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FIRE FIGHTER TRAINER ENVIRONMENTAL CONSIDERATIONS. PHASE II. AP--ETC(U)

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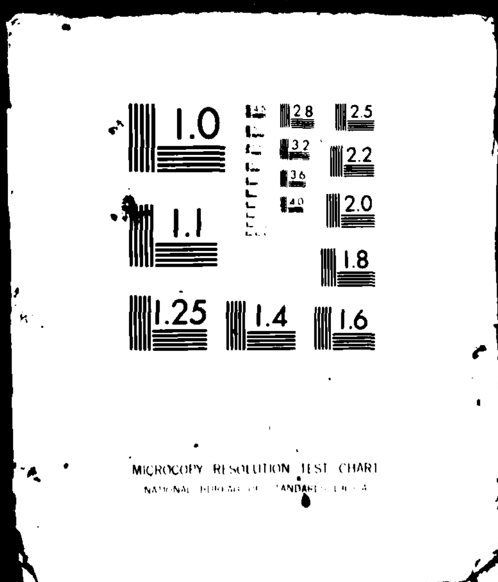

LEVEL III

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Contract No. N61339-79-C-0011, Mod. No. P00007

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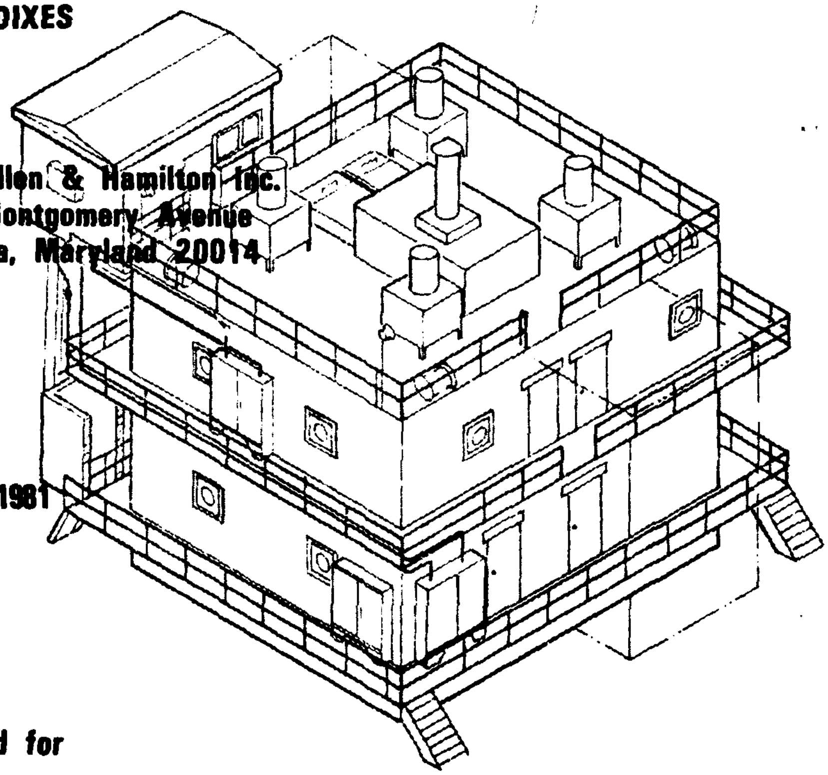
FIRE FIGHTER TRAINER ENVIRONMENTAL CONSIDERATIONS PHASE II

APPENDIXES



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31 July 1981

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APPENDIX A

CONSTRAINTS

APPENDIX A

CONSTRAINTS

This appendix is included for explanation of environmental constraints as described in the original Phase I report.

A.1 Health and Safety Constraints. Under the authority of Executive Order 12196, Occupational Safety and Health Programs for Federal Employees (effective October 1, 1980), and revised 29 CFR 1960, Basic Program Elements for Federal Employee Occupational Safety and Health Programs (effective October 15, 1980), the 19F1 AFFT will be subject to the same health and safety constraints as the private sector. In addition, because of the Navy's long-standing concern with safety and health matters, all Naval commands, under the direct order of OPNAV, are required to comply with the most stringent health standards and/or recommendations that are used by OSHA, NIOSH, ANSI, ACGIH, or other standard-setting organizations. This rule is excepted when there is a "uniquely military" justification for not complying. In that situation, separate NAVOSH standards may be developed by the Bureau of Medicine and Surgery.

Enforcement of all safety and health criteria is solely the Navy's responsibility and is carried out by the Naval Environmental Health Center and the Environmental Preventive Medicine Unit. States with individual occupational safety and health programs will exempt Federal facilities from state inspections.

Specific guidelines are set for many of the potentially toxic materials used in the 19F1 AFFT. Those materials that do not have standards require evaluation for potentially hazardous exposures. The operating parameters of the 19F1 AFFT require consideration of the recommended guidelines for confined spaces. In addition, there are standards regarding hazards from physical agents such as noise and nonionizing radiation from hot environments causing burns and heat stress.

The Naval Safety Center is responsible for Naval onshore personnel safety. Navy policy is to follow good safety practices as outlined by OSHA, the National Electrical Code (NEC), the National Fire Prevention Association (NFPA), and the International Fire Service Training Association. The Navy's safety standards are outlined in a manual entitled "Safety Precautions," NAVMAT P-5100. The Navy has also adopted the Fire Fighting Occupational Safety Standards of the International Fire Service Training Association and follows the recommended practices for tank testing concerning gas-free engineering and confined spaces.[1]

[1] U.S. Navy, "Gas-Free Engineering," Naval Ship Technical Manual, NAVSEA 5908CH STM-030, Vol. 3, Chpt. 074, 1979.

Guidelines for exposure to chemical contaminants and physical agents and the minimum internal environmental oxygen requirement as well as the sources of these guidelines are presented in Table A-1. These guidelines reflect the original materials to be used in the 19F1, as well as the various decomposition and combustion products. In general, these guidelines are more stringent than previous ones.

Several of the chemical agents used in the AFFT (i.e., propane and propylene glycol) may also have a significant safety hazard potential. Safety requirements for these agents are included in explosion-related guidelines. In specific applications, however, these requirements may need modification.

The confined space condition of the 19F1 further requires consideration of the specific potential safety hazards associated with burning in a confined atmosphere. These guidelines relate to oxygen deficiencies, exhaust ventilation, flammable parameters, dilution ventilation, and NEC and NFPA requirements for electrical equipment. Some of the key guidelines are presented in Table A-2. In addition to these guidelines, there are other guidelines that cover general safety, proper working/walking surfaces, ladders, means of egress, and fire protection.

A.2 Constraints Related to Air Pollution. Air pollution control requirements for a particular facility may be governed by the applicable emissions standards or by the state ambient air quality standards, depending on the type and amount of emissions from the facility and the existing air quality at the facility site. These two sets of regulations as well as Japanese air pollution-control regulations are discussed in the following subsections.

A.2.1 U.S. Ambient Air Quality Standards. Ambient air quality standards exist at both the federal and state levels. Many states have adopted the federal ambient standards, but some states have promulgated more stringent standards or added other pollutants to those regulated at the national level. National ambient air quality standards have been established for seven criteria pollutants.

Of the nine states designated as AFFT sites, only Connecticut, Rhode Island, and Virginia have completely adopted the federal standards. The other states have adopted more stringent standards for one or more of the seven pollutants. In addition, several of the states have promulgated standards for pollutants not regulated at the federal level. The regulatory status of each state is summarized in Table A-3.

TABLE A-1. GUIDELINES FOR EXPOSURE TO CHEMICAL CONTAMINANTS AND PHYSICAL AGENTS AND THE MINIMUM INTERNAL ENVIRONMENTAL OXYGEN REQUIREMENT

	Guidelines		Source
	TWA[1]	STEL[2]	
Chemical Contaminant			
Propane	1,000 ppm	-	3
Propylene Glycol	-	-	
PKP	5 mg/m^3	-	4
AFFF	-	-	
HF	3 ppm	-	4
Polytetrafluoroethylene Decomposition Products	As low as possible	As low as possible	4
NO_x	3 ppm	5 ppm	4
NO_2	1 ppm	-	4
NO	25 ppm	-	4
HC	-	-	4
CO_2	5,000 ppm	15,000 ppm	4
CO	50 ppm	400 ppm	4
Silica (Amorphous)	3 mg/m^3	-	4
Physical Agent			
Heat	Maximum body temperature of 100.4° F or 27.9° C (TWA)		5
Noise	90dBA[6]		3
Minimum Internal Environmental Oxygen Requirement			
O_2	20%		7
	18%		4

See notes on following page.

Notes

[1]Threshold limit value - time-weighted average.

[2]Threshold limit value - short-term exposure limit.

[3]29 CFR Part 1910 - Occupational Safety and Health Standards.

[4]Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment as adapted by the American Conference of Governmental Industrial Hygienists (ACGIH).

[5]Criteria Document on Occupational Exposures to Hot Environments, National Institute of Occupational Safety and Health (NIOSH), 1972.

[6]A-Weighted Sound Pressure Level - 8-hour exposure limit.

[7]Naval Ship Technical Manual, "Gas Free Engineering," NAVSEA 5908CH STM-030, Vol. 3, Chpt. 074, 1979.

TABLE A-2. SAFETY GUIDELINES RELATED TO 19F1 AFFT

NIOSH criteria for working in confined spaces recommends:

- Prohibited entry for hot work if 10 percent of the lower flammable limit (LFL) is exceeded.
- Continuous general ventilation where a toxic atmosphere is being produced.
- All electrical equipment must comply with NEC and NFPA #70.
- Exhaust stream must be diluted below the permissible exposure level (PEL) or 10 percent of the LFL, whichever is lower.
- Where PELs are exceeded, respirator protection is recommended.

NAVSEA Gas Free Engineering Office recommends:

- Internal environmental O_2 supply should be the same as outside atmosphere.
- Entrance into confined space for hot work requires that 10 percent of the lower explosive limit (LEL) not be exceeded.

TABLE A-3. AMBIENT AIR QUALITY STANDARDS

	Carbon Monoxide (mg/m^3)	Hydrocarbons ($\mu g/m^3$)	Lead ($\mu g/m^3$)	Ozone ($\mu g/m^3$)	Nitrogen Dioxide ($\mu g/m^3$)	Sulfur Dioxide ($\mu g/m^3$)	Total Suspended Particulates ($\mu g/m^3$)
Federal[1]	10 8 hrs. 40 1 hr.	160 3 hrs.	1.5 3 mos.	235 1 hr.	100 annual	80 annual 365 24 hrs. 1,300 3 hrs.	75 annual 260 24 hrs.
California[2]	10 12 hrs. 40 1 hr.	Federal	1.5 30 days	200 1 hr.	500 1 hr.	0.05 ppm 24 hrs. 0.5 ppm 1 hr.	60 annual 100 24 hrs.
Florida	Federal	Federal	Federal	Federal	Federal	60 annual 260 24 hrs. 1,300 3 hrs.	60 annual 150 24 hrs.
Hawaii	5 8 hrs. 10 1 hr.	100 3 hrs.	Federal	100 1 hr.	70 annual 150 1 hr.	20 annual 80 24 hrs. 400 3 hrs.	55 annual 150 24 hrs.
Illinois[3]	Federal	Federal	Federal	Federal	Federal	Federal	73 annual 260 24 hrs.
South Carolina[4]	Federal	Federal	Federal	Federal	Federal	Federal	60 annual 250 24 hrs.
Washington[5]	Federal	Federal	Federal	0.08 ppm 1 hr.	Federal	0.02 ppm annual 0.1 ppm 24 hrs. 0.4 ppm 1 hr.	150 24 hrs.
Japan[6]	10 ppm 24 hrs. 20 ppm 8 hrs.	-	-	-	0.04-0.06 ppm 24 hrs.	0.04 ppm 24 hrs. 0.1 ppm 1 hr.	100 24 hrs. 200 1 hr.

[1] Connecticut, Rhode Island, and Virginia have adopted the federal standards.

[2] California also has the following standards: H_2S, 0.03 ppm (1 hr.); sulfates, 25 mg/m^3 (24 hrs.).

[3] Illinois also has the following standard: photochemical oxidants, 160 $\mu g/m^3$ (1 hr.)

[4] South Carolina also has the following standards: gaseous fluorides, 0.8 ppm (30 days), 1.6 ppm (7 days), 2.9 ppm (24 hrs.), and 3.7 ppm (12 hrs.).

[5] Washington also has the following standards: fluorides (as HF), 2.9 $\mu g/m^3$ (24 hrs.), 1.7 $\mu g/m^3$ (7 days), and 0.84 $\mu g/m^3$ (30 days).

[6] Japan also has the following standard: photochemical oxidants, 0.06 ppm (1 hr.).

[7] Rhode Island also has the following standard: H_2S, 0.01 ppm (1 hr.).

A.2.2 U.S. Emission Limitation Standards. In some areas, the ambient standards for one or more pollutants are currently being violated, while in other areas, the ambient air quality is better than the set limitations. The Clean Air Act requires those areas exceeding standard values to control emissions from both existing and new sources. Those areas that fall within the air quality standards must prevent significant deterioration of the air quality by requiring controls on new sources of emissions.

EPA has established emission standards for total suspended particulates, NO_x, SO_2, CO, and volatile organic compounds from certain classes or types of new stationary sources. Most states have adopted EPA regulations with minor modifications. The proposed fire fighter training facility is not included in any particular class or category of sources for which emission standards have been established. Therefore, it must meet general emission-control requirements, the most notable of which are the limitations placed on visible emissions.

Most states have established an opacity standard for controlling visible emissions. Table A-4 summarizes the opacity standards for the nine states under consideration and lists possible exemptions for fire-fighting facilities. Currently, only three of the states have any exemption provisions, and these are specific for open-burning facilities. It is doubtful, however, that these exemptions will pertain to the AFFT, as it is not classified as an open-burning facility.

A.2.3 Other U.S. Regulations. Another general requirement at each AFFT site will be to obtain an air pollution permit to construct and operate the proposed facility. Some states have established a minimum threshold, such that any source with emissions above the threshold must obtain a permit and comply with the emission-control requirements stipulated in the permit. In San Diego, a source emitting any pollutant over 10 pounds per hour must use the Best Available Control Technology (BACT). The BACT is determined on the basis of energy, environmental, and economic impacts of alternative control strategies. The other states will require a case-by-case review.

In addition to these requirements, EPA has established national emission standards for four pollutants that are considered to be carcinogenic or mutagenic hazards. These pollutants include asbestos, mercury, beryllium, and vinyl chloride. Three substances that are considered potential pollutants include benzene, radionuclides, and inorganic arsenic.

TABLE A-4. VISIBLE EMISSION STANDARDS

State	Opacity Standard	Exemptions for Fire-Fighting Training
California (San Diego)	Not to exceed 20 percent any time.	None.
Connecticut	Not to exceed 20 percent, except for 5 minutes in any 1 hour up to 40 percent opacity is allowed.	Fire-fighting training under open-burning conditions is exempted.
Florida	Not to exceed 20 percent.	None.
Hawaii	Not to exceed 40 percent, except for 3 minutes in any 1 hour up to 60 percent is allowed.	None.
Illinois	Not to exceed 20 percent, except for 3 minutes in any 1 hour up to 40 percent is allowed.[1] Not to exceed 30 percent, except for 8 minutes in any 1 hour up to 60 percent is allowed.[2]	None.
Rhode Island	Not to exceed 20 percent, except for 3 minutes in any 1 hour.	None.
South Carolina	Not to exceed 20 percent, except for 6 minutes in any 1 hour but no more than 24 minutes per day up to 60 percent is allowed.	Fire-fighting training exempted from open-burning regulation.
Virginia	Not to exceed 20 percent, except for two 6-minute periods in any 1 hour.	Fire-fighting training exempted from open-burning regulation.
Washington	Not to exceed 20 percent, except for 15 minutes in any 8-hour period.	None.

[1]New fuel combustion sources with actual heat input > 250 million Btu/hr.

[2]All other sources.

Pollutants other than those discussed may be subject to control requirements established by the state or local air pollution-control agencies on a case-by-case basis.

A.2.4 Japanese Air Pollution-Control Regulations. The Japanese Air Quality Bureau is in charge of establishing and enforcing air pollution, noise and odor pollution, and automotive pollution-control regulations. The Air Pollution Control Law was promulgated in 1968 to give the Japanese government authority to set environmental quality and emission standards, regulate soot and dust emissions, and establish a system of air pollution monitoring and surveillance.

The AFFT proposed for Japan must conform with Japanese environmental quality standards presented in Table A-3. These standard values are comparable to the U.S. ambient air quality standards.

Emission standards regulate the emissions from a particular type of facility and are specific to the particular type of operation performed at the facility. Because none of the present emission standards are specific to the AFFT, the fire fighter trainer and other similar facilities will most likely be regulated on a case-by-case basis.

A.3 Constraints Related to Wastewater Discharges. The effluent generated by the AFFT will be discharged into natural waters and sewage treatment plants at locations across the country. This discharge of industrial wastewater is regulated by the Clean Water Act, which gives state and local governments jurisdiction in establishing water pollution-control programs. Industrial wastewater such as the AFFT effluent may be disposed of by direct discharge into local receiving waters or by discharge into a publicly owned treatment works (POTW) or municipal sewage treatment plant. Each option is regulated under separate but interrelated laws at the federal, state, and local levels.

A.3.1 Direct Discharge. Direct discharge of industrial wastewater into receiving waters is regulated at the federal and state level. States have promulgated water-quality standards that specify maximum pollutant concentrations in bodies of water, depending on the designated use of receiving water (i.e., boating, wildlife habitat, commerce, etc.). Both EPA and the individual states use these water-quality standards as a basis for a second regulatory approach--the issuance of discharge permits.

Regional offices of EPA have had the initial responsibility for establishing the major permit program--the National Pollutant Discharge Elimination System (NPDES). Subsequently, many states have applied for and received approval to operate their own NPDES programs and have assumed the permit functions from EPA. Many states, however, do not have NPDES authority and do not intend to obtain it. Instead, they work with EPA by certifying NPDES permits before they are issued. In some cases, states without NPDES authority operate independent permit programs. Both NPDES and independent state permits are issued based on the water-quality standards for the site in question, the identity and concentration of pollutants in the discharge, and an engineering assessment of technically feasible control measures.

A.3.2 Discharge Into a POTW. States may establish controls on discharges into POTWs through their permit programs if the programs cover discharges into sewer systems as well as into waters of the state. Although some state permit programs have this authority, this type of discharge is usually regulated by either effluent standards or pretreatment standards promulgated at the local level.

Effluent standards, the most commonly used regulatory tools, specify maximum concentrations of pollutants allowable in industrial discharges. Pretreatment standards are specific to industrial processes and their discharges and must be approved by EPA. Many states are presently in the process of developing pretreatment programs for specific industries, but few, if any, are expected to apply to the AFFT operations.

A.3.3 Regulatory Status of AFFT Sites. Table A-5 summarizes the regulatory status of each AFFT site. It presents general requirements at state and local levels for both direct discharge and discharge into a POTW.

A.3.3.1 Direct Discharge. At most AFFT sites, direct discharges are regulated by either a state NPDES program or an independent state permit program. Bangor, Washington, on the other hand, has no state-regulated permit program for federal facilities and relies completely on the regional EPA NPDES programs. Direct discharge is not permitted in Newport, Rhode Island, San Diego, California, and Pearl Harbor, Hawaii. In Norfolk, Virginia, the state has deferred its permit authority to EPA, but EPA will not accept it. Virginia is, therefore, temporarily without any regulation on direct discharges.

TABLE A-5. AFFT WASTEWATER DISPOSAL OPTIONS - APPLICABLE STATE AND LOCAL REGULATORY REQUIREMENTS

AFFT Sites	Direct Discharge		Discharge into POTW		
	State NPDES Permit Required	Other State Permit Required	State Permit Required[1]	Pretreatment Regulations	Industrial Effluent Standards
Bangor, WA	X[2]		N/A[3]	N/A[3]	N/A[3]
Charleston, SC	X		X		X
Great Lakes, IL	X				X
Mayport, FL		X	N/A[4]	N/A[4]	N/A[4]
Orlando, FL		X	X		X
Norfolk, VA	X[5]			X	X
Newport, RI	N/A[6]	N/A[6]			X
New London, CT	X		X	X	X
Pearl Harbor, HI	N/A[6]	N/A[6]	N/A[7]	N/A[7]	N/A[7]
San Diego, CA	N/A[6]	N/A[6]			X
Treasure Island, CA	X		N/A[7]	N/A[7]	N/A[7]

[1]Includes state permits under NPDES or other authority.

[2]Washington has not yet taken over authority for Federal facilities from EPA.

[3]Not applicable; Bangor does not have sewage treatment facilities.

[4]Not applicable; POTW will not accept industrial wastewater.

[5]Virginia has deferred permit authority for Federal facilities until further notice.

[6]Not applicable; direct discharge into receiving waters not permissible.

[7]Not applicable; permitted Naval wastewater facility available.

Table A-6 presents water quality standards for specific AFFT sites where direct discharge is an option. Facilities wishing to use the direct discharge option must comply with these standards prior to issuance of either a state or NPDES discharge permit. The standards shown include those possibly relating to AFFT discharges as well as common standards that may serve as indications of the relative regulatory stringency of each state.

A.3.3.2 Discharge Into a POTW. Most AFFT sites using this wastewater disposal option must comply with industrial effluent standards imposed by local governments to ensure that wastewater entering their municipal sewage plant does not contain material that might damage the system. Effluent standards have been developed for most municipalities; however, there are some exceptions. Mayport, Florida, for example, is a site where the municipal sewage plant will not accept any industrial discharges. AFFT sites at Treasure Island, California, and Pearl Harbor, Hawaii, are not subject to local effluent standards as each has a permitted Naval treatment facility onsite. Relevant local effluent standards are summarized in Table A-7.

In addition to effluent standards, several AFFT sites are subject to further state or local regulation. In Charleston, Orlando, and New London, the state requires an NPDES permit to discharge into a POTW. Pretreatment regulations have also been approved for Norfolk and New London, but as they were written for specific industrial situations, they are not expected to apply to the AFFT facilities.

A.3.4 Japanese Requirements. The Water Quality Bureau of the Japanese Environmental Agency is responsible for controlling potentially harmful substances that might be discharged into Japanese waters. The Water Pollution Control Law, enacted in 1971, enforces Japan's water pollution regulations and standards. These regulations consist of environmental quality standards and effluent standards.

Japanese effluent standards limit the concentration of pollutants discharged into Japan's natural waters, whereas U.S. effluent standards focus on pollutants discharged into POTWs. The Japanese effluent standards set maximum permissible levels for more than a dozen pollutants that can be emitted from any source into Japanese waters. These standards are summarized in Table A-8.

Japan has also promulgated water quality standards to ensure that the pollutant concentrations of a particular

TABLE A-6. SELECTED WATER QUALITY STANDARDS FOR RECEIVING WATERS WHERE DIRECT DISCHARGE IS POSSIBLE

AFFT SITES	CLASS OF RECEIVING WATERS[1]	DISSOLVED OXYGEN	OIL AND GREASE	pH	PHOSPHOROUS	FLUORIDES	CHLORIDES	COLIFORMS
BANGOR, WA	AA	> 7 mg/l		7.0-8.5				FECAL < 14/100 ml MEDIAN; NO MORE THAN 10% > 43/100 ml
CHARLESTON, SC	SA	> 5 mg/l	NONE	± 0.33 NATURAL WATERS	< 0.05 mg/l			TOTAL < 70/100 ml MEDIAN; NO MORE THAN 10% > 230/100 ml
GREAT LAKES, IL	GENERAL	> 6 mg/l FOR 16 HOURS; 5 mg/l MIN		6.5-9.0	< 0.05 mg/l	< 1.4 mg/l	500 mg/l	FECAL < 200/100 ml MEAN; NO MORE THAN 10% > 400/100 ml
MAYPORT, FL	III	> 5 mg/l; 4 mg/l MIN	5.0 mg/l	6.5-8.5	< 0.10 mg/l	< 5.0 mg/l	< 0.01 mg/l (TOTAL RESIDUAL CHLORINE)	TOTAL < 1000/100 ml AVG.; 2,400/100 ml MAXIMUM
ORLANDO, FL	III	SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE	SAME AS ABOVE
NORFOLK, VA	II	> 5 mg/l; 4 mg/l MIN		6.0-8.5		< 1.7 mg/l[2]	< 250 mg/l[2]	
NEW LONDON, CT	B	> 5 mg/l	NONE	6.5-8.0	< 0.03 mg/l			TOTAL < 1,000/100 ml MEDIAN; NO MORE THAN 20% > 2,400/100 ml
TREASURE ISLAND, CA	NONE[3]							

[1]Each state individually sets criteria for its receiving waters and similarly uses its own grading systems.

[2]At raw water intake.

[3]Treasure Island and San Francisco have no water quality standards.

TABLE A-7. POTW INDUSTRIAL EFFLUENT STANDARDS POTENTIALLY APPLICABLE TO AFFT

AFFT Sites	pH	BOD[1]	Oil and Grease	Ammonia Nitrogen	Suspended Solids
Charleston, SC	6.5-8.5	300 ppm	100 ppm		300 ppm
Great Lakes, IL	6.0-9.0	300 ppm	75 ppm	50 ppm	350 ppm
Orlando, FL	6.5-9.5	300 mg/l	100 mg/l		300 mg/l
Norfolk, VA	6.0-9.0	250 mg/l	100 mg/l		250 mg/l
Newport, RI	$\leq$ 10.0	230 mg/l	25 mg/l[2]		285 mg/l
New London, CT	6.5-9.0		100 mg/l		100 mg/l
San Diego, CA	5.0-9.0	50 mg/l	40 ppm weekly avg.; 25 ppm monthly avg.	325 ppm	50 mg/l

[1] Biochemical oxygen demand.

[2] Floatable oil, fat, or grease not permitted.

TABLE A-8. JAPANESE EFFLUENT STANDARDS

Pollutant	Permissible Limit
Cadmium	0.1 mg/l
Cyanide	1 mg/l
Organic phosphorus	1 mg/l
Lead	1 mg/l
Chromium (VI)	0.5 mg/l
Arsenic	0.5 mg/l
Total mercury	0.005 mg/l
PCB	0.003 mg/l
pH	5.8-8.6 (water other than coastal)
	5.0-9.0 (coastal waters)
BOD, COD[1]	160 mg/l (daily average 120 mg/l)
Suspended solids	200 mg/l (daily average 150 mg/l)
Phenols	5 mg/l
Copper	3 mg/l
Zinc	5 mg/l
Dissolved iron	10 mg/l
Dissolved manganese	10 mg/l
Fluorine	15 mg/l
Coliforms	3,000 per cc[2]

[1]BOD is for waters other than coastal and lakes; COD (chemical oxygen demand) is for coastal and lakes only.

[2]Daily average.

body of water do not exceed certain levels. These standards are similar to U.S. water quality standards in that they specify the level of pollutants in a general class of receiving waters. In areas that exceed their prescribed water quality standards, the Japanese government may place more stringent control on local industrial effluents on a temporary or permanent basis.

A.4 Materials Compatibility. A critical part of this investigation concerns the compatibility of extinguishing agents, smoke-generating chemicals, combustion byproducts, and materials used in the construction of the trainer itself. Incompatibility of these materials could result in the following conditions:

- Chemical reactions of individual fire-extinguishing and smoke-generating chemicals in mixtures and among themselves

- Decomposition of individual fire-extinguishing and smoke-generating chemicals in the presence of heat

- Decomposition of mixtures composed of fire-extinguishing and smoke-generating chemicals in the presence of heat

- Chemical reactions of individual fire-extinguishing and smoke-generating chemicals with byproducts of combustion.

Compounds resulting from such decomposition or chemical reactions may be toxic or otherwise hazardous to health; combustable; environmentally undesirable; or corrosive, causing clogging, obscuration, or harming the trainer itself. Therefore, certain constraints should be placed on the specific materials used in the 19F1.

A.5 Solid Waste Disposal. Three key elements of the solid waste generated from the 19F1 AFFT include spent OBA canisters, AFFF sludge from the treatment facility, and PKP. These elements need to be evaluated as potentially hazardous wastes to assess the Navy's responsibility under the Hazardous Waste Provisions of the Resource Conservation and Recovery Act. These provisions set guidelines for the proper disposal of hazardous materials.

APPENDIX B

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APPENDIX B
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(201)646-6705

22. Jack Moss
Toxicology Department
Rohm & Haas Co.
727 Norriston Road
Spring House, PA 19477
(215)641-7000

23. Mr. Frank Nichols
President
Superior Signal Company
P. O. Box 96
West Gregstone Rd.
Spotswood, NJ 08884
(201)251-0800

24. Dr. William Niehaus
Union Carbide Corp.
Tarrytown, NY
(914)789-2232

25. Ed Pabst
Sierra Fire Equipment Co.
3804 S. Broadway Pl.
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(213)232-3131

26. Mr. Andy Pepper
Aladdin Theatrical Supply
Philadelphia, PA
(215)467-7550

27. Martin Perl
Shulton, Inc.
Clifton, NJ
(201)365-6165

28. Roger Peters
Technical Advisor
Surfactants Department
Stepan Chemical Co.
Edens & Winnetka Rds.
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(312)446-7500

29. John C. Phillips
Organic Technical Service
BASF Wyandotte Corp.
100 Cherry Hill Road
Parsippany, NJ 07054
(201)263-3400

30. Rudolf Pinter
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Boonton, NJ
(201)335-9750

31. Mr. William Quock
Dow Chemical Co.
Pittsburgh, PA
(713)238-1066

32. Sandra Reiss
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33. Robert J. Repinsky
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Kent, Ohio
(216)678-8363

34. Dr. Jack Riley
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Marinette, WI
(715)735-7411

35. J. Harold Saylor
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Cincinatti, OH
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36. Dr. Irving Schmolka
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37. Mr. Roy E. Shaffer
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U. S. Army Research & Development Command
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(301)671-2326

38. Tina Stavrakas
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39. Mr. Edmund Swiatosz
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40. Mr. Bruce Teele
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470 Atlantic Ave.
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(617)482-8755

41. Dr. Mel VerNooy
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(914)789-2251

42. Mr. Stanley Wagner
Senior Industrial Hygienist
Arco Chemical Co.
1500 Market St.
Philadelphia, PA 19101
(215)359-2235

43. Dr. Jack Watts
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University of Maryland
College Park, MD
(301)454-2424

44. Mr. Jack Weimer
Toxicology Division
Aberdeen Proving Ground, MD 22101

APPENDIX C

ONSITE SAMPLING PLAN

APPENDIX C

ONSITE SAMPLING PLAN

This appendix contains an abridged description of the original onsite sampling plan. The appendix includes modifications as indicated in the report that were made to the plan to maximize efficiency of the tests.

April 6, 1981

FIRE FIGHTER TRAINER ENVIRONMENTAL CONSIDERATIONS

ENVIRONMENTAL, HEALTH, AND SAFETY EVALUATION
OF THE
ADVANCED FIRE FIGHTER TRAINER
PHASE II

FOR

Advanced Technology Systems
17-01 Pollitt Drive
P. O. Box 950
Fair Lawn, NJ 07410

ON-SITE SAMPLING PLAN

Prepared By

BOOZ · ALLEN & HAMILTON Inc.
Energy and Environment Division

Revised April 17, 1981

Environmental, Health, and Safety Evaluation
of the
Advanced Fire Fighter Trainer

On-Site Sampling Plan

This On-Site Sampling Plan outlines Booz, Allen's planned actions for on-site testing at Norfolk, Virginia on this assignment for Advanced Technology Systems (ATS), a division of the Austin Company, under NTEC Contract No. N01339-79-C-0011-MOD. No. P00007.

The On-Site Sampling Plan summarizes the program to be conducted at Norfolk, Virginia. The plan includes:

- A procedural description of each sampling effort
- A description of the appropriate methodology for each sampling effort
- The purpose of taking each sample and the relevancy of the result
- A listing of the intended use of all required equipment with:
  - A statement and/or certificate of calibration compliance or
  - A standard traceability
  - The standard operating procedures employed.
- Booz, Allen & Hamilton personnel involved in the sampling and their respective responsibilities
- The number and type of 19F1 simulated runs
- The assistance required from ATS in operation of the trainer.

The plan includes conducting a series of runs following the two proposed scenarios (Appendix A)* so that emissions data can be collected as well as measured values for other events of interest. The precise smoke and vent timing will be determined by pretest trials. Specific tasks are:

*Note: Appendix A appears in the original onsite sampling plan.

- Measuring test cell atmosphere for concentration of simulated smoke - Triaryl Phosphate (TAP)

- Profiling temperatures of the test cell in use and adjacent areas at defined flame temperatures

- Monitoring atmospheric emmissions from each test cell, making four to six runs each on bilge, deep fat and rag bale fires

- Monitoring of CO, CO_2, O_2 and flammable gas concentrations in the test cell during fire trials to verify fixed detector responses via recorded traces

- Collecting waste water samples from the effluents of the test cells.

Exhibit I displays the detailed explanation of individual tests, equipment used, purpose of the readings and the relationship they have to the total objectives of the program. These plan parameters are further documented in Exhibit II and Appendix C.*

Prior to the initiation of the sampling program, a joint review of test procedures and test force organization will be held on site by the ATS and BAH project managers (A. Horacek and J. McCambridge). This review will include applicable safety and emergency procedures.

Exhibit III outlines the test force organization for the on-site program. Schedules are included to reflect the work to be accomplished during both the pretest of 4/24 and the on-site program of the week of 4/27/81. Additionally, a check off list for sampling has been composed.

ATS and BAH will provide assistance to NTEC staff in conducting temperature tests using the sensing equipment available. These tests will be run at times where the equipment is free for use (see tentative schedule for on-site testing).

*Note: This appears in the original onsite sampling plan.

