

**Effects of FID Oven and Sample Line
Temperature on the Measurement of
Hydrocarbon Emissions from Diesel Engines**

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Office of Air & Water Programs
Environmental Protection Agency

Background

In late December 1972, an Opel Rekord 2100D Diesel-powered sedan was delivered to the EPA facility in Ann Arbor, Michigan. The car was supplied by the General Motors Corp. at EPA request for investigation of exhaust emission as part of an ECTD technical feasibility study and evaluation of light duty Diesel vehicles. The car was also used by EPA as part of a program to investigate the measurement of hydrocarbon emissions from Diesel engines. It is that program which is reported here. The program consisted of a series of tests during which the hydrocarbon emissions were measured using the 1975 Federal test procedure (CVS 4-bag) and by simultaneous continuous analysis of the dilute exhaust using a Beckman 402 flame ionization detector.

The purpose of the tests was to determine whether there was a particular oven or sample line temperature which gave optimum results when measuring hydrocarbon emissions.

Vehicle Description

The car is a 1973 Opel Rekord 2100D, 4-door sedan. Seating capacity is five persons. Mileage at delivery was about 3000 miles.

The engine is a four-cylinder, four-stroke Diesel with a displacement of 2.1 litres and an advertised horsepower of 68 (SAE). The car is equipped with a three-speed automatic transmission and the test inertia weight was 3000 pounds.

Test Program

Standard instrumentation was used to measure CO, CO₂, HC and NO_x from the CVS sample bags. A Beckman 400 flame ionization detector (FID) was used to measure hydrocarbon concentration in the sample bags. For continuous analysis of the dilute exhaust a heated Beckman 402 FID was used, with the output signal recorded on a strip chart. The sample for the Beckman 402 was taken immediately downstream of the dilution box and delivered to the instrument through a heated sample line.

The sample line was constructed of stainless steel wrapped with heating tape and asbestos insulation. An in-line filter was located in the line about 15 cm (6") downstream of the sample probe. The purpose of this filter was to prevent

contamination of the sample line and FID with soot from the Diesel exhaust. Two thermocouples were located in the sample line, one located about 20 cm (8") downstream of the in-line filter and the other about 8 cm (3") before the sample enters the FID. Sample temperature refers to the temperature of the sample flow delivered to the FID.

A series of tests were run as directed in the Federal Register for 1975 vehicles. The purpose of these tests was to determine the effect of sample line and oven temperature of the FID when measuring hydrocarbon concentrations in the diluted exhaust.

Test Program

Cold start LA-4 tests were run at oven and sample line temperatures of 200°F, 250°F, 300°F, 350°F, and 375°F.

In addition, steady state cruises were run at each oven temperature. The car was run at a steady speed (40 or 50 mph) until fully warmed-up while the sample line was heated to approximately 425°F. When the complete system had stabilized, the sample line heaters were shut off and the line allowed to cool to 200°F. A strip chart recording was made of the hydrocarbon concentration during the cooling-off period. The chart was checked for variations in hydrocarbon concentrations as a function of sample line temperature.

Results

The parameter in which we were most interested during these 1975 FTP tests was the ratio of Hot HC/Cold HC. Cold HC refers to the hydrocarbon emissions in grams per mile determined by integration of the strip chart from the continuous analysis of the dilute exhaust.

The ratio of Hot HC/Cold HC increases with increasing oven and sample line temperature from 200°F to 375°F. The rate of increase appears to be slightly less from 300°F to 375°F than from 200°F to 300°F.

In the steady state tests, when sample line temperature was varied while holding oven temperature, the hydrocarbon concentration increased steadily with sample temperature from 200°F to 425°F. A leveling off of the rate of increase occurred between 300-350°F. The results of the 1975 tests are given in Table I.

Conclusions

The test results do not show a particular combination of oven and sample line temperatures giving optimum results when measuring hydrocarbon emissions. It appears that oven and sample line temperatures should be in the range of 350°F to 400°F to give best results.

