State of California
AIR RESOURCES BOARD

EXECUTIVE ORDER D-99
Relating to Exemptions under Section 27156
of the Vehicle Code

TURBONETICS, INC.
"TURBOFLO 360"

Pursuant to the authority vested in the Air Resources Board by Section 27156 of the Vehicle Code; and

Pursuant to the authority vested in the undersigned by Sections 39515 and 39516 of the Health and Safety Code and Executive Order G-45-5;

IT IS ORDERED AND RESOLVED: That the installation of the "Turboflo 360" turbocharger system manufactured by Turbonetics, Inc. of 20939 Brant Ave., Long Beach, CA 90810, has been found not to reduce the effectiveness of required motor vehicle pollution control devices and, therefore, is exempt from the prohibitions of Section 27156 of the Vehicle Code for 1979 and older vehicles equipped with a Chrysler 360-3 heavy-duty engine.

This Executive Order is valid provided that installation instructions for this device will not recommend tuning the vehicle to specifications different from those submitted by the device manufacturer.

Changes made to the design or operating conditions of the device, as exempted by the Air Resources Board, that adversely affect the performance of a vehicle's pollution control system shall invalidate this Executive Order.

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 a kit shall not be construed as an exemption to sell, offer for sale or advertise any component of a kit as an individual device.

This Executive Order does not constitute any opinion as to the effect that the use of this device may have on any warranty either expressed or implied by the vehicle manufacturer.

THIS EXECUTIVE ORDER DOES NOT CONSTITUTE A CERTIFICATION, ACCREDITATION, APPROVAL, OR ANY OTHER TYPE OF ENDORSEMENT BY THE AIR RESOURCES BOARD OF ANY CLAIMS OF THE APPLICANT CONCERNING ANTI-POLLUTION BENEFITS OR ANY ALLEGED BENEFITS OF THE "TURBOFLO 360".

No claim of any kind, such as "Approved by Air Resources Board" may be made with respect to the action taken herein in any advertising or other oral or written communication.

Section 17500 of the Business and Professions Code makes untrue or misleading advertising unlawful, and Section 17534 makes violation punishable as a misdemeanor.

Section 43644 of the Health and Safety Code provides as follows:

> "43644. (a) No person shall install, sell, offer for sale, or advertise, or, except in an application to the state board for certification of a device, represent, any device as a motor vehicle pollution control device for use on any used motor vehicle unless that device has been certified by the state board. No person shall sell, offer for sale, advertise, or represent any motor vehicle pollution control device as a certified device which, in fact, is not a certified device. Any violation of this subdivision is a misdemeanor."

Any apparent violation of the conditions of this Executive Order will be submitted to the Attorney General of California for such action as he deems advisable.

Executed at El Monte, California, this 29th day of February, 1980.

K. D. Drachand by RAW
K. D. Drachand, Chief
Mobile Source Control Division

State of California
AIR RESOURCES BOARD

Staff Report

December 19, 1979

# Evaluation of the Turbonetics, Inc. "Turboflo 360" Turbocharger System in Accordance with Section 2222, Title 13 of the California Administrative Code

## I. Introduction

Turbonetics, Inc., of 20939 Brant Avenue, Long Beach, CA 90810, has applied for an exemption from the prohibitions of Section 27156 of the Vehicle Code for its "Turboflo 360" turbocharger system. The system is intended for use on heavy-duty vehicles equipped with Chrysler 360 CID engines.

The system was tested at the Air Resources Board's Haagen-Smit Laboratory on a vehicle supplied by the applicant. Judgement of emissions effects were based solely on steady state raw exhaust gas emissions measurements.

## II. Vehicle Description and Testing

The test vehicle is a Fleetwood heavy-duty vehicle with a utility box body built on a Dodge model F40 chassis rated at 11,500 lbs gross vehicle weight. The vehicle is equipped with a Chrysler 360-3 heavy duty engine, 4.56 rear axle, and automatic transmission. Emission controls are EM, EGR, PCV and air injection.

