Technical Report on

Demonstration Emissions Tests for a Small Utility Engine

Dept. of MEAM
The University of Michigan

June, 1992.

UM-MEAM-92-

by

G. J. Brereton, C. Borgnakke,

Dept. of Mechanical Engineering and Applied Mechanics

The University of Michigan

Ann Arbor, MI 48109

K. Morrison, G. Schwartz,

Electro-Mechanical Associates, Inc.,

3744 Plaza Drive, Ann Arbor, MI 48104

M. Paradis

Horiba Instruments, Inc.,

3901 Varsity Drive, Ann Arbor, MI 48104

UMR1204

Abstract.

A series of IC engine emissions tests were carried out to demonstrate the capabilities of the University of Michigan emissions measurement equipment and the EMA Micro-Dyn small-engine motoring and absorbing dynamometer. The emissions tests corresponded to the SAE J1088 small-engine schedule, with the exception of fuel/airflow measurements. All preparations, measurements and tests were completed in a single three hour period, without equipment or instrumentation difficulties, even though these components were operated together for the first time.

1. TECHNICAL BACKGROUND

A trial run of the SAE J1088 small engine test schedule was carried out on a Tecumseh Model HM80 utility engine, rated at 8 HP at 3600 RPM. The engine was mounted on a EMA Micro-Dyn motoring/absorbing dynamometer. Its muffler was replaced by a 12-inch section of 3/4-inch iron pipe with a tee leading to a cavity in which the emissions sample probe was positioned, about 3 inches downstream of the exhaust manifold. This arrangement approximated the recommended configuration, avoiding pulsation and air backflow problems in testing the single cylinder engine. Oxygen content was monitored for any sign of backflow, where air infiltration would be identified clearly as an unusual increase in the oxygen concentration. The emissions sample probe was linked to the University of Michigan's Horiba EDTCS 1000 emissions analyzer via a heated line. An 87 octane unleaded gasoline was used as the fuel.

The SAE J1088 test schedule was implemented via throttle and torque control under the programmed control of the Micro-Dyn system. The basic steady-state 'A cycle' schedule of 100%, 75%, 50%, 25%, 10% of the rated torque at 85% of the rated speed was followed, together with a measurement at idle and a programmed continuous test sequence in which the engine was run for a short period at each of the test points of the J1088 sequence. Once the engine had warmed up, emissions readings typically stabilized within five minutes. In addition, a preliminary exploration of the effect of different mixture ratios on performance was carried out. Ambient conditions were 64 – 67 °F, 27.9 in. Hg, 60% relative humidity. The test results (as printed during testing) are shown in the Appendix and summarized below.

2. SUMMARY OF RESULTS

For the test sequences described above, measurements of emissions of oxygen (% volume), carbon dioxide (% volume), carbon monoxide (% volume), oxides of nitrogen (parts per million), and hydrocarbons (C_3 equivalent in parts per million) were made. Hydrocarbon measurements were made after transmission along a heated line, while other species were measured 'dry', after condensation of all water. No corrections were made to these measurements.

The first six figures in the Appendix show the measured levels for each of the test points in the SAE J1088 schedule. In all these cases, the hydrocarbon measurements were beyond the calibration of the present configuration of our Horiba test bench (valid up to 5000 ppm), which was intended for automotive engines exhausting minimal amounts of unburnt fuel. All other emissions measurements appear to match the general range of expectations. The magnitude of the carbon monoxide levels (10% to 15% volume) is particularly noticeable.

The continuous time traces of emissions levels during the test schedule allows clear comparisons of emissions with operating conditions. Trends in CO levels show an interesting behavior, tending to increase with decreasing torque at fixed speed. With the main air-fuel mixture-adjustment screw set 1/2 turn lean, relative to the position that gave maximum exhaust temperature (1200 °F) at the rated speed/load, the hydrocarbon emissions dropped below 5000 ppm for a part of the test cycle and oxides of nitrogen became detectable.

A key result of this preliminary test was the confirmation of our suspicion that hydrocarbon sensors calibrated for automotive engine testing would be quite inadequate for small engine testing. The greatly increased hydrocarbon levels require sensors calibrated at least as high as 10,000 ppm and possibly higher. We are presently investigating how best to implement the required modifications in our Horiba emissions bench.

3. CONCLUSIONS

The University of Michigan/EMA small engine group, working closely with Horiba, has successfully demonstrated its capability to carry out emissions tests on small engines with a minimum of preparation. This simple demonstration is illustrative of the technical expertise, flexibility, and co-operation of this group in undertaking small engine research and testing.

APPENDIX

Figures 1-6: Emissions levels for the 6 SAE J1088 operating conditions.

Figures 7-8: Continuous test schedule and emissions levels for mixture at recommended set point.

Figures 9-10: Continuous test schedule and emissions levels for mixture 1/4 turn lean.

Figures 11-12: Continuous test schedule and emissions levels for mixture 1/2 turn lean.

All figures are those printed during the test.

