Technical Support for Regulatory Action

In-House Test Program
Report No. 2-
Vehicle Preconditioning:
LA-4 vs. HFET

November 1975

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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
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1. Introduction

The preconditioning vehicle operation described in the Federal Register (1) requires that the test vehicle be driven over a prescribed mileage accumulation route for a period of one hour (this is usually called the AMA road route). The fuel tank is then drained and a specified type of test fuel is added. The vehicle is then driven over a simulated trip on a chassis dynamometer. The Urban Dynamometer Driving Schedule (usually called an LA-4) is used for this simulation. In the In-House Report No. 1 (2) the current preconditioning cycle consisting of both the AMA and LA-4 was evaluated to determine if the AMA segment of the cycle could be eliminated. It was shown in that report that similar exhaust and diurnal emission levels existed whether or not the AMA was conducted. Since the LA-4 is considered a typical urban driving cycle, it was concluded that the LA-4 prep cycle alone would be sufficient to precondition the vehicle. Further support of this conclusion can be drawn from another in-house study (3) conducted to determine the equivalency of an AMA + LA-4, three LA-4's + one LA-4, or one LA-4 preconditioning drive with respect to exhaust emissions. That study, based on ten (10) replicate tests on three vehicles concluded that equivalent exhaust results are achieved with any of the three preconditioning drives.

The purpose of vehicle preconditioning is to provide a relatively consistent starting base for all vehicles involved in emission testing. It is intended that this desired starting base be achieved by a preconditioning drive which tends to simulate a real-life condition that a vehicle would normally experience in its day-to-day operation. The basic vehicle preconditioning sequence involves soaking the vehicle (cold soak) prior to the diurnal test which allows the vehicle to reach a stabilized ambient temperature. The preconditioning drive is conducted prior to the cold soak, which conditions the evaporative control system (i.e. canister) and flushes out the old fuel. In addition, the preconditioning (prep) drive may standardize the vehicle if it has not been operated within a reasonable length of time.

The Highway Fuel Economy Test (HFET) cycle is a typical driving cycle for highway driving. The method of conducting the HFET test requires driving two identical cycles; the first intended to warm up the vehicle and the second cycle is used to measure the vehicle's highway fuel economy. If the LA-4 prep cycle and the two HFET prep cycles can be shown to condition the vehicle equivalently, then the HFET cycle could be used to replace the LA-4 prep.

Replacing the LA-4 prep with the HFET prep would likely have an economic advantage. Currently, if a HFET cycle is run, it is run at the end of the Hot Soak test and is an additional test. This additional test adds time to the overall procedure and requires further manpower.
An alternative to replacing the LA-4 with the HFET for vehicle preconditioning is the use of an LA-4 as a warm up cycle followed by one HFET data gathering cycle. This alternative would have the advantage of simulating both urban and rural driving.

The purpose of this study is, therefore, to examine whether or not the HFET driving cycle is equivalent to the LA-4 preconditioning cycle. This test program was designed to reveal if any significant differences existed in diurnal emissions or exhaust emissions when the vehicle underwent different preconditioning drives. It was assumed that, if significant differences in diurnal losses were exhibited, the effect of the different cycles on the evaporative control system could be responsible. For all vehicles tested the evaporative control system utilized a charcoal canister as a storage media for the generated fuel vapors. In order to determine what effect the prep cycles had on the generation of fuel vapors, canister weights were taken before and after the prep drive and before and after the diurnal test.

A small portion of the test program was designed to gain insight into the alternative of using one LA-4 plus one HFET as a preconditioning cycle. By recording canister weights before and after this combined preconditioning cycle, the cycle could be evaluated to determine if the purge characteristics were similar to either a single LA-4 cycle or 2 HFET cycles. Only the Matador was used during this portion of testing as its evaporative control system was the most sensitive to the different preconditioning cycles.
2. Summary and Conclusions

The purpose of this study was to determine whether or not the two HFET cycles used for measuring fuel economy would be suitable for a preconditioning driving cycle in place of one LA-4. The main concern with using the HFET was the possibility that the purge characteristics of the evaporative emission control system would allow for purging during preconditioning and not during the exhaust emission cycle which is essentially the same as an LA-4. If this were to occur then sufficient canister capacity would enable a vehicle to pass the evaporative emissions test, and the exhaust test would be easier to pass due to the fact that hydrocarbons from the canister would not be purging into the engine.

The results of the analysis indicate that this does in actuality occur, and that on the average lower diurnal evaporative emission levels occur following HFET preconditioning for all 5 vehicles. The alternative of using an LA-4 plus one HFET for preconditioning appears to have the same effect on canister purging for one of the test vehicles and thus its use as a preconditioning cycle would probably also result in abnormally low evaporative emission levels. Thus, the use of 2 HFET cycles or one LA-4 plus one HFET does not seem suitable as a replacement for the LA-4 cycle for preconditioning. These cycles could possibly be given further consideration for use in preconditioning if they were followed by a hot soak period followed by an additional LA-4 cycle. This possibility should in the future be given more consideration.
3. Technical Discussion

Generally, a test procedure attempts to typify or simulate an actual condition. A concerted effort was expended to establish the Urban Dynamometer Driving Schedule (LA-4) as an average driving cycle (4). There was also a similar effort put forth to design the Highway cycle as a typical driving cycle (5). Each cycle is typical of a particular type of driving; the LA-4 is typical of urban driving, and the HFET is typical of rural driving. Of particular interest for either cycle is how the evaporative control system (i.e., canister) is conditioned. This conditioning is accomplished by purging (or loading, possibly) the canister during the prep drive to its normal working capacity. This allows the canister to accommodate the evaporative losses generated by the subsequent diurnal heat-build. If the LA-4 and HFET are to be considered equivalent preconditioning drives then equivalent diurnal losses and exhaust emissions should be exhibited for the two test sequences.

The exhaust emission test used during the Federal Test Procedure simulates a cold and hot start. The cold start test consists of running one LA-4 on the dynamometer. The hot start test consists of the first 505 seconds of the LA-4 cycle and is conducted after the cold start test with a 10 minute soak between tests. Since both the LA-4 and Federal Test Procedure exhaust cycles are basically the same, equal amounts of purging should occur during the preconditioning drive and exhaust test. The HFET on the other hand is an entirely different driving cycle from the exhaust cycle used, with the HFET cycle having a 29 mph higher average speed. It is conceivable that a system could be designed that would purge during the preconditioning drive and not during the exhaust test. This condition should be avoided.

