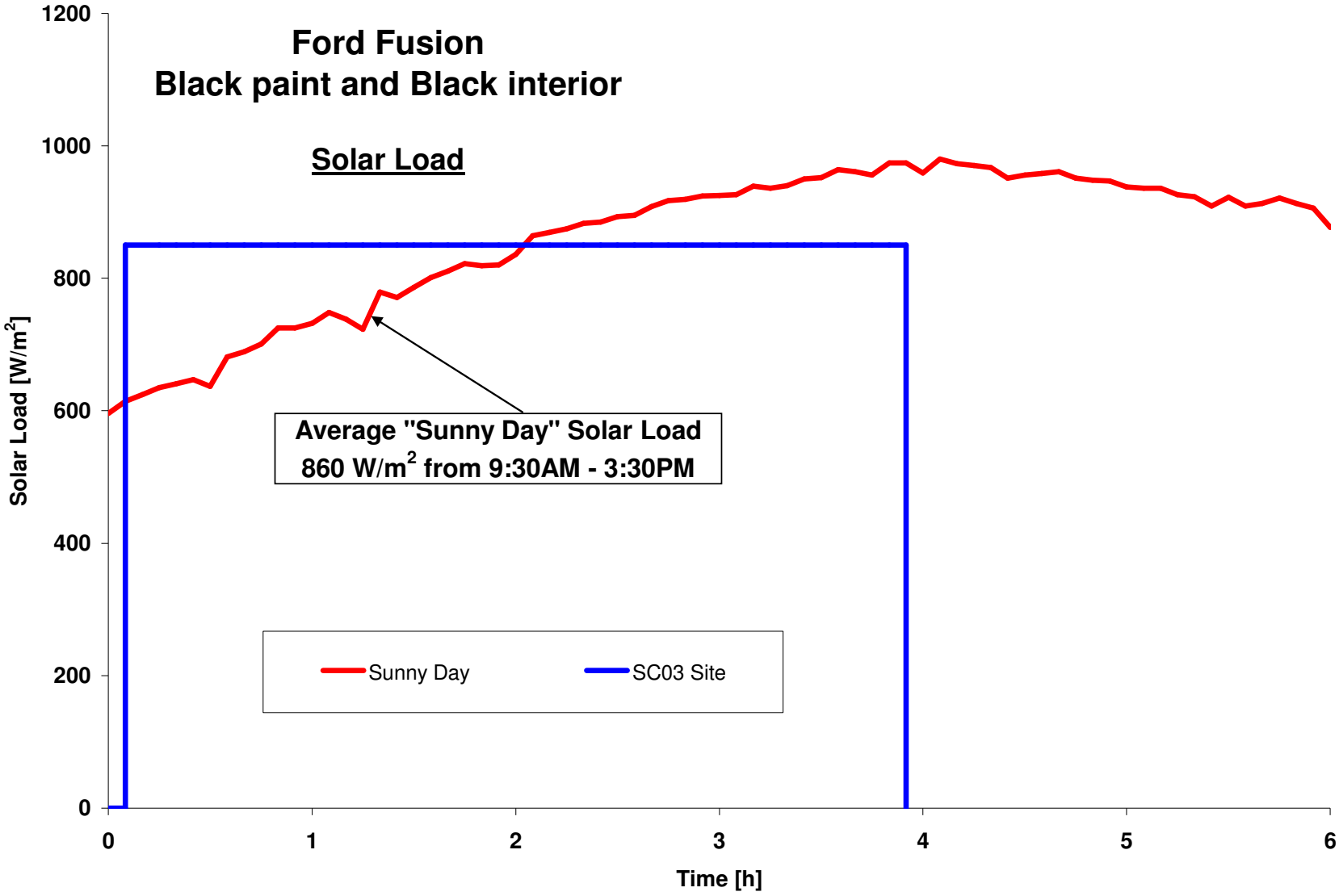
Outdoor Testing



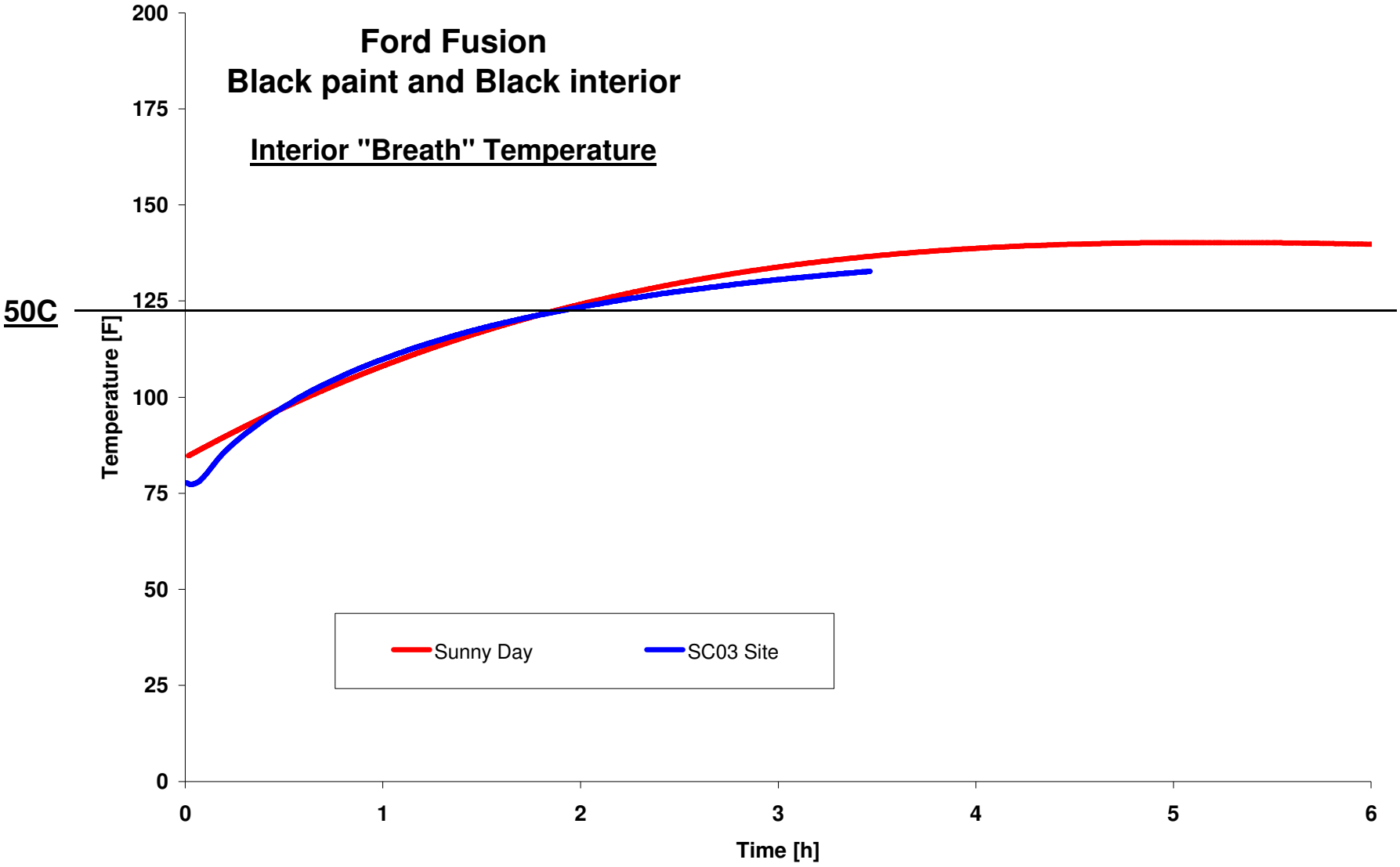
Sun and SC03 site data



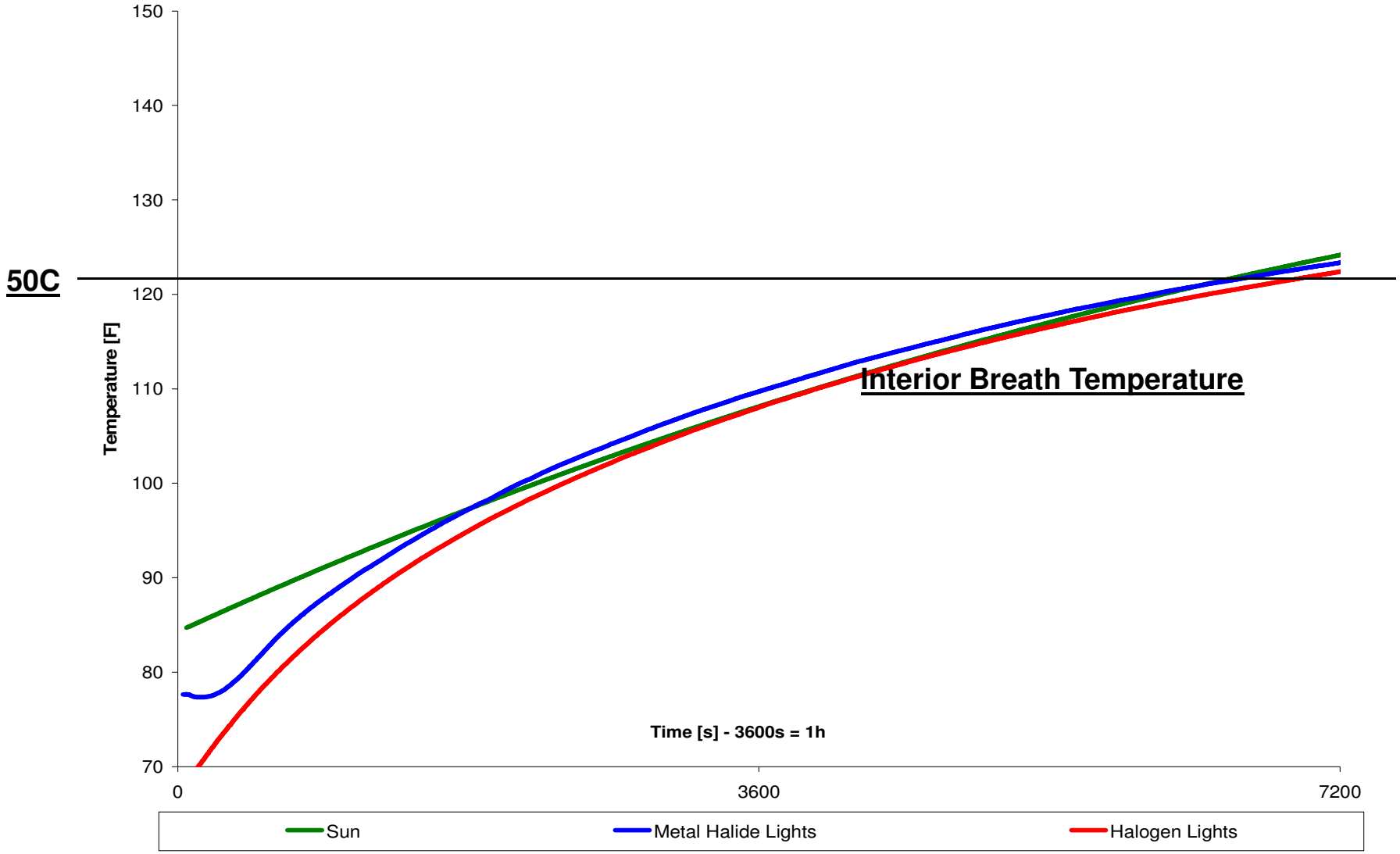
Sun and SC03 site data



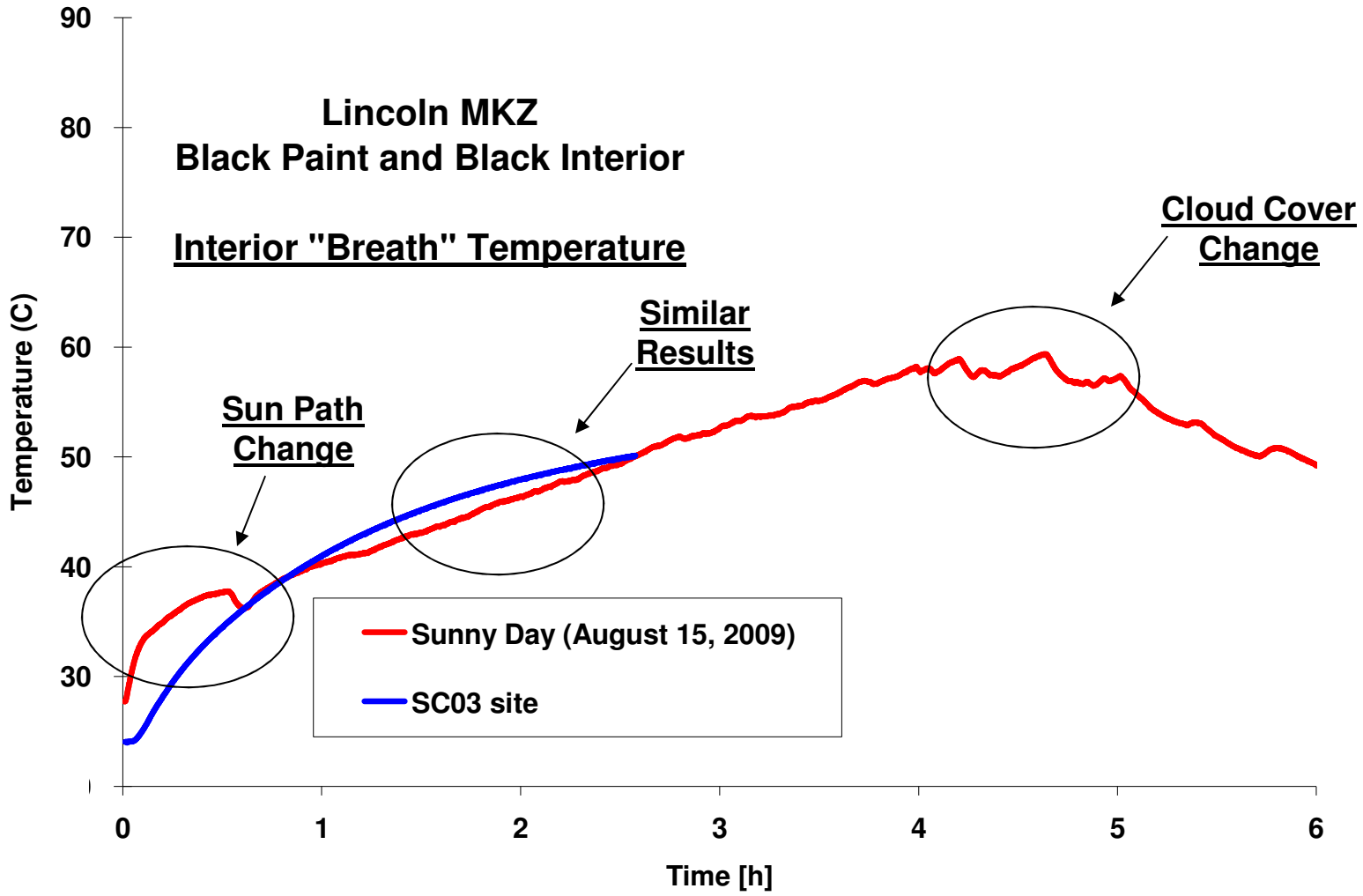
Sun and SC03 site data



Sun and SC03 site data



Sun Path and Angle of Incidence on one of the hottest days in Allen Park, MI USA



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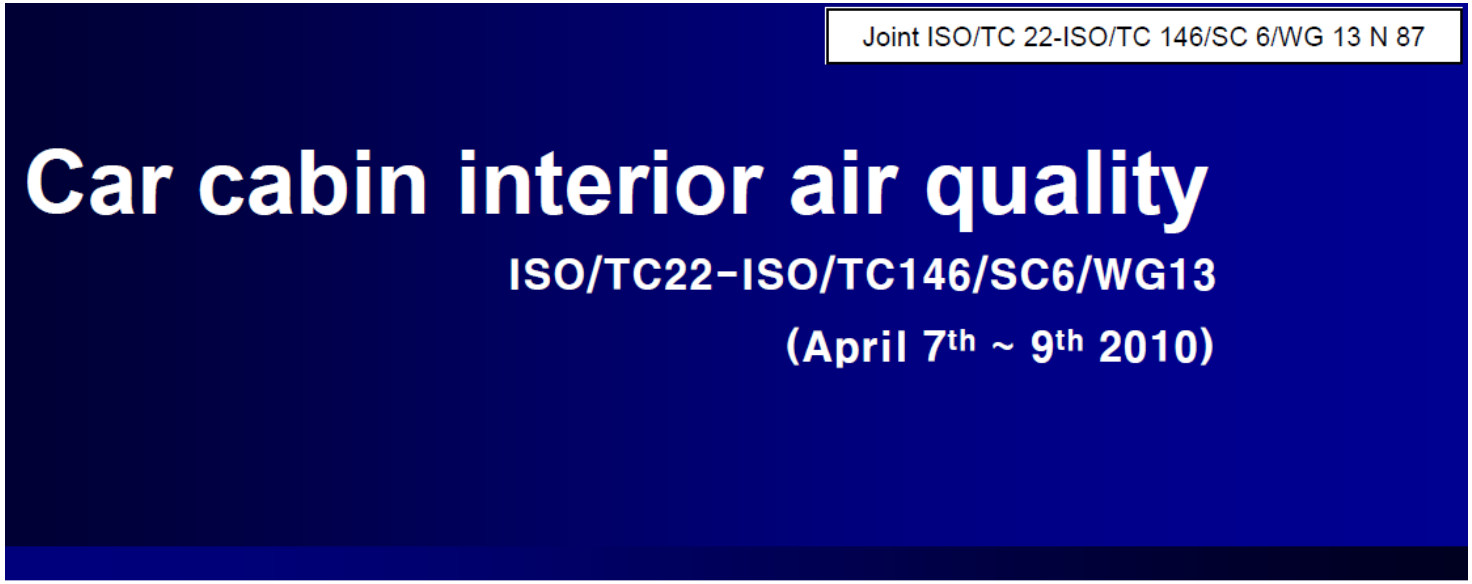

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Outdoor exposure test conditions

Test condition

1) Test period : May 2005~Jun 2006
(14 month)

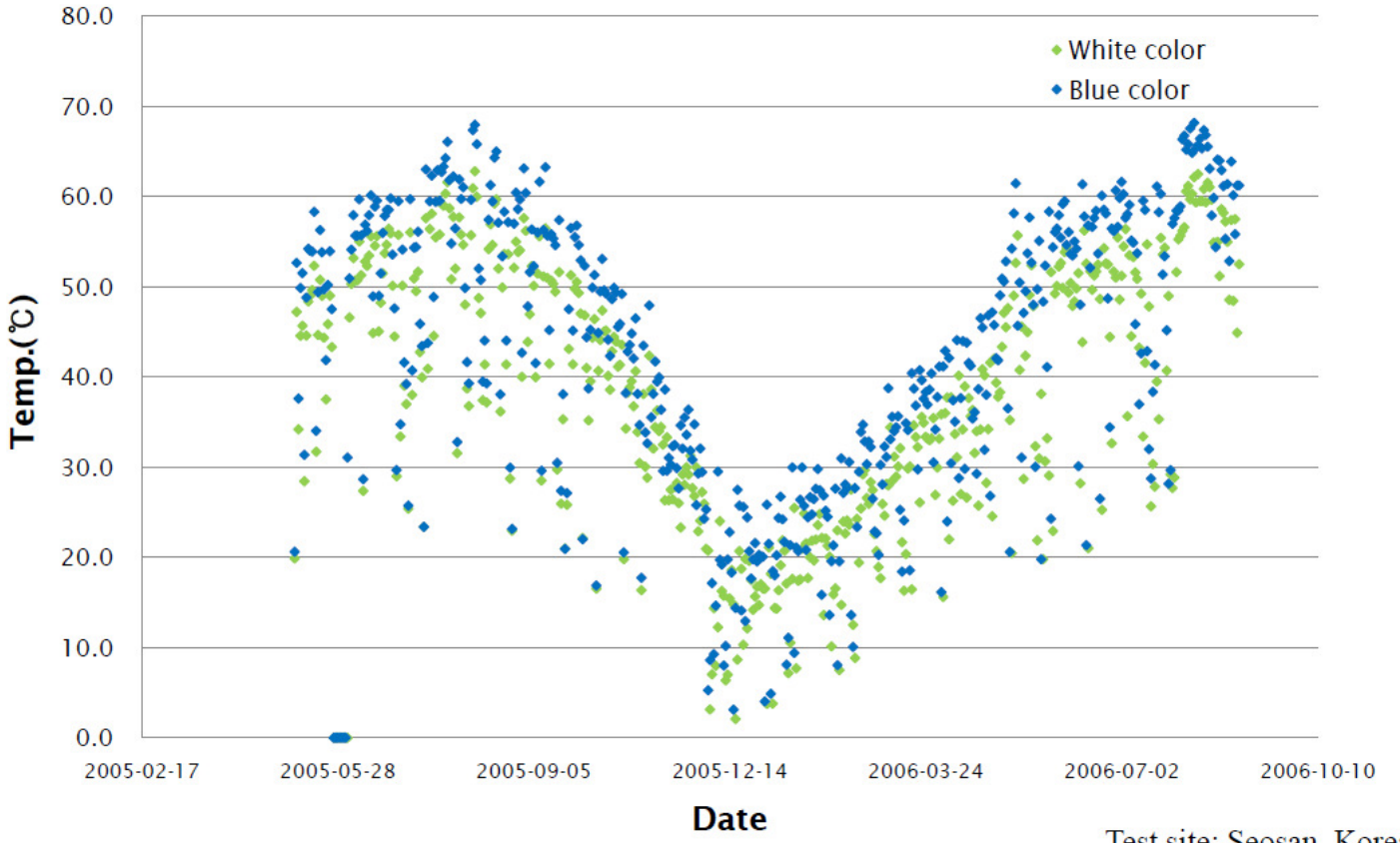
2) Test vehicle
- ▶ Blue Body Color
- ▶ White Body Color

3) Test method
- ▶ Outdoor
- ▶ Direction : South
- ▶ Angle : 0 deg.

Vehicles under Out-Door Weathering Test

ISO Presentation - N87

The highest temp. in Cabin during test period



Test site: Seosan, Korea.