Intermediate Speed: 3060 RPM

Torque: 100% of rated: 12.7 Ft-lb

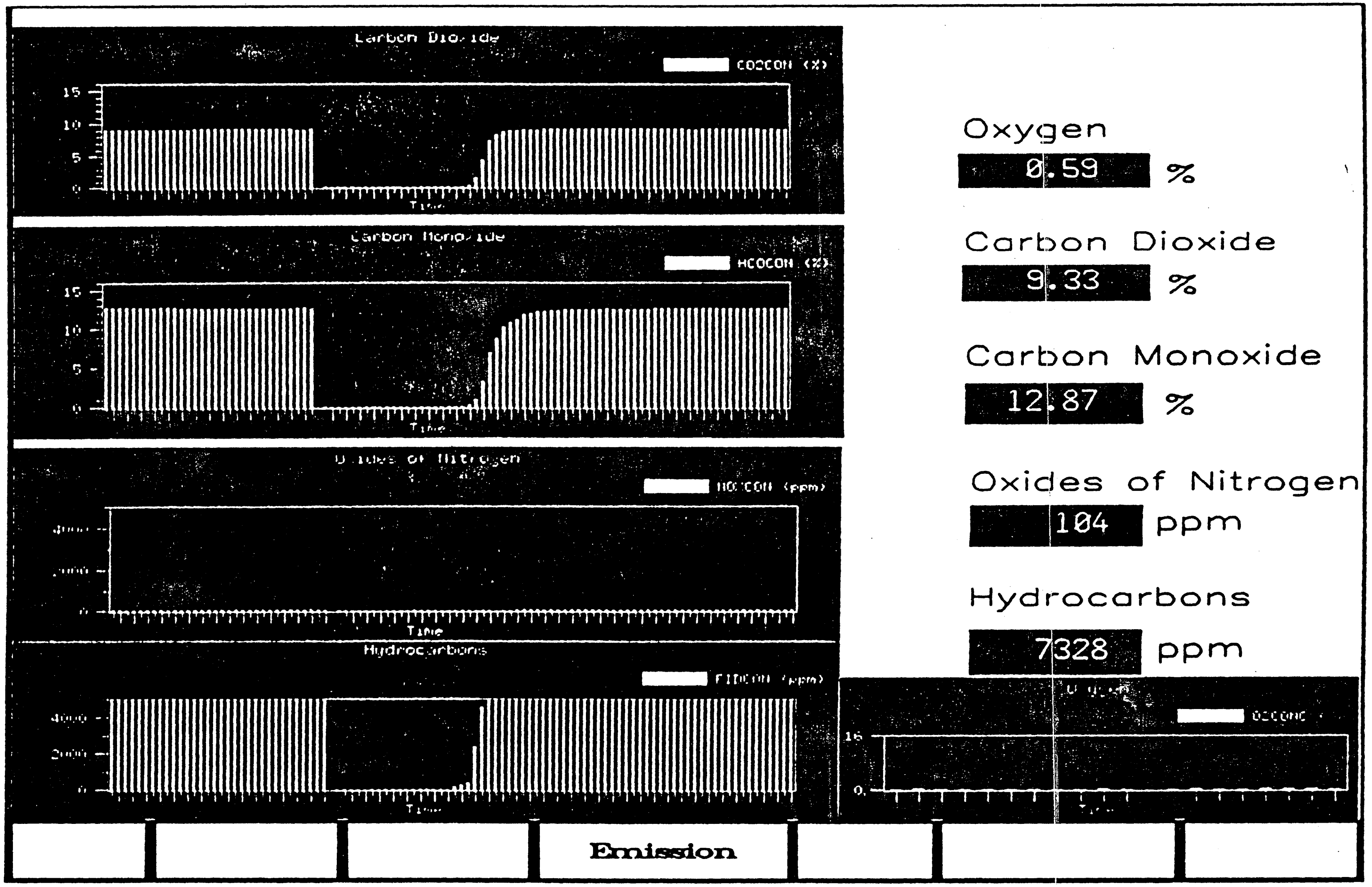

Figure 1.

Intermediate Speed: 3060 RPM

Torque: 75% of rated: 9.3 Ft-lb

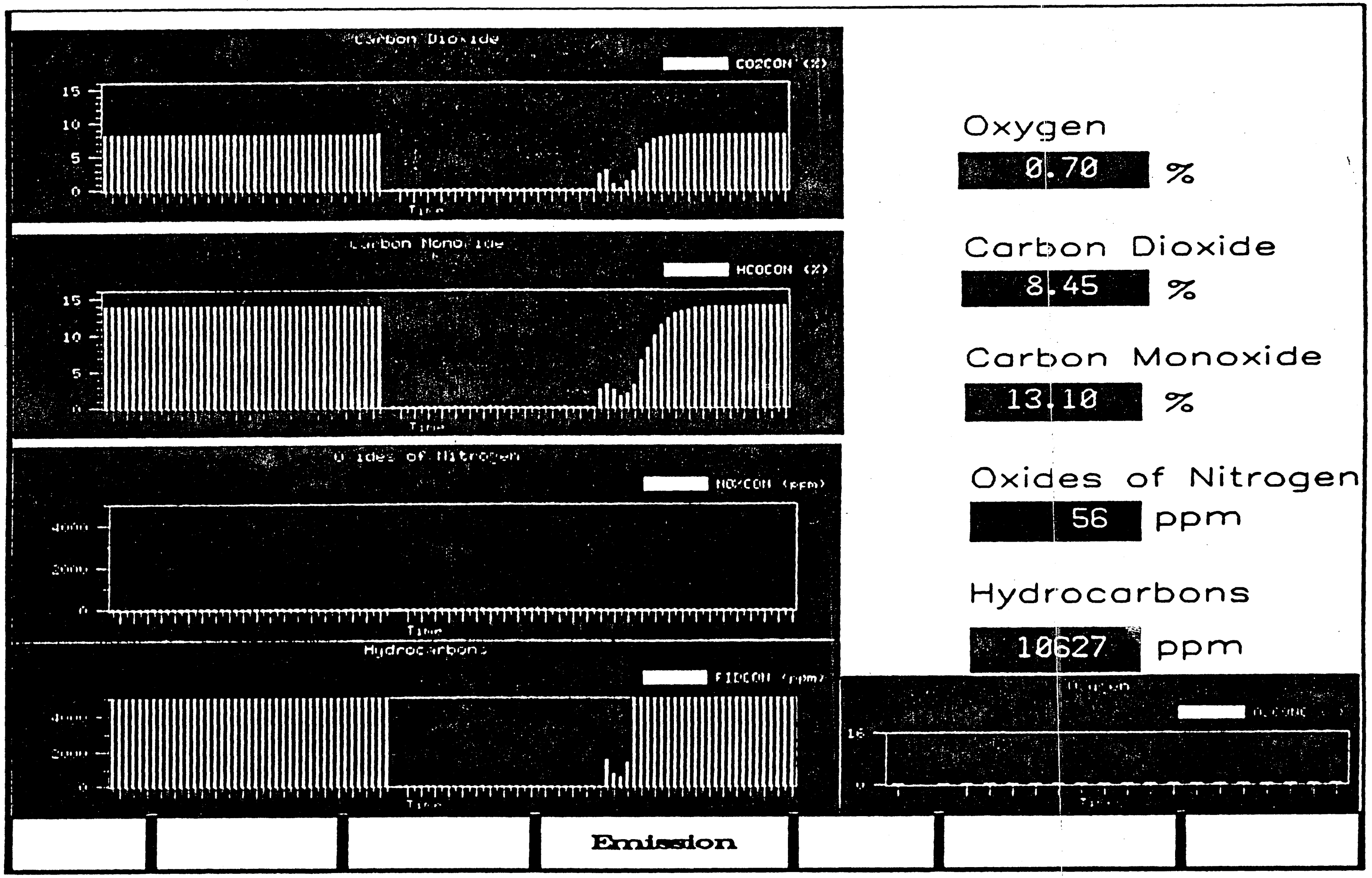

Figure 2.

