STATUS OF EMISSION CONTROL SYSTEMS

COMPATIBLE WITH LEADED GAS

Presented at the Annual Meeting of
Lead Industries Association
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F. M. Osborn, Session Chairman

Moderator: Mr. J. L. Kimberley, Lead Industries Association

Panel: Mr. O. Fremd, PPG Industries

Dr. Edward Cantwell, E.I. du Pont de Nemours, Inc.

Mr. W. E. Adams, The Ethyl Corporation

MR. OSBORN:

In order to bring us up to date on the present state of emission control systems compatible with leaded gasoline we have asked representatives of three companies who are leaders in the development of such emission control devices to fill us in. I would emphasize at this point here we are concerned particularly today with the devices rather than the broader environmental problems, but no doubt we'll touch on those also.

Here to moderate the discussion is Mr. John L. Kimberley, who was formerly Executive Vice-President of the LIA and the ZI and now, after retiring from that position, senior adviser on environmental affairs in LIA. He has been actively involved on the lead in gasoline issue since 1969 and a spearhead of the LIA activities in this area. He has presented the lead industry's position to more than twenty legislative bodies. He is a member of the American Mining Congress, American Society for Testing & Materials, British Institute of Metals, American Institute of Mining and Metallurgical Engineers, and the National Association of Corrosion Engineers. If that is not enough, he is also qualified. I am told here he holds a degree in mechanical engineering and metallurgy from Yale University. I now call on Jack to introduce his panel.

MR. JOHN L. KIMBERLEY:

Thank you, Frank.

Mr. Osborn, Gentlemen, one of the hardest things to do in a series of meetings such as this, when there is one subject of such primary importance, is to avoid repetition and I shall try my best to do just that as concerns environmental lead. I want to make a couple of comments on the matter of the reduction of lead in gasoline as proposed by the Environmental Protection Agency as was covered this morning by Mr. Mushlitz. The target of E. P. A. is to effect a 60% to 65% reduction in automotive emission lead to the atmosphere by January 1, 1977. They have no doubt gone through computer calculations and the study of voluminous reports and have come up with the opinion that, through attrition of older cars over the years and the scheduled reduction of lead in gasoline from the present 2.5 to 2.6 grams per gallon to the 1.25 grams per gallon max. that will exist after 1/1/77, such a percentage reduction in emitted lead might be accomplished. Jerry Cole has just discussed the problem of lead in your working areas. There are stack emissions to be considered, plant effluents, paints and ceramics. We have had suggestions that it is dangerous to use lead in building construction because if you had a fire you might kill the firemen. Plumbing is under attack. It is only a question of time before we hear more about lead in the single line soldered joint in a tin can. We'll hear about it in food-stuffs, but of all these threatened uses the most important is the potential loss of the lead in gasoline additives. There is to be a seminar tomorrow that will cover some of the more general aspects of lead in the environment but we are now in a spot where you should know where we stand in the way of hardware (for want of a better expression) in systems to take care of the emission problems and at the same time be compatible with lead.

The panel to discuss "lead compatible systems for automotive emissions control is well experienced in the field of gasoline and oil and lubricants. They are all well educated. They are all of substantial experience in our field of interest and I won't read the biographies because we have not got the time.

We have Ed Cantwell of DuPont, Bill Adams of the Ethyl Corporation, Roy Sugimoto and Os Fremd of the Houston Chemical Division of PPG. Each of these men has the feeling that his company is as far along in the approach to a solution of the emission problem in automobile exhaust as anyone else. I have had the experience over the last two years of watching this development very closely and must express the complete conviction that the state of the catalytic systems the automobile industry says they are going to use, (and I acknowledge they have been consistent with this), is not very much farther ahead than it was two years ago. I don't know how many of you were at the S. A. E. meetings at Detroit in January, 1972, but there were several papers on emission problems with respect to catalysts that will do the job on gaseous emissions and last 50,000 miles. Well, I don't think they have got anything that will last 5,000 miles yet, certainly every indication from the remarks made by very well qualified technical speakers from the auto industry was that the thing is still in its experimental childhood, if not infancy.

The Ethyl Corporation has been working diligently on this problem and have a well advanced system that has many merits. Obviously, I am not going to take sides on each one of the systems to be discussed. You are on your own, but I would like Bill Adams of Ethyl to discuss their Lean Reactor System, is that it, Bill? Come along, will you please?

MR. WILLIAM E. ADAMS, THE ETHYL CORPORATION:

Thank you, Mr. Kimberley.

Certainly it is a pleasure to be here today to describe The Ethyl Corporation's work on the exhaust emission systems that are compatible with leaded gasoline. In what might be a slight over-simplification we can categorize thermal reactor systems as either Rich Reactors or Lean Reactors. Both can be used with leaded gasolines and each has its own advantages in realizing low emission levels. Ethyl has worked many years to develop low emission systems based on the principle of lean air to fuel ratios. The primary reason for this in the beginning was that it just made sense to burn as much as practical of the pollution material in the cylinder itself and this remains a philosophy today. Basically, our system involves operating lean so that the emissions of all three pollutants - hydrocarbon, carbon monoxide and nitrogen oxide - are relatively small; then we add reactors to give additional reduction of hydrocarbon and carbon monoxide. These combine with oxygen that is left over from the lean combustion to give very low emission. Finally, exhaust gas recirculation is added to further reduce the oxides of nitrogen. But, in order to operate lean and retain good driveability, we must do a lot more than just lean out the carburetor by turning a screw. It has required the development of a new carburetor, in our case a three barrel carburetor that utilizes the principles of high velocities and thereby gives a good mixture distribution so that the engine fires evenly.

Additional work has gone into programmed spark advance to give optimum emission combined with good driveability.