The economic advantage of the HFET being used as a preconditioning driving cycle stems from the fact that the HFET, when conducted, is run after the hot soak and thus adds time to the overall sequence. It also requires the vehicle to be scheduled for dynamometer operation three separate times (preconditioning, exhaust test, and HFET). The HFET is currently an optional test which the manufacturers may choose to have run. It is conceivable that in the future it may be a standard part of the Federal Test Procedure. In either case, it would be cost effective to be able to gather data during the preconditioning drive which must be conducted regardless. This would mean that only 2 dynamometer operations would need to be scheduled (preconditioning and exhaust test). One issue that would still need to be resolved is whether or not the vehicle would need any additional preconditioning prior to the HFET preconditioning drive. The Federal Register (6) currently requires extensive preconditioning prior to the HFET if the vehicle has not been operated within a 24 hour period. If it is determined that this preconditioning is necessary, then the additional time to do this may make the use of the HFET a less cost-effective alternative.
It is reasonable to assume that either of the preconditioning cycles is capable of flushing out the old fuel in the system and also capable of standardizing vehicles which have not been operated within a reasonable length of time. Hot soak tests were not conducted.

The use of two HFET cycles as a preconditioning cycle would only simulate rural driving during preconditioning. The use of an LA-4 cycle to warm up the vehicle followed by an HFET data gathering cycle would have the same economic advantages as two HFET cycles but it would also simulate both urban and rural driving during preconditioning. This alternative combined cycle would, however, be somewhat longer than a single LA-4 cycle or 2 HFET cycles by approximately 10 minutes. This additional time during the preconditioning could allow the canister to abnormally purge.

The Federal exhaust test simulates normal urban driving over a 7.5 mile trip. The amount of purging which takes place during this trip should be roughly the same as the amount of purging during the preconditioning cycle if the preconditioning and exhaust emission cycles are to be considered compatible for use in the same test procedure. If an abnormally large amount of purging is expected to take place during a preconditioning cycle, the vehicle could possibly be soaked for one hour following the HFET to load the canister again and an additional single LA-4 preconditioning drive conducted after the soak. This additional cycle should purge the canister equivalent to the purge expected during the exhaust emission cycle and thus the canister would be properly preconditioned. The use of this additional preconditioning would, however, greatly reduce the cost savings advantage of using the HFET for preconditioning.

3.1 Facilities and Equipment

The LDV Evaporative Enclosure as shown in Figures 3-1 and 3-2 was used for all evaporative emission tests. The SHED is nominally 8 feet high x 10 feet wide x 20 feet long and has a measured volume of 1540 ft³. Calculation of the enclosure volume with a propane injection and recovery test compared within ±2 percent. Propane retention tests of 2 and 4 hours were performed periodically and indicated a leakage rate of less than 0.1 g/hr.

3.1.1 Test Vehicles

Five 1975 MY vehicles were used in this evaluation. The criteria for selecting the vehicles was that they had accumulated 4000 miles and had been in use for over 90 days. Additional criteria were engine fuel tank configuration and exhaust control system. Specifics of each vehicle are shown in Table 3-1.
Figure 3-1 Evaporative Enclosure (front view).

Figure 3-2 Evaporative Enclosure (rear view).
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<th>Chrysler</th>
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<td>New Yorker</td>
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<td>Canister</td>
<td>Canister</td>
<td>Canister</td>
<td>Canister</td>
</tr>
</tbody>
</table>

Table 3-1 Test Vehicle Descriptions

3.1.2 Test Fuel

Indolene Type HO lead-free test fuel was used throughout the program including vehicle preconditioning.

3.2 Test Procedures

Each of the five (5) vehicles underwent identical test sequences according to the flow diagram shown in figure 3-3. The comparative tests involved changes in the preconditioning drive only. In addition 4 preconditioning drives consisting of one LA-4 followed by one HFET cycle were conducted back to back with a one hour hot soak between each drive to evaluate the effect of the combined cycle. Only the Matador was used for this evaluation and only canister weight data were recorded during this evaluation with the Matador.

3.2.1 Vehicle Preconditioning

All vehicles except the 4 tests run on the Matador using the combined preconditioning cycle underwent a preconditioning drive followed by an 11 to 20 hour soak period at a temperature of 76 to 86°F.
Since test fuel was being continuously used for the entire procedure, including the prep cycle, the fuel was not drained and replenished prior to the dynamometer prep cycle. Two different preconditioning driving cycles were used.

The first method was the 1975 Federal Procedure (1) without the AMA road route. The second was two Highway Fuel Economy Test (HFET) cycles as described in the Federal Register (6).

Canister weights were measured before and after each preconditioning cycle.

3.2.2 Evaporative Emissions

Evaporative emission measurements were determined using the SHED technique in accordance with the SAE J171a Recommended Practice (7) with the following modifications:

1. Vehicle background emissions were considered negligible based upon a previous study (8), and were therefore not determined. All test vehicles were over three (3) months old and had accumulated 4000 miles.

2. The 60 minute heat-build for the diurnal was held to ± 2 minutes.

3.2.3 Exhaust Emissions

Exhaust emissions were determined using the 1975 Federal Test Procedure. Since it is intended to integrate the evaporative procedure along with the exhaust test, it was decided to use the present (cold-hot) exhaust test procedure driving cycle rather than the cycle proposed in the SAE procedure.
4. Test Results

A total of 58 tests was conducted. Nineteen (19) tests were conducted with an LA-4 prep, thirty-five (35) tests were conducted using 2 HFET prep cycles, and four (4) tests using one LA-4 plus one HFET prep cycles were conducted. For a few tests, only the diurnal data were used due to void CVS tests and in a few other cases only the CVS test data were used due to void diurnal tests. The individual test results for the diurnal heat-build tests and exhaust emission tests are shown in Appendices A-1 and A-2 respectively. In addition to the diurnal test results, Appendix A-1 contains the canister weight data for all tests.

4.1 Evaporative Diurnal Emissions

The individual test results for evaporative emissions are shown in Appendix A-1 and the means of the diurnal losses for each of the vehicles along with a composite mean are shown in the bar graph, Figure 4-1.

The bar graph shows that for the Camaro, Vega and Volkswagen Beetle very little difference in diurnal loss levels was observed between the two prep cycles. However, for the Matador and New Yorker a sizable difference existed, with the test conducted with an HFET prep exhibiting lower diurnal losses. This would indicate that the HFET cycle may condition the canister more than does the LA-4 driving cycle. This would seem logical as the average speed of the HFET is approximately 29 mph higher than the LA-4 and therefore a greater potential for purging the canister exists with the HFET. Whether or not this will have an effect on the amount of purging is dependent on the characteristics of the individual purge systems, however.