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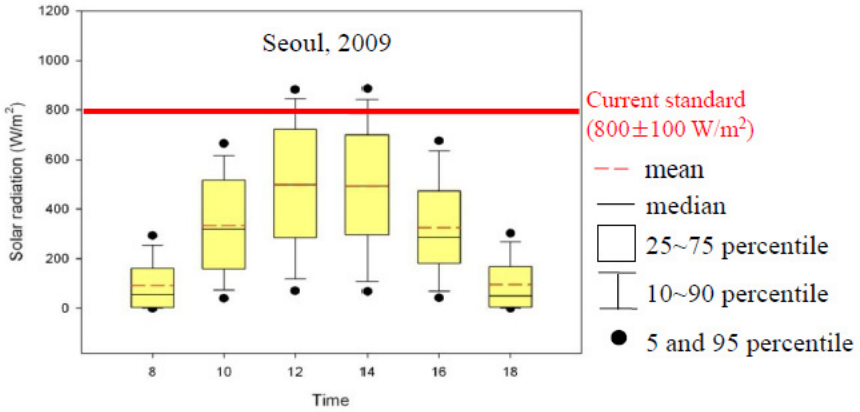
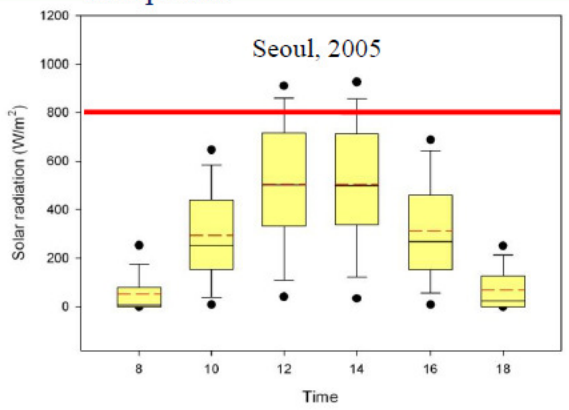
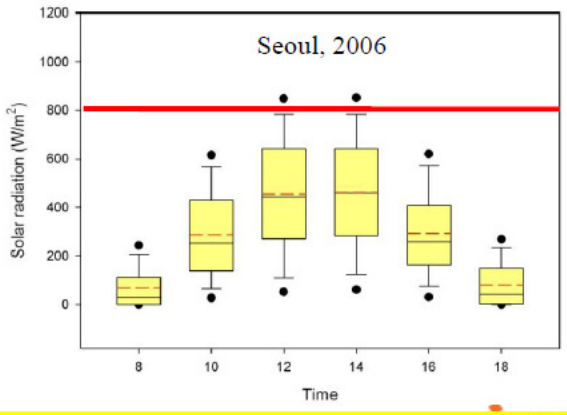
The solar radiation in Seoul(1)



Test period





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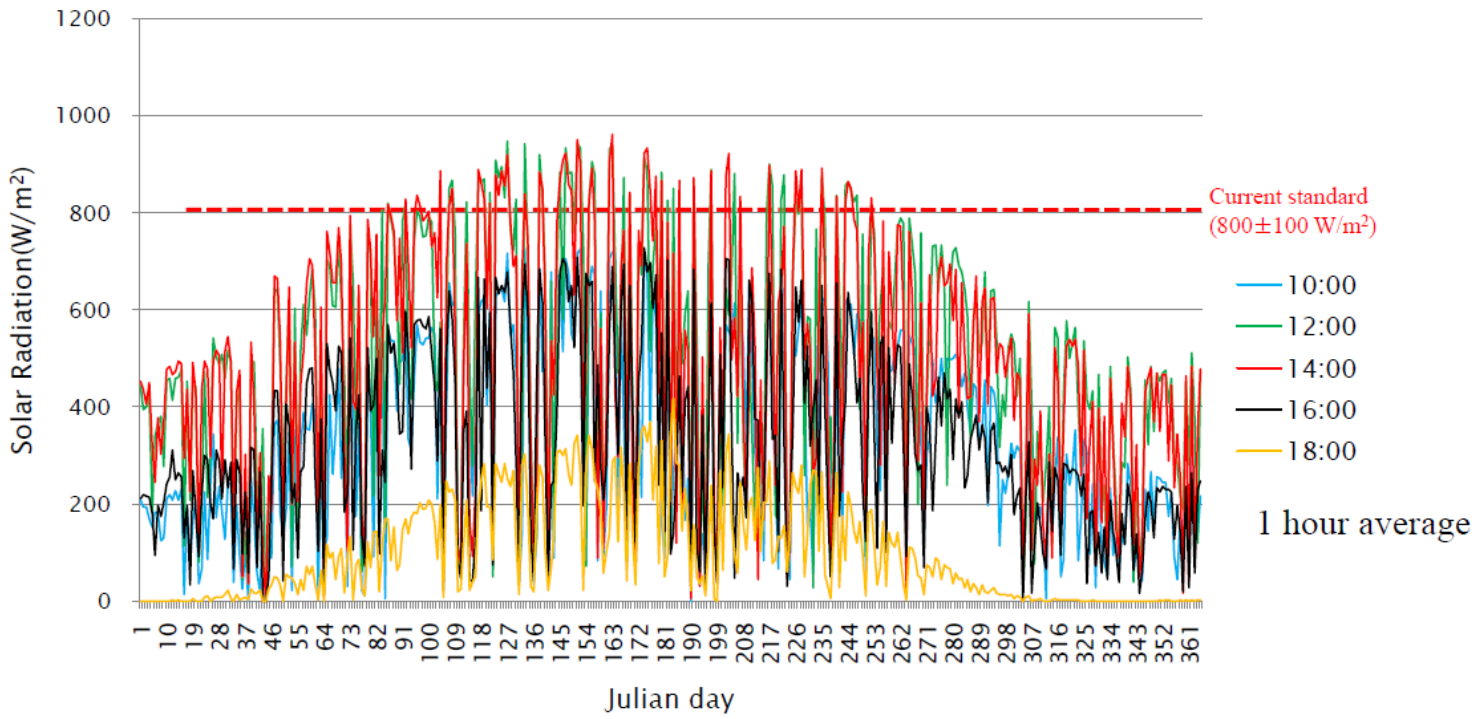
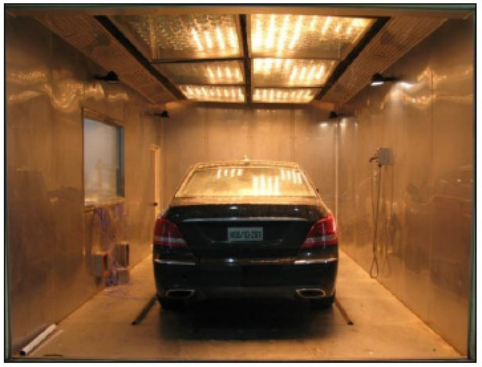
The solar radiation in Seoul(2)



ISO Presentation - N87

Chamber Test(1)



800W/㎡ (4 hours)	Temperature[℃]				
	Car Indoor air	C/Pad (Center)	Driving seat	Head rest	R/P Tray
HATCH (360㎝ X 158㎝, Silver body color)	52	71	62	53	70
SEDAN (480㎝ X 183㎝, White body color)	66	84	62	63	80
SEDAN (516㎝ X 190㎝, Black body color)	63	83	58	61	56

Test Plan with Multiple: Vehicles, Lights, Solar Loads

- Two vehicles tested both dark colors
  - Ford Fiesta (green glass)
  - Mazda 2 (combination of glass tint)
- Two light types tested
  - Halogen (500 Watt each)
  - Metal Halide (4000 Watt each) on SC03 test site (75)
- Three temperature locations
  - Breath (50 cm from top of steering wheel on a line to the bottom of headrest)
  - Top and center of headrest
  - Center of Rooftop

Pyranometer Measurement Locations

- Nine Solar load measurements were recorded at height of the roof (59 inches/150 cm) for each of the test conditions.
  - Four measurements were at the roof corners
  - One at each the center of the front, rear, driver, and passenger sides
  - One at the center of the roof

Pyranometer Measurement Locations continued...

Light Type Halogen		Vehciel Type Fiesta, Mazda 2	
	Front of Vehicle		
605	611	602	
608	594	593	
595	601	604	
Average	Max	Min	Range
601	611	593	18

Light Type Halogen		Vehciel Type Fiesta, Mazda 2	
	Front of Vehicle		
408	393	412	
386	391	403	
392	403	409	
Average	Max	Min	Range
400	412	386	26

Light Type Halogen		Vehciel Type Fiesta, Mazda 2	
	Front of Vehicle		
501	481	486	
507	493	512	
508	504	493	
Average	Max	Min	Range
498	512	481	31

Light Type Halogen		Vehciel Type Fiesta, Mazda 2	
	Front of Vehicle		
305	303	293	
306	310	301	
293	303	299	
Average	Max	Min	Range
301	310	293	17

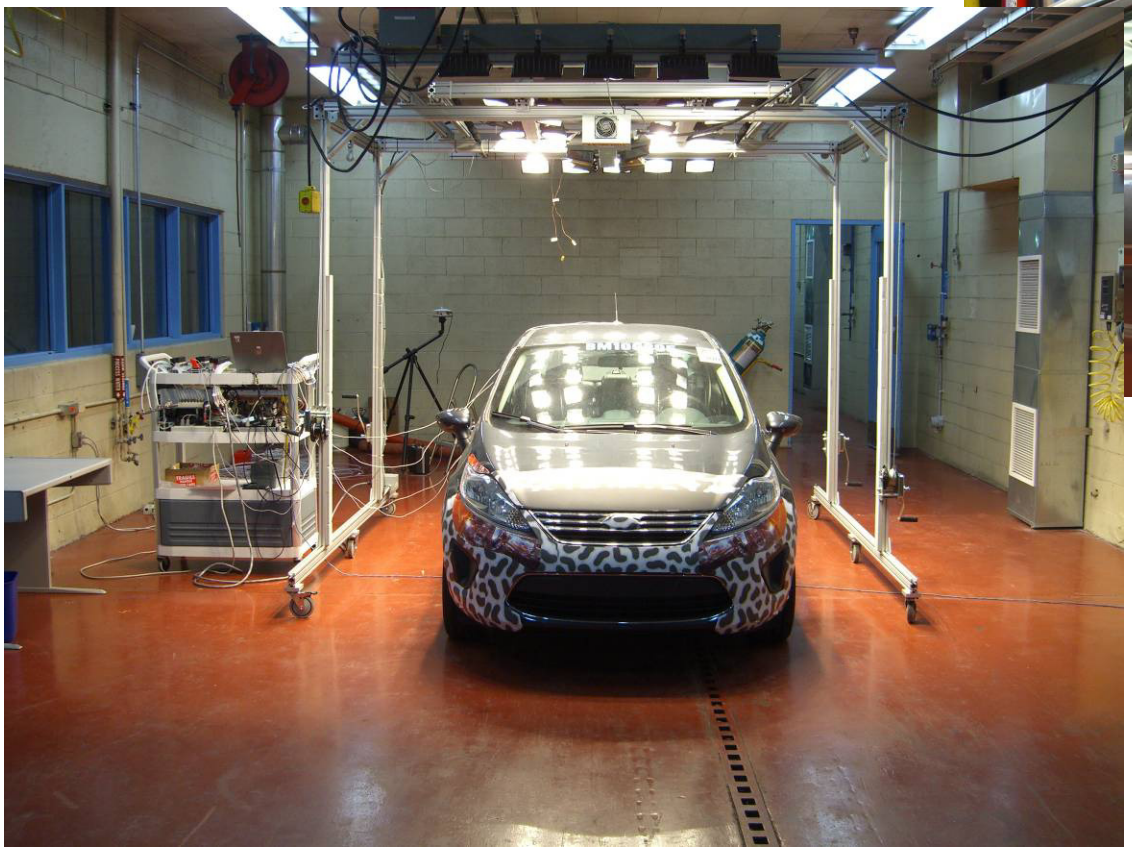
Pyranometer Measurement Locations continued...

Light Type		Vehciel Type	
Metal Halide		Fiesta	
	Front of Vehicle		
584	623	574	
586	634	581	
579	619	572	
Average	Max	Min	Range
595	634	572	62

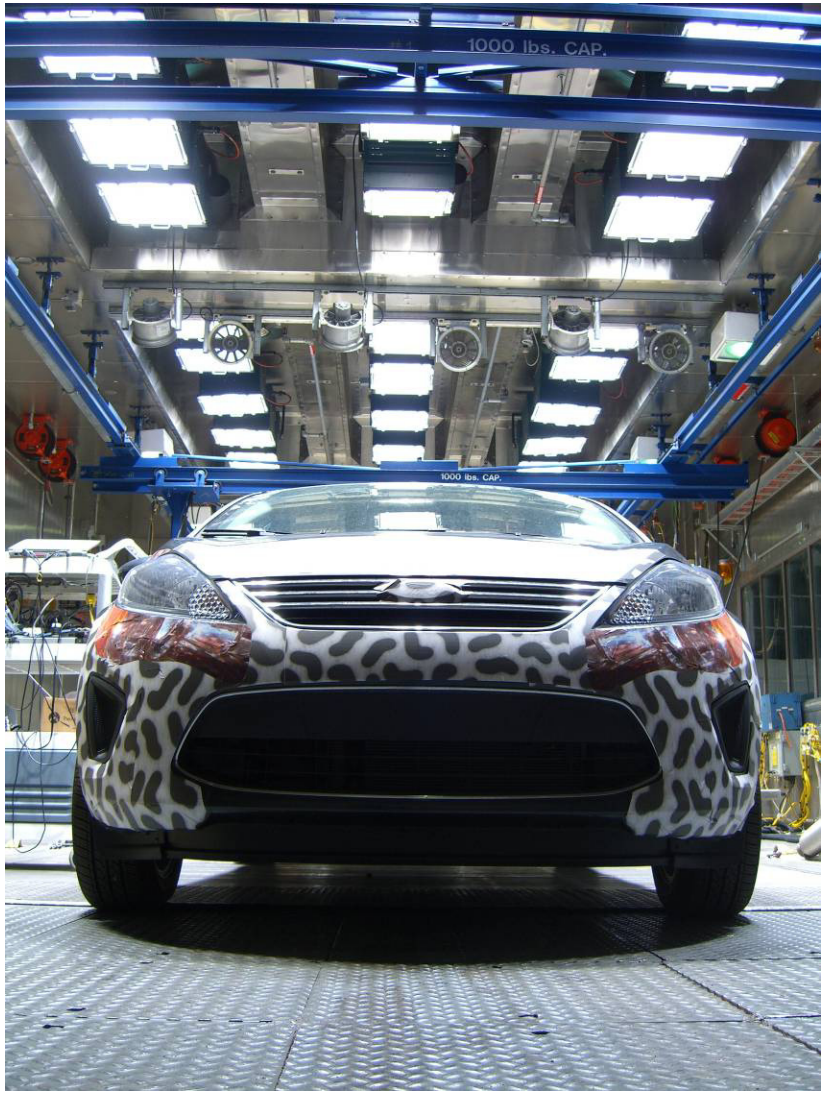
Light Type		Vehciel Type	
Metal Halide		Fiesta, Mazda 2	
	Front of Vehicle		
417	482	433	
448	502	439	
438	503	448	
Average	Max	Min	Range
457	503	417	86

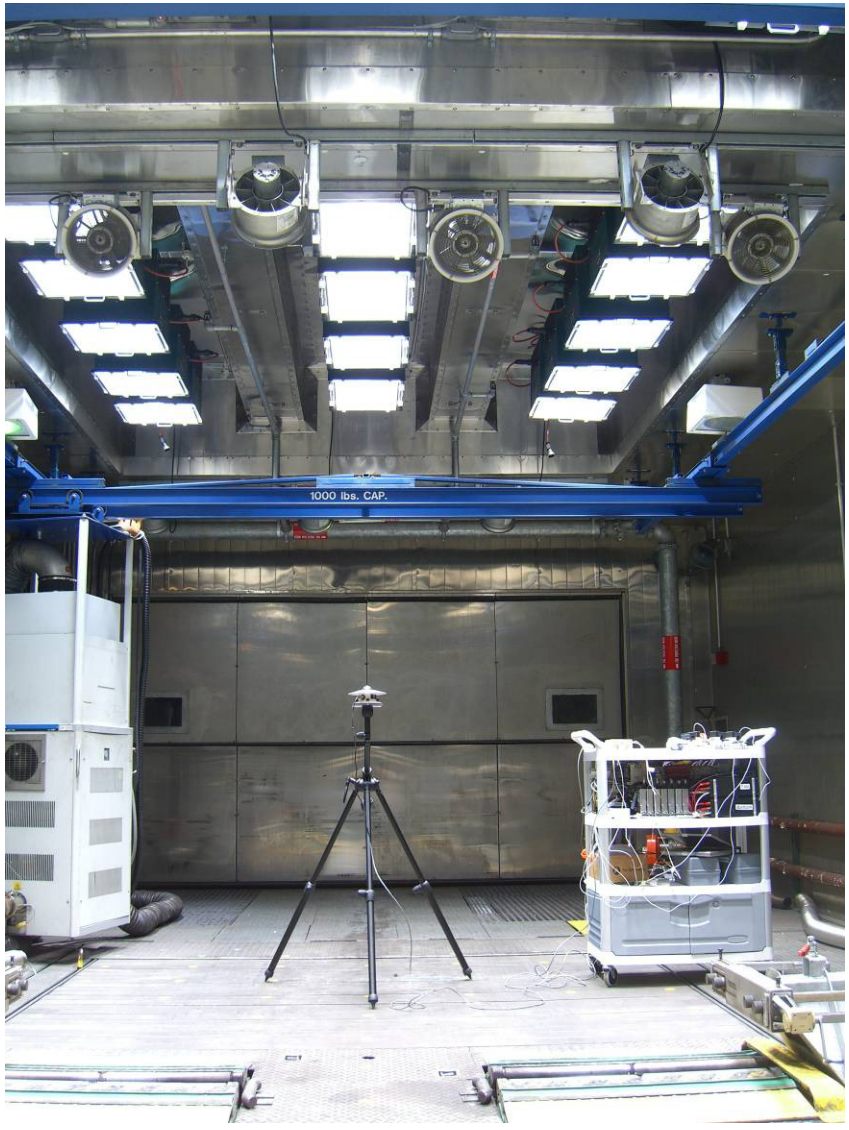
Light Type		Vehciel Type	
Metal Halide		Fiesta, Mazda 2	
	Front of Vehicle		
322	354	315	
323	390	312	
319	371	323	
Average	Max	Min	Range
337	390	312	78

Ford Fiesta and Halogen Solar Simulation

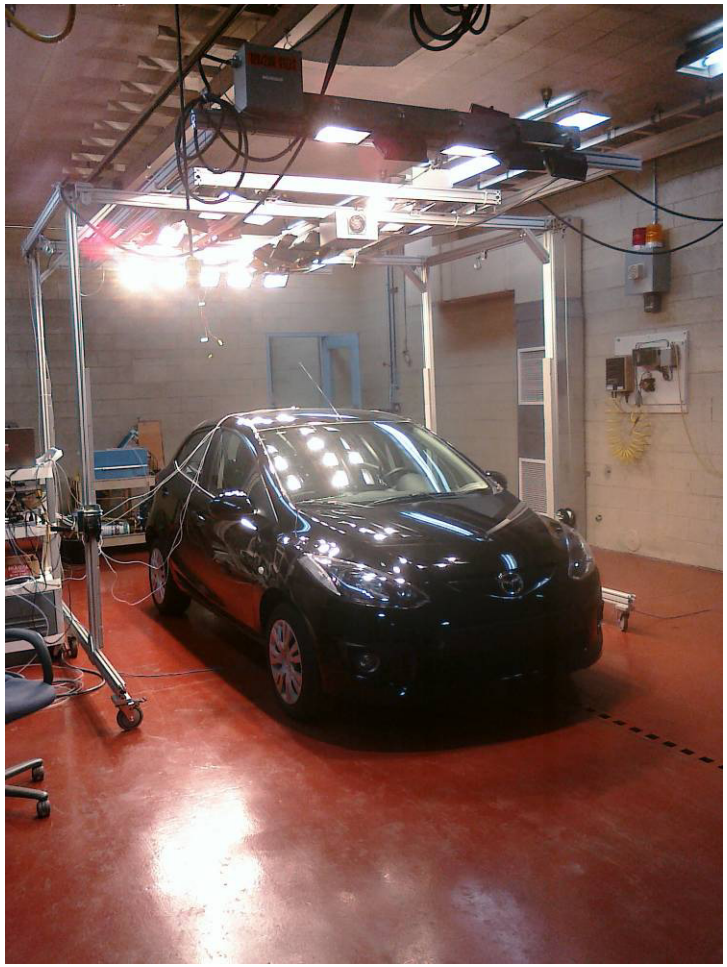


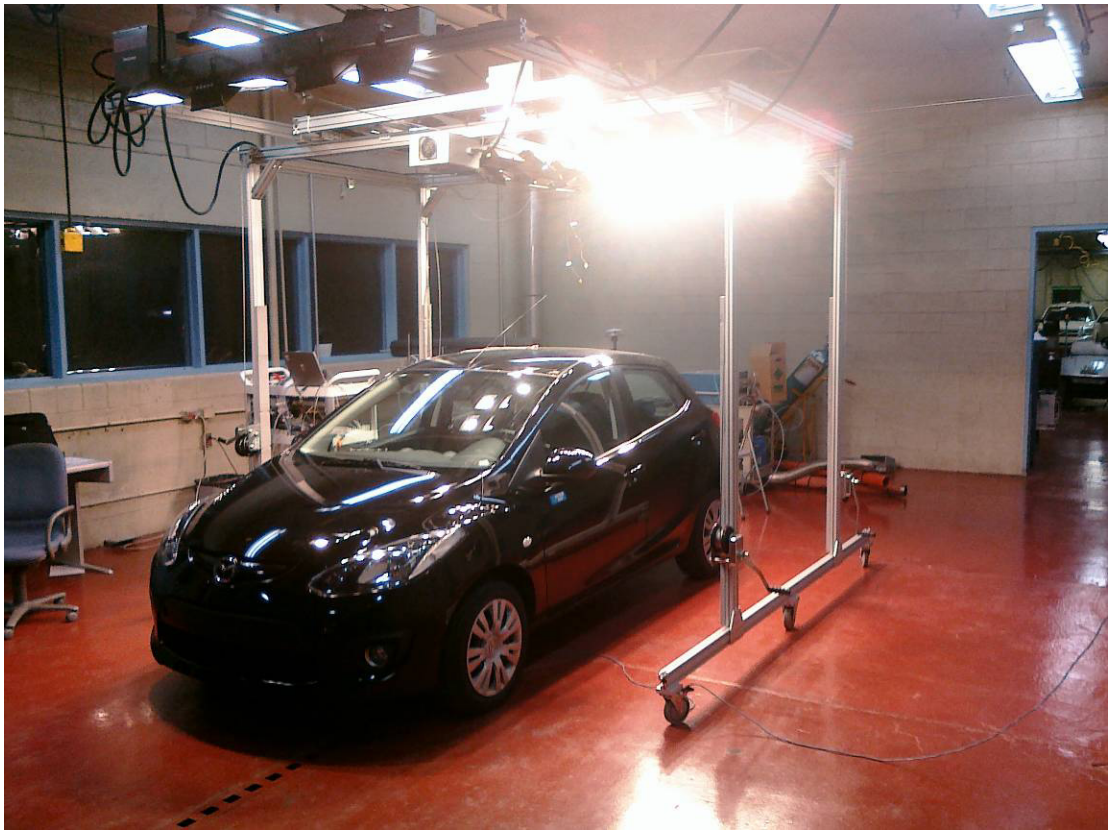
Ford Fiesta and Metal Halide Solar Simulation (SC03 site)