Now, there are several advantages to a lean fuel reactor system. First of all, the fuel economy and performance that can be obtained because the automobile can operate with a high compression ratio engine on high octane leaded gasoline. Also the lean combustion is basically economical. The only significant fuel consumption penalty for our system is that associated with exhaust gas recirculation, and for us that is about 10%. Because the engine runs lean, the exhaust, leaving the cylinder container hot and well mixed with oxygen left over from the combustion process, we don't require an air pump. And because the hydrocarbon and carbon monoxide emissions are relatively low as they leave the cylinders, the heat released in the reactors is relatively small. This is important because it means relatively low temperatures and therefore exotic exhaust system materials are not required. A last advantage is common for all reactor systems. We think that hardware systems are basically superior, at least in this stage of development, to any chemical system that we know about. The mere presence of the system on the car indicates that the system is functioning. By contrast, the catalytic system can be degraded by heat attrition, poisoning, you name it, and thereby be rendered ineffective, and a motorist has no way at all of knowing this.

Well, perhaps we can start into the slides. I might also mention that this relatively brief description of the system is supported by a brochure down at the Press table if anybody would like it. What are the emissions of the system?

Focus your attention, please, on the bottom two lines. The top line is from the 1970 test procedures and does not have much significance today. The middle line gives the emissions in grams per mile, using the present 1972 system of measurement, and, as many of you may know, the 1975 system measurement is very similar but results in slightly lower numbers. For '75 we call this (HC) maybe .5 to 1 and this one (CO) 5 to 10. And for those of you that also have memorized the 1976 emission standards, you will know that this figure for standards (referring to HC) is about 0.41, and this one (referring to CO) is about 3.4, and this one (referring to NO_2) is about .4. We can meet the 1975 one on NO_2 but not the 1976. But, at the same time, you can note the bottom line which gives the overall percent reductions from the non-modified car. I think this is a significant amount of reduction. As we go through the hearings starting next week, we will hear the stories of why the automobile companies feel they cannot meet the 1975 standards and ask for a delay. These things become more significant because, if they can't meet them, they are going to have to set interim standards, and perhaps these (referring to slide) are good enough to meet interim standards.

I want to get to the next slide because it shows very clearly the amount of reduction that has already taken place. The graph presents emission standards on a relative scale and each year has successively lower bars. Plotted on the cross-hatched area is our lean reactor car. Now even this does not tell the whole story of what a low emission control system has to accomplish. It must do more than just enable the car to pass standards at a low mileage. As you may know, the catalyst systems have shown an ability to meet 1975 standards, at least at very low mileage. The reactor systems may start at a higher level, but they can maintain stable emissions over a long period of time.

Ethyl Corporation loaned one of their lean reactor cars to the California Air Resources Board in 1970. At the present time, this car has accumulated over 20,000 miles of operation in the hands of the California State people.

The next slide shows the emissions stability for that car made during the succession of tests by the California Air Resources Board. And the tests just last week agreed well with this. As you can see, we have not been without a problem, we have replaced a timing chain. It was worn, we believe, because of iron particles in the exhaust recycle gas. We replaced it and the car has continued on and we have since installed a filter in the recycle line.

We have also been operating a car out of the Detroit laboratory using the automobile manufacturers route that is used by the car companies for durability testing of their emissions system. This slide shows the emission stability for the first 35,000 miles of testing, and mileage is still being accumulated. Here again you see a couple of repairs, including an exhaust system repair mentioned. It was not the emission system but was further down the tailpipe and we had the same timing chain problem that you saw in the California test. But this is the reason for durability testing-to find problems and resolve them.

Now, the thermal reactor systems have been shown to be the least expensive of future emission systems. This was pointed out in an unbiased report of the Aerospace Corporation to the E.P.A. in November of last year. This slide has been reproduced from that report and shows lifetime costs of emission control systems at various levels of NO_x reduction. You can see, as NO_x reduction gets more stringent, (you go to the left, you get the lower values of NO_x) it is going to cost more and certainly we agree with that. Also plotted you see the reactor systems. This is the LTR (Lean Thermal Reactor) down here and the RTR (Rich Thermal Reactor) system, and it is not hard to see that they are the lowest cost. The lean reactor is slightly lower cost than the rich reactor, but at this stage of development anyway, cannot reach quite the low values of NO_x that the rich reactor system can. But the only system that can even touch these in terms of cost is the 50,000 mile dual catalyst system. As I am sure you were aware, and as Jack mentioned, this style of system is still an objective rather than a reality. Even the 25,000 mile one up there is also in that category.

Now, let us discuss for a moment our particulate trapping system. We have been directing our research along two approaches. One is to develop a simple low-cost trap that will replace the muffler. It will cost about the same amount and have the same size, back pressure and silencing characteristics as a muffler. The second has been to design a more complex system that would catch more of the particulates but would also result in a larger, more expensive system. We have been running prototype traps. By prototype we mean the kind that directly take the place of the muffler. First we ran pre-prototypes and got some basic data. Now we are on prototypes stage on this one. This is a typical trap at the bottom with the standard muffler at the top. We call this trap the Anchored Vortex model because of its superior design that reduces particulate re-entrainment. Now, in the interest of time, I am not going to go through the flow path but let me say that it contains two anchored Vortex traps in parallel and can run 50,000 miles and more before it needs replacement. In one car over 63% of the lead burned was retained in the car and trap for over 50,000 miles. The average of several prototypes now running is in the 50% to 60% area. Now, the pre-prototypes were even more effective so that we have a goal of reaching higher values if we can find out why the compromises made in designing the prototype units resulted in a slightly lower value. These traps are effective on both large and small particulates. Tests made to measure the reduction of small air-suspended lead particulate gave reductions up to 50%.

