

State of California  
AIR RESOURCES BOARD

EXECUTIVE ORDER D-249  
Relating to Exemptions Under Section 27156  
of the Vehicle Code

DONALDSON COMPANY, INC.  
DONALDSON DIESEL PARTICULATE TRAP SYSTEM

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 Donaldson Diesel Particulate Trap System (dual wallflow ceramic monolith) comprised of a heater element, filter monolith, blower, micro-processor and air intake sensor, manufactured by Donaldson Company, Inc. of P. O. Box 1299, Minneapolis, MN 55440-1299, has been found not to reduce the effectiveness of the applicable vehicle pollution control system and, therefore, is exempt from the prohibitions of Section 27156 of the Vehicle Code for 1992 and older diesel-powered engines with a displacement between 6.0 liters and 14.0 liters.

This Executive Order is valid provided that installation instructions for this particulate trap will not recommend tuning the vehicle to specifications different from those submitted by Donaldson Company, Inc.

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

Marketing of this particulate trap using any identification other than that shown in this Executive Order or marketing of this particulate trap 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 the particulate trap shall not be construed as exemption to sell, offer for sale, or advertise any component of the kit as an individual device.

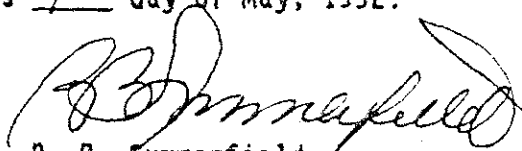
This Executive Order does not constitute any opinion as to the effect the use of this particulate trap may have on any warranty either expressed or implied by the vehicle manufacturer.

THIS EXECUTIVE ORDER DOES NOT CONSTITUTE A CERTIFICATION, ACCREDITATION, APPROVAL, OR ANY OTHER TYPE OF ENDORSEMENT BY THE AIR RESOURCES BOARD OF CLAIMS OF THE APPLICANT CONCERNING ANTI-POLLUTION BENEFITS OR ANY ALLEGED BENEFITS OF THE DONALDSON COMPANY, INC.'S DIESEL PARTICULATE TRAP SYSTEM.

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

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 13<sup>th</sup> day of May, 1992.

  
R. B. Summerfield  
Assistant Division Chief  
Mobile Source Division

*Original*

State of California  
AIR RESOURCES BOARD

EVALUATION OF DONALDSON COMPANY, INC.'S DIESEL PARTICULATE TRAP SYSTEM  
FOR EXEMPTION FROM THE PROHIBITIONS OF VEHICLE  
CODE SECTION 27156 IN ACCORDANCE WITH SECTION 2222, TITLE 13, OF THE  
CALIFORNIA CODE OF REGULATIONS

May 1992

State of California  
AIR RESOURCES BOARD

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by

Mobile Source Division  
State of California  
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(This report has been reviewed by the staff of the California Air Resources Board and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Air Resources Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.)

SUMMARY

Donaldson Company, Inc., of P. O. Box 1299, Minneapolis, Minnesota 55440-1299, has applied for an exemption from the prohibitions in Section 27156 of the California Vehicle Code (VC) for the Donaldson Diesel Particulate Trap System. The particulate trap is designed for installation on all 1992 and older diesel-powered engines with displacements between 6.0 and 14.0 liters.

Based on the results from emission tests performed at an independent laboratory on a 1990 Detroit Diesel 6V-92TA DDEC diesel bus engine, the staff concludes that Donaldson Company, Inc.'s Diesel Particulate Trap System will not adversely affect exhaust emission from vehicles for which an exemption is requested.

The staff recommends that Donaldson Company, Inc. be granted an exemption as requested and that Executive Order D-249 be issued.

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I. INTRODUCTION

Donaldson Company, Inc. of P. O. Box 1299, Minneapolis, Minnesota 5540-1299, has applied for an exemption from the prohibitions in Section 27156 of the California Vehicle Code for the Donaldson Diesel Particulate Trap System. The particulate trap is designed for installation on 1992 and older model-year diesel-powered engines with displacements between 6.0 liters and 14.0 liters.

Donaldson Company, Inc. has submitted data from emission tests conducted on a 1990 Detroit Diesel 6V-92TA DDEC bus engine at the United States Environmental Protection Agency laboratory, Ann Arbor, Michigan.