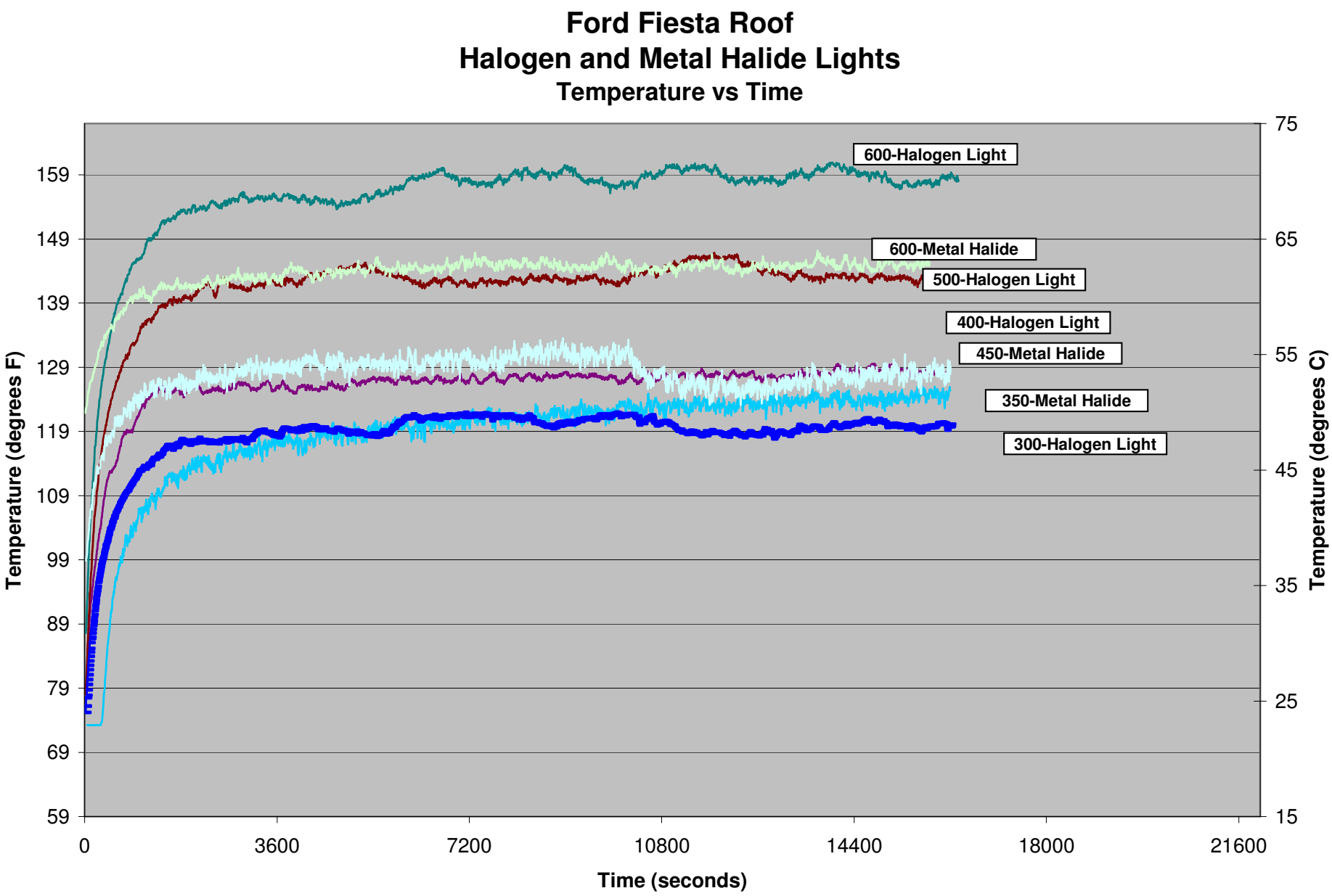


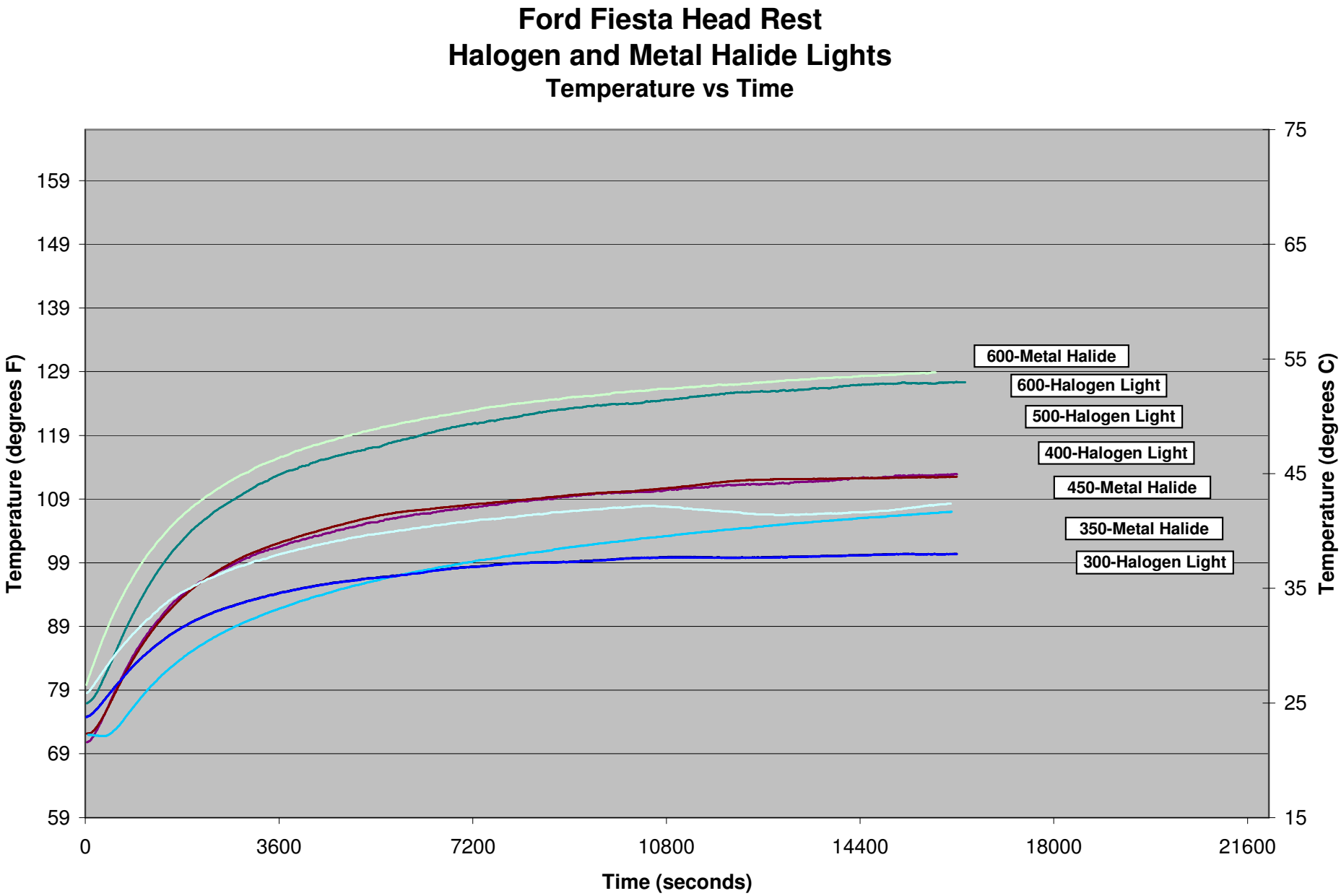


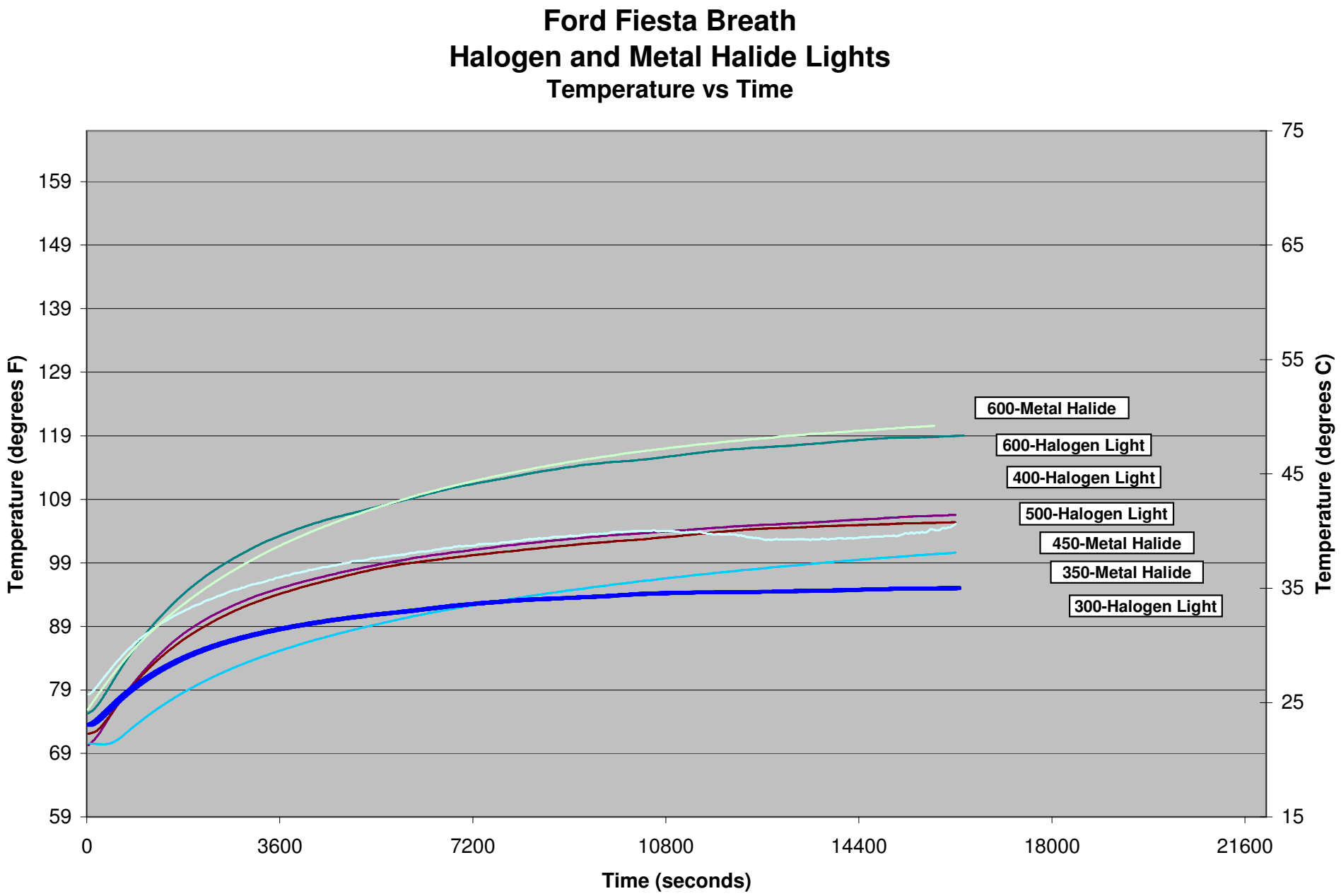
Mazda 2 and Halogen Solar Simulation

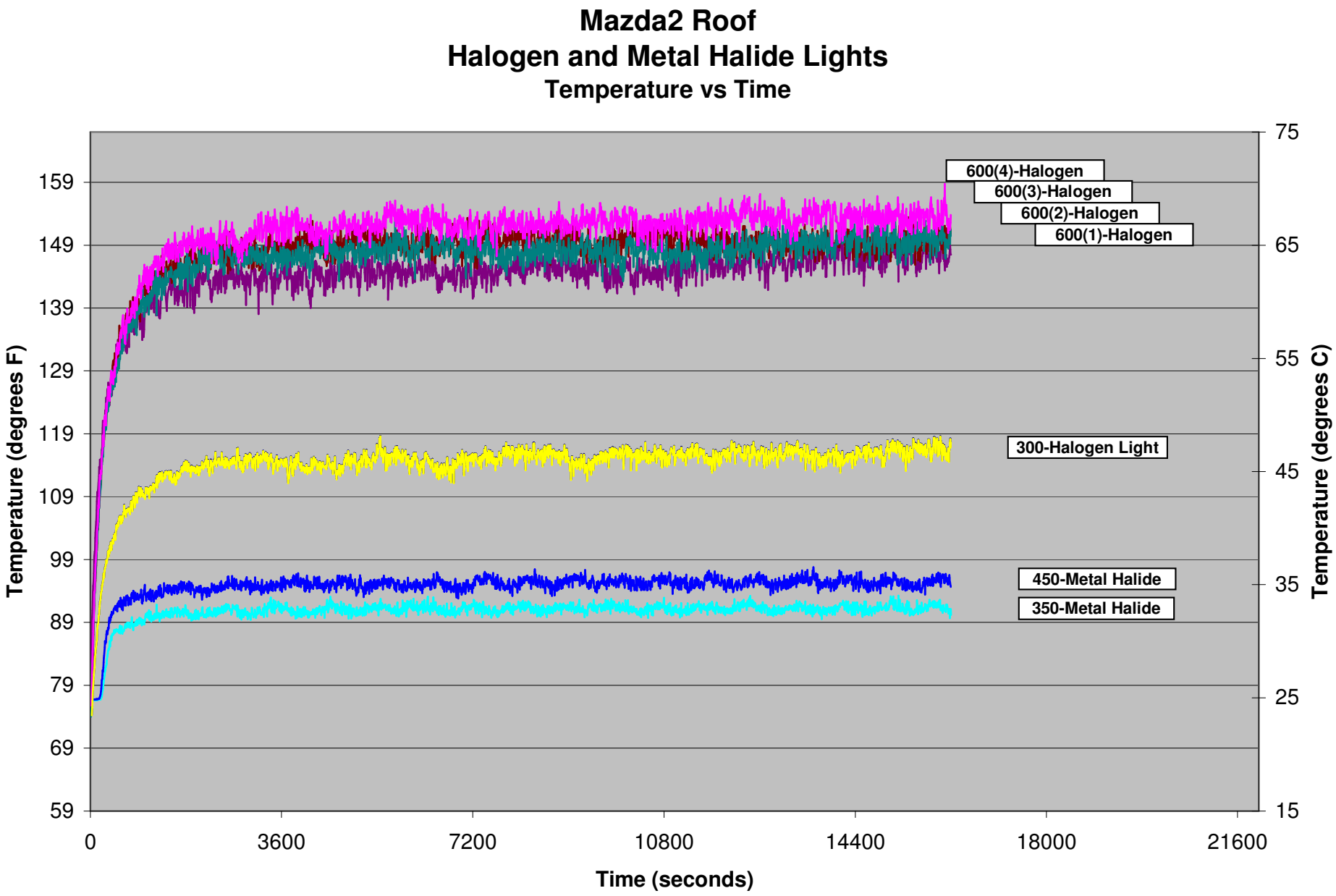


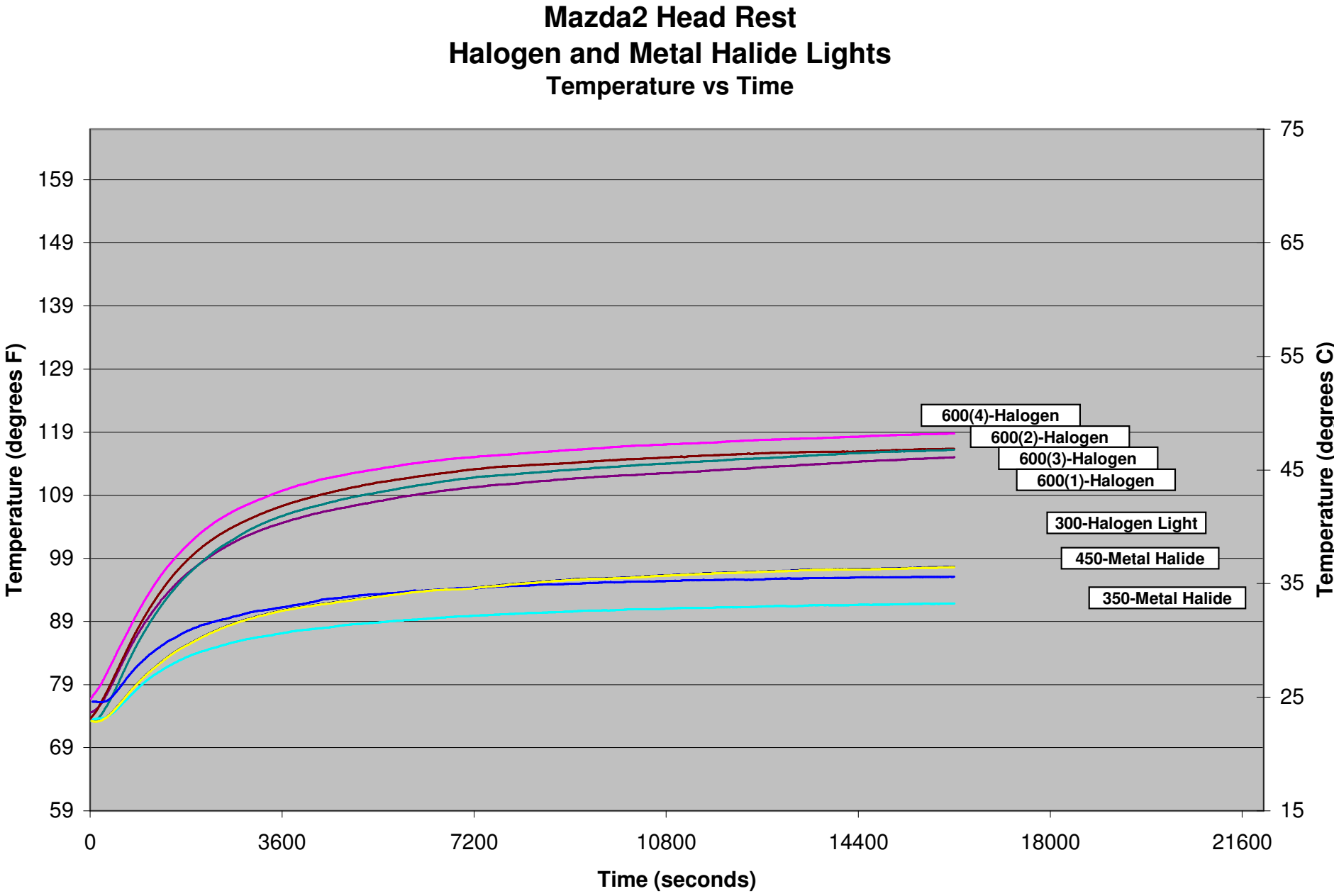


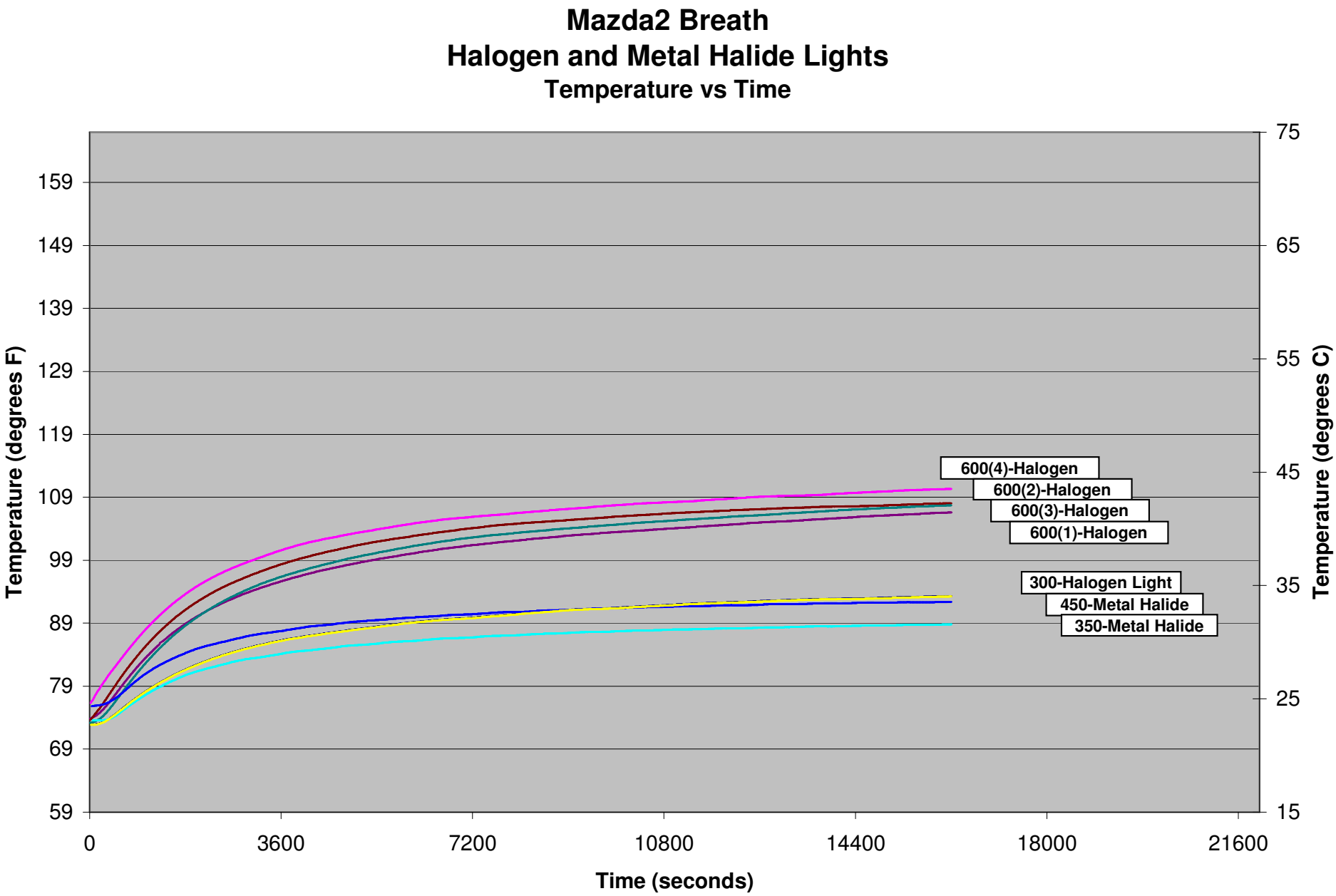

Ford Fiesta Roof
Halogen and Metal Halide Lights
Temperature vs Time
600-Halogen Light
600-Metal Halide
500-Halogen Light
400-Halogen Light
450-Metal Halide
350-Metal Halide
300-Halogen Light
Temperature (degrees F)
159
149
139
129
119
109
99
89
79
69
59
Temperature (degrees C)
75
65
55
45
35
25
15
0
3600
7200
10800
14400
18000
21600
Time (seconds)


Ford Fiesta Head Rest
Halogen and Metal Halide Lights
Temperature vs Time
Temperature (degrees F)
159
149
139
129
119
109
99
89
79
69
59
Temperature (degrees C)
75
65
55
45
35
25
15
0
3600
7200
10800
14400
18000
21600
Time (seconds)
600-Metal Halide
600-Halogen Light
500-Halogen Light
400-Halogen Light
450-Metal Halide
350-Metal Halide
300-Halogen Light


Ford Fiesta Breath
Halogen and Metal Halide Lights
Temperature vs Time
Temperature (degrees F)
159
149
139
129
119
109
99
89
79
69
59
Temperature (degrees C)
75
65
55
45
35
25
15
0
3600
7200
10800
14400
18000
21600
Time (seconds)
600-Metal Halide
600-Halogen Light
400-Halogen Light
500-Halogen Light
450-Metal Halide
350-Metal Halide
300-Halogen Light


Mazda2 Roof
Halogen and Metal Halide Lights
Temperature vs Time
600(4)-Halogen
600(3)-Halogen
600(2)-Halogen
600(1)-Halogen
300-Halogen Light
450-Metal Halide
350-Metal Halide
Temperature (degrees F)
Temperature (degrees C)
Time (seconds)
59
69
79
89
99
109
119
129
139
149
159
15
25
35
45
55
65
75
0
3600
7200
10800
14400
18000
21600


Mazda2 Head Rest
Halogen and Metal Halide Lights
Temperature vs Time
Temperature (degrees F)
159
149
139
129
119
109
99
89
79
69
59
Temperature (degrees C)
75
65
55
45
35
25
15
0
3600
7200
10800
14400
18000
21600
Time (seconds)
600(4)-Halogen
600(2)-Halogen
600(3)-Halogen
600(1)-Halogen
300-Halogen Light
450-Metal Halide
350-Metal Halide


Mazda2 Breath
Halogen and Metal Halide Lights
Temperature vs Time
Temperature (degrees F)
159
149
139
129
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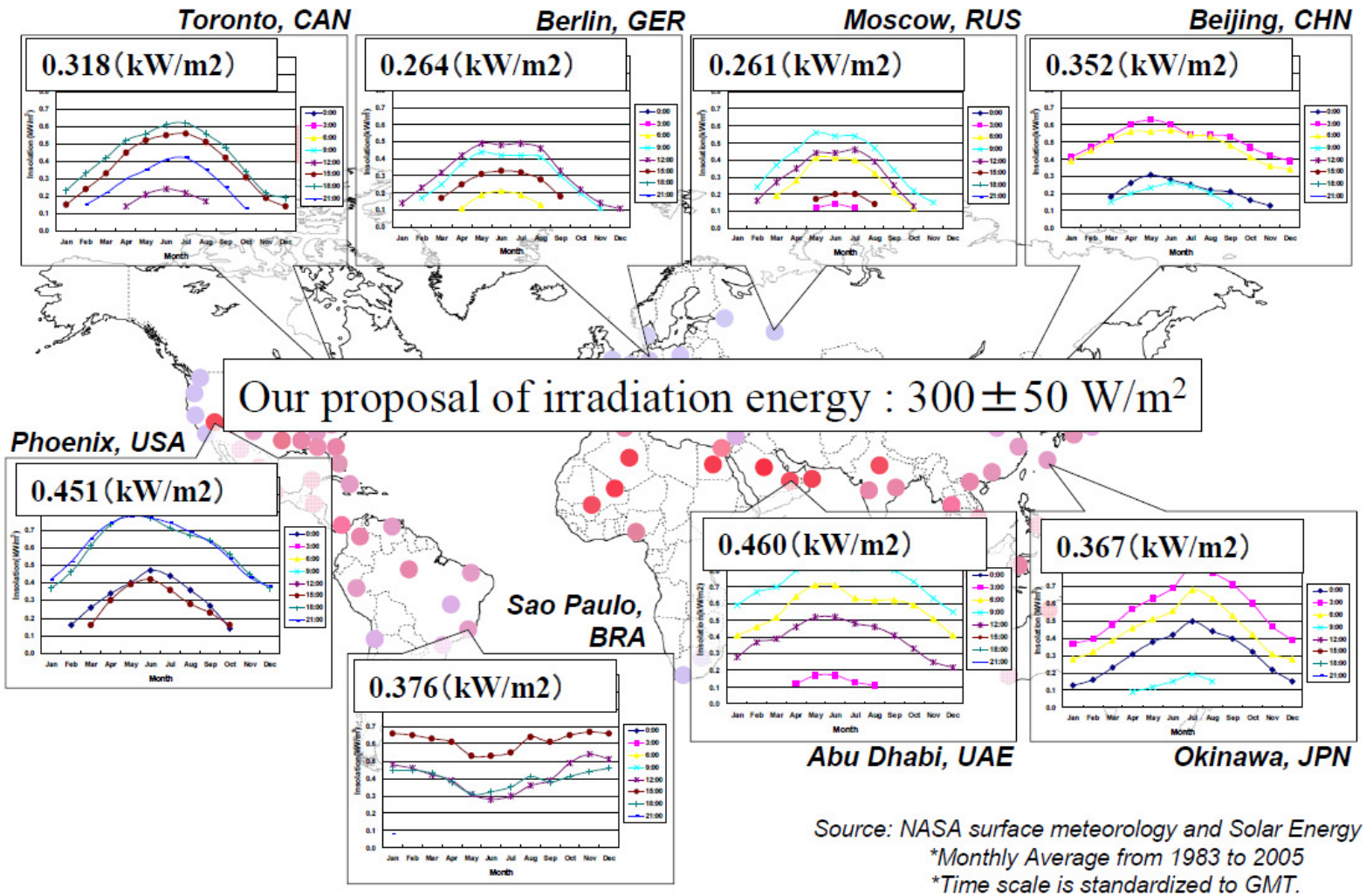
109
99
89
79
69
59
Temperature (degrees C)
75
65
55
45
35
25
15
0
3600
7200
10800
14400
18000
21600
Time (seconds)
600(4)-Halogen
600(2)-Halogen
600(3)-Halogen
600(1)-Halogen
300-Halogen Light
450-Metal Halide
350-Metal Halide