EXHIBIT I
BOOZ, ALLEN & HAMILTON INC.
DETAILED WORK PLAN
ATS FIRE TRAINING SIMULATOR

WORK TASKS & ELEMENTS	DETERMINATION TO BE MADE	PURPOSE OF DETERMINATION	METHODOLOGY	EQUIPMENT OR INSTRUMENTATION	RELATIONSHIP TO PROGRAM OBJECTIVES
1. TEST CELL PARAMETER					
• SIMULATED SMOKE CONCENTRATION	TAP CONCENTRATION	ESTABLISH IF A CONCENTRATION IS REACHED THAT COULD BE DANGEROUS OR CAUSE ADDITIONAL OPERATING PROBLEMS. PROVIDE A TARGET FOR CONTROLLING SMOKE GENERATION	COLLECT ON CELLULOSE FILTER, EXTRACT WITH ETHER AND ANALYZE WITH GAS CHROMATOGRAPHY	SAMPLING PUMP, FILTER, AND GAS CHROMATOGRAPH.	APPRAISAL OF EXPLOSION POTENTIAL AND NEED TO PROTECT OPERATORS
• TEMPERATURE	TEMPERATURE OF WALLS AND AIR, ALSO FLAME TEMPERATURE	DETERMINE RATE OF TEMPERATURE RISE IN TEST CELL AND PEAK REACHED DURING RUNS AND COOL DOWN	THERMOCOUPLES PLACED IN DESIGNATED SPOTS PER ATS DRAWINGS SK20325, SK20326, ATTACHED TO MULTI-POINT RECORDER TO PRODUCE PERMANENT RECORD. DIRECT READING DIGITAL THERMOCOUPLE FOR FLAME TEMPERATURE	ESTERLINE-ANGUS E-1124E MULTIPOINT RECORDER, CHROMEL-ALUMEL THERMOCOUPLES. WET BULB BLACK GLOBE THERMOMETER. OMEGA DIGITAL THERMOCOUPLE	DEFINE THERMAL EXPOSURE TO OPERATORS AND EFFECTS RELATIVE TO PROTECTIVE GUIDELINES. DETERMINE PROFILES THROUGHOUT TEST FACILITY TO PREDICT EFFECTS ON HARDWARE, COMMUNICATIONS AND BUILDING STRUCTURE
• CELL ATMOSPHERE	CARBON MONOXIDE (CO) CARBON DIOXIDE (CO_2) OXYGEN (O_2) FLAMMABLE GASES	TO AUGMENT FIXED SYSTEM READINGS. DETERMINE IF HAZARDOUS LEVELS ARE REACHED DURING FIRE TESTS	INSTRUMENT METHODS, INCLUDING NON-DISPERSIVE I.R. CATALYTIC DETECTORS AND THERMAL CONDUCTIVITY ARRANGED TO PROVIDE HARD COPY RECORD	RIKEN RI550A NON-DISPERSIVE INFRARED UNITS -- CO DUAL RANGE: 0-1%, 0-5%; CO_2 DUAL RANGE: 0-2%, 0-10%. TELEDYNE O_2 AND COMBUSIBLE GAS DETECTOR -- O_2: 0-30%; COMBUSTIBLE GAS: 0-5%. HEWLETT PACKARD DUAL CHANNEL STRIP RECORDERS	DETERMINE WHAT CHANGES OCCUR IN ATMOSPHERIC COMPOSITION DURING TEST FIRES. DATA WILL DEFINE IF ANY HAZARD OF CONSEQUENCE EXISTS AND IF ADDITIONAL PROTECTION IS NEEDED FOR OPERATING PERSONNEL
2. ATMOSPHERIC EMISSIONS	PARTICULATE MATTER	TO MEASURE WHETHER EMISSIONS EXCEED EPA LIMITS	EPA METHOD 5. TAKING AIR SAMPLES FROM STACK EXHAUST, CAPTURING THE PARTICULATES AND DETERMINING THEM BY GRAVIMETRIC MEANS	EPA METHOD 5 TRAIN WITH CONTROL AND RECORDING UNIT	PROVIDE A BASIS TO COMPARE EMISSION RATE WITH LOCAL AND FEDERAL REGULATIONS AND SELECTION OF ENGINEERING CONTROL METHODS TO MEET EMISSION LIMITS
3. WATER EFFLUENT • WASTE WATER FROM EACH TEST QUADRANT	PH, COD, BOD, BICARBONATES, CARBONATES, TOTAL, SUSPENDED AND DISSOLVED SOLIDS, TURBIDITY, SURFACTANTS, SULFATES, PHOSPHATES, TAP	TO PROVIDE VALUES FOR FILING WASTE WATER PERMIT OR TO DETERMINE NEED FOR PRETREATMENT	CHEMICAL ANALYSIS OF SAMPLES TAKEN FROM TEST CELL SUMPS FOLLOWING TEST FIRES AND WASH DOWN	MISCELLANEOUS LAB ITEMS AND PH METERS, ANALYTICAL BALANCES, APPROPRIATE REAGENTS	PERMITS EVALUATION OF LOAD WASTE WATER FROM THESE TRAINING UNITS WILL IMPOSE ON LOCAL SEWAGE TREATMENT PLANTS. DATA NEEDED FOR PERMIT AND TO ESTIMATE SIZE AND TYPE OF PRETREATMENT UNIT NEEDED AS NECESSARY BY LOCAL CODES

SOURCE: CASE CONSULTING LABORATORIES, INC.

WORK TASK + ELEMENTS	METHODOLOGY DETAILS
1. TEST CELL PARAMETER	THERMOCOUPLE LOCATIONS PER ATS DISCUSSION QUAD I. ATS SK 40382
• TEMPERATURE	CONTINUOUS RECORDING POSITIONS POSITION 2 DRY BULB POSITION 3 POSITION 4 POSITION 6 POSITION 7 MAX. READINGS OF FLAME TEMPERATURE AT 1A + 1B MAX. READINGS OF WET BULB GLOBE THERMOMETER AT POSITION 2 QUAD II. ATS SK 40386 CONTINUOUS RECORDING POSITIONS POSITION 3,4,5 POSITION 2 DRY BULB MAX. READINGS POSITION 1A, 1B POSITION 2 WBGT MAXIMUM TEMPERATURE INDICATORS WILL BE USED AT ADDITIONAL POSITIONS AS DEEMED NECESSARY

- CELL ATMOSPHERE

- CARBON MONOXIDE	NON DISPERSIVE IR AS REFERENCED IN EPA METHOD 10 ATTACHED, ADAPTED TO TEST CELL ATMOSPHERE. STANDARDIZED WITH CALIBRATION GAS MIXTURES
- CARBON DIOXIDE	NO APPLICABLE EPA METHOD. WILL USE NON DISPERSIVE IR AS RECOGNIZED INDUSTRIAL METHOD. CALIBRATED WITH STANDARD GAS MIXTURES
- OXYGEN	NO APPLICABLE EPA METHOD. CATALYTIC CELL DETERMINATION IN ACCORDANCE WITH INDUSTRIAL METHOD. CALIBRATION WITH STANDARD GAS MIXTURES
- FLAMMABLE GASES	NO APPLICABLE EPA METHOD. CATALYTIC OXIDATION METHOD -- THERMAL CONDUCTIVITY; INDUSTRIAL METHOD, CALIBRATE WITH STANDARD MIXTURES OF PROPANE IN AIR.

CONTINUOUS SAMPLING LOCATIONS PER ATS DISCUSSION

QUAD I. ATS SK 40382

LDQ1 POSITIONS

SOUTH EAST CORNER 5 FEET HIGH CO, CO_2, O_2
BELOW GRID BETWEEN POSITIONS 2 + 1A FOR PROPANE

QUAD II. ATS SK 40386

UDQ2 DEEP FAT

POSITION 5, CO, CO_2, O_2
BELOW GRID OPPOSITE POSITION 5 FOR PROPANE

UDQ2 RAG BALE

BETWEEN FIRE + CORNER 6 FEET HIGH CO, CO_2, O_2
BELOW FLOOR GRID OPPOSITE POSITION 5 FOR PROPANE

EXHIBIT II(3)
BOOZ, ALLEN & HAMILTON INC.
DETAILED WORK PLAN
ATS FIRE TRAINING SIMULATOR

2.	ATMOSPHERIC EMISSIONS	EPA METHOD 5. SAMPLING WILL BE COMPOSITE OF ONE STACK QUADRANT PER RUN. FOUR RUNS WILL PROVIDE CONTINUOUS COMPOSITE SAMPLE.
3.	WATER EFFLUENT	SAMPLE WILL CONSIST OF PORTIONS TAKEN FROM THREE DIFFERENT LOCATIONS WITHIN EACH QUADRANT SUMP AFTER EACH SET OF RUNS ON THE SAME FOAM.

SAMPLES FROM EACH SUMP WILL BE ANALYZED BY FOLLOWING EPA METHODS

PH	150.1
COD	410.1
BOD	405.1
$CO_3 + HCO_3$	STANDARD METHOD 403
TOT. SOLIDS	160.3
SUSP. SOLIDS	160.1
DISS. SOLIDS	160.2
TURBIDITY	180.1
SURFACTANTS	425.1
PHOSPHATES	365.2
SULFATES	375.4
TAP	NIOSH S210

SEE APPENDIX C FOR PROCEDURE DOCUMENTS

SOURCE: CASE CONSULTING LABORATORIES, INC.

PRETEST SCHEDULE
(Tentatively 4/23/81)

The following experimental tests are to be performed to evaluate the optional candidate concentrations for sensor detection:

- Foam detection
  - Triton X-100 5%
  - Triton X-100 10%
  - Ultrawet K 5%
  - Ultrawet K 10%
- Powder detection by current sensor
  - Sodium bicarbonate #2
  - Standard Sodium bicarbonate
- Powder detection by Na sensor
  - Sodium bicarbonate #2
  - Standard Sodium bicarbonate

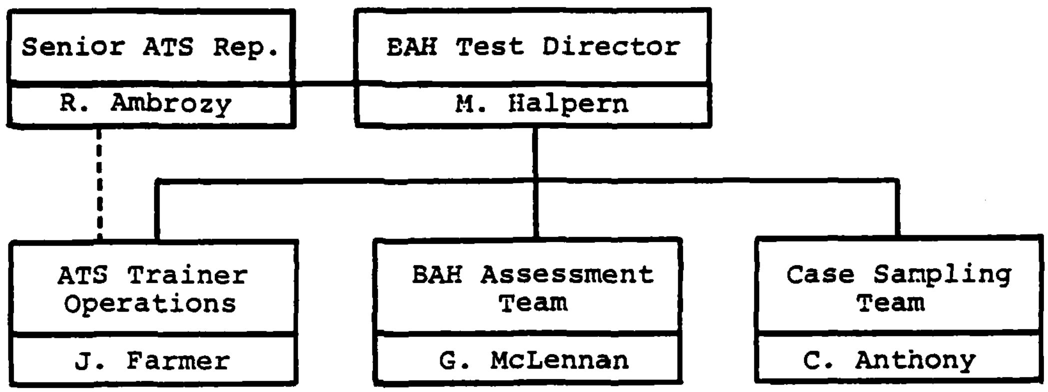
The personnel on site will be:

J. Farmer (ATS)
R. Ambrozy (ATS)
M. Halpern (BAH)

EXHIBIT III

TEST FORCE ORGANIZATION

ON-SITE SAMPLING PROGRAMS



ON SITE TESTING SCHEDULE

Mon. 4/27	8 a.m.- 2 p.m.	Travel to site Initial setups to UDQ II Prepare extinguishment agents for use
	2 p.m.- 5 p.m.	Testing TAP to determine timing/venting parameters to meet smoke criteria
Tue. 4/28	7 a.m.-10 a.m.	Group briefing and walk through dry run
	10 a.m.- 2 p.m.	Run UDQ II scenarios and temperature runs
	2 p.m.- 5 p.m.	Reset test equipment for UDQ I runs
	4 p.m.-10 p.m.	Tentative NTEC temperature tests
Wed. 4/29	8 a.m.-10 a.m.	Complete equipment setup for LDQ I runs
	10 a.m.- 2 p.m.	Run LDQ I scenarios
	2 p.m.- 6 p.m.	Follow temperature cooldown
Thur. 4/30	8 a.m.-12 p.m.	Repeat runs if required Equipment disassembly
	1 p.m.- 4 p.m.	Tentative NTEC temperature tests

STANDARD OPERATING PROCEDURES - CASE CONSULTING

Our quality assurance program is the basis for compliance with Good Laboratory Practices regulations. These regulations and practices are formulated to provide uniformity in operational laboratory functions. They address the fundamental issues of identification, sample designation, record keeping, work flow, test procedures, standardization and reporting.

Attached are pertinent sections* of our Standard Operating Procedures for the Analytical Chemistry functions which are responsible for developing the data from the fire fighter training unit at Norfolk Naval Base. These examples demonstrate the application of the GLP-Quality Assurance Regulations we practice in our laboratories.

*Note: These sections appear in the original onsite sampling plan.

EQUIPMENT

This section of the manual describes the essential elements of equipment for calibration, standardization and maintenance of all laboratory materials and equipment. These guidelines provide for scheduling periodic checks and recordkeeping.

- Equipment Inventory Index (Exhibit 5)*

  .. This index lists each item of laboratory equipment by its identification number, name and manufacturer.

- Laboratory Equipment Specification (Exhibit 6)*

  .. A form is filled out for each piece of equipment.

  .. The information on these forms summarizes the criteria for satisfactory performance and specifies the procedures for Quality Control

  .. This form includes test procedures, reference or calibration standards, maintenance source and other information pertinent to assurance of accuracy of measurement.

- Calibration And Maintenance Log (Exhibit 7)*

  .. A form is maintained for each instrument documenting periodic calibration, standardization and maintenance

  .. Dated entries are signed, and the nature of each entry indicated (i.e., calibration, standardization, corrective maintenance, etc.)

*Note: This appears in the original onsite sampling plan.

.. These forms are maintained in a loose-leaf notebook with each instrument.

- Instrument Records

.. A loose-leaf notebook is maintained for each instrument, or in some cases, groups of instruments

.. This notebook contains a copy of the Laboratory Equipment Specification form and the Calibration and Maintenance Log applying to that instrument, certifications of manufacturers or outside contractors performing periodic calibration and maintenance and instruction books.

- Each Use Calibration

.. Spectroscopic instruments generally require calibration at each use

.. Since quantitative spectrochemical analysis methods are generally comparative methods involving measurements relative to those of a material or materials of known composition, there are no absolute quantitative measurements on which calibration is generally based

.. Calibration information may consist of a criteria based on detection limits or a particular measurement of a reference material under specific conditions, which can serve as indication of proper functioning of a system or a given component of that system

.. Typical data may be given on the individual calibration log forms as representative of calibration

.. The above applies to instruments such as AA/flame emission spectrophotometers, IR spectrophotometers, visible/ultraviolet spectrophotometers and gas chromatographs

.. Documented evidence of performance and operation of these instruments is shown by satisfactory results by qualified personnel on a particular instrument or for a given procedure.

- <u>Calibration Labels</u>

  .. Labels bearing the date of last calibration and the date of the next scheduled calibration are affixed where size and shape of the apparatus permits

  .. These are initialed by the person performing the calibration.

- <u>Calibration Scheduling And Procedure</u>

  .. Scheduling of calibration and routine maintenance is contracted by means of a monthly index marked by the Manager

  .. On the first working day of the month, the Manager notifies the technical staff member of the equipment, date and action schedule for the assignment

  .. The Manager then reviews the records at the end of each month to insure that the required work has been performed

  .. This allows sufficient time to call in outside services, if applicable, preparation of QA standards and arranging work schedule to allow time to perform the scheduled service.

LABORATORY EQUIPMENT SPECIFICATIONS

ITEM: Analytical Balance

IDENTIFICATION #: 169

MANUFACTURER: Oertling

LOCATION: Lab

RANGE: 0 to 200 grams

MODEL: R20

CALIBRATION FREQUENCY: Every 6 months by Metro Balance Corporation

SERIAL #:

PRECISION: ±0.1 mg

CALIBRATION METHOD: Metro Balance Service, Inc.
See attached.
Record 1 Christian Becker
Class S weight (150 mg)
each day in logbook

ACCURACY: ±0.1 mg

REFERENCE STANDARDS: Bureau of Standards set of weights

MAINTENANCE SOURCE: Metro Balance Service, Inc.
Box 123
Old Bridge, N.J. 08857
(201) 238-0777

ACCESSORIES: None

ROUTINE MAINTENANCE: None

DESCRIPTION: The weights, hundred, tens, units and decigrams are set by dial on the front of the balance. Weights from 0.0000 to 0.1000 gra are read from an illuminated, analog screen on the front of the balance.

Standard Test Method

1. Scope:
This method is applicable to all weighing instruments where a weight can be placed in or on the instrument, and its attendent mass indicated by balance point, displacement, dial, scale, graticule, digital counter, or other similar devices, when such instrument is considered to be in balance.

2. Principle and/or Reference:
The method is based on comparing the indicated mass of a standard weight versus th certification value of that mass, this value being correlated through the transfer standard to N.B.S. certification by means of the manufacturer's certificate suppli with the standard weight set.

Reference - N.B.S. Circular # 547

3. Conditions:
The weighing instrument shall be operated in accordance with the manufacturer's instructions and shall be situated enviromentally so as to be substantially clean and not subject to undue vibration, such as would interfere with proper readings.

4. Accuracy of Standard:
The standard weights shall be considered to be transfer ("working") mass standards with manufacturer's certification attesting to their having been adjusted to meet N.B.S class S tolerances.

5. Apparatus:
5.1 Set of certified Class S weights or better - 100 grams set.

6. Standardization:
6.1 If necessary, corrections for buoyancy may be taken into account..

7. Procedure:
Step 1. Place one of the smaller weights of the weight set at or on that part of the weighing instrument where samples are normally placed. (The exact weight chosen shall be dependent on the lower working range of the particular instrument under test).

Step 2. Adjust, release or displace on the weighing mechanism of the particular instrument, in accordance with the manufacturer's instructions, such that the mass of the standards weight is indicated.

Step 3. Observe the indicated weight and adjust.

Step 4. Repeat the above steps with increasingly larger standard weights, until the entire weighing range of the instrument under test has been examined using at least five mass increments.

Step 5. When the range of the instrument under test considerably exceeds the total usable mass of the standard weight set, other weights may be standardized against the certified weights, thus creating "Temporary" transfer standards that may be aggregated to cover the usual range of the weighing device in question.

8. Calculations/Conclusions:
8.1 Duplicate observation as recorded in Step 3, will agree with each other and with the certified value of the standard weight, to within + - 1 readable unit, as specified by the manufacturer of the instrument under test.

LABORATORY EQUIPMENT SPECIFICATIONS

ITEM: pH Meter

IDENTIFICATION #: 193

MANUFACTURER: Fisher Scientific Company

LOCATION: Lab

RANGE:

Normal	Expanded
0 to $\pm$ 1400	0 to $\pm$ 140 mv
0 to 14 pH	0 to 1.4 pH

MODEL: Accumet 320

SERIAL #: 251

CALIBRATION FREQUENCY: Each use

PRECISION:

Normal	Expanded
0.025 Ph	0.0025 pH
2.5 mv	0.25 mv

CALIBARTION METHOD:

1) Electronic test for meter operation
2) Two buffers that bracket the pH of the sample record in logbook

ACCURACY:

Normal	Expanded
0.05 pH	0.005 pH
5 mv	0.5 mv

REFERENCE STANDARDS: Certified pH standards available commercially.

MAINTENANCE SOURCE:

Fisher Scientific Company
52 Fadem Road
Springfield, N.J. 07081
(201) 379-1400

ACCESSORIES: None

ROUTINE MAINTENANCE: Maintain reference electrode filling solution level. Check each use.

DESCRIPTION: The pH meter has all solid state circuitry. In the normal mode, it covers the 0 to 14 pH range or the 0 to $\pm$ 1400 mv range. In the expanded mode, it covers any selected 1.4 pH span or 140 mv span.

LABORATORY EQUIPMENT SPECIFICATIONS

ITEM:	Turbidimeter	IDENTIFICATION #:	194
MANUFACTURER:	Hach Chemical Co.	LOCATION:	Lab
RANGE:	0.0 - 1.000 NTU	MODEL:	2100 A
CALIBRATION FREQUENCY:	Each use	SERIAL #:	513
		PRECISION:	± 2% of full scale
CALIBRATION METHOD:	Use Hach standards	ACCURACY:	± 2% of full scale

REFERENCE STANDARDS: Hach Turbidity Standards Kit

MAINTENANCE SOURCE:
Hach Chemical Co.
P.O. Box 907
Ames, Iowa
(515) 232-2533

ACCESSORIES:

ROUTINE MAINTENANCE:

DESCRIPTION: Measures the turbidity of liquids.

LABORATORY EQUIPMENT SPECIFICATIONS

ITEM:	Atomic Absorption Spectrophotometer	**IDENTIFICATION #:**	170
MANUFACTURER:	Perkin-Elmer Corporation	**LOCATION:**	Lab
RANGE:	Variable	**MODEL:**	403
		SERIAL #:	42418
CALIBRATION FREQUENCY:	Each use	**PRECISION:**	Variable
CALIBRATION METHOD:	Aspiration of standard solutions	**ACCURACY:**	Variable

REFERENCE STANDARDS: Commercially certified standards or equivalent.

MAINTENANCE SOURCE:
Perkin-Elmer Corporation
511 Boulevard, P.O. Box 451
Elmwood Park, N.J. 07407
(201) 796-9400

ACCESSORIES:
1) Deuterium Arc Background Correction
2) Perkin-Elmer Lamp Warm-up Supply
3) MHS-10 Mercury Hydride System
4) Perkin Elmer Mercury Analysis System #303-0832

ROUTINE MAINTENANCE: Light each lamp at least one hour per month

DESCRIPTION: See attached.

ATTACHMENT — Atomic Absorption Spectrophotometer (403)

DESCRIPTION: This spectrophotometer is a double beam instrument which is designed to measure concentrations of metallic elements by aspiration into a flame. The readout can be taken on a recorder and/or by digital display in terms of absorbance, percent transmission or concentration. The instrument features scale expansion, scale compression and curvature correction for non-linear calibration curves. A Deuterium Arc background corrector is used to eliminate some types of interference. Two accessories allow the flameless determination of mercury, as elemental mercury and selenium and arsenic as the gaseous hydride.

LABORATORY EQUIPMENT SPECIFICATIONS

ITEM:	Stack Sampler	**IDENTIFICATION #:**	
MANUFACTURER:	Research Appliance Corp. Allison Park, PA	**LOCATION:**	Chem. Lab
RANGE:		**MODEL:**	2373-D
CALIBRATION FREQUENCY:	Periodic check on gas flow meter	**SERIAL #:**	
CALIBRATION METHOD:	Standard flow meter or wet test meter	**PRECISION:**	#A
REFERENCE STANDARDS:		**ACCURACY:**	#A

MAINTENANCE SOURCE: R.A.C.
Allison Park, PA

ACCESSORIES: Series of orifices to cover air flow ranges.

ROUTINE MAINTENANCE: None

DESCRIPTION: Sampling train and control unit for EPA Method 5, emissions from stationary sources.

LABORATORY EQUIPMENT SPECIFICATIONS

ITEM:	Oxygen Combustible Gas Analyzer	**IDENTIFICATION #:**	
MANUFACTURER:	Teledyne Analytical Instruments San Gabriel, CA	**LOCATION:**	Chem. Lab
RANGE:	Oxygen: 0-30% Combustible Gases: 0-5%	**MODEL:**	980
CALIBRATION FREQUENCY:	As used	**SERIAL #:**	1479
CALIBRATION METHOD:	Standard gases	**PRECISION:**	
REFERENCE STANDARDS:	Air for O_2 Propane in air for combustion	**ACCURACY:**	$\pm$ 0.2%
MAINTENANCE SOURCE:	J. Koch & Assoc. Blackwood, NJ		
ACCESSORIES:	None		
ROUTINE MAINTENANCE:	Check cell life periodically. Keep batteries charged.		
DESCRIPTION:	Analyzer for oxygen and combustible gases in air.		

LABORATORY EQUIPMENT SPECIFICATION

ITEM:	Carbon Monoxide Analyzer	IDENTIFICATION #:	
MANUFACTURER:	Riken	LOCATION:	Chem. Lab
RANGE:	0-1% 0-5%	MODEL:	RI-550A
CALIBRATION FREQUENCY:	Daily when used	SERIAL #:	
CALIBRATION METHOD:	Standard gases	PRECISION:	
REFERENCE STANDARDS:	CO span gases standards in air or N_2	ACCURACY:	$\pm$ 2% of full sca
MAINTENANCE SOURCE:	CEA Instruments Westwood, NJ		
ACCESSORIES:	None		
ROUTINE MAINTENANCE:	None		
DESCRIPTION:	Non-dispersive infrared analyzer.		

LABORATORY EQUIPMENT SPECIFICATIONS

ITEM: Carbon Dioxide Analyzer

IDENTIFICATION #:

MANUFACTURER: Riken

LOCATION: Chem. Lab

RANGE: 0-2%
0-10%

MODEL: RI-550A

CALIBRATION FREQUENCY: Daily when used

SERIAL #:

CALIBRATION METHOD: Standard gases

PRECISION:

REFERENCE STANDARDS: CO_2 span gas standards in air or N_2

ACCURACY: $\pm$ 2% of full scale

MAINTENANCE SOURCE: CEA Instruments
Westwood, NJ

ACCESSORIES: None

ROUTINE MAINTENANCE: None

DESCRIPTION: Non-dispersive infrared analyzer.

BAH Personnel Involved in the On Site Sampling and Their Individual Responsibilities

Name	Responsibility
Dr. Marc Halpern*	Coordinate activities and act as a liaison between ATS, BAH, and case personnel.
Mr. George McLennan	Maintain contact with other BAH staff and test director, assist in temperature profiling and be supportive to emissions monitoring as required.
Ms. Sara Armentrout	Monitor hard copy data from ATS detection equipment in control room.
Ms. Christine Evanik	Monitor hard copy data from BAH detection equipment.
Dr. Adrienne Zahner	Monitor temperature sensing equipment and record relevant supportive information.

* BAH Test Director. Direct and control all BAH and Case Consulting Laboratories' personnel on-site.

Case Consulting Personnel

Mr. Charles Anthony, President of Case Consulting Laboratories, Inc., will be in charge of the program and be actively participating in the laboratory and field determinations. He is a highly experienced chemical engineer with extensive work in evaluating atmospheric contamination problems, water pollution, fire protection engineering and explosion prevention.

Dr. Robert Barnes, Manager of Chemical and Analytical Services, will direct the chemical determinations of the collected samples. He is a highly qualified professional with a Ph.D. in analytical chemistry and has directed numerous programs in laboratory experimental procedures to determine reactivity of materials and the determination of pollutants in air, water and soil.

Mr. Leonard Mackowiak, manager of Product and Material Services, will be directing the field sampling work supported by suitable technicians. He has conducted several air monitoring sampling programs and is well experienced in instrumentation, experimental set up to measure events and interpretation of recorded data.

Mr. Frank Ellison, a senior research chemist, will be making the laboratory determinations on the field collected samples. Mr. Ellison has more than 25 years of highly diversified laboratory background and is an expert in trace compound determinations in water, air and commercial products.

BAH PERSONNEL LOCATIONS DURING TESTS

LDQ I Scenario

M. Halpern	Control room
G. McLennan	Mobile to exterior of facility where needed
S. Armentrout	Control room
C. Evanik	Outside LDQ I
A. Zahner	Outside LDQ I
C. Anthony	Outside roof level
Case Tech I	At Q I stack-roof level
Case Tech II	Outside - LDQ I

UDQ II

M. Halpern	Control room
G. McLennan	Mobile to exterior of facility where needed
S. Armentrout	Control room
C. Evanik	Outside - UDQ II
A. Zahner	Outside - UDQ II
C. Anthony	Outside - roof level
Case Tech I	At Q II stack - roof level
Case Tech II	Outside - UDQ II

Note: All personnel will be outside the facility during test performance. However, the Navy will provide eight (8) OBA units for emergency use and Booz, Allen will reimburse the Navy for any canisters used.

Number and Type of 19F1 Simulated Runs

Two separate series of 4-6 runs are planned for the 19F1. Each series will be based on actually following and carrying out the training scenarios formulated by ATS/BAH with the concurrence of NTEC. These scenarios realistically simulate the proposed training scenarios in Lower Deck Quad I and Upper Deck Quad II. (See Exhibits A-I and A-II.)*

Integrated waste water and particulate samples as outlined in Exhibit II will be taken for each set of scenario runs (with each foam) including a 2 minute washout of the facility after each run. Stack emissions will be continuously monitored by both ATS and BAH detection equipment. The air emissions data will be recorded separately for each run. Additionally, a blank water sample will be taken and subjected to the same battery of tests as the actual wastewater samples. Smoke concentration samples (TAP) will be collected as an integrated sample over each set of scenarios.

At least four runs will be performed to develop temperature profiles. The intention will be to conduct these temperature tests concurrently with the runs following the Lower Deck Quad I and Upper Deck Quad II scenarios. The temperature data will continue to be collected for several hours after the scenario runs to observe the building cooldown. A series of seven sample sites (including a WBGT) will be monitored for temperature. These sites will utilize either continuous temperature monitors with hard copy or maximum temperature indicators (as cited in ATS Drawings SK20325 and SK20326 in Appendix B).*

*Note: This appears in the original onsite sampling plan.

ATS Assistance Required in Operation of the Device

The ATS personnel will be an integral component to the successful completion of the on-site testing. ATS will be required to assist in two key areas:

- Control room operations
- Performing the firefighting scenarios.

ATS staff will operate the device as well as the remote equipment such as the ventilation equipment. ATS will also provide the manpower (familiar with the designated scenarios) to conduct the training exercises.

APPENDIX C*

Reference Methodologies

Method No.		Contaminant
EPA	5	Particulate Emissions
	10	Carbon Monoxide Emissions
	105.1	pH
	160.1	Residue, Filterable
	160.2	Residue, Non-Filterable
	160.3	Residue, Total
	180.1	Turbidity
	405.1	Biochemical Oxygen Demand
	410.1	Chemical Oxygen Demand
	425.1	Surfactants
	403	Carbonates
	365.2	Phosphorus
	375.4	Sulfate
NIOSH	S 210	Triphenyl Phosphate

*Note: This appears in the original onsite testing plan.

ON-SITE SAMPLING CHECKLIST

UDQ II	Run	
	1	Foam - Triton X-100/Powder - Sodium Bicarbonate #2
	2	Foam - Triton X-100/Powder - Sodium Bicarbonate #2
	(3)	Foam - Triton X-100/Powder - Sodium Bicarbonate #2
	4	Foam - Ultrawet K/Powder - Sodium Bicarbonate #2
	5	Foam - Ultrawet K/Powder - Sodium Bicarbonate #2
	(6)	Foam - Ultrawet K/Powder - Sodium Bicarbonate #2

( ) = Optional

The following protocols will apply:

- Air emissions to be monitored for each run above
- Temperature tests to be concurrently run with the above runs
- Integrated smoke sample to be collected during above runs or under a separate run
- The quadrant will be washed down after each run for 2 minutes.
- A wastewater sample will be taken after the whole set of runs and washdowns for each candidate foam.

ON-SITE SAMPLING CHECKLIST

LDQ I	Run	
	1	Foam - Triton X-100/Powder - Sodium Bicarbonate #2
	2	Foam - Triton X-100/Powder - Sodium Bicarbonate #2
	(3)	Foam - Triton X-100/Powder - Sodium Bicarbonate #2
	4	Foam - Ultrawet K/Powder - Sodium Bicarbonate #2
	5	Foam - Ultrawet K/Powder - Sodium Bicarbonate #2
	(6)	Foam - Ultrawet K/Powder - Sodium Bicarbonate #2

( ) = Optional

The following protocols will apply:

- Air emissions to be monitored for each run above
- Temperature tests to be concurrently run with the above runs
- Integrated smoke sample to be collected during above runs or under a separate run
- The quadrant will be washed down after each run for 2 minutes.
- A wastewater sample will be taken after the whole set of runs and washdowns for each candidate foam.

NOTE: A blank water sample will be collected from a supply source to the facility

APPENDIX D

RECOMMENDED SUBSTITUTE SPECIFICATIONS

ARCO Chemical Company
Division of AtlanticRichfieldCompany

Material Safety Data Sheet
MSDS

ARCO Chemical Company requests Customer to study this Data Sheet and become aware of Product hazards. To promote safe handling Customer should (1) notify its employees, agents and contractors of the information on this Data Sheet, and any Product hazards and safety information, (2) furnish a copy of this Data Sheet to each of its customers for the Product and (3) request such customers to notify their employees and customers for the Product of the information on this Data Sheet and any Product hazards and safety information.

Section I – General

Manufacturer's name: ARCO Chemical Company Division of Atlantic Richfield Company

Material name: Ultrawet K

Manufacturer's address: 1500 Market Street, Philadelphia, PA 19101

Emergency telephone (24 hour): (215) 353-8300

Name (brand-trade) and synonyms: Ultrawet K

Chemical family: Linear Alkyl Aryl Sulfonate

Section II – Summary of hazardous information

No data

Summary: CAUTION -- MATERIAL IS A MODERATE SKIN AND EYE HAZARD.

Mildly irritating to mucous membranes. Fatiguing agent to skin of humans.

Section III – Physical and reactivity data

Boiling point (°F): N/A

Evaporation rate (ratio of time) (N/A = 1)

Other: N/A

Vapor pressure (mm Hg at 70 °F): N/A

Incompatibility (materials to avoid): N/A

Vapor density (air = 1 at 60-99° F): N/A

Stability: (X) Stable ( ) Unstable

Conditions to avoid:

Specific gravity (H_2O = 1 at 39.2° F): 0.5 @ 25°C

Hazardous polymerization may: ( ) Occur (X) Not occur

Appearance and odor: Light, cream colored flakes with bland odor.

