

US EPA ARCHIVE DOCUMENT

MOBILE6 Workshop October 1, 1997



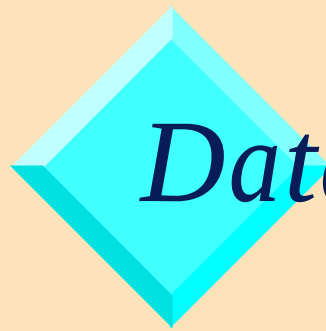
EPA's Proposal for MOBILE6

# *Exhaust Emissions Due to Engine Starts*



# *Definition of Engine Start Emissions*

- ❖ Modeled as grams per start
- ❖ Basic start defined as 12 hour soak
- ❖ Defined as the difference between identical driving cycles with and without an engine start
- ❖ Adjusted for soak times less than 12 hours



# *Data Sources*

- ❖ Federal Test Procedure (FTP)
  - Large Sample of Emission Factor Tests
  - Coverage of Standards, Vehicle Types, Technologies
- ❖ California study on effects of soak time
- ❖ Instrumented Vehicles
  - Starts Per Mile
  - Soak Time Distribution



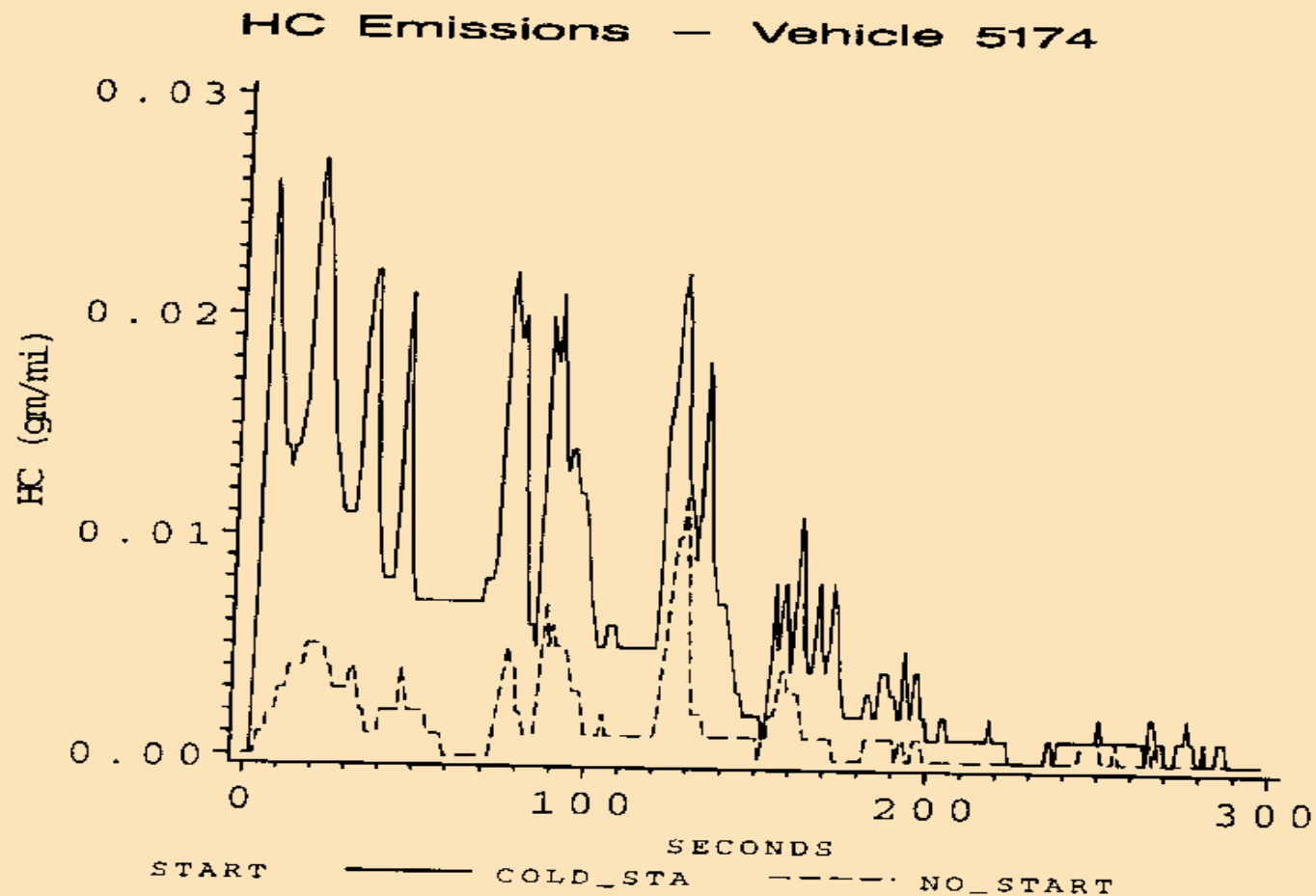
## *Extracting Starts from the FTP*

- ❖ 505 Cycle used for FTP Bag 1 & 3
- ❖ vehicles tested using 505 cycle with no engine start

Basic Start = FTP Bag 1 - Hot Running 505

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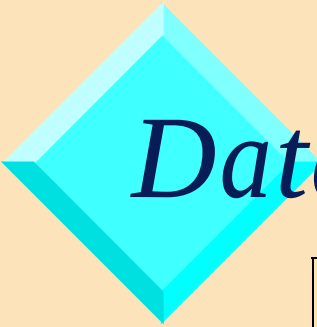
# Example of Data





# *Data Sample Description*

- ❖ 77 vehicles
- ❖ Cars and Light Trucks
- ❖ 1983 through 1996 model years



# Data Sample Description

**Table 2**

**Sample Descriptive Statistics**

|                               | Sample without vehicle #16 |         |        |        | Full Sample (77 cases) |         |        |        |
|-------------------------------|----------------------------|---------|--------|--------|------------------------|---------|--------|--------|
|                               | Mean                       | Std Dev | Min    | Max    | Mean                   | Std Dev | Min    | Max    |
| FTP HC                        | 1.35                       | 2.19    | 0.07   | 11.55  | 1.34                   | 2.18    | 0.07   | 11.55  |
| FTP CO                        | 19.66                      | 39.90   | 0.58   | 203.43 | 19.43                  | 39.68   | 0.58   | 203.43 |
| FTP NOx                       | 1.16                       | 1.17    | 0.08   | 5.58   | 1.15                   | 1.16    | 0.08   | 5.58   |
| Bag 1 HC                      | 1.83                       | 2.03    | 0.29   | 10.78  | 1.82                   | 2.02    | 0.29   | 10.78  |
| Bag 2 HC                      | 1.29                       | 2.51    | 0.01   | 14.37  | 1.27                   | 2.50    | 0.01   | 14.37  |
| Bag 3 HC                      | 1.11                       | 0.22    | 0.01   | 10.77  | 1.10                   | 0.21    | 0.01   | 10.77  |
| Running 505 HC                | 0.91                       | 1.80    | 0.01   | 11.04  | 0.92                   | 1.79    | 0.01   | 11.04  |
| Bag 1 CO                      | 23.57                      | 34.68   | 2.54   | 150.03 | 23.33                  | 34.52   | 2.54   | 150.03 |
| Bag 2 CO                      | 20.02                      | 47.22   | 0.00   | 253.71 | 19.76                  | 46.96   | 0.00   | 253.71 |
| Bag 3 CO                      | 16.02                      | 32.55   | 0.04   | 162.32 | 15.86                  | 32.37   | 0.04   | 162.32 |
| Running 505 CO                | 15.88                      | 37.24   | 0.04   | 224.70 | 16.37                  | 37.24   | 0.04   | 224.70 |
| Bag 1 NOx                     | 1.56                       | 1.23    | 0.22   | 5.76   | 1.55                   | 1.22    | 0.22   | 5.76   |
| Bag 2 NOx                     | 0.92                       | 1.09    | 0.01   | 5.63   | 0.91                   | 1.09    | 0.01   | 5.63   |
| Bag 3 NOx                     | 1.32                       | 1.38    | 0.04   | 5.79   | 1.30                   | 1.37    | 0.04   | 5.79   |
| Running 505 NOx               | 1.19                       | 1.33    | 0.01   | 5.47   | 1.17                   | 1.33    | 0.01   | 5.47   |
| (Bag 1 HC - Running 505 HC)   | 0.92                       | 1.02    | -3.17  | 5.99   | 0.90                   | 1.03    | -3.17  | 5.99   |
| (Bag 1 CO - Running 505 CO)   | 7.70                       | 20.01   | -93.98 | 120.22 | 6.96                   | 20.90   | -93.98 | 120.22 |
| (Bag 1 NOx - Running 505 NOx) | 0.37                       | 0.64    | -3.62  | 1.88   | 0.37                   | 0.63    | -3.62  | 1.88   |