We have also been testing a more complex trap that incorporates an agglomerator in the system just prior to the trap. An agglomerator is a box filled with expanded metal which serves to trap the small particles and allows them to grow before releasing them to the trap. We have been using this on a Toyota car and found it very effective. For 42,000 miles the car and trap have retained 70% of the lead burned and compared to the similar car with a standard exhaust system, the car with a trap shows about 72% reduction in air-suspended lead emissions.

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More advanced concept systems involve absolute filters after the inertia device or chemical scrubbers. These demonstrate the capability of removing virtually all of the lead in the exhaust but these systems are in the early stages of development. Work needs to be done to extend the operating life and reduce the size or costs, but this work is going forward.

Now, I would also like to mention briefly our cooperative work started recently with the Jensen Brothers of Copenhagen, Denmark. As you may know, Ethyl Corporation announced that it had entered into an agreement with Jensen and Company of Copenhagen in mid-March to evaluate their emission reduction system. We also have an option to obtain exclusive commercial rights to the system in North America. The Jensen system which was developed in facilities provided at the Technical University of Denmark with support by A/S Kosangas International of Copenhagen has attracted world wide attention. It consists basically of a reduction catalyst followed by a thermal reactor. At a press conference in Copenhagen on January 11, the Jensen Brothers announced that the device removed about 90% of the carbon monoxide, more than 90% of the hydrocarbons, about 80% of the nitrogen oxide and about 50% of the lead compounds in the exhaust gas. They reported that the reduction catalyst has been tested for over 35,000 kilometers (about 22,000 miles) on leaded gasoline at 3 grams per gallon with little decrease in activity. The catalyst shows low attrition and does not contain expensive noble metals.

Jensen and Company, the holders of the rights to the system, have been formed by the Jensen Brothers and Kosangas International to license and promote this system. At this time we are aggressively evaluating the system but have no further data to report.

Thank you.

(Applause)

MR. KIMBERLEY:

Thanks, Bill.

Gentlemen, I would like to make two comments. First of all, hold your questions until all the gentlemen have spoken. You might get your answers from the later speakers.

The reports that you are hearing will be presented at Environmental Protection Agency hearings that are starting in Washington next week. In Washington starting April 11, in Dallas starting April 27 and in Los Angeles starting May 2nd. We will all be presenting the story as you are hearing it, plus many other aspects.

I would like to call on Dr. Edward Cantwell to tell you about the Du Pont system.

DR. EDWARD CANTWELL, E.I. DU PONT DE NEMOURS, INC.:

Today I would like to review briefly the progress we have made at Du Pont in the development of lead compatible exhaust emission control systems based on thermal reactors. Our philosophy has been to develop a total, integrated system which controls simultaneously the gaseous and particulate emissions from motor vehicles operating on leaded gasoline. As shown in the first slide, this system consists of three major portions. First, thermal reactors replace the conventional exhaust manifolds and serve as a high temperature holding zone where the hydrocarbons and carbon monoxide can undergo essentially complete oxidation when mixed with the air from the air pump. Second, an exhaust gas recirculation system is used which, in conjunction with modifications to the carburetor, reduces nitrogen oxide levels. Finally, a trapping system is used to remove most of the lead particulate matter from the exhaust gas before the exhaust gases leave the tail pipe of the car.

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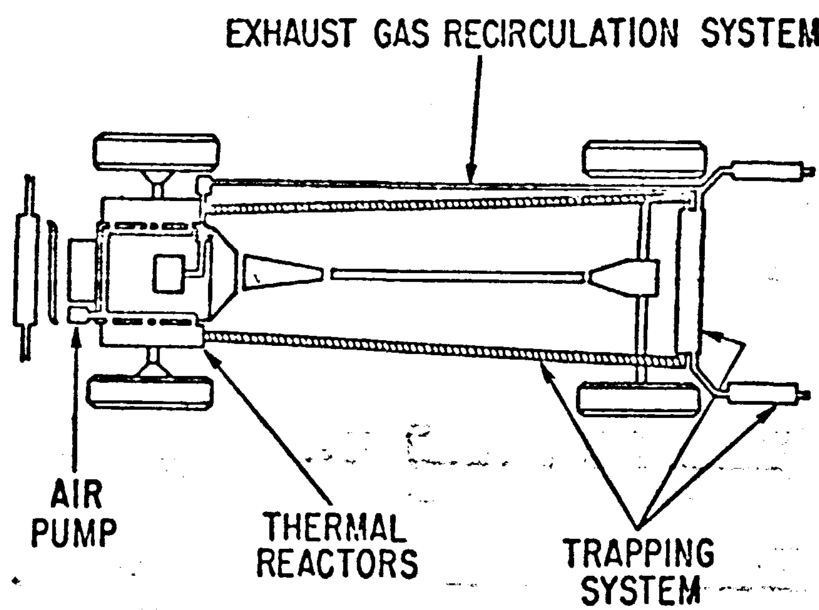
DUPONT TOTAL EMISSION CONTROL SYSTEM



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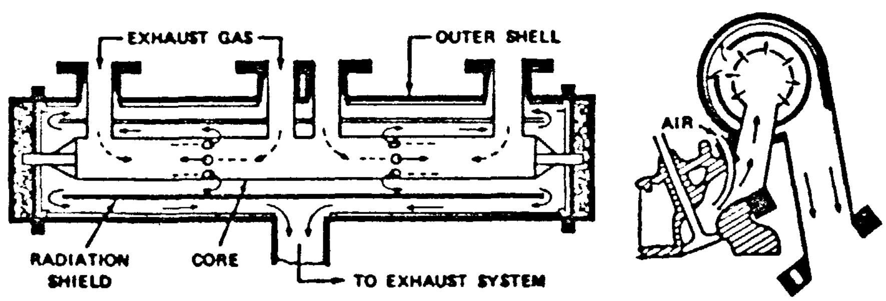
Slide 2

EMISSION CONTROL SYSTEMS

1970 STANDARD SEDAN 350 CID
- INSULATED THERMAL REACTORS
- EXHAUST GAS RECIRCULATION
- ENRICHED CARBURETOR
- TRAPS

1971 COMPACT CAR 1.6 LITER
- TYPE V THERMAL REACTOR
- EXHAUST GAS RECIRCULATION
- ENRICHED CARBURETOR
- TRAPS

Slide 3



Type V Shielded Exhaust Manifold Reactor.

