EPA-AA-TAEB 76-11

An Evaluation of the Electro-Dyn Super Choke

January 1976

Technology Assessment and Evaluation Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Environmental Protection Agency

Background

The Environmental Protection Agency receives information about many devices for which emission reduction or fuel economy improvement claims are made. In some cases, both claims are made for a single device. In most cases, these devices are being recommended or promoted for retrofit to existing vehicles although some represent advanced systems for meeting future standards.

The EPA is interested in evaluating the validity of the claims for all such devices, because of the obvious benefits to the Nation of identifying devices that live up to their claims. For that reason the EPA invites proponents of such devices to provide to the EPA complete technical data on the device's principle of operation, together with test data on the device made by independent laboratories. In those cases in which review by EPA technical staff suggests that the data submitted hold promise of confirming the claims made for the device, confirmatory tests of the device are scheduled at the EPA Emissions Laboratory at Ann Arbor, Michigan. The results of all such confirmatory test projects are set forth in a series of Technology Assessment and Evaluation Reports, of which this report is one.

The conclusions drawn from the EPA confirmatory tests are necessarily of limited applicability. A complete evaluation of the effectivenss of an emission control system in achieving its claimed performance improvements on the many different types of vehicles that are in actual use requires a much larger sample of test vehicles than is economically feasible in the confirmatory test projects conducted by EPA. 1/ For promising devices it is necessary that more extensive test programs be carried out.

The conclusions from the EPA confirmatory tests can be considered to be quantitatively valid only for the specific type of vehicles used in the EPA confirmatory test program. Although it is reasonable to extrapolate the results from the EPA confirmatory test to other types of vehicles in a directional or qualitative manner, i.e., to suggest that similar results are likely to be achieved on other types of vehicles, tests of the device on such other vehicles would be required to reliably quantify results on other types of vehicles.

In summary, a device that lives up to its claims in the EPA confirmatory test must be further tested according to protocols described in footnote 1/ to quantify its beneficial effects on a broad range of vehicles. A device which when tested by EPA does not meet the claimed results would not appear to be a worthwhile candidate for such further testing from the standpoint of the likelihood of ultimately validating the claims made. However, a definitive quantitative evaluation of its effectiveness on a broad range of vehicle types would equally require further tests in accordance with footnote 1/.

1/ See Federal Register 38 FR 11334, 3/27/74, for a description of the test protocols proposed for definitive evaluations of the effectiveness of retrofit devices.

The Electro-Dyn Choke Corporation of Niagara Falls, New York has developed a thermostatically controlled, electric-assist choke which it claims will reduce fuel consumption when compared to conventional chokes. Two Electro-Dyn choke assemblies were made available to the EPA for evaluation purposes.

Test Vehicle and Device Description

The vehicle used in the evaluation is part of the EPA fleet of test vehicles. It is a 1971 Ford Galaxie powered by a 351 cu in./5753 cc V-8 engine. The transmission is a three speed automatic. A tabulation of vehicle characteristics is given on the Test Vehicle Description sheet at the end of this report.

The standard choke assembly on the 1971 Ford uses a bimetallic spring to control the position of the choke blade. Hot air from the exhaust manifold is transported through an insulated tube to the housing containing the bimetallic spring. When the engine is cold, the choke blade is fully closed. After the engine is started, hot air rising from the exhaust manifold heats the bimetallic spring, causing the choke blade to move gradually to the open position.

The Electro-Dyn Choke also uses a bimetallic spring to control the opening of the choke blade. However, the spring is electrically heated, and the insulated heat tube is not used. The voltage supplied to the heating element is regulated by a temperature sensor that is mounted on the engine block (see Figure 1). In the case of this installation, the temperature sensor was mounted under the right front head bolt. This sensor is designed to control the opening of the choke as a function of engine temperature. In addition, the sensor is designed to prevent the choke from closing during warm starts after engine cool down unless the block has cooled sufficiently to require choke usage.

The installation instructions call for the initial adjustment to be made with the choke cover and spring at about 70^{o}F. The bimetallic spring housing is rotated until the choke blade just closes. If stalling is a problem in cold weather, then the bimetallic spring housing is rotated 1/8 inch in the "rich" direction.

Test Program

All tests were conducted in accordance with the 1975 Federal Test Procedure ('75 FTP). Evaporative losses were not measured.

