EPA-420-S-77-101

ASSESSMENT OF A PROPOSED EPA REGULATION WHICH WOULD REDUCE CARBURETOR ADJUSTABILITY

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For: The Environmental Protection Agency
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THE AUTHOR

Carl E. Burke recently retired from American Motors after 30 years of service. Prior to retirement he had held the position of Director of Environmental and Energy Regulations immediately preceeded by the position of Chief Engineer of Power Plants and Emission Control. As Chief Engineer, he was responsible for power plant design and development including the design and certification of vehicle emission control systems. The author represented the corporation on the Motor Vehicle Manufacturers Association in various capacities and on the Coordinating Research Council. The author is a member of the Society of Automotive Engineers. Prior to working for American Motors, he was employed for a period of 10 years in engineering test and development of industrial, farm equipment and truck engines. The author graduated from Michigan State University with a BSME degree.

INDEX

Section 1

PRELIMINARY MEETINGS

On March 10, 1977, C. E. Burke of C. E. Burke Engineering Services met with John P. Dekany, Division Director of the Environmental Protection Agency Emission Control Technology Division, and Charles Gray and Karl Hellman of his staff in Ann Arbor, Michigan. The purpose of the meeting was to outline the objectives and other details of the request by EPA for a study of a regulation EPA planned to propose which would, in effect, reduce carburetor adjustability. Other meetings and discussions were subsequently held to develop the details of this request.

It was agreed that for the purposes of submitting his bid, the writer would consider the proposed regulation to require certification vehicles for the 1980 model year to meet emission standards with any or all of the carburetor adjustments affecting seven carburetor parameters set at any point within the available adjustment range or at any missadjustment which could be accomplished using normally available hand tools.

The writer submitted the bid of C. E. Burke Engineering Services in a letter to John P. Dekany dated April 4, 1977 which was subsequently accepted. Service order CD-7-0152-A, provided to C. E. Burke Engineering Services, authorized the work herewith reported.

Section 2

SCOPE OF WORK

The purpose of this study is to determine the impact of an EPA regulation, targeted for the 1980 model year, which would require that carburetor adjustments be limited such that emission data certification vehicles could meet emission standards regardless of carburetor adjustment settings. The carburetor parameters to be considered are:

1. Idle mixture
2. Idle speed (minimum speed)
3. Choke bi-metal setting
4. Choke vacuum break setting
5. Accelerator pump quantity
6. Power enrichment calibration
7. Part throttle calibration

The impacts to be determined on the manufacturers and the purchaser/owner are:

1. Manufacturing lead time
2. Original equipment manufacturer (O.E.M.) costs
3. Service costs and quality
4. Warranty costs
5. In-use problems

Section 3

CONTRACTOR'S INTERPRETATION OF THE REGULATION REFERENCED IN THE INTENT TO DEVELOP RULEMAKING PUBLISHED IN FEDERAL REGISTER VOL. 42, NO. 104 DATED MAY 31, 1977

Understanding of the regulation is based on preliminary meetings discussed in Section 1. Definition and clarification of two basic questions are required when addressing this study and meeting the objective as described in the Scope of Work. The two questions are:

1. What is an adjustment?
2. What defines the limits of an adjustment?

The contractor (C. E. Burke) defines an adjustment as a means external to the carburetor capable of changing the calibration of a parameter and accessable without dissassembly of the carburetor.

The limits of an adjustment are defined as the maximum change that can be made toward either extreme, intentionally or unintentionally, either by hand or using normally available hand tools such as screw drivers, socket wrenches or pliers.

Section 4

RATIONAL AND APPROACH

The assessment of the impact of the proposed regulation as outlined in the Scope of Work is addressed from the view point of a Chief Engineer of a typical automobile manufacturer; however, it is not an assessment of the impact on the total automobile industry. Discussion is limited to two carburetor types, a 1V and a staged 2V, as would be used on 4 or 6 cylinder engines in compact cars. Although the carburetors selected are currently in production and scheduled for 1980, the study is not intended to cover the great diversity of carburetors currently in production or scheduled for production in 1980. As a point of reference, we are considering a total annual volume of 400,000 cars.

Included in the study is consideration of the impact on engineering, manufacturing, sale, and owner satisfaction with the vehicle throughout its useful life which is considered 10 years and 100,000 miles. Proper servicing and overall performance of the vehicle is of great importance since it reflects on repeat sales and the overall public image of the manufacturer.

