Technical Support Report for Regulatory Action

Motorcycle Usage

January 1976

Notice

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Standards Development and Support Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Office of Air and Waste Management
U.S. Environmental Protection Agency
Abstract

The 1974 Gallup Motorcycle Survey is analyzed to obtain average urban usage data. Data obtained include average trip length, frequency, and speed plus areas commuted through. A qualitative comparison to the NPRM Motorcycle Driving Cycles is made. Areas where additional data would be useful are identified.
Introduction

This report presents an analysis of motorcycle usage data available from the 1974 Gallup Motorcycle Survey. In addition to simply presenting these data, an attempt is made to compare motorcycle usage with the Federal Test Procedure (FTP) driving cycle being proposed in the NPRM for testing motorcycles. It is recognized that insufficient survey data exist to fully quantify how motorcycles are used; the attempt in this report is to study the available data, qualitatively compare the data to the driving cycles, and recommend areas in which additional data would be useful.

Summary

- The average urban trip length for street legal motorcycles is 5.2 miles.
- The average trip frequency is 3.2 trips per day. (Motorcycle use is seasonal; these data are representative of use in the month of May.)
- The calculated average commuting trip speed is 29 miles per hour.
- Small displacement motorcycles are used less frequently and over shorter distances at lower speeds.
- Over one half the large displacement motorcycles but slightly less than 20 percent of the small displacement motorcycles use the freeways for commuting.
- It is recommended that the light duty vehicle weighting factors be used for calculating emissions from uncontrolled and 1978 level controlled motorcycles. The effect of weighting factors on calculated emissions will become more important as emissions from motorcycles are controlled, and the determination of more accurate weighting factors specific to motorcycles would be recommended.
- The usage data obtained from the Gallup Survey is insufficient to determine if a different driving cycle for motorcycles is needed. Because the usage data indicate higher average speeds and shorter trip lengths for motorcycles, obtaining more detailed usage data to further quantify driving characteristics is recommended.

Discussion

A subset of the Gallup National Motorcycle Survey data was used for this analysis. The subset contained data which were the intersection of the following categories of responses and classifications:
Street and Dual Purpose Motorcycles
Engine Displacement ≥ 50 cc
Registered
Working Odometer
Reside in a city with population of ≥ 50,000

This subset is representative of street legal motorcycles whose owners reside within cities with populations greater than or equal to 50,000. This data set was chosen so that the data would be as representative of urban motorcycle usage as possible.

The specific Gallup survey questions upon which the following data are based are presented in the Appendix.

Average Trip Length

Tables I and II present a summary of trip characteristics for commuting and non-commuting trips. The overall average trip length is calculated by weighting the trip lengths by both the frequency of trips and by the percent of the population which is making the specific type of trip. The latter weighting is required because motorcycles are not used for all types of trips (only 59 percent of owners use motorcycles to commute, for example).

The average trip length, based on the data in Table I and II is calculated to be:

<table>
<thead>
<tr>
<th>Average urban trip length</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC ≥ 50</td>
</tr>
<tr>
<td>CC ≥ 170</td>
</tr>
<tr>
<td>50 ≤ CC &lt; 170</td>
</tr>
</tbody>
</table>

The trip length shown above is representative of urban use. For the average trip length for "non-commuting trips greater than 10 miles one way", (a survey question, see the Appendix), it was assumed the first 10 miles of each trip was urban and therefore 10 miles was used for that trip length. No actual average length for trips greater than 10 miles is known since the survey question was "open ended"; only trip frequency was asked.