Vehicle test weight was increased to 10,800 lbs by loading ballast into the utility box. Both the baseline and device (turbocharger) tests were conducted with the vehicle set to OEM specifications. Road load horsepower (1XRL) was determined to be 32 hp at 50 mph (11 in Hg, 2900 rpm) by road test. The test was conducted with the choke, heated air intake, and vacuum throttle positioner disconnected. These items are deemed to have no significant effect on a hot-start steady state test. The hoses carrying radiator water to the manifold adapter water jacket were also disconnected. Production turbochargers will have a valve that controls the flow of heated water to the jacket. The ambient temperature during testing was considered high enough that no adapter heating for evaporation of fuel was required.

Testing consisted of a series of hot-start steady state runs on a heavy-duty chassis dynamometer. Emissions data were collected at 20, 30, 40, 50 and 60 mph at multiples of one, two and three times road load horsepower. Two times road load (2XRL) was 64 hp at 50 mph. 3XRL was adjusted to 92 hp at 50 mph rather than 96 hp because the baseline vehicle was at WOT at 92 hp, 50 mph.

Rear dual tires were inflated to their maximum rated pressure of 70 psi. Regular grade tank fuel was used on the baseline test, premium grade tank fuel was used on the device test.

Results of emission measurements are given in Table 1. Note that a set of turbocharger emission measurements were taken at 58 mph, 1XRL and that 60 mph, 3XRL measurements were deleted in the turbocharged test for lack of baseline comparison data.

Table 1 - Raw Exhaust Emissions Measurements

| Speed (mph) | HC (ppm) | | CO (%) | | NOx (ppm) | | Manifold Vacuum (in Hg) | |
|---|---|---|---|---|---|---|---|---|
| | baseline | device | baseline | device | baseline | device | baseline | device |
| idle | 69 | 8 | 0.41 | 0.36 | 39 | 79 | 15.0 | 16.0 |
| 20, 1XRL | 25 | 8 | 0.25 | 0.20 | 307 | 307 | 15.0 | 14.0 |
| 30, " | 25 | 8 | 0.20 | 0.20 | 484 | 461 | 13.2 | 11.5 |
| 40, " | 17 | 8 | 0.20 | 0.15 | 744 | 744 | 12.0 | 10.0 |
| 50, " | 8 | 8 | 0.20 | 0.15 | 1465 | 1111 | 11.0 | 8.0 |
| 58, " | - | 8 | - | 0.20 | - | 1403 | - | 6.5 |
| 60, " | 25 | 0 | 0.20 | 1.89 | 1899 | 794 | 9.0 | 5.5 |
| idle | 130 | 8 | 0.31 | 0.20 | 59 | 119 | 15.0 | 17.0 |
| 20, 2XRL | 17 | 8 | 0.25 | 0.41 | 372 | 350 | 14.0 | 13.5 |
| 30, " | 25 | 8 | 0.20 | 0.25 | 647 | 599 | 11.0 | 10.0 |
| 40, " | 17 | 17 | 0.20 | 0.20 | 1196 | 1084 | 8.0 | 6.5 |
| 50, " | 8 | 25 | 0.25 | 0.68 | 1560 | 1283 | 5.0 | 2.0 |
| 60, " | 69 | 34 | 8.32* | 5.59 | 222 | 576 | 0.5 | (1.0)** |
| idle | 104 | 43 | 0.31 | 0.20 | 39 | 119 | 15.0 | 17.0 |
| 20, 3XRL | 43 | 51 | 0.20 | 0.25 | 671 | 529 | 13.5 | 10.0 |
| 30, " | 25 | 51 | 0.20 | 0.20 | 769 | 1056 | 8.5 | 6.5 |
| 40, " | 8 | 69 | 0.20 | 0.25 | 1465 | 1592 | 4.5 | 2.0 |
| 50, " | 51 | 17 | 7.55 | 4.31 | 307 | 647 | 0 | (1.0)** |

*limit of instrument range
**psig

## III. System Description

The Turboflo 360 major components consist of a distributor diaphragm, manifold adapter, AiResearch turbocharger, wastegate, and modified exhaust system. Miscellaneous installation hardware is included, as well as instruction to make minor modifications to stock vehicle components.

