



# *Consumer Use of A/C Systems*

**Ward Atkinson**  
**Sun Test Engineering**



# *Consumer Vehicle Use*

- Average private vehicle travel trip time  
1995 **20.1 minutes**
- Average private vehicle trip length 1995  
**11.8 miles**
- Average private vehicle trip speed 1995  
**35.4 mph**

# *A/C System Performance*

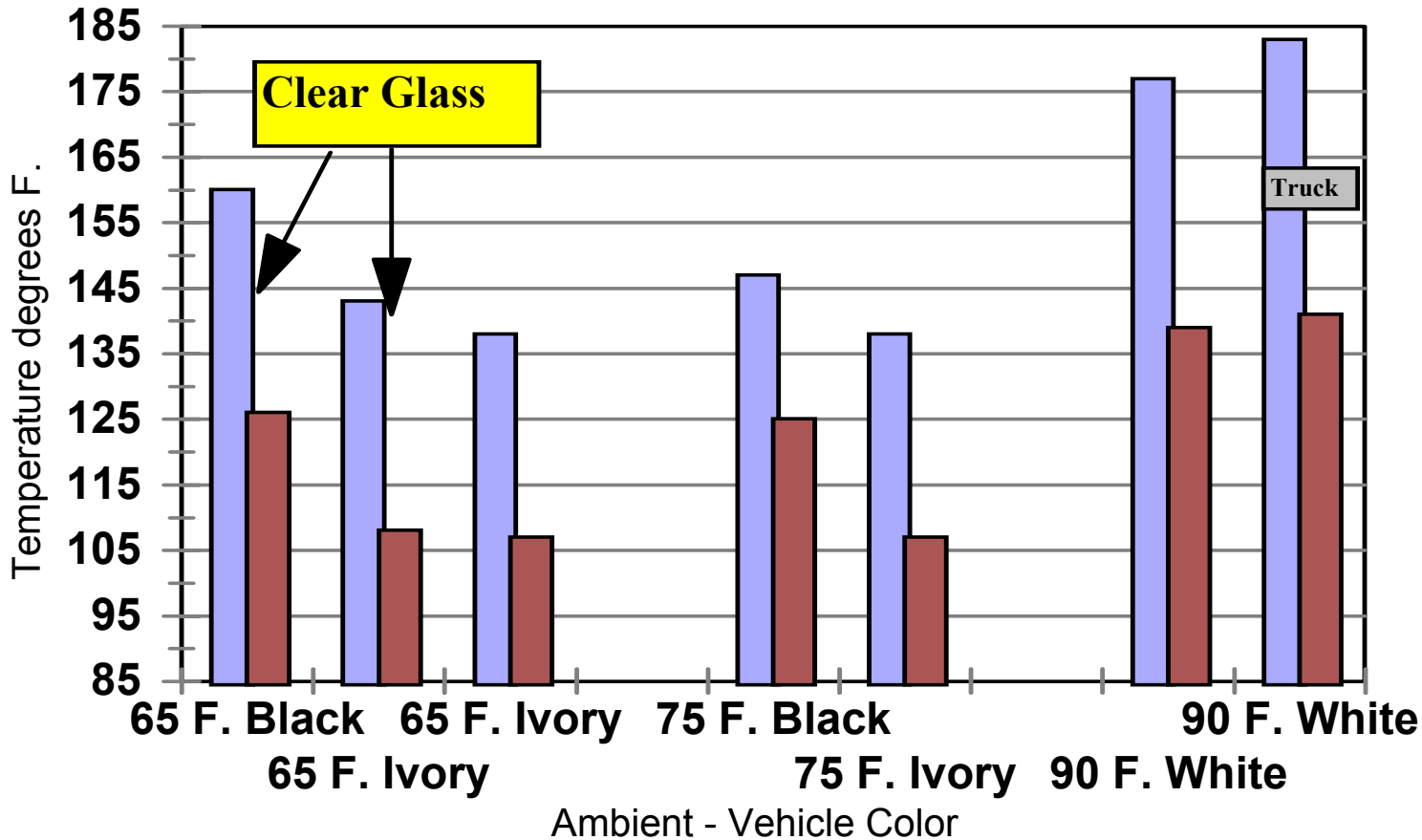


- **Many Factors Determine Comfort**
  - **Vehicle Colors**
  - **Location and Amount of Glass**
  - **Total System Airflow**
  - **Panel Outlets**
  - **Refrigeration Capacity**
  - **Environment**

# Interior Soak Temperatures

- Many Factors Determine Comfort
  - Vehicle Colors
  - Location and Amount of Glass
  - Total System Airflow
  - Panel Outlets
  - Refrigeration Capacity