Intermediate Speed: 3060 RPM

Torque: 50% of rated: 6.4 Ft-lb

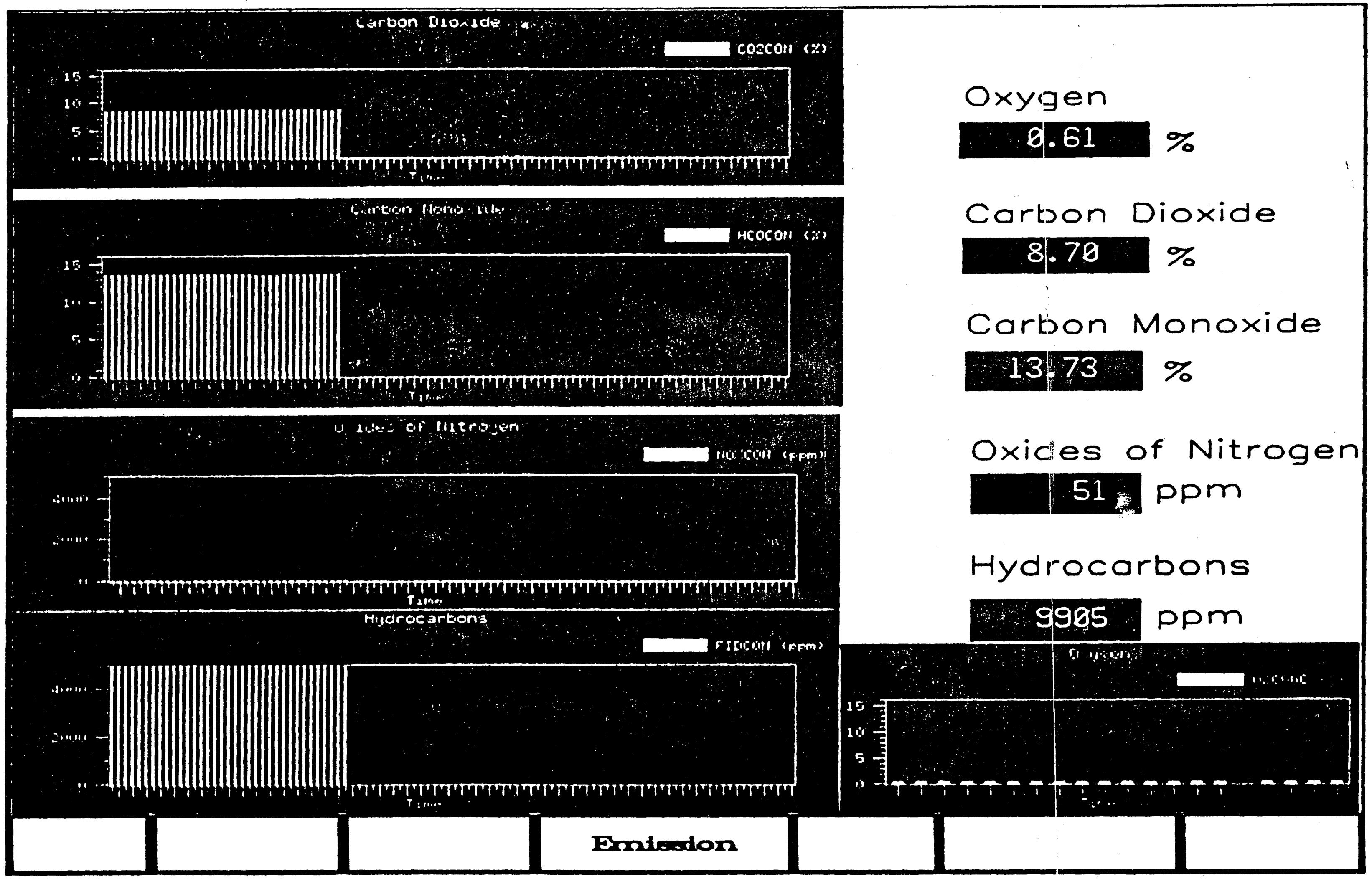

Figure 3.