The study does not provide detailed design information on means of meeting the requirements of the regulation although it will reference design concepts. Detailed projections on the affect of the proposed regulation on warranty costs or servicing costs over the life of the vehicle are not provided since the basic information required is not available at this time.

Although the contractor had meetings with carburetor suppliers,

representatives of the petroleum and fuel additive industries, and replacement carburetor manufacturers for the purpose of expanding his background in the technical areas affected, the views expressed are those of the contractor based on his judgment.

Section 5

ORGANIZATIONS CONTACTED

Cardo Automotive Products, Inc.
Philadelphia, Pennsylvania

Carter Carburetor Division, ACF Industries
St. Louis, Missouri

Champion Parts Rebuilders, Inc.
Oak Brook, Illinois

Chevron Chemical Company, Oronite Additives
San Francisco, California

Chevron Research Company
Richmond, California

Ethyl Corporation, Research Laboratories
Detroit, Michigan

Holley Carburetor Division, Colt Industries
Warren, Michigan

Mobil Research and Development Corporation
Paulsboro, New Jersey

Purpose of meetings: 1. To contact normal carburetor suppliers and discuss action to be taken in regard to the proposed regulation. This is the normal course of action of a Chief Engineer. 2. To contact other organizations who may have information on the impact of the regulation, especially as it affects the performance of the manufacturers' vehicles after sale.

Section 6

IMPACT OF THE PROPOSED REGULATION

In this section the contractor addresses each of the seven carburetor parameters that are listed in the Scope of Work in terms of the five impacts listed.

The issue of carburetor deposits and the effects of gasoline additives will be covered in a separate discussion.

A summary including the contractor's recommendations will conclude the report.

Idle Mixture

Design and manufacturing - On the 1V and staged 2V carburetors under discussion, the current 1977 carburetor designs have mixture adjustments and the adjustment range is limited by a plastic cap. The limits could be exceeded, however, by the use of excessive force with available hand tools. In all probability, the emission standards could not be achieved at the maximum range of the adjustment achieved in this manner. A redesign is required to meet the requirements of the proposed regulation.

To meet the requirements of the regulation would require elimination of the external mixture adjustment at the time the carburetor is shipped from the carburetor manufacturer. The design to be employed on both the 1V and the staged 2V carburetor could be a hardened steel cup plug or plate pressed into the carburetor body covering the idle mixture screw. The idle mixture screw would be available during the manufacture of the carburetor.

This new design could be made available for 1980 model year production. The calibration of the fixed mixture setting would be that required to meet emission certification.

Costs of the non-adjustable mixture designs on the two carburetors under consideration would not be available from the carburetor suppliers since the final designs would not be resolved at this point. The contractor's broad estimate of the cost increase (customer cost in 1977 dollars) of the carburetor would be 15¢ to 25¢ with a range of tooling costs from $20,000 to $100,000.

Since mixture is not normally adjusted during vehicle manufacture, no significant impact would be felt during this process.

We are optimistic that certification can be accomplished without mixture adjustment. Carburetors without caps, making the mixture screws accessable, would be available during engineering development and finalizing of emission control system specifications.

We are concerned that a non-adjustable mixture in either carburetor would have serious impact on the performance of the vehicles in use. Idle quality problems could not be adequately serviced in all cases and would result in higher servicing costs during the life of the vehicle. Aftermarket carburetor rebuilders would, in all probability, produce replacement carburetors without mixture adjustment since their policy is to match original equipment carburetors. It can be projected that the sale of replacement carburetors would increase since ready means to correct idle mixture related driveability problems or non-complying emissions

would not be available. In many cases, however, this would not correct the driveability problem, and it would result in a high rate of return of replacement carburetors with its consequent negative impact on the business. This situation would be relieved to some extent if a means to adjust mixture in service was developed and incorporated in the design which was not as readily accessible as is the case in current external adjustments.

Mixture adjustment has been available and required in vehicles since the introduction of mass-produced automobiles. The limiter caps installed on current vehicles still allow for adjustment when the need arises although, admittedly, this has been abused from the standpoint of emission control.