We have installed such control systems on two vehicles, a standard sized sedan with a 350 CID V-8 engine and a compact car with a 1.6 liter four-cylinder engine. As shown in slide 2, the full-sized sedan had insulated thermal reactors, exhaust gas recirculation, enriched carburetion and traps. The compact car was equipped with a shielded thermal reactor, exhaust gas recirculation, and enriched carburetion, and a trapping system.

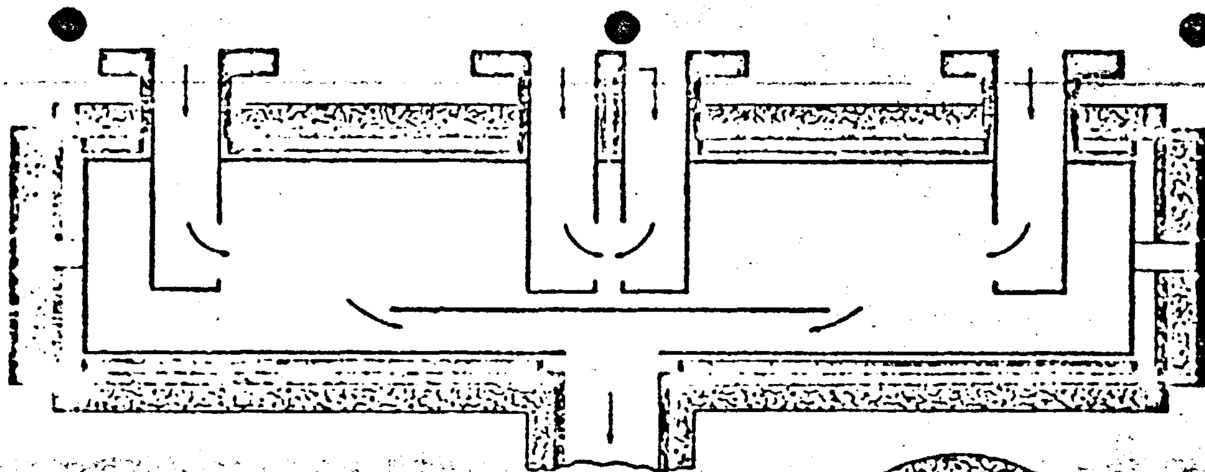
The thermal reactor, slide 3, designed for the compact car is the Type V reactor which we described at the meeting of the Lead Industries Association two years ago. The reactor consists of an outer shell which bolts directly to the cylinder head of the engine so that the exhaust gases and the air which is injected into the exhaust ports enter into the central core of the reactor. Mixing of the gases takes place in the core and due to the high temperatures essentially complete oxidation of the hydrocarbons and carbon monoxide takes place. The exhaust gases flow out of the core through the radial holes and flow first through the annular space between the core and the heat sheild and then between the heat shield and the outer shell of the reactor. Thus, the core temperature is maintained at a high value both by the shields which prevent the loss of radiant heat and by the hot, reacted exhaust gases surrounding the core.

Slide 4 shows a schematic drawing of the Type VIII reactor which has been designed for the sedan. This reactor is of the same physical size as the Type V but uses external insulation instead of the internal heat shielding to maintain the necessary high temperatures. The injected air and exhaust gases enter into the reactor through the extended inlet necks and flow into the core area through the directional slots in the necks. The gases are directed away from the walls of the reactor and quenching of the oxidation reaction is minimized during the cold start. The external insulation on the reactor and the first several feet of the exhaust pipe serves to maintain the necessary high temperatures.

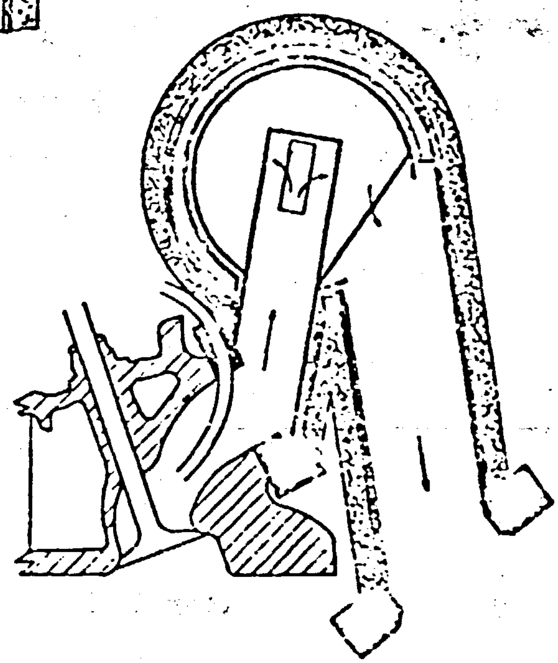
The exhaust gas recirculation systems used on both of these vehicles are similar to those developed by Esso Research & Engineering and used successfully by us in the past. About 12 to 13 percent of the exhaust gas is recirculated from the exhaust system back into the carburetor above the throttle plate but below the venturi section. A simple on-off valve and a metering orifice control the flow rate in the sedan and turn the exhaust gas off at idle and at wide-open-throttle so as not to interfere with full-throttle performance. However, in the case of the compact car it is necessary to leave the exhaust gas recirculation on at all times since the car operates at wide-open-throttle during portions of the emission test.