Soak Condition Different Ambients



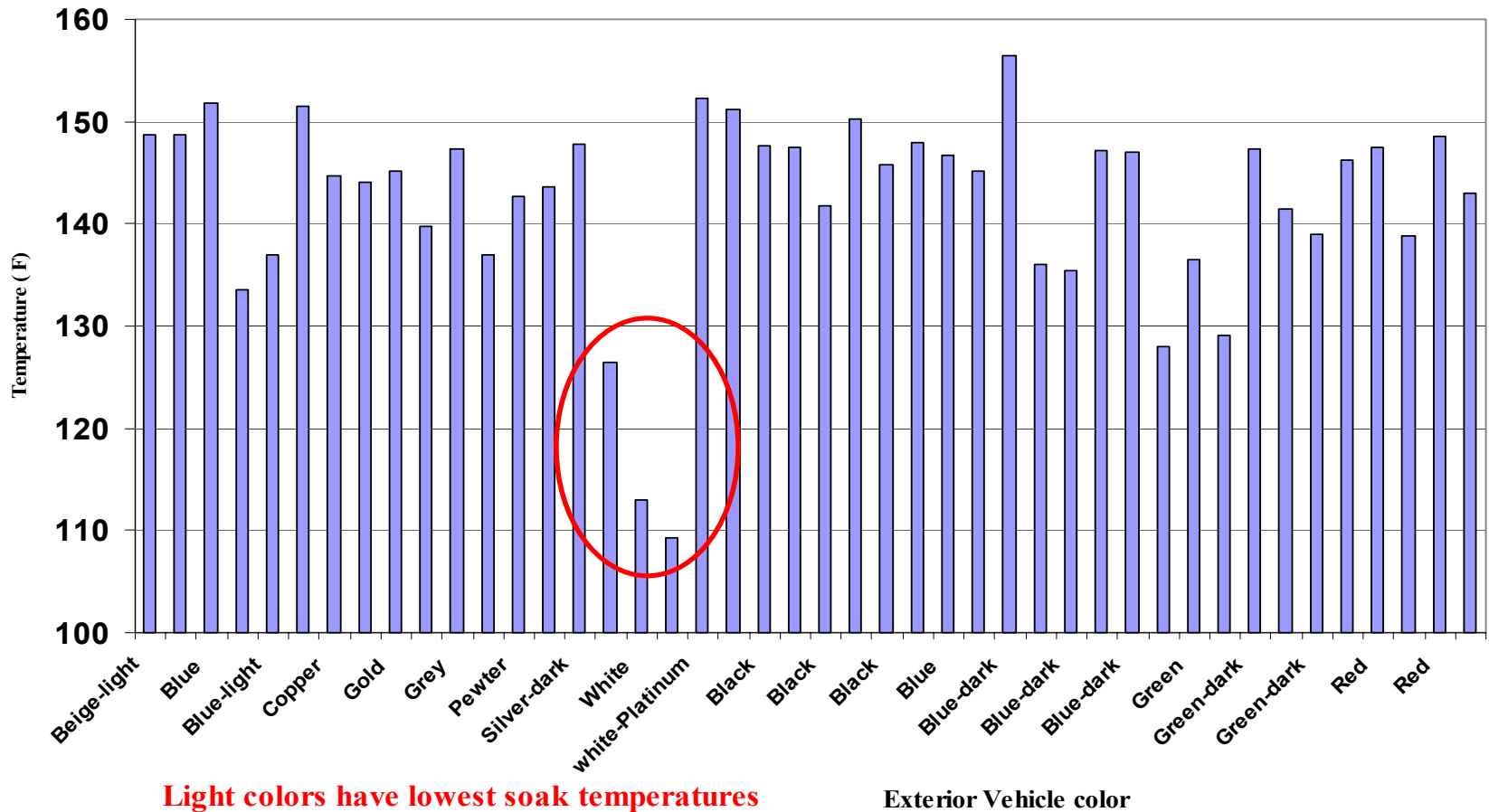
Sun Test 5-99

I.P. Surface
  Breath Level

# Interior Soak Temperatures

- Many Factors Determine Comfort
  - Vehicle Colors
  - Location and Amount of Glass
  - Total System Airflow
  - Panel Outlets
  - Refrigeration Capacity

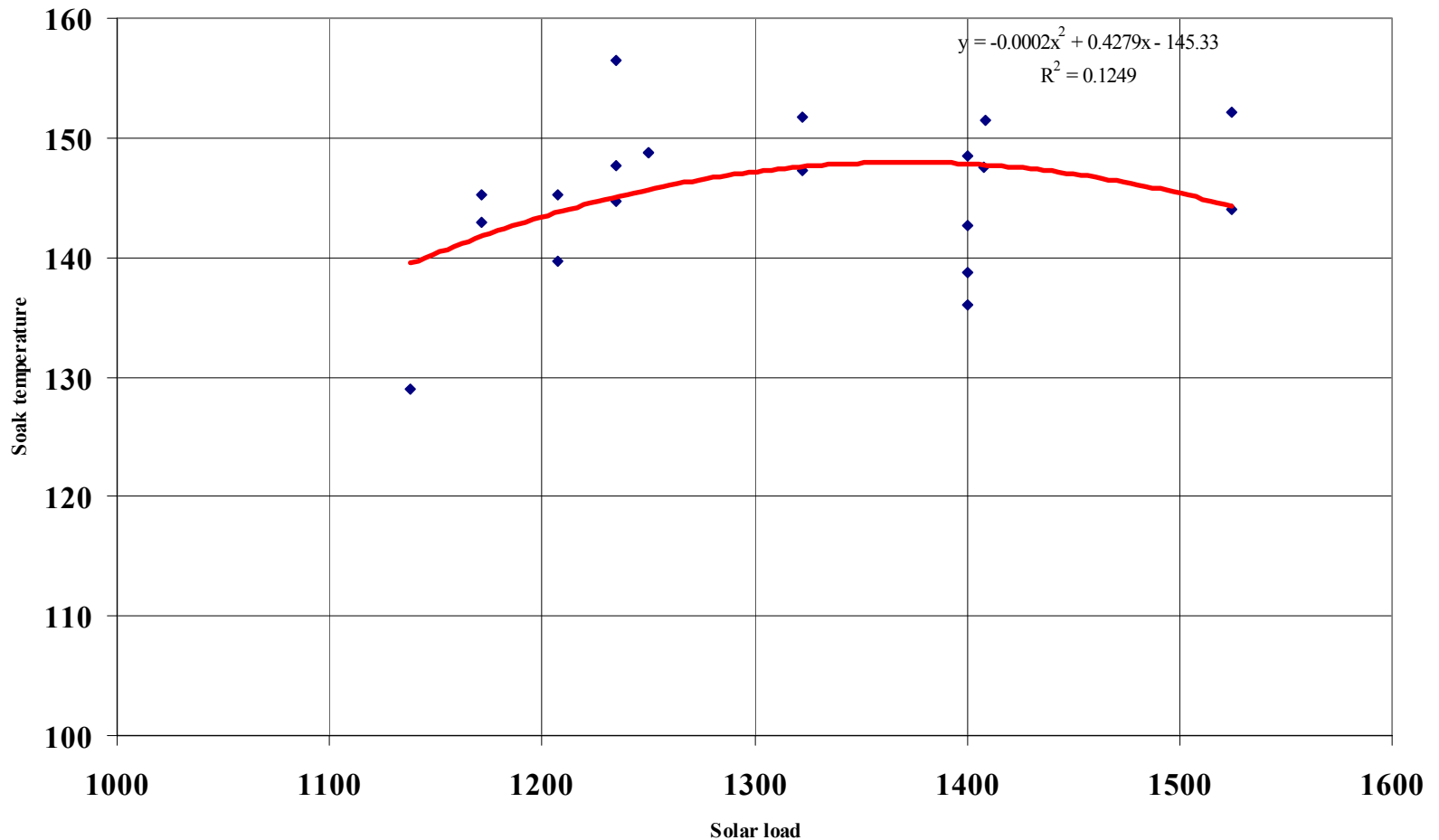
## Soak temp vs Colors



# Summary of Vehicle Soak Breath Level Temperature

- Many Factors Determine Comfort
  - Vehicle Colors
  - **Location and Amount of Glass**
  - Total System Airflow
  - Panel Outlets
  - Refrigeration Capacity