Volatile characteristics: Negligible

Hazardous decomposition products: Primarily carbon dioxide and small quantities of oxides of sulfur.

Solubility in water: Complete

Section IV – Fire and explosion data

Flash point (°F): N/A (method used) ( )

Flammable limits at normal atmos. temp. and pressure (% by volume in air): Lower flammable limit N/A; Upper flammable limit N/A

Autoignition temp. (° F): N/A

Extinguishing media: Water, foam, carbon dioxide.

Special fire fighting procedures:

For fires involving this material, do not enter any enclosed or confined fire space without proper protective equipment including self contained breathing apparatus.

Unusual fire and explosion hazards:

Combustible when in direct contact with flame.

Section V – First aid and emergency procedures

Note to physician: Treat symptomatically.

Eye contact / Skin contact: Flush eyes with low pressure water for at least 15 minutes. If irritation persists, seek medical attention.
Skin: Remove from skin with copious amounts of water; seek medical attention if irritation persists.

Inhalation: This material is not expected to present an inhalation hazard.

Ingestion: This material is not expected to present an ingestion hazard.

Adapted from USDL Form OSHA-20 — May 1972 N/A = Not applicable **Important: See reverse side for disclaimer**

ARCC-1798 (10-78) Front

MSDS

Material name
Ultrawet K

Section VI — Health hazard data

Primary hazard
May cause eye and skin irritation upon direct contact.

Route of exposure	Affected	Signs and symptoms
Eye contact	X	This material may cause minor eye irritation upon direct contact.
Skin irritation	X	This material may cause minor irritation following prolonged direct contact.
Inhalation		
Ingestion		
Skin absorption		

Effects of overexposure
Excessive direct contact with eyes and skin will cause irritation.

Section VII — Spill or leak procedures

Precautions if material is spilled or released
Sweep and shovel into container. Wash residue with plenty of water.

Waste disposal methods
S[redacted]incineration with other refuse. Material may be d[redacted] sanitary sewer. This product is b[redacted]

Section VIII - Special protection information

Ventilation
Use in well ventilated areas.

Eye protection
Chemical type goggles or face shield should be worn when eye contact is likely.

Skin protection
Avoid prolonged or repeated skin contact, and use good personal hygiene.

Respiratory protection
MESA-NIOSH approved respiratory protection for dust should be used if airborne dust is generated when handling product.

Other protection
N/A

Section IX — Handling and storage

Store in cool, dry area.

General comments
N/A

Date issued
April 1979

Solvents and
Specialty Chemicals

Division of AtlanticRichfieldCompany
1500 Market Street
Philadelphia, Pennsylvania 19101

Ultrawet® K Surfactant

ULTRAWET K surfactant is a biodegradable sodium linear alkylate sulfonate flake. This product exhibits the excellent quality and performance characteristics typical of the complete Ultrawet surfactant series. Ultrawet K surfactant is recommended for use in various industrial and heavy-duty household detergent applications.

BIODEGRADABILITY

ULTRAWET K surfactant easily satisfies any known existing standard for biodegradability.

TYPICAL PROPERTIES

Physical Form	Cream Colored Flake
Active Ingredient, Dry Basis Wt. %	91
Moisture, Wt. %	1.1
pH (10% Solids)	7.8
Color, Klett-Summerson (10% Solids)	125

PACKAGING

Polyethylene Lined Paper Bags	50 lbs. net
55-gal. Fiber Drums	200 lbs. net

U-10

Specialty Chemicals

Division of AtlanticRichfieldCompany
1500 Market Street
Philadelphia, Pennsylvania 19101

Effective July 1, 1981 (Superseding April 1, 1981)

Price Per Pound

ULTRAWET DRY PRODUCTS
DRUM DRIED LAS FLAKES

PRODUCT	FORM	PACKAGE NET WT.	LESS THAN T/L (1)	T/L (2)
Ultrawet K	Flake	bag 50 lb.	80.0	75.0
Ultrawet K	Flake	fiber drum 200 lb.	85.0	80.0
Ultrawet K Dense	Powder	fiber drum 220 lb.	85.0	80.0
Ultrawet KX	Flake	fiber drum 200 lb.	85.0	80.0
Ultrawet DS	Flake	bag 50 lb.	80.0	75.0
Ultrawet DS	Flake	fiber drum 200 lb.	85.0	80.0
Ultrawet DS Dense	Powder	fiber drum 220 lb.	85.0	80.0
Ultrawet SK	Flake	bag 50 lb.	48.0	43.0
Ultrawet SK	Flake	fiber drum 200 lb.	51.0	46.0

90% ACTIVE DRUM DRIED AOS FLAKE

Ultrawet AOK	Flake	fiber drum 180 lb.	1.00	96.0

ULTRAWET LIQUIDS

PRODUCT	FORM	DRUM NET WT.	LESS THAN T/L (1)	T/L(2)	BULK(3)
Ultrawet 30DS	Liquid	480 lb. fiber	31.0	27.0	19.0
Ultrawet 45DS	Liquid	480 lb. fiber	35.0	31.0	23.0
Ultrawet 42K	Slurry	480 lb. fiber	35.0	31.0	23.0
Ultrawet 45KX	Liquid	480 lb. fiber	35.0	31.0	23.0
Ultrawet 60L	Liquid	500 lb. fiber	55.0	51.0	43.0
Ultrawet 68KN	Slurry	450 lb. fiber	52.0	48.0	40.0
Ultrawet 40SX	Liquid	530 lb. fiber	27.0	23.0	15.0
Ultrawet 60K	Slurry	480 lb. fiber	43.5	39.5	53.0 (4)
Ultrawet 99LS	Liquid	450 lb. steel	65.0	61.0	53.0
Ultrawet N	Liquid	450 lb. fiber	79.0	75.0	67.0

(1) F.O.B. Warehouse Shipping Point
(2) F.O.B. Producing Point 24,000 lb. min.
(3) F.O.B. Producing Point 2,000 gal. min.
(4) 100% Active Basis in Bulk

Prices and Terms are subject to change without notice

TRITON® X-100

NONIONIC SURFACTANT

TRITON X-100 is a biodegradable liquid anhydrous 100-percent active nonionic surface-active agent. Its chemical composition is a water-soluble isooctylphenoxypolyethoxyethanol containing an average of 10 moles of ethylene oxide. TRITON X-100 is useful as an emulsifier, wetting agent, and detergent.

TYPICAL PROPERTIES *(These do not constitute specifications)*

Appearance	Clear liquid
Color (APHA)	100
Odor	Mild
Viscosity (Brookfield), cps @ 25°C	240
Pour Point	7°C (45°F)
Specific Gravity @ 25°C	1.065
pH (5% Aqueous Solution)	6.0 8.0
Cloud Point (1% Aqueous Solution)	63 69°C
Density, lb/gal	8.9
Flash Point (Tag. Open Cup), °F	>300

SOLUBILITY

TRITON X-100 is soluble in all proportions at 25°C in water, benzene, toluene, xylene, trichloroethylene, ethylene glycol, ethyl ether, ethyl alcohol, isopropyl alcohol, ethylene dichloride and most other solvents. Solutions containing one percent or five percent TRITON X-100 in 40 percent phosphoric acid or 30 percent hydrochloric acid are stable at least 48 hours at room temperature. The product is insoluble in kerosene, mineral spirits, and V.M.P. naphtha unless a coupling agent is used. Oleic acid is an effective coupling agent for TRITON X-100 in systems based on kerosene.

COMPATIBILITY

TRITON X-100 is compatible with anionic, cationic, and nonionic surface-active agents. Like other alkyl aryl polyether alcohols, it discolors on dry caustic and anhydrous metasilicate; however, TRITON X-100 can be used in formulations containing moderate quantities of these alkalies without exhibiting objectionable instability. TRITON X-100 is stable in the presence of the mild alkaline builders normally employed in the preparation of metal cleaners and cleaning compounds.

DETERGENCY

TRITON X-100 is a highly effective hard-surface detergent; it is also effective in textile cleaning operations and is used in "built" formulations designed for home and industrial laundering. In some fabric washing operations, TRITON X-114 might be preferred for specialty products designed to remove particularly oily soils or to display controlled foaming.

FOAMING PROPERTIES

TRITON X-100 has good foaming characteristics and may be used in combination with certain high-foaming anionic surface active agents, such as TRITON X-301 (an alkyl aryl polyether sulfate), alkyl sulfates, alkyl aryl sulfonates or fatty acid amide condensates. For markedly reduced foam, TRITON X-100 may be blended with TRITON CF-10.

Ross-Miles foam data are presented in Table I.

TABLE I
Ross-Miles Foam Heights

Product	Percent Concentration	Temperature, °F	Foam Height in Millimeters	
			Initial	5 Minutes
TRITON X-100	1.0	120	228	23
TRITON X-100	0.1	120	110	25
TRITON X-100	0.01	120	20	20
TRITON X-100: TRITON X-301 at 2:1 ratio, solids basis	0.1	120	165	95

SURFACE TENSION

TRITON X-100 exhibits good surface activity as indicated by the lowering of the surface tension of water. The data given in Table II were obtained by using a Du Nouy tensiometer.

TABLE II
Surface Tension at 25°C

Dynes per Centimeter

	Percent Concentration		
	1.0	0.1	0.01
TRITON X-100	30	30	31

Surface tension of distilled water at 25°C is 72 dynes per centimeter.

DRAVES WETTING TEST

The Draves Test determines the concentration of wetting agent needed to sink a weighted cotton skein in an aqueous solution in a given time. A 3-gram hook and a 5-gram skein of gray cotton yarn are used. The procedure is detailed in the Yearbook of the American Association of Textile Chemists and Colorists as Standard Test Method 17-52.

	10 seconds	25 seconds	50 seconds
TRITON X-100	0.092%	0.048%	0.025%

VISCOSITY

The data in Table III illustrate the viscosity of TRITON X-100 and solutions.

TABLE III

Viscosity in centipoises at Percent Concentration

Temp.	10	30	50	70	90	100
25°C	2	80	GEL	530	280	270
50°C	3	40	110	100	50	50
25°C/ 1M NaCl	7	150	640	470	260	–
25°C/ 1M $CaCl_2$	7	240	1010	560	310	–

The increased viscosity and gel formation at concentrations around 50 percent are probably due to interference with flow that results from hydration of the oxyethylene ether linkages in the aggregates. The effect of increasing temperatures and/or salt concentration is to produce partial dehydration of these linkages and to allow freer flow. In making solutions, gel formation can be prevented by adding TRITON X-100 to warm water with agitation.

BIODEGRADABILITY

TRITON X-100 degrades 90 percent or more, as determined from the loss of foaming properties in river water die-away tests and in laboratory semicontinuous activated sludge units. In further laboratory studies with TRITON X-100, comparable degradation was observed in continuous activated sludge units and in bench-scale septic tank percolation field units. Field tests have confirmed the validity of the laboratory tests. In a full-scale sewage treatment plant, TRITON X-100 was degraded 90 percent or more as estimated from the loss of surfactant properties and by cobalt thiocyanate analysis. Details are presented in Bulletin CS-445.

APPLICATIONS

TRITON X-100 is useful in applications requiring good detergency and wetting. It may be used to improve the detergency and wetting properties of formulations designed for use in laundries, in metal cleaning, and in specialty items for home and industrial use.

TRITON X-100 offers exceptional hard-surface detergency and is recommended as a base ingredient in floor cleaners, detergent-sanitizers, liquid hand dishwashing detergents, and metal cleaners. Formulations are available upon request.

TRITON X-100 may be added to powdered products to reduce dustiness and to improve detergency. Concentrations as low as 0.25 percent are effective. Various powdered formulations utilizing up to 10 percent TRITON X-100 may be prepared that retain their free-flowing characteristics. Specific recommendations for adding liquid surface-active agents to powdered preparations are available upon request.

TRITON X-100 is useful in applications demanding rapid wetting action. This characteristic, in conjunction with good detergency on fabrics, makes the product well suited for specialized applications such as the hand washing of delicate synthetic fabrics. TRITON X-100 also may be used in pesticide formulations, including those applied to growing crops or in post harvest treatments.

FOR INDUSTRIAL USE ONLY
NOT FOR USE IN HOUSEHOLD AREA

WARNING: CONTACT CAUSES EYE DAMAGE – CAUSES SKIN IRRITATION – HARMFUL IF SWALLOWED

Avoid contact with eyes. Wash thoroughly after handling. Do not take internally. Remove wetted clothing and launder before rewearing.

In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get prompt medical attention; wash skin thoroughly with soap and water. If a large amount (more than about 1 ounce) is swallowed and victim is conscious, induce vomiting by giving two glasses of water to drink and sticking finger down throat. Call physician. Never give anything by mouth to an unconscious person.

KEEP OUT OF REACH OF CHILDREN

TOXICITY: ANIMAL STUDIES

Acute Oral Toxicity (LD_{50}) in rats: 1900 ± 100 mg/kg.

Acute Dermal Toxicity: TRITON X-100 was not lethal to rabbits when applied at 3 g/kg under a sleeve to intact or abraded skin for 24 hours. Slight to moderate irritation of skin occurred.

Acute Inhalation Toxicity: Exposure for one hour to air saturated with vapors generated from a sample of TRITON X-100 at 35°C was not lethal to rats. The nominal concentration was 21.5 mg/liter of air.

Eye Irritation: In the unwashed rabbit eye, a 0.1% solution produced very slight irritation. The irritant threshold level in the eye is 0.5%. Immediate irrigation of the eye after contact with a 10% aqueous solution greatly reduced the irritation, which disappeared completely within a week. Contact of the product as supplied causes severe irritation of the eye.

[redacted] bluegills, the toxicity [redacted]r 96 hours is > 10 mg/liter in a dynamic bioassay [redacted] At levels of 5.6 mg/liter and 8.7 mg/liter, respectively, no effect was observed.

[redacted] *Local Reaction on Skin:* Patch tests with undiluted TRITON X-100 on 50 subjects produced no primary irritation or sensitization reactions.

NOTE: TRITON X-100, like most organic compounds, should not be used or compounded with oxidizing or reducing agents, since such mixtures may be explosive.

For additional information or assistance, contact our technical representative. He will be pleased to help you.

ROHM AND HAAS COMPANY
CORPORATE HEALTH AND SAFETY
INDEPENDENCE MALL WEST
PHILADELPHIA, PA. 19105

EMERGENCY PHONE
215-592-3000 (ROHM AND HAAS)
800-424-9300 (CHEMTREC)

HAZARD RATING:
4 = EXTREME
3 = HIGH
2 = MODERATE
1 = SLIGHT
0 = INSIGNIFICANT
* = CHRONIC HEALTH HAZARD — SEE SECTION IV

Fire: 1 Reactivity: 0 Health: 3 Special:

LIST 7

MATERIAL SAFETY DATA SHEET

MATERIAL	CODE	FREIGHT CLASSIFICATION
TRITON® X-100 SURFACTANT	6-1572	CLEANING COMPOUND NOIBN LIQUID

FORMULA	CHEMICAL NAME AND SYNONYMS
	Octylphenoxypolyethoxyethanol nonionic surfactant

I. HAZARDOUS INFORMATION

SUMMARY	WEIGHT %	TWA/TLV
Octylphenoxypolyethoxyethanol (high health hazard)	99+	None established

II. PHYSICAL DATA

APPEARANCE — ODOR — PH.: Clear viscous liquid; mild odor; pH of 5% soln. 6-8			VISCOSITY: 240 cps (Brookfield)
MELTING OR FREEZING POINT: 45F pour point	BOILING POINT: 270C (520F)	VAPOR PRESSURE (MM HG): Nil @ 20C	VAPOR DENSITY (AIR = 1): 21.0
SOLUBILITY IN WATER: Complete	PERCENT VOLATILE (BY WT.): 0	SPECIFIC GRAVITY (WATER = 1): 1.07	EVAPORATION RATE (BUTYL ACETATE = 1): Less than 1

III. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT	AUTO IGNITION TEMPERATURE	LOWER EXPLOSION LIMIT %	UPPER EXPLOSION LIMIT %
> 300F (TOC)	NA	NA	NA

EXTINGUISHING MEDIA

[ ] FOAM [ ] "ALCOHOL" FOAM [X] CO_2 [X] DRY CHEMICAL [X] WATER FOG [ ] OTHER

SPECIAL FIRE FIGHTING PROCEDURES

Wear MESA/NIOSH approved self-contained breathing apparatus (Schedule 13).
Use water spray to cool fire-exposed containers.

UNUSUAL FIRE AND EXPLOSION HAZARDS

Explosive mixtures may form by compounding with strong oxidizing or reducing agents.

IV. HEALTH HAZARD DATA

RECOMMENDED ROHM AND HAAS HEALTH GUIDE TWA (MAXIMUM TIME WEIGHTED AVERAGE CONCENTRATION FOR AN 8-HOUR WORK PERIOD)

None established

EFFECTS OF OVEREXPOSURE

Direct contact with the eyes will cause severe persistent irritation. Corneal damage will occur after prolonged contact. Repeated or prolonged skin contact may cause mild to moderate irritation. Vapors, given off at high temperatures, may cause throat irritation. This material is rated a high health hazard due to corneal damage.

EMERGENCY AND FIRST AID PROCEDURES

INHALATION

Move subject to fresh air.

EYE AND SKIN CONTACT

Flush eyes with plenty of water for at least 15 minutes and get prompt medical attention; wash skin thoroughly with soap and water; remove and wash clothing before reuse.

INGESTION

If swallowed dilute by giving water to drink and call a physician. Never give anything by mouth to an unconscious person.

FORM 930 REV. 1/79 (FRONT)

V. REACTIVITY DATA

STABILITY	CONDITIONS TO AVOID
[x] STABLE [ ] UNSTABLE	Excessive heat

HAZARDOUS DECOMPOSITION PRODUCTS

Thermal decomposition may yield oxides of carbon.

HAZARDOUS POLYMERIZATION	CONDITIONS TO AVOID
[ ] MAY OCCUR [x] WILL NOT OCCUR	NA

INCOMPATIBILITY (MATERIALS TO AVOID)

[ ] WATER [x] OTHER Avoid contact with strong oxidizing or reducing agents.

VI. SPILL OR LEAK PROCEDURE

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Wear eye protection and impervious clothing. Dike and contain spill with inert material (sand, earth, fuller's earth, etc.) and transfer liquid and solid diking material separately to containers for recovery or disposal. Floor may be slippery -- use care to avoid fall. Remove contaminated clothing and wash affected skin areas with soap and water. Wash clothing before reuse. Keep spill out of all sewers and open bodies of water.

WASTE DISPOSAL METHODS Incinerate liquid in approved equipment. Landfill contaminated diking material according to current local, state and federal regulations; recognizing that significant quantities reaching a stream or treatment plant via leachate can cause foaming. Landfill must be large enough to absorb the surfactant.

VII. SPECIAL PROTECTION INFORMATION

TYPE VENTILATION

Mechanical dilution ventilation (fan).

RESPIRATORY PROTECTION

None required for normal operations

PROTECTIVE GLOVES	EYE PROTECTION
Impervious	Splashproof goggles (ANSI Z87.1, 1968)

OTHER PROTECTIVE EQUIPMENT

Eyewash facility

VIII. STORAGE AND LABELING

STORAGE TEMPERATURE	INDOOR	HEATED	REFRIGERATED	OUTDOOR
MAX. MIN.	YES	NO	NO	YES

COMMENTS

Store away from heat sources. Low temperature storage may present handling problems due to increased viscosity. Material is corrosive to copper and brass on long storage.

IX. TOXICITY INFORMATION

Oral LD-50 (rat) = 1900 mg/kg

Dermal LD-50 (rabbit) = Greater than 3 g/kg

Eye Irritation (rabbit) - severe irritation - draize score of 54.3 (after 1 day) increased to 66.8 after 7 days. Permanent corneal damage at concentrations greater than 10%.

Skin Irritation (rabbit) - score of 2.0 in acute dermal test.

X. MISCELLANEOUS INFORMATION

TRITON® is a registered trademark of Rohm and Haas Company.

NA = NOT APPLICABLE

C = CEILING VALUE

CODE 6-1572

DATE OF ISSUE	SUPERSEDES
4/80	10/79

PREPARED BY Michelene Frostatus

ROHM AND HAAS COMPANY
INDEPENDENCE MALL WEST
PHILADELPHIA, PENNSYLVANIA 19105

HEAVY METAL CONTENT

PRODUCT: TRITON X-100

Aluminum	0.0X ppm	Germanium	N.F.	Rubidium	
Antimony	N.F.	Gold	N.F.	Silicon	0.X ppm
Arsenic	N.F.	Iron	0.X ppm	Silver	N.F.
Barium	N.F.	Lead	0.0X ppm	Sodium	XXXX.0 ppm
Beryllium	N.F.	Lithium		Strontium	N.F.
Bismuth	N.F.	Magnesium	0.0X ppm	Tellurium	N.F.
Boron	N.F.	Manganese	N.F.	Thallium	
Cadmium	N.F.	Mercury		Tin	0.0X ppm
Calcium	0.X ppm	Molybdenum	N.F.	Titanium	N.F.
Chromium	0.0X ppm	Nickel	0.X ppm	Tungsten	N.F.
Cobalt	N.F.	Phosphorus	XXX.0 ppm	Vanadium	N.F.
Columbium	N.F.	Platinum	N.F.	Zinc	N.F.
Copper	0.X ppm	Potassium	N.F.	Zirconium	N.F.
Gallium	N.F.				

Key to Spectrographic Analysis

XXXX.0 = 1000.0 to 9999.0 ppm
XXX.0 = 100 to 999 ppm
X.0 = 1 to 9 ppm
0.X = 0.1 to 0.9 ppm
0.0X = 0.01 to 0.09 ppm
N.F. = Not found

ppm = Parts per million

FORM 2890

Butylated Triphenyl Phosphates (Data listed below pertains to products containing approximately 98% BTPP isomers)

Toxicology Data:

Test	Result	Protocol	Date Tested
Acute oral LD_{50}	Greater than 4,640 mg/kg	A	7/73
	Greater than 4,640 mg/kg (2 products tested)	B	2/74
	Greater than 4,640 mg/kg	Not Available	8/76
	Greater than 5,000 mg/kg in both male and female rats	C	3/79
Acute Dermal LD_{50}	Greater than 4,640 mg/kg (2 products tested)	D	2/74
	Greater than 2,000 mg/kg	Not Available	8/76
	Greater than 2,000 mg/kg	E	3/79
Acute Inhalation	Greater than 15.7 mg/l/hr*	F	2/74
	Greater than 18.9 mg/l/hr*	G	3/74
	3.1 mg/l/hr	H	4/79
Skin Irritation	Non-irritant (4 products tested)	I (4 hr. exposure)	7/23; 2/74 3/74; 8/76
	Mild Irritant	J (24 hr. exposure)	3/79
Eye Irritation	Non-irritant	K	7/73
	Non-irritant (3 products tested)	L	2/74; 3/74
Neurotoxicity	0.0 TOCP% equivalent (2 products tested)	N	4/74
	4.0 TOCP% equivalent**	N	4/74
	0.0 TOCP% equivalent	O	11/75
Neurotoxicit	0.0 TOCP% equivalent (2 products tested)	N	4/74
	4.0 TOCP% equivalent**	N	4/74
	0.0 TOCP% equivalent	O	11/75
Neurotoxic Esterase Assay	Negative	P	In Progress

BUTYLATED TRIPHENYL PHOSPHATES

(continued)

Test	Result	Protocol	Date Tested
Acute Delayed Neurotoxicity	Results due in early 1980	Q	In Progress

Note: This protocol meets and exceeds EPA standards by including histopathology on all the animals. Slides are evaluated by board-certified veterinary pathologists.

Test	Result	Protocol	Date Tested
In Vitro Mutagenicity/ Carcinogenicity Assays			
Ames Salmonella/ Microsome Plate Assay	Negative	R	1/79
In-Vitro Transformation (BALB/3T3)	Negative	S	4/79
Mouse Lymphoma Forward Mutation Assay	Negative	T	2/79
In-Vitro Cytogenetics Assay			
Sister Chromatid Exchange	Negative	U	1/79
Chromosome Aberration	Negative	U	1/79

UNIVERSITÄT HAMBURG

University Hospital
Eppendorf
Pharmacological Institute

Date: October 14, 1977

PHARMACOLOGICAL-TOXICOLOGICAL EXPERT JUDGMENT

The examinations were carried out according to the corresponding test prescriptions of the FIFTH REPORT of the European Association for Coal and Steel on the requirements and testing of liquids of low flammability.

I. Control of identity by IR-spectrography

The prepared IR-spectrum shows the absorption bands typical for P-O; in addition phenyl substituted by propyl can be detected besides the mark of a substitution by arylalkyl.

II. Oral toxicity

The liquid was given per oral probe to mice in increasing dose. The number of animals per treatment group was six. An oral LD_{50} of 4.4 g/kg of body weight of the mouse resulted.

Point value: 5

III. Determination of the toxic effect

A Irritating effect

1. Tests on the irritating effect on the eye:

On 2 albino rabbits one drop of test liquid was inserted by an eye pipette once into the connective membrane pocket of

Date: October 14, 1977

the right eye, the eye was kept closed briefly and the treated eyes were inspected daily during the following 7 days and compared with the untreated eye.

~~On both animals no reaction could be detected on the eyes.~~

Point value: 0

2. Tests for the determination of the irritative effect on the skin

The compatibility of the liquid with the skin was tested on the shorn flank of 2 albino rabbits by the patch-test (duration of the action 24 hrs.).

24 hours after removal of the patch-test both animals showed a slight reddening of the contact surfaces. This reddening persisted 3 days, then disappeared without being transformed into a oedeme.

Point value: 3

B. Tests for the determination of the toxicity of the aerosol

1. Cold aerosol

In an aerosol generator (air flow rate 15 l/min) 8 ml/h of the liquid, warmed to 50°C, were transformed into an aerosol to which 3 Wistar-rats were exposed in a gassing cage for 1 hour.

During the application of the aerosol the behavior of the animals was normal, also the breathing activity was not changed.

During the subsequent 14-day observation time all 3 animals showed a weight increase which corresponded to that of the controls.

Point value: 0

Date: October 14, 1977

2. Hot aerosol

The aerosol of the liquid heated to 150° C was tested by the same method. Consumption 9 ml/h.

During the exposure the animals behaved normally. A vigorous cleaning of the snout was conspicuous which indicates an irritative effect (translator: some words seem to be missing here) and spontaneous motor activity was normal, the weight development corresponded to that of the control animals. After 14 days of observation the disection showed no particular evidence in the lung, liver or kidney.

Point value: 0

C. Thermal decomposition products

1. Method

For the generation of thermal decomposition products 0.6 ml/min of the liquid were sprayed through a Bosch-injection pump onto a steel plate heated to 200° C or 700° C. The sucked-off gases (10 l/min) were mixed with fresh air in the ratio 1:2 and placed into an animal container for the toxicological test in which 3 rats were exposed to this mixture during 1 hour.

a) 200° C

During the exposure the animals behaved quietly. The breathing was normal. During the subsequent 14-day observation time a slightly reduced increase of the body weight was observed, compared to the control group. The disection after the 14-day observation time showed no special evidence on lung, liver and kidney.

Point value: 4

Date: October 14, 1977

b) 700° C

During the exposure the animals showed quiet and non-conspicuous motor activity; 30 minutes after start of the application all 3 animals showed distinct snapping breathing. After the test the breathing very quickly became normal. The weight development during the 14-day observation was distinctly reduced compared to the control group.

Point value: 4

D. Evaluation of the results

	Point no.	Factor	Point sum
Oral toxicity	5	1	5
Irritative effect at the eye	0	5	0
Irritative effect on the skin	3	5	15
Aerosol 50° C	0	2	0
Aerosol 150° C	0	2	0
Decomposition products 200° C	4	1	4
Decomposition products 700° C	4	1	4
			28

E. Testing for neuro-toxicity

Individual doses of 5 ml/kg of the original liquid were applied to 6 chickens (White Leghorn) of about 2 kg weight by a throat probe on 5 consecutive days. The animals were observed during the following 21 days, then were killed and the marrow of the neck, the lumbar marrow and the N. ischiadicus were examined histologically for demyelination. In deviation from the Fifth Luxemburg Report the total amount of the liquid which was applied was 25 ml/kg.

Date: October 14, 1977

The treated animals behaved normally during the observation time and were in no way disturbed in their motor activity.

A parallel control group of 6 chickens was treated with a single dose of 0.5 g/kg of triortho cresyl phosphate. After 14 days following this dose all chickens showed the paralysis of the lower extremities typical for phosphate ester, a demyelination was confirmed histologically.

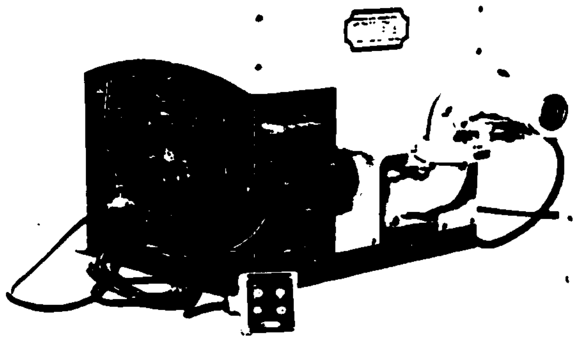
The liquid is not neuro-toxic. It complies also with the other required conditions for a permit, listed in the Fifth Luxemburg Report.

Prof. Dr. H.F. Benthe

Tifa®

POWERFOGGER MODEL 100E

Thermal Fogger



DIMENSIONS .... Length 0·82 m
Width 0·64 m
Height 0·97 m

WEIGHT .... (empty) 261 kg

Maximum Formulation throughput 455 l/h

Fog Output .... 425–566 m³/min

Tifa Powerfoggers

These Powerfoggers are the latest models in the TIFA range of world famous fog generators.

In addition to their primary function of dispersing insecticides and other chemical formulations as thermal fogs, these Powerfoggers accept all standard accessories for misting, spraying and dusting.

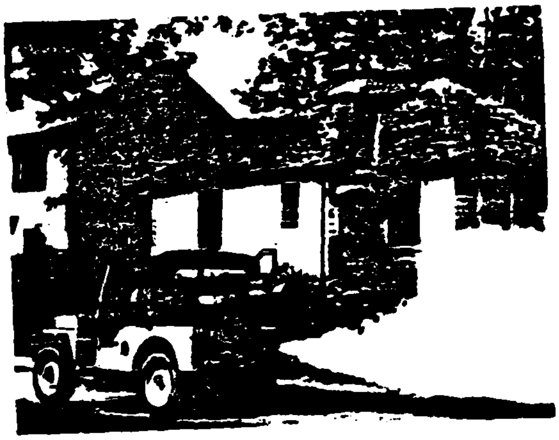
For more than 20 years TIFA has been giving world wide service to users for control of disease-carrying flies, mosquitoes and other insect pests; also those insects which destroy valuable stocks of grain, flour, cereal and other food products.

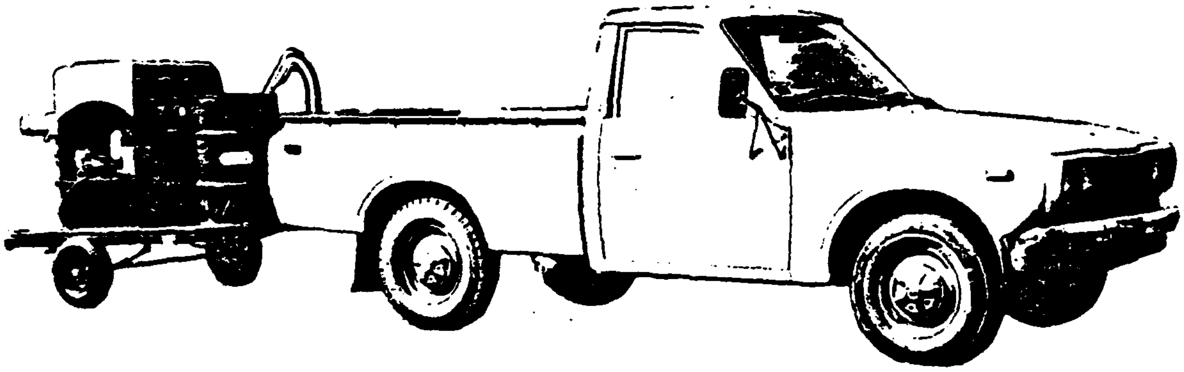
Powerfoggers are used for control of insect pests in:–
Municipal and Public Health projects.
Food and Grain Stores.
Food.
Tobacco and Drinks Industry.
Animal and Poultry husbandry.
Hospitals.
Ships.
Stadiums and Drive-in Cinemas, using pyrethrum, organo-chlorine or organo-phosphorous insecticides; germicides, disinfectants and deodorants

EIGHT REASONS FOR USING THE TIFA POWERFOGGER:

Low operating costs;
Saving in formulation costs;
Speed of operation;
Power to tackle the big problems;
The fog penetrates and envelops;
Disperses a wide range of chemicals;
Versatility-fogging, misting, spraying;
Reliability and service guaranteed by more than 25 years field experience.