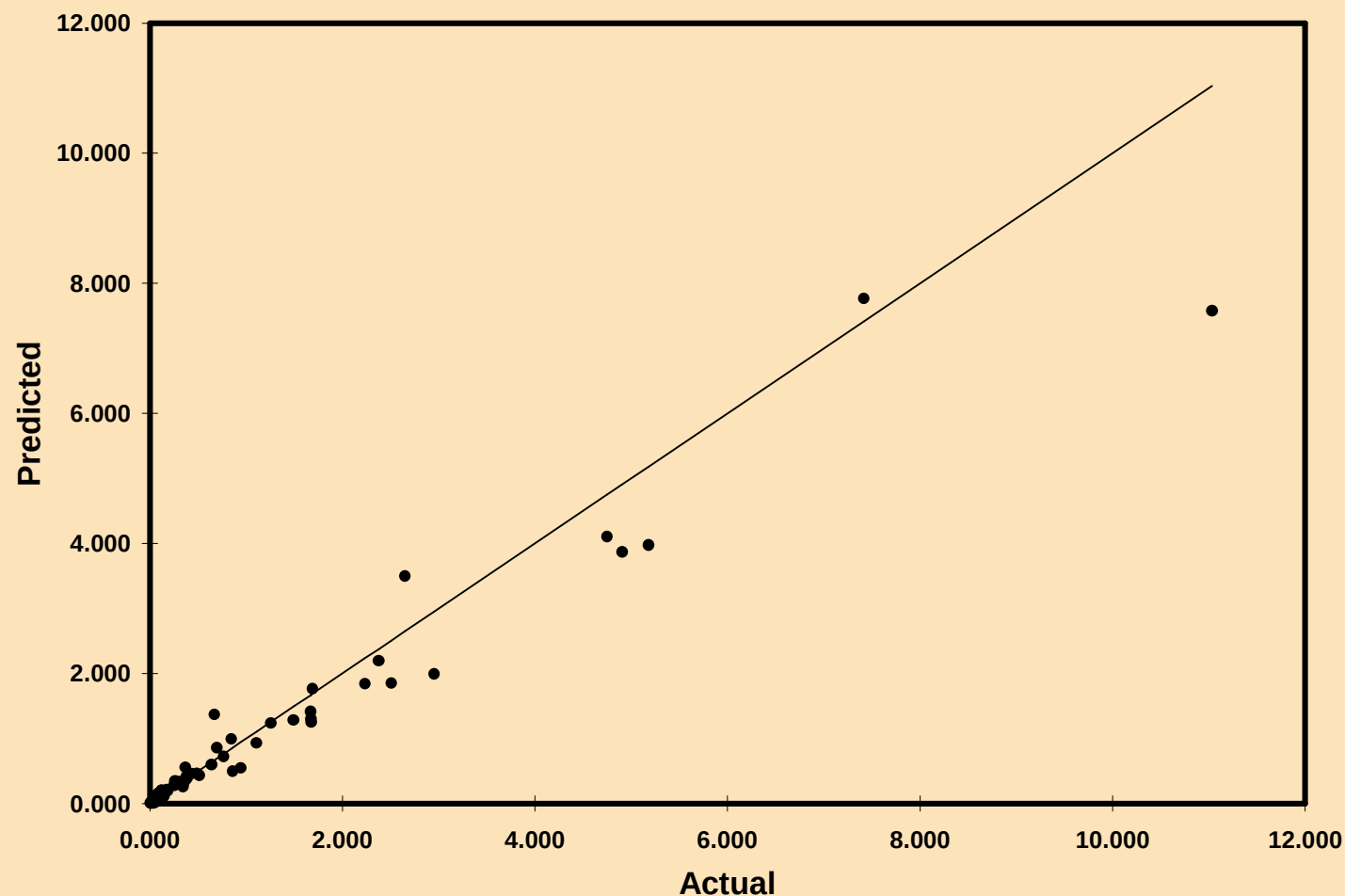
# *Calculation of Hot Running 505*

- ❖ Bag 1, 2 & 3 from the FTP
- ❖ Constant “D” includes adjustment to reduce Log translation bias

$$\text{HR505} = \text{Exp}(A * \text{LN}(\text{Bag1}) + B * \text{LN}(\text{Bag2}) + C * \text{LN}(\text{Bag3}) + D)$$

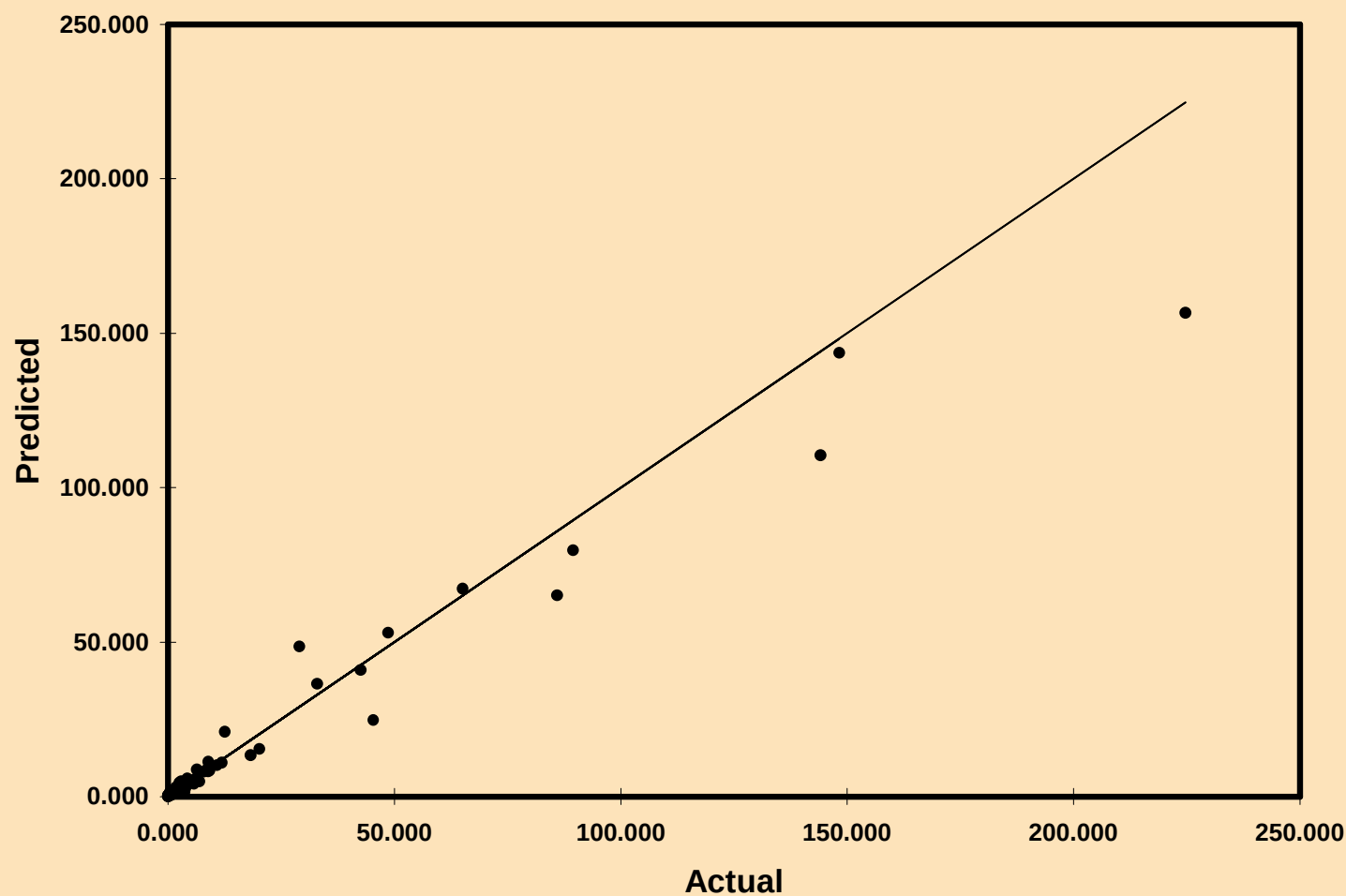
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# *Calculated vs Actual Hot Running 505 HC Emissions*



