Appendix 1: Test Procedure

1.0 Objective and Background

The objectives are to:

1. **Collect emissions and canister purge flow data using the following vehicle operating modes:**

   - Two Acceleration Simulation Modes (5015 and 2525)
   - A 50 mph steady sta te mode at road load
   - An idle mode in Drive
   - An idle mode in Neutral

2. Make the emissions measurements using a certified BAR90 analyzer (for HC, CO, and CO_2) with an integrated NO analyzer of the fuel cell type for NO measurements.

EPA will use the data to compare the effectiveness of these procedures as a substitute or alternative to the IM240. On July 7 or 8, 1992, the Office of Management and Budget (OMB) cleared EPA's proposed I/M Rule, which currently requires the IM240 procedure to be used for I/M testing in some areas. In negotiations with OMB, EPA agreed to evaluate the Acceleration Simulation Mode short test as an alternative to the IM240. When EPA agreed to perform this evaluation, it was anticipated that enough time was available for a fair evaluation. However, a July 9, 1992, court order (Natural Resources Defense Council versus U.S. EPA) requires the EPA administrator to sign the final I/M rule by October 27, 1992 and publish it by November 6, 1992. This means that EPA should get the final rule to OMB early in October, so the need to collect this data is urgent. The proposed I/M rule was signed by the Administrator on July 9, 1992, and published on July 28, 1992.

The proponents of the Acceleration Simulation Mode Test (ASM) persuaded OMB that these tests were almost as effective as the IM240 as an I/M test, but because the equipment required for the ASM is considerably less expensive, it allows a "test & repair" type of I/M network to continue, whereas requiring the IM240, they claim, would force businesses to go to a "test-only" type of I/M network.

The lower cost of the emissions measurement equipment is the salient feature that makes the ASM attractive to its proponents. Therefore it is important to evaluate data collected with durable economical equipment recommended by ASM proponents (such as systems used in Florida) **Was the analyzer used so proven? J.S. told me it was a prototype NO analyzer** , along with the ASM procedure. Although more expensive IM240-type equipment can be used to collect ASM emissions data, it will not provide EPA with the information needed to determine whether the economical equipment is suitable. On the other hand, the ASM proponents are not likely to accept EPA's evaluation of data collected using unproven or prototype economical equipment. It is therefore crucial to use proven equipment, such as that used in Florida utilizing a fuel-cell NO analyzer.

EPA must evaluate the effectiveness of the ASM test, using the economical emissions measurement equipment, that the ASM proponents recommend as alternatives to IM240 with the CVS-based emissions measurement system that EPA now requires in the proposed I/M rule.

2.0 Phoenix Lane Procedure

The following is a description of the performance of the necessary evaluation conducted under an EPA contract with Automotive Testing Laboratories, Inc. (ATL) in Phoenix, Arizona.

ATL ~~shall manage~~ **managed** this project in such a way that bias ~~is~~ **was** not introduced to the evaluation of the ASM steady state procedures with the Allen analyzers **If I'm not mistaken, Allen's analyzer was not used** . Whenever ATL ~~becomes~~ **became** aware that a procedural bias ~~exists~~ **existed**, the project officer ~~will be~~ **was** immediately informed to initiate discussions on how to alleviate the bias.

Because of the urgent need for these data, the "EF & IM240 Targeted Repairs" task ~~will be~~ **was** suspended after the cars currently at the lab ~~are~~ **were** completed. The "Resting Losses & Diurnals" task and the "Commercial Repairs" task ~~will be~~ **was** restricted to the vehicles that will be tested for this task, which are discussed below.

- This procedure ~~will be~~ **was** restricted to 1983 and newer light duty vehicles with fuel injection, when available. Carbureted 1983 & newer vehicles ~~will be~~ **were** tested when fuel injected vehicles ~~are~~

were unavailable. Pre-1983 light duty vehicles ~~will be~~ **were** tested only when 1983 and newer vehicles ~~are~~ **were** unavailable.

- Each light duty vehicle ~~shall receive~~ **received**:

1. A steady state series that~~includes~~ included the following modes in the sequence listed:

-

ASM5015 with purge,
-

ASM2525 with purge,
- 50 mph at road load, with purge,
-

idle test (automatic transmissions in drive),
-

idle test (automatic transmissions in neutral) for the first 50 cars. Car 51 and subsequent cars will not get the 5th mode.