Soak temperature vs solar load



# *Effect of Panel Outlets/Airflow On Occupant Comfort*

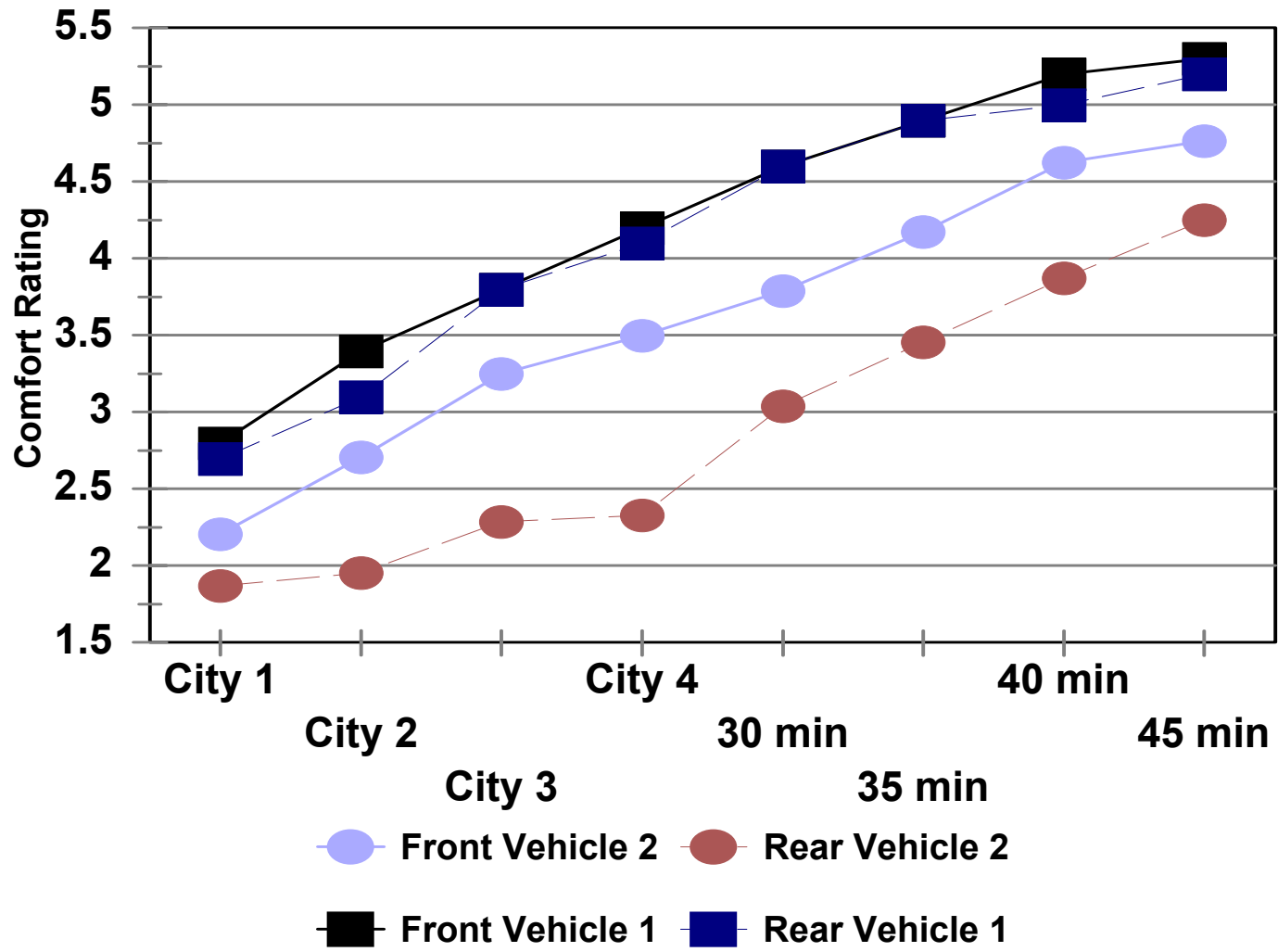
- **Many Factors Determine Comfort**
  - Vehicle Colors
  - Location and Amount of Glass
  - Total System Airflow
  - **Panel Outlets**
  - Refrigeration Capacity

- **Similar Intermediate Vehicles** Ambient 102/112F
  - Breath Level City Traffic 78 F and 79 F
  - Breath Level Road Speed 72 F and 71 F
  
  - Panel Temperature City Traffic 56 F and 50 F
  - Panel Temperature Road Speed 47 F and 48 F

# Passenger Comfort Two Different Intermediate Vehicles

- Many Factors Determine Comfort
  - Vehicle Colors
  - Location and Amount of Glass
  - Total System Airflow
  - **Panel Outlets**
  - Refrigeration Capacity

## Front vs. Rear Seat Comfort

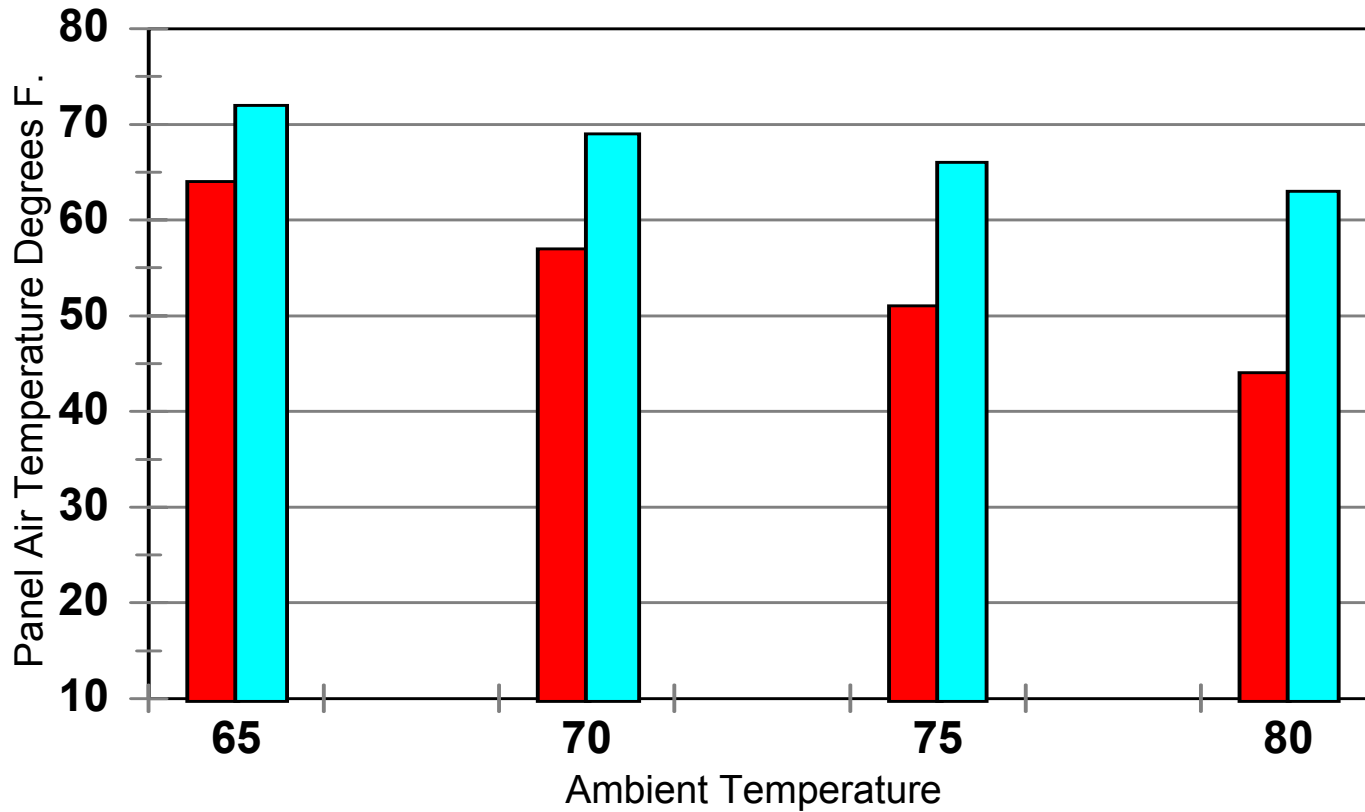


# Cooling is Required Above 65 F Ambient

- **Many Factors Determine Comfort**
  - Vehicle Colors
  - Location and Amount of Glass
  - Total System Airflow
  - Panel Outlets
  - **Refrigeration Capacity**