The system is designed to increase the mass of air-fuel mixture in the cylinders over that inducted by a naturally aspirated engine.

The system operates by drawing air through a remote air cleaner and large diameter tube to a carburetor inlet adapter. The air then passes through the carburetor to a manifold adapter which routes the air-fuel mixture to the turbocharger compressor housing. A small portion of the mixture is recirculated through two small openings in the manifold adapter floor during moderate to high flowrates. The purpose of the openings is to allow a part of the air-fuel mixture to bypass the compressor and enter the mainfold directly at idle and off-idle to prevent fuel puddling on the adapter floor and to promote better cold start driveability.

The exhaust gas from both exhaust manifolds is routed to the turbine inlet and then to the exhaust pipe and muffler. A wastegate is located between the left exhaust manifold and the turbine housing to allow exhaust gas to bypass the turbine at a preset pressure for control of maximum pressure in the intake manifold.

Specific modifications of the original equipment (OE) engine to adapt it to the "Turboflo 360" are as follows:

A. Air Induction System

The air cleaner housing is moved from the carburetor to a remote location near the front of the vehicle. A large diameter flexible hose is used to duct air to the carburetor. The PCV line and heated air intake system will remain connected. The purpose of the modification is to obtain lower temperature inlet air, and to allow space for the turbocharger installation without modifying the engine cover.

B. Fuel System

1. Premium grade fuel is recommended for the turbocharged engine while the naturally aspirated engine is designed to operate on regular grade leaded fuel. This recommendation is made to prevent detonation during hot weather or heavy load operating conditions.

2. The OE Carter fuel pump is replaced by a larger capacity pump (80 gpm) to prevent loss of fuel pressure at maximum demand.

3. The OE Carter Thermo-Quad carburetor is modified by replacing the metering rods with #1996 rods having smaller diameter midrange and power steps to increase fuel flow.

4. The carburetor bowl vent tube is shortened by 3/4" to allow clearance between the top of the vent tube and the air inlet adapter.

C. Ignition System

1. A dual diaphragm providing both normal advance and retard under boost replaces the OE vacuum advance diaphragm. Ignition retard under boost is used to prevent detonation.

2. The signal to the advance/retard diaphragm is modified from direct ported vacuum to a ported vacuum/manifold vacuum combination. This is accomplished by teeing a manifold vacuum source into the ported vacuum line, and placing a calibrated orifice in the ported vacuum line and a check valve in a manifold vacuum line. This configuration provides a normal ported signal to the diaphragm at idle and off-idle which gradually gives way to the manifold vacuum signal as manifold vacuum drops and finally goes to a positive pressure acting as a retard signal.

D. Exhaust System

1. The OE exhaust manifolds are retained, but the exhaust tubing is replaced to route exhaust gases through the turbine housing. The exhaust from the left (driver's side) cylinder bank is carried under the engine by a crossover pipe where it joins exhaust gas from the right bank before entering the turbocharger on the right side of the engine.

2. Exhaust gas from the turbine runs through a single pipe to a set of low restriction dual mufflers supplied in the kit. The purpose of the dual mufflers is to reduce exhaust back pressure.

3. A wastegate is located on the crossover pipe to cause exhaust gas to bypass the turbine. It acts as a boost control to prevent engine damage when the differential pressure across the compressor reaches 5 psi or more. Production wastegates will be nonadjustable.

IV. Discussion

Turbonetics uses OE tune-up specifications, but alters the fuel metering characteristics, vacuum advance curve, and some vacuum signals to compensate for the turbocharger system installation.