II. CONCLUSIONS

Based on the results from emission test conducted at the United States Environmental Protection Agency laboratory on a 1990 Detroit Diesel 6V-92TA DDEC bus engine, the staff concludes that Donaldson Company, Inc.'s Diesel Particulate Trap System will not adversely affect exhaust emissions from vehicles for which an exemption is requested.

III. RECOMMENDATION

The staff recommends that Donaldson Company, Inc. be granted Executive Order D-249 for exemption of their Diesel Particulate Trap System for installation on 1992 and older model-year diesel-powered engines with displacements between 6.0 liters and 14.0 liters.

#### IV. DEVICE DESCRIPTION

The Donaldson Diesel Particulate Trap System is designed for installation on 1992 and older model-year diesel-powered engines with displacements between 6.0 liters and 14.0 liters. It functions as an automatic diesel engine exhaust particulate filter, oxidizer, and muffler system. Engine exhaust flows into a cleaner assembly that catches and holds the exhaust particulate. When the filter element is full, the engine exhaust is diverted to a second cleaner assembly and the first one is automatically regenerated, or cleaned. Exhaust particulate continues to accumulate in the second cleaner until its element is full. Engine exhaust is then routed back to the first cleaner, the second cleaner regenerates, and the cycle is repeated. The Donaldson Diesel Particulate Trap System consists of several interrelated subsystems; the air and exhaust system, heater system, sensor system, control system and the diagnostic system. The kit operates in conjunction with the original equipment manufacturer (OEM) emission control systems already certified with the stock engine. The tune-up specifications remain the same.

The air and exhaust system components include the engine air cleaner, an engine intake air flow sensor, engine exhaust piping, exhaust cleaners, exhaust tail pipes and a mechanical exhaust pressure relief valve. The air and exhaust system assembly serves two primary purposes: it filters the engine exhaust to remove particulate matter and it reduces the exhaust noise level to satisfy noise pollution requirements.

The heater system consists of an electrical resistance coil heater element, a ceramic heat reflecting disc, an electric relay and a circuit breaker. The system's function is to heat the trapped particulate to ignition temperature so that it will burn and can be passed to the atmosphere in a



gaseous form, the regeneration cycle.

The sensor system monitors pressure and temperature inputs from the system. It includes pressure transducers and thermocouples. The output information consists of electrical signals sent to the controller. The control system, consisting of a microprocessor, thermocouple interface module, and wiring harness, monitors the condition of the cleaner assemblies and controls the filter element loading and regeneration cycles.

Three types of sensors are used to determine when a filter element is full, a pressure transducer provides a differential pressure reading across the filter element, a thermocouple measures the temperature at each filter element inlet, and an air flow sensor measures engine intake air flow. The controller microprocessor uses this information to monitor the filter element load and to initiate and control the cleaner switching and regeneration process.

Regeneration consists of heating the particulate caught in the filter element to a temperature at which it oxidizes or burns. A blower injects air into the cleaner to provide oxygen required to burn the particulate and to expel the gas out of the particulate trap to the exhaust tail pipe in a gaseous form.

The diagnostic system assists in determining the cause of malfunctions as well as alert the vehicle operator of its occurrence. A service light is mounted on the instrument panel so the vehicle operator will know when a fault has occurred in the particulate trap system. The light is illuminated when the vehicle run switch is in the "on" position and the engine is not running. When the engine is started and the RPM cutout is energized, the light will turn off if certain diagnostic codes do not exist in the particulate trap system. If there are active codes, the service light will be illuminated when the engine is running. There are two types of codes, active codes and historic codes.

The active code indicates a condition that has occurred since the engine was last started, while a historic code indicates a condition that occurred prior to the last time the engine was stopped and then restarted. A fault that occurs, but does not recur after an engine stop and restart, will result in a historic code without a corresponding active code. Appendix A contains a list of the diagnostic codes used for the particulate trap system. Appendix B contains a schematic of the Donaldson Particulate Trap System.