ISO%2DTC146%2DSC6%2DWG13_N0088_contribution_S_Otsuka

1.Solar energy at world principal cities



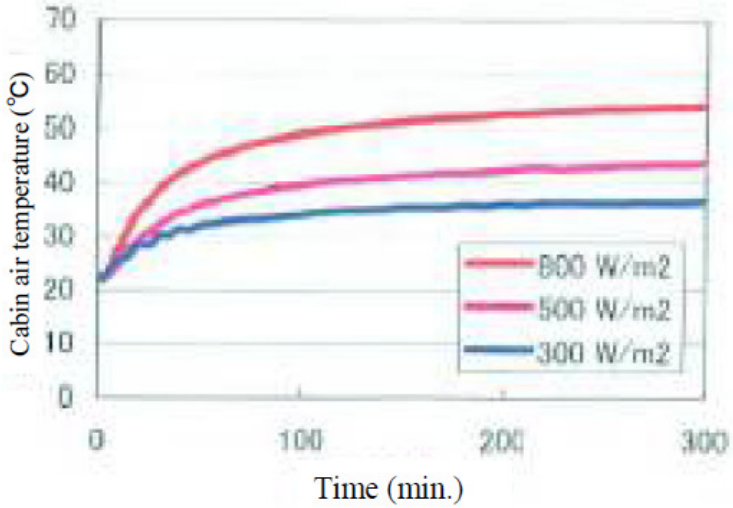
Source: NASA surface meteorology and Solar Energy
**Monthly Average from 1983 to 2005*
**Time scale is standardized to GMT.*

ISO%2DTC146%2DSC6%2DWG13_N0088_contribution_S_Otsuka

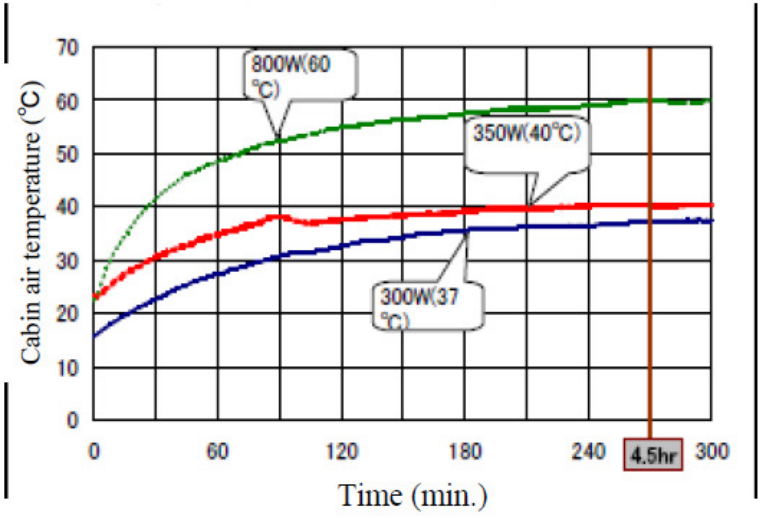
2. Study of irradiation energy effects

2-1. Comparison study for lamp specification difference

Halogen lamp results



Infrared lamp results



Cabin air temperature(℃)

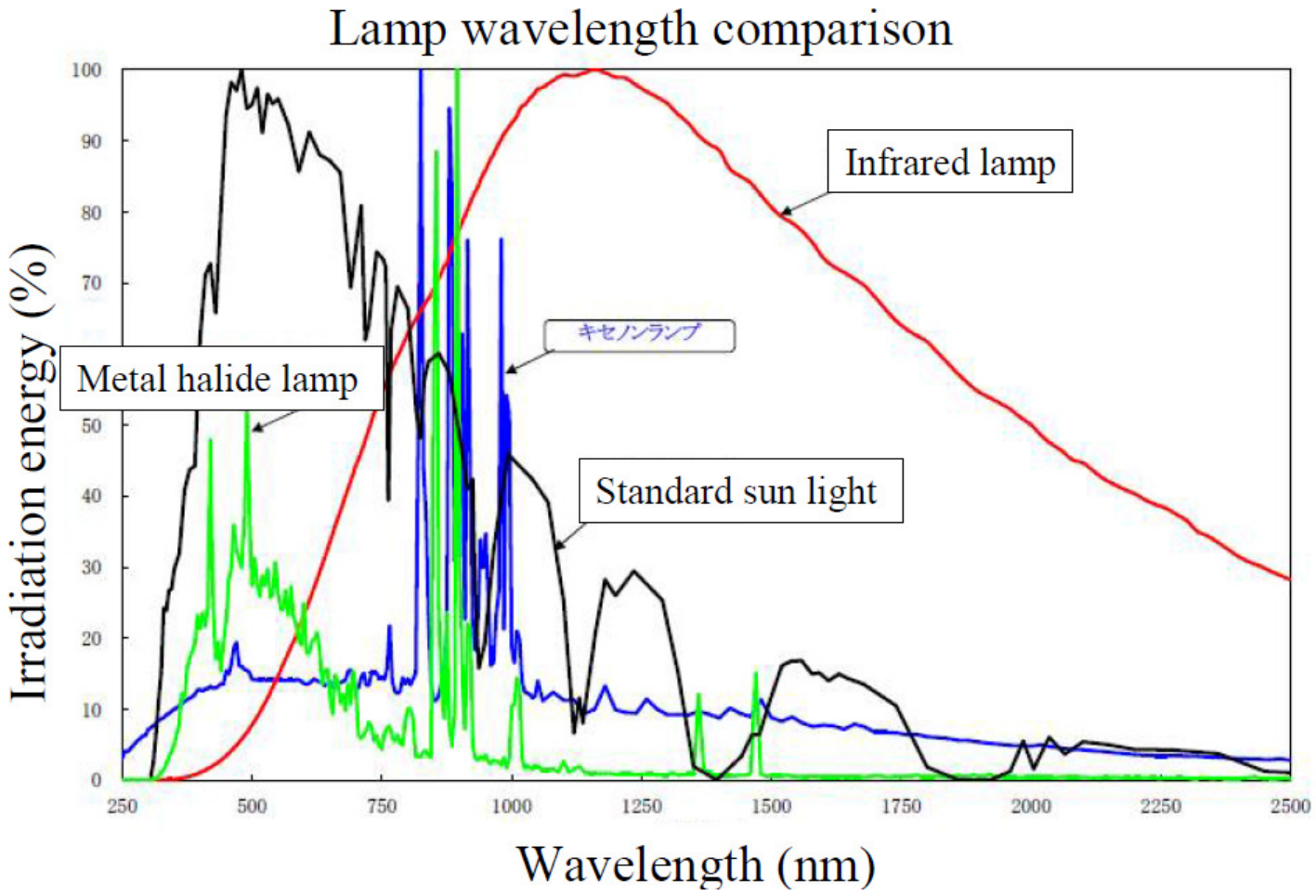
	Halogen lamp A	Halogen lamp B*	Infrared lamp
800W/m2	54.5	49.0	60.0
500W/m2	45.2	39.5	No data
350W/m2	No data	No data	40.0
300W/m2	38.3	33.8	37.0

*Halogen lamp B is filtered lamp

ISO%2DTC146%2DSC6%2DWG13_N0088_contribution_S_Otsuka

2. Study of irradiation energy effects

2-1. Comparison study for lamp specification difference



ISO%2DTC146%2DSC6%2DWG13_N0088_contribution_S_Otsuka

4.1 heating lamps

The lamps should be powered to create 300 W/m^2 ± 50 W/ m^2 on the roof surface of the test vehicle. Distance of the lamps to the roof of the test vehicle should be conformed to guaranteed distance of each irradiation system. The heating area covers the area of the test vehicle cabin and 1 m more to each side. There are no lamps shining from the side.

The specification of lamp should be Metal Halide, Quartz halogen with dichroic mirrors or sodium iodide.

The spectroscopic of lamps shall satisfy the following conditions.

<320nm : 0%

320nm ~ 400nm :0% ~ 7%

400nm ~ 780nm:45% ~ 55%

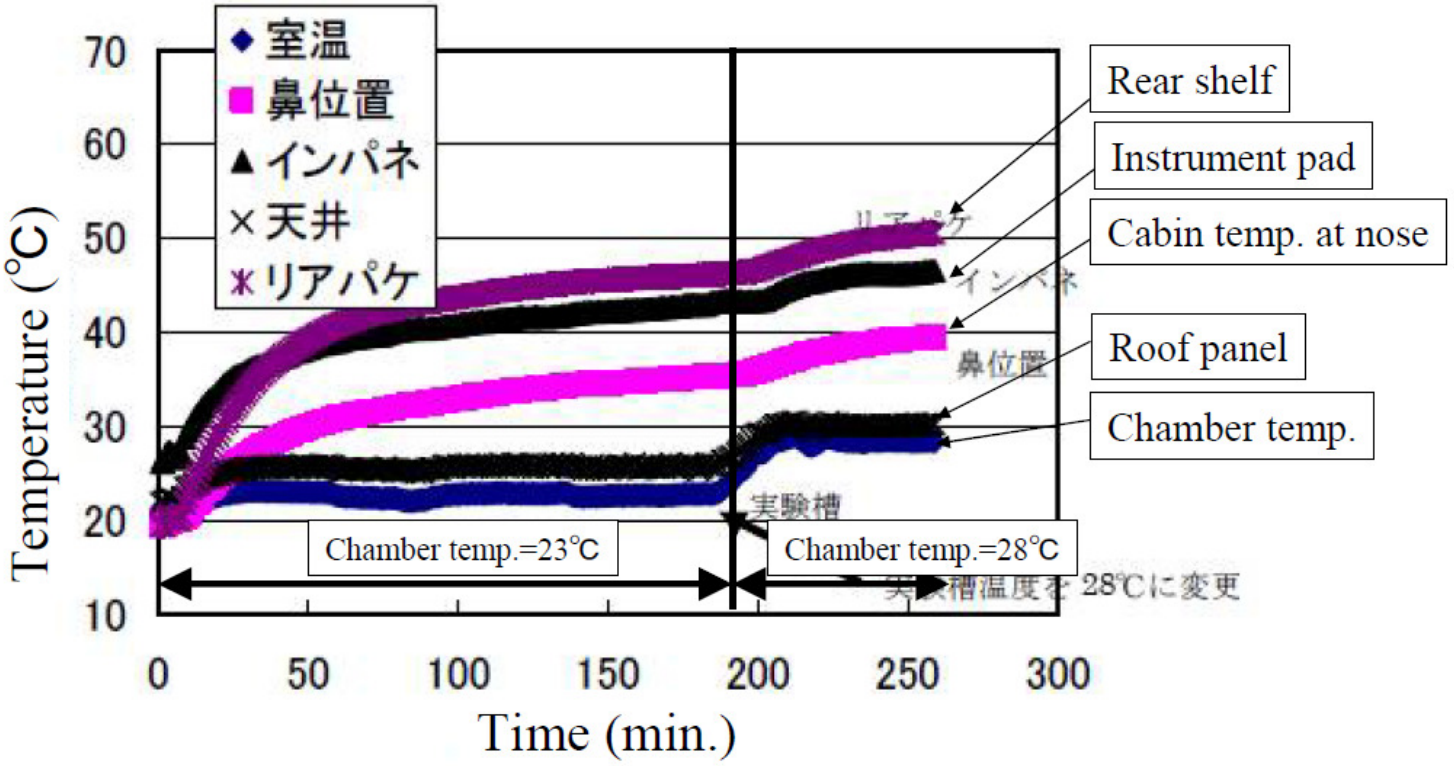
>780nm:35% ~ 53%

NOTE The power of lamp simulates the mean sun irradiation in Europe, Asia, North-America etc.

ISO%2DTC146%2DSC6%2DWG13_N0088_contribution_S_Otsuka

2. Study of irradiation energy effects

2-2. Chamber temperature influence on cabin temperature



Test conditions
1.Irradiation energy: 270W/m2
2.Lamp: Infrared lamp
3.Distance (lamp to roof): 1.5m

ISO%2DTC146%2DSC6%2DWG13_N0088_contribution_S_Otsuka

2. Study of irradiation energy effects

2-2. Chamber temperature influence on cabin temperature

6.1 Requirements for the whole vehicle test chamber

The whole vehicle test chamber with the following requirements is assembled as shown in Figures 1, 2 and 3. The following requirements shall be met:

a) The whole vehicle test chamber shall be large enough to accommodate the complete test vehicle.

b) The temperatures inside of the whole vehicle test chamber are: 23 °C ± 2 K (to be discussed) (during the heating phase the temperature in the whole vehicle test chamber is allowed to raise to 30 °C to 35 °C). A heating and ventilation system (including the adjustment of the humidity) and, if necessary a cooling system, is necessary. Sampling point for the background concentrations in the whole test chamber: more than 1 m beside the test vehicle and in the height of the lower window frame of the front door.

…the whole test chamber have to keep 23 ℃±2K.

Joint ISO/TC 22-ISO/TC 146/SC 6/WG 13 N 91

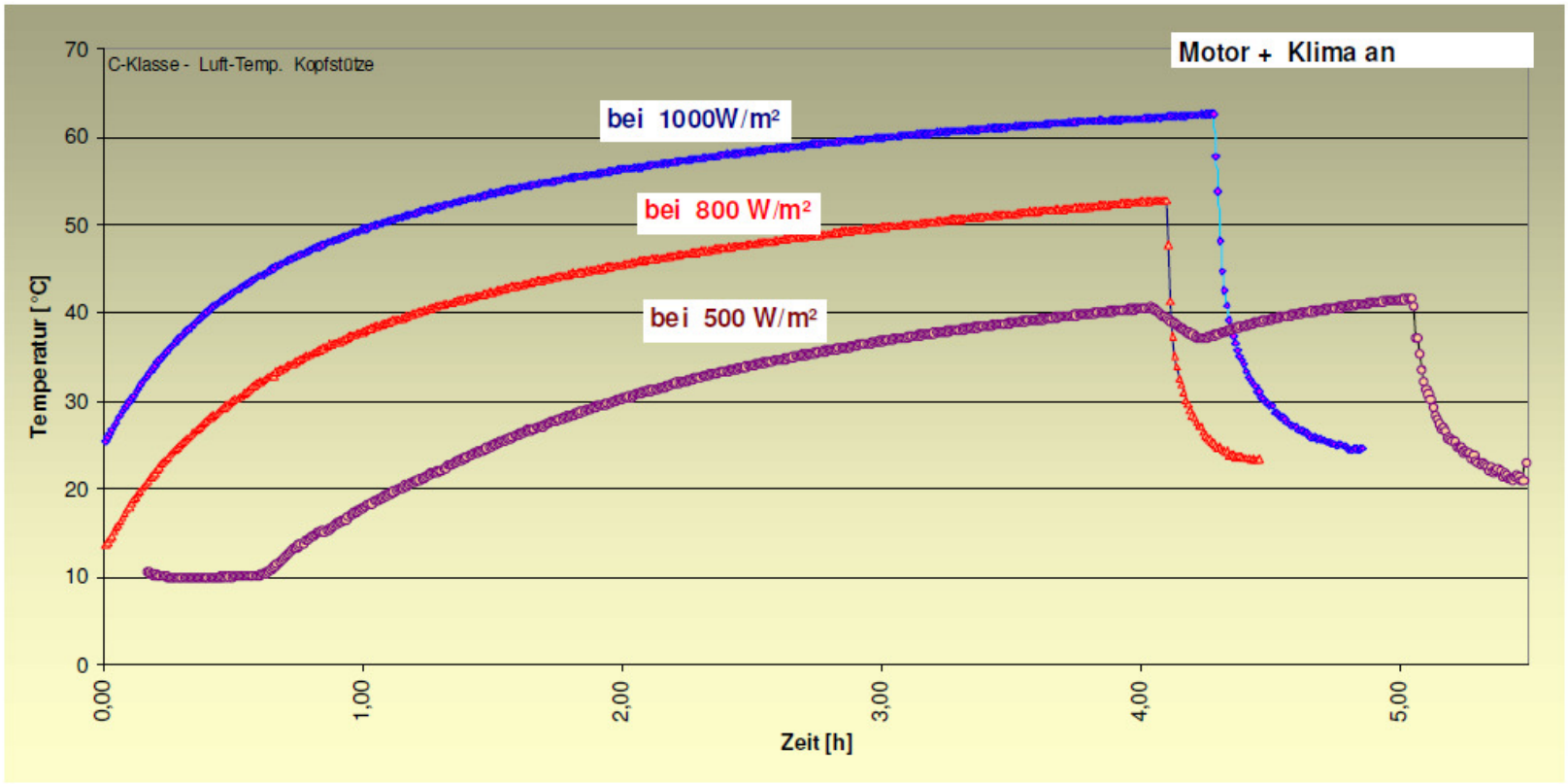
Mercedes-Benz

Fahrzeug: Mercedes-Benz C-Klasse, Limosine, W204
Lack: silber-metallic

Strahleranordnung analog Iso-Norm-Entw. 12/2009 (senkrecht von oben)

Luft - Temperatur im Fzg.-Innenraum in Kopfstützenhöhe

Vergleich Sonnensimulation 500 / 800 / 1000 W/m²



Joint ISO/TC 22-ISO/TC 146/SC 6/WG 13 N 96
IR_radiation_Mangoo Kim (Korea)

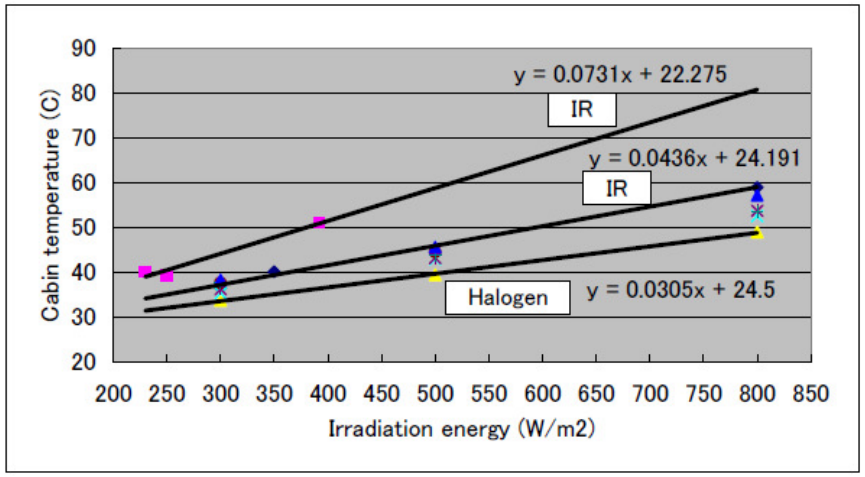
Car cabin air temperature with IR radiation

Lamp : IR light

Lamp Intensity	300 W m^{-2}	400 W m^{-2}	500 W m^{-2}
Cabin air Temperature	29 C	38 C	45 C

ISO%2DTC146%2DSC6%2DWG13_N0098_ISO_CD12219%2D1_energy_study_Otsuka - 1 of 2

Irradiation energy vs Cabin temperature



		A	B	C	D	E	F	G	H
vehicle	category (segment)	B	D	A	C	B	D	A	A
	color	black	black	pink gold	silver	yellow pearl	silver	black	black
test chamber	size(m3)	52	132	284	284	284	284	340	340
	lamp type	IR	Halogen IR	Halogen	Halogen	Halogen	Halogen	Halogen+ Metal halide	Halogen+ Metal halide
	irradiation area(m2)	12.3	12.5	13.8	13.8	13.8	13.8	15.6	15.6

Cabin temperature :40℃

IR 243～363W/m3

Halogen 367～508W/m3

ISO%2DTC146%2DSC6%2DWG13_N0098_ISO_CD12219%2D1_energy_study_Otsuka - 2 of 2

Attached please find test results of energy.
Conclusion:

Irradiation energy should be control 350 W/m2 ± 50 W/ m2 with lamp correlated sun light such as halogen or metal halide. 350 W/m2 is a mean value of global main city. When use IR radiator, need adjust power of radiator to be same cabin temperature condition with specified radiator such as halogen or metal halide.

So we proposed in ISO describe as below,

Halogen radiators or metal halide radiators (wave length < 300 nm could be filtered out). The radiators should be powered to create 350 W/m2 ± 50 W/ m2 on the roof surface of the test vehicle. The heating area covers the area of the test vehicle cabin and 1 m more to each side (footprint). There are no radiators shining from the side. If use infrared radiators, adjust power of radiator to reach cabin temperature as same as specified radiator such as halogen or metal halide.

ISO%2DTC146%2DSC6%2DWG13_N0115_Irradiation_energy_value_measuremen

Test results to verify the irradiation energy value

Working items:

Definition of the irradiation energy value for different Lamp Types.

The following Lamp Types would be tested:
- IR Lamps
- Metal-halogen-Lamps (SOLISI-Test chamber)

The Test car was a Polo (Car-class A0)

The Temperature Measurement was done in the position described in the DIS ISO 12219-1

ISO%2DTC146%2DSC6%2DWG13_N0115_Irradiation_energy_value_measuremen

Test results to verify the irradiation energy value

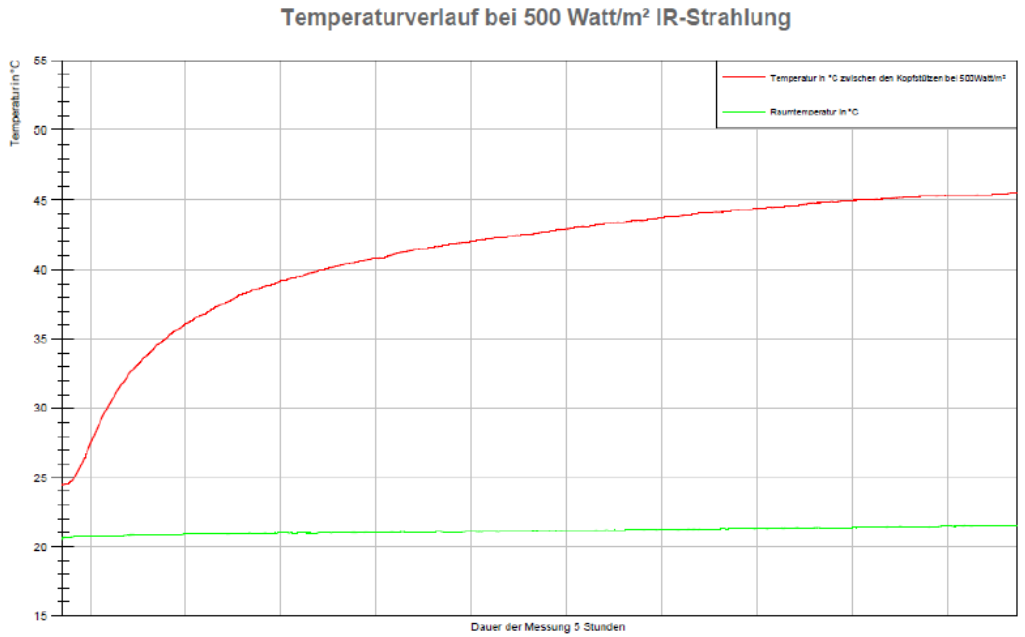
Test situation for the IR-Lamp testing:

- The side overlay of the radiation is 0.5 meter
- The radiation value was measured in the middle of the roof
- The start temperature for each measurement was 23 ℃