OPERATIONAL VERSATILITY





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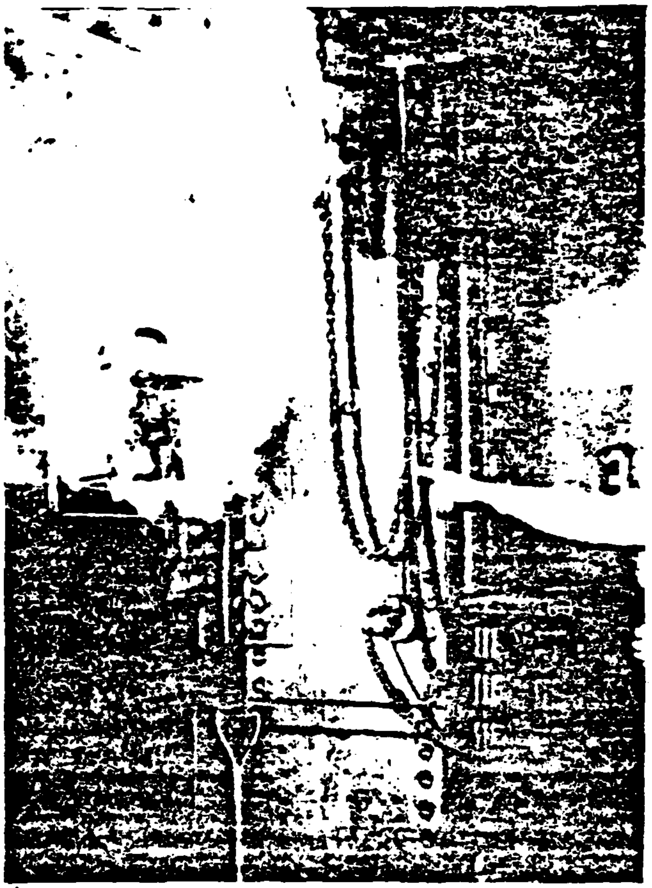
BULLETIN NO. 467

TIFA

STEAM

Fog-fire-resistant, nontoxic, is new tool to . . .



Find those costly boiler-casing, condenser leaks

By J STEPHEN UNGAR
Asst Chief Performance Engineer
Consolidated Edison Co of N. Y.

► PRESSURIZED FOG, generated from a commercial fire-resistant lubricant, can pinpoint efficiency-killing and costly air leaks. Power-plant offenders are: boiler settings and casings, turbine casings, condenser shells and connected piping.

Boiler casings move continuously because of expansion and contraction from heat intensity changes. Such motion often causes leakage, through settings and casings, which may cut down *on overall boiler performance. If leakage* aids combustion, that's fortunate, but such select leakage is uncommon.

Most leakage ups the load on induced-draft fan or chimney and interferes with admission of air needed for good combustion. Further, leakage can increase fouling rate of heat transfer surfaces and decrease boiler's smokeless steaming capacity. Operators have to be constantly on the alert for casing leaks in order to keep boilers at peak performance.

Many leak-detecting methods take too much labor and time. One such *method involves use of lighted candles* while pulling a suction on the inside of the casing. It's a tedious process which, by its very nature, discourages those using it.

A less time-consuming and more effective method uses smoke bombs. These are lit in the furnace. Closing the outlet damper forces smoke through any opening in the casing. Big disadvantage is that too much smoke generates in too brief a period. This large volume of smoke seeps through leakage areas so quickly that frequently it obscures actual leak sources.

We wanted a method that would spot leaks quickly and accurately. And we wanted to control the spotting medium

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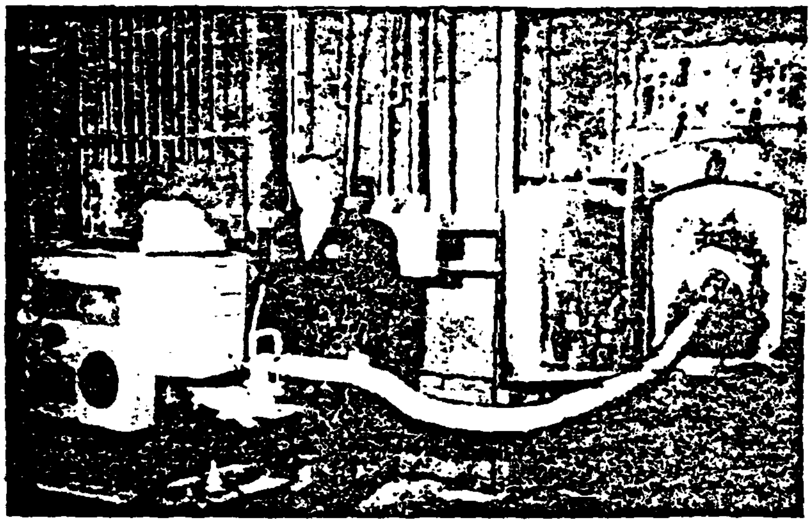
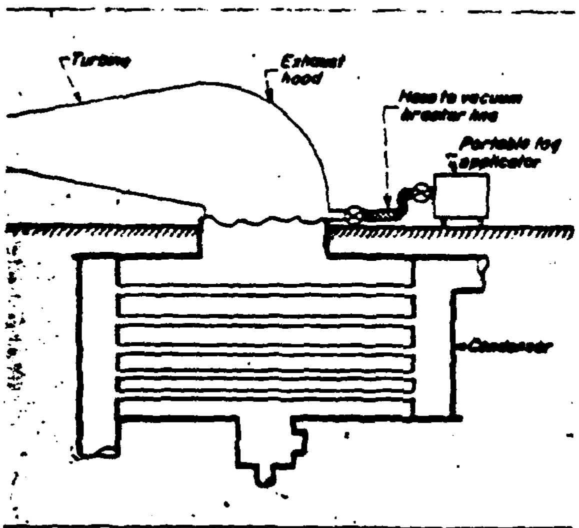


GENERATOR, connected by flexible hose to sealed observation door, fills boiler casing with visible fog. Boiler forced-draft fan builds up slight furnace pressure



TURBINE CASING, condenser shell are subjected to fog pressure of 6 to 9 in. water through hose to vacuum-breaker piping

so it wouldn't obscure visibility around the boiler casing. Further, it had to be fire resistant, explosion-proof, nontoxic.

We did a lot of digging around for the right method and came up with one that involved use of an industrial fog applicator. With this, we generate a visible fog and inject it, under pressure, into the boiler furnace. Pressurized fog seeps through casing openings, reveals them to an observer. Our method can be used on a hot boiler just off the line, or on one that has been idle for some time.

We check boilers for air leaks as soon as they come off the line. This gives the maintenance crew the number and location of leaks found, and they're ready to seal them as soon as the boiler cools. Before boilers go back in service, we use fog again. This tells us whether or not we've done a good sealing job and gives a general appraisal of boiler casing tightness.

Preparing a boiler for testing is fairly simple. Boiler or stack dampers are closed tight enough to permit only slight leakage. F-d fan is rolled just fast enough to build furnace pressure up to about ½ in. water. Fog is injected through a furnace observation door, photo, left. It's necessary, of course, to close all other observation doors and to seal such large openings as the slag taps. Shortly after injection, fog will appear from any existing openings in setting and casing. Observers then mark leak sources.

We get best results when atmosphere around the boiler isn't saturated with fog. To control this, we generate fog for about 15 seconds every two or three minutes. Photo, p 114, shows how this gives us enough fog to reveal leaks without obscuring the source.

We use fog to find condenser leaks, too. Air leakage into a condenser can occur through (1) low-pressure end of turbine casing (2) condenser shell (3) connected piping. It's costly because it hurts condenser vacuum, causes more heat loss to cooling water, cuts turbine output for a given steam flow.

Checking condenser leaks. One way is to flood the steam side up to turbine exhaust flange and let water flow through any openings in shell or connected piping. Remaining parts, subject to leakage, are candled when turbine is in service, preferably at low load. But, experience shows that this method bypasses some leaks, even when they're excessive. Fog, however, spots them all in a hurry.

Technique differs slightly from that used for boiler-casing leaks. We inject fog into turbine-exhaust hood through a vacuum-breaker line. Gas generator supplies pressure of about 6 to 9 in. water in the turbine and condenser. Fog injection is intermittent—about 15 seconds every five minutes. Then leaks show up and results are often surprising. We find leaks in supposedly sound areas. Conversely, we are gratified to find that some suspected sources of leakage are good and tight.

We're well satisfied with results from this method. In several instances, detecting leaks in boiler casings netted us improved combustion which considerably cut the combustible in flyash. In one particular check of condenser cooling-water piping, we found the leakage we'd suspected was impairing the circulating-pump capacity.

As stated, the liquid used with the fog generator is Chem Chex 220. Resultant fog is fire resistant and nonexplosive. As a matter of fact, it'll extinguish an acetylene torch.

Toxicity is low. This was perhaps the most important factor when we selected the liquid from those available. We proved beyond a doubt that, in concentrated or diffused form, the fog is harmless to personnel. The concentration of toxic material falls well below allowable limits for daily exposure.

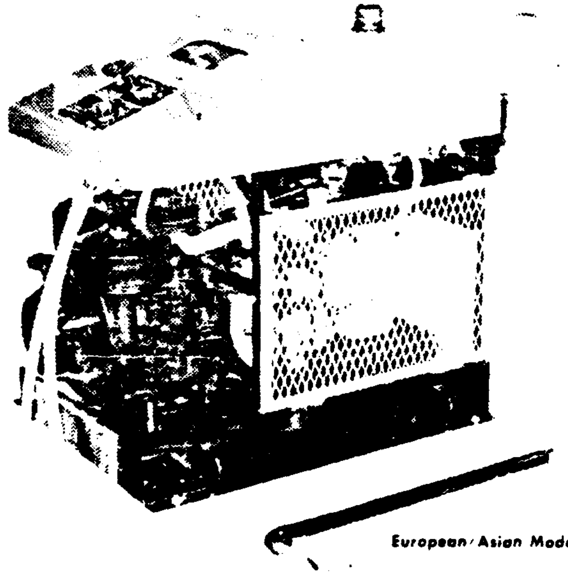
DISCUSSION

As was to be expected, samples #2 and #4 yielded high concentrations since they were taken directly in the escaping fog. #4 was higher than #2 because more shots of fog were introduced during this sampling period and because ambient air velocities were lower at this location. As noted previously, exposure of the worker to these concentrations is infrequent and of short duration. The use of a respirator approved for organic mist and vapor would give more than adequate protection.

General air concentrations during fogging were 1.10 mg/cu meter but rapidly decreased to a negligible concentration of 0.07 mg/cu meter one half hour after its conclusion.

Consistent ratios were not found between the bubbler sample (vapor plus mist) and the filter paper sample (theoretically mist alone). This may be due to the presence of varying concentrations of mist during the different sampling periods or varying degree of mist retention of the different non-uniform porosity filter papers used. Another factor could be indeterminate volatilization and loss of collected mist during the sampling period. In any event, the bubbler samples show total concentration of Chem Chex 220 in air.

However, collection of oil by filter paper samples may be considered as evidence of the presence of mist, although it is questionable whether it is a quantative index of the amount actually present. The existence of mist is corroborated by visual observation in this plant and by Konimeter samples taken previously. These are instantaneous samples of air impinged in a dry state into a vaseline coated glass slide so that the particles are retained. By using a non-coated slide, most of the solid dust particles would escape and the mist droplets collected. Qualitative microscopical examination of slides obtained by the technique revealed the presence of droplets of mist ranging from approximately 0.5 to 2 microns in size. (Any larger mist droplets would probably have been shattered by this technique.)



European/Asian Model

SUMMARY

1. Boiler leak detecting operations are performed approximately once every two weeks, lasting from 30 minutes to one hour each time.

2. The worker engaged in the spotting of the leaks is intermittently and briefly exposed at these times to concentrations of Chem Chex 220 ranging from approximately 3 to 6 milligrams per cubic meter of air.

3. The other workers normally stationed in the room during fogging operations are exposed for 30 minutes to one hour to concentrations of Chem Chex 220 on the order of 1 milligram per cubic meter. These concentrations decrease rapidly after the conclusion of fogging operations.

4. One half hour after the conclusion of fogging operations the room was virtually cleared of Chem Chex 220 with negligible residual concentrations of 0.07 milligrams per cubic meter.

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which the operating staff had been unable to find with the usual methods.

In this case it was not necessary to bring the furnace under vacuum. The fog was introduced through a flexible hose at one side of the furnace with the opposite side being left open until fog began to escape. Even before closing the opening, leaks became visible, and appeared still more clearly when the furnace, filled with fog, was put under slight pressure.

The testing of a conduit having a diameter of 1100 mm by 125 m (44" x 412') used for removing fumes can be given as a further example. When in operation a vacuum should exist in this pipe. If any leaks are present, allowing unwanted air to be drawn in, this will lead to a reduction in the quantity of fumes drawn off. In this case it was very easy to fill the whole pipe with fog while the suction fan was running, and then switched off. As long as no fog escaped at the seams of the pipe, one could be sure that the line was tight.

Refractory furnaces have been tested for tightness of the jet pipes by closing the gas valves and introducing the fog through the inlet connector of the combustion air blower while it is running.

A large foundry has bought the machine in order to be able to examine the extensive blast furnace gas pipework, with pipe diameers of more than 1 m, for furnace gas losses.

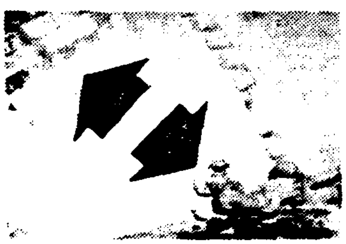
These few examples alone show that the TIFA fogging machines can be used not only for steam boiler plants as originally intended but also for other thermal installations. As such it is a valuable aid to industry for keeping the downtime of furnaces to a minimal, as well as contributing to the saving of both fuel and power.

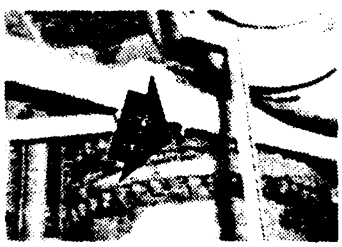
CHEM-CHEX 220

There are many leak-detecting methods, but most require excessive labor and time. One such method mentioned previously involves use of lighted candles while pulling a suction on the inside of the casing. It's a tedious process which, by its very nature, discourages those using it.

A less time consuming and more effective method is through the use of smoke bombs. The big disadvantage is that too much smoke generates in too brief a period. This large volume of smoke seeps through leakage areas so quickly that frequently it obscures actual leak sources.

Then there is the new Fog Check Method using Chem-Chex 220 a product that is fire resistant, explosion proof, and non-toxic to operating personnel. Chem-Chex 220 can be used in any standard TIFA machine for checking leakage when boilers are hot or cold. The usual duration of this test varies for ½ to 1 hour but it is still much shorter and more precise than other methods. Normally a test can be run with three men, one to operate the fogger and two to mark. Chem-Chex sustains a steady fog, thus allowing more time for checking leakage


Both leaks found by TIFA


Cracked expansion joint leaks


Light load, heavy-cost leak


Unsuspected leak means SS


TIFA found leaking casting


Leaks only occasionally


Tight? TIFA showed it leaked


Potential leaks in bolted flange

EXPLOSION PROOF, AND NON-TOXIC

REPORT ON ENVIRONMENTAL SURVEY OF BOILER TESTING OPERATIONS

Approximately every two weeks, one of the high pressure boilers in the boiler room is removed from service for overhaul, cleaning and repair. This procedure includes the detection of any leaks which may have developed.

In detecting the leaks, Chem-Chex 220 oil fog is prepared in a fog machine and forced into the boiler at high pressures. This fog escapes into the room from leaks in the boiler housing and can be detected by visual observation. As soon as a leak is thus spotted, the repair man is dispatched to the point to identify the area. During this operation, intermittent shots of fog are injected into the boiler, so that the worker can outline the exact area of the leak while the fog is escaping. This exposes him to dense clouds of fog for the time it takes to indicate the area, usually one to four minutes. This process is repeated for as many times as there are leaks.

It was stated that this entire process takes approximately 30 minutes to one hour (once every two weeks). From two to three quarts of Chem Chex are used for each complete test.

In addition, other workers in the boiler room are exposed to varying amounts of the vapor and mist which permeate the room during the fogging operations. The degree of exposure will depend on how close the particular leaks are to areas where these workers are normally stationed and to the air movement patterns in the room during fogging operations.

General ventilation of the room is excellent and the room rapidly cleared at the conclusion of fogging.

LOCATION OF SAMPLES

Representatives of management and labor both wished samples taken directly at points of leakage, although it was pointed out to them that these could be expected to yield high concentrations. Other samples were taken to indicate general room concentrations before, during, and after fogging.

SAMPLING & ANALYTICAL TECHNIQUE

The methods devised by Hunter and reported in Elkins were used.

This method, which involves scrubbing of the sampled air by a fritted glass bubbler containing isopropyl alcohol will collect both oil vapor and mist, with 100% efficiency as determined by the Navy. As a corollary, it was decided to determine, if possible, how much of the oil was present as a mist. It was felt that filter paper samples might collect the particular mist and all the vapor to pass through. Filter paper samples were therefore taken simultaneously with the bubbler (isopropyl alcohol) samples.

The samples were analyzed for phosphate and reported as tricresyl phosphate.

AIR SAMPLES

1 On floor at west side fire door of Boiler #53 which was fogged for 10 minutes one half hour before sampling. High ambient air velocities.

	mg/cu meter	PPM
Bubbler Sample	0.03	0.002
Filter Paper Sample	0.006	0.0004

2 Same location as #1. Fogging going on intermittently. Visible fog escaping from loose fire door. High ambient air velocity. Sampling apparatus six feet downward from escaping fog.

	mg/cu meter	PPM
Bubbler Sample	3.10	0.20
Filter Paper Sample	0.28	0.018

3 Between #51 and #61 boilers at east side of floor in general air. Boiler #53 still being fogged. High ambient air velocity. Visible fog intermittently swirling in area.

	mg/cu meter	PPM
Bubbler Sample	1 10	0.07
Filter Paper Sample	0.15	0.01

4 At southwest corner of economizer platform at top of Boiler #53. Fogging going on more frequently than in #2 above. Sampling apparatus in fog. Low ambient air velocity.

	mg/cu meter	PPM
Bubbler Sample	6.32	0.42
Filter Paper Sample	1.24	0.08

5 On floor near east end of #53 in general air. One half hour after conclusion of fogging. All visible evidence of fog gone. Room clear. Medium ambient air velocities.

	mg/cu meter	PPM
Bubbler Sample	0.07	0.005
Filter Paper Sample	0.01	0.0007

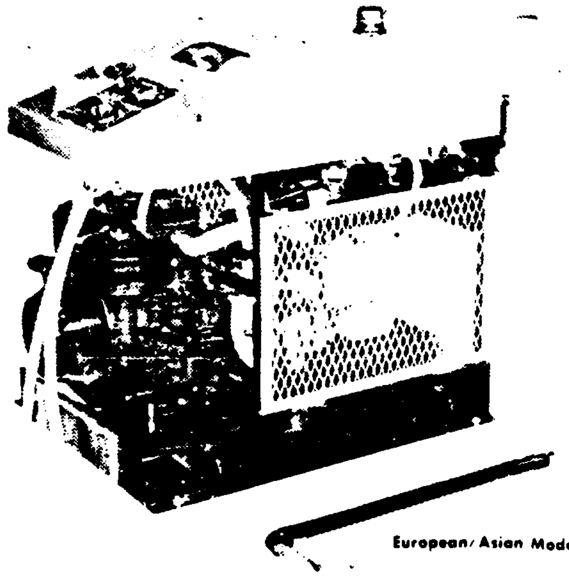
NOTE The data has been expressed in terms of both mg/cu meter and PPM. Since mist as well as vapor is present, the mg/cu meter figure is the preferable index, as PPM is applicable only to vapor. The PPM data, which are calculated from the mg/cu meter data, are much lower than the latter, because the molecular weight of tricresyl phosphate, to which PPM is inversely proportional, is so high.

DISCUSSION As was to be expected, samples #2 and #4 yielded high concentrations since they were taken directly in the escaping fog. #4 was higher than #2 because more shots of fog were introduced during this sampling period and because ambient air velocities were lower at this location. As noted previously, exposure of the worker to these concentrations is infrequent and of short duration. The use of a respirator approved for organic mist and vapor would give more than adequate protection.

General air concentrations during fogging were 1.10 mg/cu meter but rapidly decreased to a negligible concentration of 0.07 mg/cu meter one half hour after its conclusion.

Consistent ratios were not found between the bubbler sample (vapor plus mist) and the filter paper sample (theoretically mist alone). This may be due to the presence of varying concentrations of mist during the different sampling periods or varying degree of mist retention of the different non-uniform porosity filter papers used. Another factor could be indeterminate volatilization and loss of collected mist during the sampling period. In any event, the bubbler samples show total concentration of Chem Chex 220 in air.

However, collection of oil by filter paper samples may be considered as evidence of the presence of mist, although it is questionable whether it is a quantative index of the amount actually present. The existence of mist is corroborated by visual observation in this plant and by Konimeter samples taken previously. These are instantaneous samples of air impinged in a dry state into a vaseline coated glass slide so that the particles are retained. By using a non-coated slide, most of the solid dust particles would escape and the mist droplets collected. Qualitative microscopical examination of slides obtained by the technique revealed the presence of droplets of mist ranging from approximately 0.5 to 2 microns in size. (Any larger mist droplets would probably have been shattered by this technique.)



European/Asian Model

SUMMARY

1. Boiler leak detecting operations are performed approximately once every two weeks, lasting from 30 minutes to one hour each time.

2. The worker engaged in the spotting of the leaks is intermittently and briefly exposed at these times to concentrations of Chem Chex 220 ranging from approximately 3 to 6 milligrams per cubic meter of air.

3. The other workers normally stationed in the room during fogging operations are exposed for 30 minutes to one hour to concentrations of Chem Chex 220 on the order of 1 milligram per cubic meter. These concentrations decrease rapidly after the conclusion of fogging operations.

4. One half hour after the conclusion of fogging operations the room was virtually cleared of Chem Chex 220 with negligible residual concentrations of 0.07 milligrams per cubic meter.

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APPENDIX E

SURFACE-ACTIVE AGENTS: U.S. PRODUCTION AND SALES, 1979

APPENDIX E

SURFACE-ACTIVE AGENTS: U.S. PRODUCTION AND SALES, 1979

Listed below are all surface-active agents for which reported data on production of sales may be published. (Leaders (..) are used where the reported data are accepted in confidence and may not be published or where no data were reported.)

SURFACE-ACTIVE AGENTS	PRODUCTION [1]	SALES [2]		
		QUANTITY [1]	VALUE	UNIT VALUE [3]
	1,000 pounds	*1,000 pounds*	*1,000 dollars*	*Per pound*
Grand total	4,948,439	2,859,480	1,143,506	$0.40
Benzenoid [4]	1,235,265	677,840	296,902	.44
Nonbenzenoid [5]	3,713,174	2,181,640	846,604	.39
AMPHOTERIC				
Total	20,519	19,297	18,835	.98
ANIONIC				
Total	3,158,586	1,497,966	419,102	.28
Carboxylic acids (and salts thereof), total	878,120	175,209	69,707	.40
Amine salts of fatty, rosin, and tall oil acids	672	251	320	1.27
Carboxylic acids having amide, ester, or ether linkages	4,402	4,581	5,992	.55
Coconut oil acids, potassium salt	...	1,615	1,512	.94
Coconut oil acids, sodium salt	151,362	2,417	1,168	.48
Mixed vegetable fatty acids, potassium salt	3,654	2,884	6,548	2.27
Oleic acid, potassium salt	1,464	...	...	...
Oleic acid, sodium salt	594	174	151	.87
Tall oil acids, potassium salt	10,501	3,907	2,214	.57
Tall oil acids, sodium salt	2,501	1,449	385	.27
Tallow acids, sodium salt	387,359	23,418	7,818	.33
All other carboxylic acids (and salts thereof)	315,611	134,513	43,599	.32
Phosphoric and polyphosphoric acid esters (and salts thereof), total	38,681	24,732	19,432	.79
Alcohols and phenols, alkoxylated and phosphated, total	19,399	16,587	12,290	.74
Dinonylphenol, ethoxylated and phosphated	1,080	757	594	.78
Mixed linear alcohols, ethoxylated and phosphated	3,836	3,143	2,325	.74
Nonylphenol, ethoxylated and phosphated	5,795	4,234	2,953	.70
Phenol, ethoxylated and phosphated	1,346	989	745	.75
Tridecyl alcohol, ethoxylated and phosphated	814	590	507	.86
All other	6,528	6,874	5,166	.75
All other phosphoric and polyphosphoric acid esters (and salts thereof)	19,282	8,145	7,142	.88
Sulfonic acids (and salts thereof), total	1,641,120	1,067,108	207,612	.19
Alkybenzenesulfonates, total	655,612	184,591	76,856	.42
Dodecylbenzenesulfonic acid	216,278	107,405	39,554	.37
Dodecylbenzenesulfonic acid, calcium salt	10,514	9,564	8,186	.86
Dodecylbenzenesulfonic acid, isopropylamine salt	3,739	3,655	2,399	.66
Dodecylbenzenesulfonic acid, sodium salt	307,036	43,957	14,251	.32
Dodecylbenzenesulfonic acid, triethanolamine salt	5,181	5 420	2,447	.45
All other	112,864	14,590	10,019	.69
Ligninsulfonates, total	806,134	750,394	55,780	.07
Ligninsulfonic acid, ammonium salt	13,941	12,864	765	.06
Ligninsulfonic acid, calcium salt	590,131	540,524	22,095	.04
Ligninsulfonic acid, chromium salt	98,898	95,865	15,326	.16
Ligninsulfonic acid, iron salt	2,110	2,110	368	.17

See footnotes at end of table.

SURFACE-ACTIVE AGENTS	PRODUCTION[1]	SALES[2]		
		QUANTITY[1]	VALUE	UNIT VALUE[3]
ANIONIC--Continued	*1,000 pounds*	*1,000 pounds*	*1,000 dollars*	*Per pound*
Sulfonic acids (and salts thereof)--Continued				
Ligninsulfonates--Continued				
Ligninsulfonic acid, sodium salt	99,765	97,742	16,938	$0.17
All other	1,289	1,289	288	.22
Naphthalenesulfonates	21,330	16,228	9,550	.59
Sulfonic acids having amide linkages, total	5,785	3,976	4,510	1.13
Sulfosuccinamic acid derivatives	3,987	2,208	1,749	.79
Taurine derivatives	1,798	1,768	2,761	1.56
Sulfonic acids having ester or ether linkages, total	71,274	32,274	36,017	1.12
Sulfosuccinic acid esters, total	25,600	19,534	17,117	.88
Sulfosuccinic acid, bis(2-ethylhexyl)ester, sodium salt	20,909	15,618	14,836	.95
All other	4,691	3,916	2,281	.58
Other sulfonic acids having ester or ether lingages	45,674	12,740	18,900	1.49
All other sulfonic acids (and salts thereof)	80,985	79,645	24,899	.31
Sulfuric acid esters (and salts thereof), total	552,725	215,819	117,286	.54
Acids, amides, and esters, sulfated, total	24,279	18,317	11,325	.62
Butyl oleate, sulfated, sodium salt	877	854	377	.44
Isopropyl oleate, sulfated, sodium salt	92	92	78	.85
Oleic acid, sulfated, disodium salt	6,672	6,495	2,243	.35
Propyl oleate, sulfated, sodium salt	474	203	106	.52
Tall oil sulfated, sodium salt	2,544	1,282	394	.31
All other	13,620	9,391	8,127	.87
Alcohols, sulfated, total	246,367	52,649	45,116	.86
Dodecyl sulfate, ammonium salt	14,486	12,961	10,808	.83
Dodecyl sulfate, magnesium salt	209	166	230	1.39
Dodecyl sulfate, sodium salt	19,883	18,510	16,295	.88
Dodecyl sulfate, triethanolamine salt	5,973	5,401	4,903	.91
Octyl sulfate, sodium salt	241	145	156	1.08
All other	205,575	15,466	12,724	.82
Ethers, sulfated, total	262,714	128,488	53,597	.42
Dodecyl alcohol, ethoxylated and sulfated, sodium salt	14,760	14,522	11,771	.98
Mixed linear alcohols, ethoxylated and sulfated, ammonium salt	95,125	68,676	21,552	.31
Mixed linear alcohols, ethoxylated and sulfated, sodium salt	139,437	35,706	13,280	.37
All other	13,392	9,584	6,994	.73
Natural fats and oils, sulfated, total	19,365	16,365	7,248	.44
Castor oil, sulfated, sodium salt	5,365	5,079	2,617	.52
Cod oil, sulfated, sodium salt	1,230	1,206	342	.28
Tallow sulfated, sodium salt	3,619	3,470	1,227	.35
All other	9,151	6,610	3,062	.46
Other anionic surface-active agents[6]	47,940	15,098	5,065	.34
CATIONIC				
Total	294,222	214,697	177,326	.83
Amine oxides and oxygen-containing amines (except those having amide linkages), total	78,350	23,872	19,185	.80
Acyclic, total	69,541	18,391	15,170	.82
(Tallow alkyl)amine, ethoxylated	3,002	2,656	1,772	.67
All other	66,539	15,735	13,398	.85

See footnotes at end of table.

SURFACE-ACTIVE AGENTS: U.S. PRODUCTION AND SALES, 1979--Continued

SURFACE-ACTIVE AGENTS	PRODUCTION[1]	SALES[2]		
		QUANTITY[1]	VALUE	UNIT VALUE[3]
CATIONIC--Continued				
Amine oxides and oxygen-containing amines (except those having amide linkages)--Continued	*1,000 pounds*	*1,000 pounds*	*1,000 dollars*	*Per pound*
Cyclic (including imidazoline and oxazoline derivatives)	8,809	5,481	4,015	$0.73
Amines and amine oxides having amide linkages, total	30,275	21,725	18,370	.85
Tall oil acids-diethylenetriamine condensate	7,223	6,940	3,156	.45
Tall oil acids polyalkylenepolyamine condensate	6,880	6,144	5,381	.88
All other	16,172	8,641	9,833	1.14
Amines, not containing oxygen (and salts thereof), total	85,406	74,278	60,774	.82
Diamines, polyamines, and amino salts, total	25,353	23,202	16,329	.70
Imidazoline derivatives	974	1,078	1,637	1.52
N-(9-Octadecenyl)trimethylenediamine	1,689	1,658	1,430	.86
All other	22,690	20,466	13,262	.65
Primary monoamines, total	31,355	26,337	19,832	.75
(Hydrogenated tallow alkyl)amine	4,182	3,403	2,421	.71
9-Octadecenylamine	4,937	4,719	3,763	.80
(Tallow alkyl)amine	15,000	11,314	6,261	.55
All other	7,236	6,901	7,387	1.07
Secondary and tertiary monoamines, total	28,698	24,739	24,613	.99
N,N-Dimethyloctadecylamine	1,227	1,134	1,230	1.08
All other	27,471	23,605	23,383	.99
Quaternary ammonium salts, containing oxygen	12,835	8,960	9,588	1.07
Quaternary ammonium salts, not containing oxygen, total	86,647	85,171	68,181	.80
Acyclic, total	68,998	68,079	44,326	.65
Bis(hydrogenated tallow alkyl)dimethylammonium chloride	52,126	52,349	26,746	.51
All other	16,872	15,730	17,580	1.12
Benzenoid, total	17,649	17,092	23,855	1.40
Benzyl(coconut oil alkyl)dimethylammonium chloride	130	106	147	1.39
Benzyldimethyl(mixed alkyl)ammonium chloride	11,045	10,940	16,104	1.47
Benzyltrimethylammonium chloride	955	943	598	.63
All other	5,519	5,103	7,006	1.37
Other cationic surface-active agents	709	691	1,228	1.78
NONIONIC				
Total	1,475,112	1,127,520	528,243	.47
Carboxylic acid amides, total	70,004	46,910	35,152	.75
Diethanolamine condensates (amine/acid ratio=2/1), total	22,015	16,609	10,940	.66
Capric acid	97	112	104	.92
Castor oil acids	2,585	1,210	751	.62
Coconut oil acids	10,679	8,454	5,399	.64
Coconut oil and tallow acids	1,884	1,835	1,159	.63
Lauric and myristic acids	2,637	1,615	1,477	.91
Oleic acid	833	...	...	...
Stearic acid	412	...	...	...
Tall oil acids	218	218	147	.67
All other	2,670	3,165	1,903	.60

See footnotes at end of table.