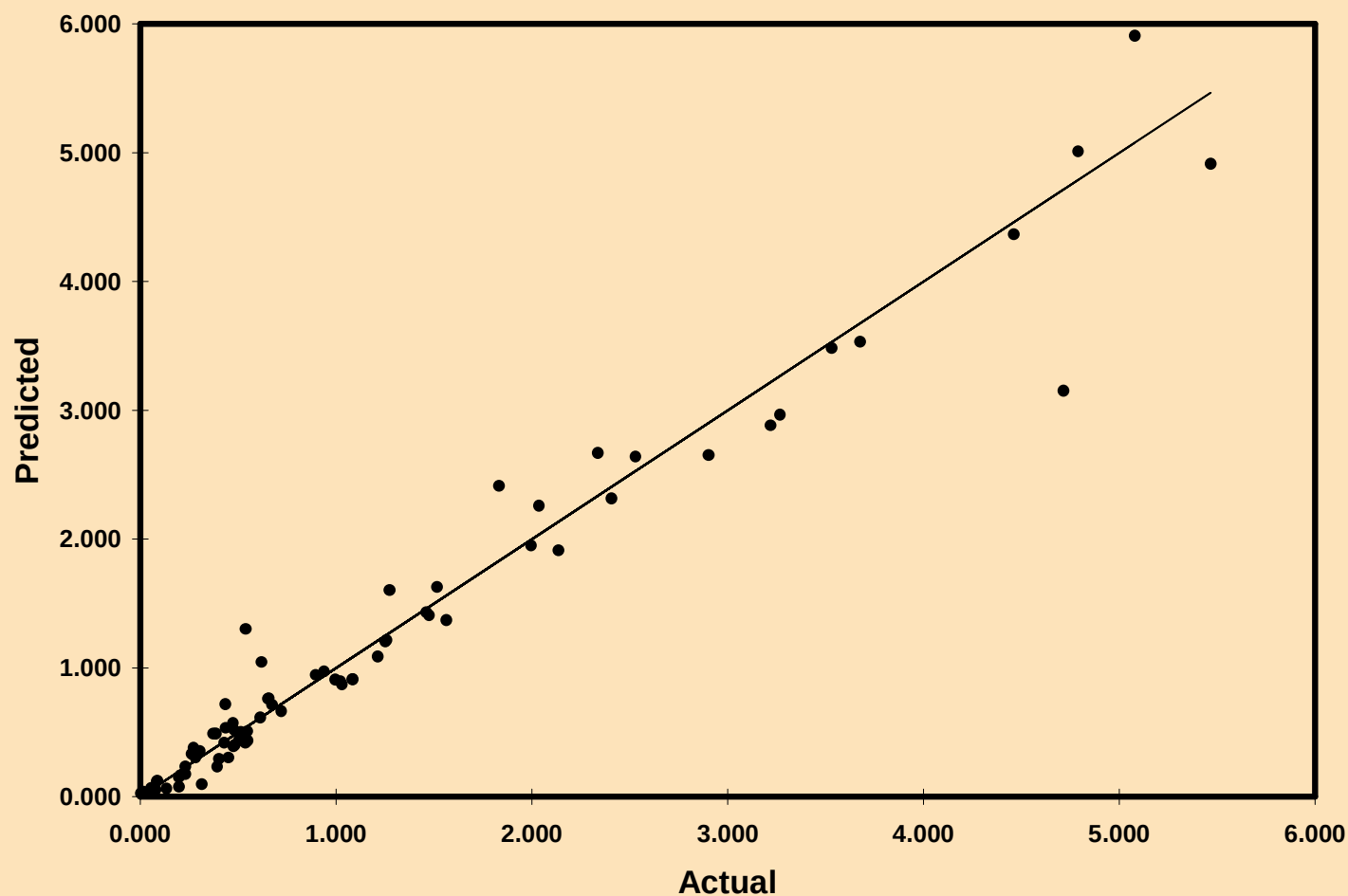
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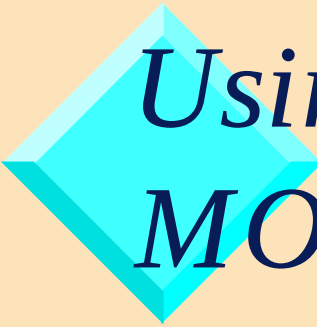
# *Calculated vs Actual Hot Running 505 CO Emissions*



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# *Calculated vs Actual Hot Running 505 NO<sub>x</sub> Emissions*





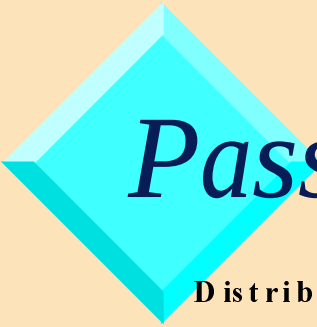
# *Using Hot Running 505 in MOBILE6*

- ❖ Calculate basic (12 hour soak) start emission rate
- ❖ Calculate basic running (non-start) emission rate

$$\text{Basic Start} = (\text{FTP Bag 1} - \text{Hot Running 505}) * 3.59 \text{ miles}$$

$$\text{Basic Running} = \text{Hot Running 505} * 0.479 + \text{FTP Bag 2} * 0.521$$

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# Passenger Car Data Sample

**Distribution of Vehicles by Model Year and Technology\***

| <b>M Y R</b> | <b>C a r s<br/>O P L P</b> | <b>C a r s<br/>C L<br/>C A R B</b> | <b>C a r s<br/>T B I</b> | <b>C a r s<br/>P F I</b> | <b>C a r s<br/>A L L</b> |
|--------------|----------------------------|------------------------------------|--------------------------|--------------------------|--------------------------|
| 81           | 367                        | 657                                | 15                       | 29                       | 1068                     |
| 82           | 71                         | 71                                 | 74                       | 8                        | 224                      |
| 83           | 63                         | 57                                 | 127                      | 62                       | 309                      |
| 84           | 5                          | 30                                 | 46                       | 35                       | 116                      |
| 85           | 24                         | 74                                 | 56                       | 66                       | 220                      |
| 86           | 7                          | 34                                 | 60                       | 92                       | 193                      |
| 87           | 1                          | 17                                 | 76                       | 106                      | 200                      |
| 88           |                            | 15                                 | 69                       | 113                      | 197                      |
| 89           |                            | 22                                 | 38                       | 103                      | 163                      |
| 90           |                            |                                    | 160                      | 250                      | 410                      |
| 91           |                            |                                    | 91                       | 426                      | 517                      |
| 92           |                            |                                    | 57                       | 347                      | 404                      |
| 93           |                            |                                    | 29                       | 366                      | 395                      |
| A L L        | 538                        | 977                                | 898                      | 2003                     | 4416                     |