These four or five modes will be referred to as the ASM series.

2. An IM240 with purge.

3. A pressure test.

****1,2,and 3 above need to be indented the next section is section 2.1****

~~2.1~~ 3.1 Procedure Sequence

- In general all odd numbered vehicles got the IM240 as the initial test and all even numbered vehicles got the ASM as the initial test.

- The first car tested each day ~~will get~~ **got** the IM240 as the initial test, directly followed by the ASM series. The second car tested each day ~~will get~~ **got** the ASM series as the initial test, directly followed by the IM240. This means that all odd numbered vehicles ~~will get~~ **got** the IM240 as the initial test and all even numbered

vehicles ~~will get~~ **got** the ASM series as the initial test. As an alternative, all odd run numbers ~~get~~ **got** IM240s first and all even run numbers ~~get~~ **got** the ASM series first. ~~ATL can recommend a method that is efficient and unbiased~~ ATL

- Data collected ~~shall include~~ **included** a number 1 or 2 in a field named ~~"Lane ASM"~~ "Test.order" to designate whether the ASM series procedure was run first or second. This is redundant, but ~~will function~~ **functioned** as a check-digit to help ensure accurate communication.

~~2.2~~ 3.2 Measurement Equipment

- For the ASM series, a certified BAR90 HC/CO/CO_2 exhaust emission analyzer ~~shall be~~ **was** used to measure HC, CO, and CO_2, with an integrated NO analyzer using a fuel cell sensor. For policy reasons, a prototype analyzer ~~can~~ **was** not be used for this testing, since it ~~will~~ **would** open the data to question. **Again, was the analyzer used really like a Florida analyzer?** Florida is the only I/M program utilizing NO analyzers for light duty vehicles in high-production centralized I/M lanes. ATL ~~should~~ only ~~acquire~~ **acquired** a NO analyzer/BAR90 analyzer combination proven in high-production testing that ~~can provide~~ **provided** second-by-scond data for HC, CO, CO_2, and NO. The data output from the analyzers ~~shall go~~ **went** to 3-1/2 inch floppy discs that ~~include~~ **included** ~~the~~ run number, time (sec), mode number, vehicle speed, purge flow, NO (ppm), HC (ppm), CO2 (%), CO (%), actual torque, required torque, actual horsepower and required horsepower. ~~and the time (in 24 hour format) at the beginning of each mode and at engine start.~~

- A 50 liter/min Sierra flow meter ~~will be~~ **was** used to measure total canister purge flow. The flow meter system output ~~will be~~ **was** the cumulative second-by-second data for total flow recorded on the 3-1/2" floppy discs discussed above ~~that includes~~ **included** ~~the run number and the time (in 24 hour format) at the beginning of each mode and at engine start, in ASCII format.~~

- For the IM240, normal measurements with the CVS system ~~will continue~~ **continued** at the lane, including purge flow. ~~AT the earliest possible date, the~~ **The** contractor ~~shall upgrade~~ **upgraded** the measurement capabilities to report the following measurements:

We didn't use this upgrade data for anything and I've have never seen it before. I'd delete all but the first sentence of this section.

Number of seconds from key-on to:

1. **start of procedure**
2. **start of purge (must separate noise from start of purge)**
3. **first reading of ³1.0 liters/minute**
   first reading of ³5.0 liters/minute
4. **1 liter of purge**

~~Total purge from start of procedure to end of procedure, as is now being reported, shall continue.~~

ATL ~~shall~~ **did** not delay the initiation of testing to provide items 2 through 4, but item 1 ~~should be~~ **was** implemented with the first test. ~~Also, if ATL can more quickly provide second-by-second purge (total purge up to the particular second reported) along with #1, EPA can use the second-by-second data to determine items 2 through 4.~~

- The Clayton electric dyno ~~will be~~ **was** used for both the ASM series and the IM240.

2.3 Procedure Details

- The Clayton dyno ~~will be~~ **was** used for both the IM240 and the ASM series. The dyno horsepower settings for the ASMs test are listed in Attachment 1. The horsepower and inertia weight settings for the IM240 ~~will be~~ **were** as normally performed. The minimum inertia weight setting (2,000 lbs.) ~~shall be~~ **was** used for the ASMs.

