Evaluation of the IPM RS-5 Flame Ionization Detector

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Background

On January 23, 1973, a demonstrator model of the IPM RS-5 flame ionization detector was delivered to the Ann Arbor EPA facility by sales representative Phillip Thomas. The unit was to be used to measure hydrocarbons in the exhaust of both gasoline and diesel engines as part of an evaluation program. Results were compared with similar tests run with a Beckman 402 FID.

There are two important features which set the IPM FID apart from others on the market. First, the fuel is pure hydrogen rather than a hydrogen-helium mixture. The manufacturer claims that this results in a higher flame temperature (about 2000°F as compared to about 1400°F in the Beckman 402) which is said to result in a better breakdown of heavier hydrocarbons. The second important feature is an adjustment for oxygen interference. Essentially this involves optimizing the flame to avoid interference from oxygen brought in with the sample.

Instrument Description

The IPM is a compact unit with dimensions 270 X 420 X330 (10.6 X 16.5 X 13 inches) mm, and a weight of 17 kg (37.5 lbs). Maximum range is 0-10,000 ppm carbon and minimum range is 0-10 ppm carbon. Oven temperature is adjustable from ambient to 200°C (392°F). A gauge on the front panel indicates sample flow in millimeters of water, and a porous ceramic filter is removable through the front of the unit. Claimed detector response time is 0.5 seconds. There is no indicator for flame out.

The instrument comes with either a three or six meter (10 or 20 ft.) stainless steel heated sample line. Provision is made for measuring sample temperature entering the burner but no means is provided for measuring temperature in the sample line. The unit can be obtained for operating on 115 volt AC power supplies.

Test Program

Tests were run on the Mercedes-Benz Diesel, the Opel Diesel, and on two 197- prototype Mazdas with rotary engines. Tests were run according to the 1975 Federal Test Procedure. One test was run on the Opel Diesel with the Beckman 402 and the IPM sampling in parallel. In addition, bag samples were made containing ethyl alcohol, methyl alcohol and formaldehyde (37% formaldehyde, 12% methyl alcohol, remainder water), and analyzed with both the Beckman 402 and IPM. The evaluation did not include a measure of the relative response of the IPM (compared to the Beckman 402) to different hydrocarbon compounds.

Sample point for the FID was immediately downstream of the dilution box. The sample was drawn through a transverse probe mounted in the CVS duct. Initially the sample line supplied with the IPM unit was used. After several tests, the electrical power supply line to the heating element broke off flush with the FID and was not repairable without disassembling the FID. In the interests of time, it was decided to use another sample line. An attempt was made to use the Beckman Teflon sample line, but we were unable to heat the line to a sufficient temperature. The third and final sample line which was used successfully for the remainder of the tests was the stainless steel line built in-house by our laboratory personnel. This line included an in-line filter located a short distance after the probe to prevent soot build-up in the sample line and FID.

Sample line temperature was 375°F with the stainless steel line and approximately 177°F with the Beckman Teflon line. Oven temperature of the IPM was 170-175°C (338-347°F). Oven temperature of the Beckman 402 was 375°F.

Results

Testing the Mazdas gave an opportunity to use the IPM on a vehicle which required the use of two ranges on the FID. Approximately the first 40 seconds of bags 1 and 3 required the use of the 0-1000 ppm range. The remainder of the bags were run on a range of 0-100 ppm. When switching down from the higher range to the lower range, it took from two to four seconds for the instrument to recover from being pegged below zero. According to the manufacturer's representative this is due to a loaded capacitor's having to bleed-off before the instrument responds accurately to conditions in the flame. The same effect occurs when changing from the 0-100 ppm range to the 0-10 ppm range. The The recovery time in this case is somewhat longer, about ten seconds.

The instrument has good retention of its calibration when switching from one range to another, provided that it is calibrated in the higher of the two ranges. There is little zero shift when changing ranges.

Results obtained from testing the Mercedes Diesel were consistent with previous results (see Table I). IPM FID data gave approximately twice the grams per mile obtained from the cold bags. When running the Beckman 402 and IPM FIDs in parallel, approximately the same concentrations of hydrocarbons were obtained from both instruments (see Table II).

When testing the bag samples of aldehydes and alcohols, we were looking for a comparison with the Beckman 402 to see if the IPM gave substantially higher readings. This was not the case as both the Beckman and IPM gave approximately the same readings on the bags.

Conclusions

In general, the IPM unit gave satisfactory performance throughout the evaluation period. It showed somewhat faster response than the Beckman 402, and was much less sensitive to physical disturbances than the Beckman. The IPM would probably be a better unit for operation on a routine basis than our Beckman 402 because of its greater stability.

The substitution of knobs in place of adjusting screws for control of fuel and air flows would improve the ease of operation and also quicken the procedure for optimizing the flame.

We did not consistently see the higher peak hydrocarbon concentrations in Diesel exhaust that the manufacturer claims we should see. The probable reason for this is that we sample dilute rather than raw exhaust.

TABLE I

IPM RS-5 FID
Mercedes-Benz 220 Diesel

	Gaseous Emissions (grams/mile)				
Test No.	HC Hot FID	HC Cold Bag	CO	CO_2	NOx
1	---	0.19	1.58	434.97	1.55
2	0.30	0.18	1.51	416.80	1.17
3	0.40	0.16	1.34	409.82	1.45
4	0.37	0.16	1.46	411.76	1.38
average of tests 2-4	0.36	0.17	1.44	412.79	1.33
average of six tests using Beckman 402 FID	0.35	0.19	1.38	454.24	1.55

TABLE II

OPEL REKORD DIESEL
Beckman 402 FID and IPM FID

Hydrocarbon Concentrations (ppm)

	Beckman 402	IPM
Bag 1	35.36	31.84
Bag 2	19.08	18.56
Bag 3	31.08	30.11

TABLE III

Operating Characteristics of the IPM RS-5 FID

IPM RS-5

Operating features:

- span and zero insensitive to scale changes
- span and zero have negligible drift during testing ('75 FTP) (less than .5 ppm) and minimal from day to day
- stable readings, steady signals
- stabilizes near final nominal values within a few hours from cold start
- fast response
- fast approach to nominal values
- easy correction for O_2 interference
- calibration relatively easy
- provision for sample line heating automatically controllable
- provision for sample heating
- sample & sample line heating adjustable
- flexible stainless steel heated sample line
- sample temperature monitoring (in sample block)
- low gas consumption
- flame easily ignited
- no problem with flame outs
- compact
- simplified

Some possible desired features (all easily incorporated):

- provision to monitor gas temperature in sample line
- readily adjustable sample temperature set point