![Figure 4-1 Diurnal HC Losses for LA4 and HFET Preps](image-url)
4.2 Canister Weights

Figure 4-2 shows the mean canister weights for each vehicle and prep cycle through the test sequence. It should be remembered that different control systems and purge systems are represented by the different vehicles. This fact makes it somewhat difficult to evaluate differences between the two prep drives as the different control systems may react differently to either of the prep cycles. Three important facts do, however, emerge from studying these figures. First, the amount of purging appears to depend on the initial level of canister weight. In comparing the Camaro and Vega diagrams it can be seen that for the Camaro the HFET cycle purges the canister more than the LA-4 cycle, but for the Vega just the opposite is true. However, for all vehicles a greater amount of purging takes place when the canister is at an initially higher weight. Secondly, it is apparent that in spite of different amounts of purging some systems are still capable of storing roughly the same amounts of diurnal losses. The Camaro, Vega, and Volkswagen show different trends in the amount of purging for the two prep drives, but the diurnal losses appear very nearly the same. For the Matador and New Yorker, the diurnal loss levels are larger than for the other three vehicles and they both appear to do better with the HFET preconditioning drive. This fact may be due to the particular system designs. These facts indicate that although the two driving cycles are not totally equivalent some vehicle systems will react equivalently to them, whereas other vehicle systems will not with respect to their diurnal losses.

The third important fact that can be drawn from Figure 4-2 is that the Matador purge system reacts differently to the LA-4 and 2 HFET preconditioning cycles. The Matador canister is loaded during the LA-4 driving cycle and is purged during the HFET cycle. The figure shows, however, that the initial weight of the canister is higher on the average at the beginning of the tests conducted using 2 HFET cycles than at the beginning of tests in which one LA-4 preconditioning cycle was used. Closer examination of individual tests indicate that the canister always loads during an LA-4 preconditioning cycle regardless of its initial weight. The amount of purging appears to be more sensitive to the initial weight of the canister during the 2 HFET cycles, however. The greatest amount of purging generally takes place when the initial weight is the highest. Thus, the LA-4 cycle does not appear to be capable of purging the Matador's canister whereas the 2 HFET cycles have the ability to purge the canister and the amount of purging is somewhat dependent on the amount of hydrocarbons already stored in the canister.

Canister weights during the combined preconditioning driving cycle of one LA-4 cycle plus one HFET cycle are presented in Table 4-1. These data are plotted as changes in canister weight during the preconditioning drive in Figure 4-3 along with the canister weight changes during one LA-4 cycle, two HFET cycles and an AMA drive plus one LA-4 cycle. The AMA + LA-4 preconditioning cycle data were taken from the "In-house Test Program Report No. 1" (2). Only data for the Matador are shown as
Figure 4-2 Mean Canister Weights During Test Sequence for LA-4 and HFET Prep Cycles
<table>
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<tr>
<th>Test No.</th>
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<tr>
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Table 4-1 Canister Weights for LA-4+HFET Preconditioning Tests on Matador.

Figure 4-3 Canister Weight changes during Preconditioning Cycles.
the Matador was the only vehicle which had a purge system which reacted differently to different cycles. However, the fact that a system can be designed which reacts as the Matador system does is an important consideration. The figure shows that the Matador system is purged to similar levels for either the LA-4 + HFET or 2 HFET preconditioning drives which implies that only a single HFET is needed to purge the canister. The canister weight data for the AMA + LA-4 prep showed that purging did take place during the AMA road route drive but due to the loading of the canister during the LA-4 cycle which followed, the overall effect on the canister during the preconditioning was a slight increase in canister weight. This fact reemphasizes the fact that the Matador canister cannot purge during an LA-4 cycle.

4.3 Exhaust Emission Results

It is felt that in order to conclude that the two preconditioning driving cycles are equivalent, similar exhaust results should also be exhibited regardless of prep cycle used. It was assumed that if any differences in exhaust emission levels existed they would be most noticeable in Bag 1 of the exhaust test. Therefore, both Bag 1 and composite exhaust results were analyzed. Mean Bag 1 exhaust levels are shown in Figure 4-4 and mean composite exhaust levels are shown in Figure 4-5.

The results from the Bag 1 exhaust analysis shown in Figure 4-4 indicate that, for the Camaro, Vega and Volkswagen, no large differences in exhaust emissions exist. This is also the case for those vehicles for composite exhaust results as indicated by Figure 4-5.

The Matador and New Yorker do show somewhat larger differences for some exhaust components between the two prep cycles. The New Yorker has higher HC and CO emissions for both Bag 1 and composite tests when the HFET is used as a preconditioning drive when compared to emissions levels seen when an LA-4 prep is used. Looking closer at individual data shows that the differences in CO levels are not statistically significant. However, differences in HC levels are statistically significant. A look at the individual test data reveals that HC levels increased with successive tests run with an LA-4 prep and that the HC level measured during the last test was as high as HC levels measured during the HFET preconditioning tests which were run some time later. The differences in exhaust HC and CO levels could have been due to a deterioration with time or other unaccounted for influences. The effect of the different preconditioning drives cannot be discounted as a possible cause, but an adequate explanation of why this should have the effect indicated cannot be found. The HC and CO emissions for Bag 1 and composite samples for the Matador show just the opposite trend with the higher emissions resulting when an LA-4 preconditioning drive is used. This result is strongly influenced by test No. 142 in which high HC and CO emissions occurred. The day after this test was conducted a recall notice was received for the Matador describing the need to have the
Figure 4-4a: HC emissions

Figure 4-4b: CO emissions

Figure 4-4c: CO₂ emissions

Figure 4-4d: NOₓ emissions

LA-4 Prep  
HFET Prep
carburetor fuel inlet sealing plug and secondary throttle lockout level replaced. One effect of this condition is to cause the throttle plates to stick open if a cold engine is accelerated to an open throttle position during the choking cycle. This particular test was run sometime after the first two tests on the Matador were conducted using an LA-4 prep. For this reason the exhaust emissions results of the Matador tests are somewhat questionable. The only other large difference in exhaust emissions was the difference in NOx levels between the two preps for the Matador. Again, the above mentioned problem could have been responsible for this result.