#### V. PARTICULATE TRAP EVALUATION AND DISCUSSION

A 1990 Detroit Diesel 6V-92TA DDEC diesel bus engine was used for the evaluation of the Donaldson Diesel Particulate Trap System. Donaldson Company, Inc. also submitted test data conducted by Chevron Research and Technology Company on an Detroit Diesel 6V-92TA engine using the Central Business District Cycle but the test data was not used in the evaluation since baseline emission levels using the same test engine were not provided.

Emission tests against the baseline were conducted by the United States Environmental Protection Agency Laboratory for Donaldson Company, Inc. consisting of one Heavy-Duty Federal Test Procedure emission test in the baseline configuration and one Heavy-Duty Federal Test Procedure emission test in the modified (particulate trap system) configuration. During the particulate trap emission test, emission measurements were performed when the particulate trap was regenerating. Appendix C contains the composite result evaluation method which shows how the regeneration portion was compiled in the final emission test results. The regeneration weighing factor (1/6) is conservative compared to the weighing factor currently used by the original equipment manufacturers (1/12-1/20). This calculation procedure is designed to

generate an emission result/value which approximates the average emission rate that the system would generate in the field. A critical assumption of this procedure is that a heavy-duty Federal Test Procedure which occurs when a trap is half-loaded generates emission results which represent an average of those produced throughout the loading of a trap. The ARB did not perform tests to confirm the test results submitted by the applicant. A summary of the test results is shown below:

Exhaust Emissions Test Results  
On A 1990 Detroit Diesel 6V-92TA DDEC Diesel Bus Engine

<u>Test Mode</u>	<u>Exhaust Emissions (gm/BHP-hr)</u>				
	<u>HC</u>	<u>CO</u>	<u>NOx</u>	<u>PM</u>	<u>PMc*</u>
Device	.592	3.015	4.830	.053	.092
Baseline	.696	2.543	5.015	.352	.391
Standard	1.3	15.5	6.0	.60	

\* Corrected for use of low sulfur fuel.

The device emission test results did not show any significant increase in emissions.

The staff also reviewed the durability of the particulate trap system and its impact on emission performance of the affected vehicles. Donaldson has been field testing their particulate trap system on a fleet of 400 urban buses in New York for approximately 3 years with minimal problems. With the many hours of operation and its malfunction diagnostic capability, staff is confident the Donaldson Diesel Particulate Trap System will not affect the durability of the vehicle's emission control system. Detroit Diesel is currently going through new engine certification using the Donaldson Diesel Particulate Trap System as a component. While the Detroit Diesel particulate trap engine did have a failure during durability testing, it was due to a weld

in the particulate trap bracket and not the actual particulate trap system. The bad weld caused the heater coils to deteriorate and fail. The ARB, however, allowed Detroit Diesel to replace the heater coils and continue durability testing since the core was not damaged. The core is the component in the particulate trap which controls the emission values. The staff viewed the failure of the bracket weld as an installation problem committed by Detroit Diesel, and not as a design deficiency of the particulate trap.

Therefore, the installation of the Donaldson Diesel Particulate Trap System will not have an adverse effect of exhaust emissions on the affected vehicles. Donaldson Company, Inc. submitted all the required information and fulfilled the requirements for exemption.

Appendix

## SYSTEM DIAGNOSTIC CODE CHART

DIAGNOSTIC CODES		CHECK	GO TO REPAIR SECTION
10	Space between Software Version and Active and Historic Codes		
11	No codes in the system		
12*	#2 inlet temperature low for regeneration	Heater power – 12V & 24V Vehicle charging system  Inlet valve Thermocouple TIM ECM	1 11 & Vehicle Mfr Info 2 7 8 8
13*	#1 filter inlet temperature too high during loading	Thermocouple TIM ECM	7 8 8
14*	#2 filter inlet temperature too high during loading	Thermocouple TIM ECM	7 8 8
15	Engine air flow sensor over range	Engine air flow sensor ECM	6 8
16	Engine air flow sensor under range	Engine air flow sensor ECM	6 8
17	Not used		
18	Not used		
19	Not used		
20	Not used		
21*	#1 differential pressure sensor above range	Pressure transducer Combustion air blower system TIM ECM	5 4 8 8

NOTE: Codes marked with an asterisk (\*) will illuminate an instrument panel light.