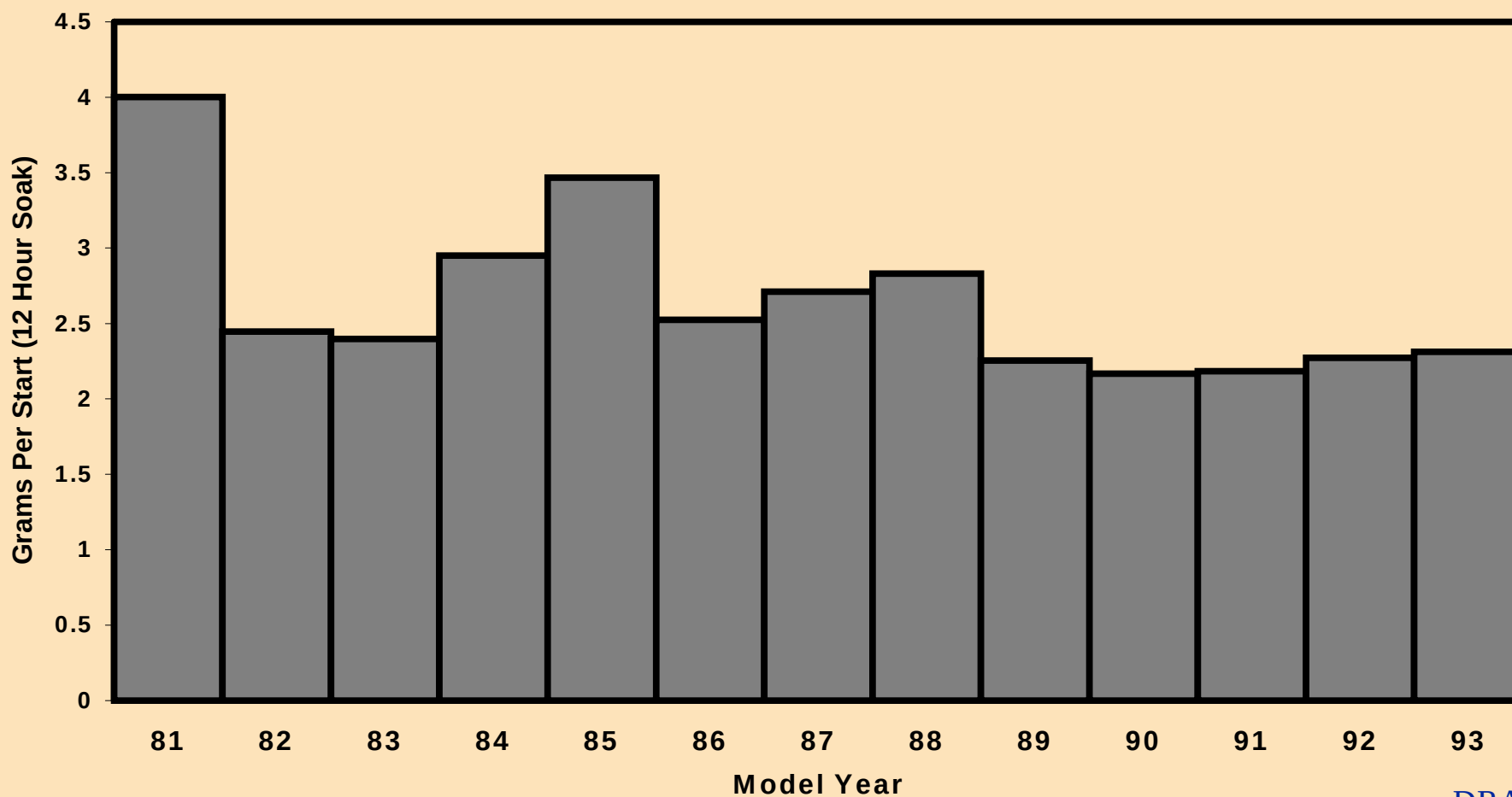
\* No entry indicates no data available for that model year/technology type in the FTP dataset used for this analysis.

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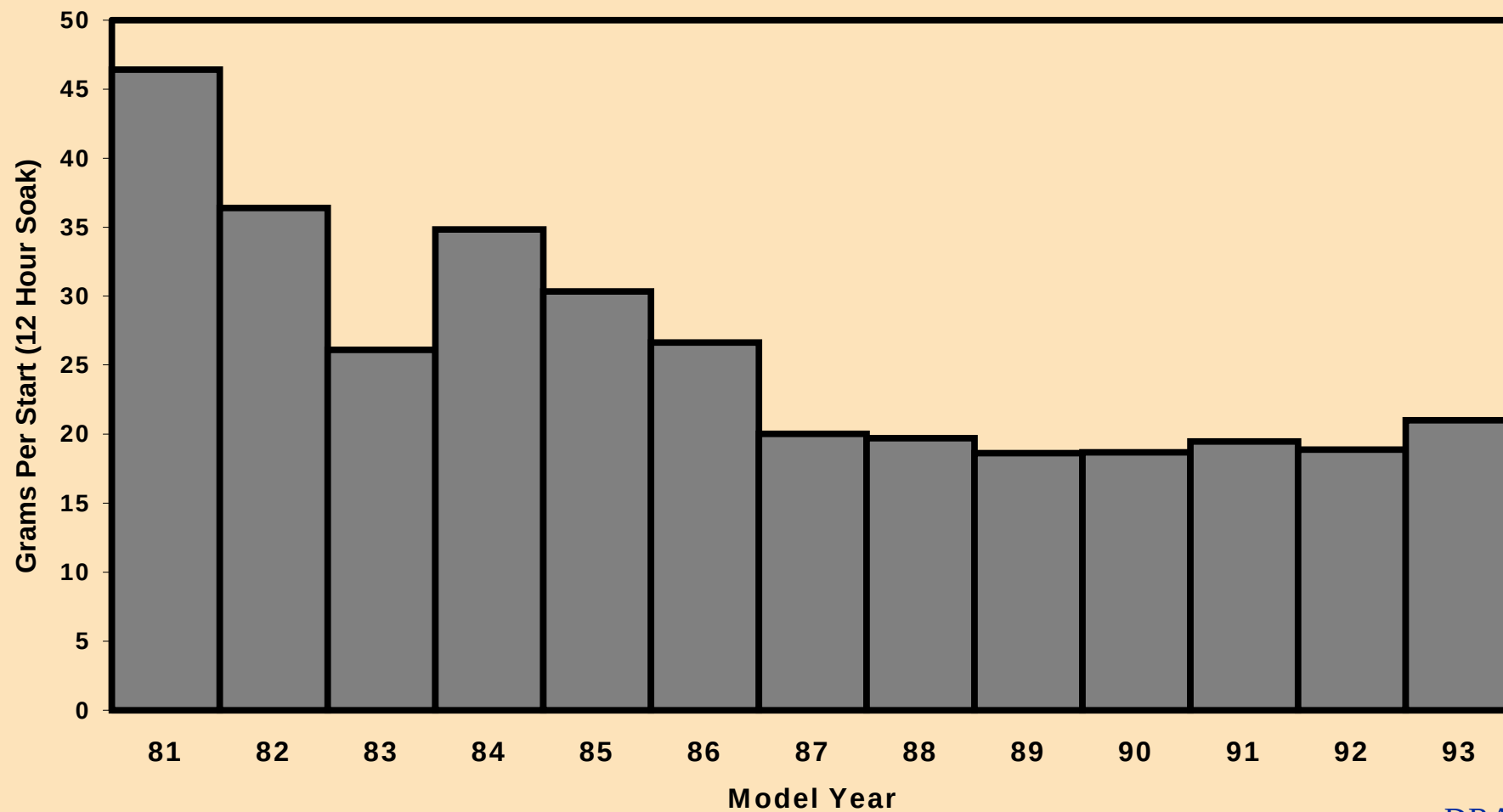
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# *Average HC Start Emissions*