Intermediate Speed: 3060 RPM

Torque: 25% of rated: 3.2 Ft-lb

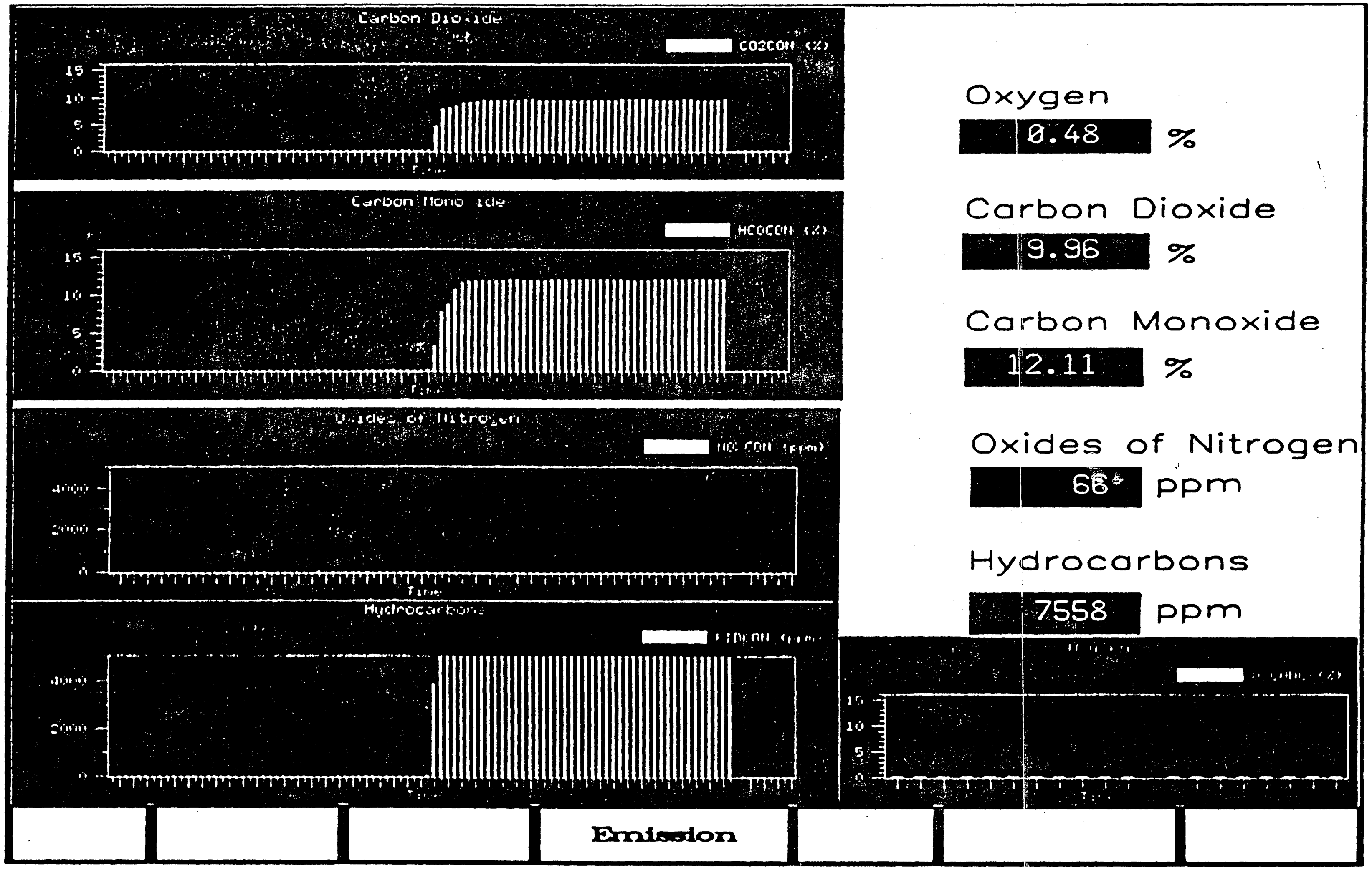

Figure 4.

Intermediate Speed: 3060 RPM

Torque: 10% of rated: 1.8 Ft-lb

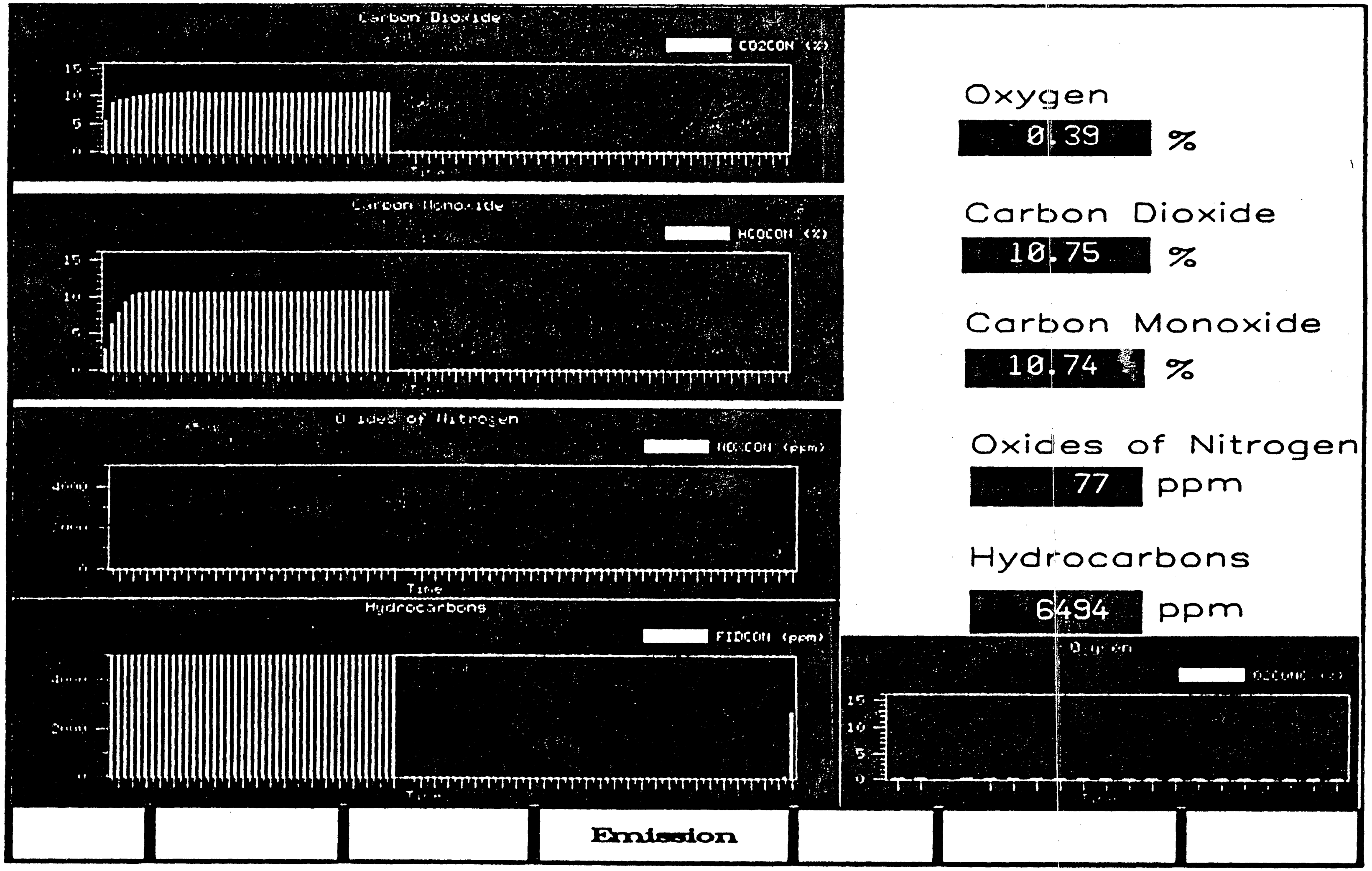

Figure 5.