## Panel Outlet Air Temperature @ 170 CFM

To Maintain 75 Degree F. Breath



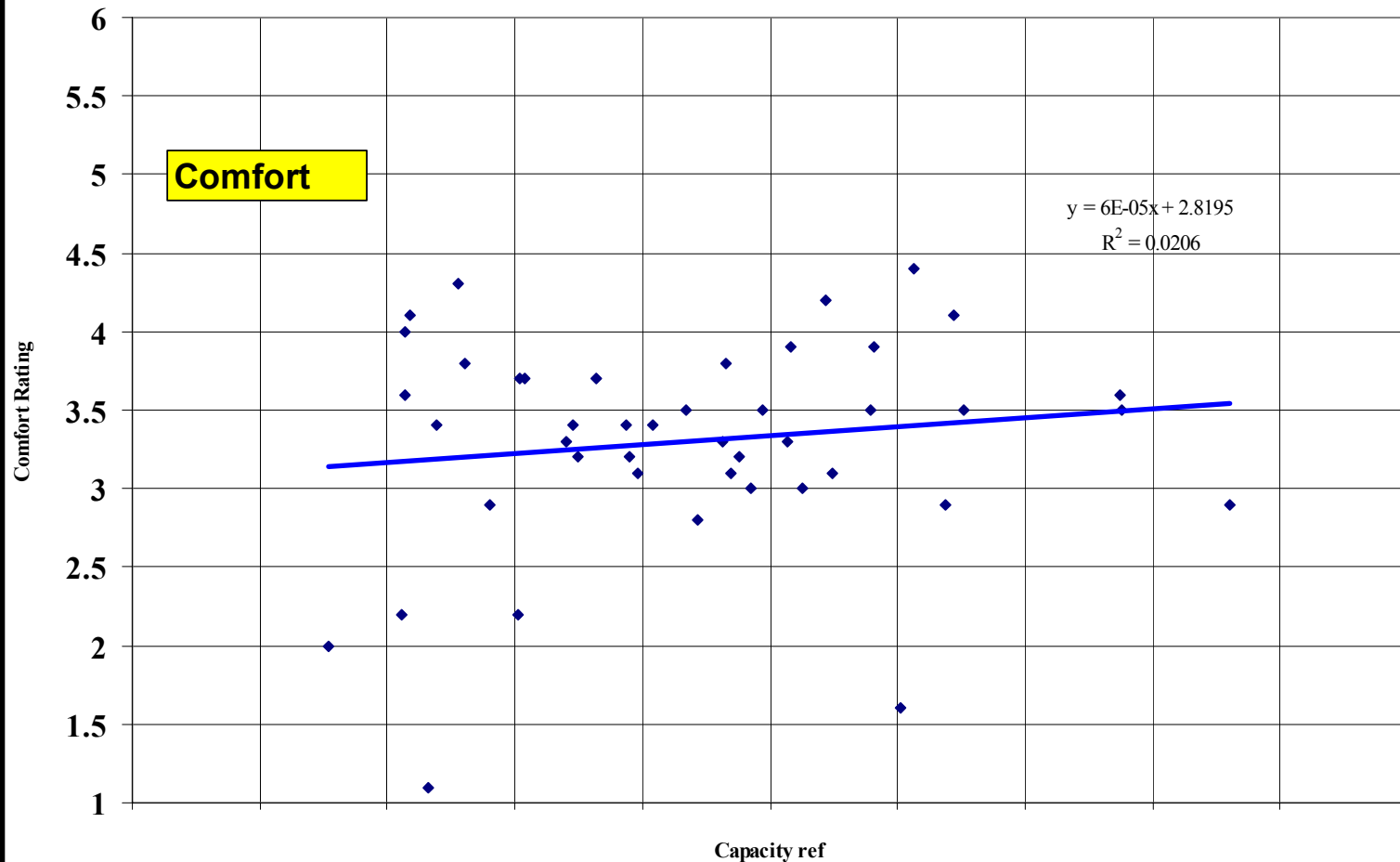
Sun Test 5-99

 **With Sun**  **No Sun**

# City Traffic Comofort

- **Many Factors Determine Comofort**
  - Vehicle Colors
  - Location and Amount of Glass
  - Total System Airflow
  - Panel Outlets
  - **Refrigeration Capacity**