The degree of control of gaseous emissions given by these systems on the two vehicles is shown in slide 5. The exhaust emission levels are expressed in grams per mile as measured by the 1975 Environmental Protection Agency Test Procedure. As can be seen, the hydrocarbon levels from both of these vehicles are well below the proposed 1975 hydrocarbon standards of 0.41 gram per mile. In the case of carbon monoxide and nitrogen oxides, the emission levels are quite low but do not meet the standards. Nitrogen oxides have been reduced to below 0.4 of a gram per mile by increasing the amount of exhaust gas recirculation. However, the achievement of such low levels of nitrogen oxides has resulted in unacceptable losses in vehicle performance. We believe that optimization of these control systems will allow further reductions in the emission levels and will reduce the fuel economy and performance penalties.

The performance of the vehicles with the control systems adjusted to give the levels just shown is illustrated on slide 6. The fuel economy was measured over a 22-mile city-surburban driving course and the accleration times measured on the road.



TYPE VIII INSULATED THERMAL REACTOR



Slide 5

THERMAL SYSTEMS CONTROL EMISSIONS

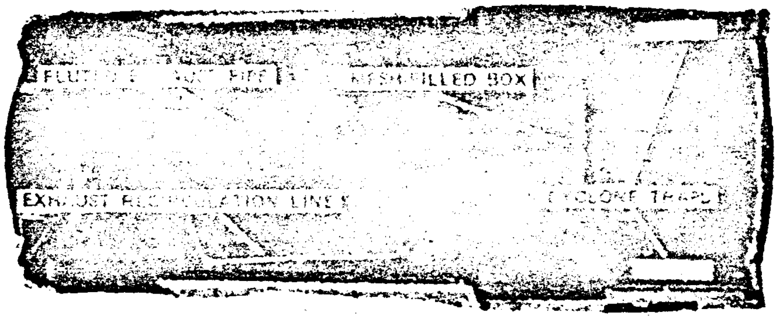
	EMISSION LEVELS, GRAMS/MILE		
	HC	CO	NO_x
1975-76 STANDARDS	0.41	3.4	0.4
1970 STANDARD SEDAN	0.16	6.6	0.57
1971 COMPACT CAR	0.24	5.0	0.61

Slide 6

VEHICLE PERFORMANCE

	LOSS, PERCENT	
	STANDARD SEDAN	COMPACT CAR
FUEL ECONOMY	26	17
ACCELERATION TIME 0-60 MPH	7	18

Slide 7



Car Equipped with Exhaust Gas Recirculation and Exhaust Particulate Traps.

Slide 8

PARTICULATE TRAPPING SYSTEM

1970 STANDARD SEDAN	LEAD EMISSIONS, GRAMS/MILE TOTAL	AIR SUSPENDABLE LAB	AIR SUSPENDABLE ROAD
STANDARD	0.17	0.043	0.061
TRAPPING SYSTEM	0.016	0.015	0.014
PERCENT REDUCTION	91	65	77

Slide 9

MUFFLER LEAD TRAP

1970 STANDARD SEDAN	AIR SUSPENDABLE LEAD EMISSIONS - LAB GRAMS/MILE	PERCENT REDUCTION
STANDARD	0.029	
MUFFLER LEAD TRAP	0.006	79

CONCLUSIONS

- GASEOUS EXHAUST EMISSIONS CAN BE REDUCED TO VERY LOW LEVELS WITH SYSTEMS COMPATIBLE WITH LEADED GASOLINE.
- THESE LEAD COMPATIBLE SYSTEMS ARE BEING IMPROVED.
- LEAD EMISSIONS, BOTH TOTAL AND AIRBORNE, CAN BE REDUCED TO VERY LOW LEVELS WITH TRAPPING SYSTEMS.

Fuel economy for the cars equipped with the control systems when compared with the standard vehicle was reduced by 26 percent for the sedan and 17 percent for the compact. Full throttle accleration performance of the sedan was nearly equivalent to the standard vehicle because the exhaust gas recirculation system is turned off before reaching wide-open-throttle. In the case of the compact car, the exhaust gas recirculation system is operating at all times and the required to accelerate to 60 miles per hour was increased by 18 percent.

In addition to controlling gaseous emissions the total systems control lead particulate emissions to very low levels. Slide 7 shows a photograph of a sedan on which we installed one of our typical exhaust trapping systems. The trapping system consists first of fluted pipes to cool the exhaust gases and promote the formation of particulate lead particles. Second, a box is filled with wire mesh to agglomerate the fine lead particles and cause them to grow into larger particles. The particles are removed from the exhaust gas stream in the cyclone traps which are located at the rear of the car. We have operated similar trapping systems for over 60,000 miles and found them to be completely maintenance free. They are designed with sufficient capacity to hold all the lead consumed by the car for its lifetime and we project that they would operate for the complete life of the car with no problems.

We measured the efficiency of the trapping systems in reducing the lead emitted from the vechicle both in the laboratory and in road tests and the data are shown in slide 8. The total amount of lead emitted from the tail pipe of the sedan equipped with the trapping system was reduced by 91 percent as compared with a standard vehicle. When only the air-suspendable portion of the lead is considered, the trapping system produced a reduction of about 65 percent. We have operated vehicles in an unused Pennsylvania turnpike tunnel and measured the amount of lead that was in the air of the tunnel after driving either a standard vehicle or a vehicle equipped with the trapping system. In these over-the-road tests we found a 77 percent reduction in the amount of airborne lead remaining in the tunnel after driving the trap-equipped car as opposed to driving the standard vehicle. Thus, the reduction in air-suspendable lead is well above the 60-65 percent reduction which has been proposed by the Environmental Protection Agency.