Idle Speed: 1320 RPM

Idle Torque: 0.1 Ft-lb

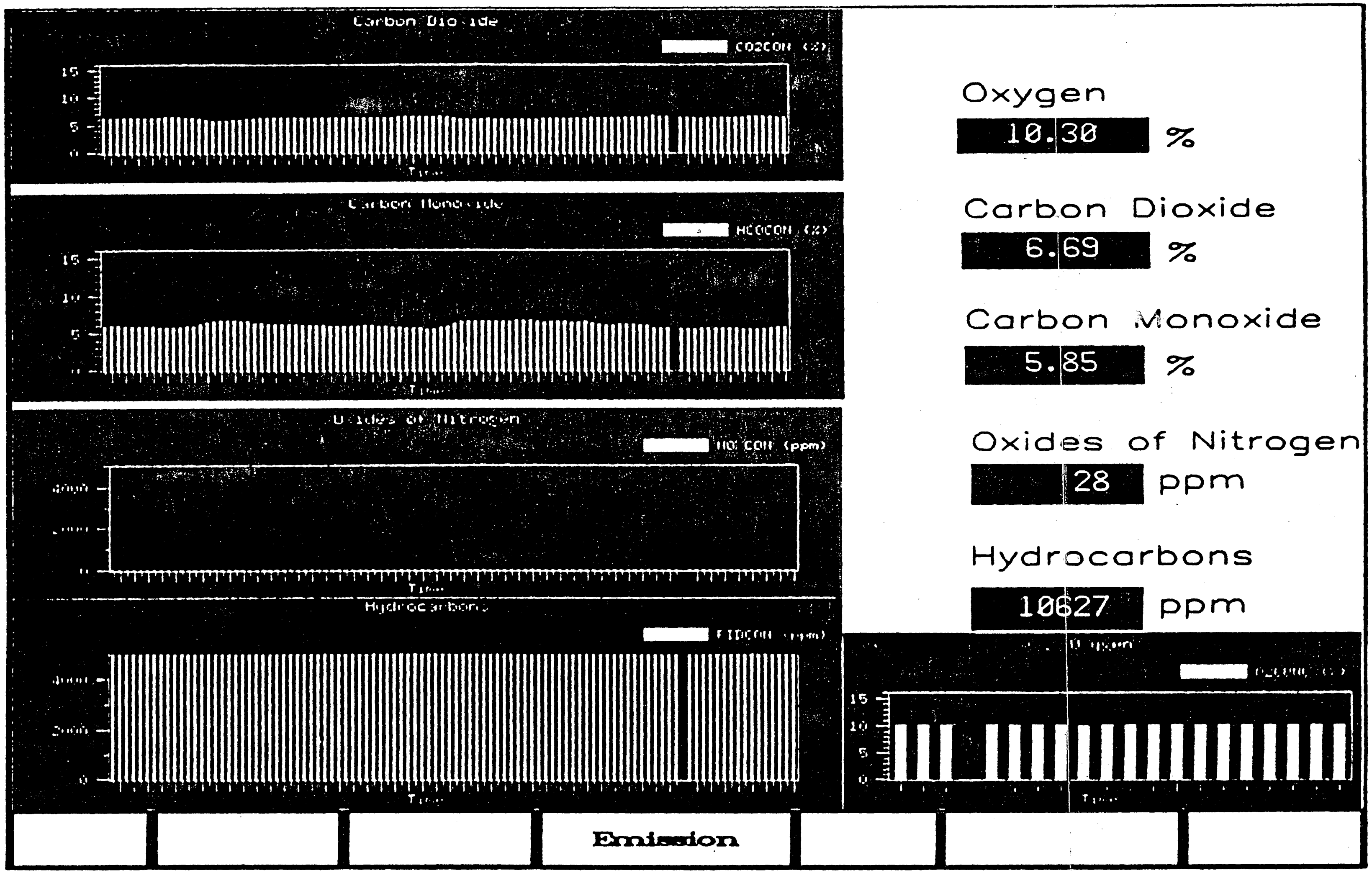

Figure 6.

0864H

Continuous test schedule: mixture at recommended set point

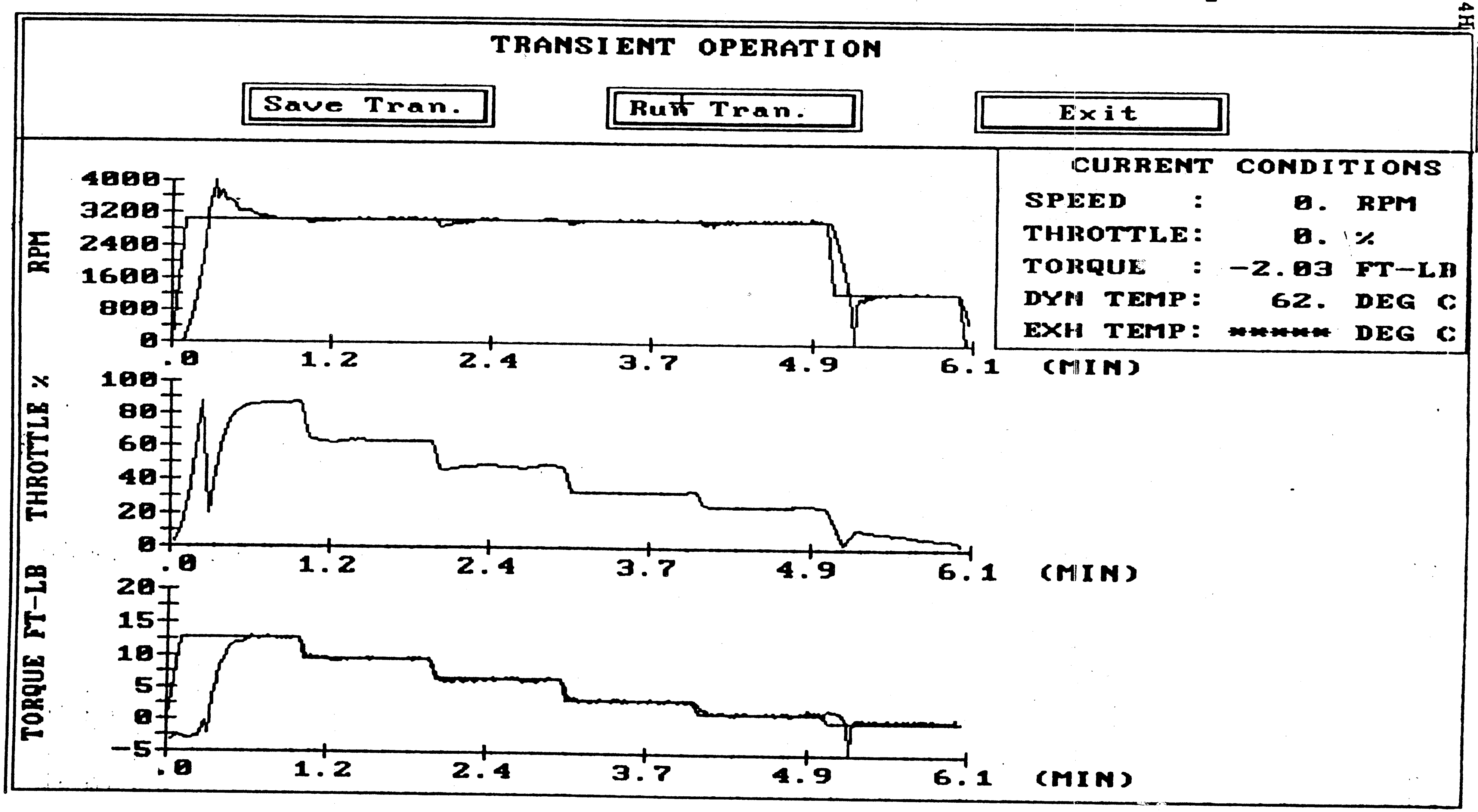

Figure 7.