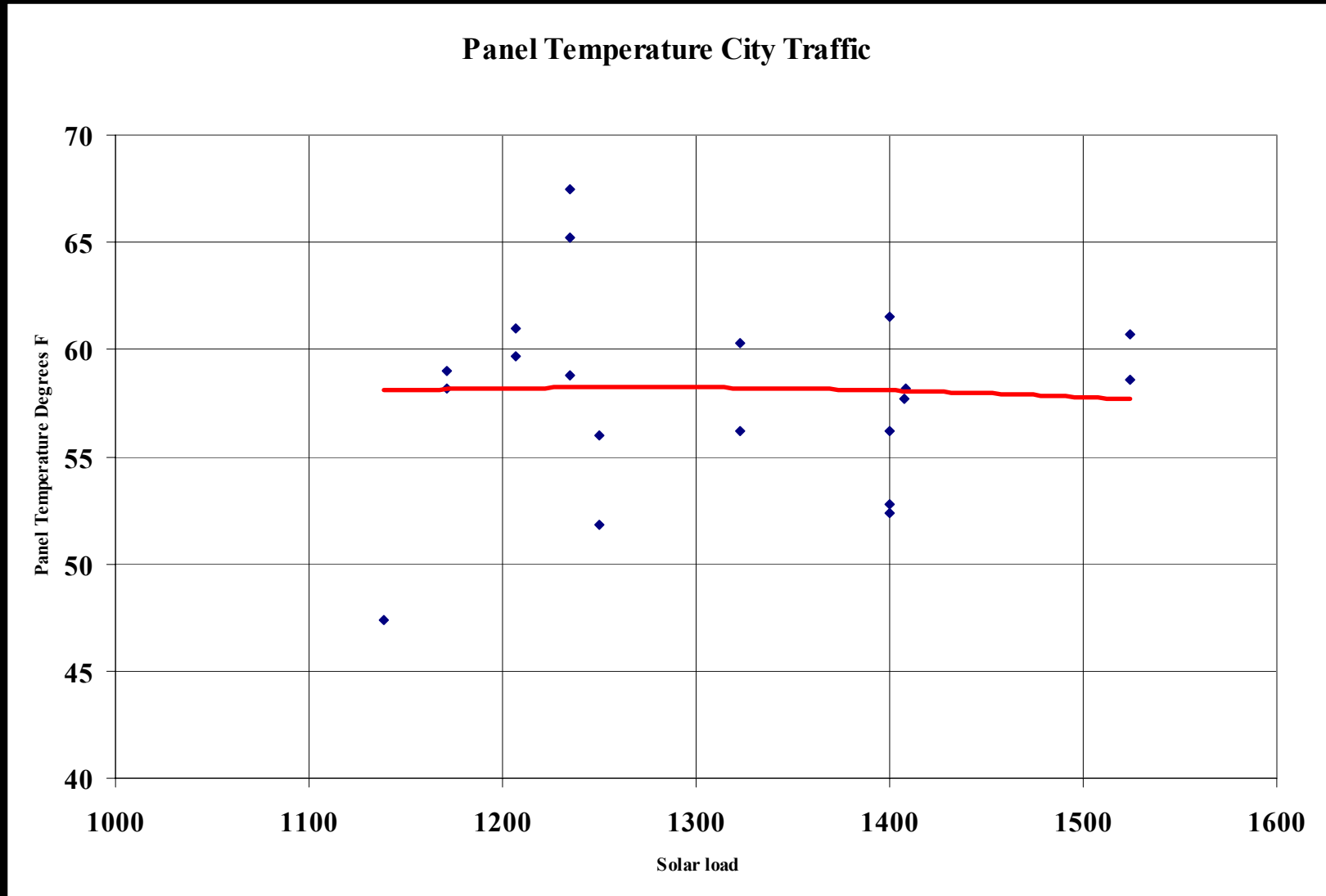
Comofort vs CT capacity reference



# Panel Outlet Temperature

## City Traffic

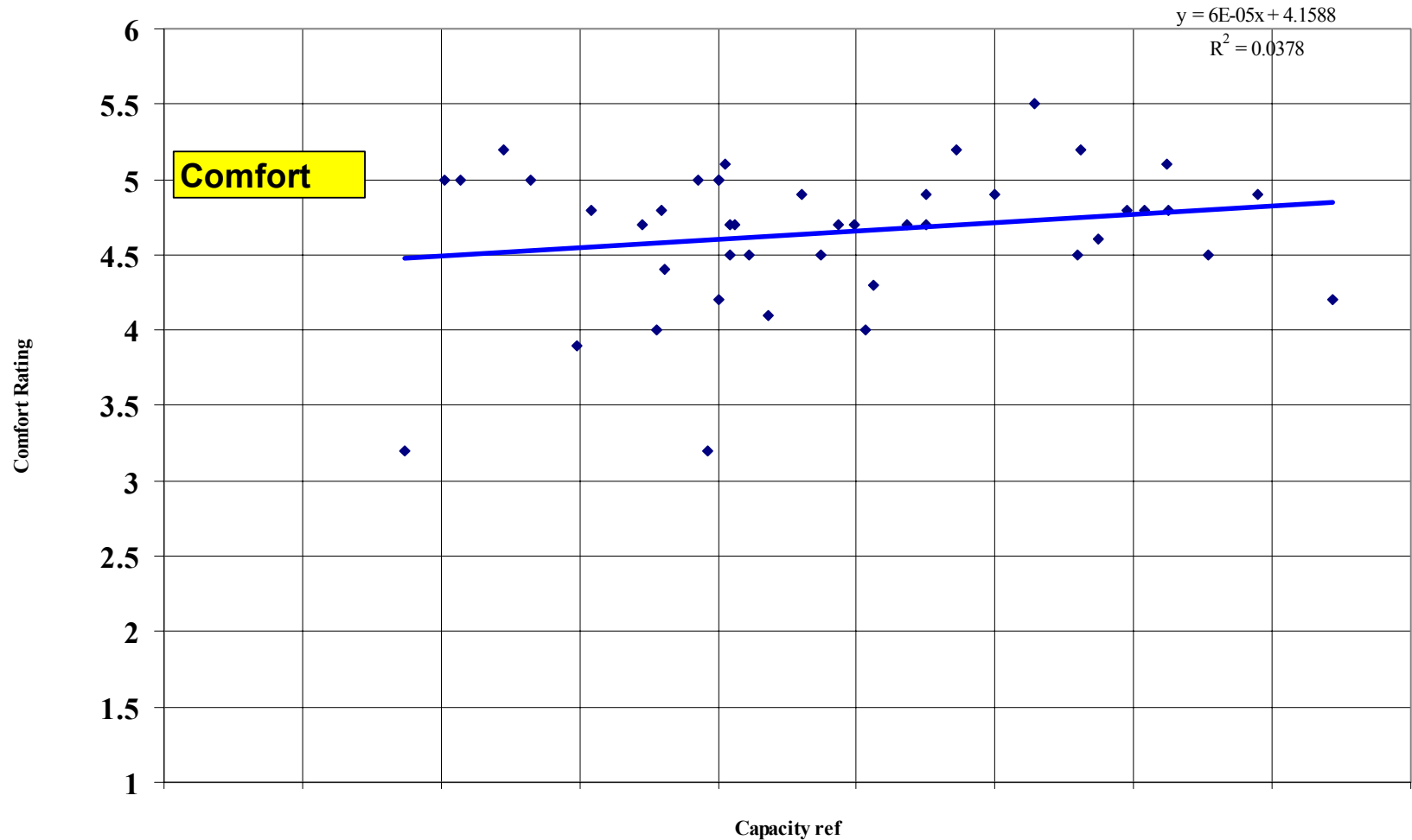
- **Many Factors Determine Comfort**
  - Vehicle Colors
  - **Location and Amount of Glass**
  - Total System Airflow
  - Panel Outlets
  - **Refrigeration Capacity**



# Road Speed Comfort

- Many Factors Determine Comfort
  - Vehicle Colors
  - Location and Amount of Glass
  - Total System Airflow
  - Panel Outlets
  - Refrigeration Capacity

