State of California
AIR RESOURCES BOARD

EXECUTIVE ORDER D-189
Relating to Exemptions under Section 27156
of the Vehicle Code

TECHNOLOGIES, LTD.
PLATINUM VAPOR INJECTOR

WHEREAS, Vehicle Code Section 27156 and Title 13 California Code of Regulations (hereafter "CCR") Section 2222(e), authorize the California Air Resources Board (ARB) and its Executive Officer to exempt add-on and modified parts from the prohibitions of Vehicle Code Section 27156.

WHEREAS, Technologies, Ltd. has applied to the ARB for exemption from the prohibitions of Vehicle Code Section 27156 for the Platinum Vapor Injector device.

WHEREAS, pursuant to the authority vested in the Executive Officer by Health and Safety Code Section 39515 and in the Chief, Mobile Source Division by Health and Safety Code Section 39516 and Executive Order G-45-5, the Air Resources Board finds:

1. Platinum Vapor Injector is an add-on device that introduces a small amount of platinum and rhenium into the intake manifold of the engine.

2. Platinum Vapor Injector is intended for use with a required motor vehicle pollution control system.

3. Platinum Vapor Injector by being installed in the engine alters the original design of a motor vehicle pollution control system.

4. Platinum Vapor Injector is a device subject to the prohibitions of Vehicle Code Section 27156 and an add-on part as defined by 13 CCR Section 1900(b)(1).

5. Platinum Vapor Injector does not reduce the effectiveness of any required motor vehicle pollution control device.

6. The ARB in the exercise of technical judgement, is aware of no basis on which the Platinum Vapor Injector device will provide either a decrease in exhaust emissions or an increase in fuel economy.

7. It has not been determined what effect the use of Platinum Vapor Injector may have on any warranty, either expressed or implied, by the manufacturer of a motor vehicle on which the device is installed.

8. Platinum Vapor Injector is not a certified motor vehicle pollution control device pursuant to Health and Safety Code Section 43644.

9. The ARB by granting an exemption to Technologies, Ltd. for the Platinum Vapor Injector device does not recommend or endorse in any way the Platinum Vapor Injector device for emissions reduction, fuel economy, or any other purpose.

IT IS HEREBY RESOLVED that Platinum Vapor Injector is exempt from the prohibitions of Vehicle Code Section 27156 for installation on 1989 and earlier model-year diesel-powered vehicles subject to the following conditions:

1. This exemption shall not apply to any device, apparatus, or mechanism advertised, offered for sale or sold with, or installed on, a motor vehicle prior to or concurrent with transfer to an ultimate purchaser.

2. No changes are permitted to the device as described in the staff report. Any changes to the device applicable model-year, or other factors addressed in this Executive Order must be evaluated and approved by the ARB prior to marketing in California.

3. Marketing of this device using an identification other than that shown in this Executive Order or marketing of this device for an application other than those listed in this Executive Order shall be prohibited unless prior approval is obtained from the Air Resources Board. Exemption of this product shall not be construed as an exemption to sell, offer for sale, or advertise any component of the product as an individual device.

4. Any oral or written references to this Executive Order or its content by the Technologies, Ltd., its principals, agents, employees, distributors, dealers, or other representatives must include the disclaimer that the Executive Order or the exemption it provides is not an endorsement or approval of any fuel economy or emissions reduction claims for Platinum Vapor Injector and is only a finding that the device is exempt from the prohibitions of Vehicle Code Section 27156.

Violation of any of the above conditions shall be grounds for revocation of this order. The order may be revoked only after ten day written notice of intention to revoke the order, in which period the holder of the order may request in writing a hearing to contest the proposed revocation. If a hearing is requested, it shall be held within ten days of receipt of the request and the order may not be revoked until a determination after hearing that grounds for revocation exist.

Executed at El Monte, California, this 18th day of April, 1989.

K. D. Drachand, Chief
Mobile Source Division

State of California
AIR RESOURCES BOARD

EVALUATION OF THE TECHNOLOGIES, LTD. PLATINUM VAPOR INJECTOR DEVICE FROM THE PROHIBITIONS IN VEHICLE CODE SECTION 27156 IN ACCORDANCE WITH SECTION 2222, TITLE 13, OF THE CALIFORNIA CODE OF REGULATIONS

April, 1989

Issue Date: April, 1989

EVALUATION OF THE TECHNOLOGIES, LTD. PLATINUM VAPOR INJECTOR DEVICE FROM THE PROHIBITIONS IN VEHICLE CODE SECTION 27156 IN ACCORDANCE WITH SECTION 2222, TITLE 13, OF THE CALIFORNIA CODE OF REGULATIONS

by

Mobile Source Division

State of California
Air Resources Board
9528 Telstar Avenue
El Monte, CA 91731

SUMMARY

Technologies, Ltd. of P. O. Box 25324 Albuquerque, NM 87125, applied for exemption from the prohibitions in Section 27156 of the California Vehicle Code for their Platinum Vapor Injector (PVI) device. The device is designed for installation on 1989 and older model-year diesel-powered vehicles.

Based on the following: (1) previous testing of the device by the Air Resources Board (ARB) on a gasoline powered vehicle; (2) the emissions test results on a diesel engine conducted by Detroit Diesel Corporation; (3) the smoke opacity test results conducted by Southern California Rapid Transit District (RTD); (4) the staff's engineering evaluation; and (5) the exemption of devices that operate in a manner similar to PVI, the staff believes that PVI will not have any effects on the exhaust emissions from diesel-powered vehicles.

The staff recommends that the PVI device be exempted from the prohibitions in Vehicle Code Section 27156 and that Executive Order D-189 be issued.