Continuous emissions record: mixture at recommended set point

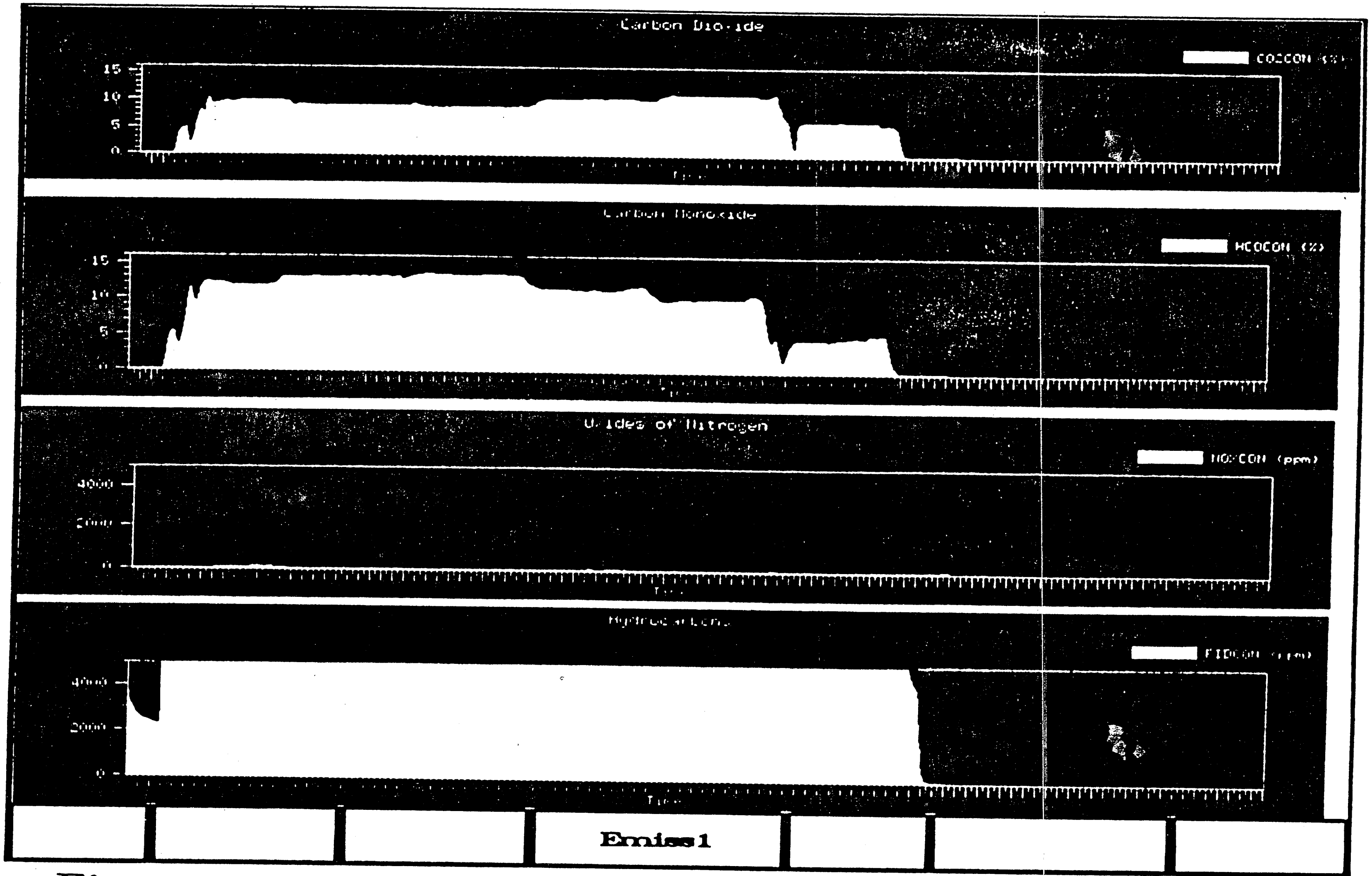

Figure 8.