- Manual transmission vehicles ~~will be~~ **were** tested in second gear for both the ASM5015 and the ASM2525. The 50 mph road load mode ~~will use~~ **used** the top non-overdrive gear, typically 4th gear on a 5-speed, 4th gear on a 4-speed, and 3rd gear on a 3-speed.

- The engine ~~will be~~ **was** shut off prior to the IM240 and the ASM5015 (as will normally be done by I/M programs to connect the purge meter), regardless of which procedure ~~is~~ **was** performed first, and restarted just prior to initiating these procedures. The engine ~~should~~ **was** not ~~be~~ shut off between modes, and the vehicle ~~should be~~ **was ~~not~~ **cars did not return to idle****accelerated from the current mode up to the next mode speed, without first returning to zero.

- The ASM emission sampling period and the canister purge flow measurement period ~~are~~ **were** as follows:

1. The exhaust emission measurement period for each ASM mode ~~will begin~~ **was begun** after the vehicle speed ~~has~~ **had** achieved the nominal speed (15, 25, or 50 mph, and 0 mph idle) ±2 mph. The sampling period ~~will continue~~ **continued** for 30 seconds after the exhaust sample first ~~gets~~ **got** to the analyzer sensor. The emission scores for HC, CO, CO_2, & NO ~~will be~~ **were** reported every second for 30 seconds on each mode. CO_2 ~~is~~ **was** not absolutely necessary, but ~~is~~ **was** desirable.

1. Each ASM mode was initiated after the vehicle speed had achieved the nominal speed (15, 25, or 50 mph, and 0 mph idle) ±2 mph. Once up to speed, sampling of one second average concentrations continued for 40 seconds. Emission scores for HC, CO, CO2 and NO were reported for each second. Emissions scores for the first 10 seconds of each mode were ignored to allow the dynamometer to stabilize and to allow for the transport of the exhaust to the analyzer.

2. ~~The purge flow reported shall be~~ **was** ~~the total flow from the start of the acceleration to the end of the 30 second emission sampling period for each mode.~~ The purge flow reported was the second by second cummulative flow over the entire ASM cycle, including transient accelerations. The nominal acceleration rate ~~should be~~ **was** 3.3 mph/sec., with a minimum acceleration rate of 1.8 mph/sec and a maximum of 4.3 mph/sec. The table below lists the minimum, nominal, and maximum acceleration times **used** to accelerate from one mode to another. For example, the table shows that the time to accelerate from 25 mph to 50 mph should be 7.6 secs., but can take as long as 13.9 secs., and as little as 5.8 secs. The zero to 60 mph time is provided to indicate how the specified acceleration times relate to a commonly known reference of vehicle performance.

	Acceleration Rate (mph/sec)	Time to Accelerate from-to: 0-15 mph (secs)	15-25 mph (secs)	25-50 mph (secs)	0-60 mph (secs)
Minimum	4.3	3.5	2.3	5.8	14.0
Nominal	**3.3**	**4.5**	3.0	7.6	**18.2**
Maximum	1.8	8.3	5.6	13.9	33.3

- During the accelerations between modes, the dynamometer load setting ~~shall~~ **did** not exceed road load.

3.0 Lab Recruitment

Light duty vehicles that received all of the lane tests (IM240, ASM series, and Arizona I/M test), ~~will be~~ **were** recruited for testing at ATL's laboratory. Cars ~~shall be~~ **were** categorized as passing or failing using the IM240 cutpoints in the table below:

~~**Phoenix Lane IM240 Cutpoints for Lab Procurement**~~

~~**Model Years**~~	~~**HC g/mile**~~	~~**CO g/mile**~~	~~**PFI NO* g/mile**~~	~~**TBI NO* g/mile**~~
~~1986+~~	~~>1.10~~	~~>15.0~~	~~>2.4~~	~~>1.6~~
~~1983-85~~	~~>1.20~~	~~>16.0~~	~~>2.4~~	~~>1.6~~

~~* These IM240 cutpoints yield FTP NO levels of approximately 1.15 g/mile using regression equations in Appendix E of the I/M Rule Technical Support Document.~~