The trapping systems described require complete replacement of the exhaust system. We have been working recently to develop a trap which would replace only the muffler of the vehicle. This muffler trap is the same size, shape and fits in the same location as the standard muffler on the vehicle. It contains an agglomerating media and cyclones to remove the lead particulate matter from the exhaust. Such a trap would be less expensive than the trapping system and would offer the possibility of being used as a retrofit device to be installed on vehicles now on the road. Slide 9 shows some of the early performance data on this muffler lead trap. During the first 20,000 miles of operation the air-suspendable lead emissions, as measured in our laboratory, have been reduced by 79 percent when compared with a standard vehicle. We are quite pleased with the early performance of this muffler lead trap and plan additional development work to evaluate its long-term performance.

We believe that the performance of the exhaust emission control systems we have developed lead to the conclusion shown on the last slide.

1. The gaseous exhaust emissions from motor vehicles can be reduced to very low levels with systems compatible with leaded gasoline.
2. These lead compatible systems are being improved continually and we believe eventually they will be able to meet the 1975-1976 gaseous emission standards.
3. The lead emissions from vehicles, both total and airborne, can be reduced to very low levels with practical trapping systems.

MR. KIMBERLEY:

Next we will hear from PPG Industries. This firm has not been in the field as long as Ethyl and du Pont, (I think that is correct), but their device has created a great deal of enthusiasm. I am sure you will be interested. Os, I don't know how you are going to do this.

MR. O. FREND, PPG INDUSTRIES:

Thank you, Jack.

First of all I would like to introduce myself and my capacity with PPG Industries. My name is Os Frend, I am General Sales Manager for Houston Chemical Company, which is a division of PPG Industries.

I am going to describe to you how and why we got into this field or trapping devices. Dr. Roy Sugimoto, who is Houston Chemical Technical Director at Corpus Christi, Texas, will advise you concerning the performance of our unit and its operation and, finally, I shall close by discussion on who is interested in the PPG type system and what its possibilities are we believe for commercialization.

First I would like to point out that, while PPG Industries believes that with the present ambient lead air content there has been no indication whatsoever of creating the slightest medical problem, we still feel that it is best to look at the problem of lead by attacking it at the automotive exhaust system rather than taking lead out of gasoline. And that has been the policy enunciated by our management at PPG Industries.

About two years ago, Mr. Ed Cole, President of General Motors, stated that it was General Motors hope and desire that lead could be removed from gasoline. We decided at that time to look at the possibility and feasibility, both from the technical as well as from the economical viewpoint, of actually removing lead particulates at the end of the exhaust pipe. We incorporated the assistance of several divisions of PPG, namely our Glass Division, our Fiberglass Division and our Coatings & Resins Division, all of whom have played a role in reaching this point now where we think we have a trap fairly close to ultimate commercialization. The Glass Division worked on this by the development of a high porosity type glass. The Fiberglass Division of PPG has had considerable background and experience in working on fibreglass filters for the tobacco industry, and we have acquired quite a bit of knowhow in that. The Coatings & Resins Division has had the job of working and developing a high temperature binder that could be placed on the surface of our fibreglass paper. We looked at the possibility of a total system, one which would incorporate an agglomerator cyclone system and also a final filter. The role of the agglomerator cyclone system is to take out the larger particles of lead and other particulates as they are formed. The final filter is to take out practically all of the fine particulates, including lead, that pass through the system.

We have reached the point now, after several thousand miles of work, including a contract that we have with South West Research Institute on the testing of a small automotive fleet which Dr. Sugimoto will describe the types of equipment and where we stand on that as well as on several cars in a Corpus Christi taxi cab fleet.

Finally, we have our own test fleet involving several cars of our Sales Department within Houston Chemical in several geographical locations, including cold climates and warm climates, to test the efficiency of the unit.

I might point out that we also have talked to several muffler companies to determine the economic feasibility of developing this system on a commercial basis.

From all indications, using the agglomerator cyclone type of filter as the ultimate possibility on a single exhaust system, we would expect to produce or be able to have produced our total system for approximately $6.00 more than a conventional muffler which it would replace. On a dual exhaust system the cost would be approximately $10.00-$11.00 more to manufacture as compared with the conventional muffler. This is $10.00 - $11.00 more than the conventional muffler, I might point out.

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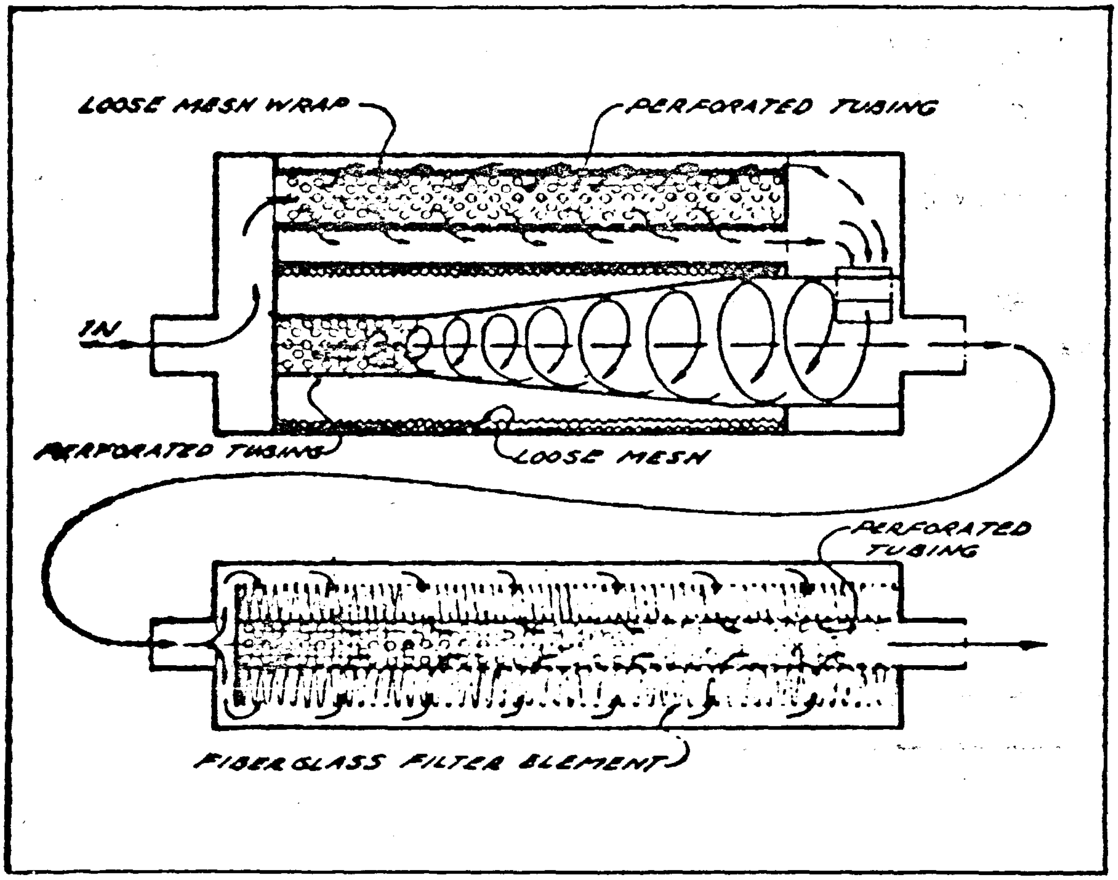