Two baseline tests were run with the vehicle adjusted to the manufacturer's specifications. After completion of baseline tests, the Electro-Dyn choke was installed on the test vehicle. Two choke kits were supplied to the EPA, and a series of three tests was run on the test vehicle with each unit installed. After completing the testing of the two choke installations, the original Ford choke was re-installed, and two more baseline tests were run.

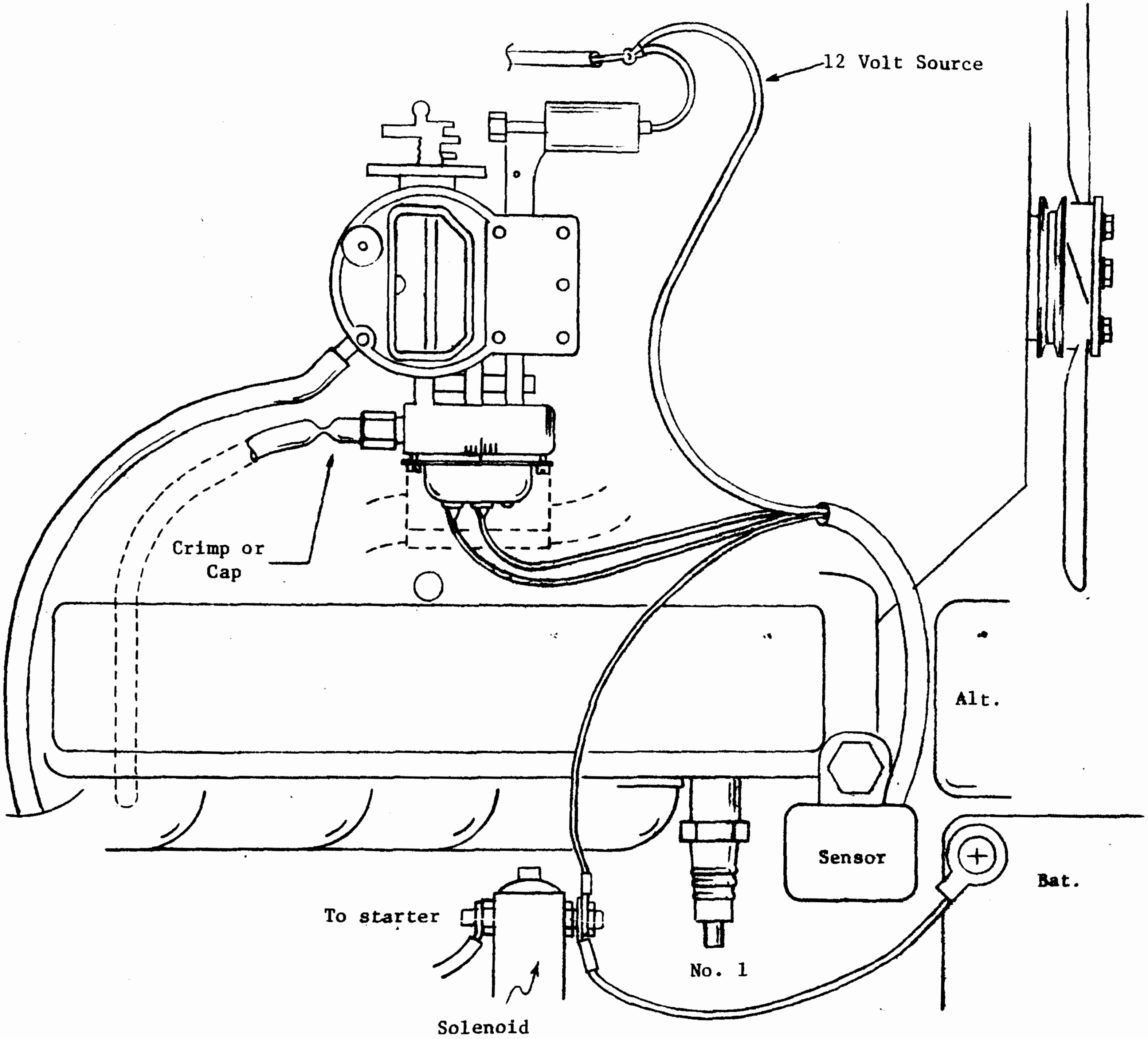

Figure 1: Schematic of Electro-Dyn Installation

Test Results

Exhaust emission data, summarized below, illustrate the effects of the Electro-Dyn choke.