# Average CO Start Emissions

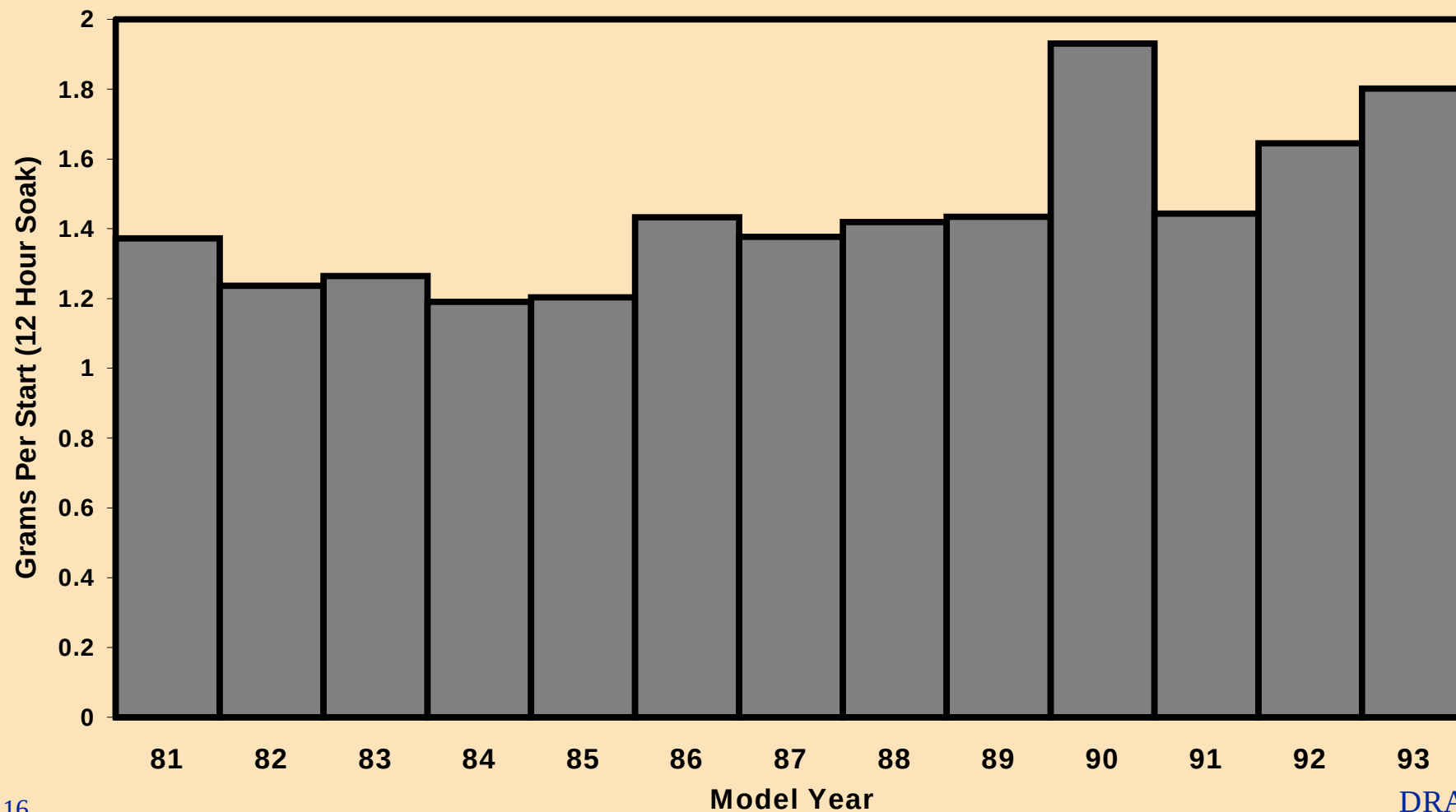




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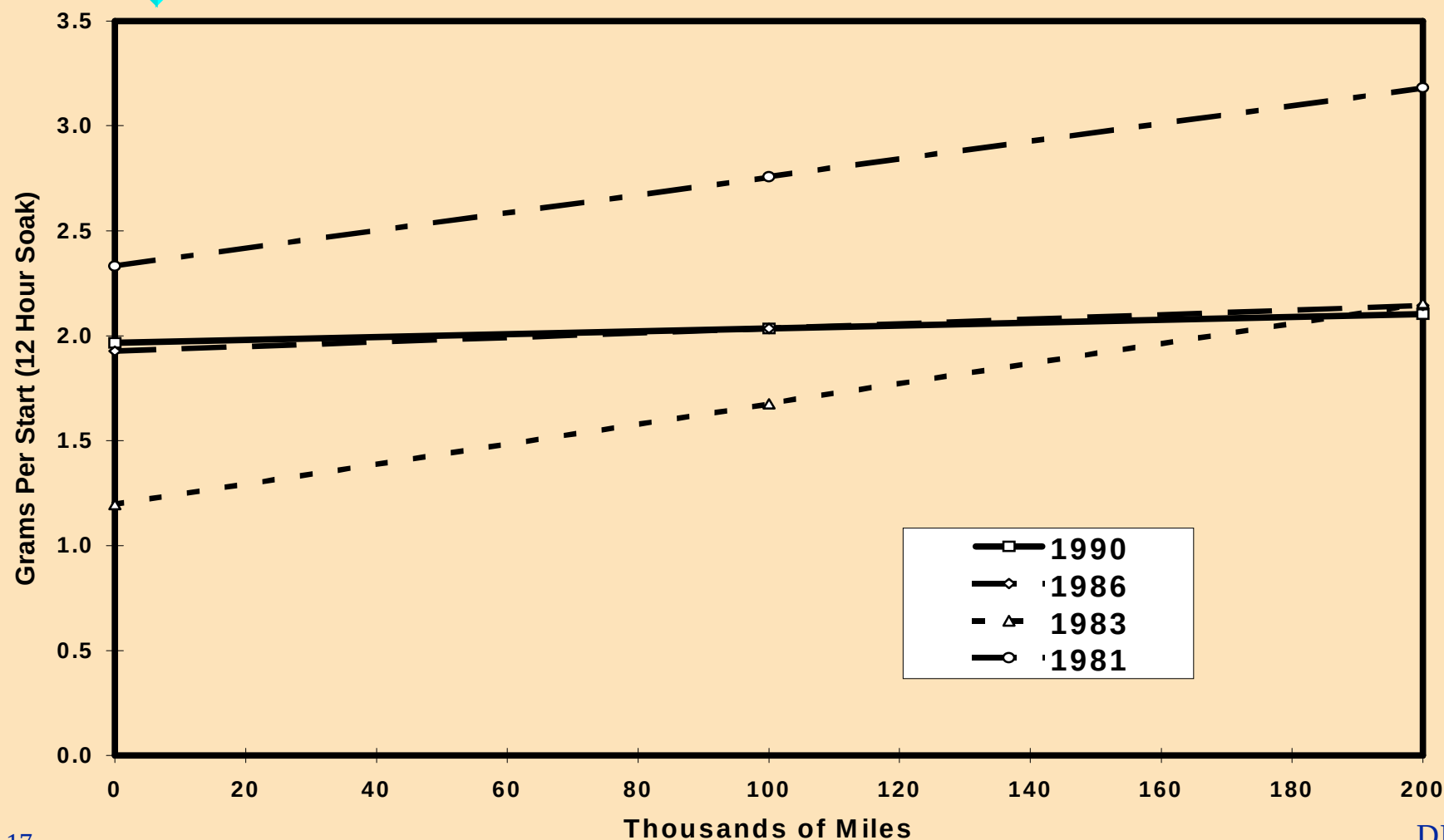


