

DISCUSSION

*J. J. Mikita*¹ (written discussion)—I should like to comment on the authors' presentation on the effect of leaded and unleaded combustion chamber deposits on exhaust hydrocarbon emissions. As many of you know, a vast amount of data is available on this subject. The authors of today's paper refer to two previous publications, the Pahnke and Squire *Oil and Gas Journal* paper of 1966 on a nominal 18,000 mile, 18 months 122-car consumer-operated test and the Gagliardi Society of Automotive Engineers (SAE) paper of 1967 on a four-car 12,000 mile proving-ground rapid mileage accumulation test. Other important papers on this subject are the Gagliardi and Ghannan² SAE paper of 1969 covering the results obtained with eight cars operated in home-to-work commuter service, the 1969 Pahnke and Conte³ paper discussing the results of a 36-car consumer-operated test of 12 months and 12,000 miles duration, and the 1969 Hall, Felt, and Brown⁴ paper presenting detailed results of a test on 60 pairs of cars employee owned and operated and on 21 cars used in general transportation service.

These well-documented papers present a tremendous amount of information on literally hundreds of cars operated on the road. These data, I think, make quite clear one important point: that the effect we are talking about is dependent on how vehicles are operated. In our consumer-type service tests, cars with leaded combustion chamber deposits emit about seven percent more hydrocarbons in the exhaust than cars with unleaded deposits. With rapid mileage accumulation, this figure in other tests is about 20 percent. It is important to note that seven percent reported by Pahnke and his associates applies to cars with and without emission control devices, that is, to cars emitting about 225-ppm NDIR hydrocarbons and

¹ Petroleum Chemicals Division, E. I. duPont de Nemours Co., Inc., Wilmington, Del. 19898.

² Gagliardi, J. C. and Ghannan, F. E., "Effects of Tetraethyl Lead Concentration on Exhaust Emissions in Customer Type Vehicle Operation," *International Automotive Engineering Congress*, Society of Automotive Engineers Paper No. 690015, Detroit, Mich., 13-17 Jan. 1969.

³ Pahnke, A. J. and Conte, J. F., "The Effect of Combustion Chamber Deposits and Driving Conditions on Vehicle Exhaust Emissions," *International Engineering Congress*, Detroit, Mich., 13-17 Jan. 1969.

⁴ Hall, C. A., Felt, A. E., and Brown, W. J., "Evaluating Effects of Fuel Factors on Stabilized Exhaust Emission Levels," *International Automotive Engineering Congress*, Detroit, Mich., 13-17 Jan. 1969.

as well as the cars at the 500-ppm level. It is not unreasonable then to predict that this seven percent figure also would apply to cars emitting lower levels of hydrocarbons. Thus, the effect at a level of 100 ppm would be only 7 ppm, a difference which is difficult to measure.

The reason why leaded combustion chamber deposits are not too un-different from nonleaded deposits in regard to exhaust hydrocarbon emissions stems from the fact that under consumer-type driving conditions the use of unleaded fuels leaves appreciable quantities of deposits in the combustion chamber and these deposits, too, increase emissions substantially. In our 122 nondevice equipped car consumer-type test, the NDIR hydrocarbon emissions of the 59 cars operated on unleaded fuel increase from an average of 427 to 568 ppm, or 33 percent. On the 18 device equipped cars, six each of the three popular car brands with engine displacements of approximately 300 CID, the NDIR hydrocarbon emissions increased from 193 to 246 ppm, or 28 percent. These data, I believe, illustrate clearly that cars operated on unleaded fuel by families in their normal day-to-day driving will show increases in hydrocarbon emissions with mileage as does similar operation with leaded fuel. When we talk about similar operation with leaded fuels what we are saying is that the use of TEL will further increase these emissions by about seven percent.

Now, to get back to the authors' paper, there is not enough information presented to show how the 460 miles per week were accumulated. For example, were the cars driven over a fixed course for a certain number of hours each day without cool down? If there were cool downs, how many were there? In other words, just exactly how was the mileage accumulated? But in any event, it is stated that the net NDIR hydrocarbon emissions increase with leaded gasoline was 32 ppm higher than that obtained with unleaded fuel. Using an engineer's scale on Fig. 4, this works out to be an effect of about 25 percent. It's interesting that in this test, the hydrocarbon emissions did not increase with unleaded fuel; in fact, they decreased. This is contrary to all our experience with cars used in normal service. And this, of course, throws some question on the significance of the test.

But a far more important point has to do with Conclusion No. 6 which says: "exhaust hydrocarbon levels of vehicles operated on fuel leaded to 3.13 g/gal are significantly greater than the exhaust hydrocarbon levels of vehicles operated on unleaded fuel." I would like to know the author's intention with regard to the exact meaning of the word "significant." If they meant to say "statistically significant," then that is one thing. On the other hand, if the term is meant to mean the usual dictionary definition, that is, "important" or "of consequence," I want to take exception to it. And I want to take exception to it because I do not think such a broad general statement can be made on the basis of the limited data obtained in this program and in face of the extensive data available from consumer-type operations.

I want to thank the authors for sending me an advance copy of their paper. And I want to thank Mr. Niles for giving me this opportunity to discuss the paper.

R. P. Doelling (author's closure)—In his discussion, Dr. Mikita asked for more information on how vehicle test mileage was accumulated and on our intention with regard to the exact meaning of the word “significant.”

Mileage accumulation was accomplished by selecting six employees with long travel distances to and from the Laboratory (40 to 100 miles each way) and allowing them to operate the six test vehicles as they would their own vehicles. Vehicle operation, therefore, was between their homes and Cities Service daily and around their local area in the evening and on weekends, or under consumer-type conditions. In order to average the different driver habits and keep mileage accumulation rates for the individual vehicles constant, the vehicles were rotated through the six drivers on a regular schedule.

The meaning of the word “significant” as used in Conclusion No. 6 related to the statistical significance of the increase in hydrocarbon emissions. As a conclusion based upon the data obtained from our program, the approximately 25 percent increase in hydrocarbon emissions we measured is also of consequence in attempts to meet exhaust emission standards.