Circumstances that call for mixture adjustment and potential impacts of its elimination are:

1. Induction system leaks develop in vehicles in use at the many gasketed joints and hose connections during the normal life of the vehicle. When minor leaks develop and before they are readily detectible, a mixture adjustment is required. It can be assumed that the potential for induction leaks can be reduced by improved design and material. The cost and lead time for this is not known because the extent of the problem has not been identified. The emission control system includes many calibrated air flows which are flowing into the induction system at idle and are included in the original mixture setting calibration. These fixed flows include PCV, choke heat air, evaporative control system, and others. When

the calibration of these units change, a new mixture setting may be required to maintain proper air/fuel ratio and idle quality.

2. During the life of the vehicle, valve seating, piston ring function, and other engine parameters deteriorate stressing idle quality. The normal idle quality of a vehicle meeting emission standards has very little margin, being set at slightly less than best idle quality in the lean direction. An older vehicle may require mixture adjustment to maintain acceptable idle quality.

3. During the life of the vehicle, deposits form in the carburetor originating from atmospheric contaminants, engine blow-by, gasoline gums, and exhaust gas recirculation gases. These deposits affect idle mixture, especially in the case of deposits near the throttle plate and idle port and tend to cause idle mixture to go richer. Deposits in other locations in the carburetor have caused other areas of the calibration to go rich or lean. Until such time as this problem is resolved, which will be covered in other areas of this report, idle mixture adjustment is required to compensate for the deposit effects at idle.

4. The most practical and readily available method of setting idle mixture in service to the requirements of exhaust emission control and the manufacturer's specifications is the lean drop method. An adjustable idle mixture is required to use this method.

Impact on servicing costs and quality - As previously pointed out, in normal use, there is a need, due to changing engine conditions, to re-adjust idle mixture to maintain adequate idle quality. Idle quality problems such as stalling and roughness are readily apparent to the driver and are problems he will seek to have corrected. Although the source of the problem may not be carburetor related, the job of finding these non-carburetor problems is often difficult, time consuming, and consequently, costly. If the problem is a minor induction system leak, the problem can be corrected by carburetor mixture adjustment. Lacking a mixture adjustment, there may be a tendency to recommend a replacement carburetor. This can involve a cost of $25 to $53 plus labor, without correcting the problem. If the problem was carburetor deposit related, it would have corrected the problem, however, depending upon the extent of the deposit, a mixture adjustment could correct the idle quality complaint at lower cost. Warranty costs, we project, would increase due to lack of means for the dealer to correct a common complaint, however, there is no data available for the writer's determination of the magnitude of this increase.

Extensive field studies of vehicles in service are required to identify the problems that may be created by the elimination of idle mixture adjustment and to evaluate the performance of non-adjustable idle systems.

The closed loop exhaust sensor carburetor control systems proposed for future emission control systems will not, at their current state of development, alter the positions taken in the preceeding on idle mixture adjustment.

Idle Speed (Minimum)

Design and manufacturing - Idle speed is adjustable on the two carburetors under consideration. If we set aside, for the moment, other problems, it can be said that a design which sets a low limit to idle speed could be tooled and produced for the 1980 model year. The detail of the design is not available, but if it consisted of an additional idle stop screw, covered or eliminated after setting on the carburetor flow box, the added cost per carburetor could reach 20¢ with a tooling cost of $50,000.

The design would have no direct effect on the process of vehicle manufacture although idle speed problems that would come up as a result of this design would be more time consuming to correct on the assembly line.

On the basis that the vehicle would be required to meet emission certification standards at the minimum idle speed, this speed would then be essentially the low limit of the recommended idle speed. When the total carburetor-engine-vehicle system tolerance range is considered, it would result in being forced to select a higher than desirable recommended idle speed. This would result in owner complaints and increased service and warranty costs. The extent of this cost increase is not predictible since the degree of the problem will not be known until considerable engineering investigation is conducted.

A further problem relates to the impact this requirement would have on the anti-dieseling solenoid controls now used which function to close the throttle below curb idle when the ignition

is shut off. Although other designs have been used to accomplish this same function, they are more complex involving basic carburetor design changes. The writer is refering to a design to cut off idle fuel flow at engine ignition cut off. Costs are not available since a design on which to base a cost is not available on the two carburetors under study. We question that lead time is adequate should this route be selected.

Many factors affect idle speed of vehicles in use such as break-in, climatic conditions, and varying engine conditions. An excessively high idle speed which may result from a minimum limit device on the carburetor cannot be tolerated since, with automatic transmissions, it stresses the brake system and can result in safety hazards. There must be a method available to reduce idle speed and it is the writer's opinion that the manufacturer would be forced to accomplish this by other means should control be limited at the carburetor. This would increase the cost of the system.