Continuous test schedule: mixture 1/4 turn lean

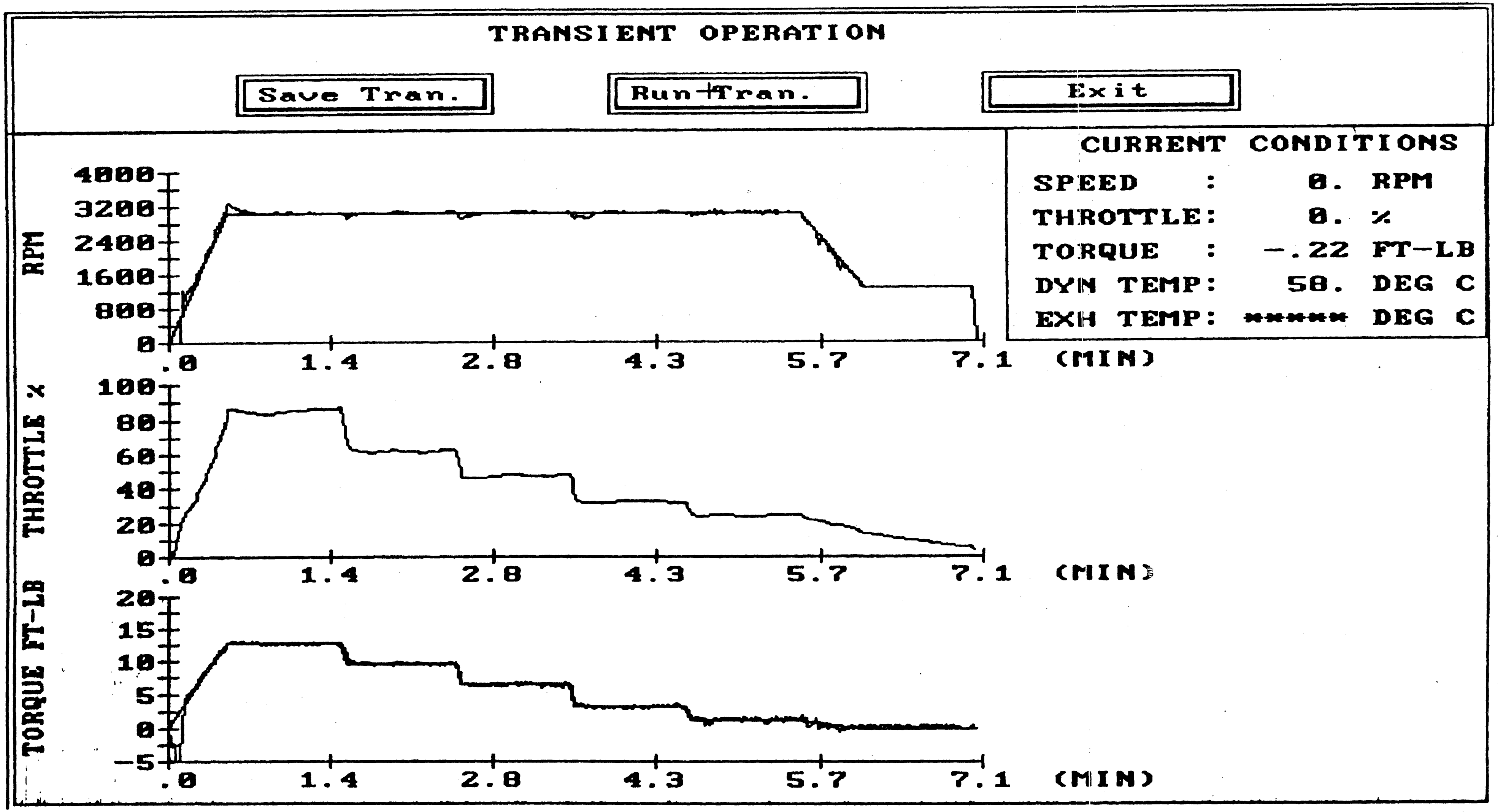

Figure 9.

Continuous emissions record: mixture 1/4 turn lean

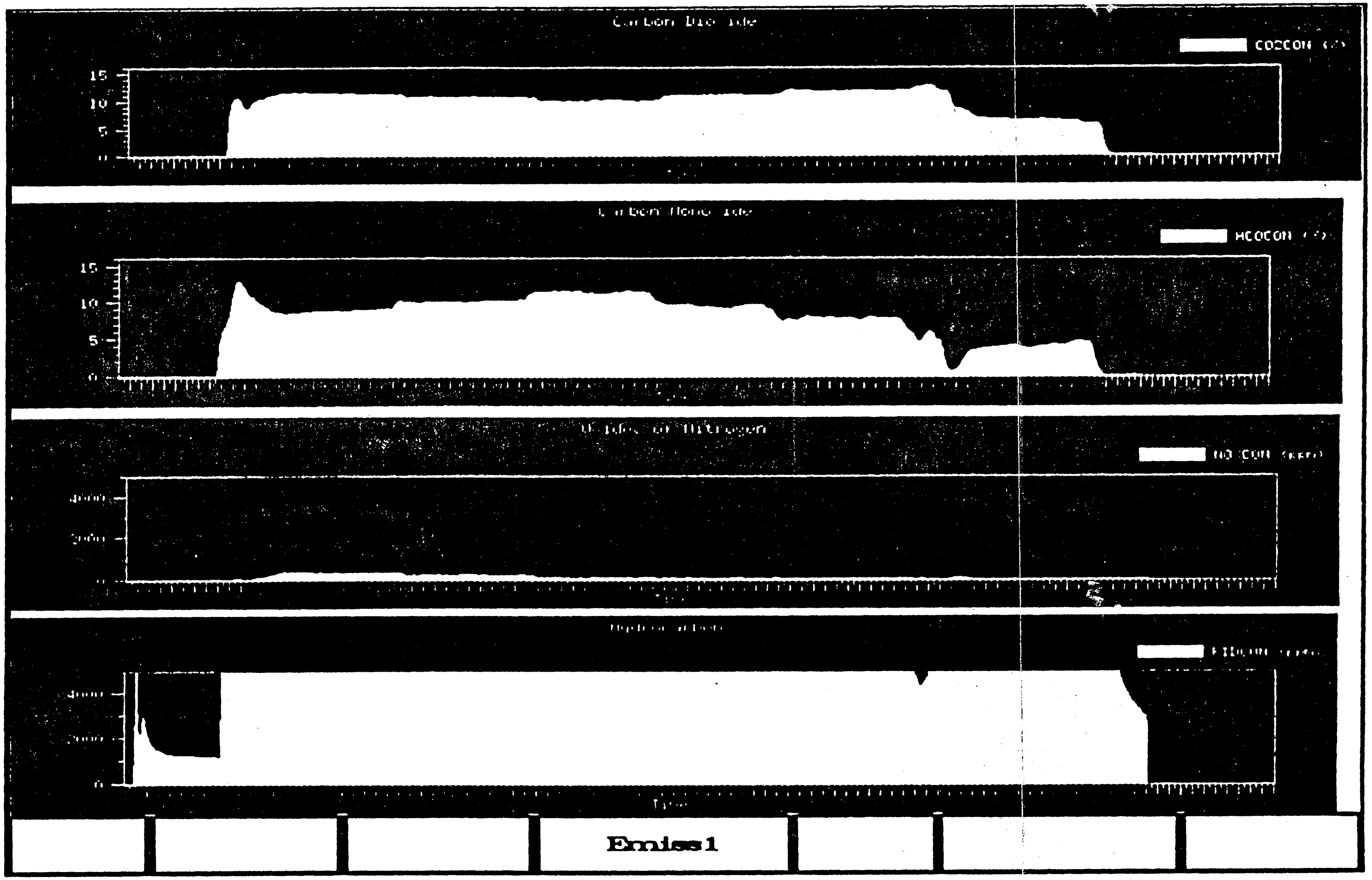

Figure 10.