Frequency of Trips

Motorcycles differ from light duty vehicles in that their use is frequently seasonal or may be of a recreational nature only. Thus the average number of trips per day, as determined from the survey data, will vary depending on whether those data indicating zero trips of a specific type are included in the average. For example, 49 percent of the owners surveyed did not take any 2 to 10 mile non-commuting trips in the last week. Because respondents were asked questions about usage in the month just prior to the survey, these data are representative of use in the month of May. The results may be different for other seasonal periods.
The average frequency of all types of trips combined, which includes in the calculation those owners not using their motorcycles for a specific type of trip in the last week, (i.e., zero trip response), was calculated by summing the number of trips for each category for each survey response. The average number of trips per day (zero trip motorcycles included) is:

\[
\begin{array}{lcl}
\text{Average Trip Frequency in May} \\
\text{CC} & > & 50 \\
\text{CC} & > & 170 \\
50 & \leq & \text{CC} < 170 \\
\end{array}
\]

3.1 trips/day  
3.6 trips/day  
1.7 trips/day

\textbf{Weekly Mileage}

As a check on the validity of the average trip frequency and length, the calculated weekly mileage is compared to the estimated weekly mileage (a survey question, see the Appendix). The estimated average weekly mileage includes inactive motorcycles.

\textbf{Comparison of Weekly Mileage, Miles}

\[
\begin{array}{lcl}
\text{Calculated} & \text{Estimate} & \text{Estimate} \\
(1) & (2) & (2)(3) \\
\text{Total Weekly Mileage} & \text{On Road Weekly Mileage} \\
\hline
\text{CC} & > & 50 \\
113 & & 109 \\
& & 93 \\
\text{CC} & > & 170 \\
136 & & 128 \\
& & 115 \\
50 & \leq & \text{CC} < 170 \\
48 & & 45 \\
& & 33 \\
\end{array}
\]

(1) Miles per trip times trips per day times 7 days per week.  
(2) A Survey Question  
(3) Off road riding not included

The weekly mileage calculated from the average trip lengths and frequencies compare closely with the survey's estimated total weekly mileage. The calculated mileage is higher than the estimate of weekly on road mileage, however. Considering that the results are calculated from estimates, the agreement is good and supports the calculated values of trip and length frequency.

\textbf{Average Speed}

The survey asked how long it took to travel to work or school. Using these data plus the average commuting trip length, an average speed was calculated. The average speed for commuting trips is:

\[
\begin{array}{lcl}
\text{Calculated Average Commuting Trip Speed} \\
\text{CC} & > & 50 \\
29.2 & \text{mph} \\
\text{CC} & > & 170 \\
30.2 & \text{mph} \\
50 & \leq & \text{CC} < 170 \\
22.7 & \text{mph} \\
\end{array}
\]
The large displacement motorcycles show a higher average speed, probably due to traveling part of the trip at highway speeds (see next section). Breaking the commuting trips into school and work trip speeds, the large displacement work trip is the only type of commuting trip with a significantly higher average speed.

<table>
<thead>
<tr>
<th>Calculated Average Commuting Trip Speed</th>
<th>To Work</th>
<th>To School</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC &gt; 170</td>
<td>32.8 mph</td>
<td>23.1 mph</td>
</tr>
<tr>
<td>50 ≤ CC &lt; 170</td>
<td>22.8 mph</td>
<td>22.4 mph</td>
</tr>
</tbody>
</table>

No data on non-commuting trip speeds are available from the survey.

Areas Commuted Through

Commuters were asked what areas they commute through. The results are presented in Table III. The data show about one half commute through downtown and industrial areas, and about 80 percent commute through suburban and residential areas. There is little difference among the two engine displacement classes. Approximately 20 percent commute through rural areas. Only three percent commute solely in rural areas, which is a result of analyzing only the responses from city dwellers.

Fifty-five percent of the large displacement owners commute on the freeways, while only 19 percent of the small motorcycles are used on the freeways for commuting. The latter figure reflects the fact that in many states the smaller displacement motorcycles are legally prohibited from using the freeways.

Hot/Cold Weighting Factors

The data needed to determine the hot/cold start weighting factors, which are used in the total emissions calculations, are not available from the Gallup Survey. In the NPRM, the light duty vehicle value of 0.43 cold starts per start is used.