Comfort vs CT capacity reference

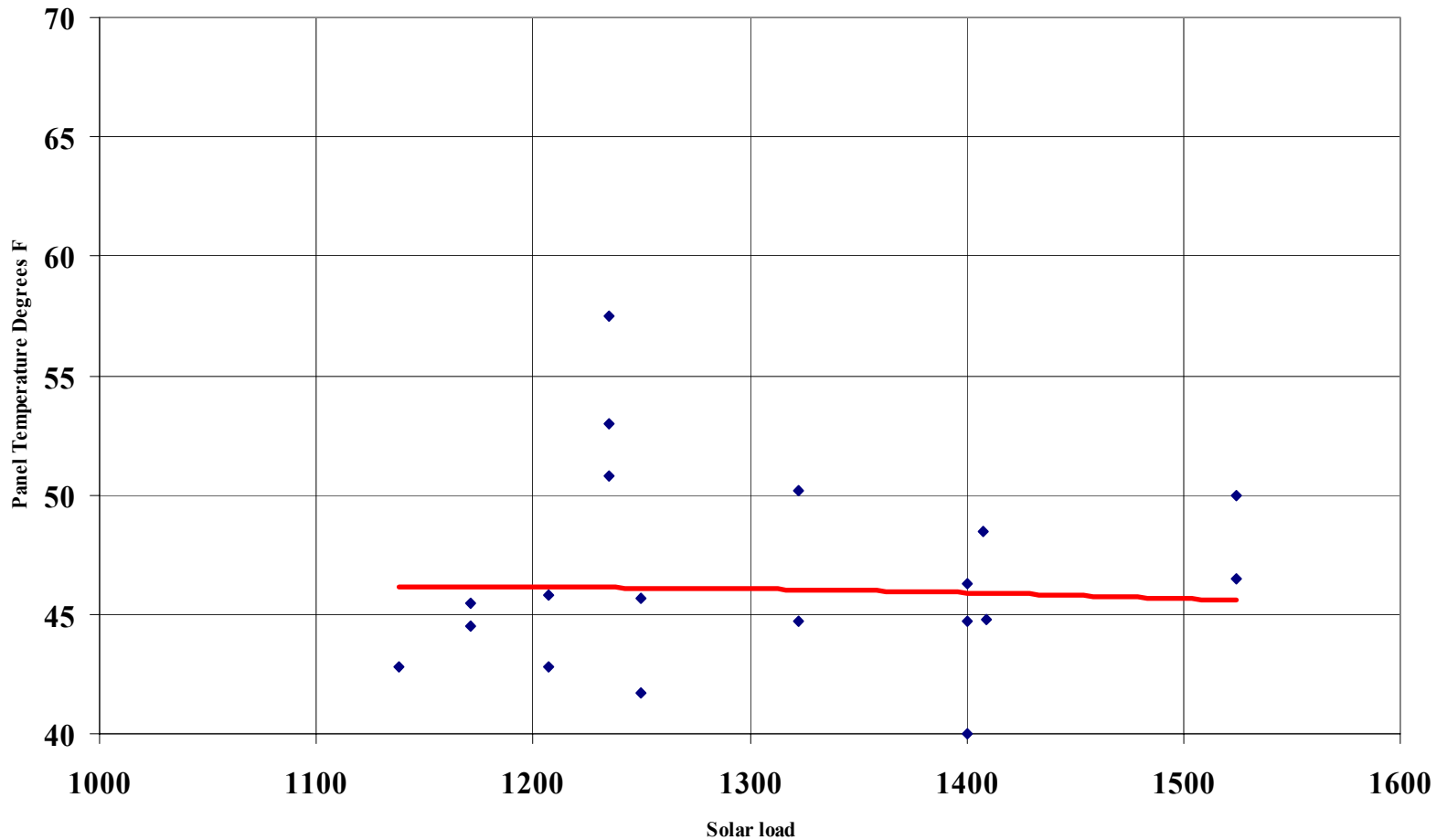


# Panel Outlet Temperature

## Road Speed

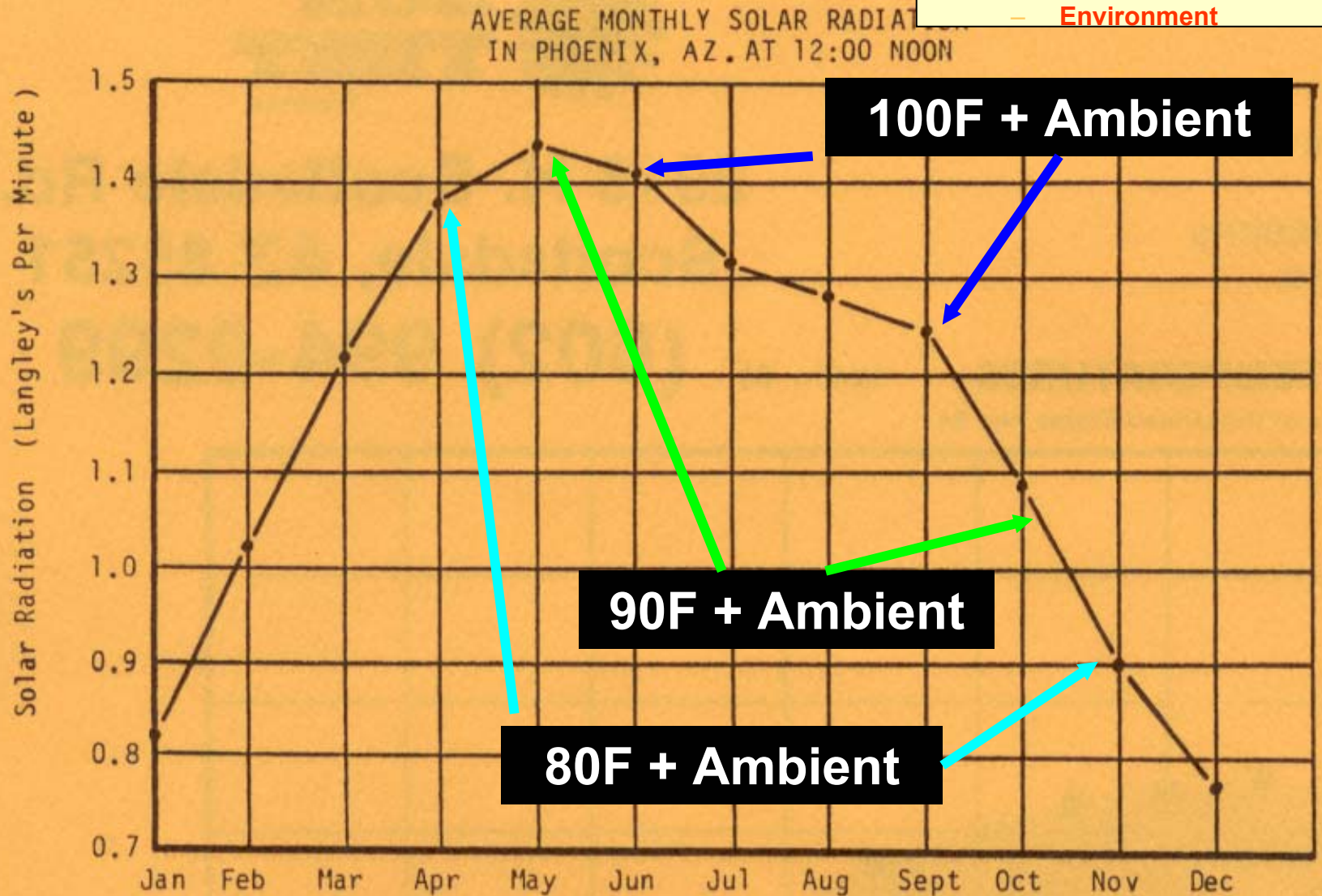
- **Many Factors Determine Comfort**
  - Vehicle Colors
  - Location and Amount of Glass
  - Total System Airflow
  - Panel Outlets
  - **Refrigeration Capacity**

Panel Temperature Road Speed



# Phoenix Solar Radiation

- Many Factors Determine Comfort
  - Vehicle Colors
  - Location and Amount of Glass
  - Total System Airflow
  - Panel Outlets
  - Refrigeration Capacity
  - Environment



# *Vehicle Fuel Consumption*

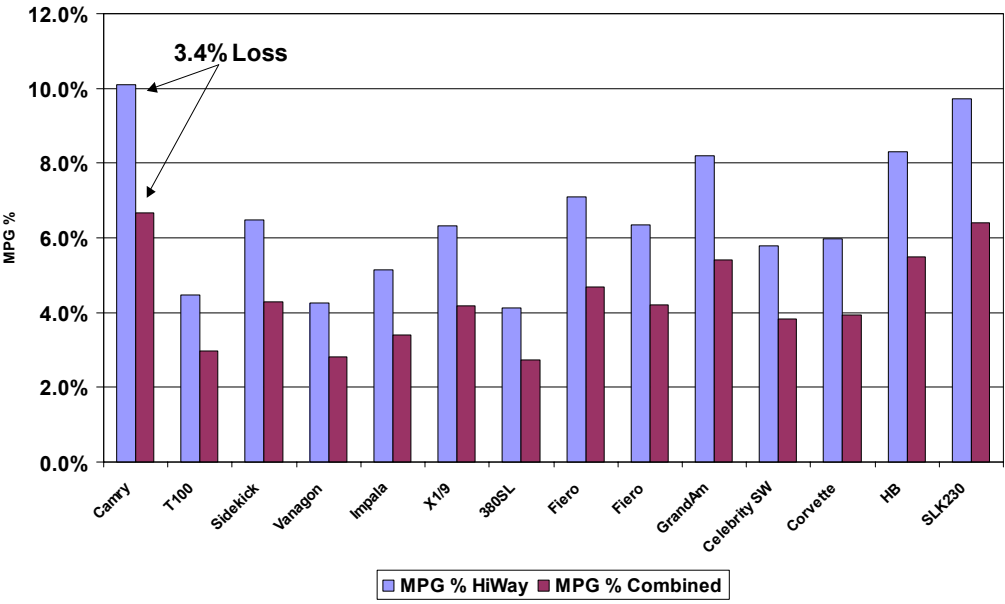


- **Effect of No A/C vs.. Open Windows**
- **Full A/C Capacity vs.. Comfort Requirements**
- **Maximum Energy Soak and Cooldown**
  - **Variation Due To Ambient Temperature**
- **Road Speed Energy Greatly Reduced**