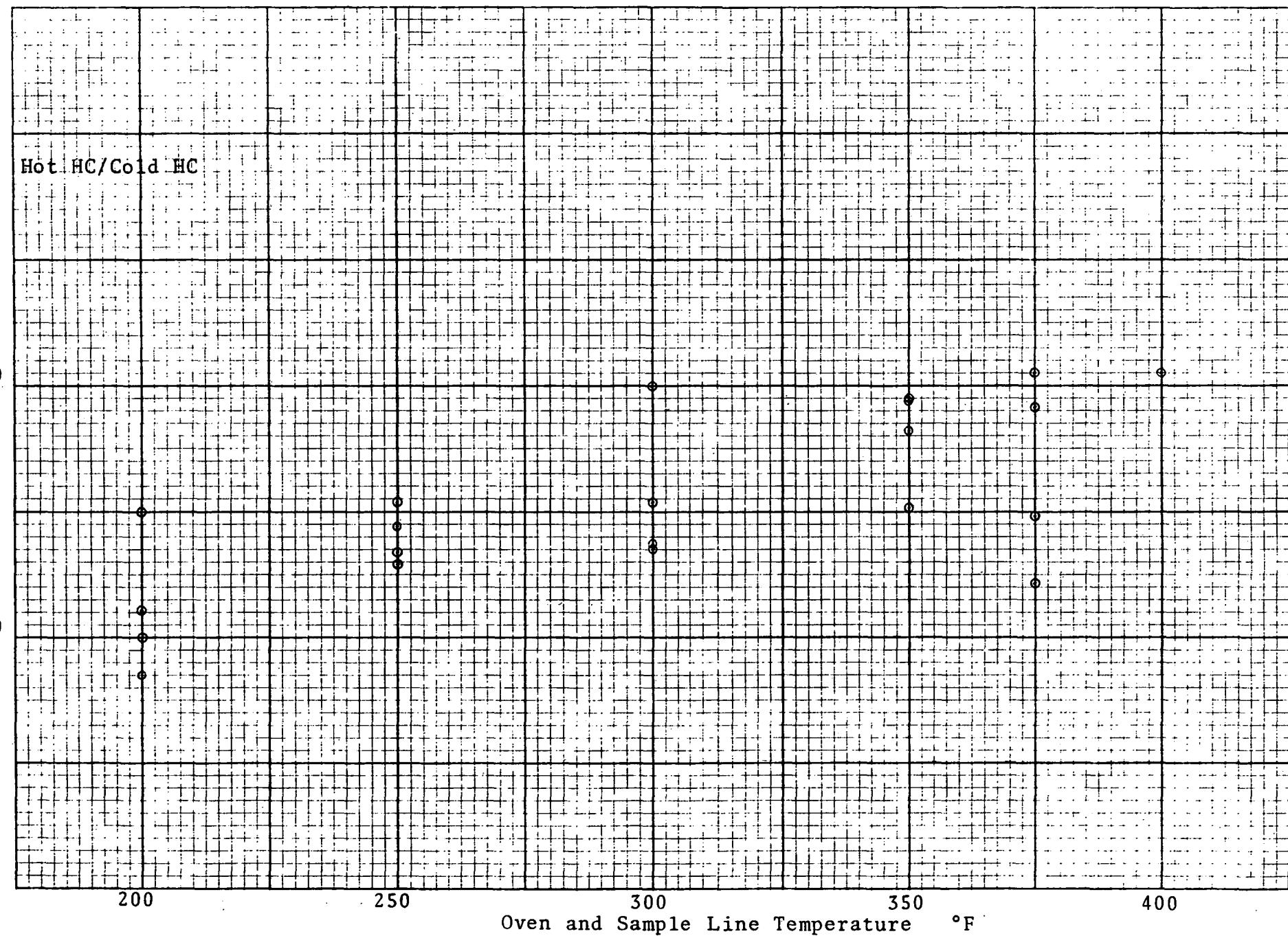
TABLE I

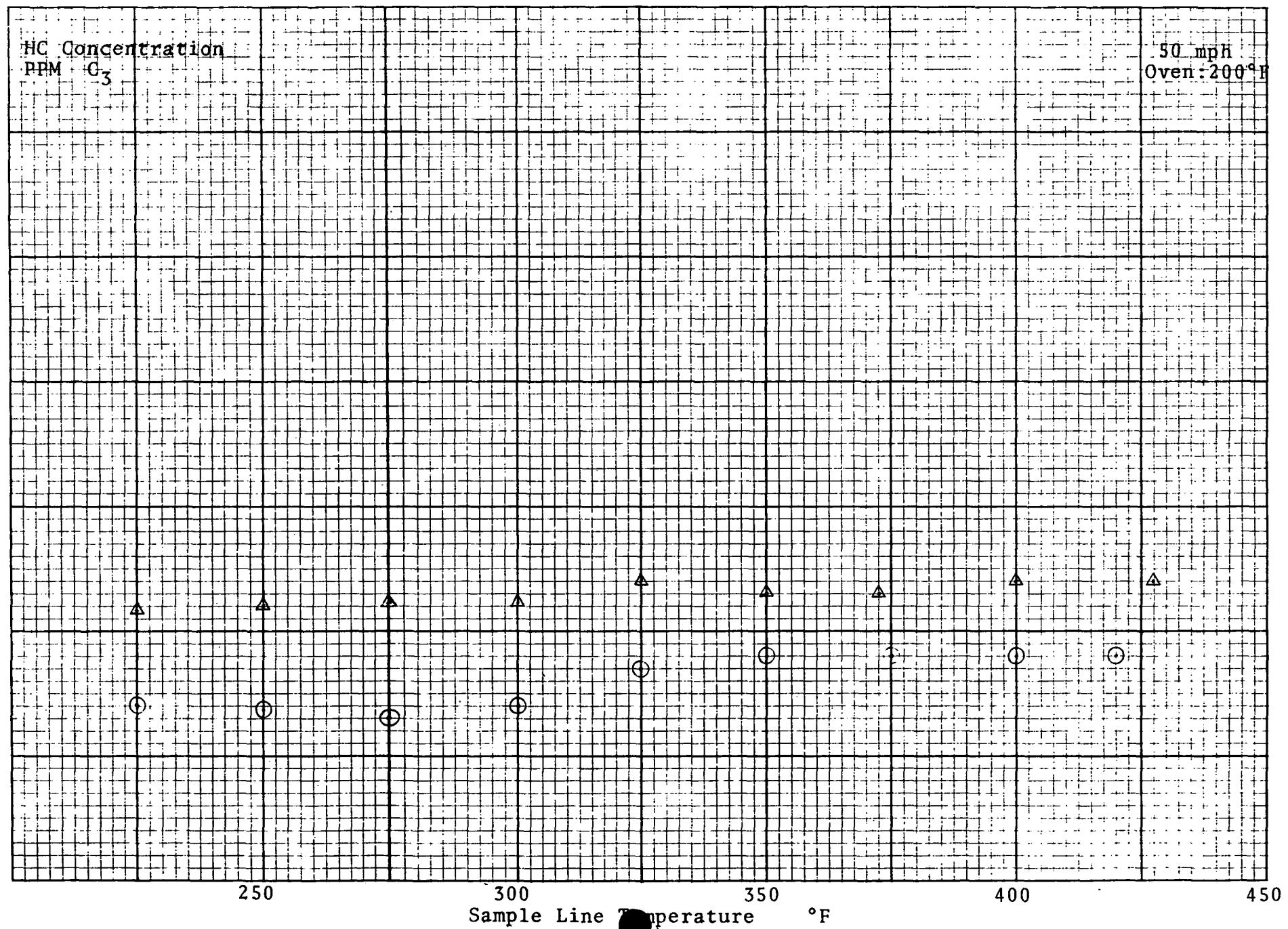
OPEL DIESEL
Mass Emissions
grams per mile
1975 FTP