CONTENTS

EVALUATION OF THE TECHNOLOGIES, LTD. PLATINUM VAPOR INJECTOR DEVICE FROM THE PROHIBITIONS IN VEHICLE CODE SECTION 27156 IN ACCORDANCE WITH SECTION 2222, TITLE 13, OF THE CALIFORNIA CODE OF REGULATIONS

I. INTRODUCTION

Technologies, Ltd. of P. O. Box 25324 Albuquerque NM 87125, has applied for exemption from the prohibitions of Section 27156 of the California Vehicle Code for their Platinum Vapor Injector (PVI) device. The device is designed for installation on 1989 and older model-year diesel-powered vehicles.

The applicant submitted a sample, drawings and specifications of the device for our inspection and evaluation.

II. CONCLUSION

Based on the following: (1) previous testing of the device by the Air Resources Board (ARB) on a gasoline powered vehicle; (2) the emissions test results on a diesel engine conducted by Detroit Diesel Corporation; (3) the smoke opacity test results conducted by Southern California Rapid Transit District (RTD) ; (4) staff's engineering evaluation of the device; and (5) the previous exemption of devices that operate in a manner similar to PVI, the staff believes that PVI will not have any effects on exhaust emissions or fuel economy.

III. RECOMMENDATION

The staff recommends that Technologies, Ltd. be granted an exemption from the prohibitions in California Vehicle Code Section 27156 for their PVI device and that Executive Order (E.O.) D-189 be issued.

IV. DEVICE DESCRIPTION AND OPERATION

The PVI device is a vapor injection system. It consists of a plastic case, a 12 or 24 volt electrical hook-up and a platinum vapor supply hose. The case dimensions are: 6-1/4" width; 2-5/8 depth; and 8" height. The case contains a reservoir with ethylene glycol solution, a small vacuum pump, and tubings which connect the reservoir to the vacuum pump. The vacuum pump is to compensate for the lack of vacuum in a diesel engine at low rpm.

The reservoir is made of molded plastic . There are two outlet nipples with a 0.015 orifice on the upper part of the reservoir both of which are connected to the vacuum pump. A 5/8" fill tube with a screw cap is made an integral part of the reservoir. A 1/16" hole is to be drilled in the middle of the cap, during installation of the device, as the only opening to the atmosphere. The bottom of the tube is connected to the reservoir. A fill line is marked on the side of the reservoir to indicate the limit of the reservoir's filling capacity to approximately one-half of its volume (nominal fill is approximately one pint). The proprietary platinum solution is to be added to the reservoir when the installation is complete. See appendix A for installation instructions and Appendix B for PVI drawings.

In operation, negative pressure from the vacuum pump at low rpm and the engine intake manifold at high rpm is applied to the upper portion of the reservoir through the connecting tubings. This allows air from the atmosphere to enter through the fill tube into the bottom portion of the reservoir. The air then bubbles through the fluid and rises to the upper

portion of the reservoir to be mixed there with the liquid vapor. This mixture is then drawn into the engine's intake manifold via the air intake hose between the air filter and the intake manifold.

V. DEVICE EVALUATION

Evaluation of the PVI device is based on the following:

A. The ARB's comparative emission tests on a 1980 model-year Chevrolet Monte Carlo with a 305 CID gasoline powered engine. The results does not show any effects on exhaust emissions or fuel economy. See Appendix C for the ARB's comparative emissions test results.

B. Detroit Diesel Corporation's back-to-back tests on a 1988 model-year diesel engine using federal transient emission test cycle. The results shows that the device has negligible effects on the exhaust emissions. The comparative test results are shown in Appendix D.

C. The RTD's comparative smoke tests on diesel buses to determine the effects of the PVI on exhaust smoke opacity. The results indicate that the PVI has no effect on exhaust smoke from diesel buses. Appendix E shows the RTD test results.

D. Staff's engineering evaluation of the device indicate that the PVI does not have any effects on exhaust emissions or fuel economy.

E. The previous evaluation of devices that operate similar to PVI showed that vapor injector devices that meet ARB's requirement of orifice size would not have any adverse effects on the exhaust emissions.

VI. DISCUSSION

Technologies, Ltd. claims that; (1) the platinum solution aids in a faster and more complete combustion of the fuel by catalytic split of molecular O_2 to radical O; (2) reduction of smoke up to 60%; (3) reduction in CO emissions; and (4) additional engine life time. However, the company does not offer any scientific explanation to substantiate these claims. The comparative emission test results that were used for evaluation of the device did not show any effects on the exhaust emissions.

In the past the ARB has evaluated several vapor injectors that operate similar to PVI. During these evaluations, it was found that the air-bleed orifice size of the device determines whether the device would adversely affect vehicular emissions. The PVI's orifice (0.015) is below the maximum allowable limit. Since qualifying for an exemption from prohibitions of Vehicle Code Section 27156 is based on not adversely effecting exhaust emissions, the staff recommends that Technologies, Ltd. be granted an exemption as requested.

TECHNOLOGIES, LTD.

