RESEARCH PROGRAM PRESENTATION

LEAD AEROSOL SIZE DISTRIBUTIONS IN AUTOMOBILE EXHAUSTS

Objective

The objective of this research program is to compare carefully lead aerosol characteristics in the exhausts of automobiles both with and without hydrocarbon control devices and to do these studies in a large test chamber so that exhaust dispersion conditions would approximate those which are active in the atmosphere.

Discussion

We now know that over the next ten years most automobiles sold in the U.S. will be required to have modifications which will reduce hydrocarbon and CO emissions from the exhaust by 80 per cent or more. Modifications of the exhaust system have been introduced by GM and Ford, but whether these modifications will alter the lead aerosol emissions as well as the hydrocarbons apparently remains to be determined. Depending upon the relative effects of various conditions within the modified exhaust system, one might postulate the production of a lead aerosol with either a larger or smaller size distribution when compared to that from a current unmodified exhaust system. An increase in the lead particle size distribution could be expected if agglomeration or surface retention and scaling were increased, whereas an extended zone of high temperature which maintained the lead compounds in a vapor state for a prolonged period might reduce the size distribution. The chemical nature of the lead and the amount retained by the exhaust system may also be altered by the exhaust hydrocarbon control modifications.

As described below, these exhaust studies would be conducted by introducing the engine exhaust directly from the tail pipe into a very large chamber--volume approximately 1000 cubic meters. The available chamber is an underground bunker previously used for NIKE missile storage. Since the chamber is underground, the test vehicle can be placed directly over the chamber and the exhaust directed downward into the chamber. Thus, ducting of the test stream is practically eliminated and there can be little question that the full size spectrum of exhaust aerosols reaches the chamber. In the chamber, because of its large size, dispersion and dilution of the exhaust should proceed in a manner which is generally similar to the processes acting in the open atmosphere. In the chamber, dilution and cooling of the exhaust should be relatively rapid and wall effects would be minor.

Exhaust aerosol studies using this chamber facility should provide data on aerosol characteristics which can be extrapolated to the real urban atmosphere. Thus this program would be an important link between the Institute's previous studies of lead aerosols in urban atmospheres and the laboratory studies such as those carried out by Hirschler.

These research results would seem to have applications of more than academic interest to the industry because this type of research on automobile exhaust emissions could provide the lead industry with information from which future environmental conditions could be estimated based on changes being made in automobile design. In addition, as mentioned above, the data which would be obtained from the large test chamber would aid in relating laboratory and atmospheric research findings.

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Method of Approach

As indicated above, our method of determining lead aerosol characteristics would be to operate test cars on a chassis dynamometer, to introduce the exhaust directly into a large test chamber, and to take samples of the aerosol from the chamber for size analyses, and chemical determinations. Total lead emissions from the exhaust system would be determined by sampling a small aliquot of the exhaust stream at the tail pipe. For these chamber studies we have nearby and presently available to us a large underground bunker which was built for a NIKE missile. It is about 60 x 40 x 15 feet in size. It can be closed off and would be well suited for these studies because exhaust gases going into the chamber would be diluted in a manner quite similar to the way they are diluted in the atmosphere. We could even place the dynamometer and vehicle inside the chamber if this seemed desirable. Large particle fallout from the exhaust system could be determined by positioning sampling instruments in the bunker directly under the exhaust gas entry port. Samplers would also be positioned some distance away from the entry port where exhaust conditions would be more nearly like those encountered on the sidewalk beside a major street. Fans would be used to mix the air in the chamber but at a relatively slow rate.

For test vehicles we would suggest, at least as a start, small compact 6's and larger, heavier V8's. Since we want to check on possibly large changes, these test cars probably should be GM and Ford products rather than Chrysler products because Chrysler is obtaining exhaust control by carburetion and ignition changes, while GM and Ford are using the manifold-oxidation system. Each car would be tested with and without the hydrocarbon control unit installed and for several dynamometer cycles which would typify urban and highway driving. Fuel consumption and operational parameters would also be obtained for each test.

A program on the nature of the aerosols in auto exhaust could obviously be long and complex unless strict control were maintained on the number of variables considered and on the number of objectives to be achieved by the program. We believe that this research on lead aerosols should start with the testing of only a few automobiles selected on the basis of an estimate of the diversity of conditions within the exhaust systems. Furthermore, driving cycles should be chosen which might be expected to produce a wide divergence in the nature of the lead emissions. The analysis of the initial test results should then show whether there is any necessity for further research involving a more realistic cross section of the automobile population and probable operating conditions.

Since we would have to install a dynamometer at our test installation, a logical question is whether it might not be easier to construct a test chamber at an existing facility having a dynamometer and then carry out the program there. In answer to this, it is our belief that our available chamber, because of its large size, offers a unique opportunity to approximate atmospheric dilutions of the full exhaust stream in a system where ducting of the exhaust will not be necessary, wall losses will be a minimum, and residence times in the chamber can be relatively long. These factors seem to be especially valuable ones for this proposed program where direct applicability of the results to the open atmosphere is one of the research goals. Thus, we believe that our suggested approach, bringing the dynamometer to the chamber site, is the one most likely to provide reliable research data on the nature of lead aerosol emissions from exhaust-controlled automobiles.

Except for the dynamometer and the automobiles, we have available to us both the equipment and the analytical experience necessary to carry out this program. In many respects this proposed program would relate closely to our previous research for the Lead Zinc Research Organization, and as a result there should be little test procedure development necessary.

PROGRAM COSTS

It has already been mentioned that this study would not have to be a long term or complex effort to provide a useful amount of research data, and a preliminary estimate of costs has been made on the basis of a limited test program. This preliminary cost figure for the research, but excluding costs of a chassis dynamometer and the necessary test cars, is approximately $32,000. A lease arrangement can probably be made for a portable chassis dynamometer. Test cars could either be leased or purchased.

This research program could probably be completed in a period of 6 to 8 months. It could be begun early in 1967.

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