The importance of accurately knowing the weighting factors depends on the ratio of cold transient to hot transient emissions. For simplicity, consider the equation for weighted mass emissions in which the distance has been eliminated. The total weighted emissions can be expressed as:

\[ Y_{wm} = \frac{n_c}{n_t} Y_{ct} + \frac{n_h}{n_t} Y_{ht} + \frac{n_s}{n_t} Y_s \]  

(1)

where

\[ Y_{wm} = \text{Total weighted mass emissions of a given pollutant.} \]

\[ Y_{ct} = \text{Mass emissions from the cold transient portion of the driving cycle.} \]
\[ Y_{ht} = \text{Mass emissions from the hot transient portion of the driving cycle.} \]

\[ Y_s = \text{Mass emissions from the stabilized portion of the driving cycle.} \]

\[ n_t = \text{Total number of starts per day.} \]

\[ n_c = \text{Number of cold starts per day.} \]

\[ n_h = \text{Number of hot starts per day.} \]

Substituting \( 1 - n_c/n_t \) for \( n_h/n_t \) and taking the derivative of \( Y_{wm} \) with respect to \( n_c/n_t \) gives:

\[
\frac{dY_{wm}}{d(n_c/n_t)} = Y_{ct} - Y_{ht}
\]

The change in total weighted emissions due to a change in the weighting factor \( n_c/n_t \) is equal to the difference between cold and hot transient emissions. If the hot and cold transient emissions are equal, then the weighting factors have no effect on the calculated weighted emissions.

A review of emission data collected at EPA using the NPRM test procedure shows that the ratio of cold to hot start emissions is approximately one for most motorcycles tested. Quantitatively, 85 percent of the ratios are in the range of 0.8 to 1.2. Within this range, a change in cold weighting factor of .3 (from .43 to .73, for example) results in less than a five percent change in calculated weighted emissions.

The level of transient emissions for uncontrolled motorcycles tends to mask any differences in cold and hot transient emissions. Since the proposed 1978 level of control results in only moderate decreases in emissions for most motorcycles, the ratio of cold to hot transient emissions will most likely remain at approximately one. Thus it is recommended that the light duty vehicle weighting factors be used for calculating emissions from uncontrolled and 1978 level controlled motorcycles. As motorcycles are controlled more stringently, the differences in cold and hot transient emissions may become significant, and the determination of weighting factors specific to motorcycles may be needed.

**Comparison with the FTP Driving Cycle**

The results presented in the previous sections are based on survey data, and their accuracy depends on the respondents ability to estimate frequencies, distances, and times. In addition, the data are not complete; for example the average trip velocity can be indirectly calculated only for commuting trips. With these qualifications in mind, a comparison of the Gallup survey results to the FTP for each engine displacement category is presented below. The motorcycle FTP driving cycle speed versus time
for the large displacement motorcycles is identical to the light duty vehicle driving cycle. The high speed portion of the transient test (bags 1 and 3) has been scaled down by the factor 0.64 for the small displacement motorcycles.

\[
\begin{array}{cccc}
50 \leq \text{CC} < 170 & & \text{CC} \geq 170 \\
\hline
\text{Parameter} & \text{Gallup} & \text{FTP} & \text{Gallup} & \text{FTP} \\
\text{Urban trip length, miles} & 4.0 & 6.8 & 5.4 & 7.5 \\
\text{Trip average speed, mph} & 22.7 (1) & 17.8 & 30.2 (1) & 19.7 \\
\end{array}
\]

(1) Commuting trips only.

The trip lengths obtained from the survey are shorter than represented by the test procedure, and the average commuting speeds are higher. The average speed would probably be reduced, especially for the large motorcycles, if data on non-commuting trips were available and were included. The argument that motorcycles are constrained by traffic to the same average speeds as light duty vehicles is still strong. The reduction of the maximum test speed for small displacement motorcycles appears justified based on their lower trip speed and the small percentage of reported freeway usage (Table III).