SURFACE-ACTIVE AGENTS: U.S. PRODUCTION AND SALES, 1979--Continued

SURFACE-ACTIVE AGENTS	PRODUCTION[1]	SALES[2]		
		QUANTITY[1]	VALUE	UNIT VALUE[3]
NONIONIC--Continued				
Carboxylic acid amides--Continued	*1,000 pounds*	*1,000 pounds*	*1,000 dollars*	*Per pound*
Diethanolamine condensates (other amine/acid ratios), total	30,890	24,064	18,981	$0.79
Coconut oil acids (amine/acid ratio=1/1)	16,427	15,961	11,619	.73
Lauric acid (amine/acid ratio-1/1)	8,479	4,520	4,322	.96
Lauric and myristic acid (amine/acid ratio=1/1)	...	2,348	2,068	.88
Linoleic acid	299	277	276	1.00
Oleic acid (amine/acid ratio=1/1)	173	119	85	.72
Stearic acid (amine/acid ratio=1/1)	135	124	73	.59
All other	5,377	715	538	.75
All other carboxylic acid amides, total	17,099	6,237	5,232	.84
Coconut oil acids, ethanolamine condensates	5,353	1,842	1,350	.73
All other	11,746	4,395	3,882	.88
Carboxylic acid esters, total	254,349	195,517	133,297	.68
Anhydrosorbitol esters, total	33,077	22,244	16,433	.74
Anhydrosorbitol monolaurate	...	3,481	3,043	.87
Anhydrosorbitol mono-oleate	5,721	5,372	4,177	.78
All other	27,356	13,391	9,213	.69
Diethylene glycol esters, total	1,421	1,145	875	.76
Diethylene glycol monolaurate	205	207	161	.78
Diethylene glycol mono-oleate	27	32	30	.92
Diethylene glycol monostearate	238	249	200	.80
All other	951	657	484	.74
Ethoxylated anhydrosorbitol esters, total	29,806	27,125	19,073	.70
Ethoxylated anhydrosorbitol mono-oleate	5,274	4,810	3,303	.68
Ethoxylated anhydrosorbitol monostearate	9,750	8,521	5,931	.70
All other	14,782	13,794	9,839	.71
Ethylene glycol esters, total	3,935	3,684	2,029	.55
Ethylene glycol monostearate	1,587	1,476	891	.60
All other	2,348	2,208	1,138	.52
Glycerol esters, total[8]	77,594	63,025	41,001	.65
Glycerol esters of chemically defined acids, total	22,923	18,862	11,882	.63
Glycerol mono-oleate	3,654	3,164	2,258	.71
Glycerol monostearate	18,334	14,745	8,547	.58
All other	935	953	1,077	1.13
Glycerol esters of mixed acids, total	54,671	44,163	29,119	.66
Glycerol monoester of hydrogenated cottonseed oil acids	2,562	1,326	1,444	1.09
Glycerol monoester of hydrogenated soybean oil acids	10,983	9,953	7,425	.72
All other	41,126	32,884	20,250	.62
Natural fats and oils, ethoxylated, total	18,614	18,918	11,268	.60
Castor oil, ethoxylated	9,157	8,944	5,026	.56
Hydrogenated castor oil, ethoxylated	...	4,798	3,421	.71
Lanolin, ethoxylated	1,679	1,596	1,252	.78
All other	7,778	3,580	1,569	.44
Polyethylene glycol esters, total	48,140	38,556	20,863	.54
Polyethylene glycol esters of chemically defined acids, total	24,843	19,814	14,433	.73
Polyethylene glycol dilaurate	1,312	1,127	1,003	.89
Polyethylene glycol dioleate	3,028	977	685	.70
Polyethylene glycol distearate	2,916	2,697	2,279	.85
Polyethylene glycol monolaurate	6,298	5,041	4,106	.81
Polyethylene glycol mono-oleate	4,327	3,734	2,217	.59
Polyethylene glycol monostearate	6,028	5,507	3,641	.66
All other	934	731	502	.69

See footnotes at end of table.

SURFACE-ACTIVE AGENTS	PRODUCTION[1]	SALES[2]		
		QUANTITY[1]	VALUE	UNIT VALUE[3]
NONIONIC--Continued	*1,000 pounds*	*1,000 pounds*	*1,000 dollars*	*Per pound*
Carboxylic acid esters--Continued				
Polyethylene glycol esters--Continued				
Polyethylene glycol esters of mixed acids	23,297	18,742	6,430	$0.34
Polyglycerol esters	1,049	1,027	1,048	1.02
1,2-Propanediol monolaurate	76	69	94	1.37
1,2-Propanediol monostearate	2,101	1,657	1,336	.81
All other carboxylic acid esters	38,536	18,067	19,277	1.07
Ethers, total	1,119,286	879,402	354,436	.40
Benzenoid ethers, total	432,833	362,562	136,457	.38
Dodecylphenol, ethoxylated	15,780	14,790	5,781	.39
Nonylphenol, ethoxylated	307,747	266,603	94,100	.35
Phenol, ethoxylated	2,899	2,037	1,004	.49
All other	106,407	79,132	35,572	.45
Nonbenzenoid ethers, total	645,958	488,262	202,225	.41
Chemically-defined linear alcohols, alkoxylated, total	14,550	10,062	6,792	.69
Decyl alcohol, ethoxylated	4,554	2,909	1,167	.40
9-Octadecenyl alcohol, ethoxylated	1,655	494	452	.92
Oleyl alcohol, ethoxylated	346	282	385	1.36
All other	7,995	6,377	4,788	.75
Mixed linear alcohols, alkoxylated, total	631,409	478,200	195,433	.41
Mixed linear alcohols, ethoxylated	567,183	445,803	179,898	.40
Mixed linear alcohols, ethoxylated and propoxylated	28,854	28,745	12,660	.44
All other	35,372	3,652	2,875	.79
Other ethers and thioethers, total	40,495	28,578	15,755	.55
Mixed alcohols, ethoxylated	1,568	1,355	1,047	.77
Tridecyl alcohols, ethoxylated	9,367	7,521	2,845	.52
All other	29,560	19,702	11,863	.60
Other nonionic surface-active agents[7]	31,473	5,691	5,358	.94

[1]All quantities are given in terms of 100 percent organic surface-active ingredient.
[2]Sales include products sold as bulk surface-active agents only.
[3]Calculated from unrounded figures.
[4]The term "benzenoid" used in this report, describes any surface-active agents, except lignin derivatives, whose molecular structure includes 1 or more 6-membered carbocyclic or hetercyclic rings with conjugated double bonds (e.g., the benzene ring or the pyridine ring).
[5]Includes ligninsulfonates.
[6]Includes all other natural fats and oils, sulfated.
[7]Includes trimethylnonyl alcohol, ethoxylated; octyl phosphate, ethoxylated; trimethylalpropane, ethoxylated; and tri(castor oil alkyl) phosphate.
[8]Complex glycerol esters are included in all other carboxylic acid esters.

APPENDIX F

ORIGINAL TABULAR DATA AND GRAPHICS

LDQI INTERNAL ATMOSPHERE

(As Measured by ATS Equipment)

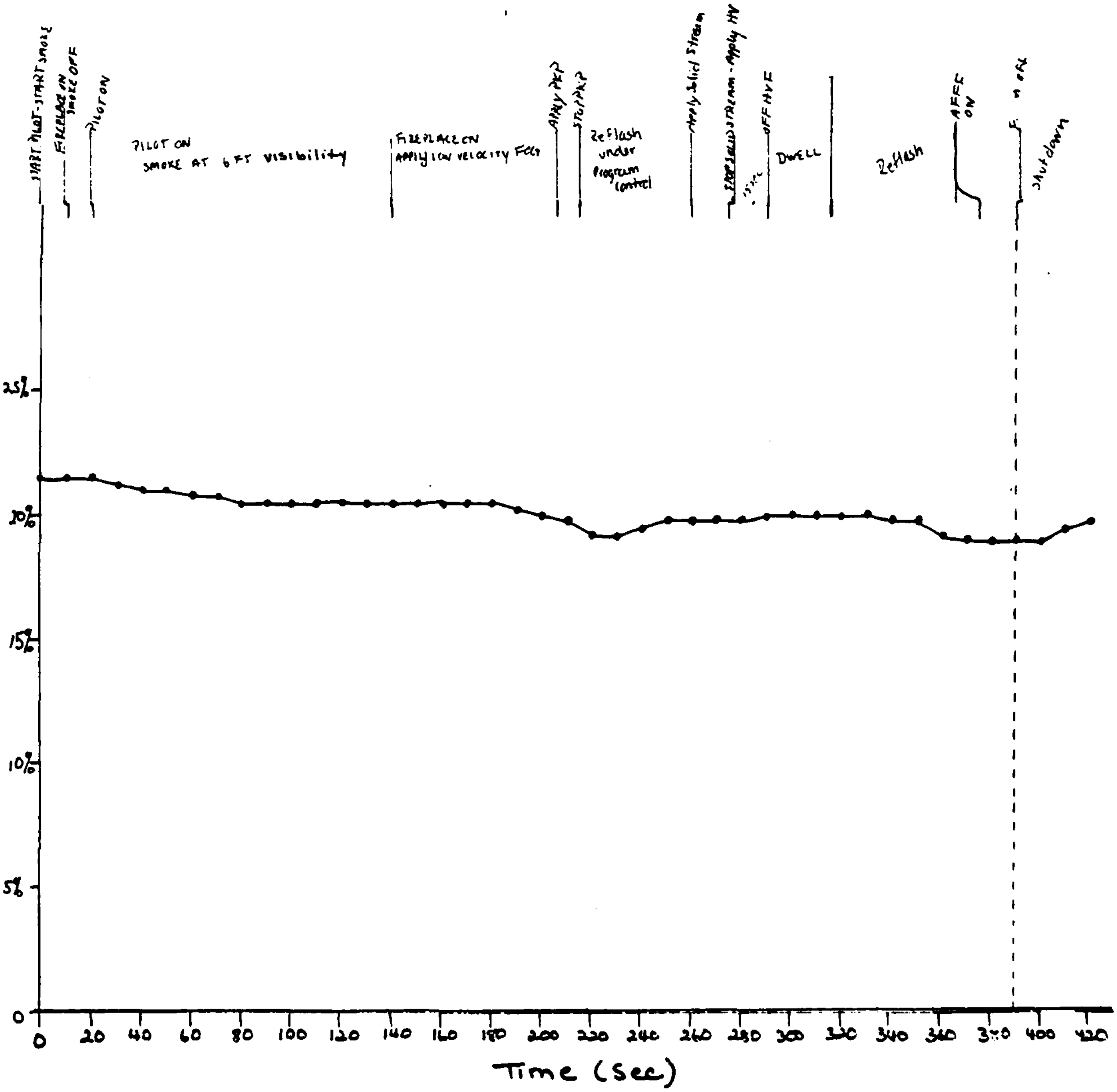
TABLE F-1. LDOI SCENARIO - RUN 3

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	21.5	40	60	1.5	1,300
10	21.5	40	65	1.5	1,600
20	21.5	40	70	2.0	2,800
30	21.25	50	65	2.5	6,500
40	21.0	60	70	2.5	7,900
50	21.0	75	80	2.4	8,700
60	20.75	85	105	2.5	9,200
70	20.75	100	120	2.5	9,400
80	20.5	100	115	2.75	9,600
90	20.5	100	110	3.0	9,800
100	20.5	110	110	3.0	9,900
110	20.5	115	105	3.25	10,000
120	20.5	115	100	3.5	10,000
130	20.5	105	100	3.6	10,000
140	20.5	90	100	3.75	10,000
150	20.5	80	95	4.0	10,000
160	20.5	70	90	4.25	10,300
170	20.5	60	95	4.5	10,800
180	20.5	60	100	4.5	11,200
190	20.25	60	110	4.5	12,400
200	20.0	70	110	4.9	13,600
			(120 at ≈ 215 sec.)		
210	19.75	80	120 (off chart at ≈ 219 sec.)	5.25	15,700
					(15,400 at ≈ 217 sec.)
220	19.25	140	off chart (on chart at ≈ 227 sec.)	5.75	15,600

TABLE F-1 (Continued)

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
230	19.25	840	850	11.0	15,200
240	19.5	660	500	10.3	14,100
			(440 at ≈ 244 sec.)		
250	19.75	470	465	9.5	13,800
260	19.75	390	320	9.5	14,000
270	19.75	320	300	9.5	14,200
			(off chart at ≈ 274 sec.)		
280	19.75	490	off chart	12.25	13,000
290	20.0	880	off chart	17.25	12,500
300	20.0	950	off chart	16.25	12,000
310	20.0	825	off chart	14.5	12,400
320	20.0	660	off chart	13.3	13,300
			(on chart at ≈ 322 sec.)		
330	20.0	480	770	12.5	13,600
340	19.75	380	630	12.0	14,200
350	19.75	320	420	11.75	15,200
360	19.25	250	300	11.25	16,000
370	19.0	210	260	11.1	16,500
			(220 at ≈ 377 sec.)		
380	19.0	190	240	11.0	18,900
390	19.0	210	280	10.75	16,400
400	19.0	350	310	9.5	14,800
410	19.5	375	290	9.25	14,000
420	19.75	310	200	8.25	11,500

LDQI RUN 3 - O_2 LEVELS



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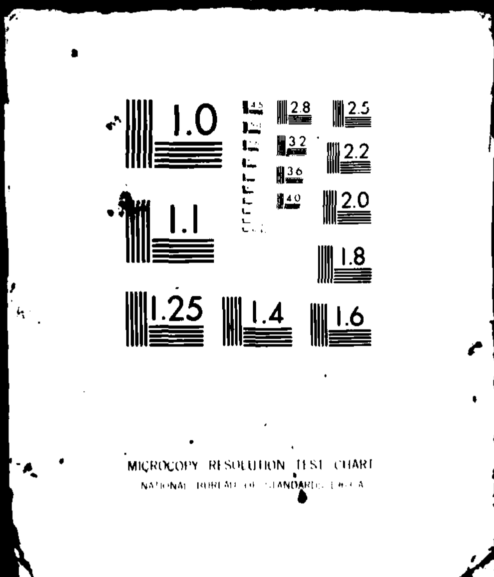
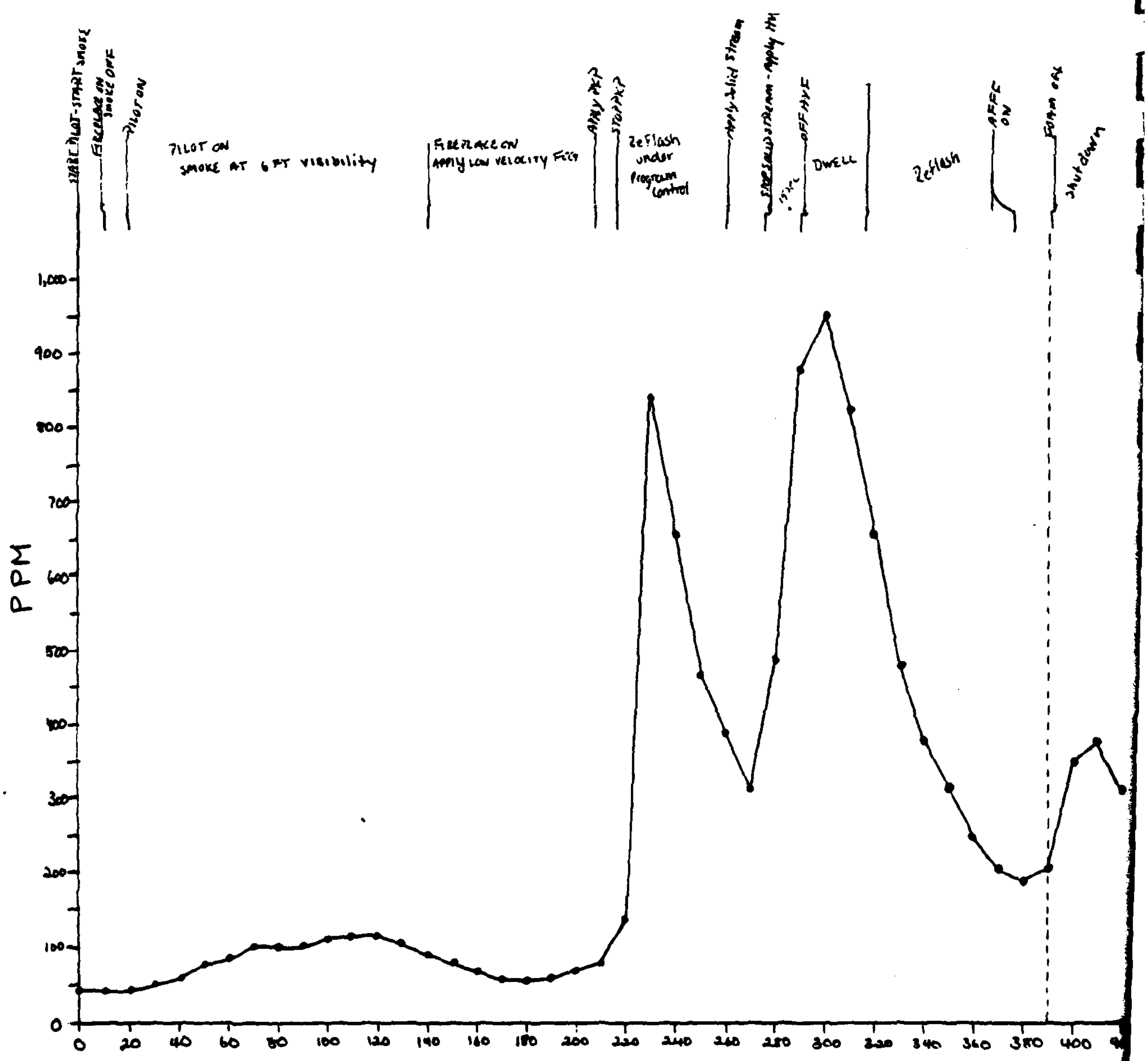
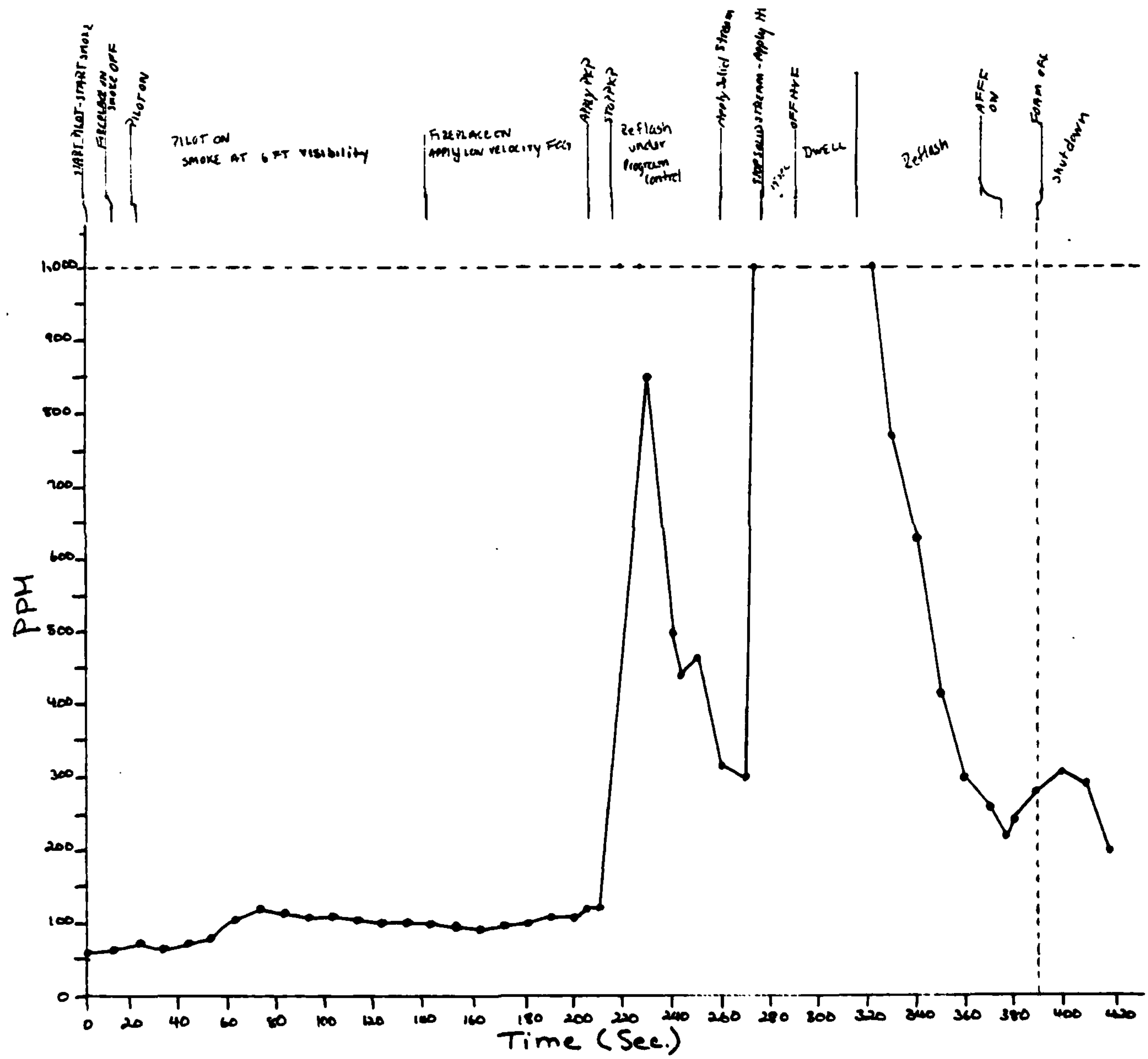


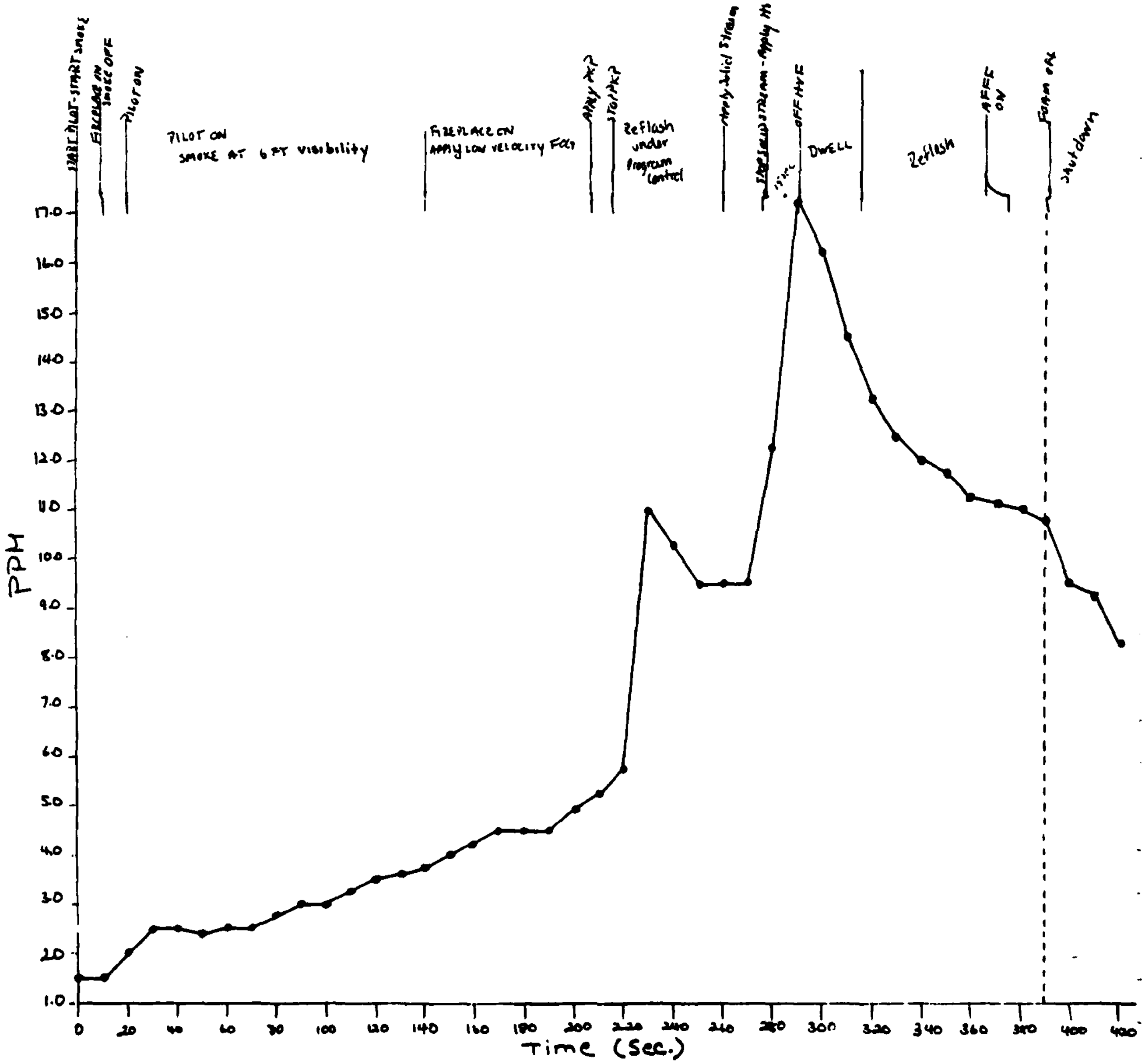
LDQI RUN 3 - CO LEVELS



LDQI RUN 3 - HC LEVELS



LDQI RUN 3 - NO_x LEVELS



LDQI RUN 3 - CO_2 LEVELS

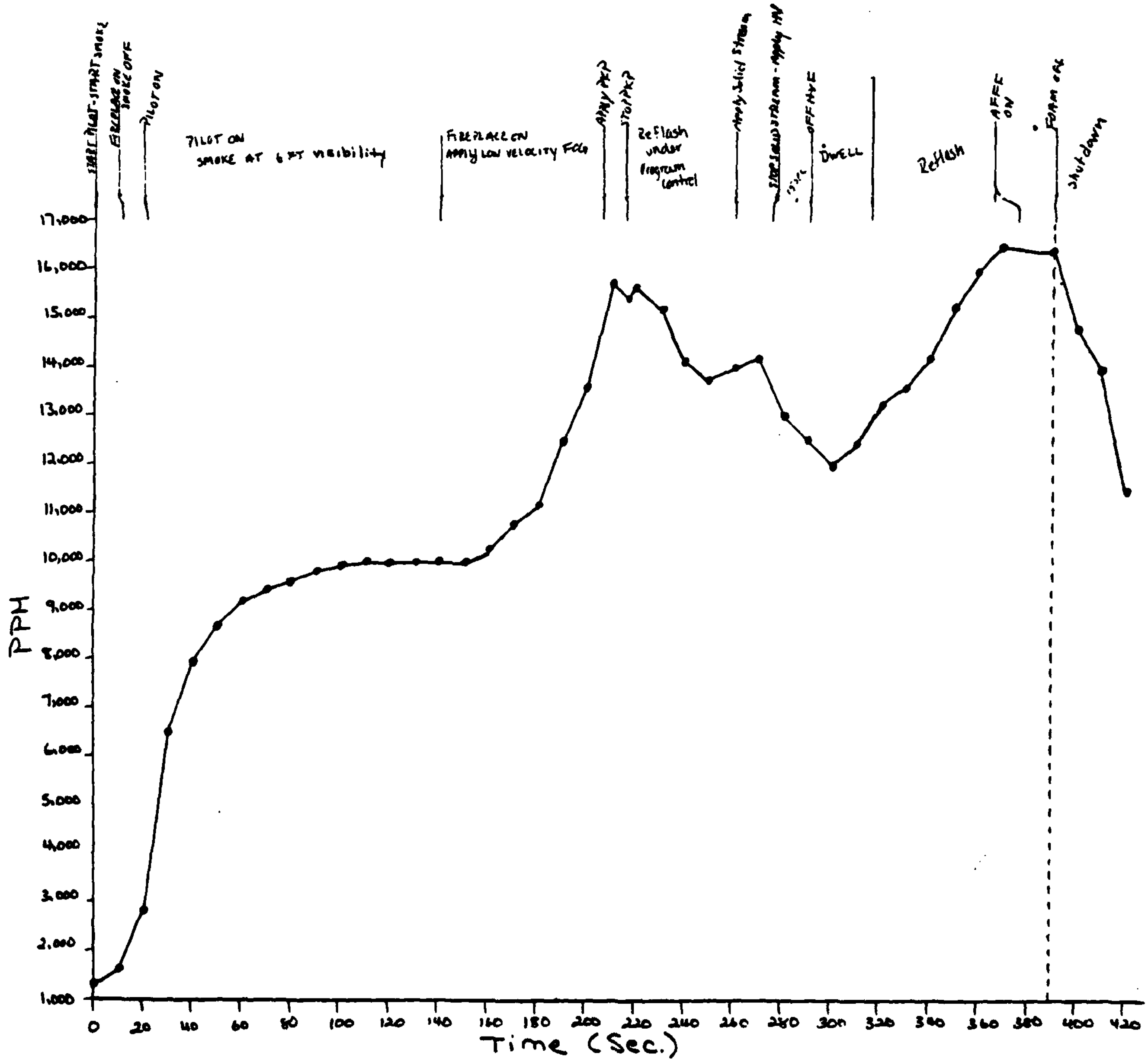


TABLE F-2. LDQI SCENARIO - RUN 4

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	21.75	90	90	2.0	1,600
10	21.75	80	110	2.0	1,800
20	21.5	70	100	2.5	3,800
30	21.5	70	100	2.8	6,200
40	21.25	80	90	3.0	7,400
50	21.0	95	95	2.9	8,400
60	21.0	95	100	3.2	8,800
70	21.0	85	100	3.5	9,000
80	20.75	80	100	3.7	9,300
90	20.75	80	100	3.75	9,500
100	20.75	80	100	4.0	9,600
110	20.75	80	100	4.0	9,700
120	20.75	80	100	4.0	9,700
130	20.75	80	95	4.1	9,700
140	20.75	75	85	4.25	9,800
150	20.75	65	80	4.4	9,900
160	20.75	60	80	4.5	9,900
170	20.75	60	80	4.5	10,000
180	20.5	60	85	4.75	10,400
190	20.5	55	90	5.0	11,100
200	20.5	60	110	5.0	11,800
210	20.25	65	120	5.0	12,800
220	20.0	70	130	5.0	14,300
230	19.5	90	140 (off chart at ≈ 239 sec.)	5.25	15,800
240	19.25	370 (820 at ≈ 248 sec.)	off chart (on chart at ≈ 245 sec.)	7.25	16,000

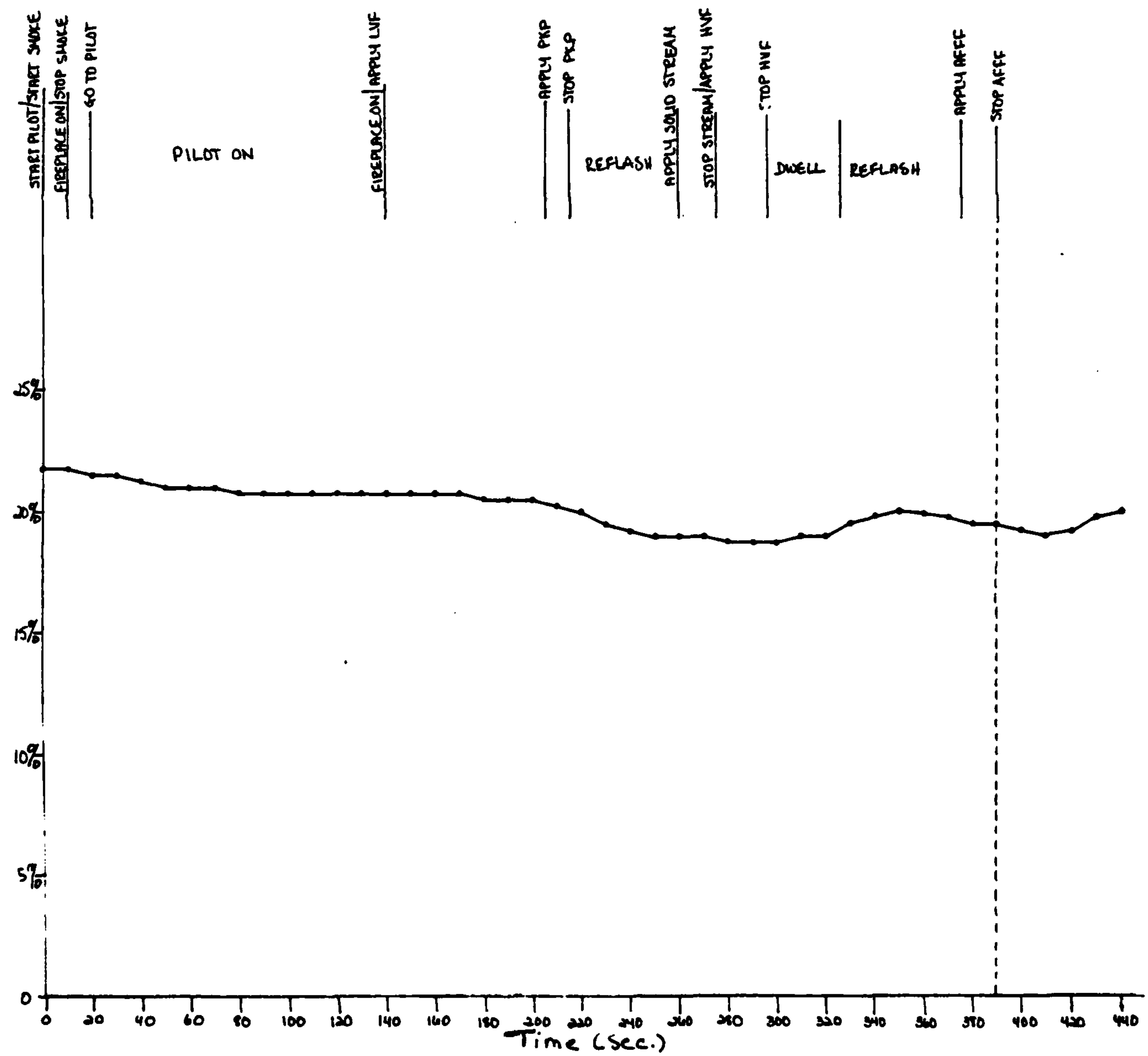
TABLE F-2 (Continued)

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
250	19.0	800	720	12.25	16,100
260	19.0	620	530	12.25	16,500
270	19.0	480	370	12.0	17,000
280	18.75	405	325	11.75	17,400
290	18.75	380 (370 at ≈ 295 sec.)	320 (off chart at ≈ 294 sec.)	11.75	17,700
300	18.75	660 (off chart at ≈ 305 sec.)	off chart	15.75	16,700
310	19.0	off chart	off chart	21.25	16,000
320	19.0	(1,020) (1,000 at ≈ 328 sec.)	off chart	17.5	14,800
330	19.5	970	off chart	15.5	13,800
340	19.75	825	off chart	13.9	13,200
350	20.0	600	off chart (on chart at ≈ 357 sec.)	13.0	13,700
360	19.9	500	720	12.75	14,200
370	19.75	360 (340 at ≈ 377 sec.)	600	12.5	16,900
380	19.5	380 (460 at ≈ 386 sec.)	570	12.4	15,400
390	19.5	430	380	12.5	15,800
400	19.25	340	300	12.5	16,500
410	19.0	310	380 (400 at ≈ 415 sec.)	12.25	16,300