Phoenix Lane IM240 Cutpoints for Lab Procurement

Model Years	**HC g/mile**	**CO g/mile**	**NOx g/mile**
1983+	>0.80	>15.0	>2.0

The following table provides ~~The~~ **the** laboratory recruitment goals for the pass/fail categories ~~are~~ listed **as** a percentage of the total number of cars recruited to the lab for this task. ~~ATL should try to keep the recruitment balanced.~~

~~**Phoenix Lab Recruitment Goals Using Lane IM240 Categories**~~

~~**Model Years**~~	~~**HC/CO Pass**~~	~~**HC/CO Fail**~~	~~**PFI NO Pass**~~	~~**PFI NO Fail**~~	~~**TBI NO Pass**~~	~~**TBI NO Fail**~~
~~1986+~~	~~10%~~	~~10%~~	~~10%~~	~~10%~~	~~10%~~	~~10%~~
~~1983-85~~	~~6.6%~~	~~6.6%~~	~~6.6%~~	~~6.6%~~	~~6.6%~~	~~6.6%~~

Phoenix Lab Recruitment Goals Using Lane IM240 Categories

Model Years	**HC/CO Pass**	**HC/CO Fail**	**NOx Pass**	**NOx Fail**
1986+	15%	15%	15%	15%
1983-85	10%	10%	10%	10%

4.0 Commercial Repair Recruitment

Vehicles that ~~fail~~ **failed** the Arizona I/M test, and ~~have~~ **had** received an IM240 and an ASM series, ~~shall have~~ their owners **were** offered $50 to return for these lane tests after commercial repairs. Owners of vehicles that

failed the Arizona I/M test, and received and IM240/ASM series, were offered $50 to return to the lane for after repair tests. These vehicle owners ~~will~~ **were** only ~~be~~ ~~recruited~~ offered this incentive if they ~~refuse~~ **refused** to participate in the laboratory testing program or if their vehicles ~~are~~ **were** not needed for laboratory recruitment. Recruiting vehicles for laboratory tests ~~is~~ **was** a higher priority than for commercial repair participation.

The owners ~~are to be~~ **were** informed that they must return with repair receipts indicating repairs by a commercial establishment with itemized labor and parts costs to qualify for the $50 incentive. ATL ~~will include~~ **included** either the original receipts or copies in the vehicle test packets that ~~are~~ **were** provided to EPA. In addition, ATL provided summarized comments and data for these vehicles seperately.

Vehicles returning after commercial repairs ~~will follow~~ **followed** the procedure-sequence algorithm previously discussed.

5.0 Lab Procedure

The lab procedure is summarized in ~~Appendix 2~~ Attachment 2 , so this section will only add explanations to the procedure listed in ~~Appendix 2~~ Attachment 2 .

5.1 Two Groups

The vehicles recruited to the lab ~~will be~~ **were** separated into two groups:

1. **Those whose initial lane test was the IM240 and~~will be~~ were repaired to IM240 targets. For the vehicles in this group, the IM240 always precedes the ASM series (see Appendix 2).**

2. **Those whose initial lane test was the ASM series and~~will be~~ were repaired to ASM targets. ~~Currently, there are~~ There were not enough data to set ASM repair targets, so IM240 targets~~will be~~ were used until ASM targets can be developed. For the vehicles in this group, however, the ASM series always~~precedes~~ preceded the IM240 (see Appendix 2).**

The order of testing for ASMs and IM240s ~~is~~ **was** switched for the two groups to avoid any bias that may occur by having one procedure always follow the other.

**** We Didn't develope ASM repair criteria so there was only one group, or maybe two groups. Those with initial IM240's repaired to IM240 targets and those with initial ASM's repaired to IM240 targets. For these groups I am not sure that the test sequence was always the same or always changed to avoid bias that might occur by having one procedure always follow the other. ****

5.2 Repair Targets

The repair targets ~~are~~ **were** to achieve 0.8/15.0/2.0 on the IM240 for both the ASM targeted group and the IM240 targeted group. Initially, repair targets ~~will~~ **were to** be provided to ATL for the ASM targeted group to replace the IM240 targets . However, due to time and data constraints this proved impossible. ~~that will be~~ **were** ~~initially used for that group.~~