INSTALLATION INSTRUCTIONS

for

THE PLATINUM VAPOR INJECTOR (PVI)

There are three components of the Platinum Vapor Injector (PVI) that are easily installed:

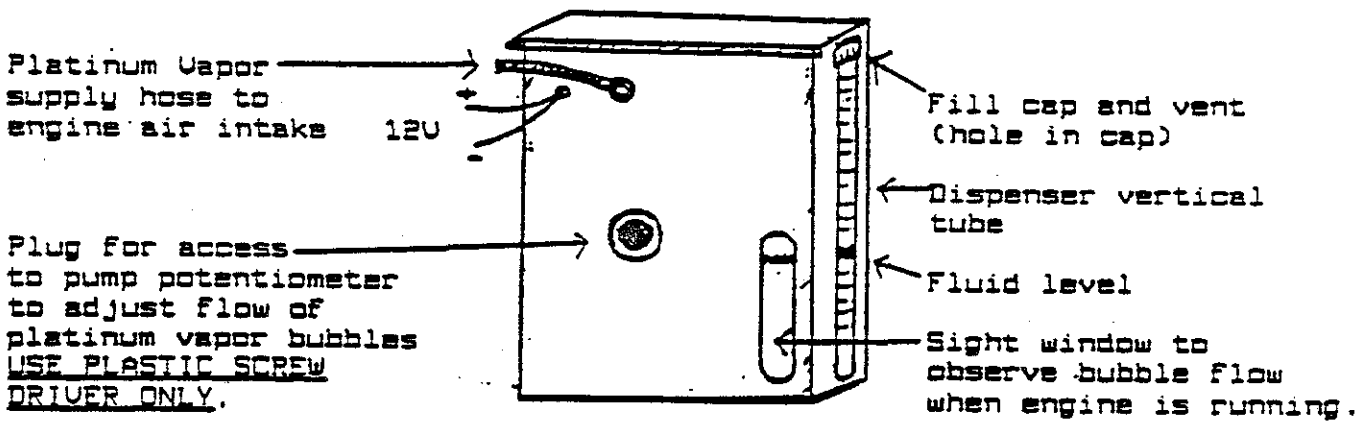
1. The side-by-side or the front-to-back dispenser/pump container case. Fig. I and Fig. II - sizes are on the diagrams.

2. The 12 or 24 volt electrical hookup.

3. The platinum vapor supply hose to the engine air supply.

DISPENSER/PUMP CASE

The side-by-side (Fig. I) dispenser case appears below:



6 1/4" W x 2 5/8" D x 8" H
Fig. I

The left-sided arrangement is exactly the same, except that the potentiometer hole is closer to the right corner of the case.

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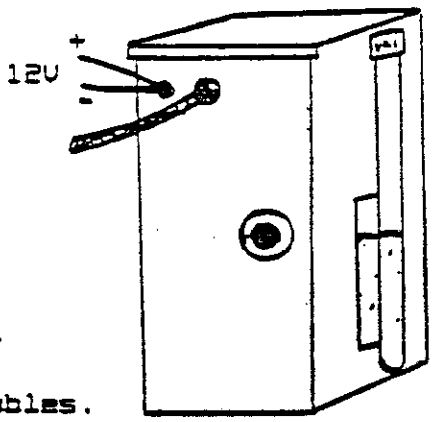

3 1/8" W x 5" D x 8" H
Fig. II

The platinum vapor dispenser can be placed at the left or right position only at the factory due to internal connections.

All connections and supply instructions apply as above or as follows. The pump potentiometer hole is at the same position whether it is L or R. Dispenser sight window is to observe bubble flow when engine is running.

Installation of Dispenser/Pump Container Case

a. The back of the case has 1/4" holes for bolt and nut or sheet metal attachment. Attach to the most convenient and advantageous position closest to the air intake and electrical injector pump terminal. The back of the case also has 3/8" slots at the top and bottom to accommodate nylon ratchet straps for securing the device in some installations.

b. DO NOT INSTALL THE PLATINUM VAPOR INJECTOR (PVI) NEAR OR ATTACH TO ANYTHING HOT.

c. A few minutes of thought and diagnosis on the first installation is necessary. No definite instructions for placement can be given as there are many variations on the same engines or because of various under-the-hood accessories.

ELECTRICAL SUPPLY

The 12 (or 24) volt positive electrical supply to the vacuum pump has to be connected to the injector pump terminal. (RED WIRE IS POSITIVE.) Carefully check your intended connection, so that the power goes on and off with the ignition key. This is a MUST as power is to be supplied only while the engine is operating. Ground the black wire.

PLATINUM VAPOR SUPPLY HOSE

The 3/16" platinum vapor supply hose is attached to the closest point, nearest to the engine of the intake air duct or to the intake side of the turbine (duct before turbine). The rubber air duct on large diesel engines can be drilled with a 1/4" drill very carefully three-fourths of its depth and then punctured with a sharp pointed awl. The 3/16" x 1/4" plastic fitting is then inserted into this hole (the 45-degree angle is to be positioned opposite airstream flow). Insert the 45-degree - 1/4" end first and then apply rubber silicone to seal and retain in proper

position. The 3/16" end is then connected, with rubber hose supplied, to the pump at the container case with the 3/16" x 3/16" fitting.

On small diesel engines, the center of the air cleaner lid is drilled with a 3/8" bit to accommodate the 90-degree nylon elbow with the 3/16" nozzle. NEVER INSTALL ANY PLATINUM VAPOR SUPPLY TO GO THROUGH THE AIR FILTER.

On some engines, such as VW diesel Rabbits, the crankcase breather hose, nearest the air cleaner box, is the best place for entry. A 90-degree nylon elbow is inserted into a 3/8" hole at the top of the breather hose and rubber silicone is applied to retain in proper position. The 3/16" end is then connected with rubber hose to 3/16" pump hose.

The above explanation serves as an example to explain the simplicity of the installation of the Platinum Vapor Injector (PVI). All installations are relatively easy, requiring little time and adaption procedures.