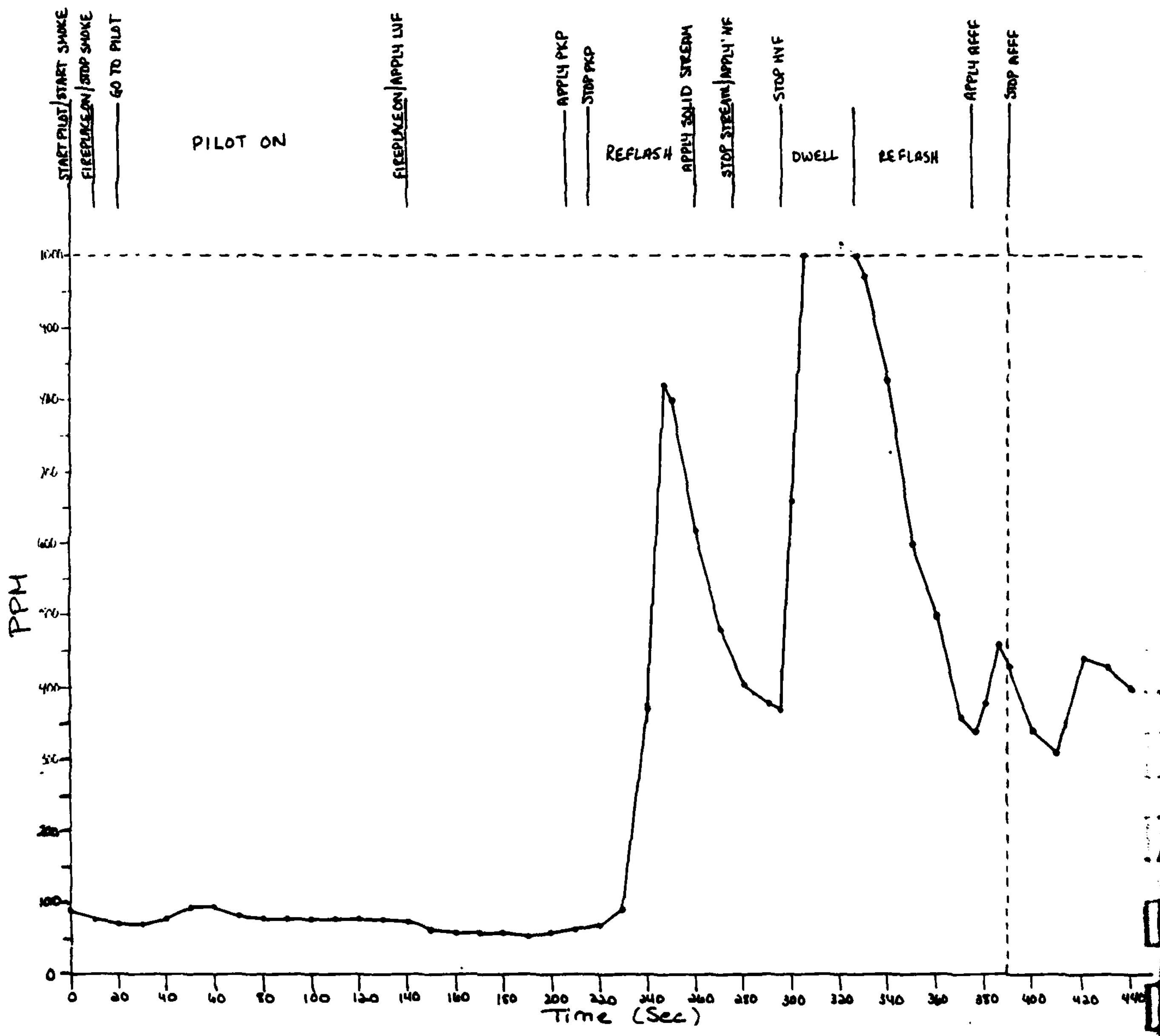
TABLE F-2 (Continued)

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
420	19.25	440	370	10.75	14,600
430	19.75	430	330	10.2	13,600
440	20.0	400	260	9.75	12,800

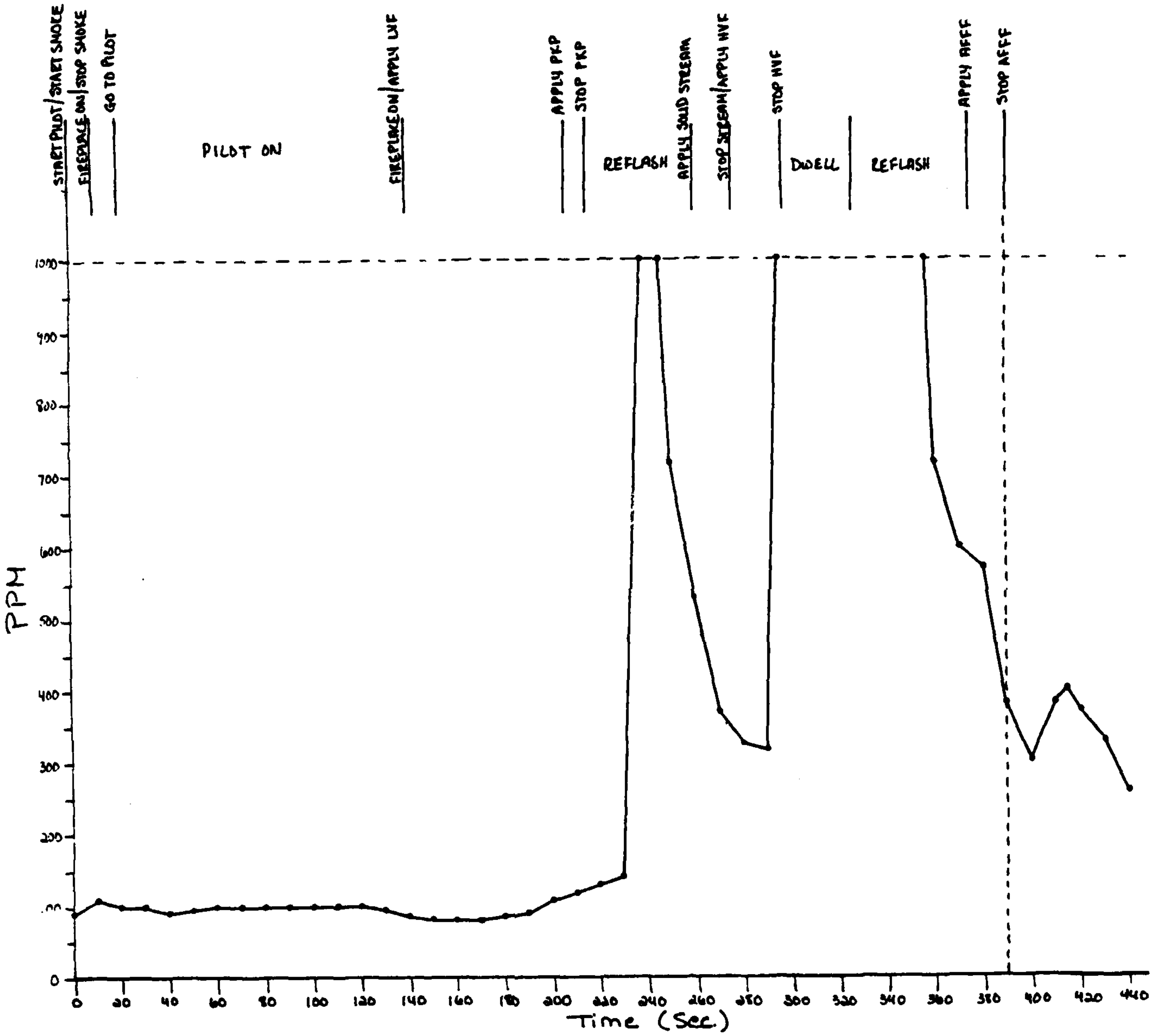
LDQI RUN 4 - O_2 LEVELS



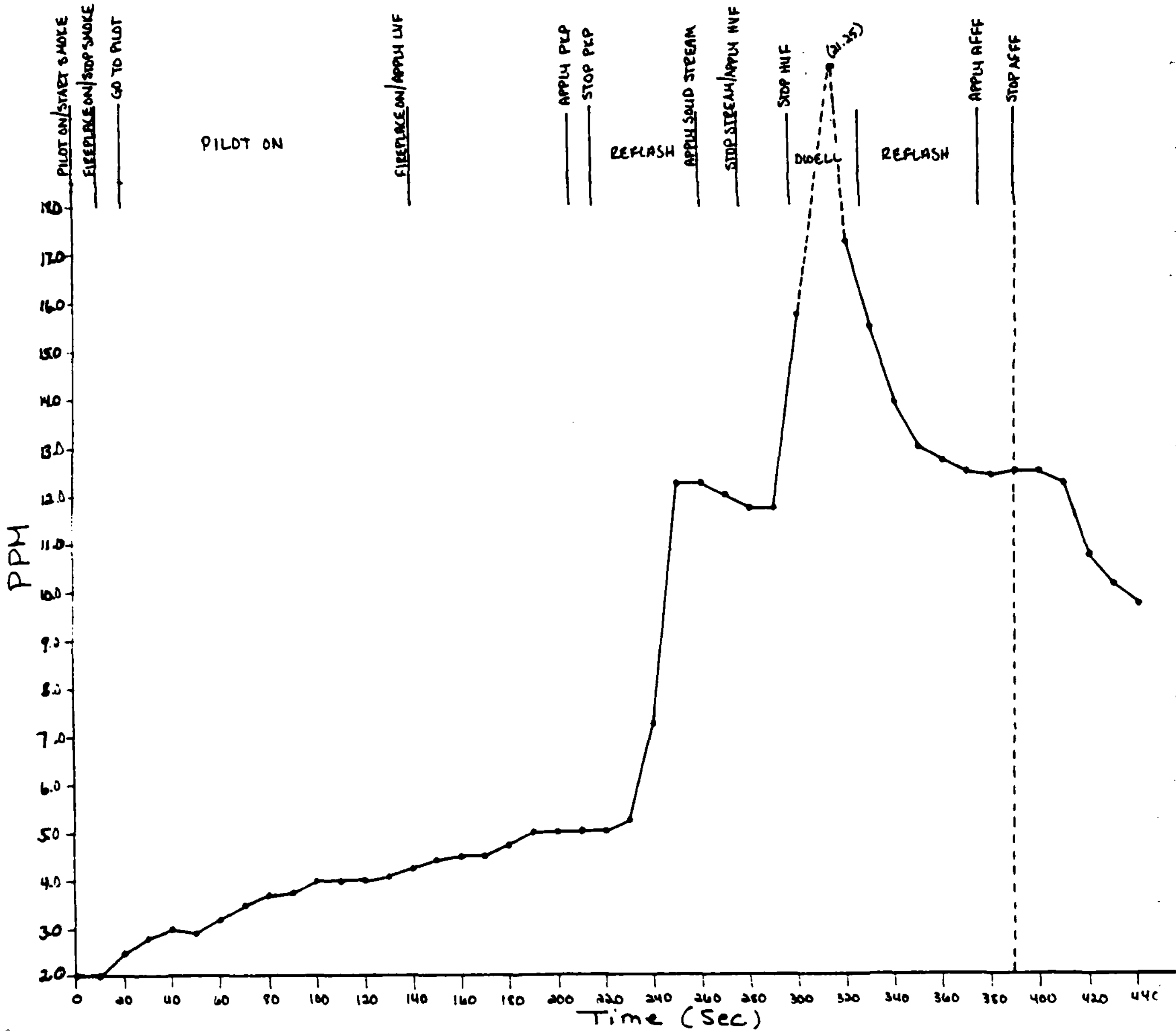
LDQI RUN 4 - CO LEVELS



LDQI RUN 4 - HC LEVELS



LDQI RUN 4 - NO_x LEVELS



LDQI RUN 4 - CO_2 LEVELS

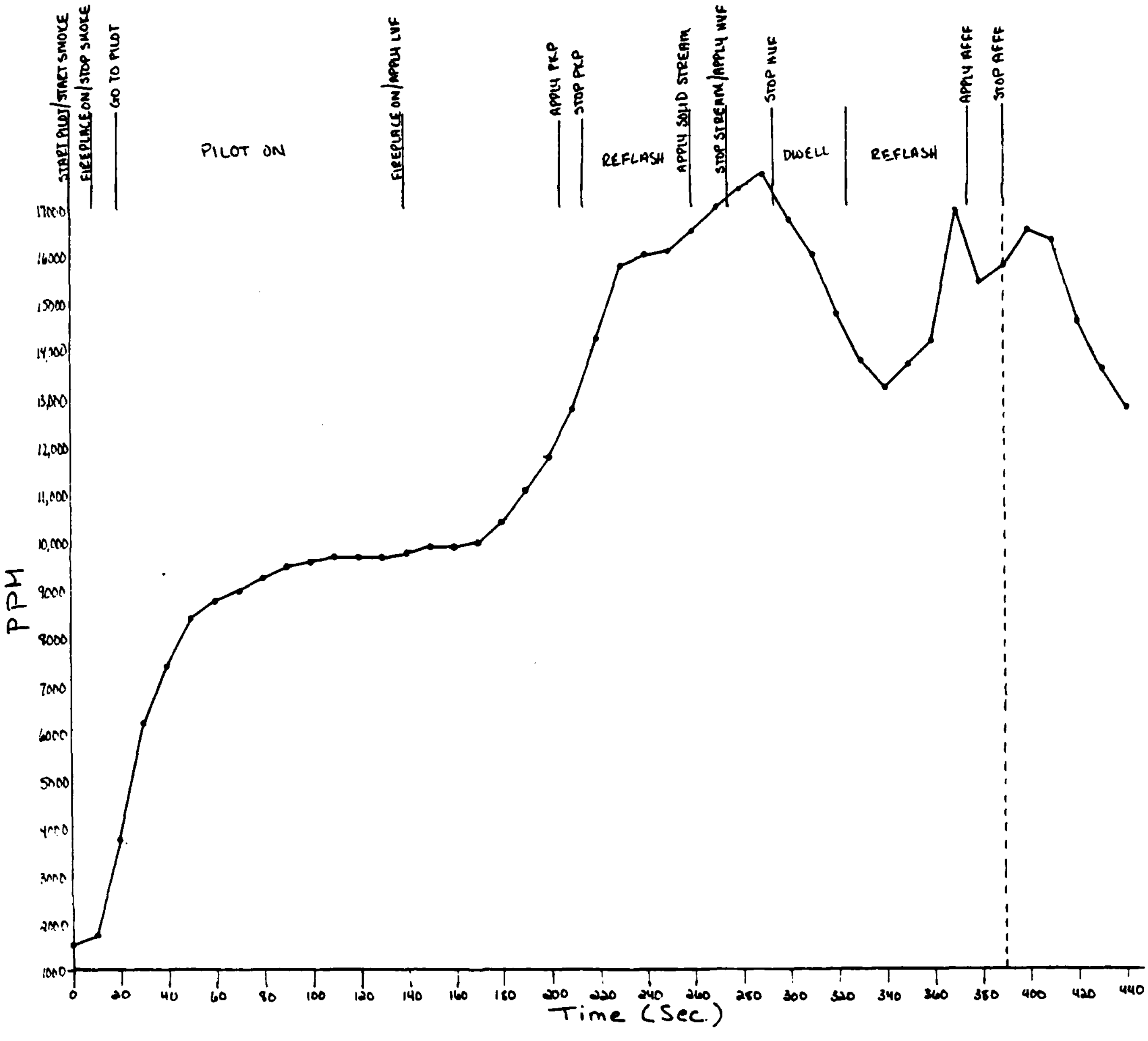


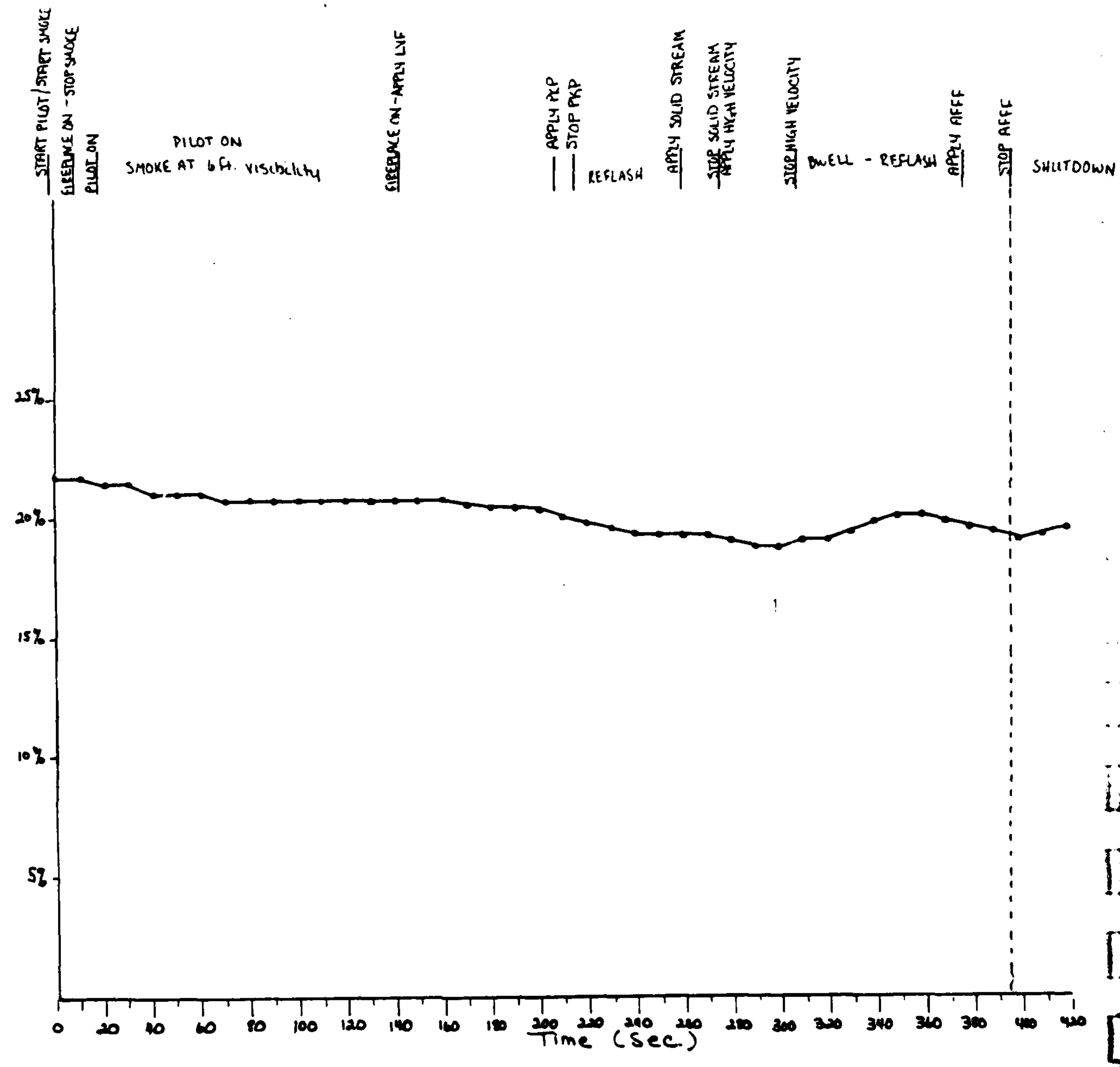
TABLE F-3. LDQI SCENARIO - RUN 5

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	21.75	60	90	2.5	1,600
10	21.75	60	100	2.5	2,800
20	21.5	65	90	3.0	5,400
30	21.5	80	85	3.5	7,500
40	21.0	85	90	3.2	8,400
50	21.0	90	100	3.0	9,000
60	21.0	100	120	3.0	9,600
70	20.75	105	130	3.2	9,600
80	20.75	120	130	3.4	9,800
90	20.75	120	120	3.5	9,800
100	20.75	120	120	3.7	10,000
110	20.75	120	115	4.0	10,000
120	20.75	115	110	4.0	10,000
130	20.75	110	115	4.0	10,000
140	20.75	110	120	4.0	10,100
150	20.75	110	120	4.25	10,100
160	20.75	105	120	4.3	10,200
170	20.6	100	120	4.5	10,400
180	20.5	100	140	4.5	11,200
190	20.5	115	160	4.3	11,600
200	20.3	130	160	4.5	12,500
210	20.0	130	160	4.75	13,800
220	19.75	130	160	5.0	15,400
230	19.5	140	440 (off chart at ≈ 233 sec.)	5.25	15,600
240	19.3	860 (off chart at ≈ 243 sec.)	off chart	10.0	15,700

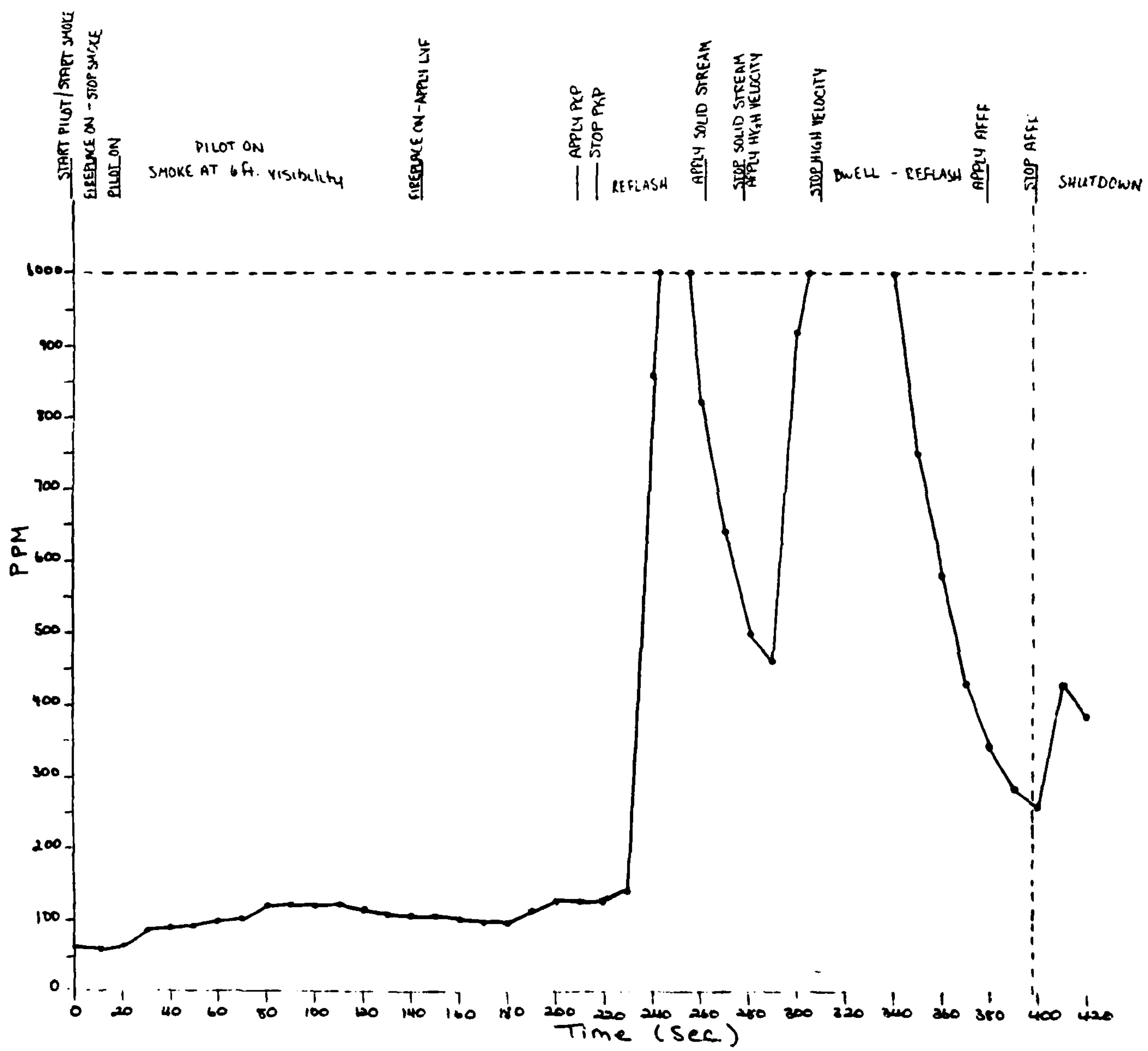
TABLE F-3 (Continued)

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
250	19.25	off chart	1,000	13.0	15,600
260	19.25	820	700	12.5	15,600
270	19.25	640	520	12.5	16,400
280	19.0	500	400	12.5	17,200
290	18.75	460	700 (off chart at ≈ 293 sec.)	12.25	17,200
300	18.75	920 (off chart at ≈ 305 sec.)	off chart	15.0	16,300
310	19.0	off chart	off chart	17.5	15,200
320	19.0	off chart	off chart	17.0	14,400
330	19.3	off chart	off chart	16.5	13,500
340	19.75	1,000	off chart	13.5	12,400
350	20.0	750	(1,060)	12.5	12,800
360	20.0	580	740	12.0	13,600
370	19.75	430	500	12.0	14,200
380	19.5	340	410	11.75	15,200
390	19.3	280	280	11.75	16,400
400	19.0	260	360	11.5	16,000
410	19.25	430	360	10.5	15,200
420	19.5	380	260	10.0	13,800