The figures also show that an average of all 5 vehicles tested shows very little difference for the different preconditioning drives.
5. Data Analysis

In order to determine if a statistically significant difference exists for mean diurnal or exhaust emission levels for tests conducted with either an LA-4 or HFET preconditioning drive, an analysis of variance test was performed. The analyses are shown in Appendix B to this report.

The analyses were based on the following hypotheses:

H0a: There is no statistically significant difference in emission levels between the five vehicles tested.

H0b: There is no statistically significant difference in emission levels between the two test sequences; one with an LA-4 and the other with an HFET preconditioning drive.

H0c: There is no statistically significant difference in emission levels due to the interaction of the test vehicle and the test sequence used.

The analysis of variance test requires that the number of replicate tests be the same for all tests. Three test results were chosen for each vehicle and test sequence. When it was necessary to eliminate test data, the middle values were used because only three tests were available for some of the vehicles. For example, if there were five test results, the high and low values were omitted and the remaining three values used.

The results of the analysis of variance tests are shown in Table 5-1. For both evaporative and exhaust emission tests the levels exhibited by the different vehicles were found to be different. A high level of confidence (90%) can be placed on this conclusion. The type of preconditioning drive used was found to significantly affect the diurnal emission levels only. A high level of confidence (95%) can be placed on the conclusion that the type of preconditioning drive used does have an effect on the diurnal losses encountered.

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Table 5-1 Summary of Analysis of Variance Evaluation
6. References


3. Vehicle Preconditioning Study, EPA-MSAPC In-House study conducted by MSAPC Ann Arbor, Michigan.


Appendix A-1a Evaporative Emission Results and Canister Weights for Tests Conducted with an LA-4 Prep.

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<th>Test No.</th>
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</tr>
<tr>
<td>0115</td>
<td>Volkswagen</td>
<td>4.44</td>
<td>37.0</td>
<td>1251</td>
<td>6.98</td>
<td>0.741</td>
<td>4.50</td>
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<tr>
<td>0116</td>
<td>Volkswagen</td>
<td>4.02</td>
<td>39.2</td>
<td>1254</td>
<td>6.61</td>
<td>0.930</td>
<td>5.00</td>
</tr>
<tr>
<td>0118</td>
<td>Volkswagen</td>
<td>4.35</td>
<td>39.2</td>
<td>1298</td>
<td>6.28</td>
<td>0.860</td>
<td>4.78</td>
</tr>
</tbody>
</table>
## Appendix B Analysis of Variance

### Analysis of Variance For Diurnal Loss Results

<table>
<thead>
<tr>
<th>Vehicle Test</th>
<th>Camaro</th>
<th>Matador</th>
<th>New Yorker</th>
<th>Vega</th>
<th>Volkswagen</th>
<th>( T_r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA-4 Prep</td>
<td>0.47</td>
<td>4.19</td>
<td>6.49</td>
<td>0.69</td>
<td>1.08</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.80</td>
<td>4.37</td>
<td>3.94</td>
<td>0.45</td>
<td>0.93</td>
<td>34.38</td>
</tr>
<tr>
<td></td>
<td>1.48</td>
<td>5.07</td>
<td>3.10</td>
<td>0.48</td>
<td>0.84</td>
<td></td>
</tr>
<tr>
<td>HFET Prep</td>
<td>0.61</td>
<td>2.91</td>
<td>2.51</td>
<td>0.52</td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.01</td>
<td>4.05</td>
<td>3.68</td>
<td>0.52</td>
<td>0.82</td>
<td>25.98</td>
</tr>
<tr>
<td></td>
<td>0.54</td>
<td>3.99</td>
<td>2.68</td>
<td>0.45</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>Tc</td>
<td>4.91</td>
<td>24.58</td>
<td>22.40</td>
<td>3.11</td>
<td>5.36</td>
<td>60.36</td>
</tr>
</tbody>
</table>

No. of columns, \( c = 5 \)

No. of rows, \( r = 2 \)

\[
\frac{T^2}{N} = 121.44
\]

\[
\Sigma X^2 = 208.66
\]

\[
\Sigma Tc^2 = 1168.45
\]

\[
\Sigma Tr^2 = 1856.94
\]

\[
\Sigma Tcr^2 = 598.91
\]

\[
SS_c = \frac{\Sigma Tc}{2/n'r} - \frac{T^2}{N} = 73.30
\]

\[
SS_r = \frac{\Sigma Tr}{2/n'c} - \frac{T^2}{N} = 2.35
\]

\[
SS_{cr} = \frac{\Sigma Tcr}{2/n} - \frac{T^2}{N} - SS_c - SS_r = 2.54
\]

\[
SS_t = \frac{\Sigma X^2}{T} - \frac{T^2}{N} = 87.22
\]

\[
SS_{res} = SS_t - SS_c - SS_r - SS_{cr} = 9.03
\]

### Source of Variation

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>M S, (SS/DF)</th>
<th>MSR, (MS/MS res)</th>
<th>( \frac{&lt;}{&gt;}(\alpha = 0.05) )</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles</td>
<td>73.30</td>
<td>5-1 = 4</td>
<td>18.33</td>
<td>40.73</td>
<td>&gt;</td>
<td>2.87</td>
</tr>
<tr>
<td>Test Type</td>
<td>2.35</td>
<td>2-1 = 1</td>
<td>2.35</td>
<td>5.22</td>
<td>&gt;</td>
<td>4.35</td>
</tr>
<tr>
<td>Vehicle-Test Interaction</td>
<td>2.54</td>
<td>(4) (1) = 4</td>
<td>0.64</td>
<td>1.42</td>
<td>&lt;</td>
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</tr>
<tr>
<td>Residual</td>
<td>9.02</td>
<td>29 - 9 = 20</td>
<td>0.45</td>
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<tr>
<td>Total</td>
<td>87.22</td>
<td>30 - 1 = 29</td>
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Hoc: Rejected a 95% C.L.

Noc: Rejected a 95% C.L.