* BUBBLE FLOW DETERMINES AMOUNT OF PLATINUM *

The bubble flow on any engine at idle should be 30 to 35 bubbles every 10 seconds. The bubble flow rate is observed at the sight window (Fig. I or II). At approximately 1500 RPM, the bubble flow rate should be <u>about double</u>. Bubble flow is the same for all engines, as only the concentration of the platinum is increased to supply the requirements of larger engines consuming more fuel.

If the flow of bubbles needs to be regulated, it is done as follows: The rubber seal plug on the pump is removed. Inside is a potentiometer control with slots. A plastic screwdriver is supplied for this adjustment. Use plastic screwdriver <u>only</u>. <u>DO NOT USE A METAL SCREWDRIVER</u> - electrical short could occur and the pump would be ruined. The potentiometer is adjusted clockwise to increase bubble flow - counterclockwise to decrease. Adjust while engine is idling at the previous instruction rate of 30 to 35 bubbles every ten (10) seconds. A faster rate of bubbles only wastes platinum.

The Platinum Vapor Injector (PVI) is now operational and ready for the platinum solution. Do this while the engine is running. Remove black cap on vertical tube and pour in the number of 1 oz. platinum concentrate vials as follows:

One vial for engines getting over 10 miles per gallon.
Two vials for engines getting 5 to 10 miles per gallon.
Three vials for engines getting below 5 miles per gallon.

Drill 1/16" hole in middle of cap - remove inner cap seal and replace cap. The hole in the cap is needed for vacuum and bubble flow. Mark the mileage and date of installation in obvious place. Also keep data in glove compartment. This is for reference to replenish the platinum approximately every 6,000 miles or 200 hours for hourly usage on stationary units.

Air Duct Brass Fitting Installation
(Alternative Method Into Metal Duct)

It may be more desirable to make the installation into the metal duct of the air supply. A Weatherhead #1541 is the ideal brass fitting to do this. The metal duct will need to be drilled and tapped to receive this threaded fitting. The end that goes into the air duct will need an extension of 1 to 1 1/2 inch copper tubing that is silver-soldered into place. The end of the copper tube should be ground to a 45-degree angle to acquire the most venturi effect. Be certain that the 45-degree angle is opposite the airstream flow. Mark outside hex on fitting to verify position, or use Weatherhead marking. This is the most ideal way but is time-consuming, and care must be taken not to allow grindings into the air intake. This will necessitate removing the rubber duct connectors and carefully cleaning all internal areas before assembling again. This fitting will be supplied at your request. Ask for W.A.D. fitting.

CAUTION LIST

1. Do not install near or on anything hot.
2. Attach firmly to resist engine and road vibrations.
3. Attach (if possible) so the pump potentiometer is accessible and visible.
4. Connect red positive wire to injector pump terminal.
5. Make proper and complete electrical connections.
6. Hose connections should not leak - attach firmly.
7. Use only plastic screwdriver if you need to adjust potentiometer for bubble flow.
8. Never flow the platinum vapors through the air filter.
9. Drill 1/16" hole in vertical tube black cap and remove inner seal.
10. Check all other previous instructions.

Phone your nearest representatives if any questions or difficulties occur:

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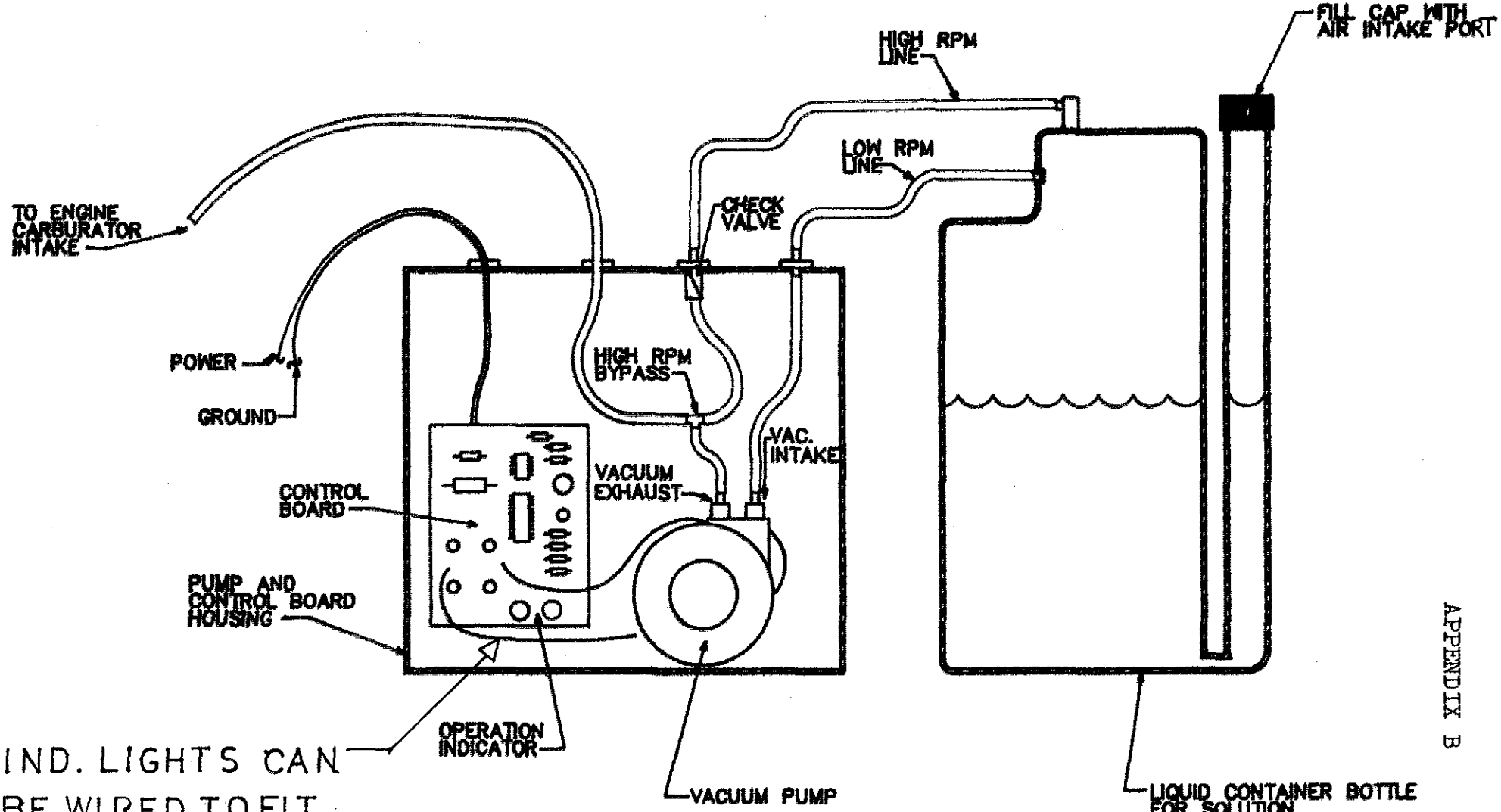
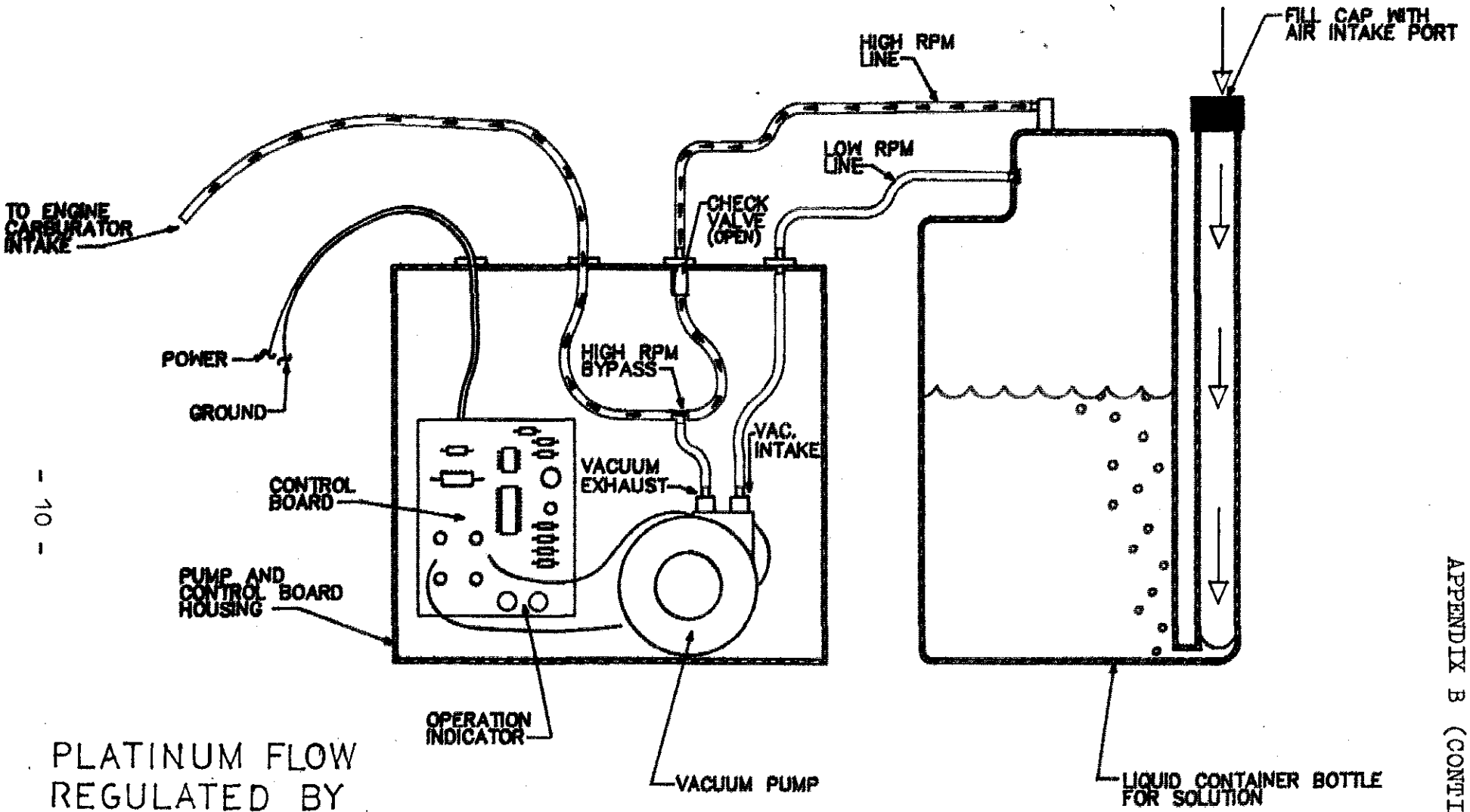