For the initial repair attempt, the mechanic ~~will~~ was only ~~be~~ aware of the lane IM240 score for both vehicle groups (initial lane test: ASM or IM240). ~~After ASM repair targets are developed, the mechanics will only be~~

~~aware of the lane ASM score for the first repair attempt on the vehicles whose initial lane test was the ASM series.~~ ~~Likewise,~~ ~~for~~ **For** subsequent repair attempts, the mechanics ~~will~~ **were** only be aware of lane and lab IM240 scores**.** ~~**or** ASM scores depending on which group the particular car is in.~~ FTP scores ~~will~~ **were** not ~~be~~ provided to the mechanics for either group. ~~and the ASM group will not have IM240 scores provided to the mechanic, and the IM240 group will not have ASM scores reported to the mechanic.~~

Repairs ~~will be~~ **were** limited to $1,000.

5.3 Laboratory Test Equipment

For the ASM series, analyzers comparable to the analyzers specified for the lane testing ~~should be~~ **were** used. IM240 and FTP ~~will be~~ **were** measured with a CVS system, which ~~will~~ **was** also ~~be~~ used for the CVS specified ASM series listed in Appendix 2. The ASM series procedures ~~will follow~~ **followed** the lane procedures as closely as possible.

to replace 5.3 above

Due to time and financial constraints EPA was unable to develop lab ASM capability. The IM240 and FTP were measured with a CVS system.

~~5.4 Output~~

~~The final report should include a brief summary of the testing performed. This may be included in the Final Report for the base work assignment.~~

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QC Steps for ASM Analysis Database

Second by Second ASM Tolerance Checks:

- Speed Tolerance - ± 15% of nominal speed for Modes 1,2,3. Allows for tolerance exceedences of less than 3 seconds in duration.

  Also checks Idle for Modes 4,5

- Mode Length - Checks to ensure that each mode contains at least 20 and less than 30 "stable" seconds.

- Hp/Torque Tolerance - Compares required and actual Hp and Torque and flags differences > ±10%

Second by Second IM240 Tolerance Checks:

- Speed Tolerance - ± 4 mph at ± 1 sec of Nominal Speed Trace. Allows for exceedences of less than 3 seconds in duration.

  Max of 70 mph, Min of 0 mph

- Background Concentration Tolerances - Flags Bkgd outside the following ranges:

  $1.8 < HC < 10.0$
  $-10.0 < CO < 30.0$
  $-0.5 < NOx < 1.25$
  $0.0 < CO_2 < 0.15$

  Background flags were ignored for the analysis.

- Test Length - Checks to ensure that the full 240 seconds are present

- Distance Tolerance - ± 5% of nominal distance

  Bag 1: $0.532 < \text{dist } 1 < 0.588$

  Bag 2: $1.393 < \text{dist } 2 < 1.469$

- Fuel Economy Tolerance - Flags fuel economies < 10 mpg and >50 mpg

- Sample Continuity and Integrity - Ensures that the sampling is continuous (i.e., sec(I) = I for I = 1 to 240) and that gram and concentration values are non-zero (HC, CO and CO2 all cannot be zero for fuel economy calculations or dilution factors).

  Non-zero concentrations not mandatory for Phoenix data 'cause concentrations are calculated not measured.

- Comparison of Composite and bag results calculated from the second by second data with composite and bags results received from ATL. Differences of > 10% are flagged

Purge Flow Data QC

- Comparison of second by second purge flow to purge flow and pass/fail status reported by ATL. All significant differences were flagged.
- Vehicles exhibiting a constant purge rate were flagged. Purge data rounded to nearest 0.01 liter/sec were used.

Bag IM240 Tolerance Checks:

- Bag-1 emissions (HC, CO, and NOx) and fuel economy are compared to the corresponding Bag-2 results (based on regression analyses previously performed on the Indiana data).

Bag IM240/FTP Tolerance Checks:

- Composite IM240 emissions (HC, CO, and NOx) and fuel economy are compared to the corresponding FTP results (based on regression analyses previously performed on the Indiana data).

Dynamometer Loading Tolerance Checks:

- The test weights and horsepower settings must be within 10% for tests performed on each vehicle.

  Vehicles > 4000 lbs all exceeded this tolerance because of the capacity of the dyno. These cars were not removed from these analyses.