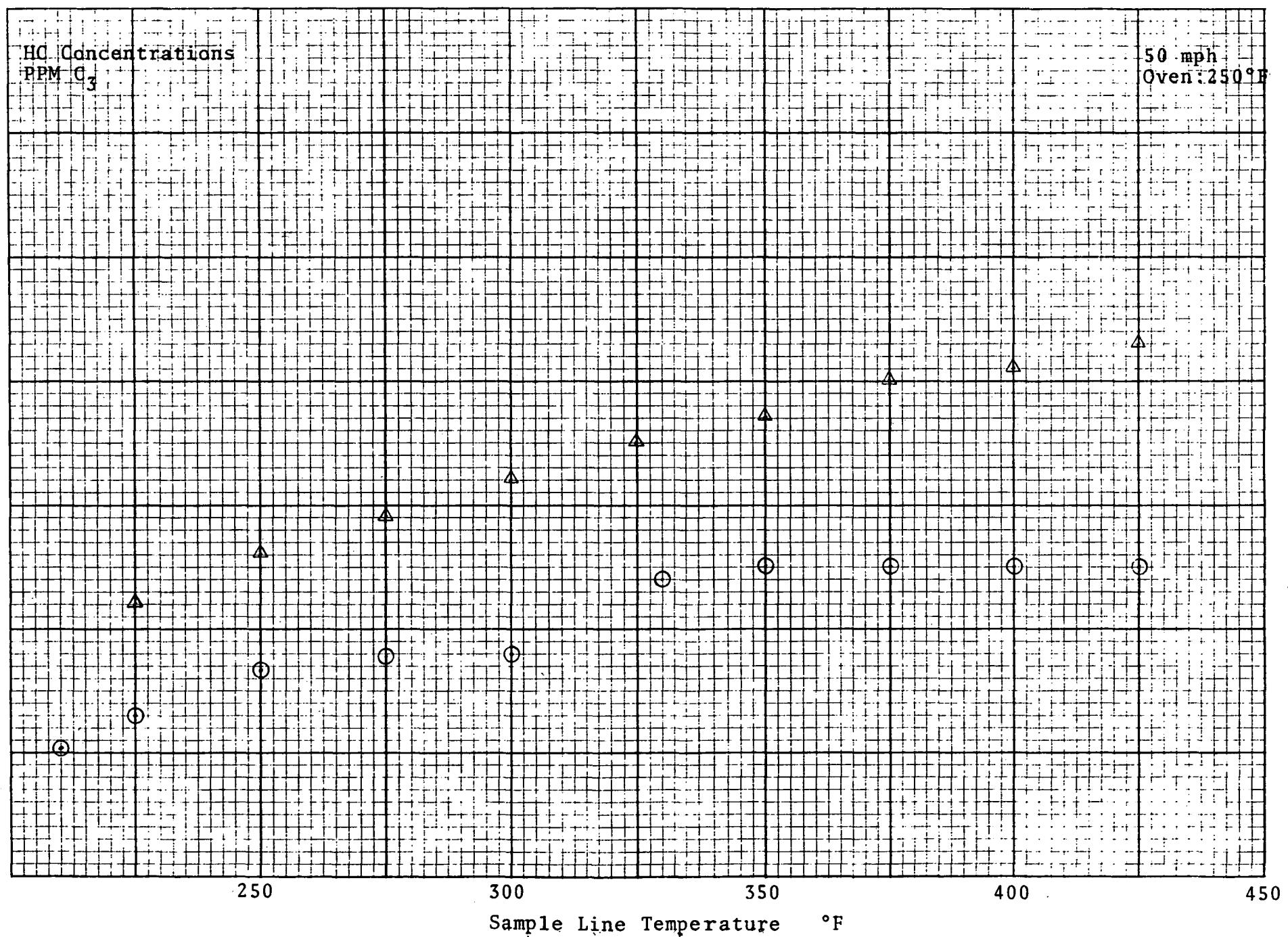
Test #	Cold HC	Hot HC	CO	CO ₂	NOx	Hot HC/Cold HC	Oven & Sample Line Temp. (°F)
16-198	0.20	0.35	1.46	427.23	1.27	1.75	200
16-238	0.16	0.39	1.07	410.66	1.24	2.44	250
16-252	0.20	0.47	1.27	430.61	1.34	2.35	300
16-263	0.19	0.45	1.20	417.29	1.35	2.37	300
16-264	0.17	0.50	1.24	427.13	1.38	2.94	350
16-265	0.17	0.48	1.17	419.98	1.32	2.82	350
16-268	0.19	0.58	1.19	409.67	1.35	3.05	400
16-271	0.19	0.48	1.27	411.95	1.29	2.53	250
16-273	0.19	0.42	1.26	416.10	1.33	2.21	200
16-331	0.19	0.58	1.36	405.14	1.36	3.05	375
16-336	0.23	0.57	1.36	410.37	1.33	2.48	375
16-368	0.21	0.48	1.36	409.25	1.59	2.29	250
16-374	0.21	0.49	1.34	419.29	1.52	2.33	250
16-378	0.21	0.42	1.42	402.51	1.55	2.0	200
16-385	0.18	0.45	1.37	404.25	1.50	2.5	200
16-388	0.19	0.48	1.31	407.18	1.47	2.53	300
16-394	0.19	0.57	1.23	421.22	1.40	3.0	300
16-396	0.24	0.70	1.40	416.75	1.59	2.92	375
16-399	0.27	0.60	1.39	411.29	1.55	2.22	375
16-420	0.21	0.62	1.44	426.88	1.55	2.95	350
16-422	0.25	0.63	1.44	419.36	1.55	2.52	350