Choke Bi-Metal Setting

This parameter is adjustable on the carburetors under study. Preliminary designs to eliminate this adjustment are available and could be tooled and implemented by the 1980 model year. We anticipate a piece cost increase of 25¢ over the current design bi-metal assembly with a tooling cost of approximately $60,000. The costs are estimates by the contractor. Accurate costs from the suppliers would not be available until final designs are completed. The change would have no significant impact on the manufacture of the carburetor or vehicle. It would have no impact on emission certification.

It is an adjustment used in the field to correct driveability complaints, however, its effectiveness is perhaps overrated. Used indiscriminately, it can have an adverse effect on vehicle emissions not commensurate to the gains achieved in driveability.

Choke Vacuum Break Setting

The 2V carburetor under consideration has an external adjustment of the choke vacuum break setting. This could be redesigned at approximately 10¢ increase in piece cost and available for 1980 model year production. Tooling costs should not exceed $40,000. Again, these are the writer's estimates in advance of final design.

The extent to which this adjustment is needed and used in service is difficult to determine, therefore, the impact on servicing quality and costs is difficult to estimate. In the interest of maintaining the manufacturers' specifications and preventing misadjustment in use, there is reason to eliminate this external adjustment.

The 1V carburetor under study does not have an external adjustment of vacuum break setting, and by the writer's definition, requires no change in this area to meet the intent of the proposed regulation. Setting the choke to specification during manufacture of the carburetor is accomplished by bending the internal linkage. Without major redesign of the carburetor, we know of no means to assemble the carburetor without some means of adjustment to specifications during assembly.

Accelerator Pump Quantity

In the case of the 2V carburetor under consideration, accelerator pump quantity is externally adjustable. This adjustment could be eliminated by the 1980 model year. No change in piece cost would result with minimal tooling cost involved.

The extent to which changes in pump quantity (pump stroke) is used in service is not clearly defined, but it is the writer's judgment that it is minimal. There may be some advantage from a driveability standpoint to move from the mean pump adjustment to prevent "slugging" at high ambient temperatures and improve warm up driving at cold ambients, however, it is the writer's judgment that the need is minimal.

In the case of the 1V carburetor under consideration, no external adjustment is available. The internal changes required to change the pump quantity involve changes in springs, shims, or plugging of a by-pass hole, if one is used in the calibration. The information required to make a change is only available to carburetor specialists. We do not judge the proposed regulation will affect this carburetor in the pump area.

Power Enrichment Calibration

The power enrichment calibration of the 2V carburetor is not considered adjustable since changes in calibration would require internal modification. The parts required and special knowledge is not readily available except to specialists.

The 1V carburetor also requires internal modifications to change the calibration. This is a metering rod carburetor requiring changes in parts and internal dimensional settings not normally available to the general public. In summary, this is not judged an adjustable parameter.

Part Throttle Calibration

The calibration of the 2V carburetor can be changed by jet replacement; this is an internal part. On the 1V carburetor, a metering rod change or a change in the metering rod operating position will alter the part throttle calibration. We do not consider this an adjustable parameter in either of the carburetors under consideration. To change the design of either of these carburetors to accomplish 100% assurance that the calibration could not be changed by a specialist through carburetor tear down and modification cannot be visualized by the writer at this time. If it is possible, we would not consider it feasible in the time frame proposed for this regulation.

Section 7

CARBURETOR DEPOSITS

In normal operation using gasolines without a proper additive, deposits form in the carburetor and intake system of the engine. The source of these deposits are atmospheric contaminants, engine blow-by, exhaust gas recirculation gases, and gasoline gums. These deposits accumulate in the throttle plate area of the carburetor affecting idle mixture and consequently, idle quality and raise idle emission of CO and HC. Deposits also accumulate in other areas of the carburetor such as at the air bleeds affecting the overall calibration and in the choke area which can affect choke performance. These deposits can accumulate at relatively low mileage.

In the consideration of a regulation which would serve to reduce carburetor adjustability, the subject of carburetor deposits is pertinant. Carburetor adjustability has served in the past to adjust carburetor metering to changing engine conditions. Deposit formation in the induction system is one of several engine and carburetor changing conditions.