# *Average NO<sub>x</sub> Start Emissions*



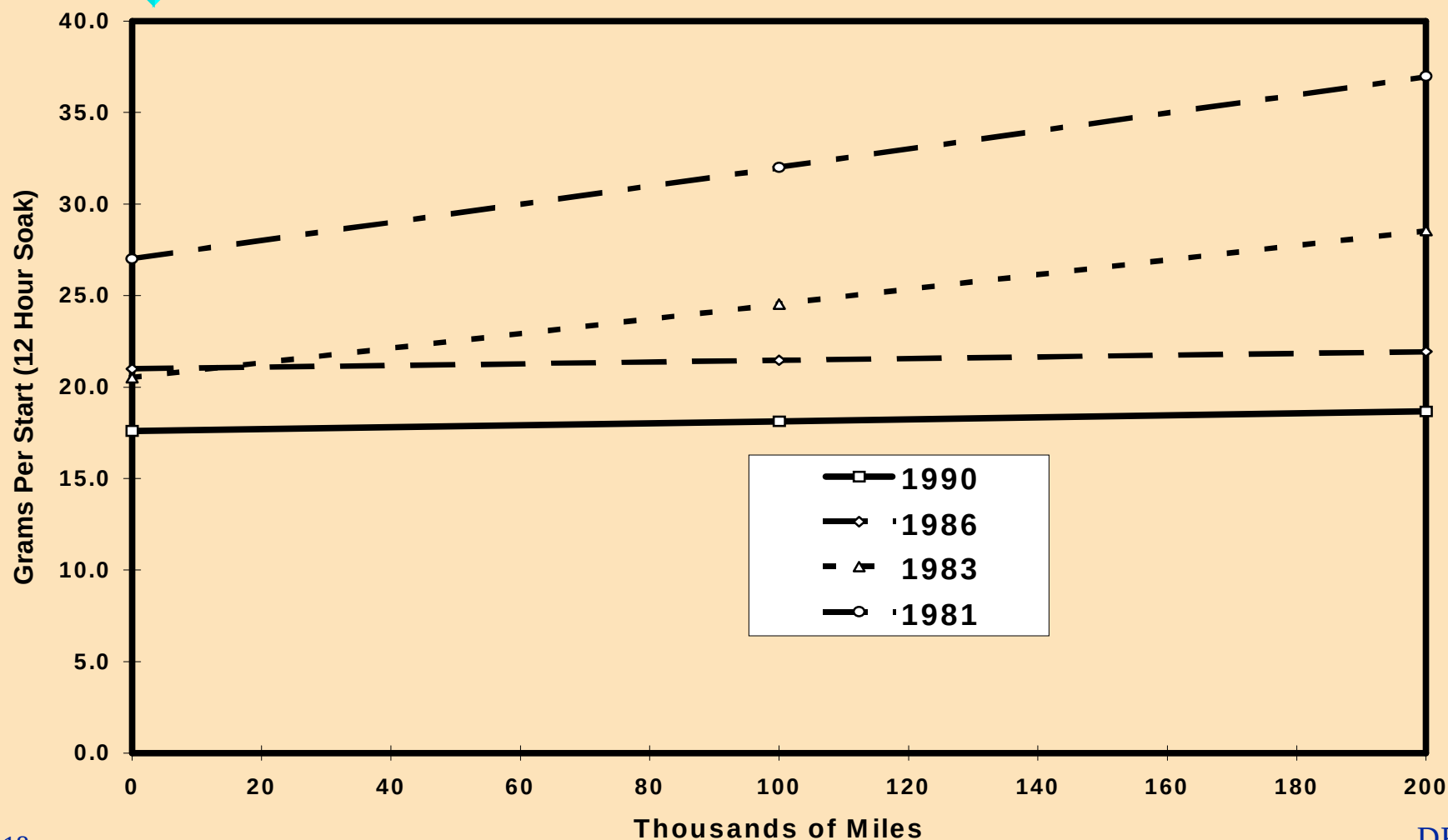
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# HC Start Emissions Versus Mileage (Corrected)



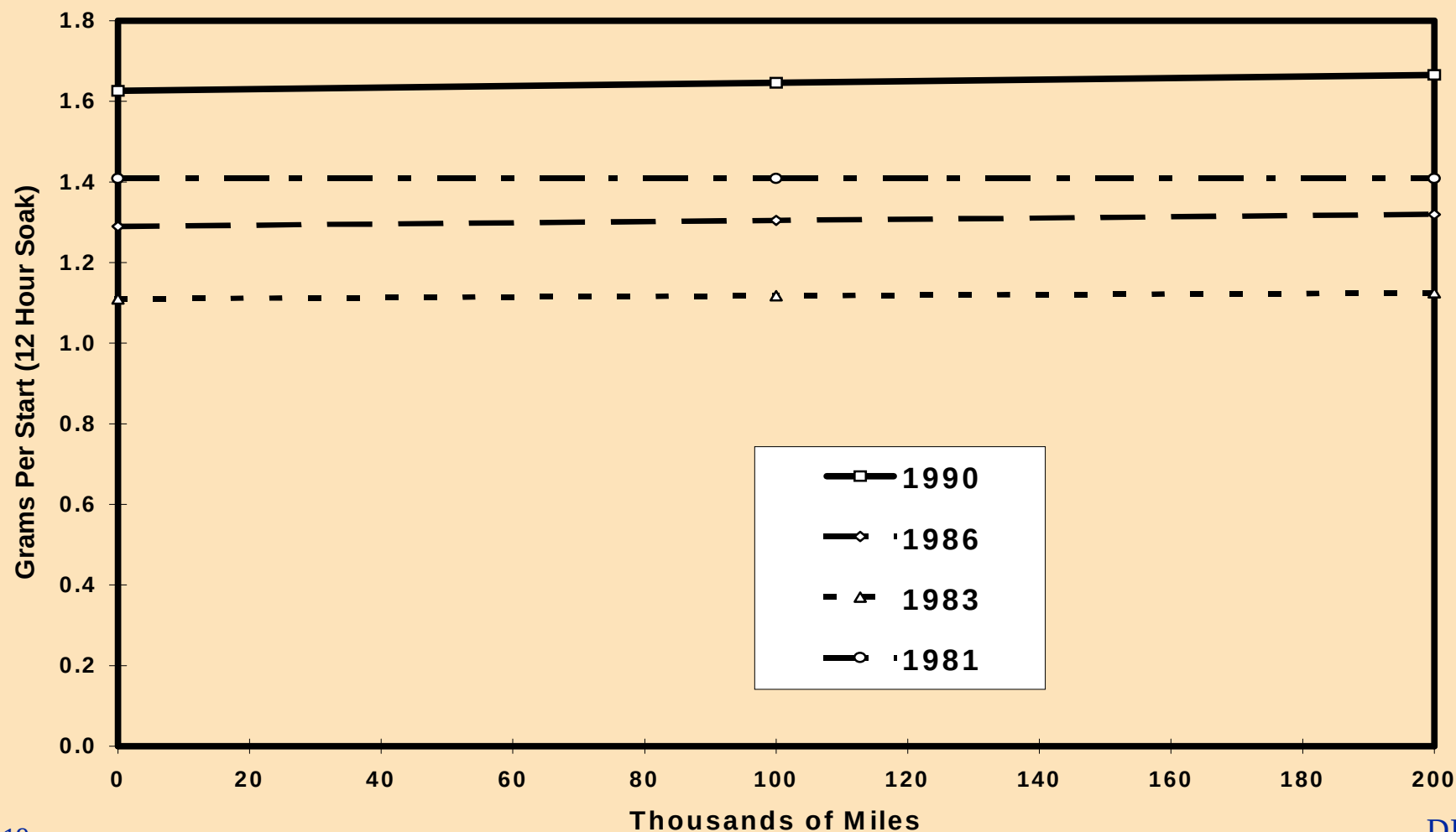
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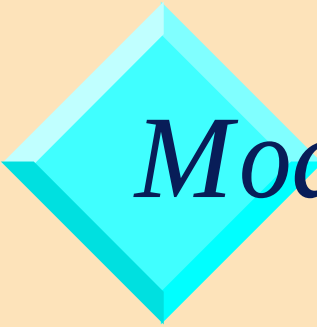
# CO Start Emissions Versus Mileage (Corrected)



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# *NO<sub>x</sub> Start Emissions Versus Mileage (Corrected)*





# *Modeling Issues*

- ❖ Should start emissions depend on mileage?
- ❖ What are start emissions for Tier 1 and LEV?