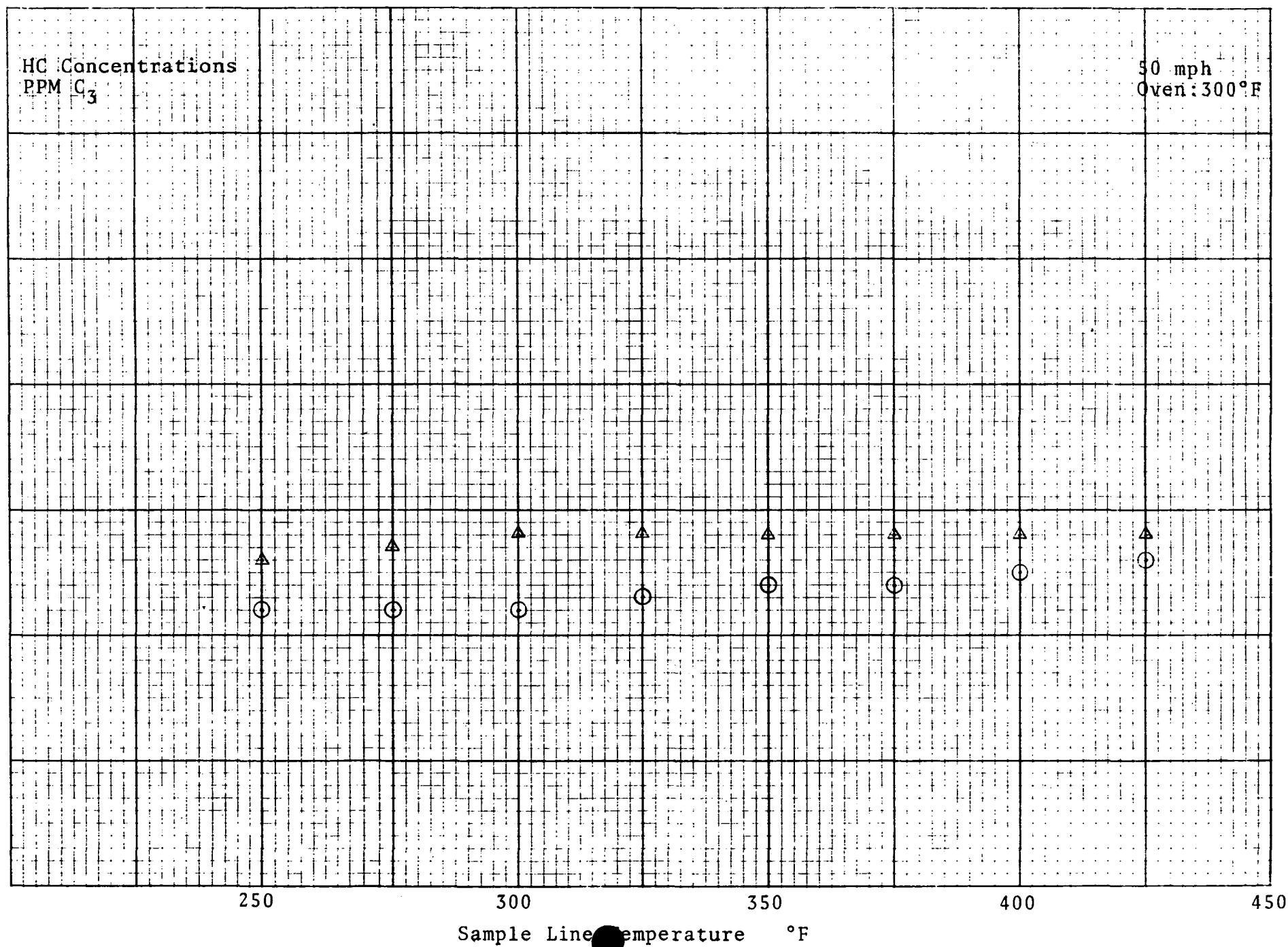
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