The Gallup data presented here is not sufficient to decide if a different driving cycle for motorcycles is needed. It does suggest, however, that trip length for motorcycles may be less than LDVs. The average speed, being based only on commuting trips and an indirect computation is insufficient to claim motorcycles in general travel at higher average speeds than LDVs. The importance of this parameter on emissions suggests that obtaining further data on average speed should be pursued.
Table I

Gallup Usage Data - Commuters

(Street Legal Motorcycles in Cities)

<table>
<thead>
<tr>
<th>Parameter (1)</th>
<th>Question Number</th>
<th>50 &lt; CC &lt;170</th>
<th>CC &gt; 170</th>
<th>CC &gt; 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commute to work only</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent that commute to work</td>
<td>16</td>
<td>26</td>
<td>51</td>
<td>45</td>
</tr>
<tr>
<td>Miles to work, 1 way</td>
<td>17</td>
<td>5.6</td>
<td>10.2</td>
<td>9.6</td>
</tr>
<tr>
<td># Trips in last 20 work days (2)</td>
<td>19b</td>
<td>16.7</td>
<td>13.8</td>
<td>14.0</td>
</tr>
<tr>
<td>Commute to school only</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent that commute to school</td>
<td>16</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Miles to school, 1 way</td>
<td>20</td>
<td>5.8</td>
<td>6.4</td>
<td>6.2</td>
</tr>
<tr>
<td># Trips in last 20 school days (2)</td>
<td>22b</td>
<td>21.2</td>
<td>19.5</td>
<td>20.0</td>
</tr>
<tr>
<td>Commute to school and work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent that commute to both school</td>
<td>16</td>
<td>9</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Miles to work, 1 way</td>
<td>17</td>
<td>5.9</td>
<td>8.7</td>
<td>8.2</td>
</tr>
<tr>
<td># Trips in last 20 work days (2)</td>
<td>19b</td>
<td>17.4</td>
<td>13.7</td>
<td>14.4</td>
</tr>
<tr>
<td>Miles to school, 1 way</td>
<td>20</td>
<td>2.6</td>
<td>7.0</td>
<td>6.3</td>
</tr>
<tr>
<td># Trips in last 20 school days (2)</td>
<td>22b</td>
<td>10.4</td>
<td>12.9</td>
<td>12.5</td>
</tr>
<tr>
<td>Calculated data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average speed to work, mph</td>
<td>-</td>
<td>23</td>
<td>33</td>
<td>32</td>
</tr>
<tr>
<td>Average speed to school, mph</td>
<td>-</td>
<td>22</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>All Commuters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent that commute</td>
<td>16</td>
<td>39</td>
<td>66</td>
<td>59</td>
</tr>
<tr>
<td>Commuting trip miles, 1 way</td>
<td>-</td>
<td></td>
<td></td>
<td>8.7</td>
</tr>
<tr>
<td># Trips in last 20 work / school days (2)</td>
<td>-</td>
<td>5.3</td>
<td>9.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>16</td>
<td>14</td>
<td>14</td>
</tr>
</tbody>
</table>

(1) All values are averages.

(2) Average of those who took trips; zero trips not included.
Table II
Gallup Usage Data - Non-Commuting Trips
(Street Legal Motorcycles in Cities)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Question Number</th>
<th>50 ≤ CC &lt;170</th>
<th>CC ≥ 170</th>
<th>CC ≥ 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>n the last 7 days (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># of trips &lt; 2 miles 1 way</td>
<td>26</td>
<td>6.8</td>
<td>8.2</td>
<td>7.9</td>
</tr>
<tr>
<td># of trips 2-10 miles 1 way</td>
<td>27</td>
<td>5.9</td>
<td>6.5</td>
<td>6.4</td>
</tr>
<tr>
<td># of trips &gt; 10 miles 1 way</td>
<td>28</td>
<td>7.2</td>
<td>4.1</td>
<td>3.9</td>
</tr>
</tbody>
</table>

(1) Average of those making non-commuting trips; zero trips not included.