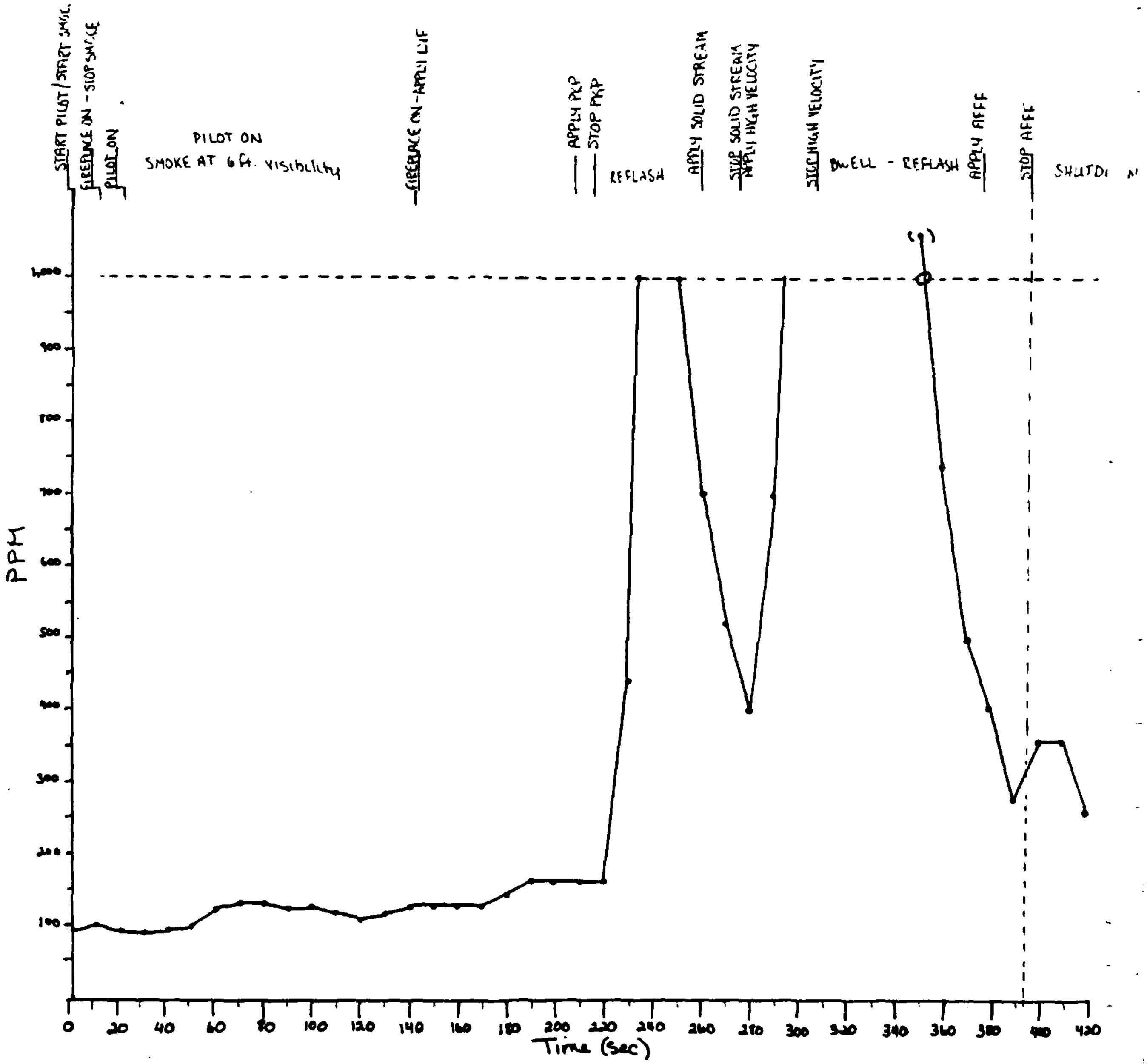
LDQI RUN 5 - O_2 LEVELS



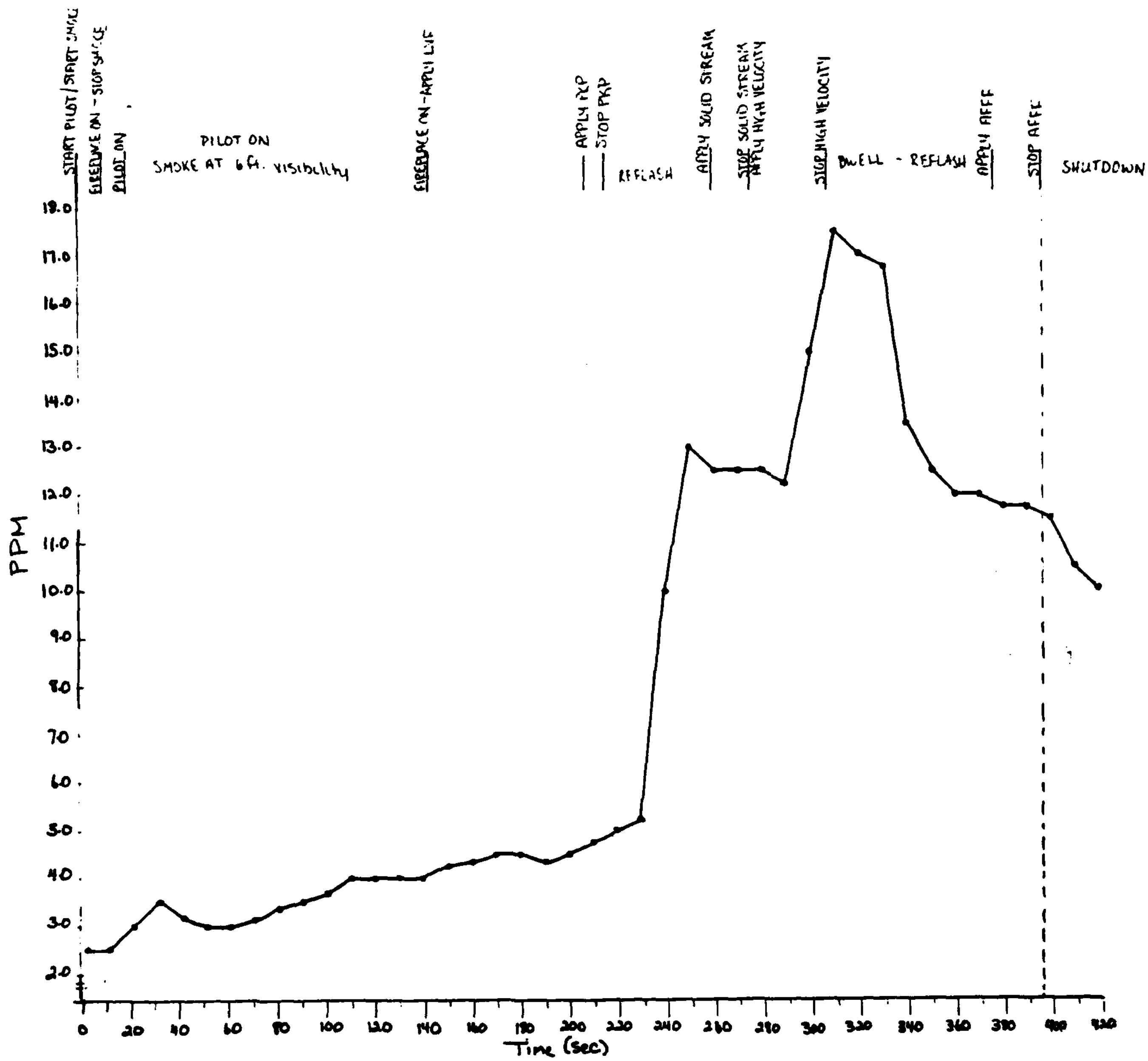
LDQI RUN 5 - CO LEVELS



LDQI RUN 5 - HC LEVELS



LDQI RUN 5 - NO_x LEVELS



LDQI RUN 5 - CO_2 LEVELS

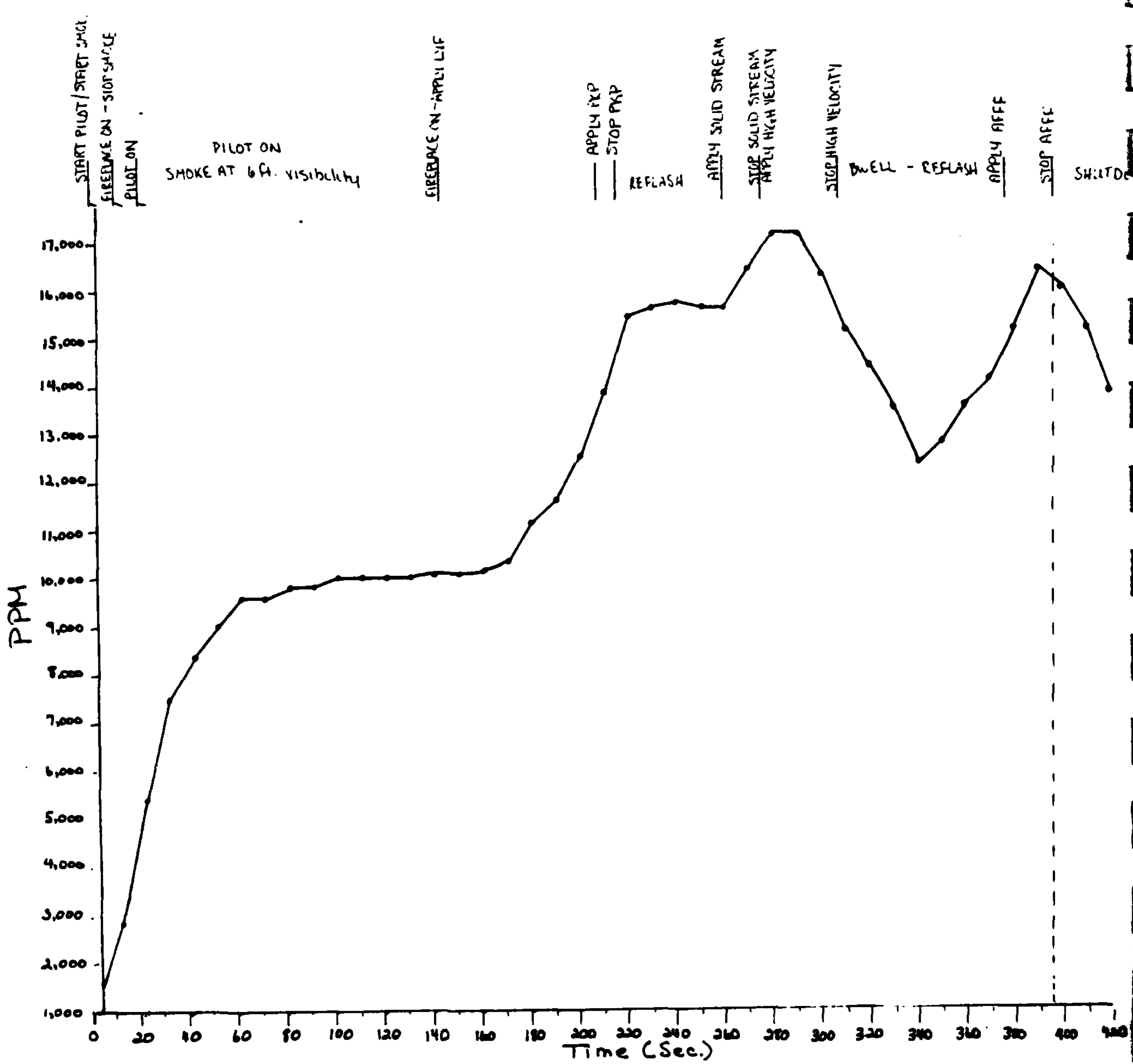


TABLE F-4. LDQI SCENARIO - RUN 6

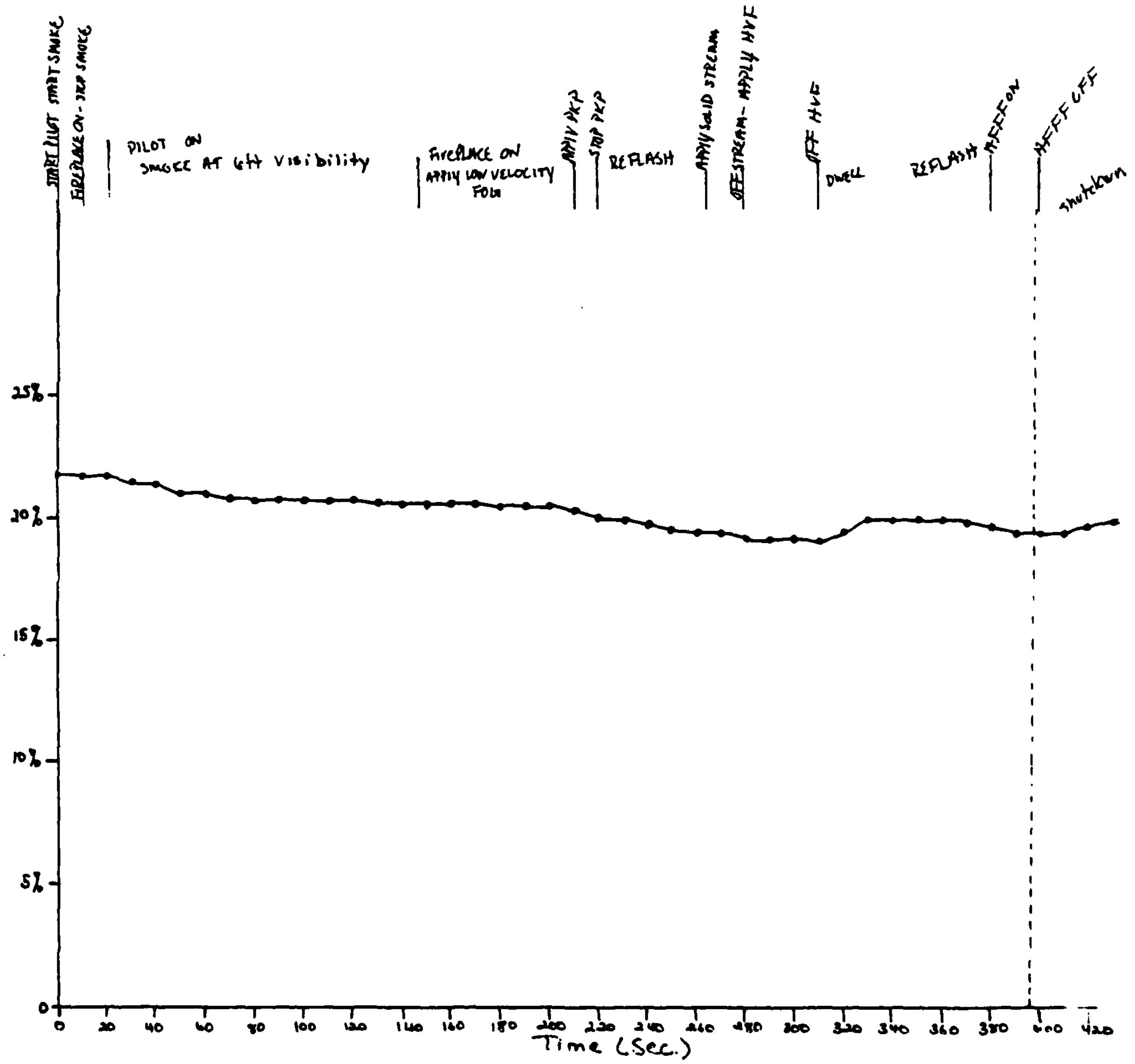
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	21.75	100	115	2.6	1,600
10	21.75	110	120	2.6	2,000
20	21.75	110	155	2.75	3,800
30	21.5	120	140	3.25	6,500
40	21.3	125	130	3.5	8,000
50	21.0	135	135	3.25	8,600
60	21.0	140	140	3.25	9,200
70	20.85	140	140	3.4	9,600
80	20.75	140	135	3.5	9,800
90	20.75	135	125	3.75	9,800
100	20.75	125	110	4.0	10,000
110	20.75	115	100	4.25	10,000
120	20.75	105	100	4.5	10,100
130	20.6	95	90	4.5	10,200
140	20.6	90	90	4.6	10,300
150	20.6	80	85	4.75	10,300
160	20.6	80	80	4.75	10,300
170	20.6	75	80	5.0	10,400
180	20.5	70	90	5.0	10,600
190	20.5	65	110	5.0	11,000
200	20.5	70	120	5.8	11,400
210	20.3	70	140	4.8	12,200
220	20.0	130	175	5.0	13,200
230	20.0	170	180	5.2	13,800
240	19.8	440	(1,040)	7.5	14,000
250	19.6	740	700	10.75	14,100
260	19.5	530	460	11.25	14,800
270	19.5	415	390	11.25	15,500
280	19.25	380	420	11.0	15,600

TABLE F-4 (Continued)

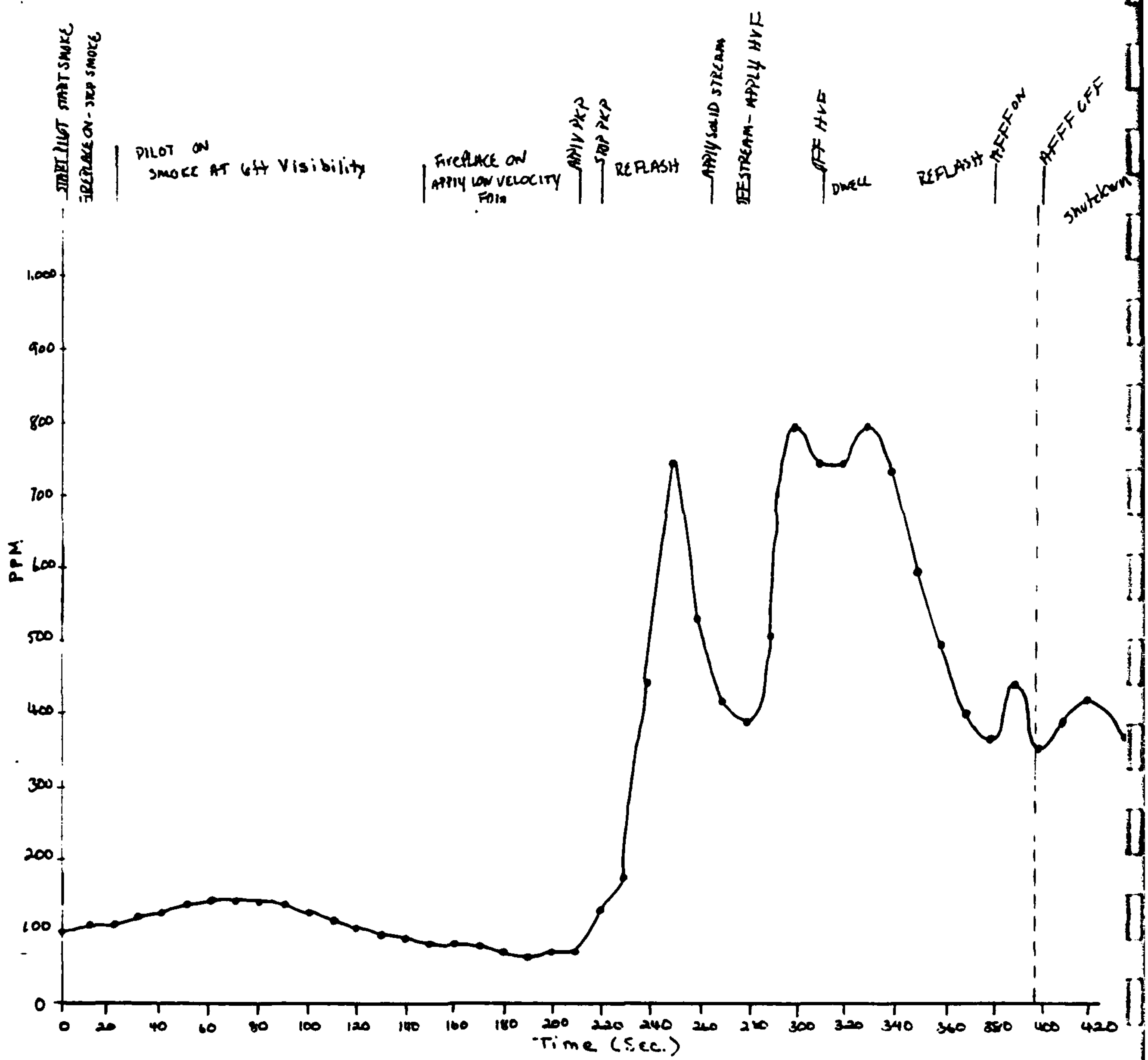
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
290	19.25	510	820 (off chart from 292-299 sec.)	11.5	15,400
300	19.25	790	940 (off chart at ≈ 306 sec.)	12.75	15,600
310	19.1	740	off chart	12.5	15,000
320	19.5	740	off chart	12.5	13,000
330	20.0	790	off chart	14.25	12,000
340	20.0	730	off chart	13.25	12,000
350	20.0	590	off chart (on chart at ≈ 357 sec.)	12.0	12,300
360	20.0	490	880	11.0	12,800
370	19.9	400	610	10.5	14,000
380	19.75	360	590	10.0	14,600
390	19.5	440	450	10.0	14,800
400	19.5	350	400	9.5	15,000
410	19.5	380	460	9.25	14,200
420	19.75	420	400	9.0	13,200
430	20.0	360	360	8.75	12,500

NOTE: Two pilots out.

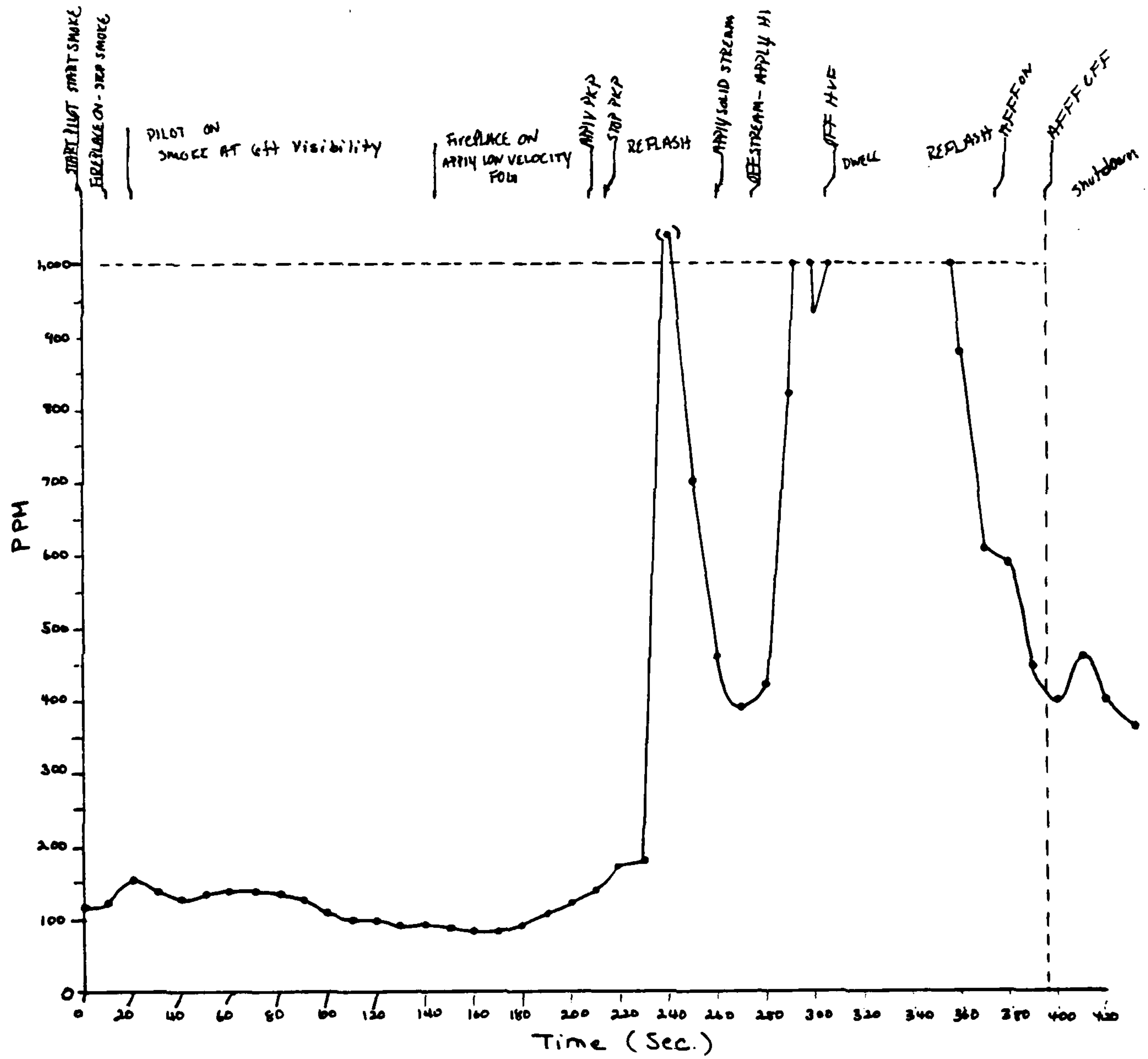
LDQI RUN 6 - O_2 LEVELS



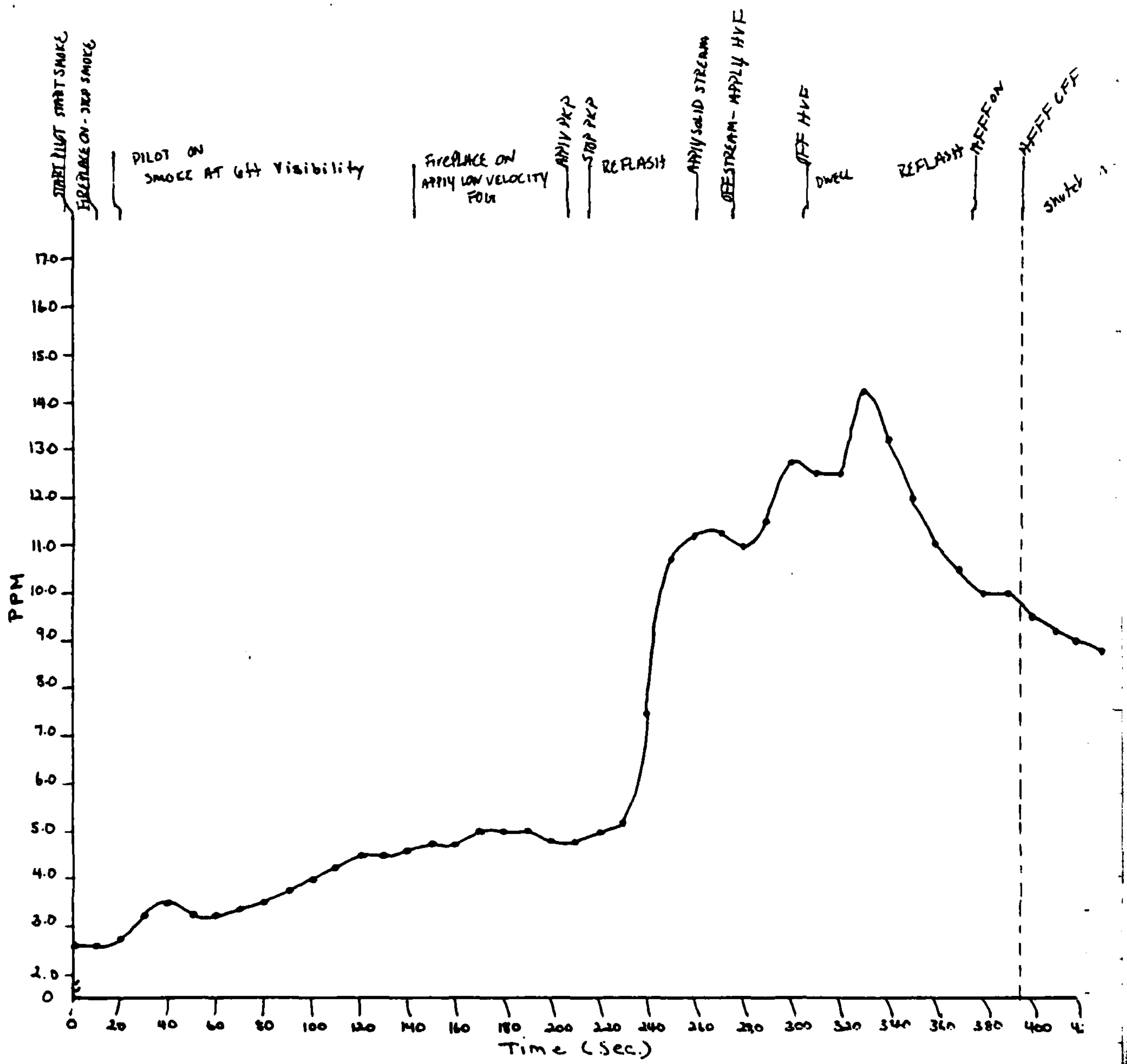
LDQI RUN 6 - CO LEVELS



LDQI RUN 6 - HC LEVELS



LDQI RUN 6 - NO_X LEVELS



LDQI RUN 6 - CO_2 LEVELS

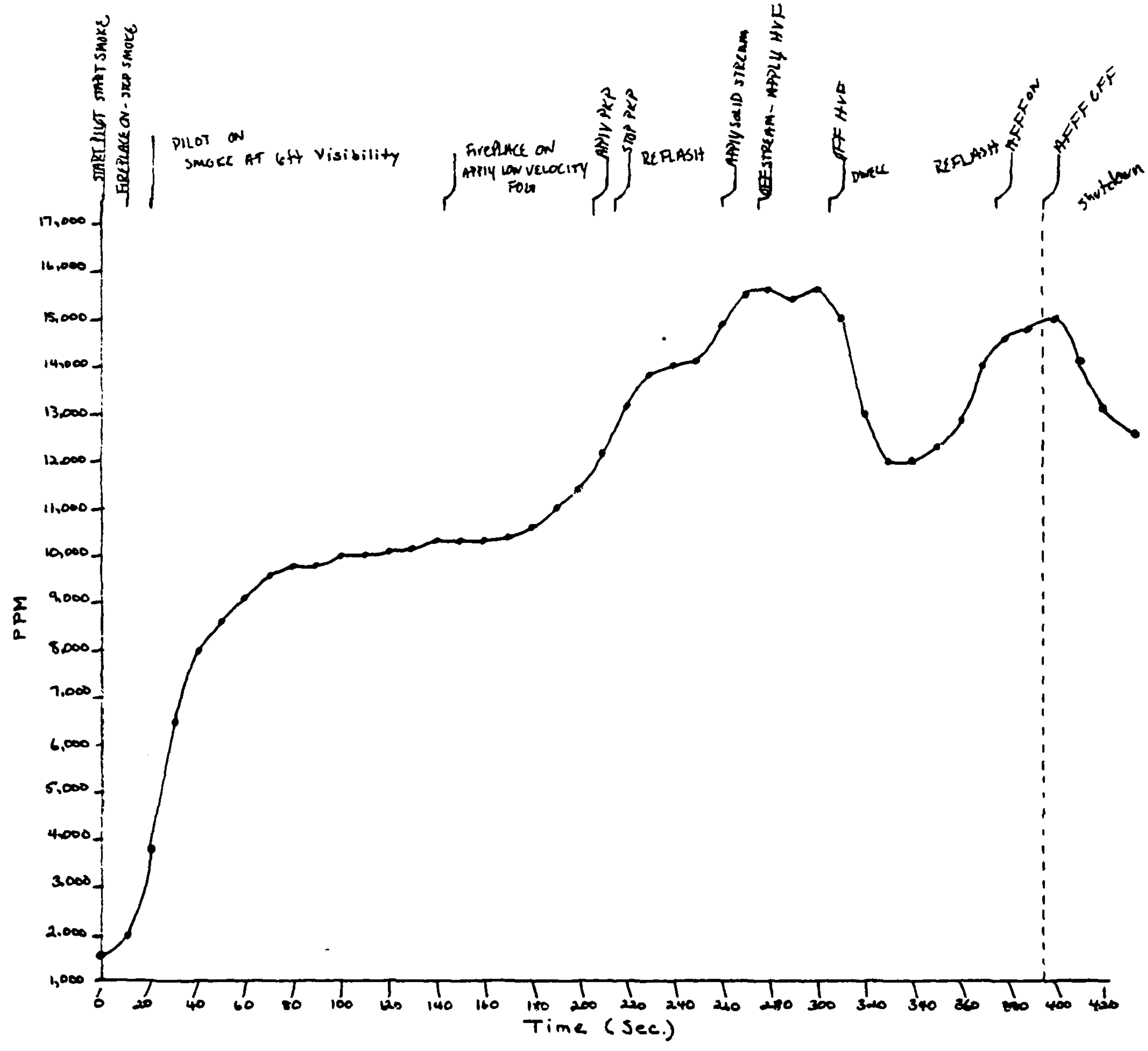


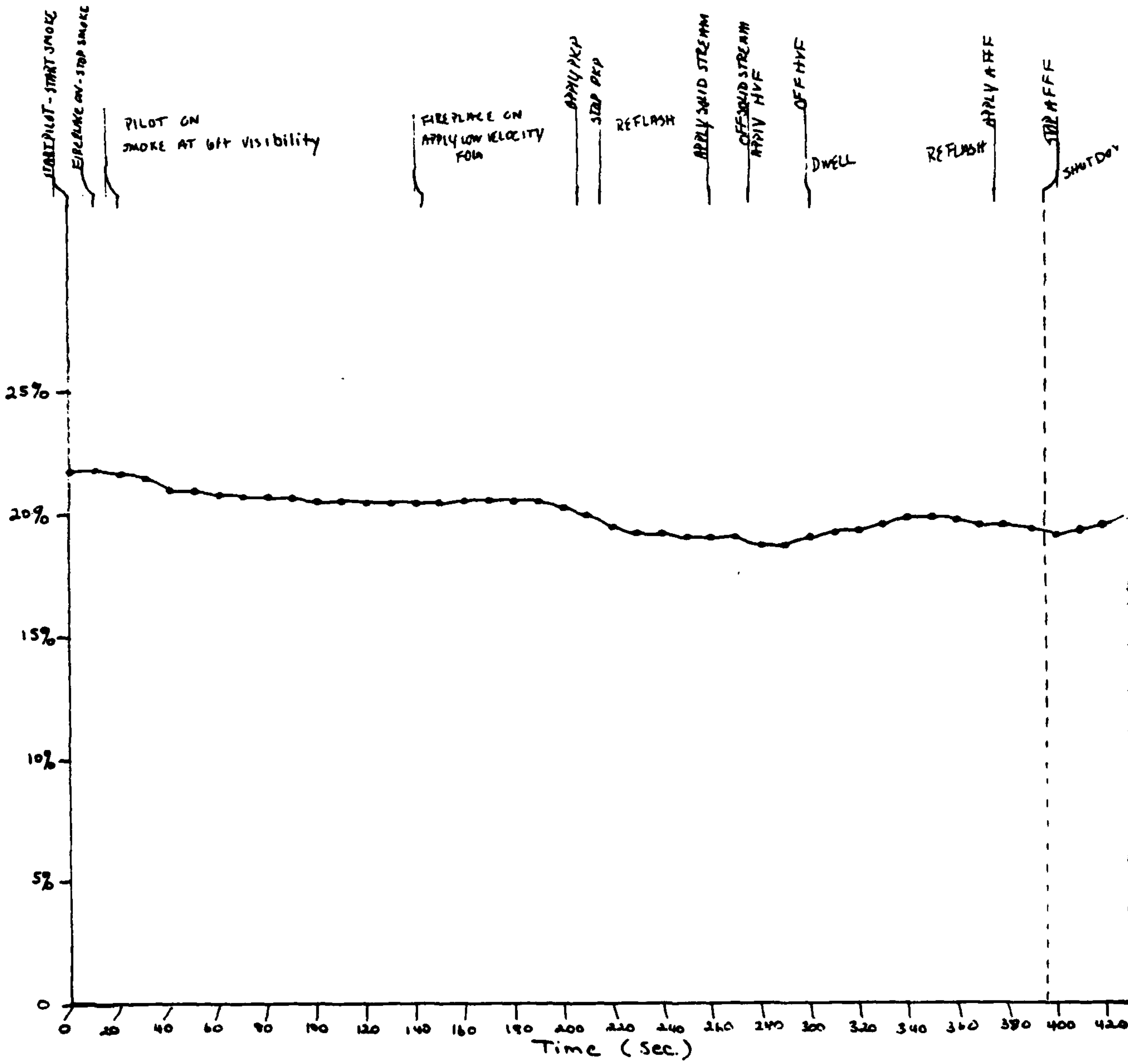
TABLE F-5. LDQI SCENARIO - RUN 9

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	21.75	80	85	2.3	1,600
10	21.75	80	110	2.5	2,100
20	21.6	85	120	2.75	4,400
30	21.5	90	110	3.5	7,000
40	21.0	100	105	3.5	8,200
50	21.0	105	105	3.6	8,700
60	20.85	100	105	3.75	9,200
70	20.75	100	105	4.0	9,600
80	20.75	100	105	4.25	9,800
90	20.75	100	105	4.4	9,900
100	20.6	95	100	4.5	10,000
110	20.6	90	100	4.6	10,100
120	20.5	90	105	4.6	10,100
130	20.5	90	120	4.4	10,100
140	20.5	95	140	4.25	10,100
150	20.5	100	130	4.4	10,000
160	20.6	90	120	4.5	10,100
170	20.6	80	110	4.75	10,800
180	20.5	80	120	5.0	11,400
190	20.5	80	130	5.25	12,100
200	20.25	90	140	5.5	13,600
210	20.0	170	230	6.25	15,000
220	19.5	240	230	6.75	16,000
230	19.2	380	800 (peak at 900 at $\approx$ 234 sec.)	7.25	15,900
240	19.2	880	800	10.5	15,800
250	19.0	780	500	12.0	16,000
260	19.0	590	430	12.25	16,200

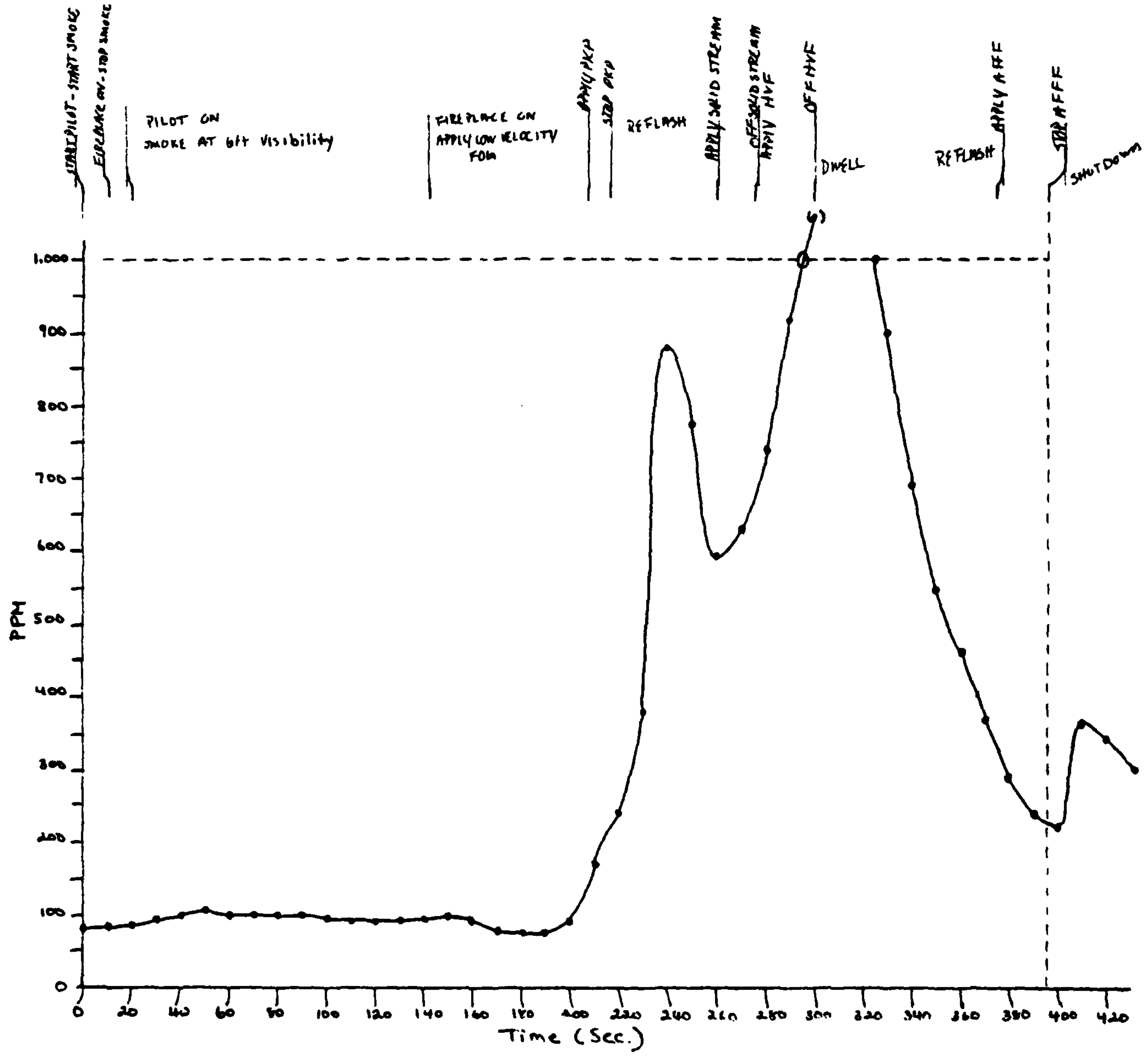
TABLE F-5 (Continued)