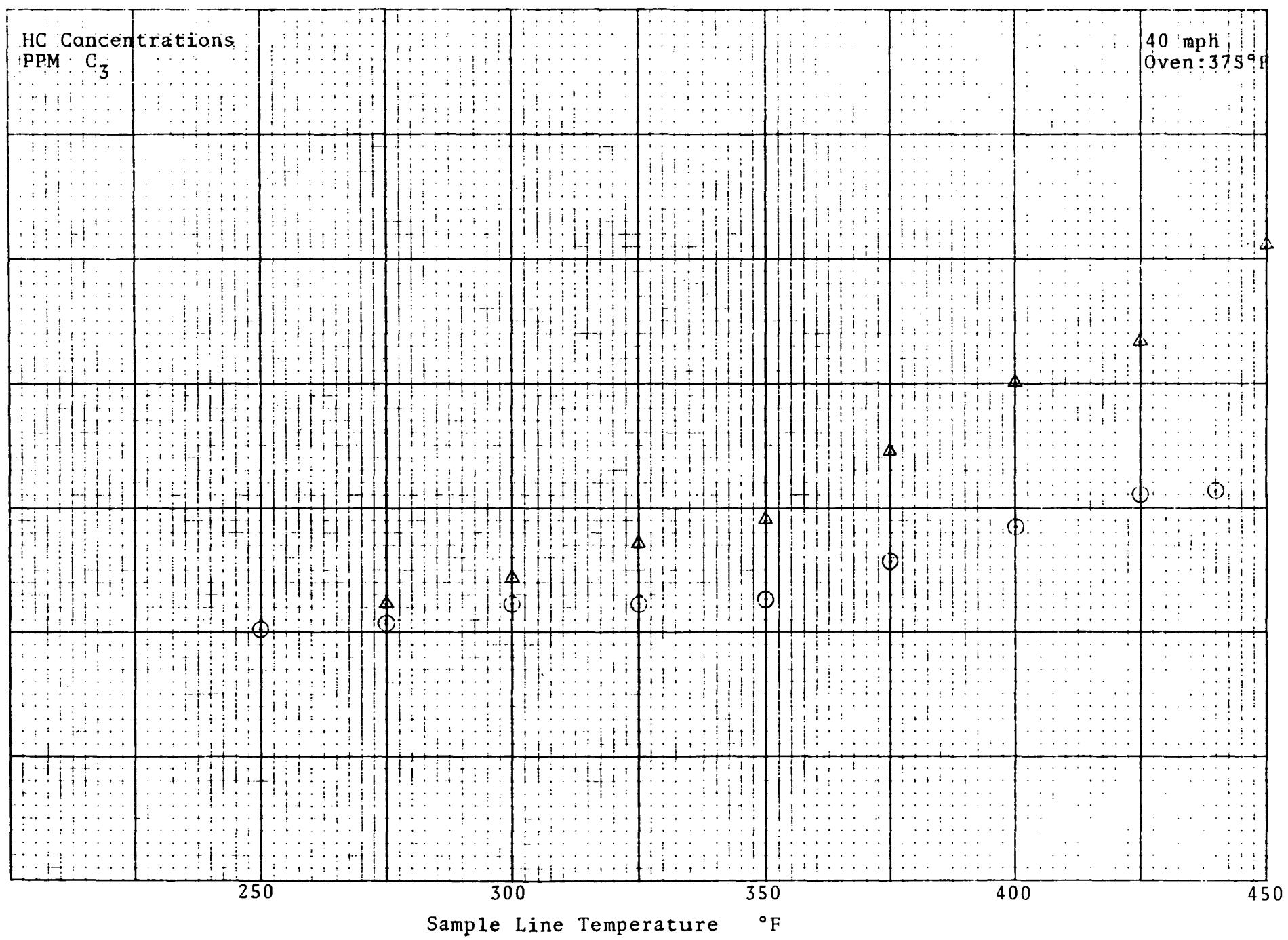
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