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What I would like to do now is to have Roy Sugimoto describe to you how this, how the PPG trapping system works and finally we'll follow up with where the system is being evaluated and what interest there has been shown by the muffler industry.

So I'll turn this over to you right now, Roy.

DR. ROY SUGIMOTO, PPG INDUSTRIES:

After a lot of trial and error, our current system is described on the board and we do have a kind of prototype with us.

Generally, it is a two-component system. The exhaust goes into the agglomerator cyclone and through this area it comes out here. This area the particles and exhaust you get agglomerated and then it is entered into a cyclone where particles of about, say, two microns or so get separated and collect in this area here. The remaining particles, along with the exhaust, then go through into a fibreglass filtering unit. It goes in and into the unit out and then it goes from outside in, in order to give us a lot of filtering surfaces.

The cars we have on test today comprise two taxi cabs with over 60,000 miles. We have three cars under consumer-type driving course in San Antonio have accumulated about 20,000, plus about six cars in consumer-type use. We have a variety of paper and some binders in this work. Our total mileage accumulated has been about 100,000 miles now with no failures on the cars that are in operation. We did have some problems earlier in the chain.

The efficiency of our filters we feel is about, or the emission of total particulate is between .01 and .02 grams per mile, that is one hundredth to two hundredths of a gram per mile. The lead particulates are even lower, of course, ranging between .002 to .004. Our results also have been confirmed with two other laboratories with more sophisticated laboratory techniques and long experience in analyzing for these particulars. Currently we are working in the area of defining a good fibreglass media. We feel that this is a very critical area because the government agencies have indicated that they would like to have the very small particulates removed.

The .01 to .02 grams or .002 to .004 gram content we feel represents a removal of about 98% to 99%, depending on the gasoline you are using of course. We do feel that the car with the most mileage logged is about 25,000 miles now and it has gone over a lot of rough road including Mexico and we have had it up north and all over. One taxi cab we have has now accumulated over 30,000 miles, and of course taxi cabs are noted for high operation. They stay idle for, especially in Corpus Christi where it is hot and the air conditioner is running, and we have had some back-fires in those instances and except during a flood our system has withstood a minor backfire. Our goal for this is 50,000 miles per unit and right now it certainly looks like we'll have a chance of attaining this and also of course we are continually striving to reduce the cost of these and we are confident that we can meet those objectives which were mentioned. Thank you.

MR. FREND:

I might also point out that we have assisted the Air Resources Board of California and equipped one of their cars with our type system and that this is under evaluation right now.

For those of you who do not know it, California does have an ambient lead aid standard which is legislated at 1.5 micrograms per cubic meter and we feel that our type of systems would enable them to meet this standard if it is regulated along these lines.

Also I might point out that our system is being evaluated in England at the present time. Also a catalyst developer is looking at our system in conjunction with his own catalyst system and, finally, one of the very large muffler companies is very interested in the PPG trapping device and is in fact modifying our system right now at the research level so that from acoustical area it will certainly be quite satisfactory. We feel that our system presently from an acoustical point of view is almost as good as the present muffler system on the road.

Thank you again.

(Applause)

MR. KIMBERLEY:

In a conversation earlier today with Dr. Edward Cantwell, there was reference made to a test recently conducted by the Environmental Protection Agency's laboratories I think in Detroit. Ed, would you come in on that?

DR. CANTWELL:

Yes, we have had one of the cars, specifically the Chevrolet, tested by the Environmental Protection Agency laboratories in Ann Arbor, Michigan, to confirm our emission results, although we don't agree exactly and no one expects to, we are trying, to major emission levels is slow, we get about 5 grams per mile. We agreed essentially on the hydrocarbons and nitrogen oxides. Within experimental error they get about 1 gram of carbon monoxide more than we do. We get 5, they got 6 to 7 and they agreed that essentially there was no difference, that this was an experimental error from lab to lab.

MR. KIMBERLEY:

Right. I would like to emphasize that, on the basis of anything I have heard or seen, these systems that have been discussed are just as far advanced as anything the automobile industry at least is talking about, and I think as evidence that this is true is the fact that the auto men are all petitioning for a delay of another year.

I think we can consider the meeting open for questions which you can direct to any gentlemen that you wish.