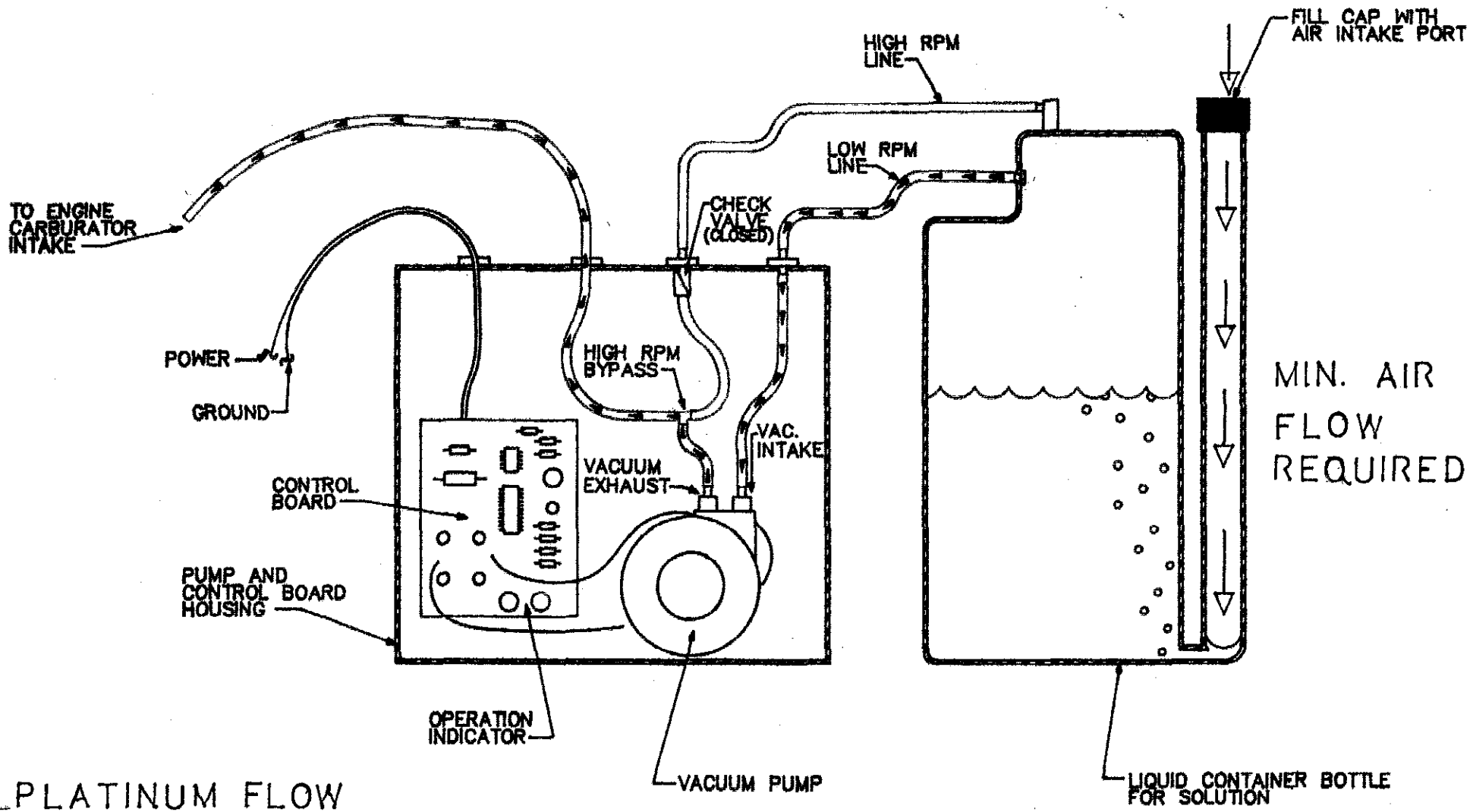
IND. LIGHTS CAN BE WIRED TO FIT A VARIETY OF APPLICATIONS

DEVICE OPERATION CONDITION – OFF



PLATINUM FLOW REGULATED BY VOLUME OF AIR DRAWN INTO ENGINE

DEVICE OPERATION CONDITION – HIGH RPM



PLATINUM FLOW REGULATED BY PUMP

DEVICE OPERATION CONDITION – LOW RPM

APPENDIX B (CONTINUED)

ARB COMPARATIVE EMISSIONS TEST RESULTS

Table 2

FIRST BASELINE TEST SERIES

TEST CONFIGURATION	Exhaust Emissions (in gm/mi) HC	CO	NOx	Fuel Economy (in mi/gal) CITY	HIGHWAY
Baseline	0.27	5.72	0.45	14.0	20.6
Baseline	0.23	5.44	0.47	14.0	20.6
AVERAGE	0.25	5.58	0.46	14.0	20.6

TABLE 3
FIRST DEVICE TEST SERIES

TEST CONFIGURATION	Exhaust Emissions (in gm/mi) HC	CO	NOx	Fuel Economy (in mi/gal) CITY	HIGHWAY
Device at 0 Miles	0.24	4.95	0.46	13.7	19.8
Device at 0 Miles	0.36	5.11	0.44	13.7	20.2
AVERAGE	0.30	5.03	0.45	13.7	20.0

TABLE 4
SECOND DEVICE TEST SERIES

TEST CONFIGURATION	Exhaust Emissions (in gm/mi) HC	CO	NOx	Fuel Economy (in mi/gal) CITY	HIGHWAY
Device after 1,000 miles	0.38	5.22	0.46	14.2	20.4
"	0.32	4.87	0.48	14.7	20.5
"	0.25	3.62	0.48	14.3	21.0
AVERAGE	0.32	4.57	0.47	14.4	20.6

TABLE 5
SECOND BASELINE TEST SERIES

TEST CONFIGURATION	Exhaust Emissions (in gm/mi) HC	CO	NOx	Fuel Economy (in mi/gal) CITY	HIGHWAY
Baseline after 1,000 mile device tests	0.32	5.53	0.42	14.2	--