DIAGNOSTIC CODES		CHECK	GO TO REPAIR SECTION
22	#1 differential pressure too high for cleaner not processing exhaust	Inlet valve	2
		Pressure transducer	5
		TIM	8
		ECM	8
23*	#2 differential pressure sensor above range	Pressure transducer	5
		Combustion air blower system	4
		TIM	8
		ECM	8
24	#2 differential pressure too high for cleaner not processing exhaust	Inlet valve	2
		Pressure transducer	5
		TIM	8
		ECM	8
25	Not used		
26	#1 temperature too low at high engine air flow during loading	Thermocouple	7
		TIM	8
		ECM	8
27	Not used		
28	#2 temperature too low at high engine air flow during loading	Thermocouple	7
		TIM	8
		ECM	8
29	Not used		
30*	#1 inlet temp low for regeneration	Heater power - 12V & 24V	1
		Vehicle charging system	11 & Vehicle Mfr Info
		Inlet valve	2
		Thermocouple	7
		TIM	8
		ECM	8
31	Not used		
32	Not used		

NOTE: Codes marked with an asterisk (\*) will illuminate an instrument panel light.

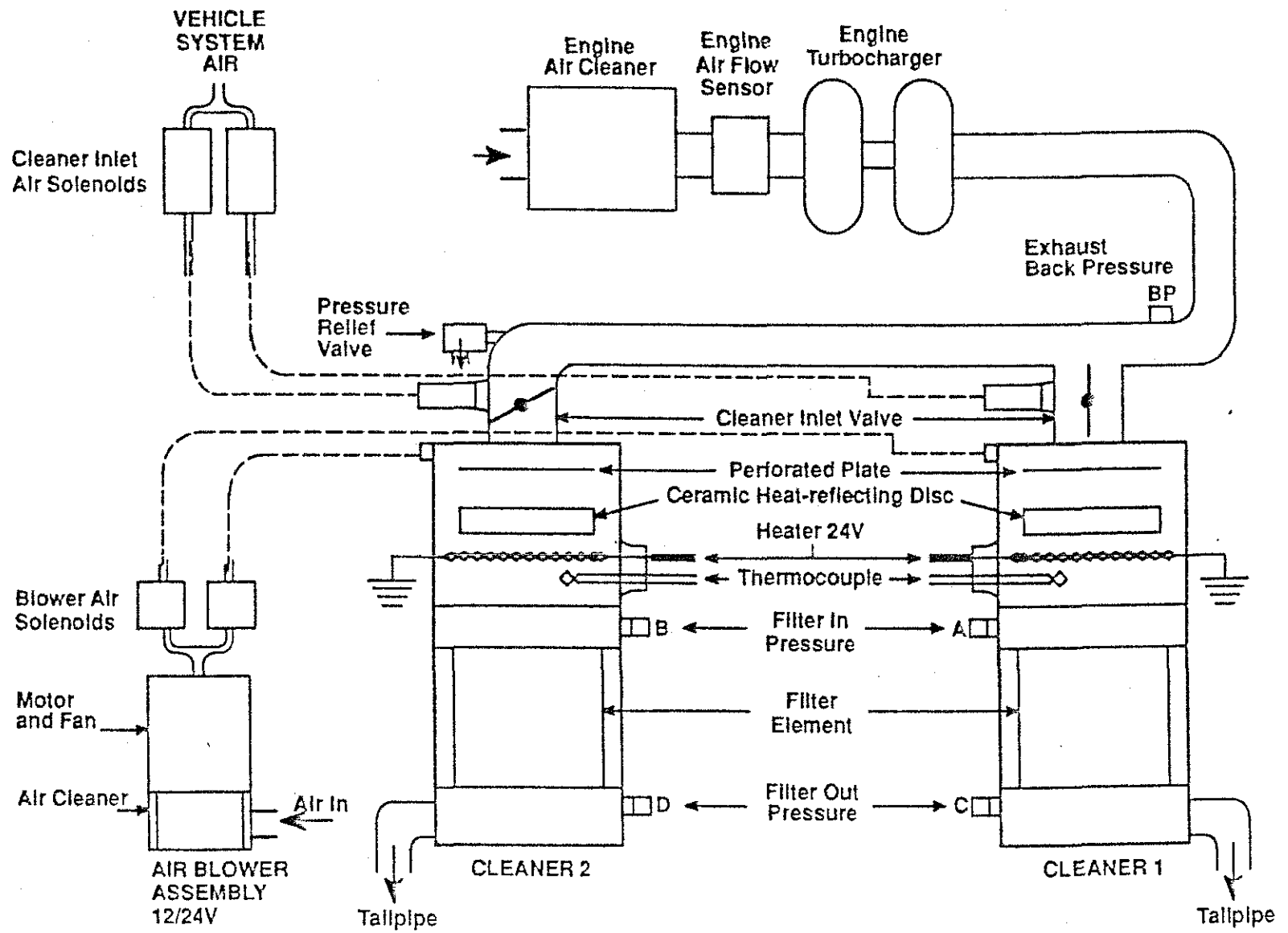
DIAGNOSTIC CODES		CHECK	GO TO REPAIR SECTION
33	Not used		
34	#1 differential pressure sensor below range	Pressure transducer TIM ECM	5 8 8
35	#2 differential pressure sensor below range	Pressure transducer TIM ECM	5 8 8
36	Back pressure sensor below range	Pressure transducer TIM ECM	5 8 8
37	24V vehicle battery voltage too low	Vehicle charging system  Combustion air blower system TIM ECM	11 & Vehicle Mfr Info 4 8 8
38	12V vehicle battery voltage too low	Vehicle charging system	11 & Vehicle Mfr Info
39	Not used		
40	Not used		
41	Not used		
42	Not used		
43	Not used		
44*	#1 temperature above range	Thermocouple TIM ECM	7 8 8
45*	#2 temperature above range	Thermocouple TIM ECM	7 8 8
46	Not used		