ISO%2DTC146%2DSC6%2DWG13_N0115_Irradiation_energy_value_measuremen

Test results to verify the irradiation energy value

Temperature curve IR-Radiation 500 W/m²/ Measure time 5 h

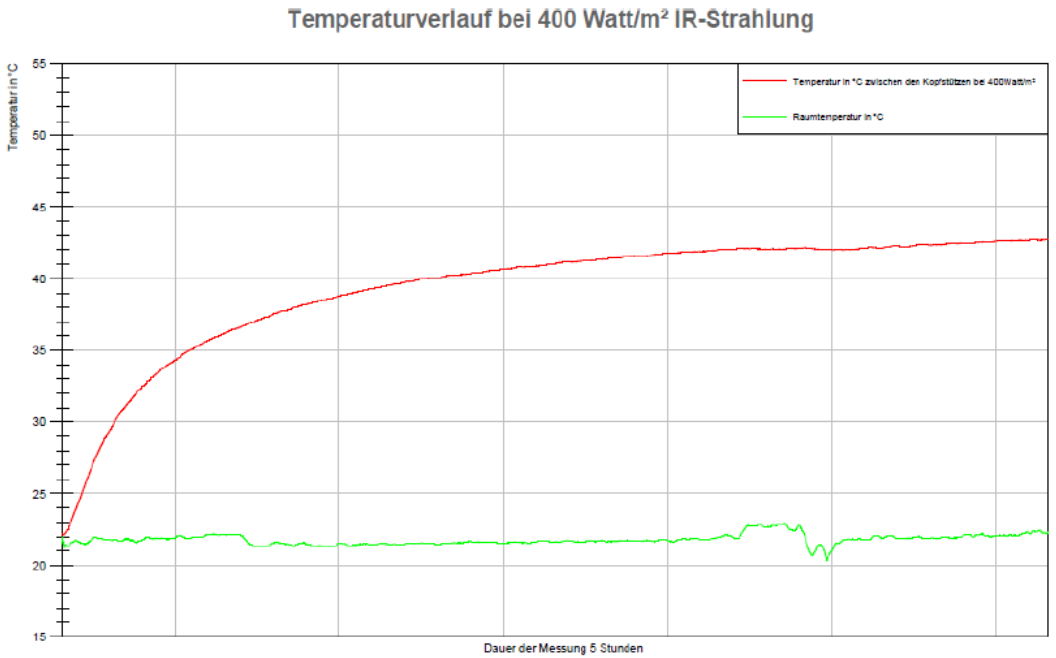


end temperature
46 °C

ISO%2DTC146%2DSC6%2DWG13_N0115_Irradiation_energy_value_measuremen

Test results to verify the irradiation energy value

Temperature curve IR-Radiation 400 W/m²/ Measure time 5 h

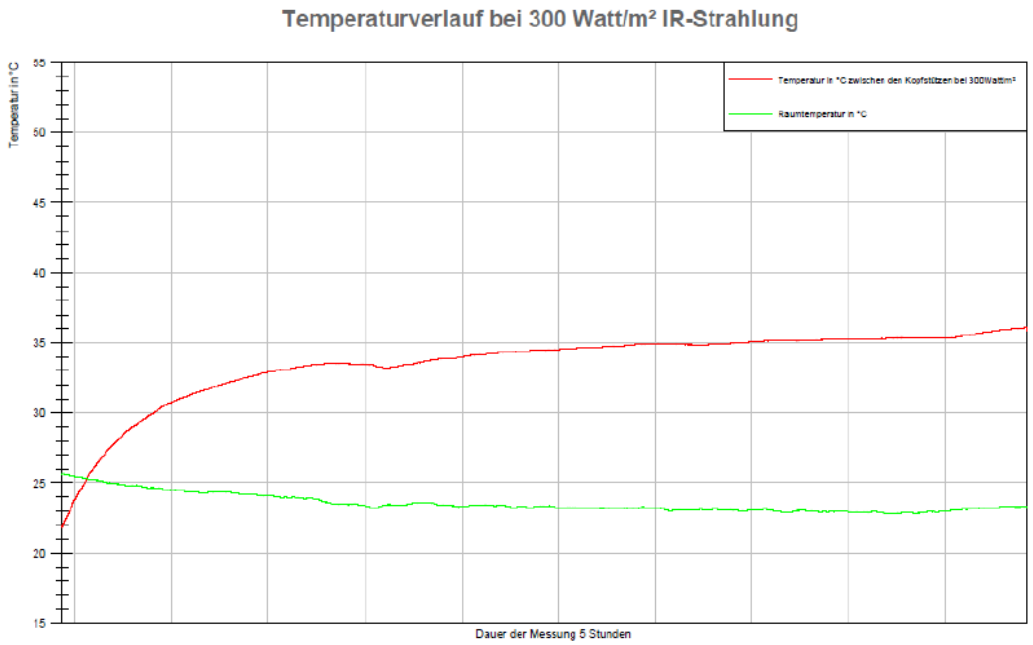


end temperature
43 °C

ISO%2DTC146%2DSC6%2DWG13_N0115_Irradiation_energy_value_measuremen

Test results to verify the irradiation energy value

Temperature curve IR-Radiation 300 W/m²/ Measure time 5 h



end temperature
35 °C

ISO%2DTC146%2DSC6%2DWG13_N0115_Irradiation_energy_value_measuremen

Test results to verify the irradiation energy value

Test situation for the SOLISI-Lamp testing:

-The side overlay of the radiation is 1.0 meter

- The radiation value was measured in the middle of the roof

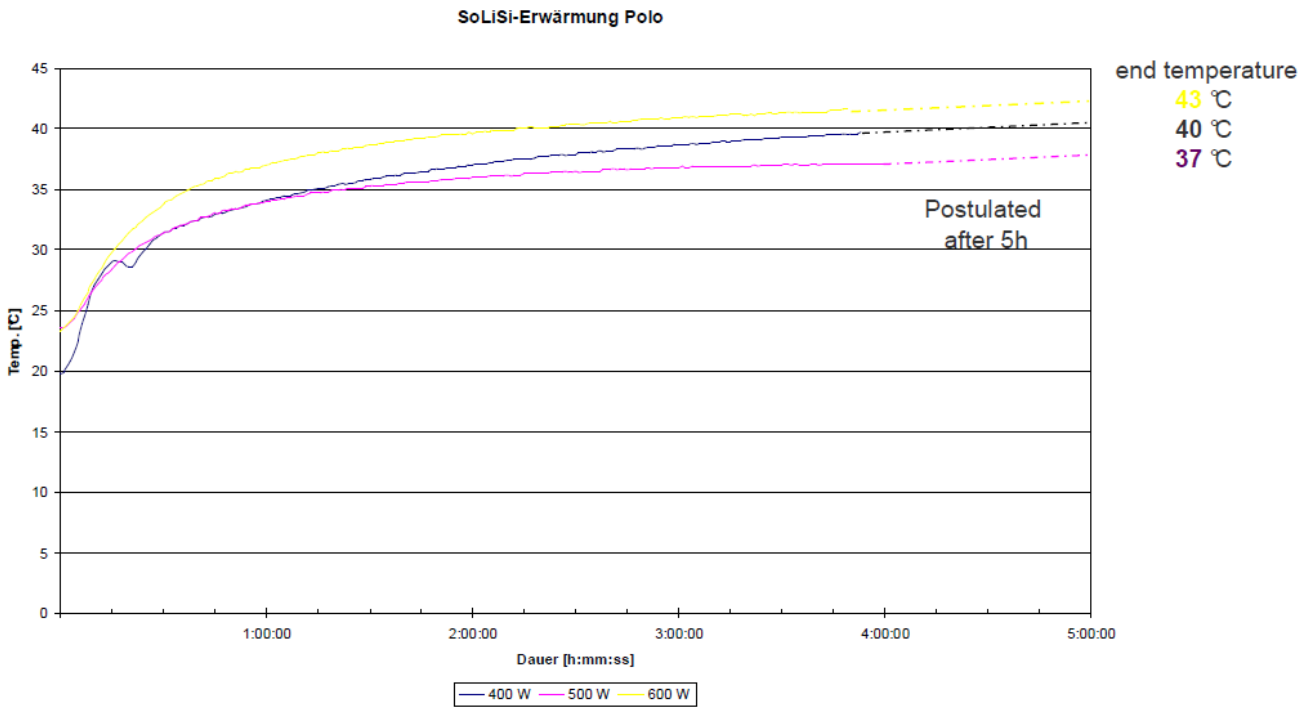
- The start temperature of the car was 23℃

- The test procedure differs between the 400/600 W/m² and the 500 W/m² test
  - by the 500 W/m² test the car was in the chamber when the lamps switch on
  - by the 400 and 600 W/m² tests, the car was driven in the chamber after the lamps are on for two hours (a metal-halogen-lamp need 1-2 hours to reach their full power)

ISO%2DTC146%2DSC6%2DWG13_N0115_Irradiation_energy_value_measuremen

Test results to verify the irradiation energy value

Temperature curves SOLISI-Radiation / Measure time 4 h



ISO%2DTC146%2DSC6%2DWG13_N0115_Irradiation_energy_value_measuremen

Test results to verify the irradiation energy value

Conclusion:

For IR-Lamps the irradiation energy value to get an interior temperature of 40 ℃ is 400 +/- 25 W/m².

Mercury-vapor-lamps have similar the same characteristic (70 to 80% IR value), so for them the same test value is to be used

Metal-halogen-lamps cannot be used for heating up cars
This has two reasons:

a. This lamp type needs 1-2 hours to get there full power, and this depends on the age of the lamp
b. The IR-radiation value of this lamps where filtered out in different ways, so the value of IR-radiation differs from type to type

ISO%2DTC146%2DSC6%2DWG13_N0116_letter_irradiation_energy_value

ISO/CD 12219-1
Irradiation energy value

Please find enclosed (see Doc. N 115) the measurement results of comparative irradiation value measurements with different lamp types.

The measurements carried out by Peter Schwarzer and investigations among the suppliers/ manufacturers of metal halide lamps resulted in the following fact:

Metal halide lamps should not be recommended in ISO/CD 12219-1 due to the fact that with this sort of lamps no reproducible heating can be reached within the heating cycle of 4 h.

This has two reasons:

a) The lamps require 1 h – 2 h to reach their final energy radiation. Since the energy radiation also depends on the age of the lamps no constant heating characteristic for the vehicles can be reached.

b) The IR fraction of these lamps, being an essential part of the heating process, is filtered out as far as possible as these lamps are needed primarily to simulate sunlight in the visible and UV spectrum. This filtration characteristic is mainly manufacturer-specific. Therefore the final resulting IR fraction during the heating process is not known and, thus, there is a risk of non-comparability between different lamp manufacturers.

From Peter Schwarzer's point of view this could be the reason for the different results of the tests carried out in Japan, Korea and the US.

Therefore, Peter Schwarzer proposes not to include the metal halide lamps and to refer only to IR lamps and halogen lamps with an irradiation of 400 +/- 25 W/m².

ISO%2DTC146%2DSC6%2DWG13_N0118_letter_Otsuka

After review of N116 & N115, I have some comments.

1. Irradiation study by Japan & Germany
I made a graph include our data & German data as attachment.
IR's results are similar between VW's and Japanese.
376W/m2@40C (VW)
362W/m2@40C (Vehicle A)
Halogen's result is similar about 400W/m2 or below.
406W/m2@40C (Vehicle C)
Average of these results is 381W/m2.

2. Outcome of the results
Metal halide lamp makes different results.
IR and halogen lamp makes similar results, but 400+/-25W/m2 is too severe condition when considering different vehicles, test equipments and lamp arrangement etc

Therefore I propose 400+/-50 W/m2 as appropriate value.

Final Conclusions

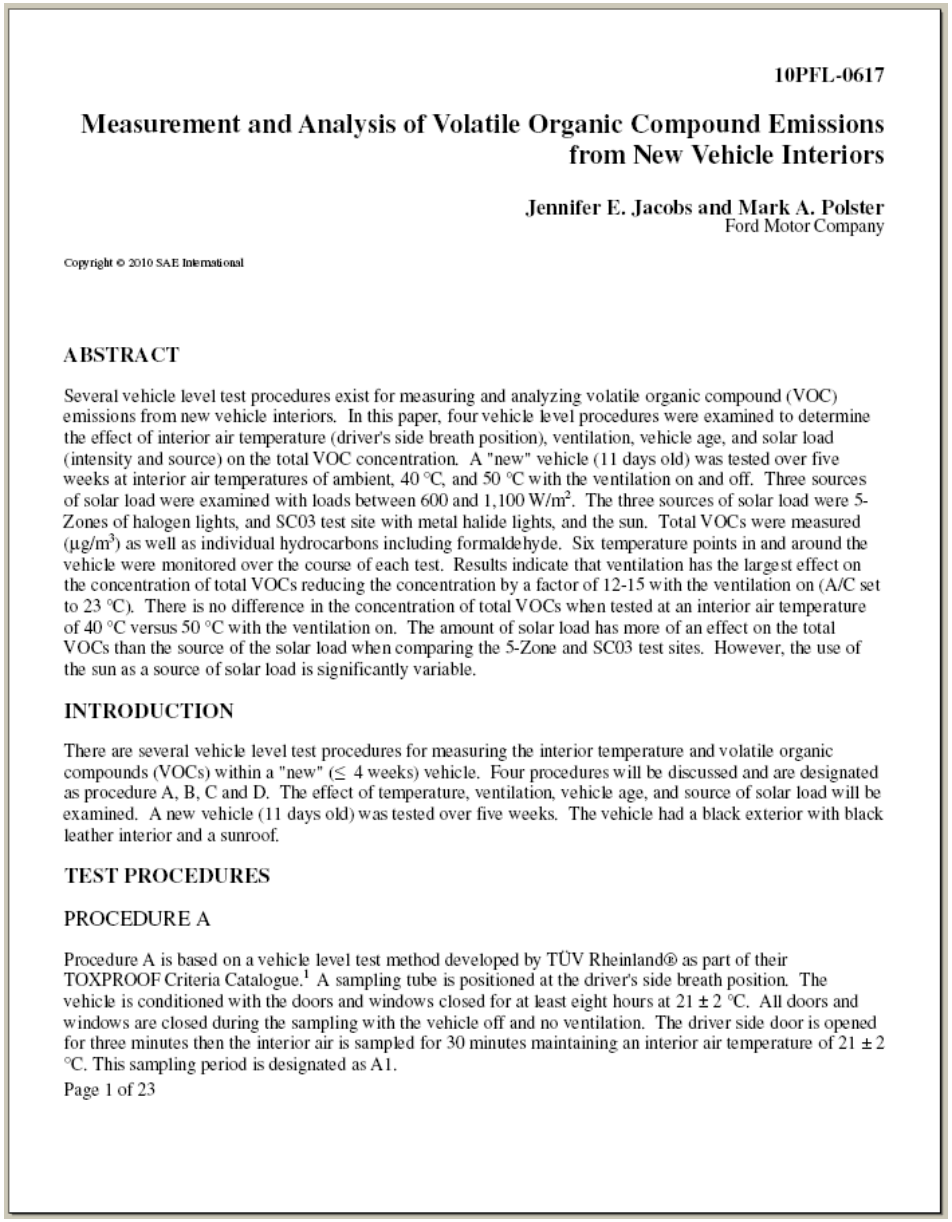
- After much discussion the WG agreed to a solar load of 400 W/m2 +- 50. This value was assumed to be a value that represented a nationalized and annualized level.

Elevated VOC Levels

- The WG shared elevated vehicle test results, both temperature and VOC levels to see the affect solar load and temperature had on VOC levels.

SAE Paper

- The final draft was submitted in January 2010
- A new vehicle was tested over 38 days
- The 23 page report show the results of 19 multiple phase tests
- Over 200 samples were collected and analyzed



10PFL-0617

Measurement and Analysis of Volatile Organic Compound Emissions from New Vehicle Interiors

Jennifer E. Jacobs and Mark A. Polster
Ford Motor Company

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ABSTRACT

Several vehicle level test procedures exist for measuring and analyzing volatile organic compound (VOC) emissions from new vehicle interiors. In this paper, four vehicle level procedures were examined to determine the effect of interior air temperature (driver's side breath position), ventilation, vehicle age, and solar load (intensity and source) on the total VOC concentration. A "new" vehicle (11 days old) was tested over five weeks at interior air temperatures of ambient, 40 °C, and 50 °C with the ventilation on and off. Three sources of solar load were examined with loads between 600 and 1,100 W/m^2. The three sources of solar load were 5-Zones of halogen lights, and SC03 test site with metal halide lights, and the sun. Total VOCs were measured (µg/m^3) as well as individual hydrocarbons including formaldehyde. Six temperature points in and around the vehicle were monitored over the course of each test. Results indicate that ventilation has the largest effect on the concentration of total VOCs reducing the concentration by a factor of 12-15 with the ventilation on (A/C set to 23 °C). There is no difference in the concentration of total VOCs when tested at an interior air temperature of 40 °C versus 50 °C with the ventilation on. The amount of solar load has more of an effect on the total VOCs than the source of the solar load when comparing the 5-Zone and SC03 test sites. However, the use of the sun as a source of solar load is significantly variable.

INTRODUCTION

There are several vehicle level test procedures for measuring the interior temperature and volatile organic compounds (VOCs) within a "new" (≤ 4 weeks) vehicle. Four procedures will be discussed and are designated as procedure A, B, C and D. The effect of temperature, ventilation, vehicle age, and source of solar load will be examined. A new vehicle (11 days old) was tested over five weeks. The vehicle had a black exterior with black leather interior and a sunroof.

TEST PROCEDURES

PROCEDURE A

Procedure A is based on a vehicle level test method developed by TÜV Rheinland® as part of their TOXPROOF Criteria Catalogue.[1] A sampling tube is positioned at the driver's side breath position. The vehicle is conditioned with the doors and windows closed for at least eight hours at 21 ± 2 °C. All doors and windows are closed during the sampling with the vehicle off and no ventilation. The driver side door is opened for three minutes then the interior air is sampled for 30 minutes maintaining an interior air temperature of 21 ± 2 °C. This sampling period is designated as A1.

Background

- Vehicle Criteria
  - New (< 4 weeks) black exterior and black interior vehicle
- Four procedures were evaluated
  - A (TUV), B (JAMA), C (ISO), D (load-based)
- Three solar load source test sites
  - ISO site, SC03 site, sun
- Various parameters were evaluated to determine the effect on concentration ($\mu g/m^3$)
  - Parameters: temperature, ventilation, vehicle age and solar load source
  - Compounds of interest: TVOCs and formaldehyde
    - 65+ hydrocarbons were analyzed including, benzene, toluene, ethylbenzene, m&p-xylenes, o-xylene, styrene, and tetradecane

Procedure Overview

All sample periods are 0.5 h

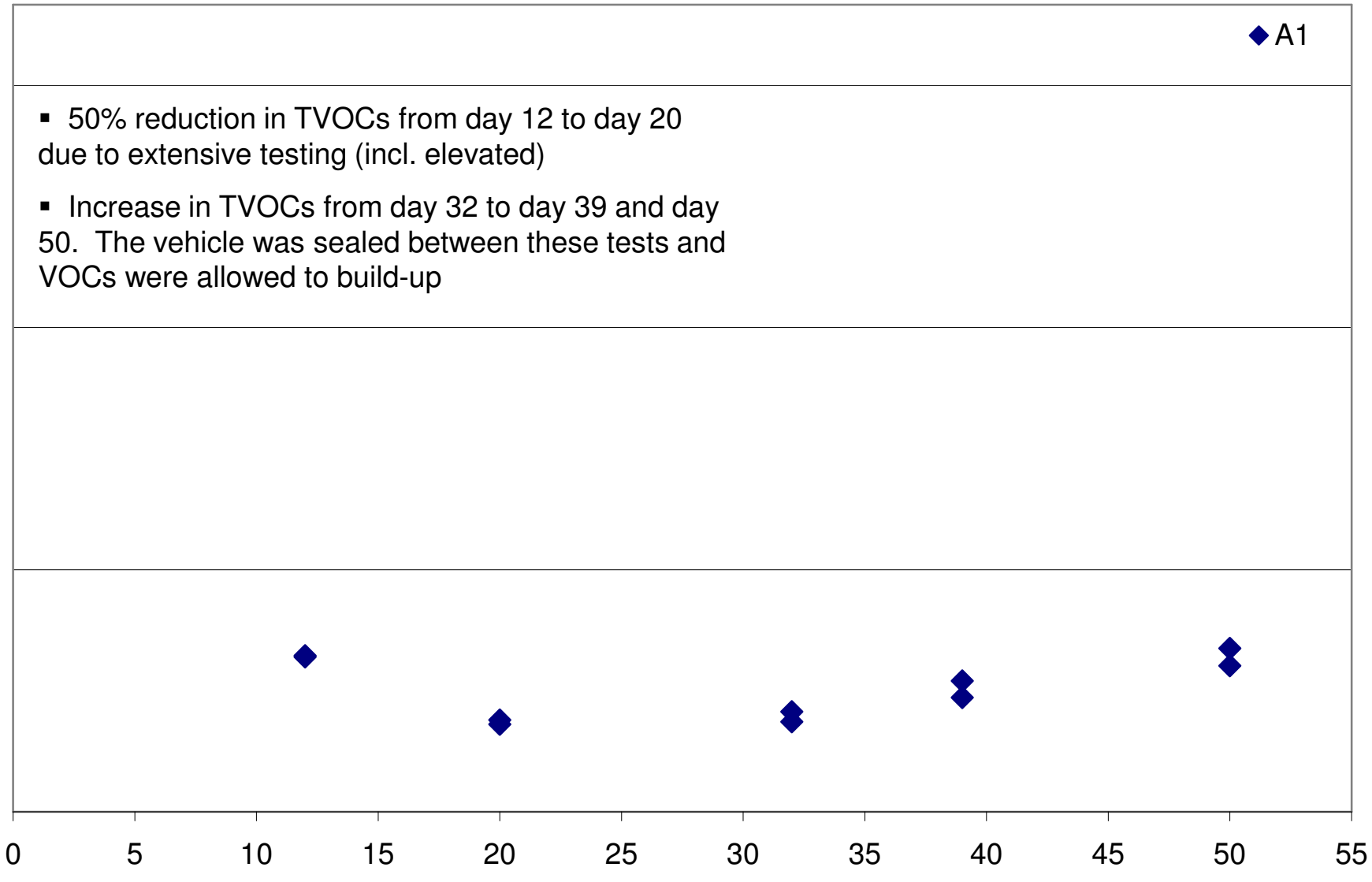
- Procedure A (TUV)
  - Soak 8+ hr
  - 3 min door opening
  - Sample @ ambient T **(A1)**
- Procedure B (JAMA)
  - Sample @ ambient T (not part of original method) **(B1)**
  - Doors open 0.5 hr
  - Heat vehicle to 40 °C and hold for 4.5 hr then sample **(B2)**
  - Open driver door for 1 min and set A/C to 23 °C then sample **(B3)**
- Procedure C (ISO)
  - Doors open 4 hr then 15.5 hr soak (no air exchange in vehicle)
  - Sample @ ambient T **(C1)**
  - Heat vehicle to 50 °C and hold for 2.5 hr then sample **(C2)**
  - Open driver door for 1 min and set A/C to 23 °C then sample **(C3)**
- Procedure D (load-based)
  - Soak 8+ hr
  - Sample @ ambient T **(D1)**
  - Apply constant load and hold for 2.5 hr then sample **(D2)**
  - Open driver door for 1 min and set A/C to 23 °C then sample **(D3)**

Results

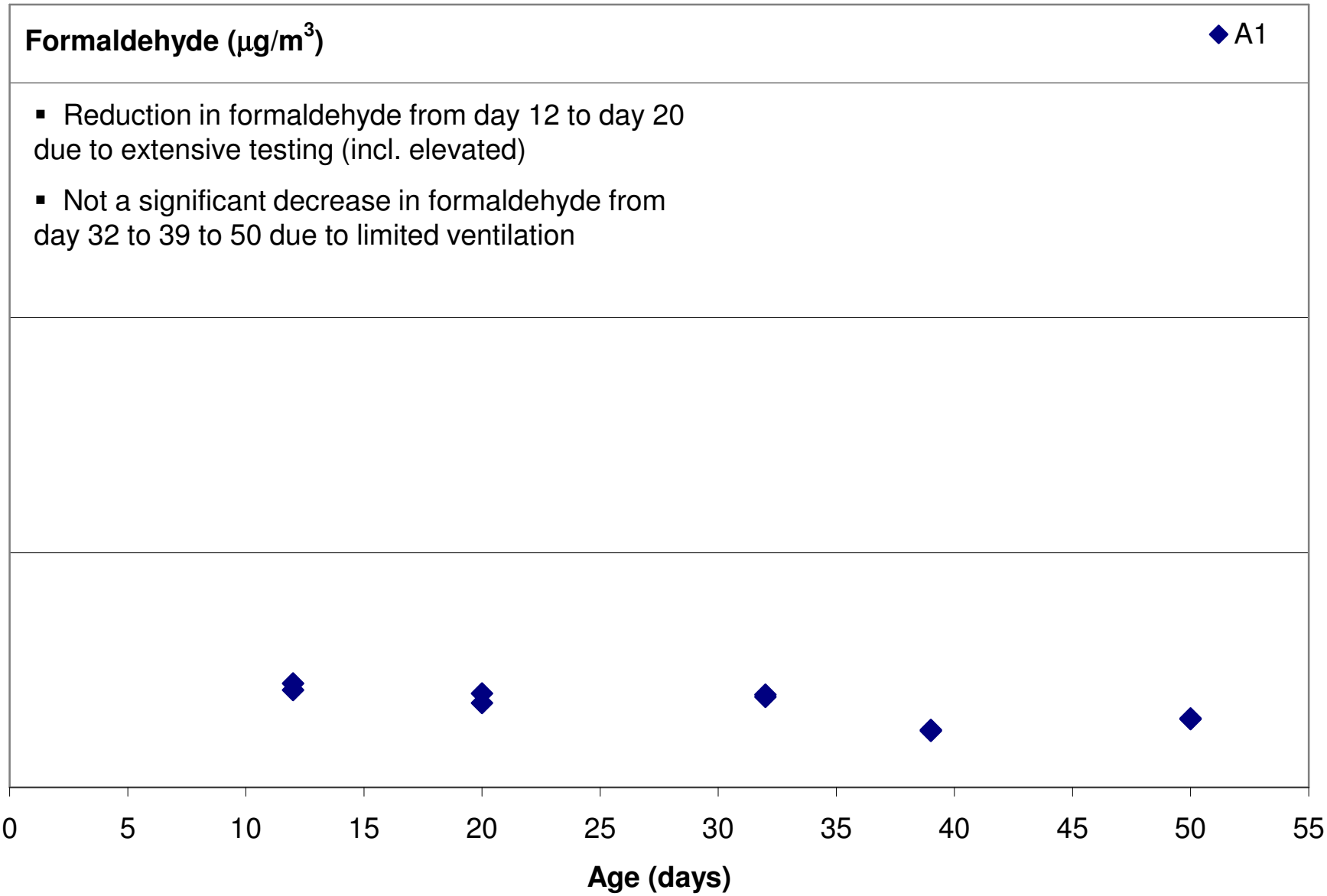
- Part 1
  - Effect of temperature, ventilation, and vehicle age
- Part 2
  - Effect of solar load source
- Part 3
  - Evaluation of a load-based approach (Procedure D only)