# *Light Duty Trucks*

- ❖ Similar methods and issues as passenger cars
- ❖ Less data
- ❖ Will borrow from cars if necessary

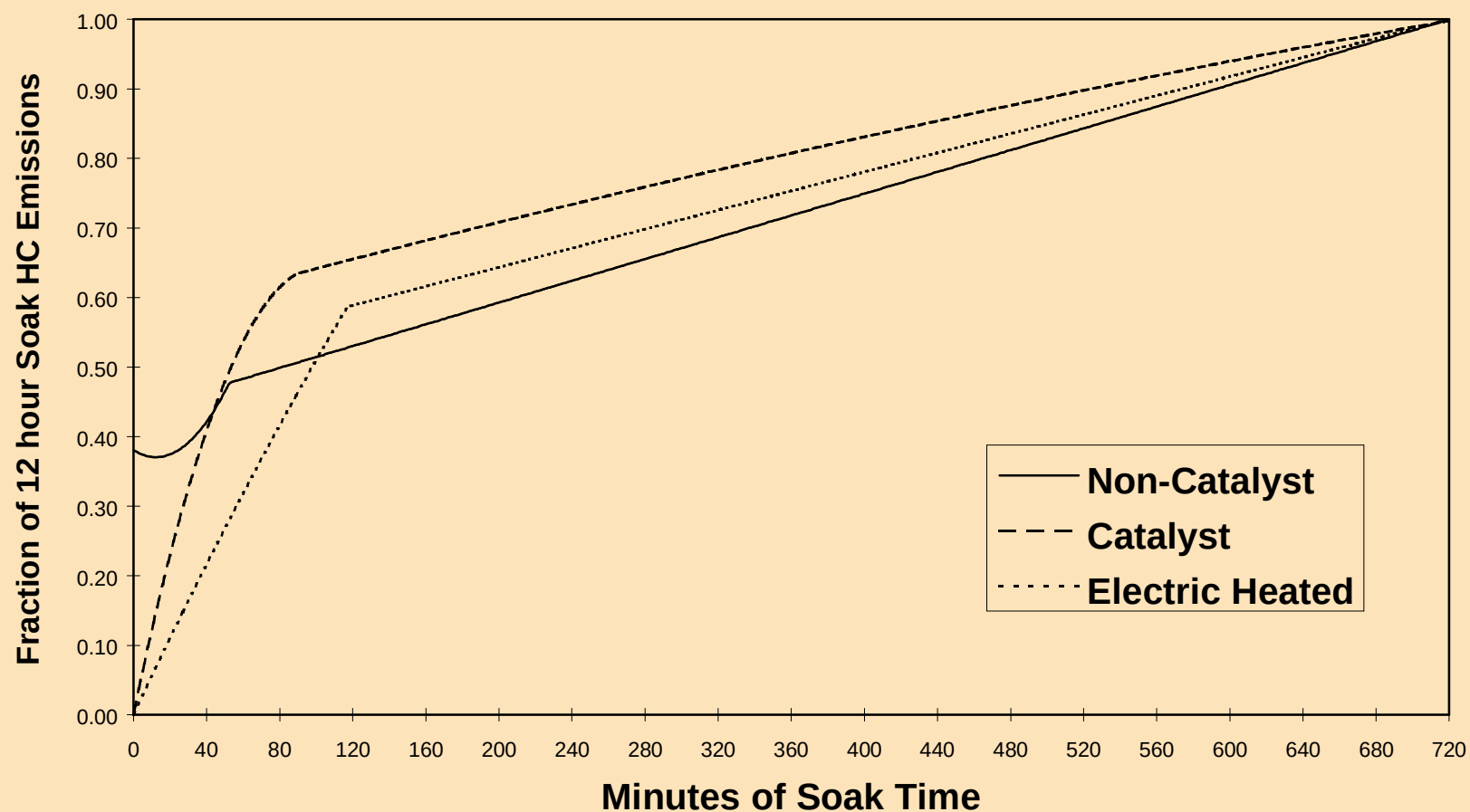


# *Start Emissions Versus Soak Time*

- ❖ California has developed relationship
- ❖ EPA proposes to use those relationships
- ❖ Normalized to EPA data emission levels

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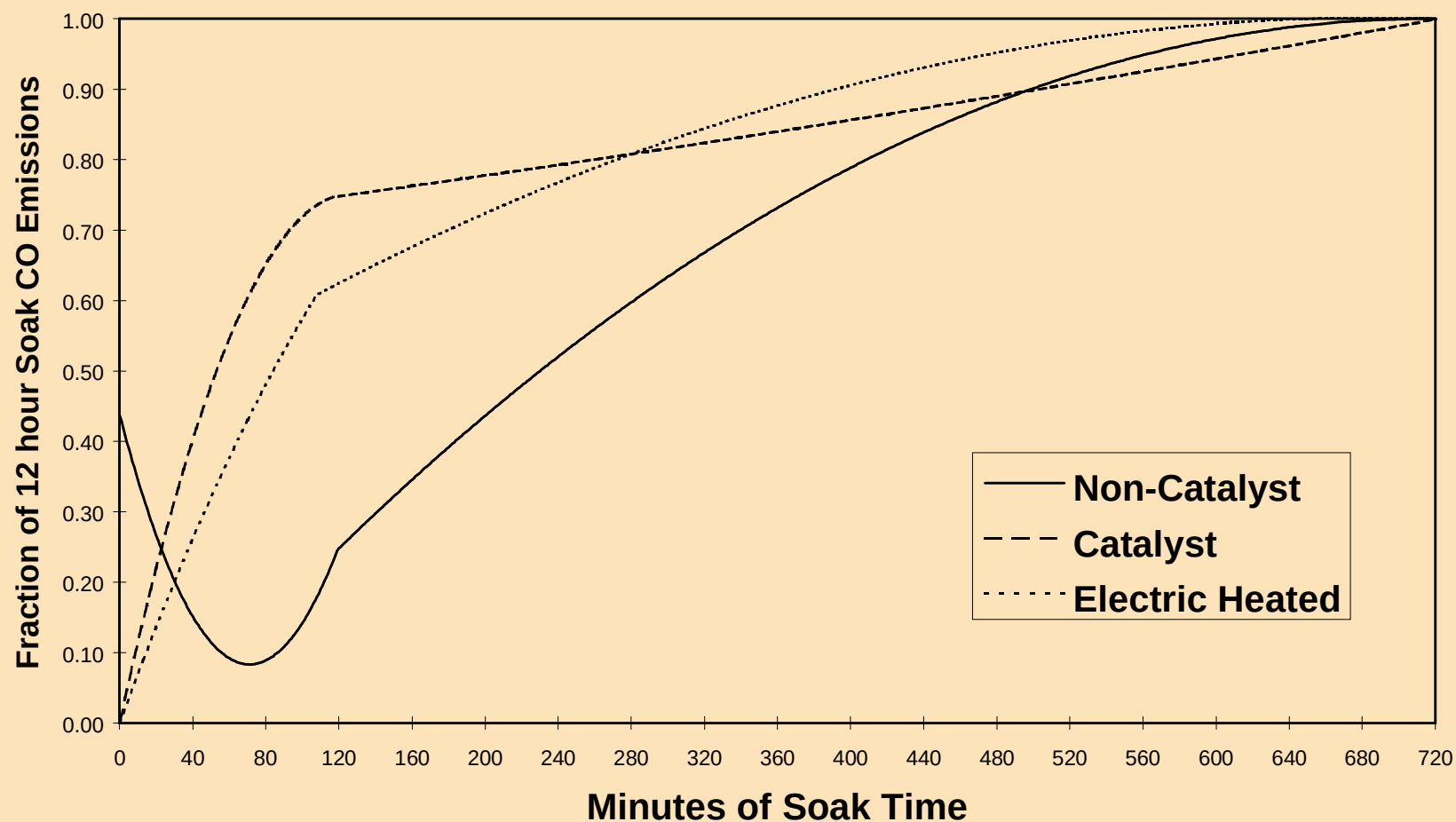
# *Effect of Soak Time on Start HC Emissions*