NOTE: Codes marked with an asterisk (\*) will illuminate an instrument panel light.



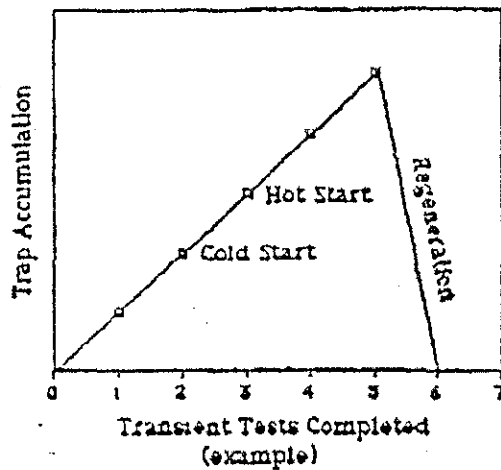
DIAGNOSTIC CODES		CHECK	GO TO REPAIR SECTION
47	Not used		
48	Not used		
49*	Back pressure sensor above range	Pressure transducer TIM ECM	5 8 8
50	24V vehicle battery voltage too high	Vehicle charging system  TIM ECM	11 & Vehicle Mfr Info  8 8
51	12V vehicle battery voltage too high	Vehicle charging system  TIM ECM	11 & Vehicle Mfr Info  8 8
52	Not used		
53	Not used		
54*	#1 filter load not calculated for over 30 minutes	Engine air flow sensor Pressure transducer TIM ECM	6 5 8 8
55*	#2 filter load not calculated for over 30 minutes	Engine air flow sensor Pressure transducer TIM ECM	6 5 8 8

NOTE: Codes marked with an asterisk (\*) will illuminate an instrument panel light.



Engine Exhaust Cleaner

## Composite Result Evaluation Method



E = emission in grams

P = power in bhp-hr

c : Cold Start

h : Hot Start

r : Regeneration

$$\frac{\frac{1}{7} E_c + \frac{6}{7} \left( \frac{1}{6} (E_r) + \frac{5}{6} (E_h) \right)}{\frac{1}{7} P_c + \frac{6}{7} \left( \frac{1}{6} (P_r) + \frac{5}{6} (P_h) \right)} = \frac{E_1}{P_2} = \text{Final Value for a Single Trap}$$

$$\frac{\frac{E_1 + E_2}{2}}{\frac{P_1 + P_2}{2}} = \frac{E}{P} = \text{Final Composite Value for System}$$

Composite Result Evaluation Method  
Figure 2