Hoc: Accepted
## Analysis of Variance for Bag 1 HC Results

<table>
<thead>
<tr>
<th>Vehicle Test</th>
<th>Camaro</th>
<th>Matador</th>
<th>New Yorker</th>
<th>Vega</th>
<th>Volkswagen</th>
<th>$T_r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA-4 Prep</td>
<td>4.88</td>
<td>3.35</td>
<td>4.04</td>
<td>9.27</td>
<td>4.61</td>
<td>75.55</td>
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<tr>
<td></td>
<td>4.83</td>
<td>3.50</td>
<td>4.06</td>
<td>7.27</td>
<td>3.83</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.96</td>
<td>5.46</td>
<td>4.79</td>
<td>6.64</td>
<td>4.06</td>
<td></td>
</tr>
<tr>
<td>HFET Prep</td>
<td>5.16</td>
<td>3.61</td>
<td>5.46</td>
<td>7.02</td>
<td>4.14</td>
<td>79.80</td>
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<tr>
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<td>4.79</td>
<td>3.66</td>
<td>6.03</td>
<td>9.01</td>
<td>4.44</td>
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<tr>
<td></td>
<td>4.24</td>
<td>3.59</td>
<td>5.29</td>
<td>9.01</td>
<td>4.35</td>
<td></td>
</tr>
<tr>
<td>$T_c$</td>
<td>28.86</td>
<td>23.17</td>
<td>29.67</td>
<td>48.22</td>
<td>25.42</td>
<td></td>
</tr>
</tbody>
</table>

No. of columns, $c = 5$

No. of rows, $r = 2$

$T^2/N = 804.45$

$E \times r^2 = 884.49$

$E Tc^2 = 5221.9$

$E Tr^2 = 12076$

$E Tc^2 = 2621.5$

$SS_c = E Tc^2/N - T^2/N = 65.87$

$SS_r = E Tr^2/N - T^2/N = 0.62$

$SS_{cr} = E Tc^2/N - T^2/N - SS_c - SS_r = 2.89$

$SS_t = E X^2 - T^2/N = 80.04$

$SS_{res} = SS_c - SS_r - SS_t - SS_{cr} = 10.66$

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>M.S. (SS/DF)</th>
<th>MSR, (MS/MS res)</th>
<th>$&lt; \alpha = 0.10$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles</td>
<td>65.87</td>
<td>5-1</td>
<td>16.47</td>
<td>30.90</td>
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<tr>
<td>Year Type</td>
<td>0.62</td>
<td>2-1</td>
<td>0.62</td>
<td>1.17</td>
<td>$&lt;$</td>
</tr>
<tr>
<td>Vehicle-Test</td>
<td>2.89</td>
<td>(4)</td>
<td>0.72</td>
<td>1.36</td>
<td>$&lt;$</td>
</tr>
<tr>
<td>Interaction</td>
<td>10.66</td>
<td>29-9</td>
<td>0.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<td>30-1</td>
<td>29</td>
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</table>

Note: Rejected a 90% C.L.

Note: Accepted

Note: Accepted
### Analysis of Variance for Bag 1 CO Results

<table>
<thead>
<tr>
<th>Vehicle Test</th>
<th>Camaro</th>
<th>Matador</th>
<th>New Yorker</th>
<th>Vega</th>
<th>Volkswagen</th>
<th>( T_r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA-4 Prep</td>
<td>84.8</td>
<td>48.9</td>
<td>173</td>
<td>117</td>
<td>35.4</td>
<td>1420</td>
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<tr>
<td></td>
<td>93.6</td>
<td>49.0</td>
<td>158</td>
<td>105</td>
<td>36.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>84.6</td>
<td>82.0</td>
<td>204</td>
<td>115</td>
<td>34.0</td>
<td></td>
</tr>
<tr>
<td>HFET Prep</td>
<td>86.7</td>
<td>55.0</td>
<td>222</td>
<td>112</td>
<td>36.9</td>
<td>1507</td>
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<tr>
<td></td>
<td>91.1</td>
<td>55.7</td>
<td>205</td>
<td>116</td>
<td>37.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>91.6</td>
<td>54.0</td>
<td>177</td>
<td>128</td>
<td>39.2</td>
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<tr>
<td>( T_c )</td>
<td>532</td>
<td>344</td>
<td>1139</td>
<td>693</td>
<td>219</td>
<td></td>
</tr>
</tbody>
</table>

No. of columns, \( c = 5 \)
No. of rows, \( r = 2 \)
No. of replicates, \( n = 3 \)
Total No. of tests, \( N = 30 \)

\[
T^2/N = 2.8558 \times 10^5
\]

\[
\sum x^2 = 3.7533 \times 10^5
\]

\[
\frac{Tc}{T^2} = 2.2269 \times 10^6
\]

\[
\sum Tr^2 = 4.2874 \times 10^6
\]

\[
\sum Tc^2 = 1.1163 \times 10^6
\]

\[
SS_c = \sum Tc^2/n - T^2/N = 8.557 \times 10^4
\]

\[
SS_r = \sum Tr^2/n - T^2/N = 2.467 \times 10^2
\]

\[
SS_{cr} = \sum Tc^2/n - T^2/N - SS_c - SS_r = 7.0330 \times 10^2
\]

\[
SS_T = \sum x^2 - T^2/N = 8.975 \times 10^4
\]

\[
SS_{res} = SS_T - SS_c - SS_r - SS_{cr} = 3.230 \times 10^3
\]

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>M S, (SS/DF)</th>
<th>MSR, (MS/MS res)</th>
<th>(&lt;) (( \alpha = 0.10 ))</th>
<th>( F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles</td>
<td>85570</td>
<td>5-1  = 4</td>
<td>21739</td>
<td>132.4</td>
<td>&gt;</td>
<td>2.25</td>
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<tr>
<td>Test Type</td>
<td>246.7</td>
<td>2-1  = 1</td>
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<td>1.53</td>
<td>&lt;</td>
<td>2.97</td>
</tr>
<tr>
<td>Vehicle-Test Interaction</td>
<td>703.3</td>
<td>(4) (1) = 4</td>
<td>175.8</td>
<td>1.09</td>
<td>&lt;</td>
<td>2.25</td>
</tr>
<tr>
<td>Residual</td>
<td>3230</td>
<td>29 - 9 = 20</td>
<td>161.5</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>89750</td>
<td>30 - 1 = 29</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

H0a: Rejected at 90% C.L.
H0b: Accepted
H0c: Accepted
### Analysis of Variance for Bag 1 CO₂ Results