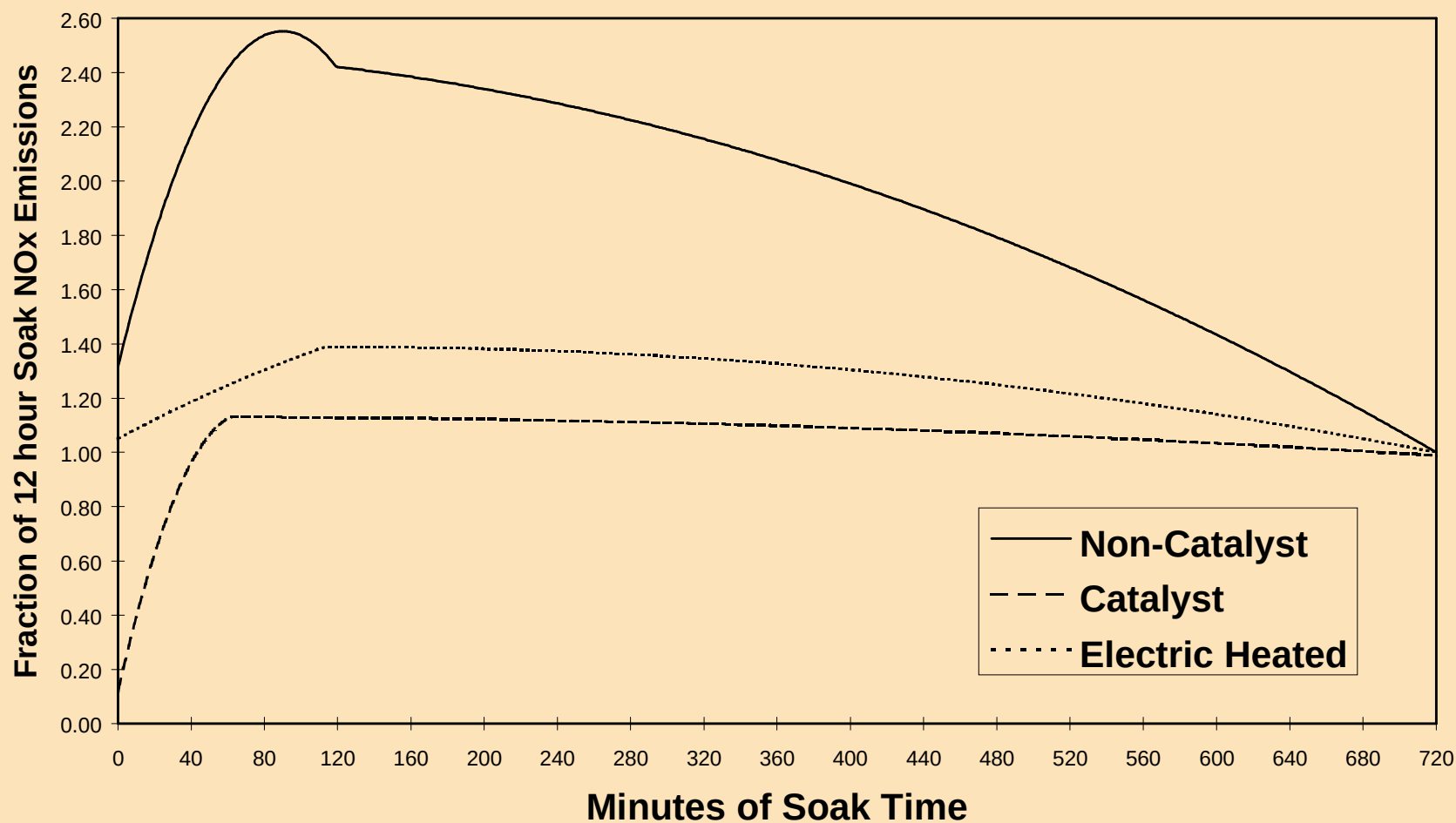
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# *Effect of Soak Time on Start CO Emissions*



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# *Effect of Soak Time on Start NO<sub>x</sub> Emissions*





# *Adjustments to Engine Start Emissions*

- ❖ Default soak time distribution
- ❖ Default number of engine starts per mile of vehicle operation
- ❖ Methane, Fuel and Temperature Corrections

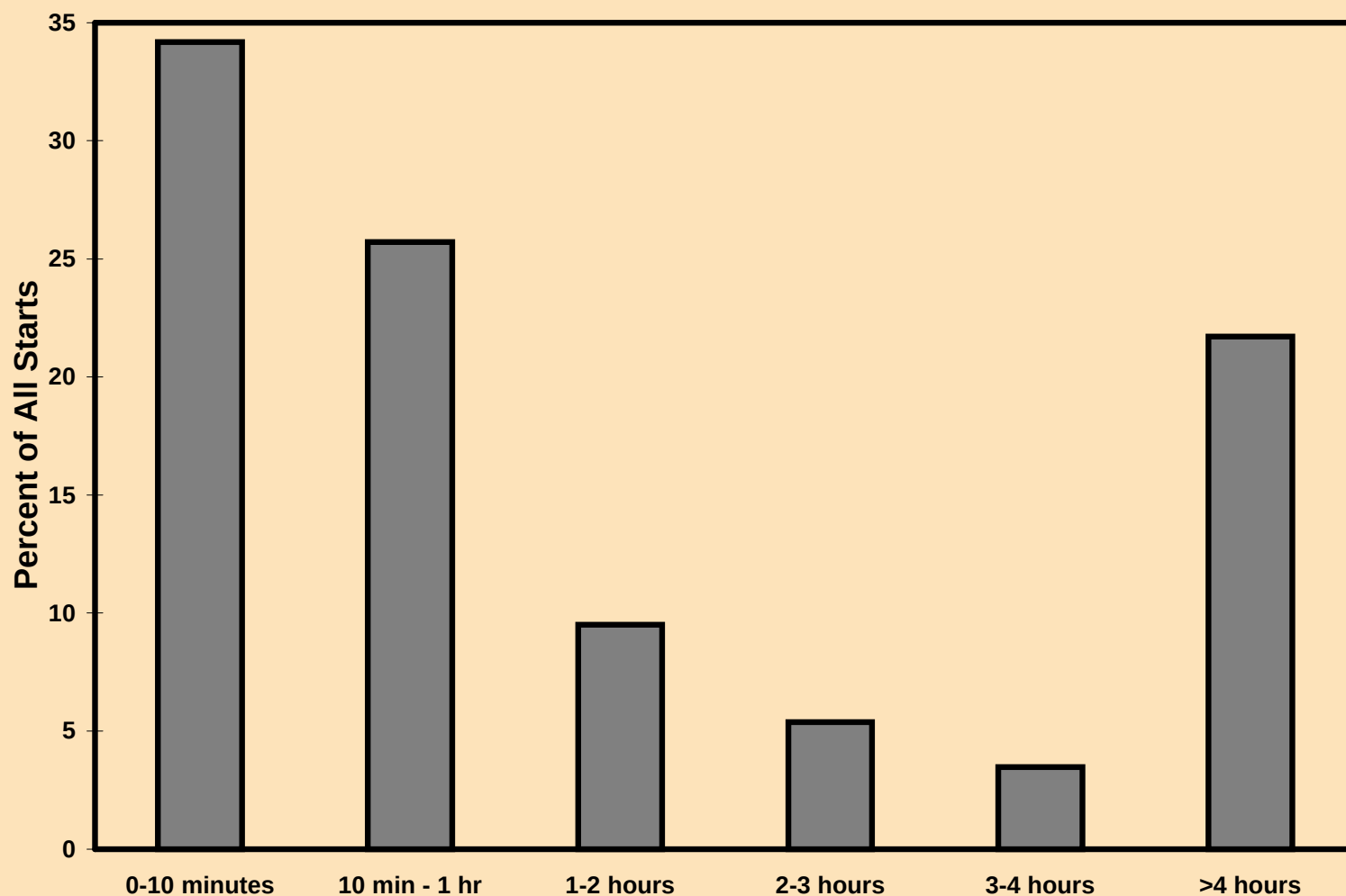


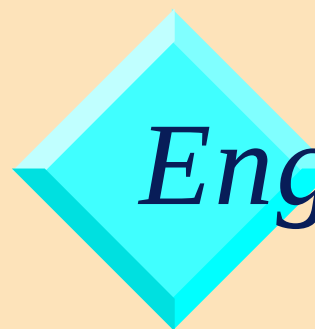
# *Travel Trip Characteristics Analysis*

- ❖ 1994 EPA Report based on instrumented vehicles
- ❖ Will be used as the basis for engine starts per mile and soak time distributions

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# *Distribution of Engine Start Soak Time*





# *Engine Starts Per Mile*

$$\text{Starts Per Mile} = \text{Starts Per Day} / \text{Miles Per Day}$$

- ❖ Used to calculate Start Emissions in grams per mile
- ❖ Will have optional output of grams per start



# *User Adjustments to Engine Starts*

- ❖ Default output will include start emissions in the emission rate
- ❖ Output option for engine start emissions in grams per start
- ❖ Optional user input of engine starts per mile of vehicle operation



# *Issues*

- ❖ Heavy Duty Vehicles
- ❖ Starts per mile by roadway type
- ❖ Special handling for engine stalls