RESULTS – Part 1

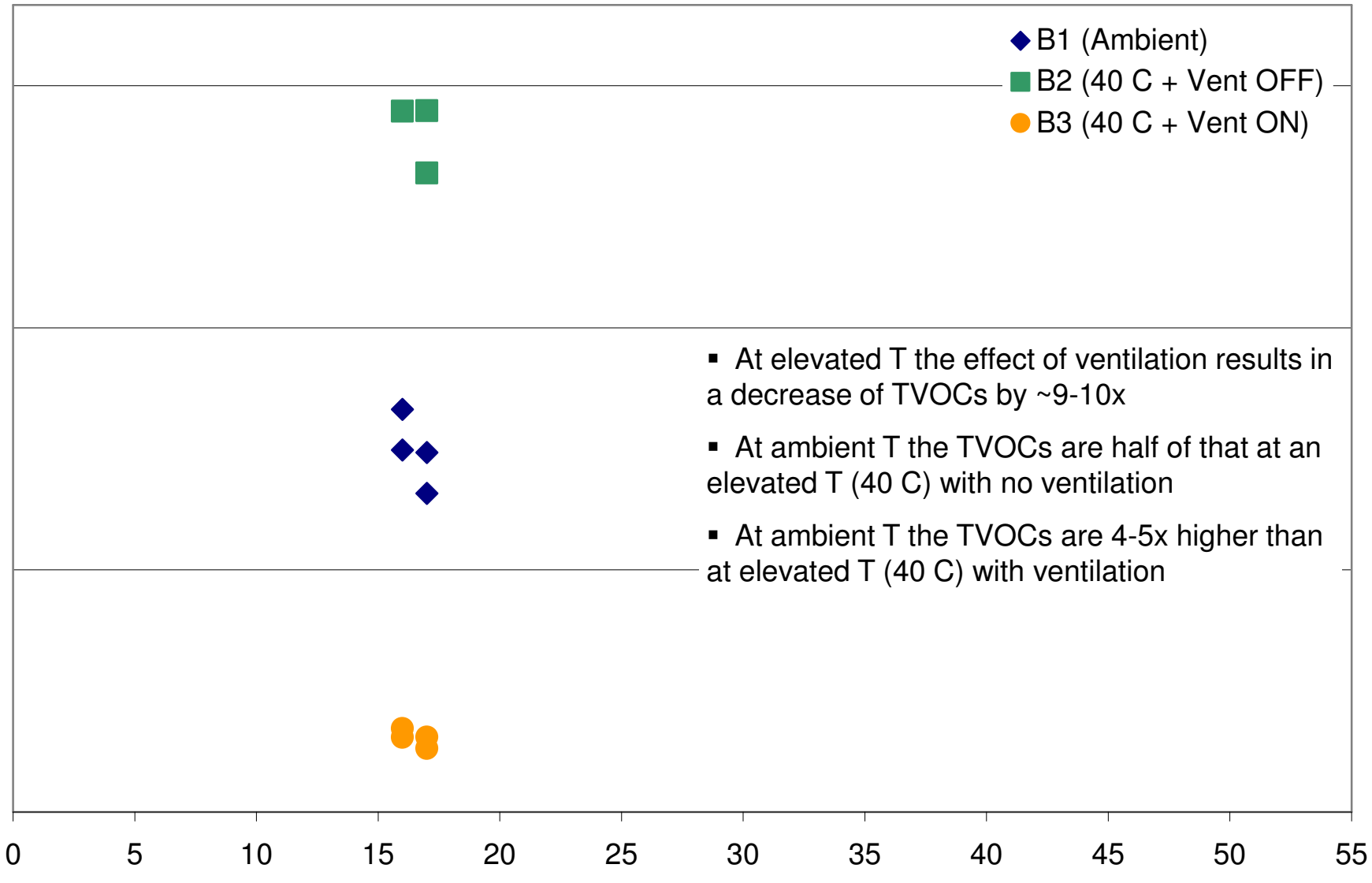
- Temperature, Ventilation, and Vehicle Age



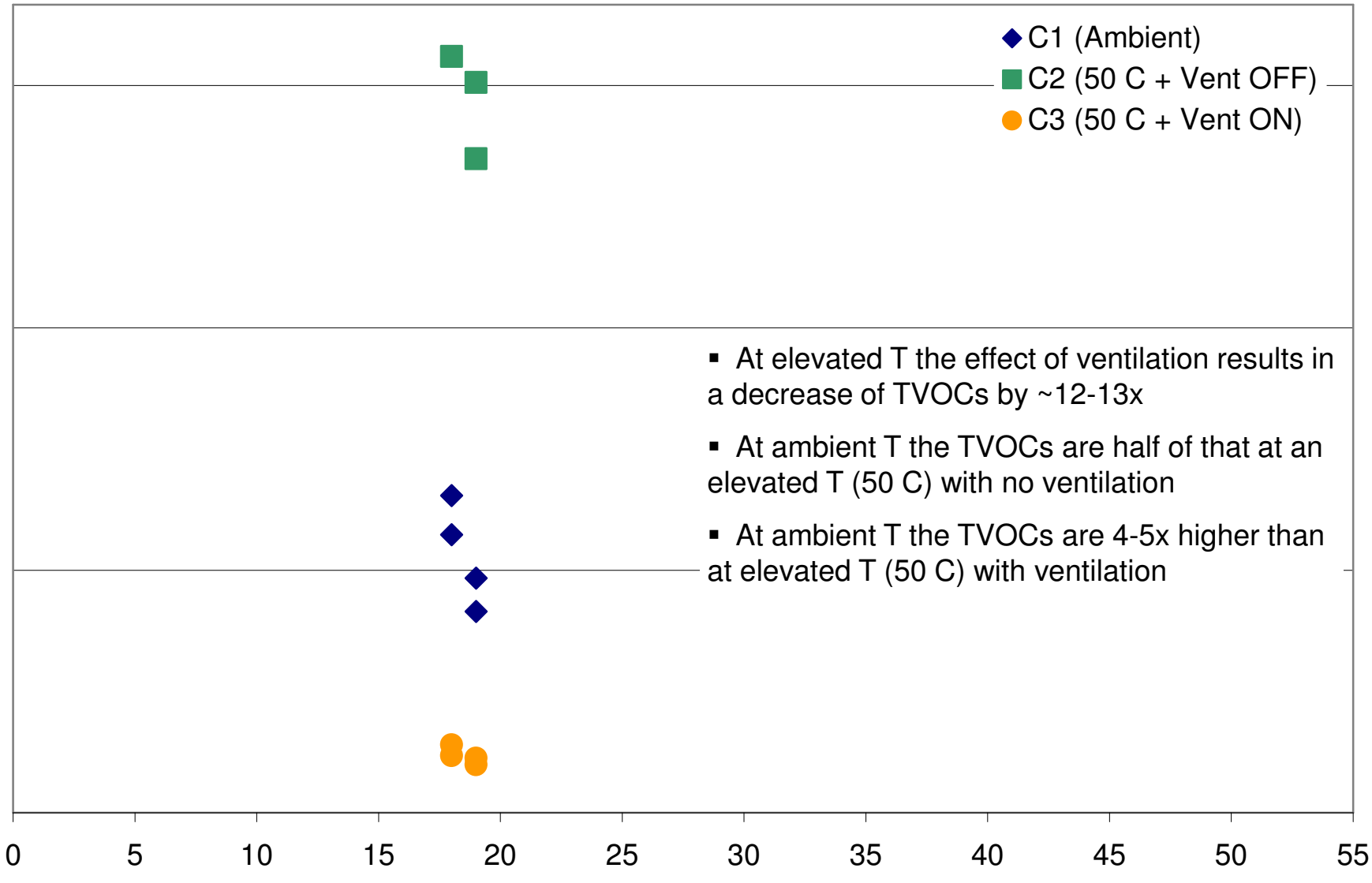
Concentration of total VOCs (C6-C16 (µg/m^3)) using Procedure A at ambient T



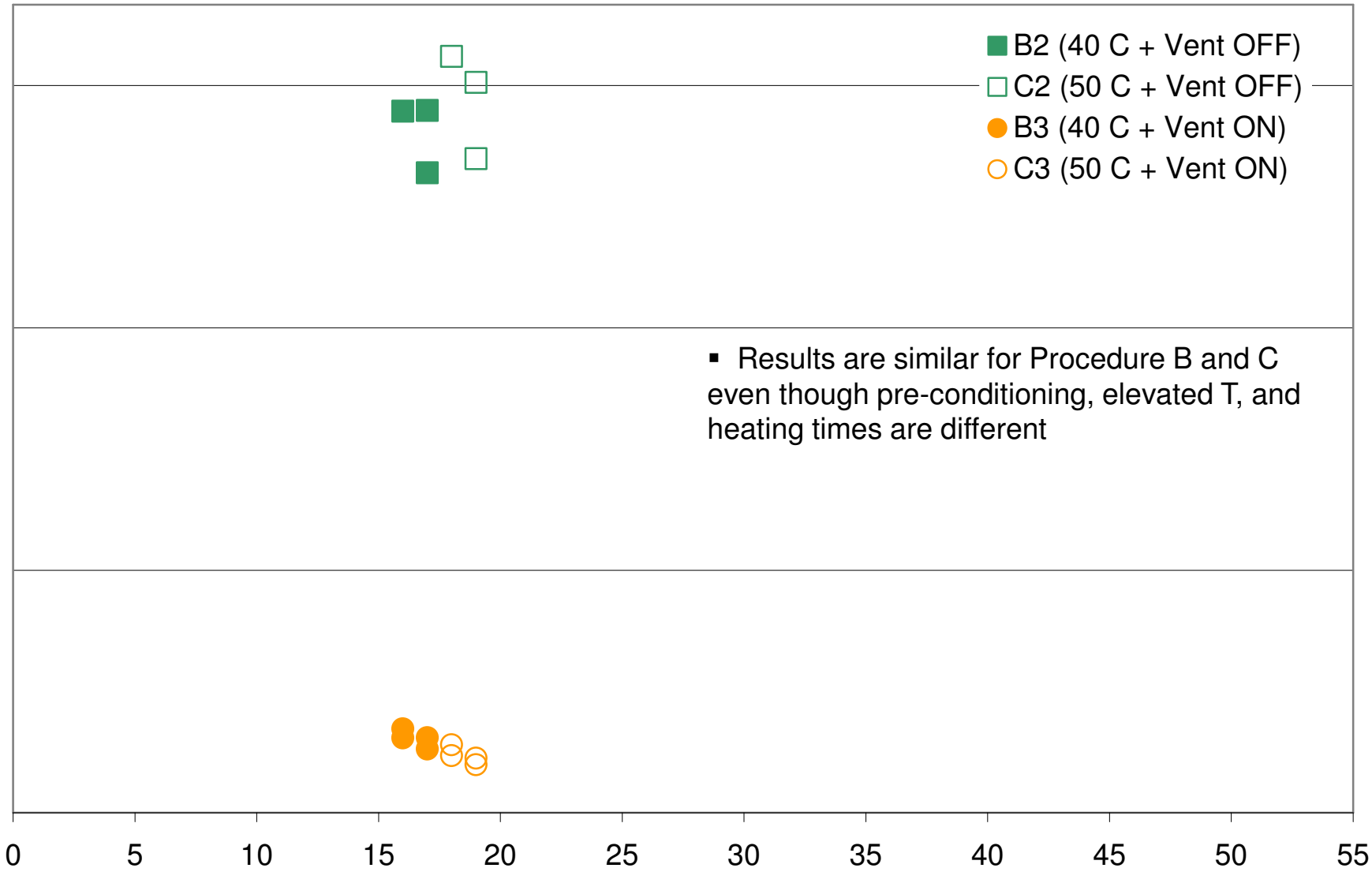
Concentration of formaldehyde (µg/m^3) using Procedure A at ambient T



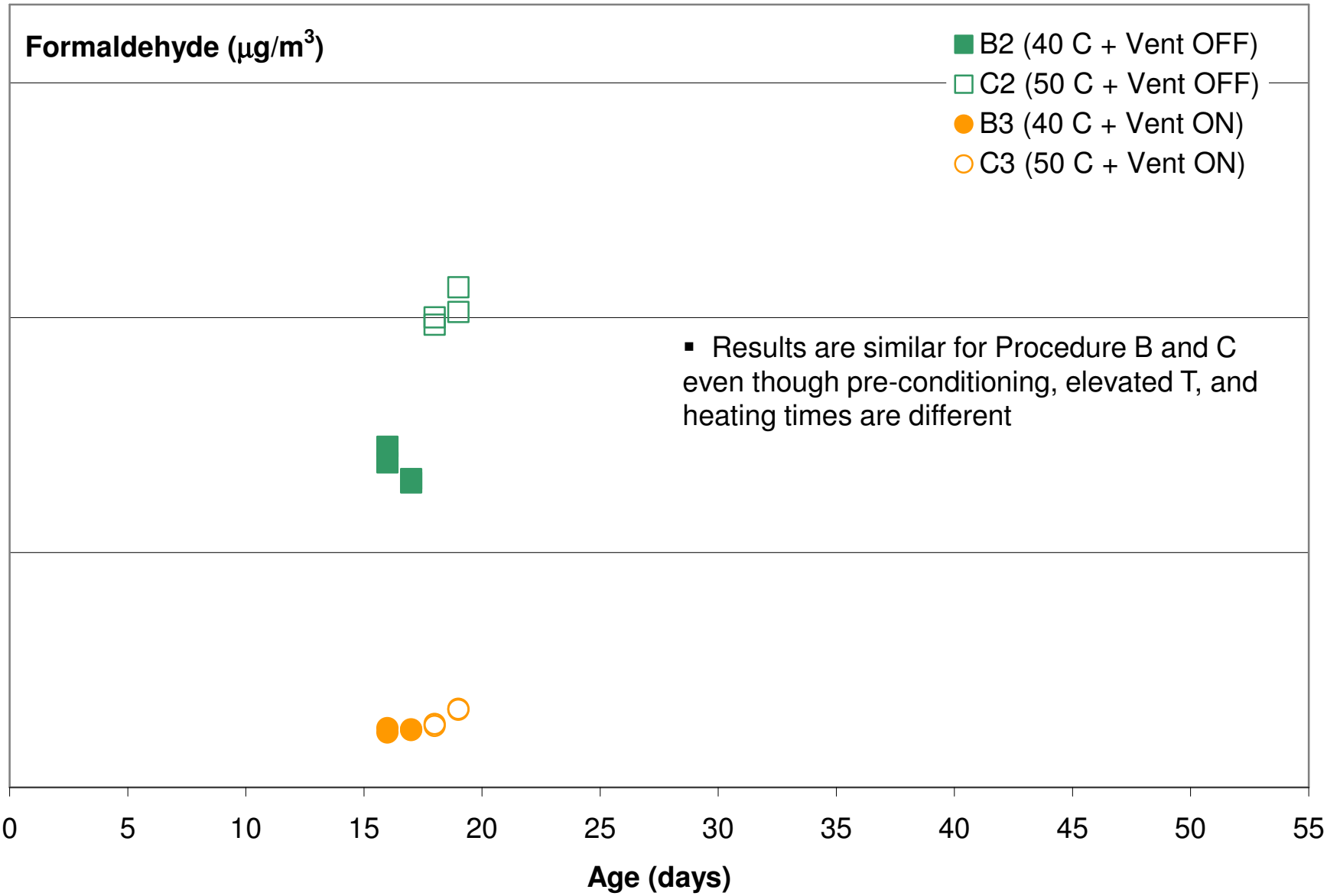
Concentration of total VOCs (C6-C16 (µg/m^3)) using Procedure B at ambient T and 40 °C



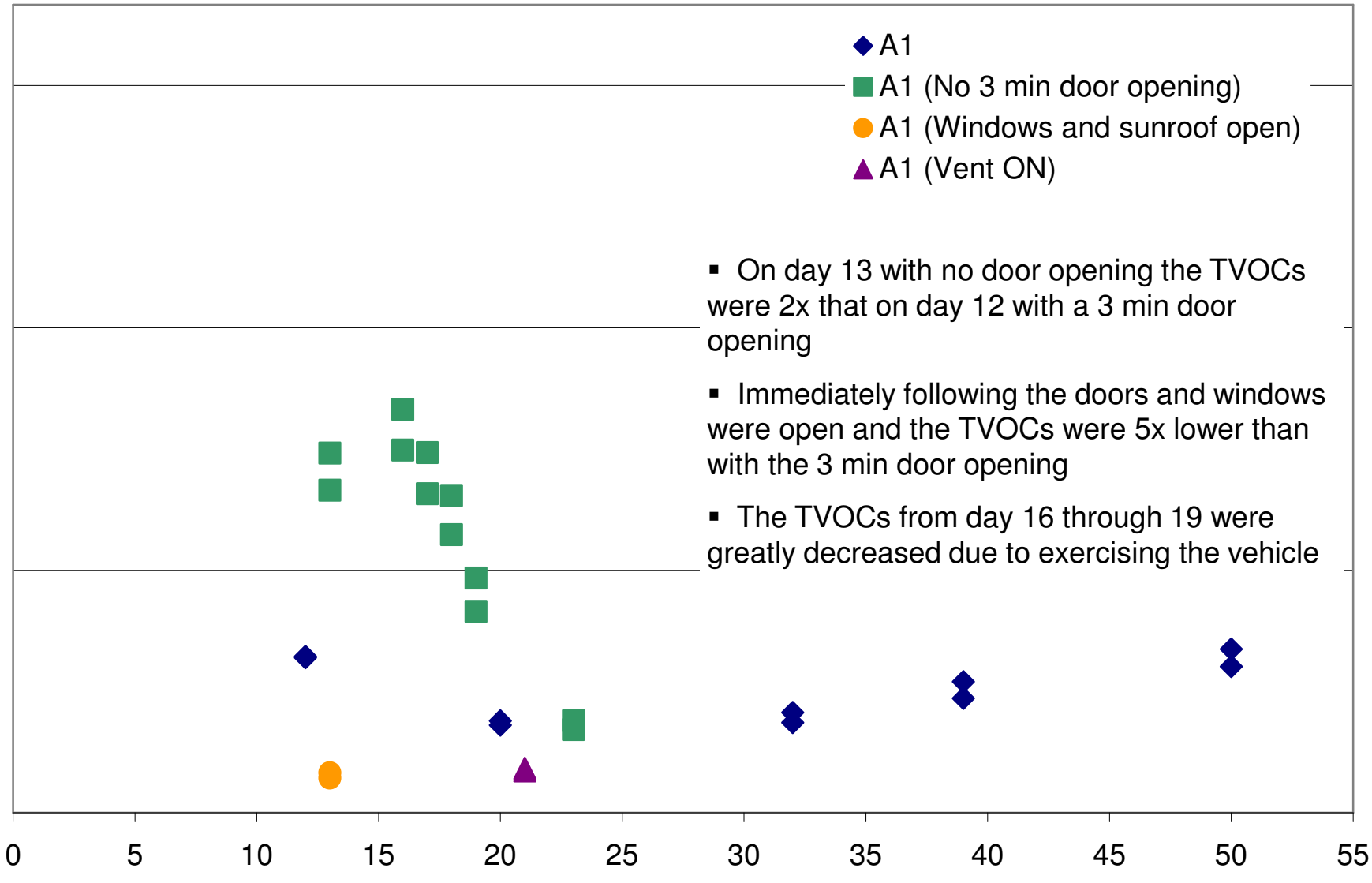
Concentration of total VOCs (C6-C16 (µg/m^3)) using Procedure C at ambient T and 50 °C



Concentration of total VOCs (C6-C16 (µg/m^3)) using Procedure B (40 °C) and C (50 °C)



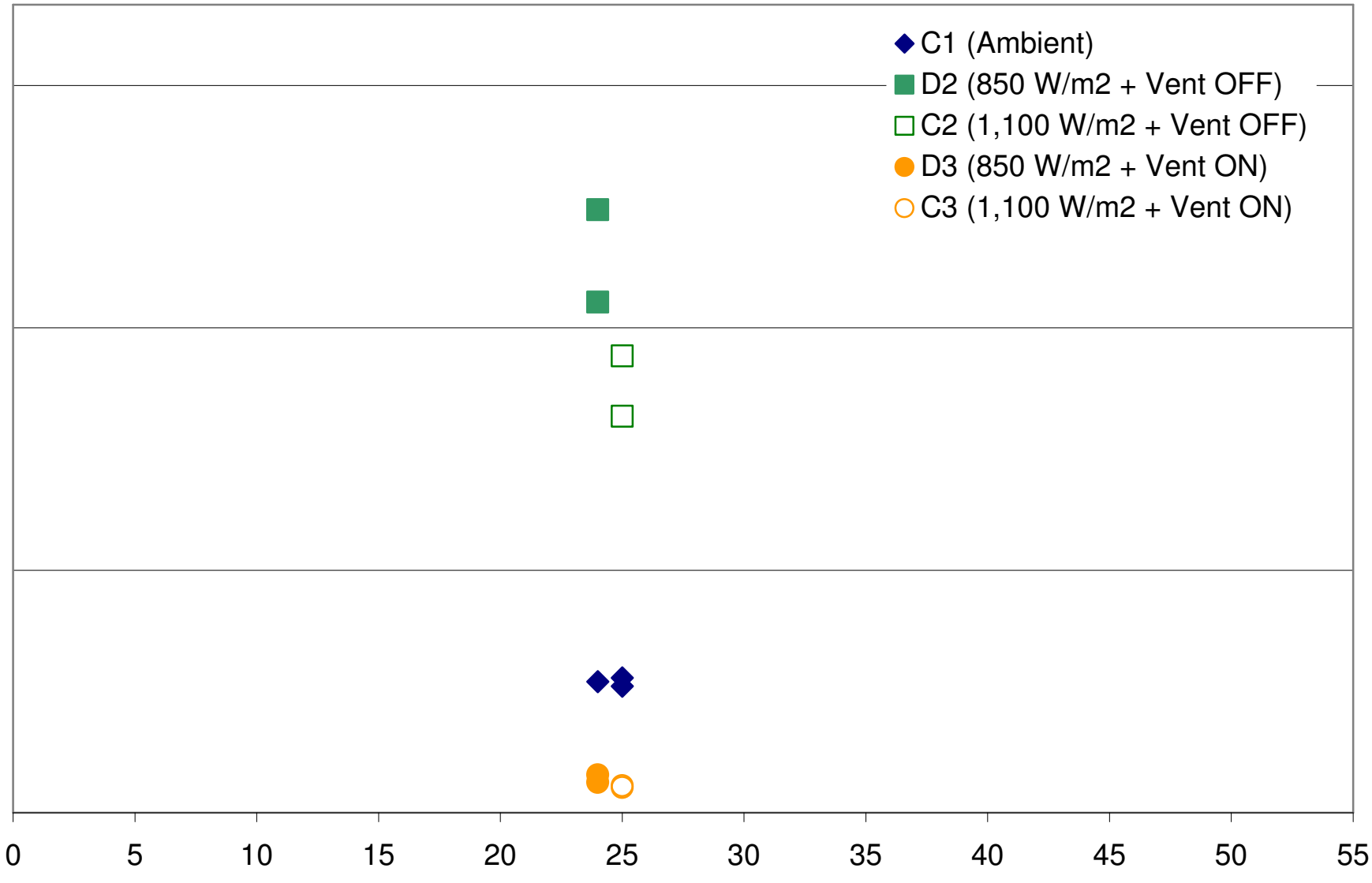
Concentration of formaldehyde (µg/m3) using Procedure B (40 °C) and C (50 °C)