'75 FTP Composite Mass Emissions
grams per mile
(grams per kilometer)

	HC	CO	NOx	Fuel Economy (Fuel Consumption)
Baseline - average of 4 tests	2.82 (1.75)	20.2 (12.6)	3.58 (2.23)	14.1 mpg (16.7 ℓ/100 km)
Choke #1 - average of 3 tests	2.86 (1.78)	20.0 (12.4)	3.72 (2.31)	14.1 mpg (16.7 ℓ/100 km)
% Change	+1%	-1%	+4%	0
Choke #2 - average of 3 tests	2.74 (1.70)	16.4 (10.2)	4.01 (2.49)	13.9 mpg (16.9 ℓ/100 km)
% Change	-3%	-19%	+12%	-1% (+1%)

The '75 FTP contains three regimes of engine operation. These are the cold transient, stabilized and hot transient conditions of operation. The Electro-Dyn choke would be expected to have no effect on exhaust emissions during the stabilized and hot transient portions of the test. The cold transient (Bag 1) portion of the test should contain all the effects of the Electro-Dyn choke, since the engine is started "cold" at the beginning of the cold transient section and is fully warmed-up at the end of the cold transient section.

The following table contains the exhaust emissions and fuel economy measured during the cold transient periods.

'75 FTP Cold Transient (Bag 1)
Mass Emissions in
grams per mile
(grams per kilometer)

	HC	CO	NOx	Fuel Economy (Fuel Consumption)
Baseline - average of 4 tests	3.44 (2.14)	47.1 (29.3)	4.47 (2.78)	12.5 mpg (18.8 ℓ/100 km)
Choke #1 - average of 3 tests	3.39 (2.11)	45.3 (28.2)	4.74 (2.95)	12.7 mpg (18.5 ℓ/100 km)
% Change	-1%	-4%	+6%	+2% (-2%)
Choke #2 - average of 3 tests	3.37 (2.09)	30.9 (19.2)	5.10 (3.17)	12.8 mpg (18.4 ℓ/100 km)
% Change	-2%	-34%	+14%	+2% (-2%)

Both the composite emissions and the Bag 1 emissions indicate that the first choke installation had a negligible effect on exhaust emissions. Changes in emissions and fuel economy were well within the limits of test variability.

The second choke installation reduced composite CO emissions 19% and increased NOx emissions 12%. No significant change in HC emissions or fuel economy occurred. The Bag 1 emission data indicate that the Electro-Dyn choke reduced CO emissions during the cold start by 34% and increased the NOx emissions by 14%. Changes in fuel economy were within test variability.

In addition to the measurement of exhaust emissions, the voltage applied to the choke heating element under the ambient conditions of the '75 FTP was measured. At an ambient temperature of 78°F, 12 volts were applied to the heating element as soon as the ignition key was switched on. This indicates that the temperature sensing unit was requiring minimum choking action, which would be the expected behavior at 78°F.

One of the claims made for the Electro-Dyn choke is that the temperature sensor will prevent the choke from closing during warm starts after engine cool down unless the block has cooled sufficiently to require choke usage. Because of the limited nature of the test program, this claim was not evaluated. No quantitative evaluation of the Electro-Dyn choke was made outside the temperature range of the '75 FTP.

Conclusions

Under the conditions of the '75 FTP, the Electro-Dyn choke did not demonstrate any significant advantages over the standard choke on the test car. The reduction in CO emissions coupled with the increase in NOx emissions is not considered an acceptable trade-off. No significant improvement in fuel economy was noted.

The substantially different results obtained with the two choke assemblies indicate some possible quality control problem or sensitivity to initial adjustment. As far as it was possible to determine, both choke assemblies were installed in an identical manner.

Because these tests did not explore the behavior of the Electro-Dyn choke at low ambient temperatures, further testing would be necessary to establish the effect on emissions, fuel economy and driveability under such conditions.