APPENDIX D

DETROIT DIESEL CORPORATION TEST RESULTS

TEST RESULTS COMPARISON

EMISSIONS	BASELINE	PLATINUM VAPOR INJECTION	
BSNOx	10.33	10.40	GM/BHP-HR
BSHC	0.39	0.42	GM/BHP-HR
BSCO	2.33	2.25	GM/BHP-HR
BSP	0.273	0.268	GM/BHP-HR
BSFC	0.394	0.396	LBS/BHP-HR
SMOKE			
1800 RPM	1.6	1.3	%
800 RPM	3.6	4.2	%
700 RPM	8.3	9.2	%
600 RPM	14.2	16.7	%
TORQUE			
1800 RPM	914.2	914.9	LB-FT
800 RPM	950.5	954.7	LB-FT
700 RPM	872.4	883.4	LB-FT
600 RPM	805.6	804.8	LB-FT
FUEL CONSUMPTION			
1800 RPM	.351	.350	LBS/BHP-HR
800 RPM	.384	.383	LBS/BHP-HR
700 RPM	.423	.419	LBS/BHP-HR
600 RPM	.461	.459	LBS/BHP-HR

APPENDIX E

RTD'S TEST REPORT

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
EQUIPMENT MAINTENANCE DEPARTMENT
EQUIPMENT ENGINEERING SECTION
INTERDEPARTMENTAL MEMORANDUM

****

DATE: October 25, 1988

TO: L.R. Davis

FROM: Vincent Pellegrin

SUBJECT: PVI Test Results

****

ASSIGNMENT

On August 2, 1988, the Equipment Maintenance Department was asked to determine the effects of a Platinum Vapor Injector (PVI) on exhaust smoke opacity. The PVI system was supplied by Technologies Limited (T.L.) of Albuquerque, New Mexico.

SUMMARY

The test results indicate that the PVI has no effect on bus engine exhaust smoke opacity.

BACKGROUND

On August 2, 1988, a meeting was held at the District's Central Maintenance Facility and included the following participants:

-SCRTD-

Don Waite	Vincent Pellegrin
Mike Leahy	Greg Davy
Rick Jager	David Lane
Frank Kirshner	Mike Bottone
Michael Singer	Jim Smart

-Technologies LTD-

Fo Farland	Michael Lebeck
J.W. Haskens	Dr. Dale Schialey

-California Air Resources Board-

Jerry Wendt	Robert Kou

The purpose of the meeting was to discuss the operating principles and installation requirements for the Platinum Vapor Injector (PVI) on District buses. Technologies Ltd.'s representatives stated that they expect a 50-90% reduction in smoke opacity with the installation of the PVI on the Detroit Diesel 6V92 TAC engine, which powers the majority of the District's bus fleet.

Mr. Farland, Chairman of the Board of T.L., requested that the District supply two (2) buses on which T.L. would install the PVI system for test purposes. He further requested that these buses exhibit higher than normal smoke opacity levels. Based on this request, the following test plan was outlined and agreed upon by T.L. and District personnel.

1. District staff will select two (2) buses that have higher than normal smoke levels.

2. District personnel will then perform a loaded mode smoke opacity test in order to determine the baseline smoke opacity levels of the buses.

3. T.L.'s representatives will then install and calibrate the PVI system on the baseline buses.

4. District personnel will then retest the PVI equipped buses to determine PVI's effect on smoke opacity levels.

DISCUSSION

The initial smoke test plan called for two buses to be tested on the chassis dynamometer at Division 3303. These buses, 8877 and 7661, were selected for their higher then normal smoke opacity levels and were baseline tested in an "as is" condition, no engine tune-ups were performed. Baseline testing began on August 1, 1988.

Following the baseline smoke test on bus 8877 and 7661, T.L.'s representatives installed the PVI system on these buses; smoke opacity tests were then performed in the PVI equipped condition. Following these tests T.L.'s representatives requested that the buses be

placed in revenue service to accumulate mileage with the PVI system operating. At this time, they stated that the PVI system would need to operate 2500 miles in order to exhibit reductions in smoke opacity levels. The District agreed to T.L.'s request and placed the the buses in normal service. After the mileage accumulation, the buses were tested again in the PVI equipped condition on August 26 and 31, 1988. (See attached test results.)

On August 4, 1988, T.L. requested that two (2) additional buses be tested for baseline smoke opacity levels then PVI equipped by T.L. and placed in normal revenue service to accumulate milage. The District also agreed to this request and bus numbers 7669 and 7658 received baseline smoke opacity test on August 5, 1988. These buses were equipped with the PVI systems by T.L. and placed in normal revenue service. On September 14 and 15, 1988, following mileage accumulation, the buses were tested in the PVI equipped condition.

SMOKE TEST PROCEDURE

The smoke test procedure used is similar to that outlined in SAE, J-35, "Diesel Smoke Measurement Procedure," with the addition of a stall torque mode. The tests are run with the bus positioned on a chassis dynamometer.

The smoke test procedure employed consists of running three consecutive smoke cycles. Throttle position during the cycle is either fully closed or fully opened. Following the instrumentation set-up, smokemeter calibration, and a 10 minute maximum power warm-up, the first smoke cycle is begun. The first cycle starts with a 20 second idle period; then the transmission is then put into drive and the bus is accelerated (1st acceleration) at approximately 1 mile-per-hour, per second, (1 mph/sec) while the transmission is allowed to up-shift into high gear bringing the engine to rated speed (2100 rpm) and power.