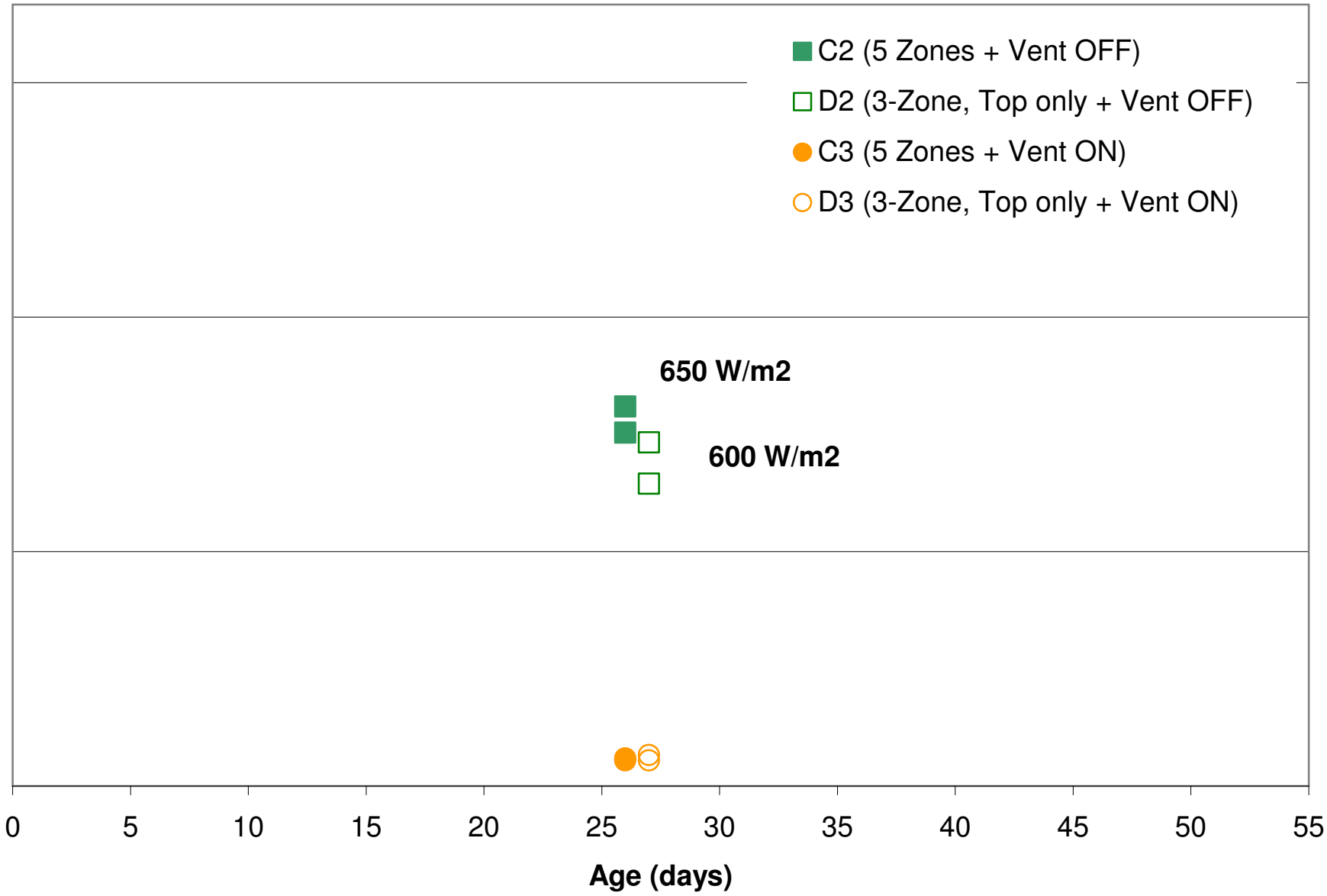
Concentration of total VOCs (C6-C16 (µg/m^3)) using Procedure A and modifications of A

RESULTS – Part 2

- Solar Load Source
  - ISO Site
  - SC03 Site
  - Sun (back-up)



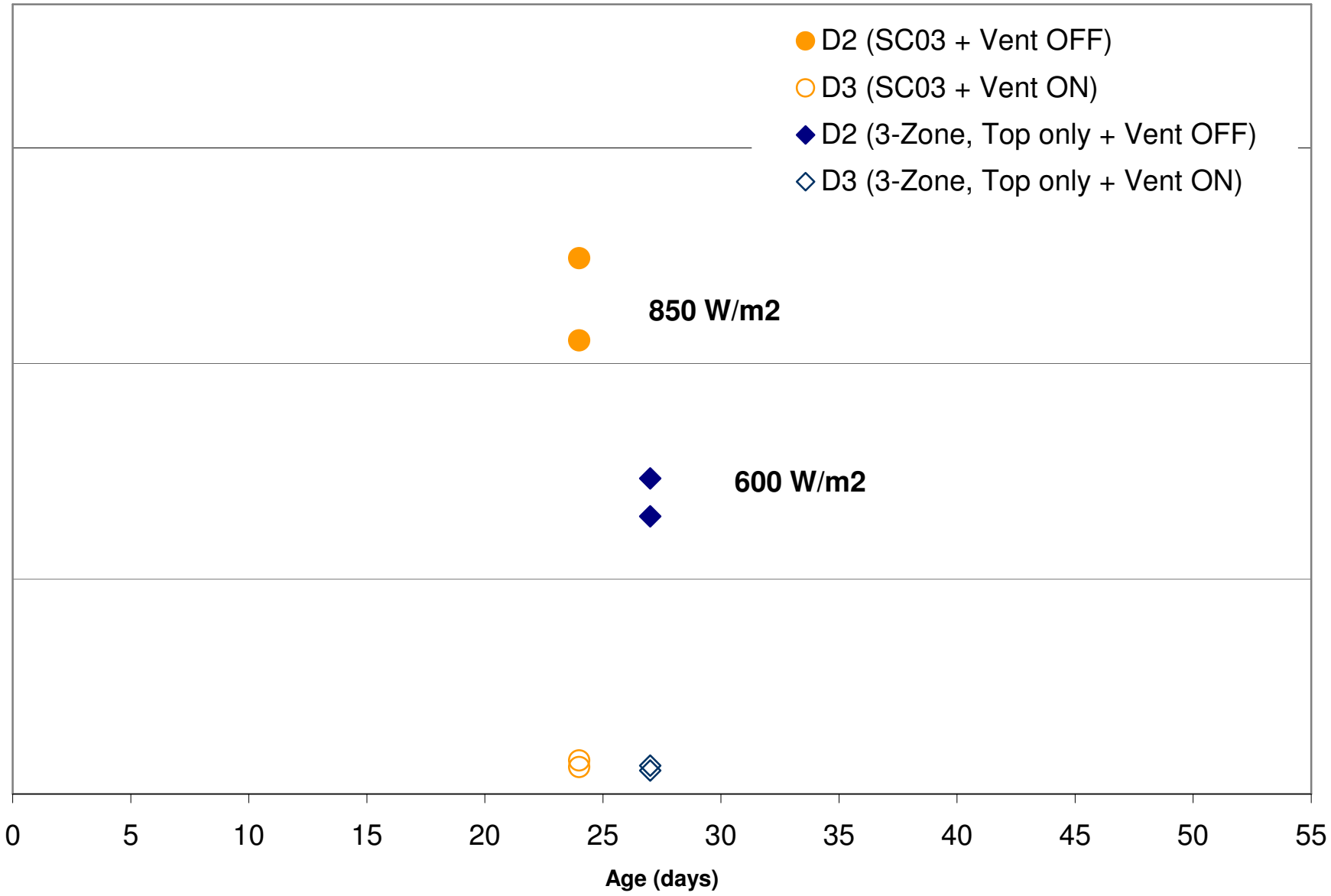
Concentration of total VOCs (C6-C16 (µg/m^3)) using Procedure C and D using SC03 site



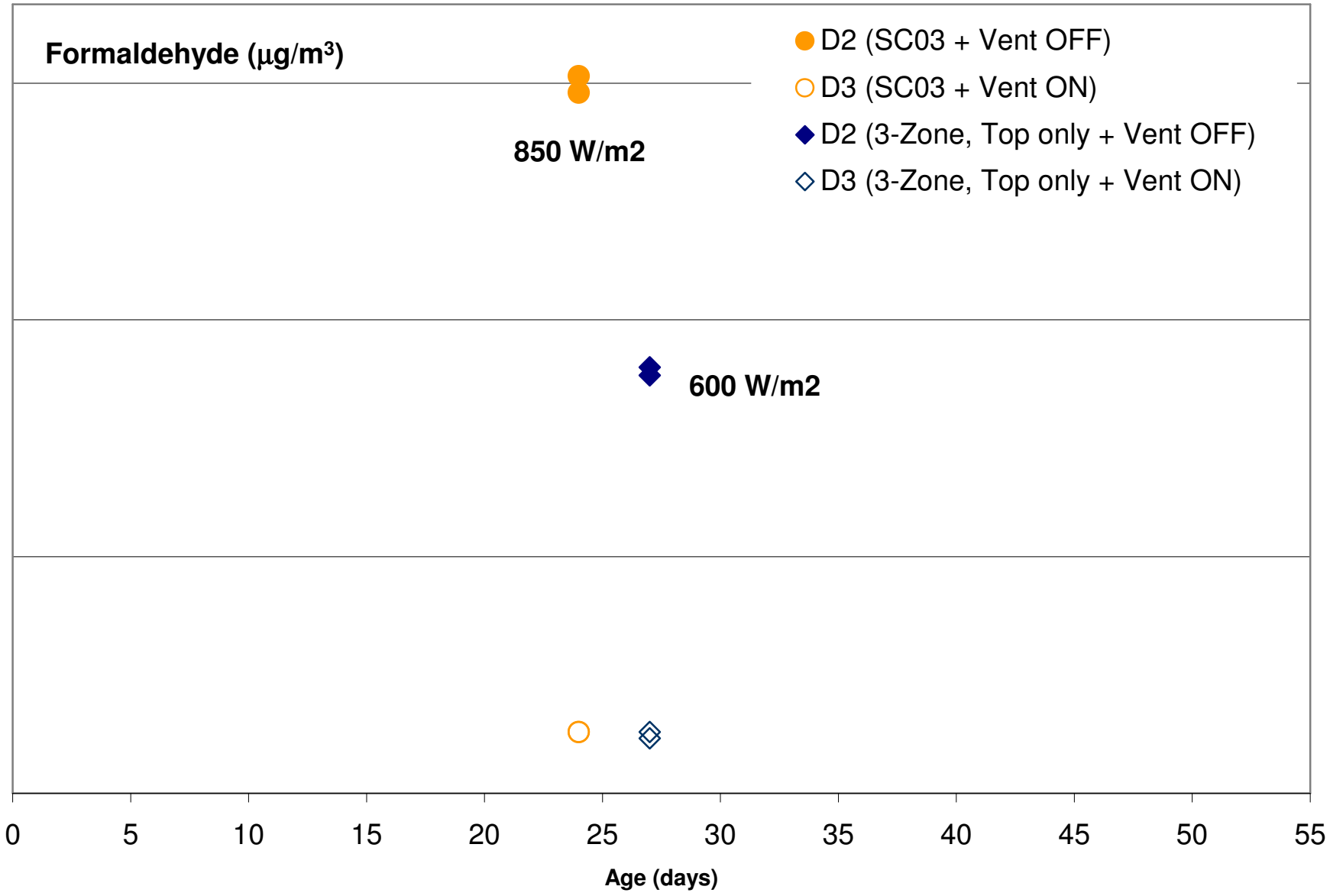
Concentration of total VOCs (C6-C16 (µg/m^3)) using Procedure C and D using ISO site

RESULTS – Part 3

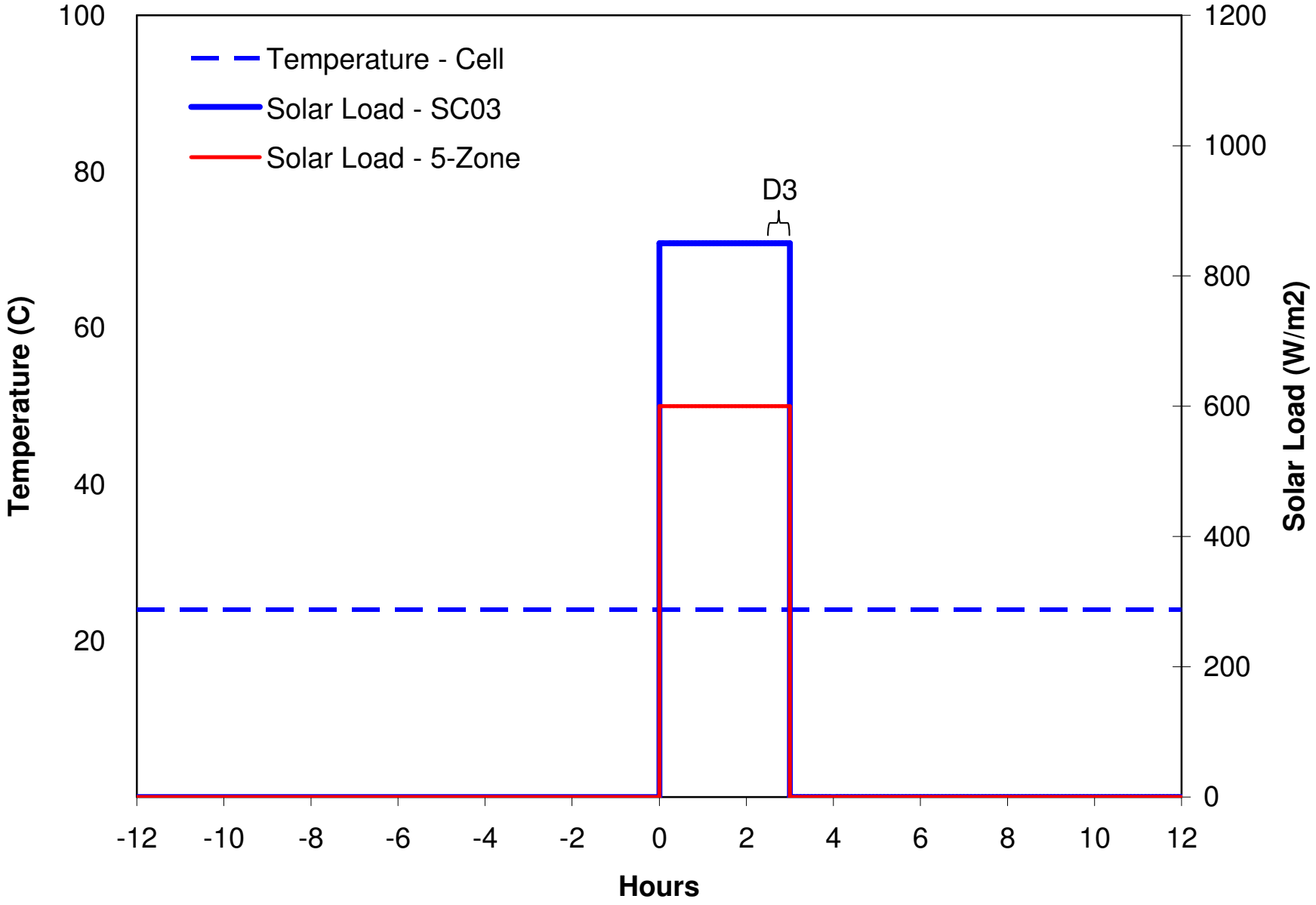
- Evaluation of Load-Based Approach
  - Procedure D only



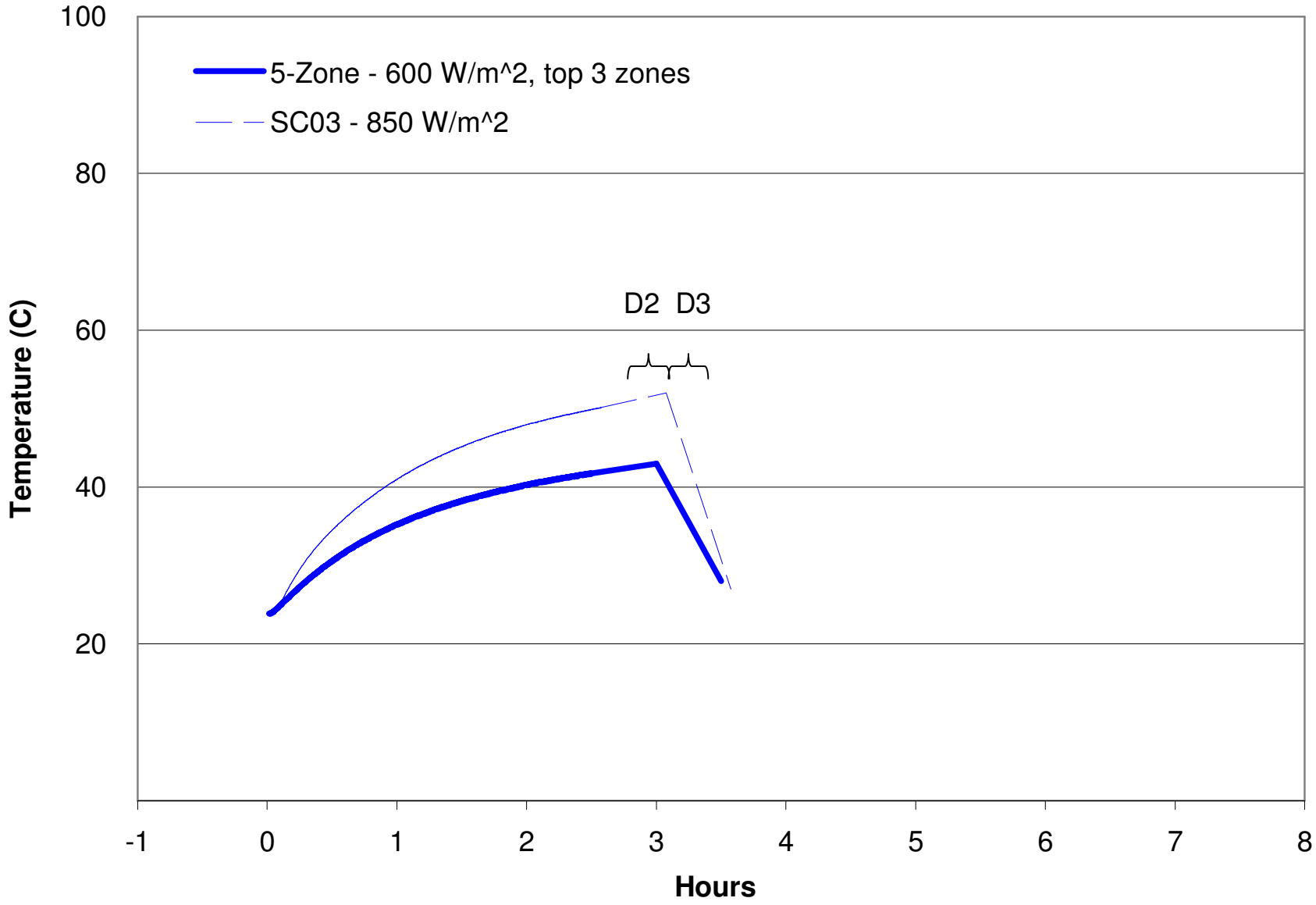
Concentration of total VOCs (C6-C16 (µg/m^3)) comparing Procedure D using SC03 & ISO



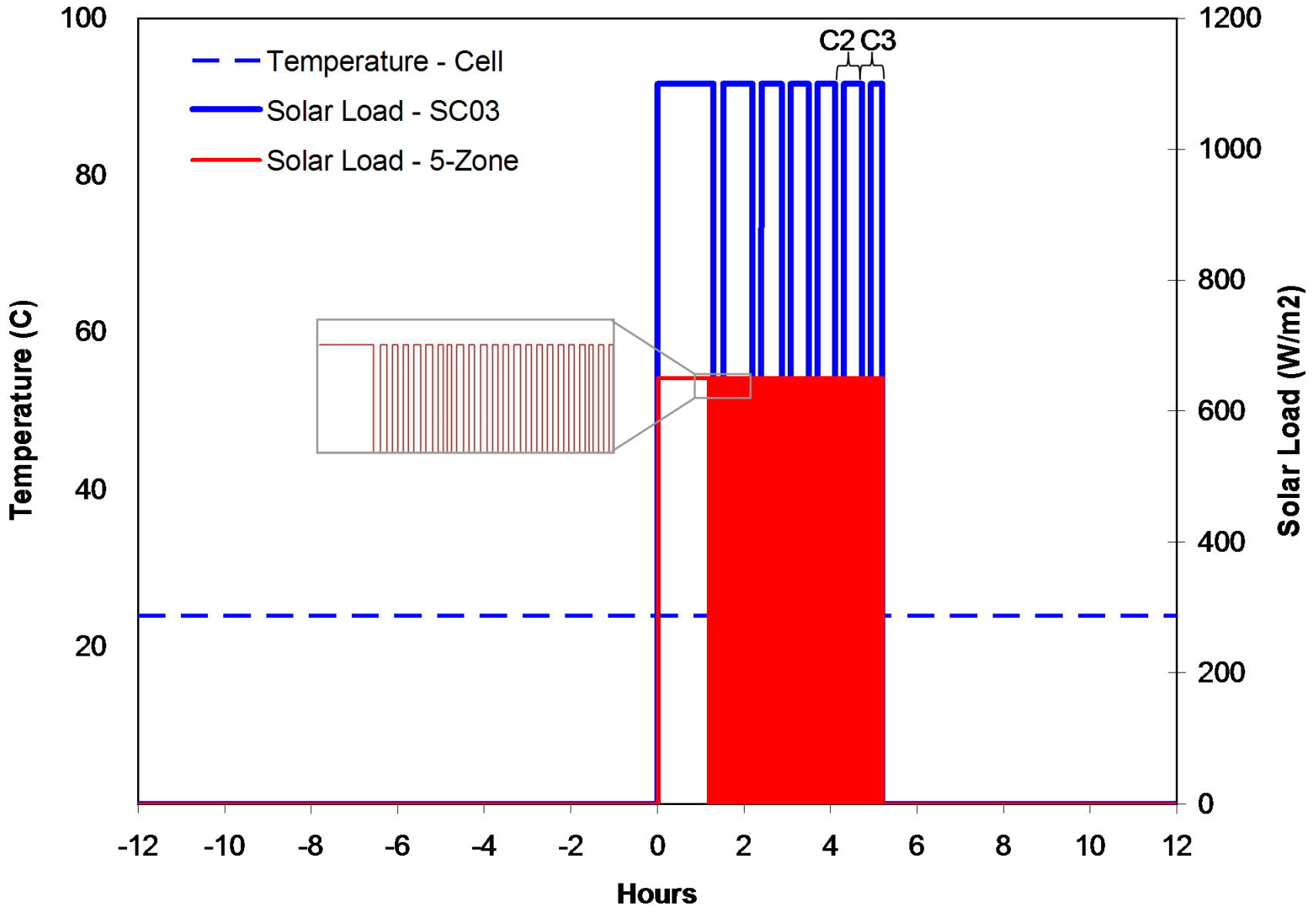
Concentration of formaldehyde (µg/m3)) comparing Procedure D using SC03 & ISO