Continuous test schedule: mixture 1/2 turn lean

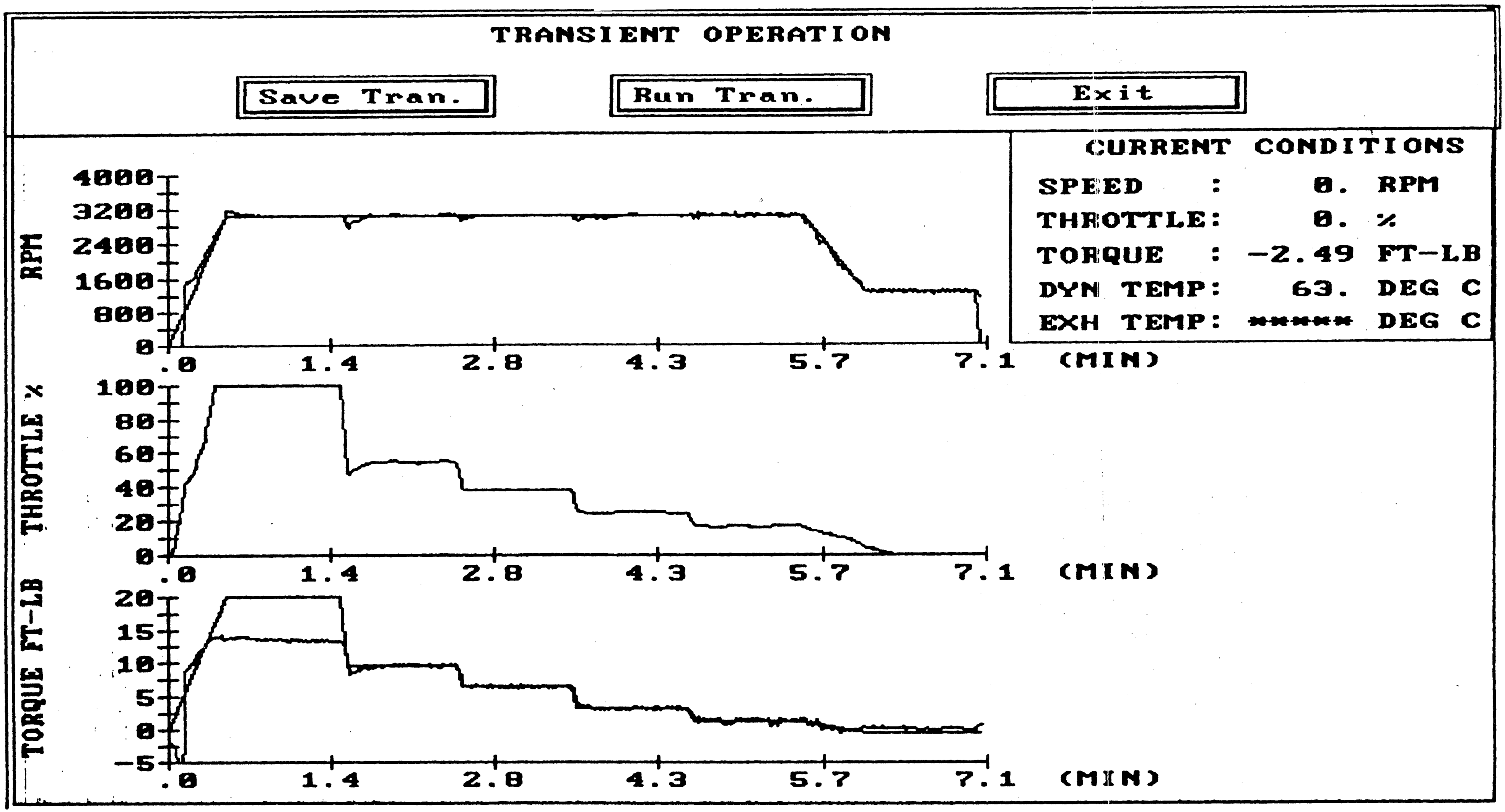

Figure 11.

Continuous emissions record: mixture 1/2 turn lean

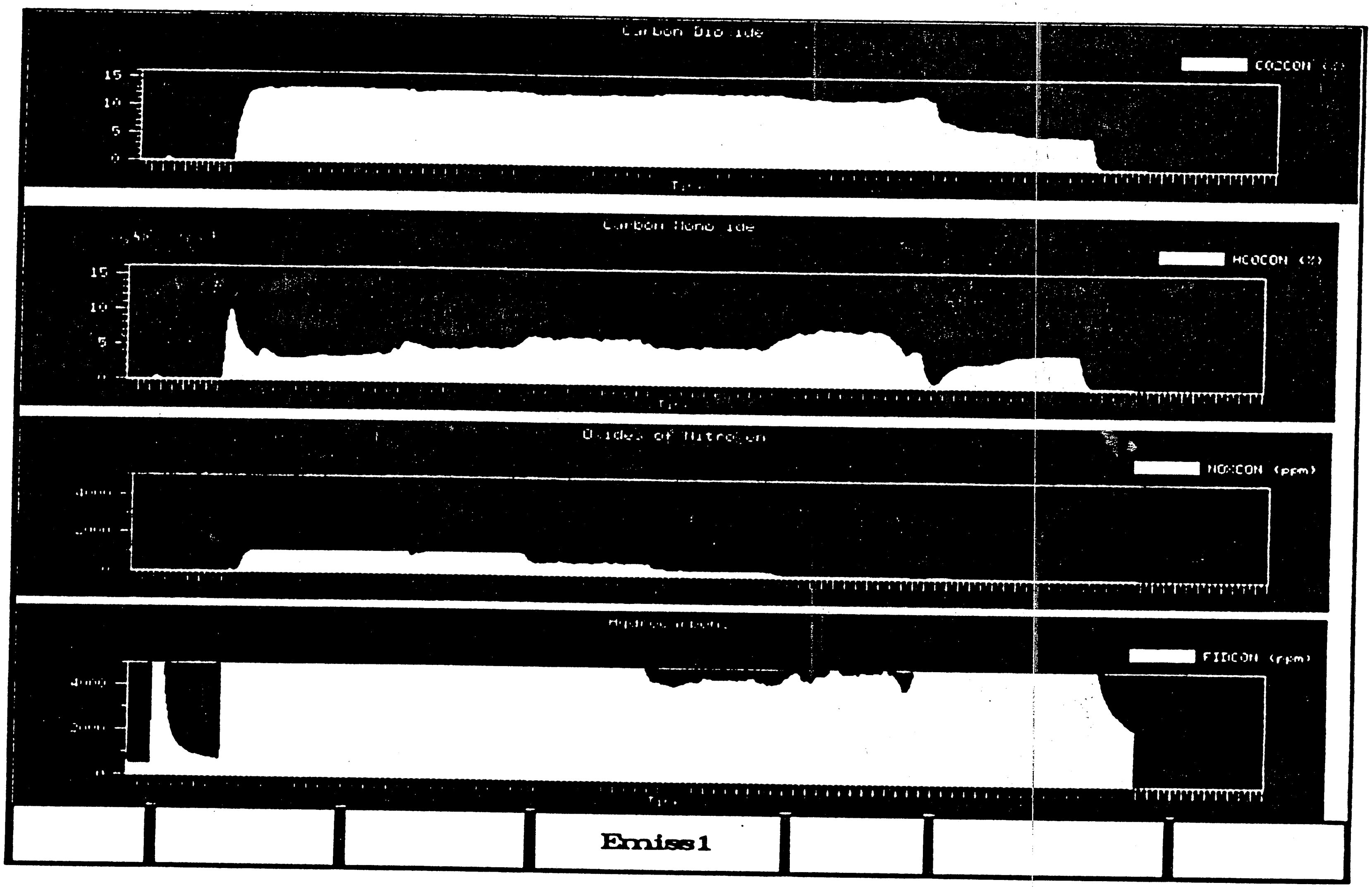

Figure 12.