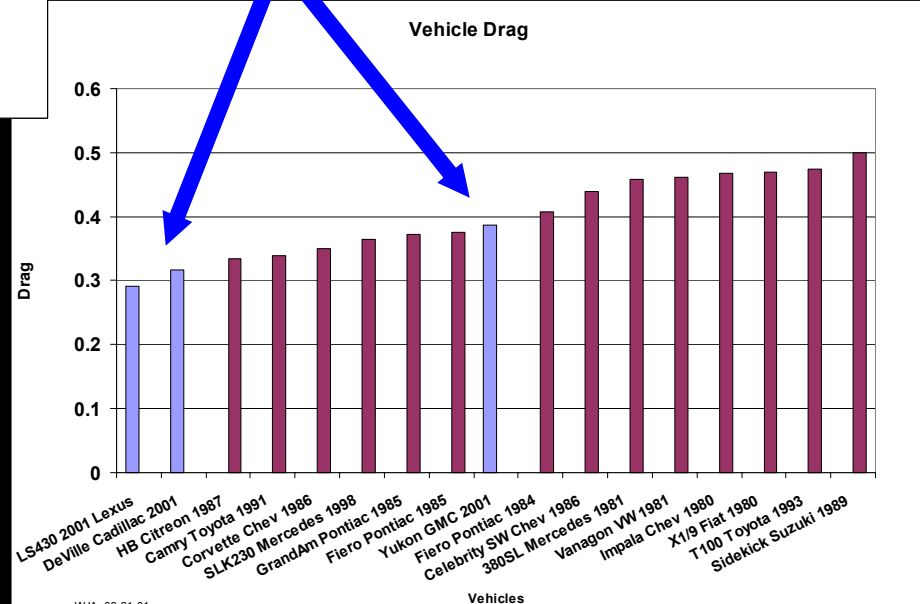
# Vehicle Drag --

- **Effect of No A/C vs.. Open Windows**
- Full A/C Capacity vs.. Comfort Requirements
- Maximum Energy Soak and Cooldown
  - Variation Due To Ambient Temperature
- Road Speed Energy Greatly Reduced

Estimated Fuel Economy Penalty Windows Down Vs CD



## Drag of Three Test Vehicles



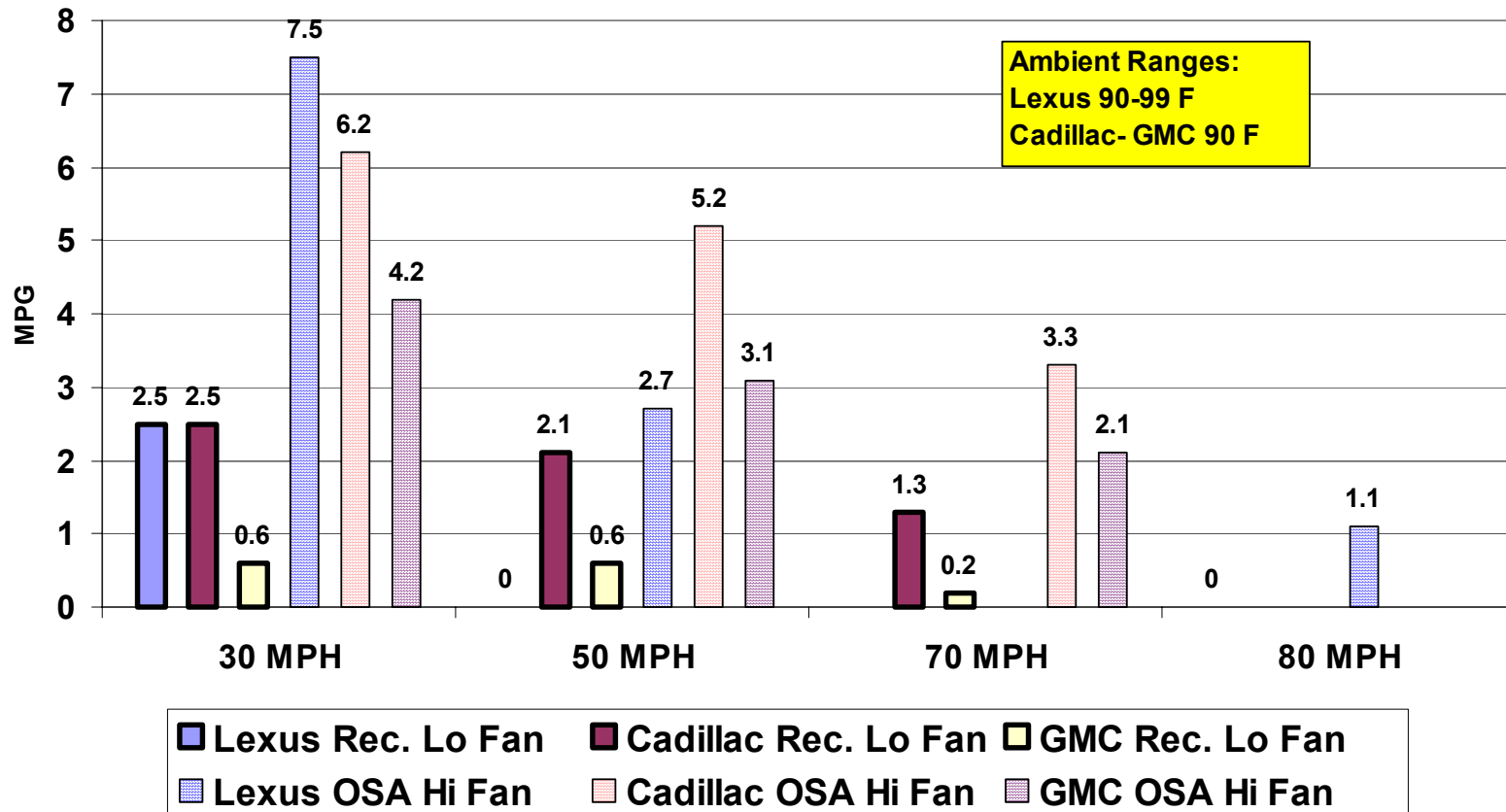
Fuel Penalty Windows Down Vs. Drag

Ranged from 1.3% -3.4%

# Effect of A/C Operation Vs. No A/C Windows Open

- Effect of No A/C vs.. Open Windows
- **Full A/C Capacity vs.. Comfort Requirements**
- Maximum Energy Soak and Cooldown
  - Variation Due To Ambient Temperature
- Road Speed Energy Greatly Reduced