<table>
<thead>
<tr>
<th>Vehicle Test</th>
<th>Camaro</th>
<th>Matador</th>
<th>New Yorker</th>
<th>Vega</th>
<th>Volkswagen</th>
<th>Tr</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA-4 Prep</td>
<td>2334</td>
<td>2380</td>
<td>3083</td>
<td>1210</td>
<td>1223</td>
<td>30759</td>
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<tr>
<td></td>
<td>2317</td>
<td>2331</td>
<td>3102</td>
<td>1218</td>
<td>1229</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2325</td>
<td>2478</td>
<td>3100</td>
<td>1188</td>
<td>1241</td>
<td></td>
</tr>
<tr>
<td>HFET Prep</td>
<td>2340</td>
<td>2466</td>
<td>3041</td>
<td>1208</td>
<td>1265</td>
<td>31122</td>
</tr>
<tr>
<td></td>
<td>2372</td>
<td>2463</td>
<td>3092</td>
<td>1212</td>
<td>1262</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2397</td>
<td>2450</td>
<td>3073</td>
<td>1227</td>
<td>1254</td>
<td></td>
</tr>
<tr>
<td>Tc</td>
<td>14085</td>
<td>14568</td>
<td>18491</td>
<td>7263</td>
<td>7474</td>
<td>T² = 61881</td>
</tr>
</tbody>
</table>

No. of columns, c = 5
No. of rows, r = 2
No. of replicates, n = 3
Total No. of tests, N = 30

\[
T = \frac{2}{N} = 1.276 \times 10^8
\]

\[
E \times T = 1.436 \times 10^8
\]

\[
\sum Tc^2 = 8.611 \times 10^8
\]

\[
\sum Tc^2 = 1.915 \times 10^9
\]

\[
\sum Tc^2 = 4.306 \times 10^8
\]

\[
SS_c = \sum Tc^2/n \cdot c - T^2/N = 1.592 \times 10^7
\]

\[
SS_r = \sum Tc^2/n \cdot c - T^2/N = 4.392 \times 10^3
\]

\[
SS_{cr} = \sum Tc^2/n \cdot c - SS_c - SS_r = 8.941 \times 10^3
\]

\[
SS_t = E \times T^2 - T^2/N = 1.600 \times 10^7
\]

\[
SS_{res} = SS_t - SS_c - SS_r - SS_{cr} = 6.667 \times 10^6
\]

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>M.S., (SS/DF)</th>
<th>MSR, (MS/MS res)</th>
<th>&lt;</th>
<th>F (α = 0.10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles</td>
<td>1.592 x 10^7</td>
<td>5-1 = 4</td>
<td>3.980 x 10^6</td>
<td>1194</td>
<td>&gt;&gt;</td>
<td>2.25</td>
</tr>
<tr>
<td>Test Type</td>
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<td>2-1 = 1</td>
<td>4.392 x 10^3</td>
<td>1.318</td>
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<td>2.97</td>
</tr>
<tr>
<td>Vehicle-Test Interaction</td>
<td>8.941 x 10^3</td>
<td>(4) (1) = 4</td>
<td>2.235 x 10^3</td>
<td>.671</td>
<td>&lt;</td>
<td>2.25</td>
</tr>
<tr>
<td>Residual</td>
<td>6.667 x 10^6</td>
<td>29 - 9 = 20</td>
<td>3.333 x 10^3</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1.600 x 10^7</td>
<td>30 - 1 = 29</td>
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</tbody>
</table>

\*Note: Rejected a 90% C.L.

\*H0: Accepted

\*H1: Accepted
### Analysis of Variance for Bag 1 NO\textsubscript{x} Results

<table>
<thead>
<tr>
<th>Vehicle Test</th>
<th>Camaro</th>
<th>Matador</th>
<th>New Yorker</th>
<th>Vega</th>
<th>Volkswagen</th>
<th>T&lt;sub&gt;r&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA-4 Prep</td>
<td>7.27</td>
<td>9.19</td>
<td>8.13</td>
<td>5.61</td>
<td>8.02</td>
<td>114.00</td>
</tr>
<tr>
<td></td>
<td>7.71</td>
<td>8.69</td>
<td>9.61</td>
<td>6.10</td>
<td>6.26</td>
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</tr>
<tr>
<td></td>
<td>7.89</td>
<td>9.29</td>
<td>7.63</td>
<td>5.89</td>
<td>6.71</td>
<td></td>
</tr>
<tr>
<td>HFET Prep</td>
<td>7.84</td>
<td>10.3</td>
<td>8.86</td>
<td>5.84</td>
<td>6.20</td>
<td>116.11</td>
</tr>
<tr>
<td></td>
<td>7.89</td>
<td>10.9</td>
<td>7.53</td>
<td>6.19</td>
<td>6.61</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.46</td>
<td>10.6</td>
<td>7.86</td>
<td>5.75</td>
<td>6.28</td>
<td></td>
</tr>
<tr>
<td>T&lt;sub&gt;c&lt;/sub&gt;</td>
<td>46.06</td>
<td>58.97</td>
<td>49.62</td>
<td>35.38</td>
<td>40.08</td>
<td>230.11</td>
</tr>
</tbody>
</table>

No. of columns, c = 5  
No. of rows, r = 2  

\[ \frac{\sum x^2}{r} = 1380.06 \]  
\[ \frac{\sum Tc^2}{c} = 10919 \]  
\[ \sum Tc^2 = 26477 \]  
\[ \sum Tc^2 = 5672.86 \]  
\[ SS_c = \frac{\sum Tc}{2/n} - \frac{T^2}{N} = 54.81 \]  
\[ SS_T = \frac{\sum Tr}{2/n} - \frac{T^2}{N} = 0.148 \]  
\[ SS_{cT} = \frac{\sum Tc}{2/n} - \frac{T^2}{N} - SS_c - SS_T = 4.309 \]  
\[ SS_T = \frac{\sum x^2}{2} - \frac{T^2}{N} = 65.090 \]  
\[ SS_{res} = SS_T - SS_c - SS_T - SS_{cT} = 5.823 \]