The turbocharger causes a delay in the operation of carburetor power enrichment circuits because vacuum at the carburetor base is no longer the same as manifold vacuum for most operating modes. Turbonetics elected to replace the primary step-up metering rods with rods that allow richer midrange and power operation. This is more desirable than referencing the enrichment circuit to intake manifold pressure since it increases the maximum primary fuel delivery capacity and compensates for the delay in secondary bore fuel metering. The delay in secondary fuel metering is a result of the throttle position on the turbocharged vehicle at a given speed and load being less than or equal to the position on a naturally aspirated vehicle where the secondary is basically mechanical (air valve modulated).

Points at which Turboflo 360 device test levels exceed the baseline are primarily in the range of speeds where transition to power enrichment occurs. For example, the device CO at 1XRL, 60 mph is 1.89% compared to 0.20% for the baseline. The CO increase is due to slightly earlier entry into the power enrichment mode. Readings taken at 58 mph, 1XRL are nearly identical to baseline results at 60 mph.

The same situation is apparent at 50 mph, 2XRL where device CO is 0.68% versus 0.25% baseline. The higher CO and HC, and lower NOx than baseline indicate slightly richer turbocharger system operation. At 60 mph, 2XRL, the baseline is fully into power enrichment denoted by extreme CO values and high HC, and the turbocharged version is not yet as rich, accounting for the low HC and CO, and higher NOx value of 576 ppm versus 222 ppm. This is demonstrated again at 50 mph, 3XRL.

The common factor among the preceding points is that they all occur during transition periods where a one or two mph variation in road speed makes large differences in emissions performance. Taking this into account, the Turboflo 360 system emissions performance is similar to that of the baseline vehicle, with the exception of two NOx measurements at 30 and 40 mph, 3XRL, and the 20, 30 and 40 mph HC measurements at 3XRL. The 40 mph, 3XRL, NOx measurement is close enough to the baseline value to be considered within the bounds of test variability. A possible explanation for the other points is connected with vapor lock problems that appeared during the test.

The test sequence was 1XRL 60, idle, 50, 40 30, 20; 2XRL 60, idle 50, 40, 30, 20; 3XRL 50, idle, 40, 30, 20. This sequence was selected to allow the drive axle tires to cool between high speed runs. Fuel vapor lock occurred at each idle on the turbocharged vehicle and became progressively worse with time. The most probable cause of the vapor lock is the high heat soak-back from the engine and turbocharger after a hard run. This may have caused the high "Turboflo 360" HC value at 20, 30 and 40 mph, 3XRL and the single high NOx value at 30 mph, if intermittent vapor lock caused fuel-air maldistribution.

There were no vapor lock problems during baseline testing; however, such problems on the turbocharged vehicle may easily be solved. Insulation might be used on the fuel pump and/or on the engine, exhaust system, and turbocharger parts, or a fuel return line may be installed on the fuel pump to recirculate fuel. A third possibility is the installation of an electric fuel pump at the rear of the vehicle. The turbocharger manufacturer has been made aware of the problem and is anxious to remedy vapor locking to avoid customer complaints. The system will be modified as necessary if vapor lock occurs on a 500 mile road test. It is possible that increased air flow and better circulation under actual road conditions will in itself prevent vapor lock.

Turbonetics has submitted a warranty statement that serves to protect emissions warranted parts in the event that damage to a part is caused by the Turboflo 360 system. In addition, Turbonetics warrants its system against manufacturing and workmanship defects for twelve months or 12,000 miles from the purchase date.

V. Conclusion and Recommendation

Comparison of the raw exhaust emissions data demonstrates that emissions performance of the "Turboflo 360" system is essentially comparable to baseline performance. Vapor lock problems are considered to be minor. The staff recommends that Turbonetics be granted an exemption from VC 27156 for its "Turboflo 360" turbocharger system on the grounds that the system will have no significant emissions impact when installed in accordance with the manufacturer's specifications.