The maximum power mode is held for approximately 20 seconds. With the throttle still held fully open, the engine is loaded down such that the rpm drops gradually to intermediate speed (lug down). The engine is brought back to idle, the service brakes are applied and the engine is accelerated (2nd acceleration) to

converter stall torque for approximately 10 seconds. At this point, the engine is returned to idle and the smoke cycle is complete. Three smoke test sequence cycles must be run back-to-back before the test is considered complete. Results from the smoke tests are given in terms of smoke opacity and are divided into five factors:

"A" factor represents acceleration smoke.

"B" factor represents lug down smoke (hill climb).

"C" factor represents peak smoke (puffs during early portions of rapid opening of the throttle).

"D" factor represents the full load, rated speed smoke characteristics of the engine.

"E" factor represents the full load intermediate speed smoke characteristics of the engine.

The smoke test chart results are validated and read according to a procedure adapted from SAE J-35. Essentially, the acceleration and lug portions of each cycle are divided into 1 second intervals. The 10 highest smoke opacity readings from the two accelerations of each cycle are recorded. The average of these 30 smoke opacity readings yield the "A" factor or acceleration smoke factor. Similarly, the five (5) highest readings from the lug down portion of each cycle are determined. The average of these 15 smoke opacity readings yield the "B" factor or lug factor. The "C" factor or peak smoke factor, is determined by taking the two highest of the 10 values selected from the acceleration portions of each cycle. The average of these six smoke opacity readings yield the "C" factor. The "D" and "E" factors are determined by locating the last 10 seconds of the maximum power and lug down modes. The average smoke readings during this period yield the "D" factor or full load rated speed smoke and "E" factor or full load intermediate speed smoke respectfully. Of these five factors, the "B" factor or lug down and the "E" factor or intermediate speed are perhaps the most repeatable followed by the acceleration or "A" factor and the full load rated speed or "D" factor. The peak or "C" factor is substantially more variable.

Smoke was determined by the end-of-stack type Wager Model P-6P smokemeter which monitored the opacity of

the raw exhaust plume as it issued from a 6-inch diameter exhaust pipe. This type of smokemeter measures the percent of light extinction by the total exhaust plume from the engine. The smokemeter was connected to a compatible strip-chart to continuously record the smoke opacity during each cycle. This meter has an accuracy of ± 1 digit and zero stability of 1 percent. Such instrumentation must be used since the human eye detects smoke opacity only near or above 4-5% level.

Engine performance and operating conditions were recorded during each test and they included:

- Road horsepower
- Charge air pressure
- Air inlet restriction
- Engine rev/min.

The results of this data indicates that road horsepower levels were relatively consistent (within 5 percent of baseline) and engine operating conditions were repeated from test to test. Air inlet restriction was kept well below engine manufacturers' recommended limits and were relatively consistent from test to test.

Modal engine RPM was held to ± 50 rpm variance between tests. Acceleration and deceleration rates were controlled as consistently as possible with the manual dynamometer controls.

RESULTS

The attached tables present the results for all the smoke tests performed on the buses in this test. All the results, whether slight increases or slight decreases in smoke levels compared to baseline are within experimental test variability and instrumentation accuracy. Thus, the PVI system has no measurable effect on exhaust smoke opacity.

Bus 8877 received a California Highway Patrol citation for excessive smoke (CVC-27153) while operating in revenue service with the PVI system. (See attachment I.) Bus 7661 was smoke tested after the removal of the PVI system and the engine was tuned to factory specifications. The "post tune-up" test showed a significant reduction in smoke opacity.

The California Air Resourses Board has supplied the following statement:

> The California Air Resources Board (CARB) staff has reviewed the Smoke Test Procedures used by the SCRTD and has found them to be among the best currently in use. The CARB staff belives that the SCRTD test procedures are more than adequate to assess the impact of the PVI device on the smoke emissions from the transit buses under test. In addition the CARB staff observed much of the SCRTD testing and found that the District's test procedures were ridgedly applied.

cc: Jerry Wendt (CARB)

BUS NO. 8877

est	"A" Accel (%)	"B" Lug (%)	"C" Peak (%)	"D" Full-Load Rated Speed (%)	"E" Full-Load Intermediate Speed (%)	Miles Accumulate On PVI
ase-ine	14.5	6.3	21.7	2.3	5.7	--
VI #1	17.4	7.7	25.3	1.9	7.7	--
VI #2	19.2	8.0	28.2	2.3	7.6	3,337

BUS NO. 7661

est	"A" Accel (%)	"B" Lug (%)	"C" Peak (%)	"D" Full-Load Rated Speed (%)	"E" Full-Load Intermediate Speed (%)	Miles Accumulate On PVI
ase-ine	26.8	1.0	47.7	1.7	1.0	--
VI #1	28.8	1.5	48.7	1.7	1.2	--
VI #2	26.9	1.0	47.3	1.7	1.0	3,840
OST UNE-JP	6.9	1.0	8.7	1.0	1.0	--

BUS NO. 7658

Test	"A" Accel (%)	"B" Lug (%)	"C" Peak (%)	"D" Full-Load Rated Speed (%)	"E" Full-Load Intermediate Speed (%)	Miles Accumulate On PVI
Base-line	10.7	1.0	21.6	1.0	1.0	--
PVI #1	10.8	1.0	20.8	1.0	1.0	4,023

BUS NO. 7669

Test	"A" Accel (%)	"B" Lug (%)	"C" Peak (%)	"D" Full-Load Rated Speed (%)	"E" Full-Load Intermediate Speed (%)	Miles Accumulate On PVI
Base-line	7.0	1.0	9.8	1.0	1.0	--
PVI #1	6.6	1.0	8.7	1.0	1.0	4,925