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS, (SS/DF)</th>
<th>MSR, (MS/MS res)</th>
<th>&lt;</th>
<th>P (α = 0.10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles</td>
<td>54.81</td>
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<td>13.70</td>
<td>47.06</td>
<td>&gt;</td>
<td>2.25</td>
</tr>
<tr>
<td>Test Type</td>
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<td>2-1=1</td>
<td>0.148</td>
<td>0.509</td>
<td>&lt;</td>
<td>2.97</td>
</tr>
<tr>
<td>Vehicle-Test Interaction</td>
<td>4.309</td>
<td>(4)(1)=4</td>
<td>1.077</td>
<td>3.702</td>
<td>&gt;</td>
<td>2.25</td>
</tr>
<tr>
<td>Residual</td>
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H0: Rejected at 90% C.L.  
H1: Accepted  
H2: Accepted
### Analysis of Variance for Composite HC Results

| Vehicle | Camaro | Matador | New Yorker | Vega | Volkswagen | T
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.524</td>
<td>.283</td>
<td>.372</td>
<td>.675</td>
<td>.832</td>
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<tr>
<td></td>
<td>.507</td>
<td>.703</td>
<td>.462</td>
<td>.679</td>
<td>.941</td>
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</tr>
<tr>
<td>HFET Prep</td>
<td>.514</td>
<td>.297</td>
<td>.419</td>
<td>.630</td>
<td>.891</td>
<td>8.464</td>
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<tr>
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<td>.524</td>
<td>.302</td>
<td>.489</td>
<td>.748</td>
<td>.930</td>
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<tr>
<td></td>
<td>.431</td>
<td>.296</td>
<td>.388</td>
<td>.745</td>
<td>.860</td>
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</tr>
<tr>
<td>T&lt;sub&gt;c&lt;/sub&gt;</td>
<td>3.028</td>
<td>2.165</td>
<td>2.340</td>
<td>4.242</td>
<td>5.346</td>
<td>F=17.121</td>
</tr>
</tbody>
</table>

No. of columns, c = 5  
No. of rows, r = 2  
No. of replicates, n = 3  
Total No. of tests, N = 30

\[
T^2/N = 9.771 \\
F \times F = 11.203 \\
\Sigma Tc^2 = 65.906 \\
\Sigma Tr^2 = 146.583 \\
\Sigma Tcr^2 = 33.059 \\
SS_c = \Sigma Tc^2/n \cdot r - T^2/N = .1213 \\
SS_r = \Sigma Tr^2/n \cdot c - T^2/N = .00124 \\
SS_cr = \Sigma Tcr^2/n - T^2/N - SS_c - SS_r = .03443 \\
SS_T = \Sigma X^2 - T^2/N = 1.4320 \\
SS_res = SS_T - SS_c - SS_r - SS_cr = .1833
\]

| Source of Variation | SS    | DF | M S<sub>c</sub> (SS/DF) | MSR, (MS/MS res) | < | F  
|---------------------|-------|----|-------------------------|------------------|---|--- 
| Vehicles            | 1.213 | 5-1=4 | 0.303                   | 33.06            | > | 2.25       
| Test Type           | 1.24 x 10^-3 | 2-1=1 | 1.24 x 10^-3          | .135             | < | 2.97       
| Vehicle-Test        | 3.443 x 10^-2 | (4) (1)=4 | 3.608 x 10^-3          | .939             | < | 2.25       
| Interaction         |       |     | 29 - 9 = 20             | 9.17 x 10^-3     |   |            
| Residual            | .1833 |      |                         |                  |   |            
| Total               | 1.4320 | 30-1=29 |                   |                  |   |            

H0: Rejected a 90% C.L.  
H1: Accepted  
H2: Accepted
## Analysis of Variance for Composite CO Results

<table>
<thead>
<tr>
<th>Vehicle Test</th>
<th>Camaro</th>
<th>Matador</th>
<th>New Yorker</th>
<th>Vega</th>
<th>Volkswagen</th>
<th>$T_F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA-4 Prep</td>
<td>9.32</td>
<td>3.06</td>
<td>10.4</td>
<td>11.5</td>
<td>4.27</td>
<td>138.56</td>
</tr>
<tr>
<td></td>
<td>11.1</td>
<td>3.01</td>
<td>14.5</td>
<td>10.6</td>
<td>4.39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.91</td>
<td>7.29</td>
<td>21.6</td>
<td>13.3</td>
<td>4.31</td>
<td></td>
</tr>
<tr>
<td>HFET Prep</td>
<td>9.23</td>
<td>3.51</td>
<td>15.8</td>
<td>11.7</td>
<td>4.73</td>
<td>144.98</td>
</tr>
<tr>
<td></td>
<td>13.4</td>
<td>3.48</td>
<td>20.2</td>
<td>11.9</td>
<td>4.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.5</td>
<td>5.55</td>
<td>14.8</td>
<td>12.9</td>
<td>4.78</td>
<td></td>
</tr>
<tr>
<td>$T_C$</td>
<td>63.46</td>
<td>23.90</td>
<td>97.30</td>
<td>71.90</td>
<td>26.98</td>
<td></td>
</tr>
</tbody>
</table>

No. of columns, $c = 5$
No. of replicates, $n = 3$
Total No. of tests, $N = 30$

\[
T^2/N = 2679.8
\]

\[
\sum x^2 = 3441.5
\]

\[
\sum Tc^2 = 19963
\]

\[
\sum Tc^2 = 40218
\]

\[
\sum Tcr^2 = 9999.9
\]

\[
SS_c = \sum Tc^2/n - T^2/N = 667.4
\]

\[
SS_F = \sum Tc^2/n^c - T^2/N = 1374
\]

\[
SS_cr = \sum Tcr^2/n - T^2/N - SS_c - SS_F = 4726
\]

\[
SS_e = \sum x^2 - T^2/N = 761.8
\]

\[
SS_{res} = SS_e - SS_c - SS_F - SS_cr = 108.3
\]

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS, (SS/DF)</th>
<th>MSR, (MS/MS res)</th>
<th>&lt;</th>
<th>F</th>
<th>(α = 0.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles</td>
<td>647.4</td>
<td>5-1=4</td>
<td>161.8</td>
<td>29.9</td>
<td>&gt;</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td>Test Type</td>
<td>1.374</td>
<td>2-1=1</td>
<td>1.374</td>
<td>.254</td>
<td>&lt;</td>
<td>2.97</td>
<td></td>
</tr>
<tr>
<td>Vehicle-Test</td>
<td>4.726</td>
<td>(4)(1) = 4</td>
<td>1.182</td>
<td>.218</td>
<td>&lt;</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual</td>
<td>108.3</td>
<td>29-9 = 20</td>
<td>5.415</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>761.8</td>
<td>30-1 = 29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- H0a: Rejected a 90% C.L.
- H0b: Accepted
- H0c: Accepted
## Analysis of Variance for Composite CO₂ Results