Table 1

'75 FTP
Mass Emissions in
Grams per Mile
(Grams per Kilometer)

Test #	HC	CO	CO_2	NOx	MPG (1/100 km)
Baseline					
76-3378	2.92 (1.81)	20.7 (12.9)	586. (364.)	3.41 (2.12)	14.1 (16.7)
76-3379	2.87 (1.78)	19.1 (11.9)	582. (362.)	3.68 (2.29)	14.3 (16.5)
77-3	2.81 (1.75)	22.2 (13.8)	592. (368.)	3.72 (2.31)	14.0 (16.8)
77-4	2.66 (1.65)	18.6 (11.6)	605. (376.)	3.49 (2.17)	13.8 (17.0)
Average	2.82 (1.75)	20.2 (12.6)	591. (367.)	3.58 (2.23)	14.1 (16.7)
Choke #1					
76-3427	2.84 (1.77)	15.7 (9.8)	599. (372.)	3.98 (2.47)	14.0 (16.8)
76-3428	2.76 (1.72)	18.6 (11.6)	579. (360.)	2.93 (1.82)	14.4 (16.3)
76-3488	2.99 (1.86)	25.8 (16.0)	587. (365.)	4.26 (2.65)	13.9 (16.9)
Average	2.86 (1.78)	20.0 (12.4)	588. (365.)	3.72 (2.31)	14.1 (16.7)
Choke #2					
76-3456	2.78 (1.73)	14.8 (9.2)	596. (370.)	4.09 (2.54)	14.1 (16.7)
76-3441	2.65 (1.65)	14.3 (8.9)	613. (381.)	4.21 (2.62)	13.8 (17.0)
76-3584	2.79 (1.73)	20.1 (12.5)	601. (374.)	3.73 (2.32)	13.8 (17.0)
Average	2.74 (1.70)	16.4 (10.2)	603. (375.)	4.01 (2.49)	13.9 (16.9)

Table II

Individual Bag Emissions in Grams per Mile

	Bag 1: Cold Transient					Bag 2: Stabilized					Bag 3: Hot Transient				
Test #	HC	CO	CO_2	NOx	MPG	HC	CO	CO_2	NOx	MPG	HC	CO	CO_2	NOx	MPG
Baseline															
76-3379	3.25	43.2	621.	4.60	12.7	2.66	13.5	588.	2.74	14.4	2.98	11.7	540.	4.79	15.6
76-3378	3.34	48.4	620.	4.24	12.5	2.71	14.9	598.	2.59	14.1	3.00	10.8	537.	4.35	15.7
Choke #1															
76-3427	3.48	38.8	623.	5.23	12.8	2.51	9.9	619.	3.02	13.8	2.98	9.4	543.	4.89	15.7
76-3428	3.18	40.3	605.	4.40	13.1	2.75	14.0	593	1.27	14.2	2.46	11.0	532.	5.01	15.9
76-3488	3.52	56.7	619.	4.60	12.3	2.91	19.9	602.	3.56	13.8	2.74	13.8	536.	5.34	15.7
Choke #2															
76-3456	3.25	25.9	615.	5.16	13.3	2.60	12.9	621.	3.27	13.7	2.76	10.3	535.	4.84	15.9
76-3441	3.41	28.0	641.	5.42	12.7	2.53	11.0	628.	3.31	13.6	2.30	10.3	562.	4.99	15.2
76-3584	3.46	38.7	633.	5.10	12.4	2.73	17.2	602.	2.92	13.9	2.39	11.4	568.	4.55	15.0
Re-baseline															
77-3	3.80	50.1	628.	4.50	12.3	2.76	17.9	600.	2.86	13.9	2.16	9.5	549.	4.77	15.5
77-4	3.36	46.6	638.	4.52	12.3	2.62	12.7	615.	2.61	13.8	2.21	8.9	563.	4.39	15.2

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1971 Ford Galaxie
Emission control system - Engine Modifications

Engine

type	4 stroke, Otto cycle, V-8, ohv
bore x stroke	4.00 x 3.50 in./101.6 x 88.9 mm
displacement	351 cu in./5753 cc
compression ratio	9.0:1
maximum power @ rpm	240 bhp @ 4600 rpm/179 kW @ 4600 rpm
fuel metering	2 barrel carburetor
fuel requirement	

Drive Train

type	front engine, rear wheel drive
tire size	H 78 x 15
curb weight	4115 lbs./1867 kg
inertia weight	4500 lbs
passenger capacity	6

Emission Control System

basic type	improved combustion
durability accumulated on system .	15500 mi./24900 km