Percent making at least 1 trip in last 7 days

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Question Number</th>
<th>50 ≤ CC &lt;170</th>
<th>CC ≥ 170</th>
<th>CC ≥ 50</th>
</tr>
</thead>
<tbody>
<tr>
<td># of trips &lt; 2 miles 1 way</td>
<td>26</td>
<td>42</td>
<td>56</td>
<td>53</td>
</tr>
<tr>
<td># of trips 2-10 miles 1 way</td>
<td>27</td>
<td>30</td>
<td>57</td>
<td>51</td>
</tr>
<tr>
<td># of trips &gt; 10 miles 1 way</td>
<td>28</td>
<td>20</td>
<td>47</td>
<td>41</td>
</tr>
</tbody>
</table>
Table III

Gallup Usage Data - Areas Commuted Through

(Street Legal Motorcycles in Cities)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Question Number</th>
<th>50 &lt; CC&lt;170</th>
<th>CC &gt; 170</th>
<th>CC &gt; 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of sample that commute</td>
<td>16</td>
<td>39</td>
<td>66</td>
<td>59</td>
</tr>
<tr>
<td>Percent of Commuters that commute through:</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downtown, industrial areas</td>
<td>49</td>
<td>48</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Suburban, residential areas</td>
<td>78</td>
<td>80</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Rural areas</td>
<td>15</td>
<td>23</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Rural areas only</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Percent that commute on freeways</td>
<td>23</td>
<td>19</td>
<td>55</td>
<td>49</td>
</tr>
</tbody>
</table>
Questions from Gallup Survey

ASK ALL OWNERS:

15. Approximately what percentage of the miles on this cycle do you think were for street riding?
   % __________ % __________ % __________

16. In which of the following ways do you use this motorcycle on the street? (read list)
   Do you...
   Commute to work? 1[ ] 1[ ] 1[ ]
   Commute to school? 2[ ] 2[ ] 2[ ]
   Ride for other purposes? 3[ ] 3[ ] 3[ ]
   None 0[ ] 0[ ] 0[ ]
   Other (specify) x[ ] x[ ] x[ ]

MOST RECENT 2nd 3rd

IF USED TO "COMMUTE TO WORK" IN Q. 16, ASK QUESTIONS 17 - 19b:

17. How many miles one way is this trip?
   Miles __________ Miles __________ Miles __________

18. How long does it take one way?
   
   Hours Minutes Hours Minutes Hours Minutes

19a. If the weather is good do you ride your motorcycle to work on a regular basis?
   Yes 1[ ] 1[ ] 1[ ]
   No 2[ ] 2[ ] 2[ ]

19b. How many round trips to work did you make during the past twenty working days?
   Number __________ Number __________ Number __________

IF USED TO "COMMUTE TO SCHOOL" IN Q. 16, ASK QUESTIONS 20 - 22b:

20. How many miles one way is this trip?
   Miles __________ Miles __________ Miles __________

21. How long does it take one way?
   
   Hours Minutes Hours Minutes Hours Minutes

22a. If the weather is good do you ride your motorcycle to school on a regular basis?
   Yes 1[ ] 1[ ] 1[ ]
   No 2[ ] 2[ ] 2[ ]

22b. How many round trips to school did you make during the past twenty school days?
   Number __________ Number __________ Number __________
ASK ALL COMMUTERS EITHER TO WORK OR SCHOOL QUESTIONS 23 & 24:

23. Do you commute either on freeways, expressways, or turnpikes with this cycle?
   Yes 1[ ] 1[ ] 1[ ]
   No  2[ ] 2[ ]

24. Which of these areas do you commute through:
   Downtown business or industrial areas? 1[ ] 1[ ]
   Suburban or residential areas? 2[ ] 2[ ]
   Rural areas? 3[ ] 3[ ]

ASK ALL OWNERS:

26. Other than for commuting ... in the past seven days how many trips did you make that were within two miles from your home?
   # of Trips

27. Other than for commuting ... in the past seven days how many trips did you make that were within two to ten miles from your home?
   # of Trips

28. Other than for commuting ... in the past seven days how many trips did you make that were over ten miles from your home?
   # of Trips

29. Considering now your motorcycle usage for all purposes to include commuting and other purposes ... Thinking now about your average weekly usage during the past four weeks, how many miles did you ride in an average week?
   Miles

   Miles

   Miles