Yes, sir?

MR. ARNOLD CROUP, OZARK LEAD:

Could we find out more about the application of the PPG system as beingcompatible with the catalyst units? You said they were testing it but . . .

MR. FREDD:

Well, this is actually, we frankly don't hold out too much hope in conjunction at least with the present catalyst systems that we know of.

However, there is one developer of catalyst who does have a very low line of temperature catalyst that has expressed the interest to putting our system in front of his catalytic converter and testing it and we presently are working up one of these systems for one of his cars. However, it is not in use at the present time.

MR. ADAMS:

Could I make a quick comment?

MR. KIMBERLEY:

Please do.

MR. ADAMS:

I might just mention, not all in jest, that all these trapping systems might be useful with catalytic systems because they may need something to catch particles coming out. I am not the only one saying that. Some of the automotive people have mentioned this distinct possibility. After all these are usually metal oxides in the catalyst. They may be in trouble if they try to push ahead with them.

MR. FREDD:

We also might point out that HEW (Health Education and Welfare) back two or three years ago proposed a particulate standard of .3 grams per mile and reduced down to .03, in other words, a 90% reduction and so this it would still be tied in not only with lead but on catalyst too.

MR. KIMBERLEY:

Right.

Others, Gentlemen?

MR. JACK McLEAN, COMINCO AMERICAN:

I would like to ask how often they have to change the fibreglass filter and is it much of a job to do? How would you do it? How would you dispose of it?

DR. SUGIMOTO:

Of course with all these experimental models we make three cartridges. (Displaying) This is approximately two-thirds of one, but for the purpose of measurements and weight, well we make these in three parts. Now, we envisioned for a commercial system a throw-away type can where the cartridges will never be removed, but the entire system thrown away after, say, 50,000 miles or whatever useful life may be. Because we are still confident we can achieve 50,000 miles.

MR. GRAHAM WALDEN, ST. JOE:

Not many of us get 50,000 miles out of a simple muffler system. Would one of you care to comment about the corrosion resistance of these from outside salt, spray and snow belt, probably inside as well?

DR. SUGIMOTO:

Yes, of course corrosion from the outside is certainly not within our control of the trapping system, but talking to a lot of the steel people and the muffler people, the steel people are producing a new stainless steel with no nickel in it. It is a high chrome stainless which they think will be used in the mufflers in the future and they expect to sell it for between 17 and 30 cents a pound, depending on whether you talk to the supplier or the buyer. And they think that these mufflers then certainly will last 50,000 miles.

DR. CANTWELL:

If I might comment on that. In the Aero Space report to the Environmental Protection Agency, the assumption was made that all emission control systems for 1975 and later model cars would have "long-life" exhaust systems on them or in other words, the exhaust systems that would last the life of the car. The contention of the muffler manufacturers and the automobile manufacturers is that this is feasible if you use the muffler grade type stainless steels or the stainless steels that Roy just mentioned. Aero Space estimated that this would cost, I believe, about $32.00

more per car, but you would save $60.00 in the cost of replacing mufflers and exhaust systems. Thus, the consumer would wind up with a net saving of about $30.00 over the lifetime of a car. These are the types of materials we used in our trapping systems; a trapping system will last the life of a car and be immune from either internal or external corrosion. Although they would cost more obviously at the beginning, we believe that this additional cost will be more than made up by the savings in future replacements.

MR. KIMBERLEY:

Is it a fair remark, Gentlemen, that the automotive industry has not given up on this approach and that there is a substantial amount of work being done by the automotive people with this type of approach? I think that is still true.

MR. ADAMS:

You are speaking traps?

MR. KIMBERLEY:

All systems, thermal reactor systems and traps.

MR. ADAMS:

I'll very quickly say that a Chrysler representative spoke about lean thermal reactors at the recent Senate Oversight Hearings. He said they were quite promising, if I can paraphase him briefly. And we know that other companies are working along these lines.

MR. KIMBERLEY:

Right, well Dr. Cantwell had already made the statement that he has one of his cars tested in the very recent past.

DR. CANTWELL:

Yes, the automobile companies are working on thermal reactors and I think it is an open secret that there will be thermal reactors on several models of cars starting in 1973 and '74 to meet California requirements. Also in 1975, reactors, either alone or with catalysts will be used. The automobile companies are working very actively on all these systems except traps. I don't know of any automobile companies that are working on traps at this time; they are interested but I don't know that they are doing much.

DR. SUGIMOTO:

I was talking to a friend of mine who was in charge of an automobile company meeting committee on trapping and we have discussed this whole problem with him and the automobile companies are certainly interested but he had a problem because he works for Ford and according to the Justice Department injunction he can't talk to General Motors or Chrysler but the automobile companies are very interested in it but not certainly as much as the hydrocarbons and the hetro-airs because those are already legislated, whereas particulates as such are not legislated at this time.

DR. CANTWELL:

Although I heard that someone in the E.P.A. has suggested that perhaps 1977 would be the target year for particulate standards if such standards are going to be instituted.

MR. SUGIMOTO:

I am sure they recognized the possibility but they have got a lot of problems already with law and certainly I think from their standpoint things that don't even pass by Congress and signed by the President have a high priority.

MR. KIMBERLEY:

Others?

Then, Mr. Osborn, I shall turn the meeting back to you.

(Applause)

MR. OSBORN:

Well, Gentlemen, for my part I have heard one of the most fascinating and encouraging presentations on this subject and I think your applause and attendance here today is evidence that you feel the same. Therefore all I intend to do is at this stage formally thank Ed, Bill, Os and Roy for giving up their time, putting so much thought into their presentation and coming along to us today.

Thank you, Jack, for a masterful handling of the meeting and at that point we shall close this subject and deal just now with a few very formal matters before formally closing the meeting.