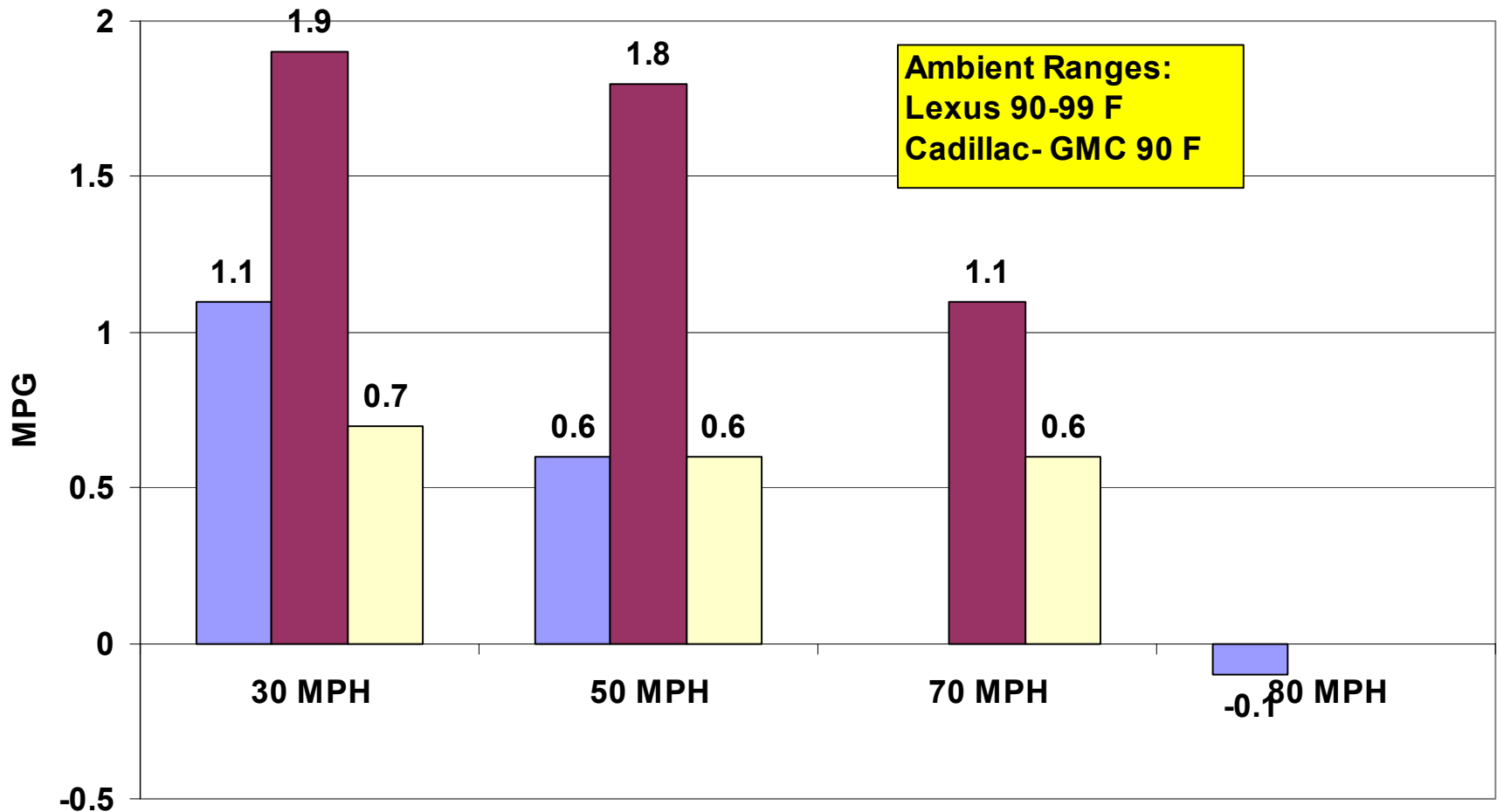
Fuel Consumption A/C Operating Rec. Lo Fan ---  
OSA Hi Fan vs. Windows Down No A/C



# Fuel Consumption

- Effect of No A/C vs.. Open Windows
- Full A/C Capacity vs.. Comfort Requirements
- **Maximum Energy Soak and Cooldown**
  - Variation Due To Ambient Temperature
- Road Speed Energy Greatly Reduced

Difference in Fuel Use OSA vs. REC (High Fan)

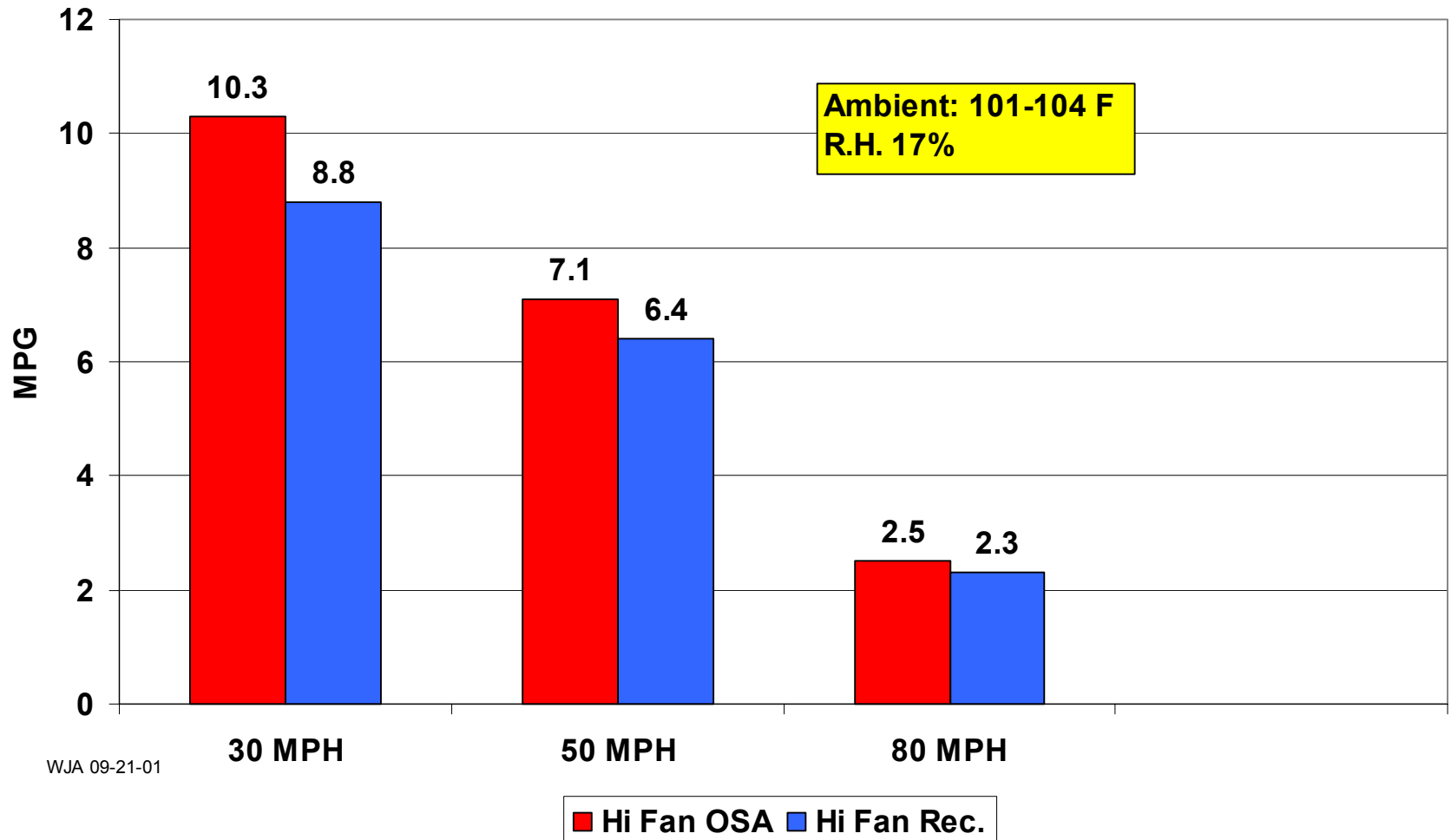


# Fuel Consumption

(Maximum Cooling)

- Effect of No A/C vs.. Open Windows
- Full A/C Capacity vs.. Comfort Requirements
- Maximum Energy Soak and Cooldown
  - Variation Due To Ambient Temperature
- **Road Speed Energy Greatly Reduced**

## Lexus Driver Information Center Fuel Consumption Hi Fan OSA & Rec vs. No A/C Windows Up



# *Simulated A/C Fuel Consumption Testing*

- **Vehicle Fuel Testing  
(Rolls Testing with Simulated Solar)**
  - Not Representative of A/C Energy Use
- **Occupant Comfort Vs. MPG Use**
  - Same A/C System For Different Vehicle Body Types



## *A/C Tunnel Simulation*

- **Does Not Represent “Real World” Results**
- **Does Not Simulate Occupant Comfort**
- **Difficult For Direct Comparison Between Test Facilities**
- **Good For “A” “B” Test Comparison**



# *A/C Tunnel Simulation Vehicle Testing*

- **System Operation**
  - Cold Panel Outlet Temperature
  - Energy -COP
- **System Controls**
  - Compressor
  - Refrigerant Flow Device
- **System Testing**
  - Single Point Vehicle Test
  - Multi Point Test