Considerable field testing has been done by the petroleum and additive industries in past years which has documented the nature and affects of induction system deposits.(1) This information has been reported and is in the public record. Considerable work on the performance of gasoline additives has been reported showing that the induction system deposit problem, particularly the carburetor deposit problem, can be effectively controlled by use of

available gasoline additives. The reports have shown that without an effective additive, the deposits cause idle mixture and the low end of the part throttle calibration to become richer, adversely affecting idle quality, fuel economy, and exhaust emissions. It may be desirable to repeat some of the work on current or advanced carburetor systems. Although the degree of the effects of additives reported to date may be debated, the trend is unmistakable.

There are gasolines sold today that do not have an effective carburetor additive. This acts to reduce the quality of idle which, in turn, will call for more frequent engine tune up, specifically idle mixture adjustment.

Effective carburetor additives exist today and could be made available in unleaded gasoline sold in 1980 given proper incentive. The writer estimates the added cost to a gallon of gasoline would fall in a range from 0.1¢ to 0.3¢. The writer is not in a position to estimate the capital costs involved.

Certain of the additives available are effective in controlling intake manifold deposits. These deposits, if present in sufficient quantity, adversely affect driveability.

In considering carburetor or total induction system additives, the need for developing a practical performance evaluation test that correlates with field performance becomes a necessity. A concern in developing the performance evaluation test is the need to recognize changing emission control system designs and possible effects on the prior established performance of an additive.

Although this is under study through CRC, a totally acceptable test has not been developed.(2) To complete this development will involve substantial cooperative work and testing.

Section 8

SUMMARY AND RECOMMENDATIONS

The proposed regulation, as presented to the contractor, has the objective to limit carburetor external adjustability. In addition, certain parameter adjustments were included which are controlled by internal components. On those occasions that carburetors are disassembled for service and replacement of parts, it is necessary on reassembly to make certain internal adjustments to compensate for slight dimensional differences in the new parts to bring the total carburetor assembly to original manufacturing specifications. To accomplish this, the carburetor design must provide this adjustability.

It is the contractor's estimate that during the life of the vehicle the carburetor must be disassembled for service at least once and possibly several times.

The carburetor rebuilding and replacement industry, as currently constituted, has the same need as the original manufacturer: to make internal adjustments to assembled specifications. As an indication of the extent of carburetor servicing and replacement during the life of the vehicle, it has been estimated that the total carburetor replacement industry produces nearly 10,000,000 units annually. Their major volumes are for cars five and six years old.

The carburetor is often subject to adjustment, tear down, or replacement as a result of misdiagnosis of driveability problems. Proven diagnostic techniques and equipment should be developed and

become generally available before the concept of the non-serviceable carburetor can be introduced. Without such techniques available to all mechanics and technicians in the service industry, the sale of replacement carburetors would increase needlessly, increasing service costs.

Contractor's position on the seven parameters:

Idle mixture - We recognize that this may be a source of misadjustment in the field and must be more effectively controlled. A fixed idle setting without some means of adjustment in service is not judged practical at the state of the art projected for 1980. Long term in use testing should be conducted to gather more information. Should a fixed idle setting or a fixed rich limit be ultimately adopted, it must be preceeded by universally available diagnostic techniques capable of identifying the cause of engine malfunctions.

Idle speed (minimum) - Although this is an external carburetor adjustment and could be included under the intent of the proposed regulation we are concerned with the problems inherent in its implementation including, to our knowledge, the current lack of feasible designs. We are also not aware of evidence that indicate emission reductions would be achieved by such a requirement.

Choke bi-metal setting - This is an external adjustment which could be eliminated if required. Servicing costs may

increase due to a possible increase in the sale of replacement bi-metal assemblies in lieu of ability to adjust.

Choke break setting - This is not considered an adjustment on the 1V carburetor under study and would not be included in the proposed regulation. This is an internal adjustment required during carburetor manufacture and at carburetor rebuild to bring the carburetor to proper specifications. On the 2V carburetor, it is an external adjustment which can be eliminated by redesign.

Accelerator pump quantity - On the 2V carburetor under study, this is an external adjustment and could be eliminated. On the 1V carburetor under study, it is not an external adjustment and should not be affected by the proposed regulation.

Power enrichment calibration - Not an external adjustment on either carburetor involved; should not be affected by the proposed regulation.

Part throttle calibration - Not an external adjustment on either carburetor; should not be affected by the proposed regulation.

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(2) Carburetor Test Procedure Panel of the Coordinating Research Council Motor Fuels and Engine Cleanliness Group. (Coordinating Research Council, Inc., 30 Rockefeller Plaza, New York, New York 10020).