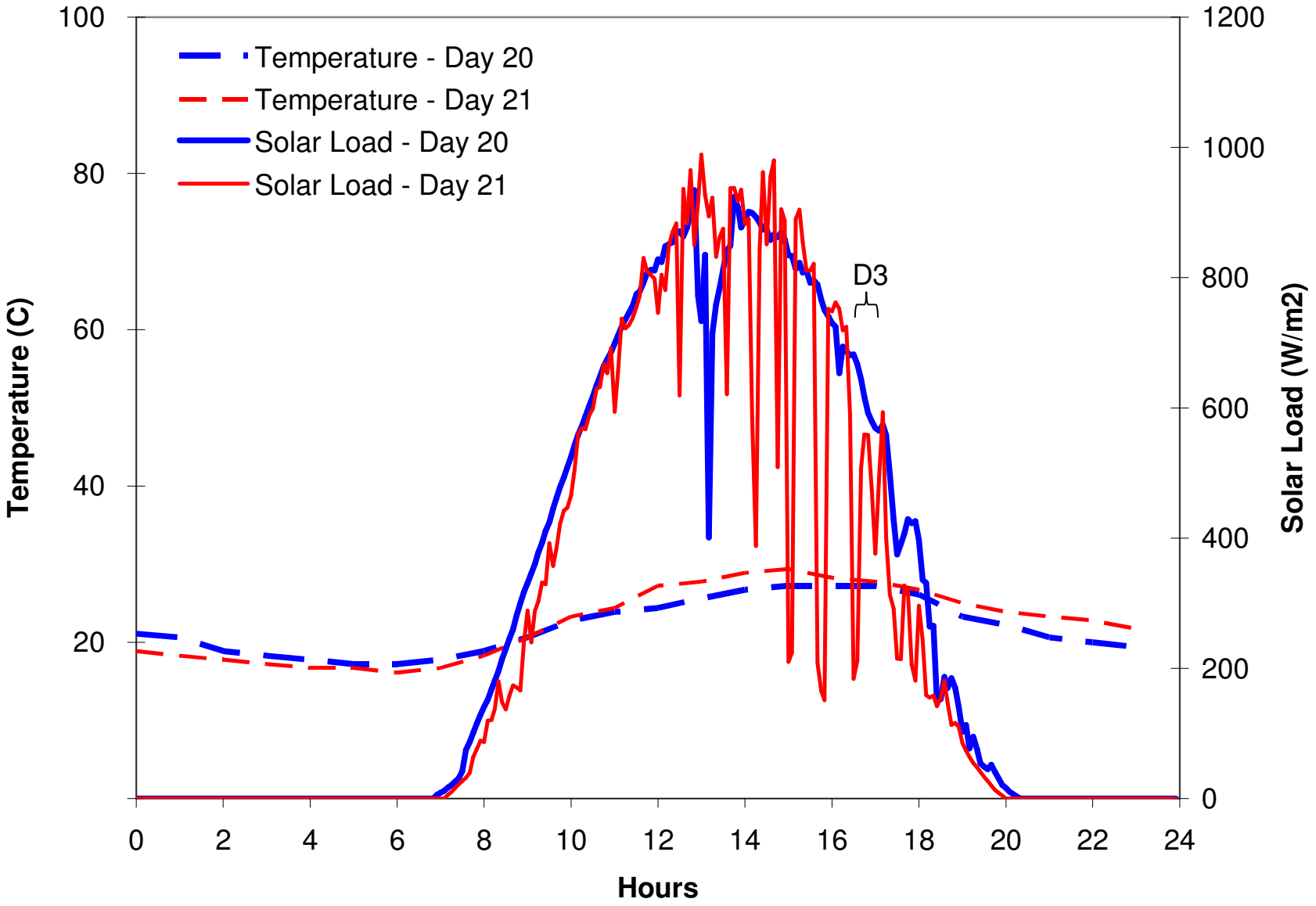
Cell Temperature (°C) from Procedure D using the SC03 and ISO test site



Breath Temperature (°C) from Procedure D using the SC03 and ISO test site

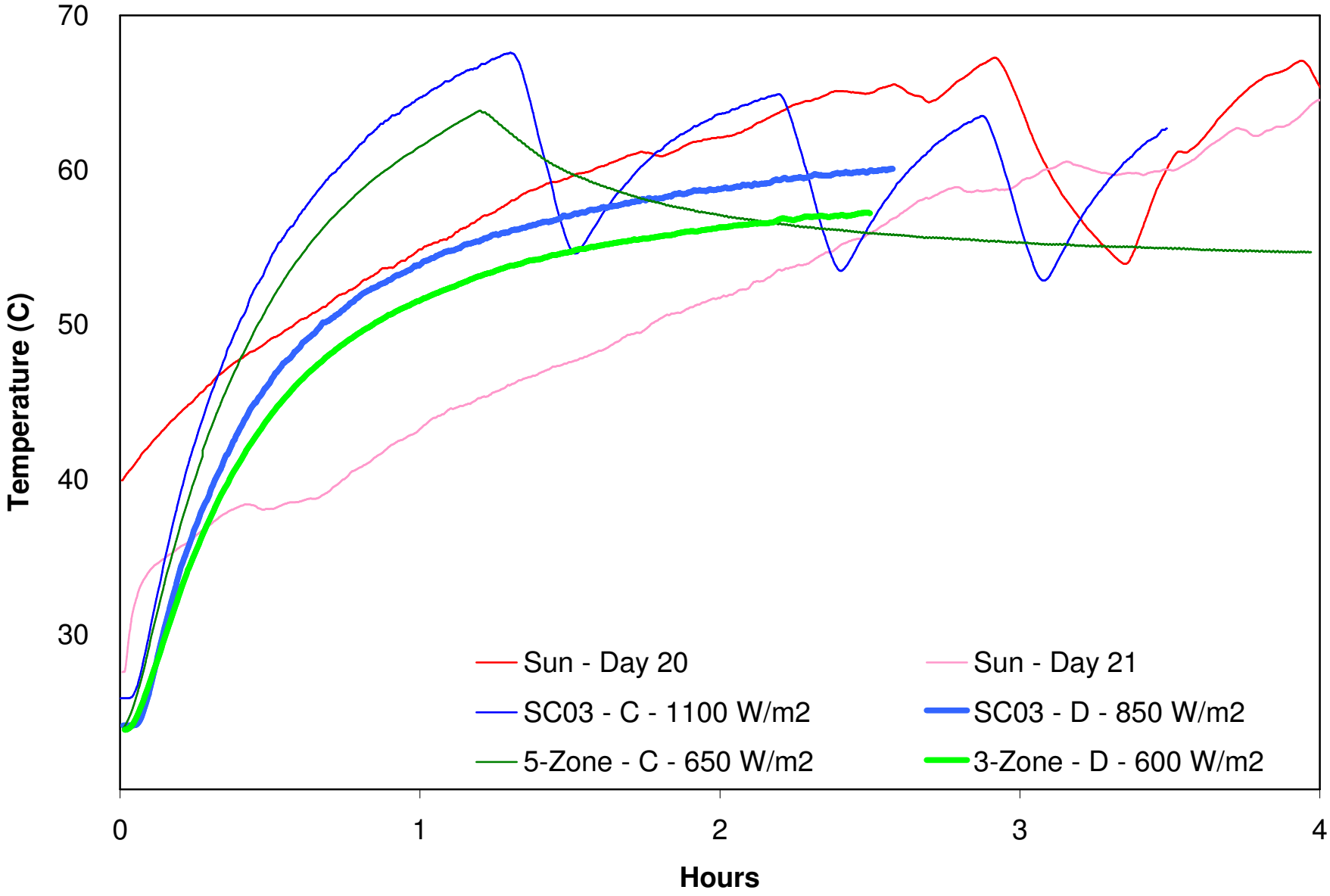


Cell Temperature (°C) from Procedure C using the SC03 and ISO sites

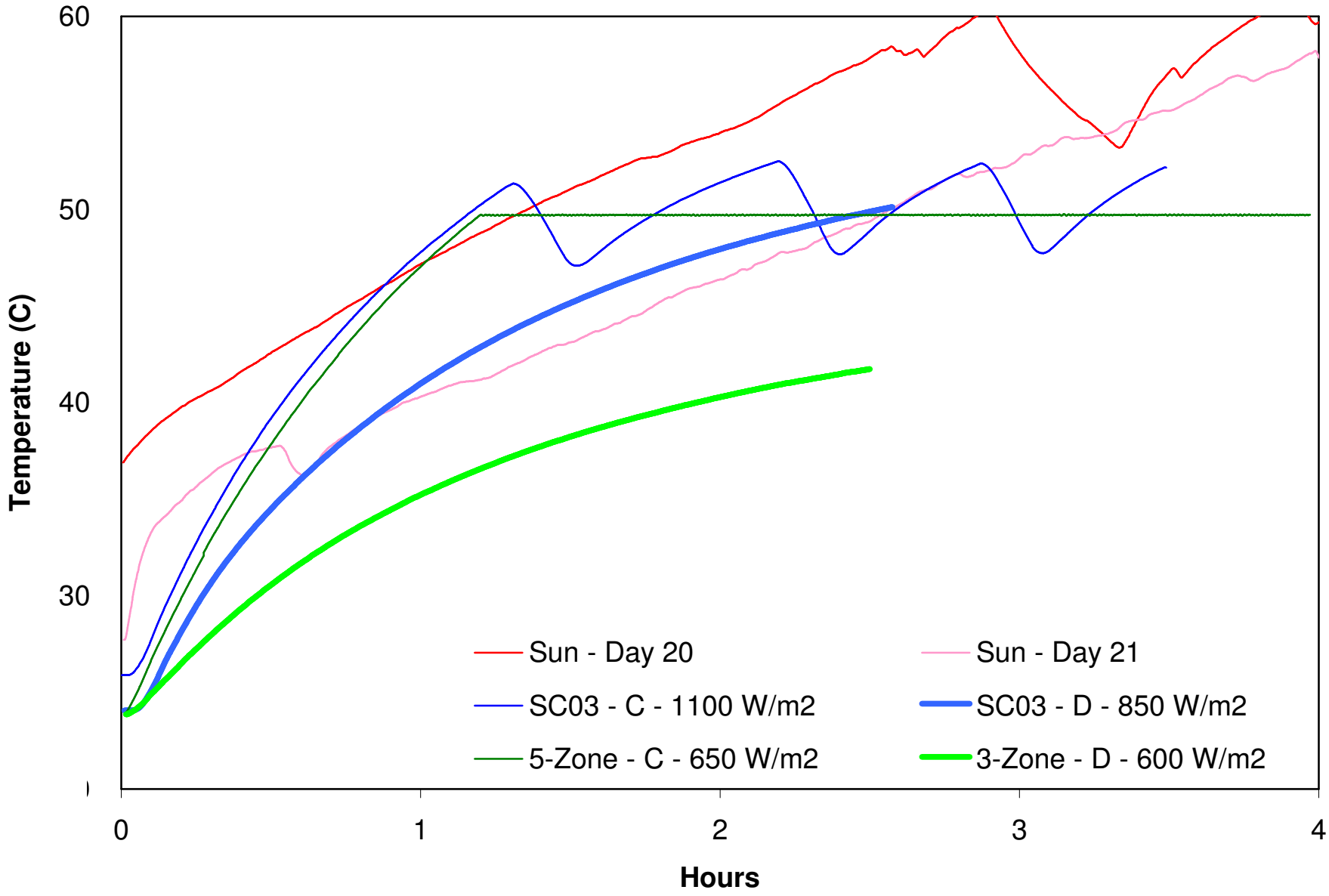


Cell Temperature (°C) from Procedure D using the sun as a solar load test site

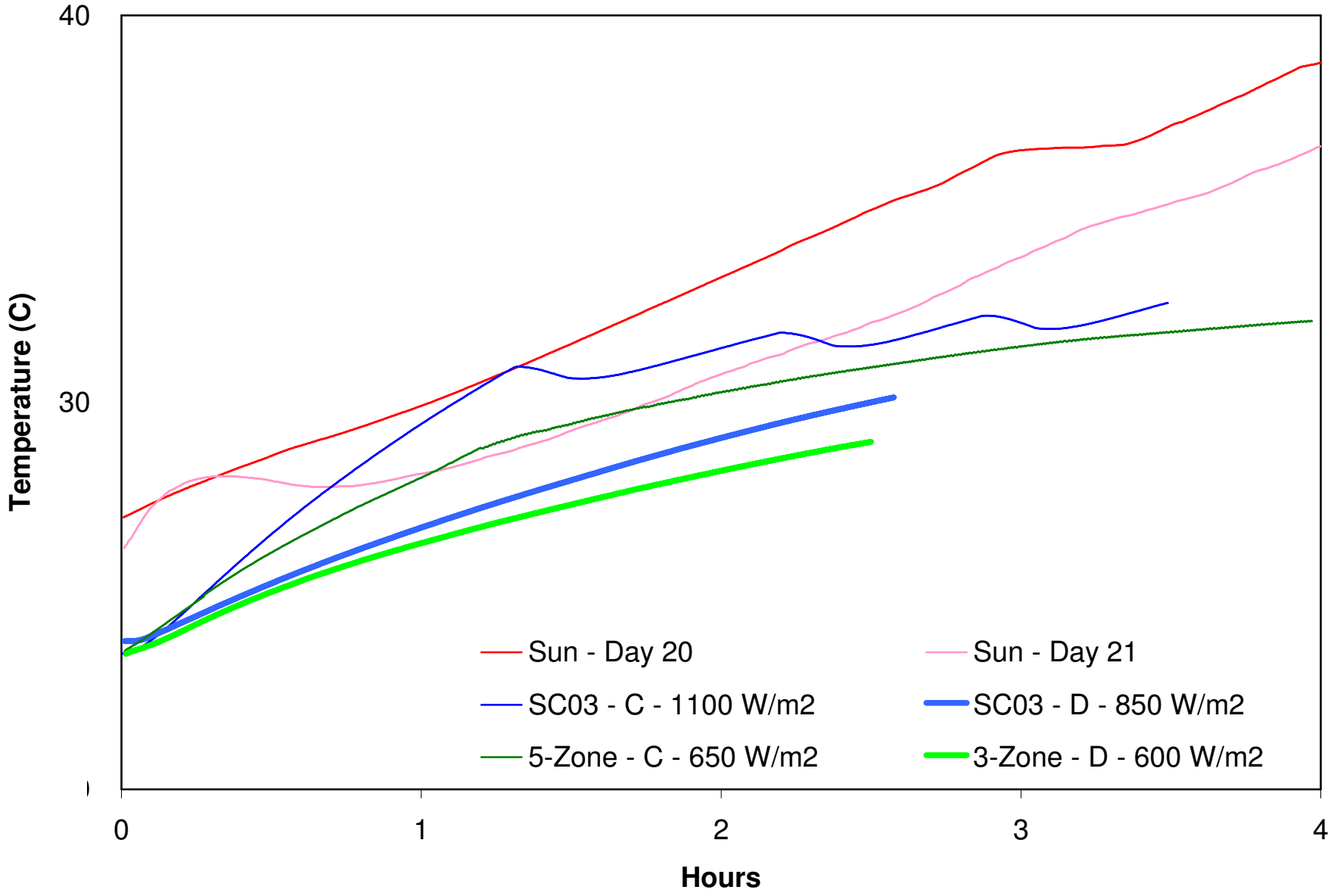
Top (Headliner) - TSD



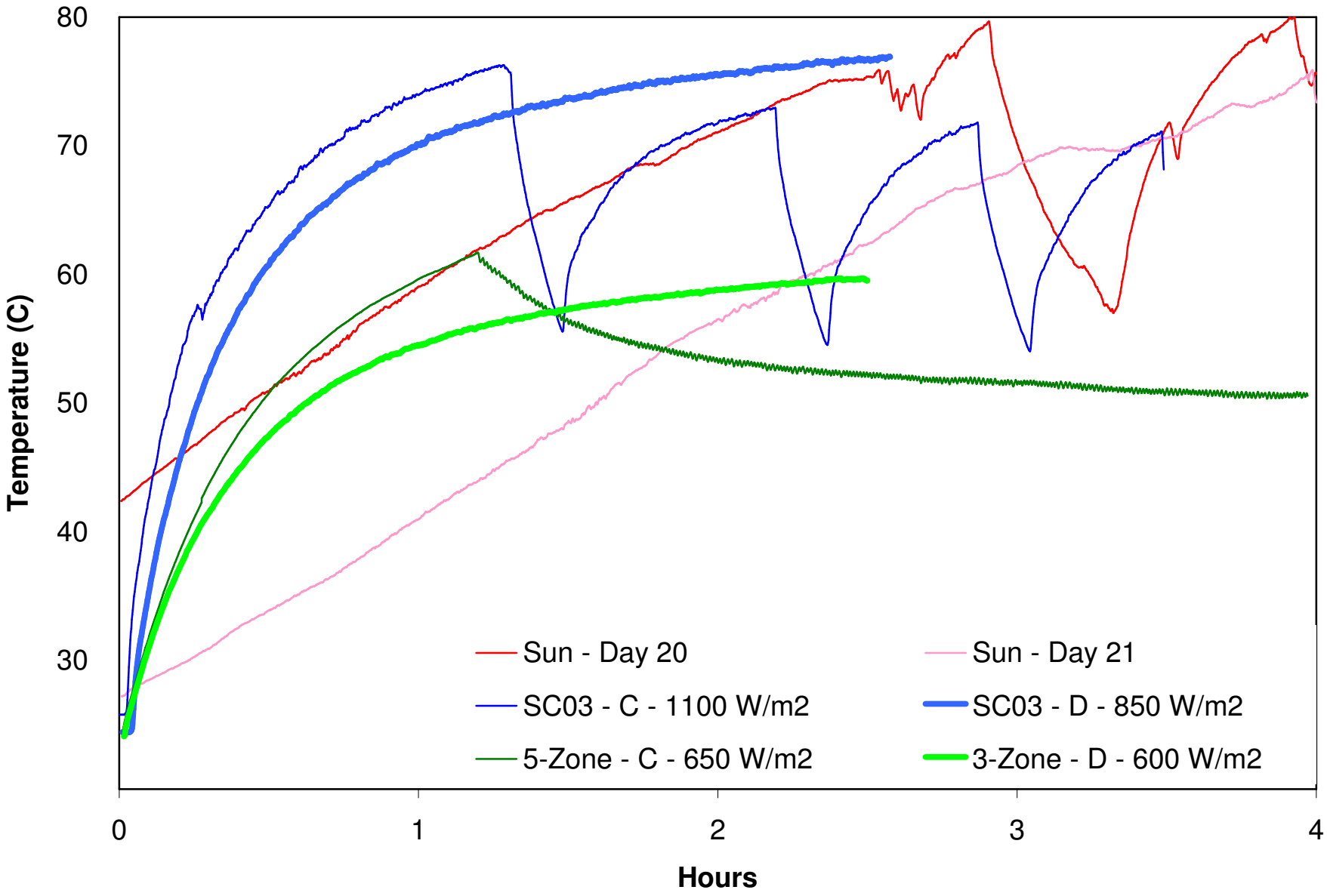
Center (Breath) - TC



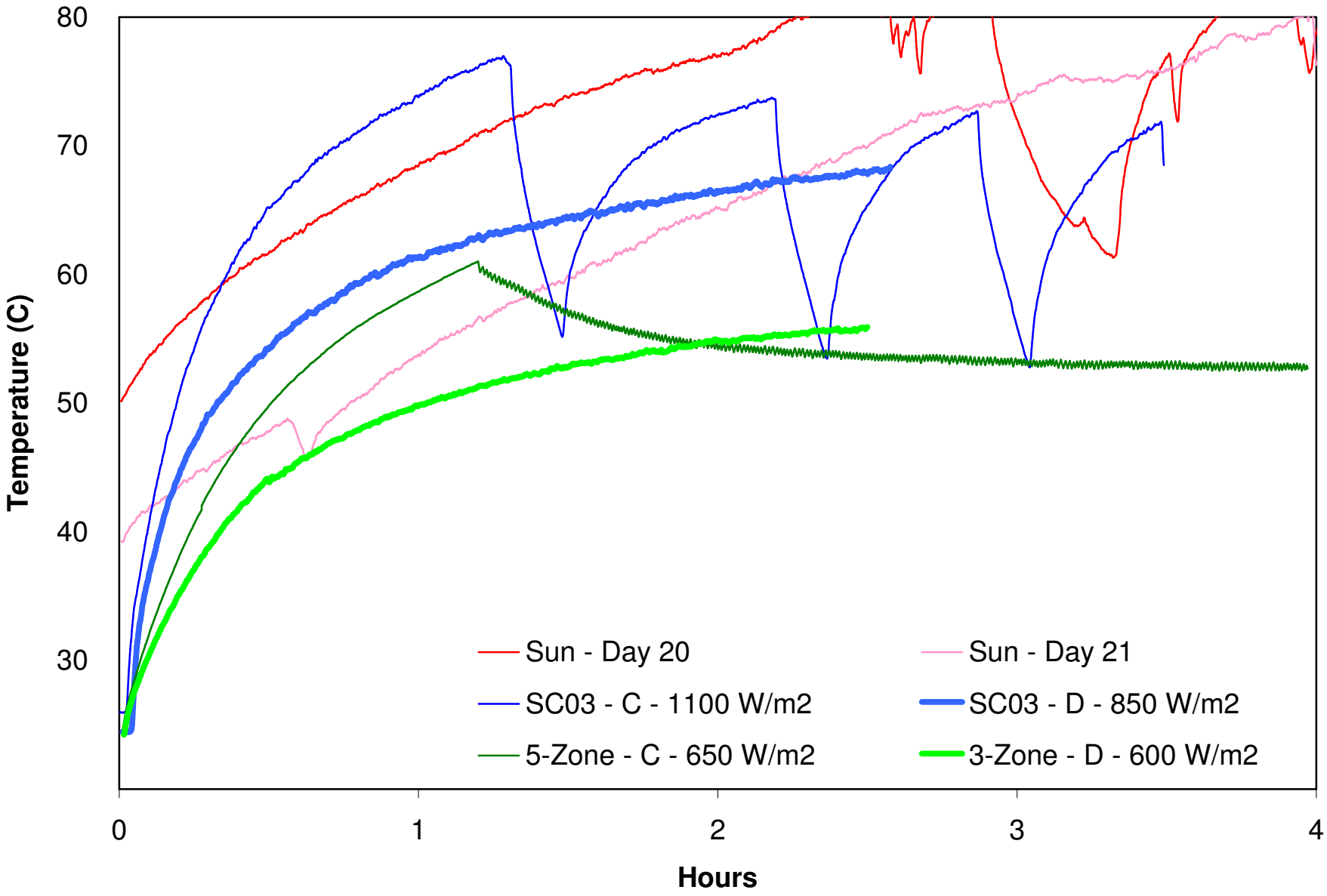
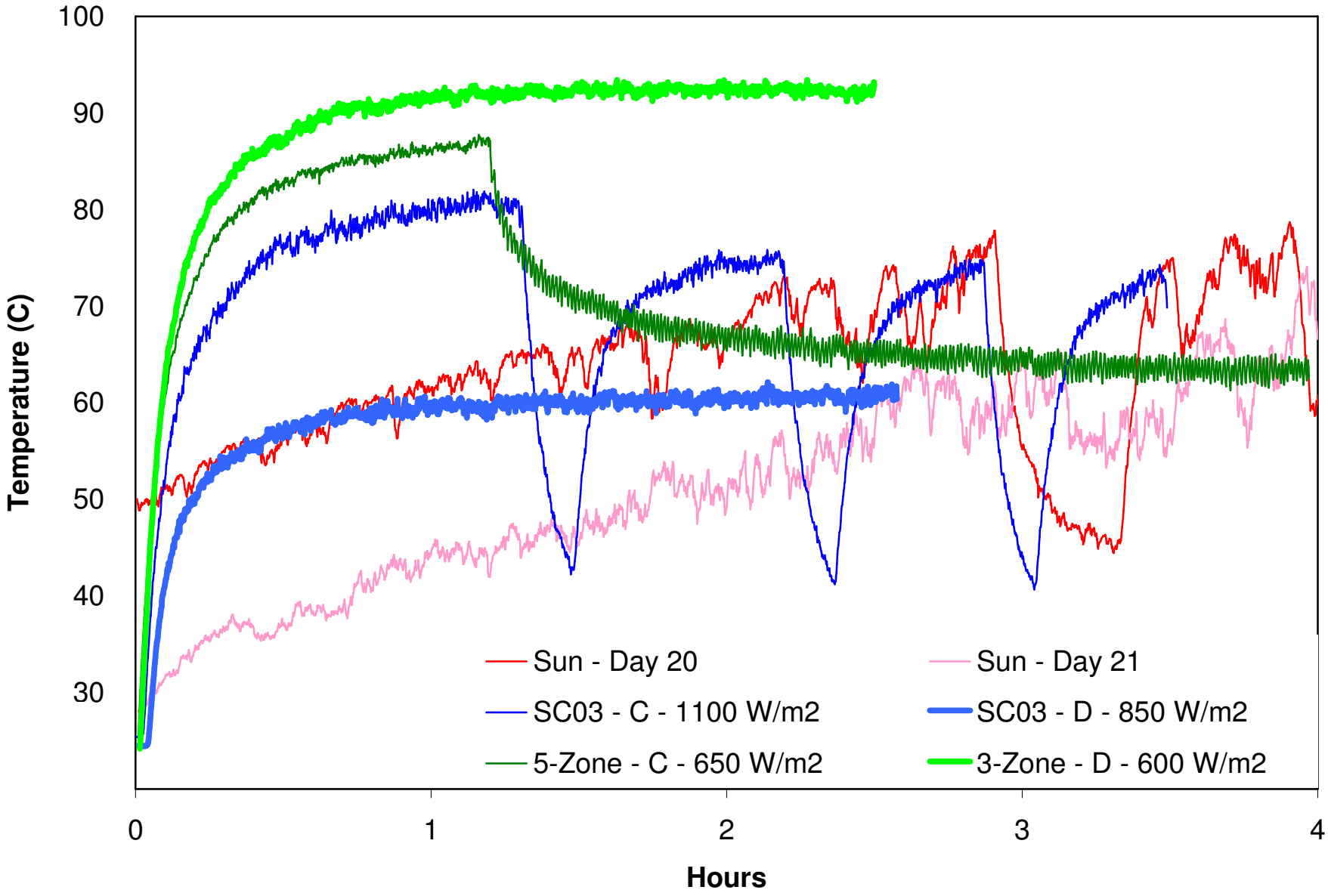
Floor (Carpet)



Rear (Hat rack) - TSH



Front (Dash) - TSI



Roof (Outside)