<table>
<thead>
<tr>
<th>Vehicle Test</th>
<th>Camaro</th>
<th>Matador</th>
<th>New Yorker</th>
<th>Vega</th>
<th>Volkswagen</th>
<th>Tᵣ</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA-4 Prep</td>
<td>647</td>
<td>649</td>
<td>818</td>
<td>358</td>
<td>361</td>
<td></td>
</tr>
<tr>
<td></td>
<td>643</td>
<td>637</td>
<td>879</td>
<td>353</td>
<td>368</td>
<td></td>
</tr>
<tr>
<td></td>
<td>645</td>
<td>671</td>
<td>858</td>
<td>348</td>
<td>358</td>
<td>8593</td>
</tr>
<tr>
<td>HFRT Prep</td>
<td>649</td>
<td>657</td>
<td>853</td>
<td>358</td>
<td>360</td>
<td></td>
</tr>
<tr>
<td></td>
<td>640</td>
<td>667</td>
<td>867</td>
<td>362</td>
<td>365</td>
<td></td>
</tr>
<tr>
<td></td>
<td>657</td>
<td>661</td>
<td>868</td>
<td>359</td>
<td>361</td>
<td>8684</td>
</tr>
<tr>
<td>( T_c )</td>
<td>3881</td>
<td>3942</td>
<td>5143</td>
<td>2138</td>
<td>2173</td>
<td>T=47277</td>
</tr>
</tbody>
</table>

No. of columns, \( c = 5 \)
No. of rows, \( r = 2 \)

\[
T^2/N = 9.9498 \times 10^6
\]
\[
\prod \tau = 1.106 \times 10^7
\]
\[
\prod T_c^2 = 6.6345 \times 10^7
\]
\[
\prod T_r^2 = 1.4925 \times 10^8
\]
\[
\prod T_c r^2 = 3.3174 \times 10^7
\]

\[
SS_c = \prod T_c 2/n \cdot r - T^2/N = 1.1077 \times 10^6
\]

\[
SS_r = \prod T_r 2/n \cdot c - T^2/N = 276.03
\]

\[
SS_{cr} = \prod T_{cr} 2/n - T^2/N - SS_c - SS_r = 90.00
\]

\[
SS_t = \prod x^2 - T^2/N = 1.1102 \times 10^6
\]

\[
SS_{res} = SS_t - SS_c - SS_r - SS_{cr} = 2.1340 \times 10^3
\]

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>MS, ((SS/DF))</th>
<th>MSR, ((MS/MS \text{ res}))</th>
<th>( \chi^2 ) (( \alpha = 0.10 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles</td>
<td>1.1077 \times 10^6</td>
<td>5-1-4</td>
<td>2.769 \times 10^5</td>
<td>2395</td>
<td>( \gg )</td>
</tr>
<tr>
<td>Test Type</td>
<td>276.03</td>
<td>2-1</td>
<td>276.03</td>
<td>2.59</td>
<td>( &lt; )</td>
</tr>
<tr>
<td>Vehicle-Test</td>
<td>90.00</td>
<td>( (4) \ (1) = 4 )</td>
<td>22.50</td>
<td>( .2 \times 109 )</td>
<td>( &lt; )</td>
</tr>
<tr>
<td>Interaction</td>
<td>2134</td>
<td>29 - 9 = 20</td>
<td>106.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual</td>
<td></td>
<td>30 - 1 = 29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1.1102 \times 10^6</td>
<td>30</td>
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</tr>
</tbody>
</table>

H₀: Rejected \( a 90\% \text{ C.L.} \)
H₁: Accepted
H₂: Rejected
Analysis of Variance for Composite NO Results

<table>
<thead>
<tr>
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<th>Vega</th>
<th>Volkswagen</th>
<th>Tr</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA-4 Prep</td>
<td>1.24</td>
<td>2.27</td>
<td>1.72</td>
<td>1.46</td>
<td>1.79</td>
<td>25.53</td>
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<tr>
<td>1.38</td>
<td>1.99</td>
<td>2.46</td>
<td>1.60</td>
<td>1.37</td>
<td>1.42</td>
<td></td>
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<tr>
<td>1.21</td>
<td>2.28</td>
<td>1.88</td>
<td>1.46</td>
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<td></td>
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<tr>
<td>HFET Prep</td>
<td>1.31</td>
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<td>1.48</td>
<td>1.34</td>
<td>26.63</td>
</tr>
<tr>
<td>1.23</td>
<td>2.60</td>
<td>1.89</td>
<td>1.54</td>
<td>1.45</td>
<td>1.40</td>
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<tr>
<td>1.37</td>
<td>2.54</td>
<td>1.89</td>
<td>1.52</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tc</td>
<td>7.74</td>
<td>14.38</td>
<td>12.21</td>
<td>9.06</td>
<td>8.77</td>
<td>52.16</td>
</tr>
</tbody>
</table>

No. of columns, c = 5
No. of rows, r = 2
No. of replicates, n = 3
Total No. of tests, N = 30

\[T^2 / N = 90.69\]
\[E \times T^2 = 96.78\]
\[E Tc^2 = 574.77\]
\[E Tr^2 = 1360.94\]
\[E Tcr^2 = 288.31\]

\[SS_C = E Tc / n - \frac{T^2}{N} = 5.11\]
\[SS_T = E Tr^2 / n - \frac{T^2}{N} = 0.0403\]
\[SS_{CR} = E Tcr^2 / n - \frac{T^2}{N} - SS_C - SS_T = 0.2658\]
\[SS_T = E \times T^2 - \frac{T^2}{N} = 6.09\]
\[SS_{Res} = SS_T - SS_C - SS_T - SS_{CR} = 0.6739\]

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>DF</th>
<th>M S, (SS/DF)</th>
<th>SSR, (MS/MSS)</th>
<th>&lt;</th>
<th>F (a = 0.10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles</td>
<td>5.11</td>
<td>5-1 = 4</td>
<td>1.28</td>
<td>38.0</td>
<td>&gt;</td>
<td>2.25</td>
</tr>
<tr>
<td>Test Type</td>
<td>0.0403</td>
<td>2-1 = 1</td>
<td>0.0403</td>
<td>1.20</td>
<td>&lt;</td>
<td>2.97</td>
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<tr>
<td>Vehicle-Test</td>
<td>0.2658</td>
<td>(4)(1) = 6</td>
<td>0.0665</td>
<td>1.97</td>
<td>&lt;</td>
<td>2.25</td>
</tr>
<tr>
<td>Interaction</td>
<td>0.6739</td>
<td>29 - 9 = 20</td>
<td>0.0337</td>
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</tr>
<tr>
<td>Residual</td>
<td>6.09</td>
<td>30 - 1 = 29</td>
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<tr>
<td>Total</td>
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</tbody>
</table>

Note: Rejected at 90% C.L.
Hib: Accepted
Noc: Accepted