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
270	19.0	630	500	12.5	16,800
280	18.75	740	720 (off chart at ≈ 286 sec.)	12.5	16,800
290	18.75	920 (off chart)	off chart	13.5	16,400
300	19.0	(1,060)	off chart	16.5	15,800
310	19.2	off chart	off chart	17.0	15,000
320	19.25	off chart (on chart at ≈ 325 sec.)	off chart	15.5	14,200
330	19.5	900	1,000	13.75	13,600
340	19.8	690	710	12.8	13,600
350	19.8	550	580	12.25	14,000
360	19.7	460	480	12.0	14,400
370	19.5	370	390	11.5	15,000
380	19.5	290	310	11.25	16,000
390	19.25	240	260	11.2	16,600
400	19.0	220	320	11.0	16,400
410	19.2	360	280	10.0	14,800
420	19.5	340	250	9.5	13,800
430	20.0	300	220	9.0	12,200

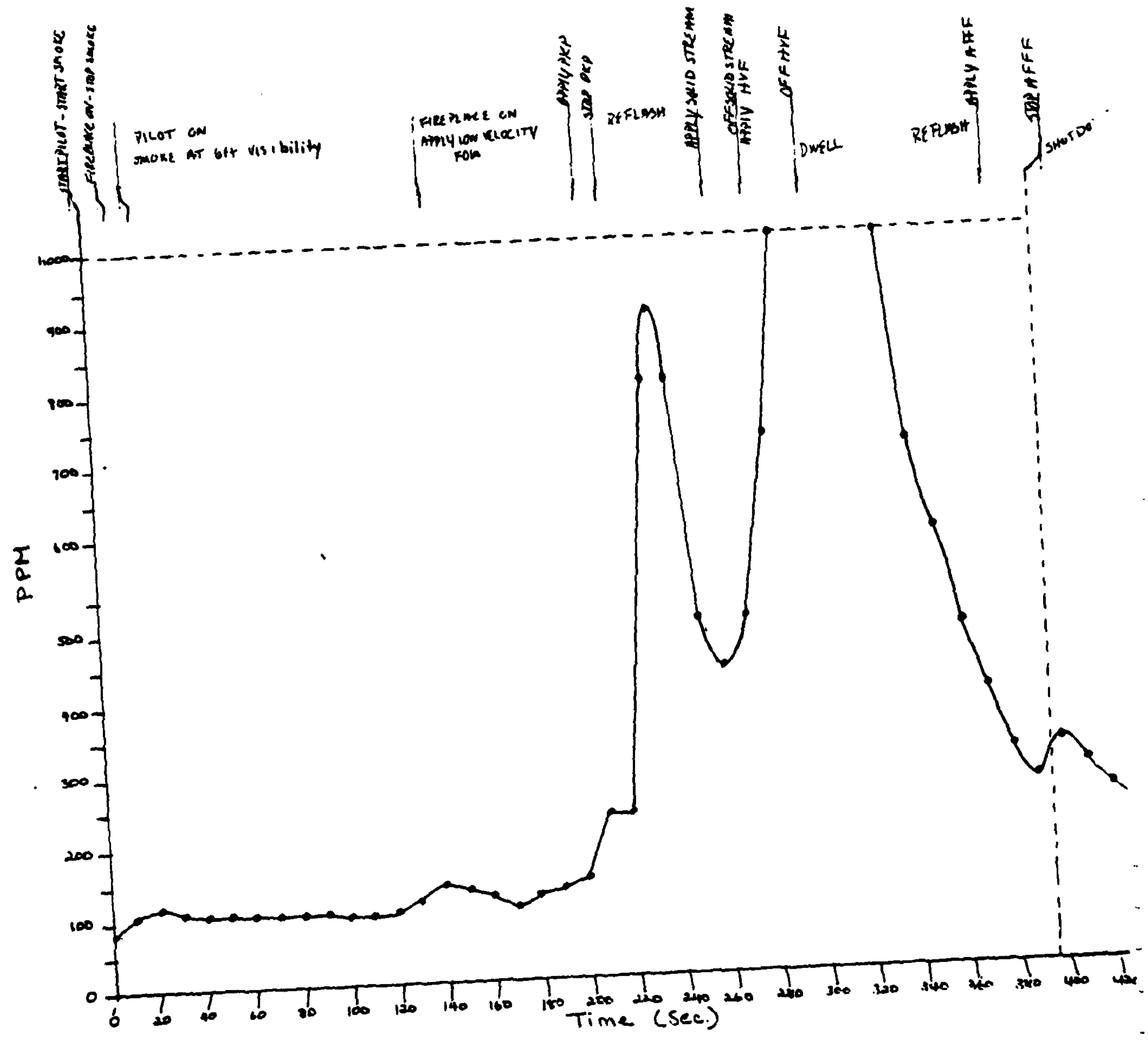
LDQI RUN 9 - O_2 LEVELS



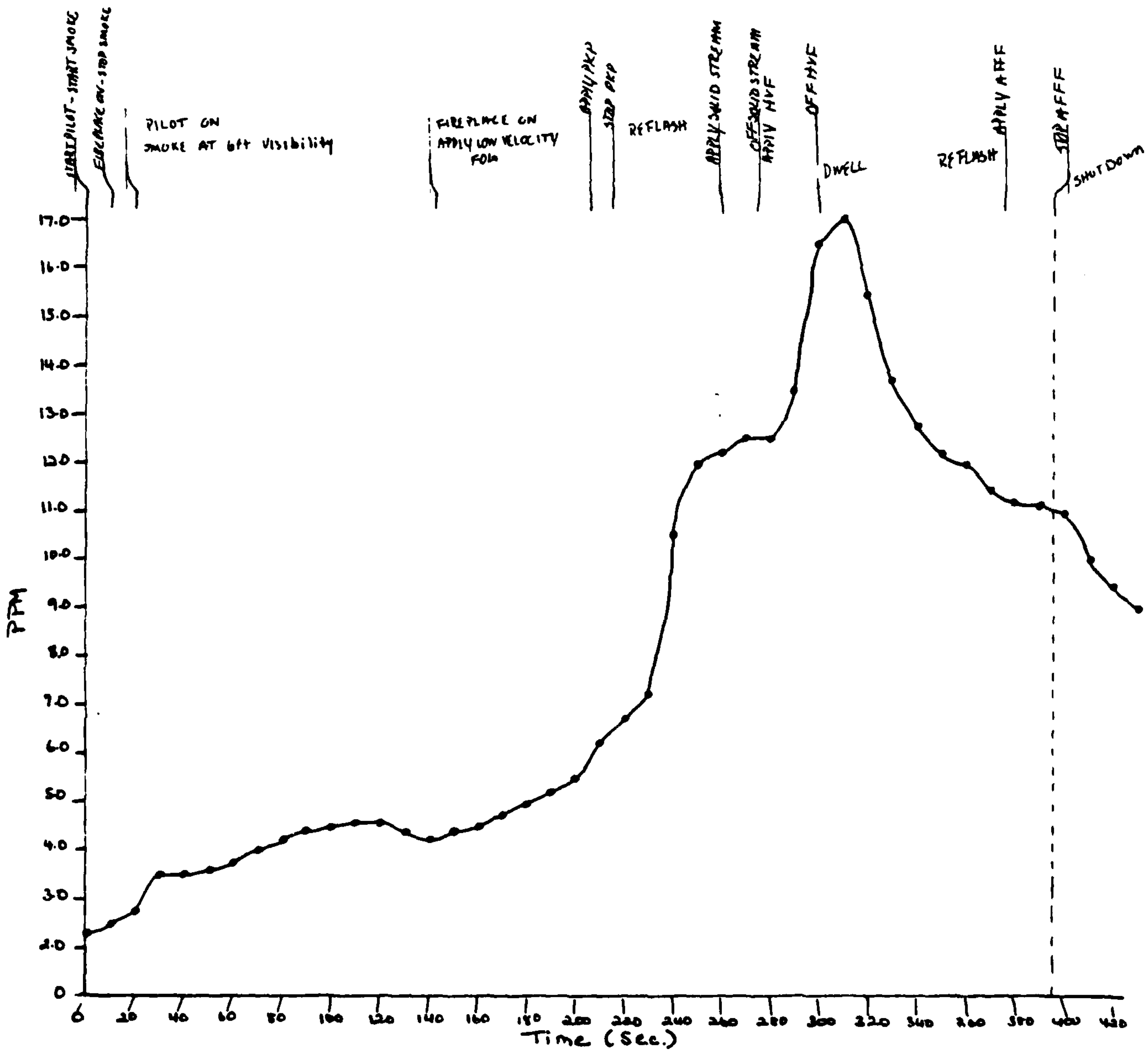
LDQI RUN 9 - CO LEVELS



LDQI RUN 9 - HC LEVELS



LDQI RUN 9 - NO_x LEVELS



LDQI RUN 9 - CO_2 LEVELS

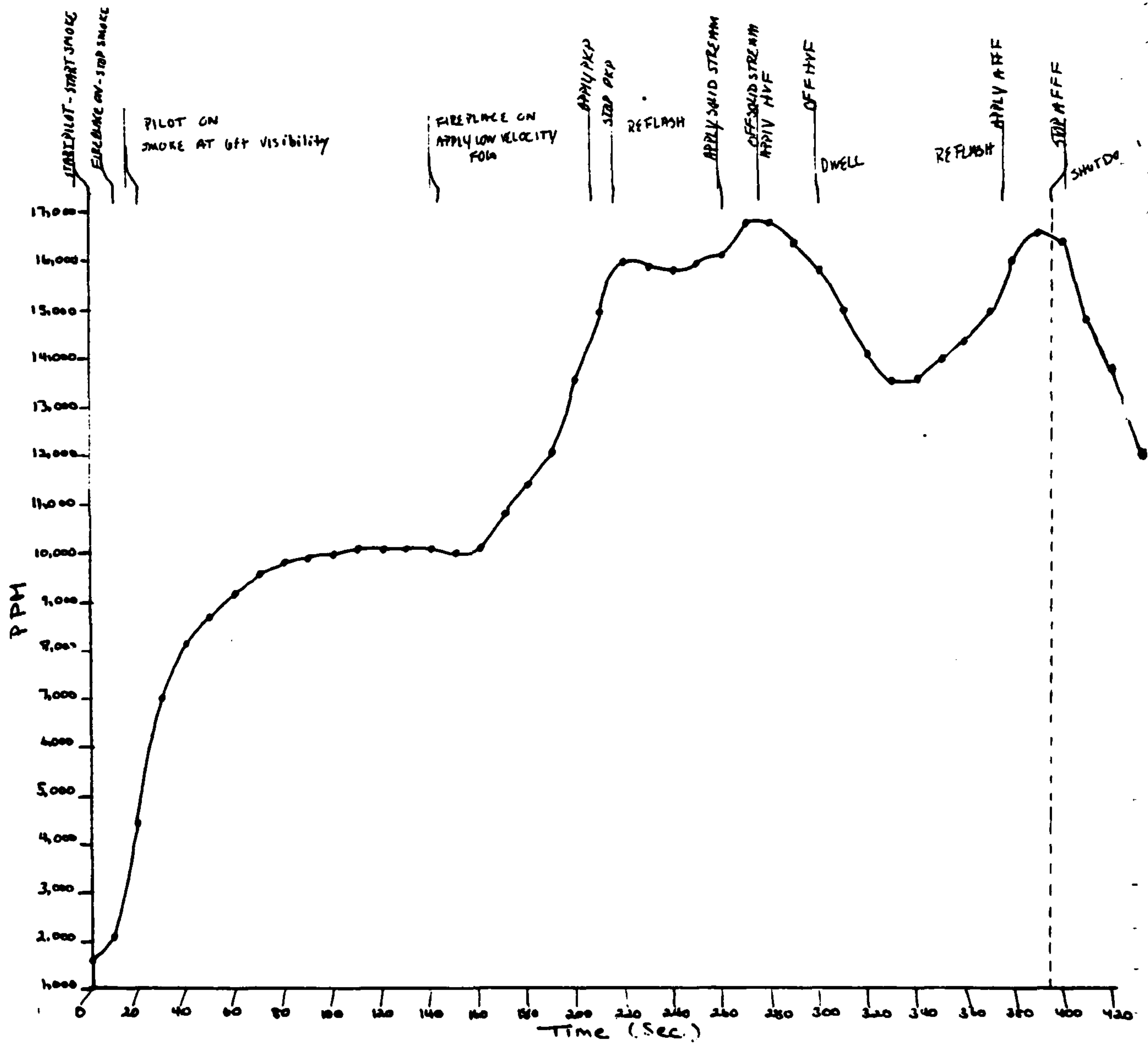


TABLE F-6. LDQI SCENARIO - RUN 10

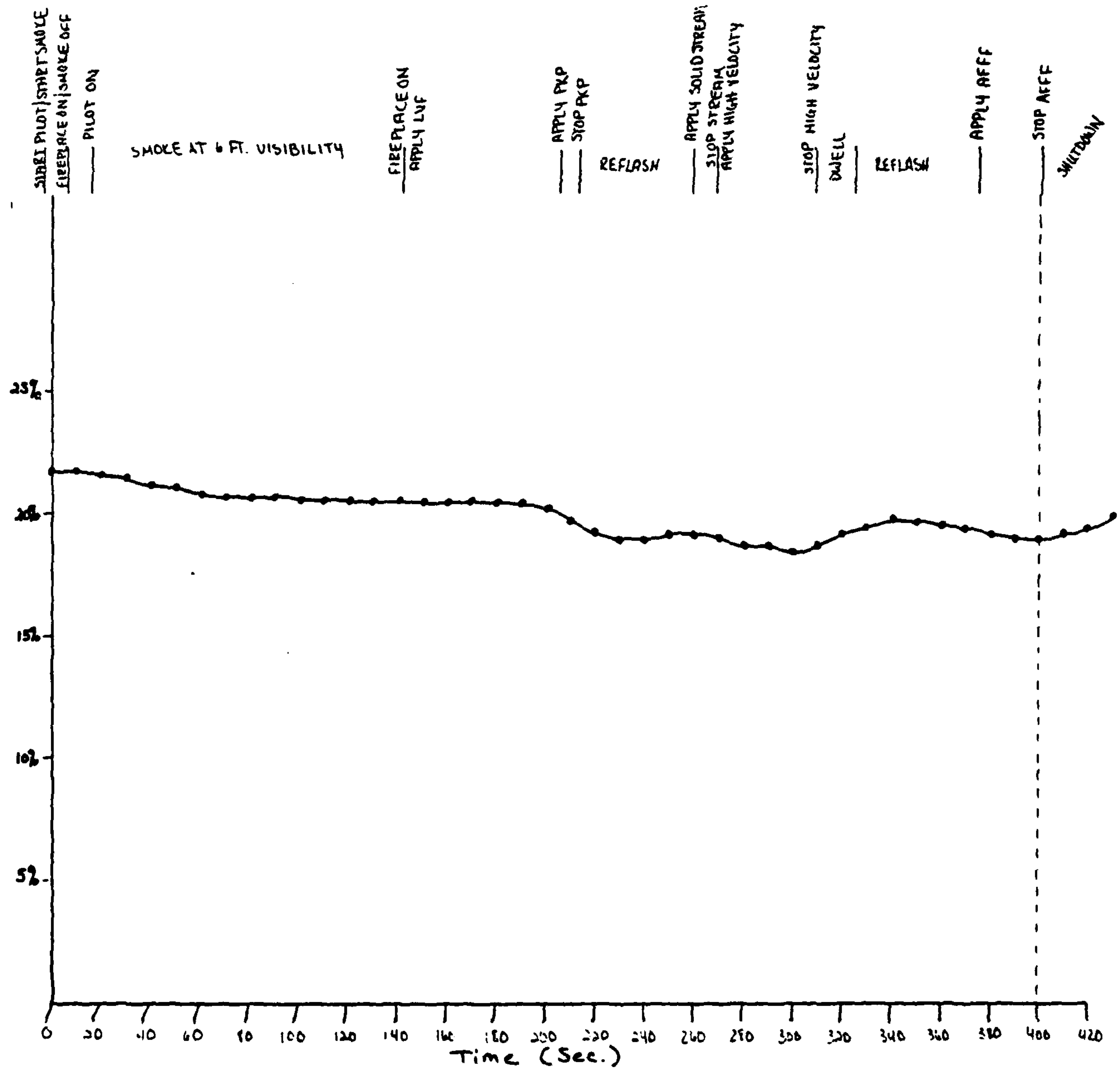
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	21.75	60	100	2.4	1,500
10	21.75	70	140	2.5	2,000
20	21.6	85	190	2.8	4,600
30	21.4	100	150	3.5	7,000
40	21.1	105	130	3.5	8,200
50	21.0	100	140	3.5	8,800
60	20.8	100	140	3.5	9,200
70	20.75	100	135	3.6	9,400
80	20.75	100	120	3.8	9,600
90	20.75	95	110	4.0	9,800
100	20.6	85	100	4.25	9,800
110	20.6	80	95	4.5	9,900
120	20.6	75	95	4.5	9,900
130	20.5	70	95	4.5	10,000
140	20.5	65	90	4.5	10,000
150	20.5	60	85	4.6	10,000
160	20.5	60	80	4.75	10,200
170	20.5	60	90	5.0	10,900
180	20.5	60	105	5.1	11,600
190	20.4	65	115	5.25	12,400
200	20.2	70	125	5.75	13,800
210	19.75	80	130	6.25	15,500
220	19.25	90	175	6.5	16,200
230	19.0	440	290	7.5	16,400
240	19.0	660	220	8.5	15,900
250	19.1	490	175	9.5	15,800
260	19.1	350	160	10.0	16,400
270	19.0	250	160	11.7	17,100
280	18.75	300	340	11.75	17,100

TABLE F-6 (Continued)

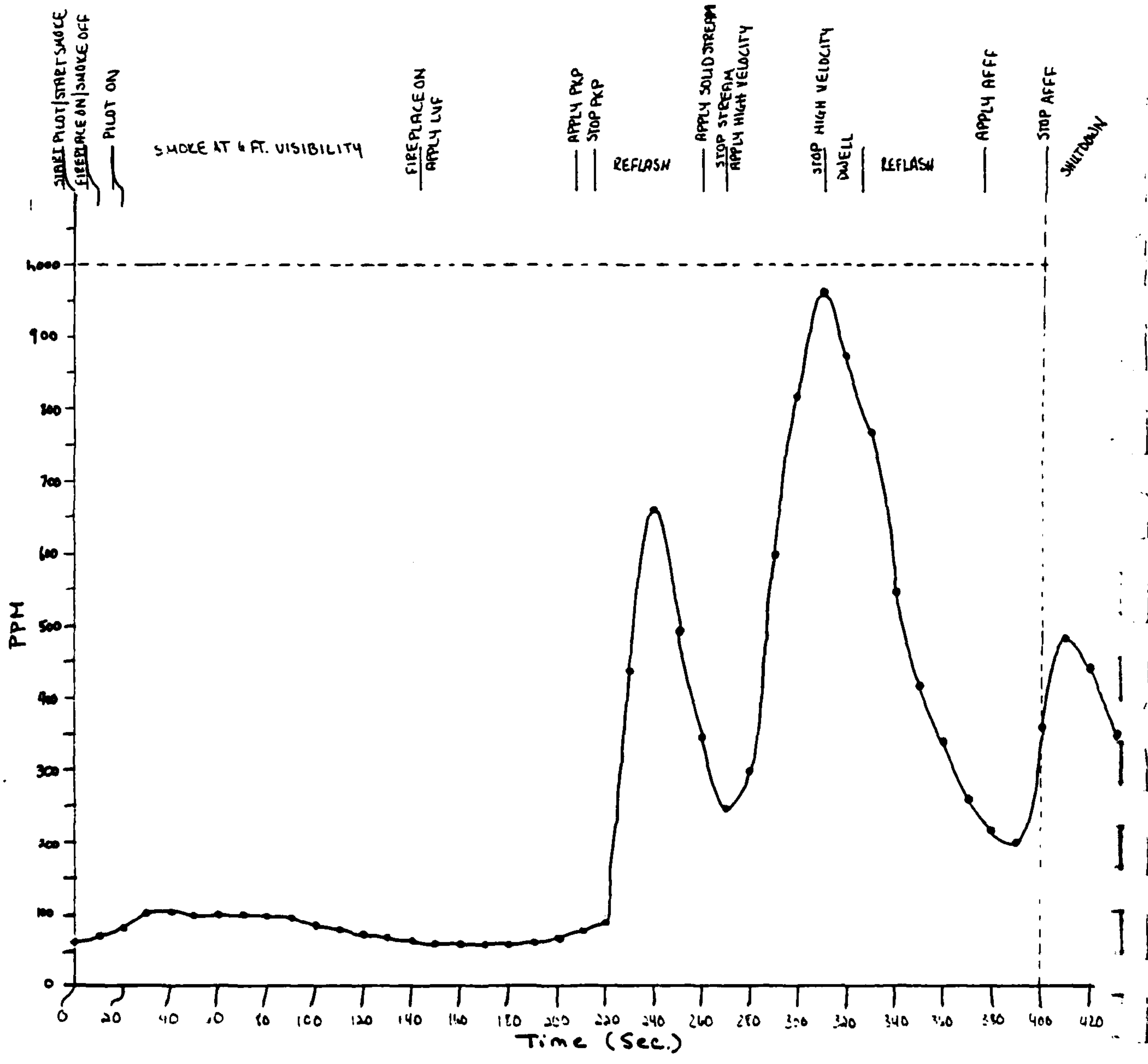
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
290	18.75	600	640 (off chart at ≈ 292 sec.)	12.5	17,800
300	18.5	820	off chart	14.5	16,800
310	18.75	960	off chart	16.5	16,000
320	19.25	870	off chart (on chart at ≈ 325 sec.)	14.0	14,000
330	19.5	770	700	12.5	13,600
340	19.75	550	470	11.75	14,000
350	19.75	420	380	11.5	14,500
360	19.6	340	280	11.5	15,200
370	19.5	260	220	11.5	16,200
380	19.2	220	175	11.75	16,900
390	19.0	200	300	11.25	16,800
400	19.0	360	430 (peak 500 at 406 sec.)	10.5	15,800
410	19.25	480	450	10.5	14,800
420	19.5	440	340	9.75	13,400
430	20.0	350	340	9.0	12,800

NOTE: No low velocity fog (LVF) used.

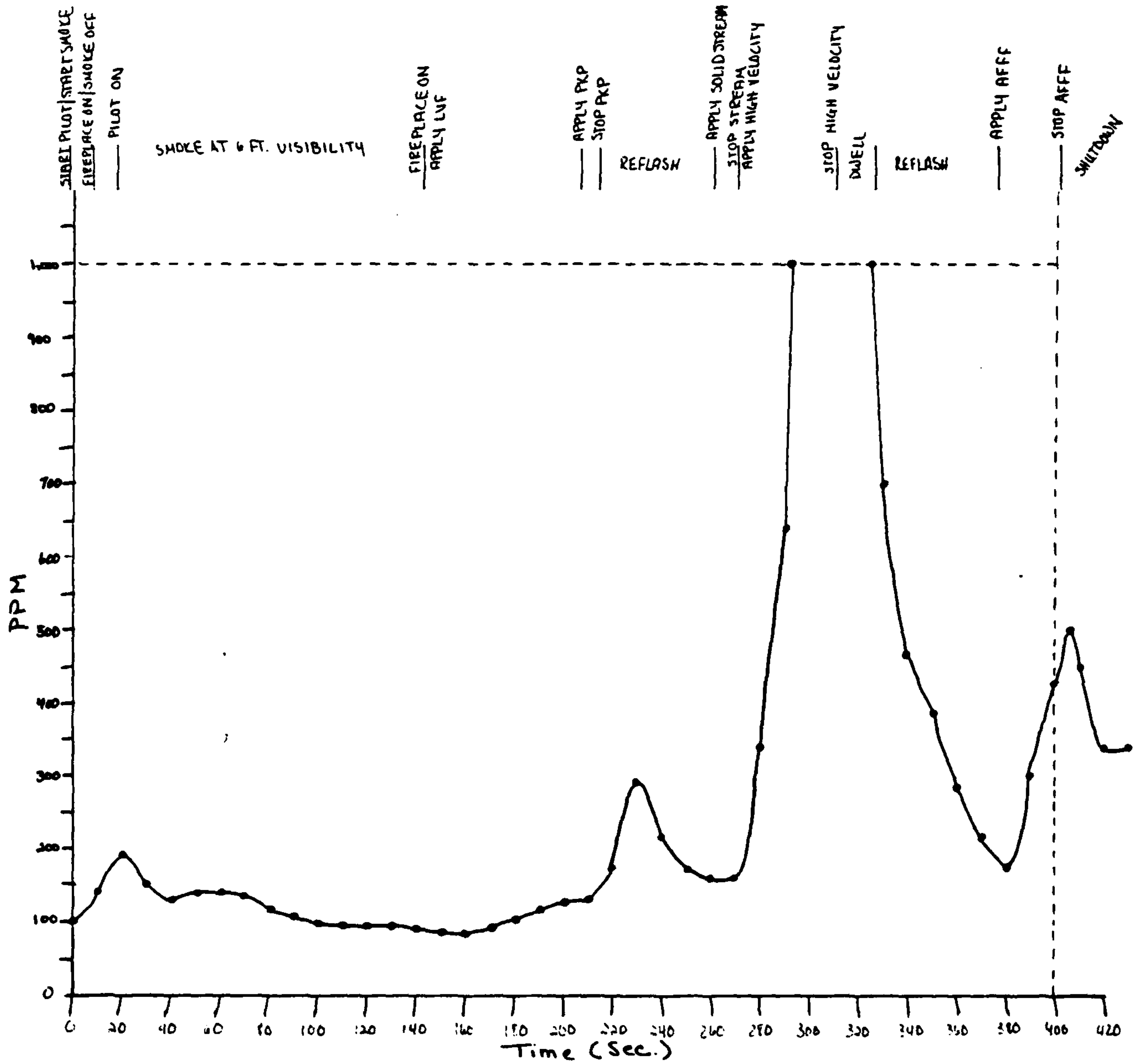
LDQI RUN 10 - O_2 LEVELS



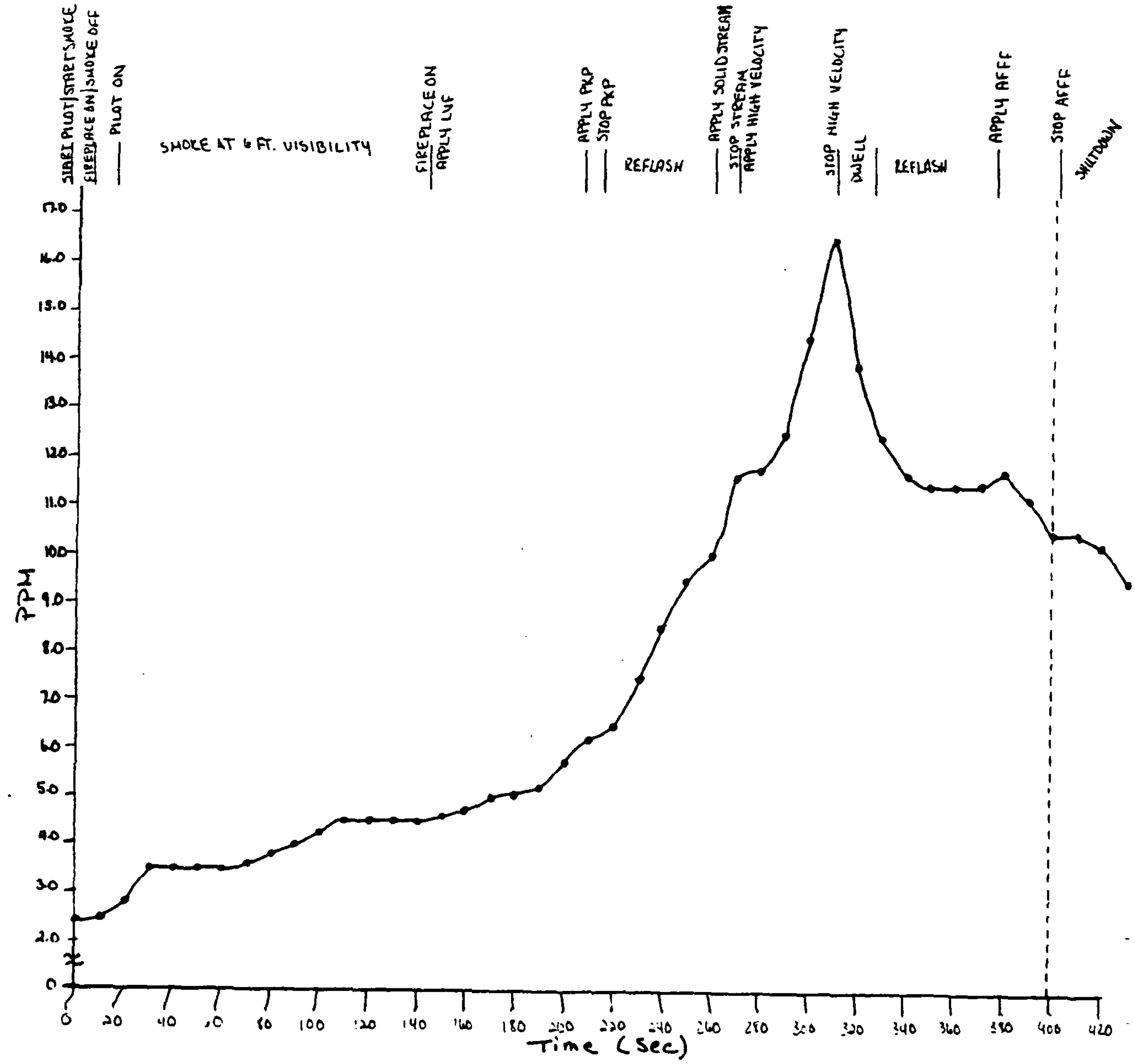
LDQI RUN 10 - CO LEVELS



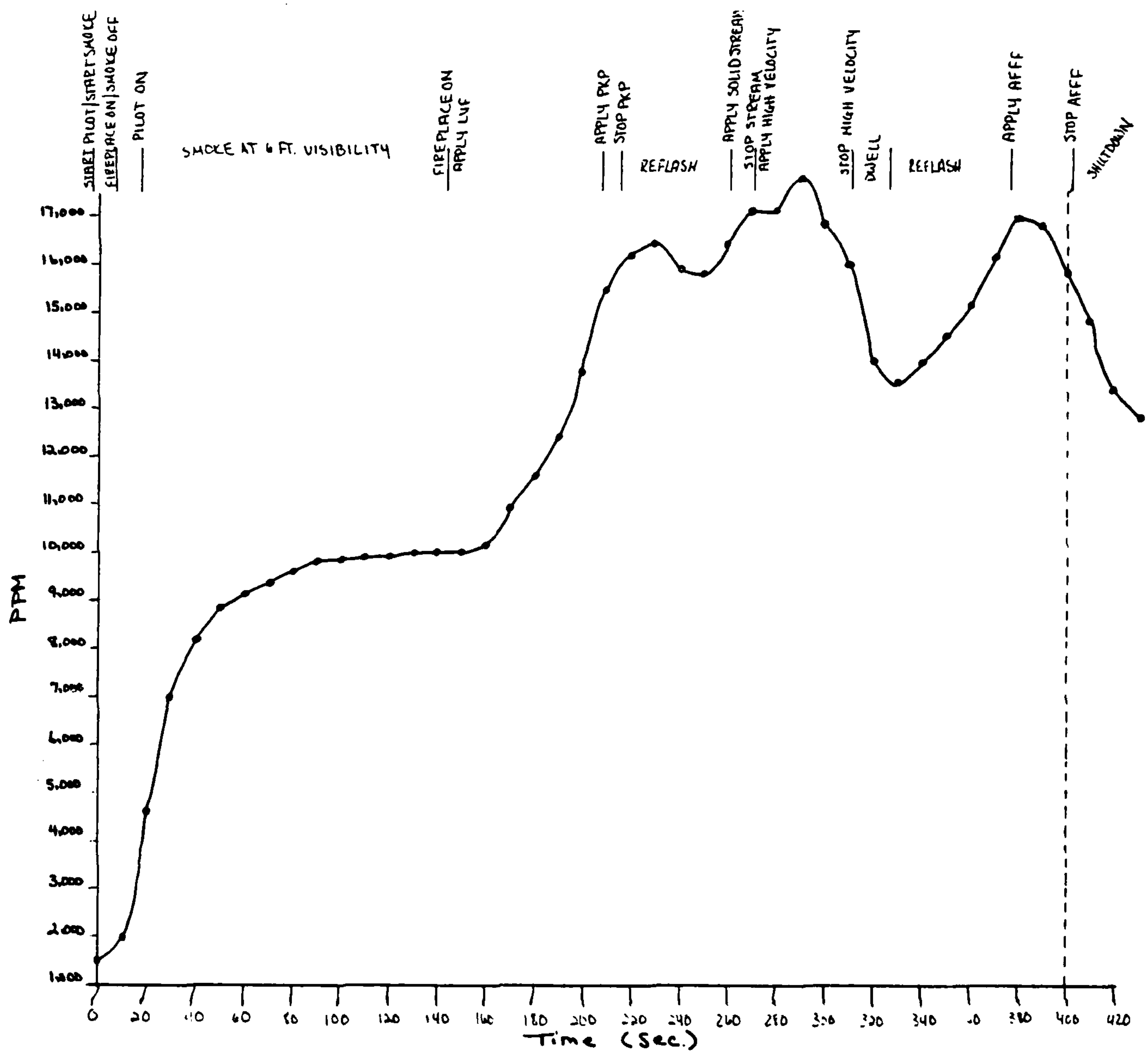
LDQI RUN 10 - HC LEVELS



LDQI RUN 10 - NO_x LEVELS



- LDQI RUN 10 - CO_2 LEVELS



UDQII INTERNAL ATMOSPHERE

(As Measured by ATS Equipment)

TABLE F-7. UDOII SCENARIO FOR DEEP FAT - RUN 3

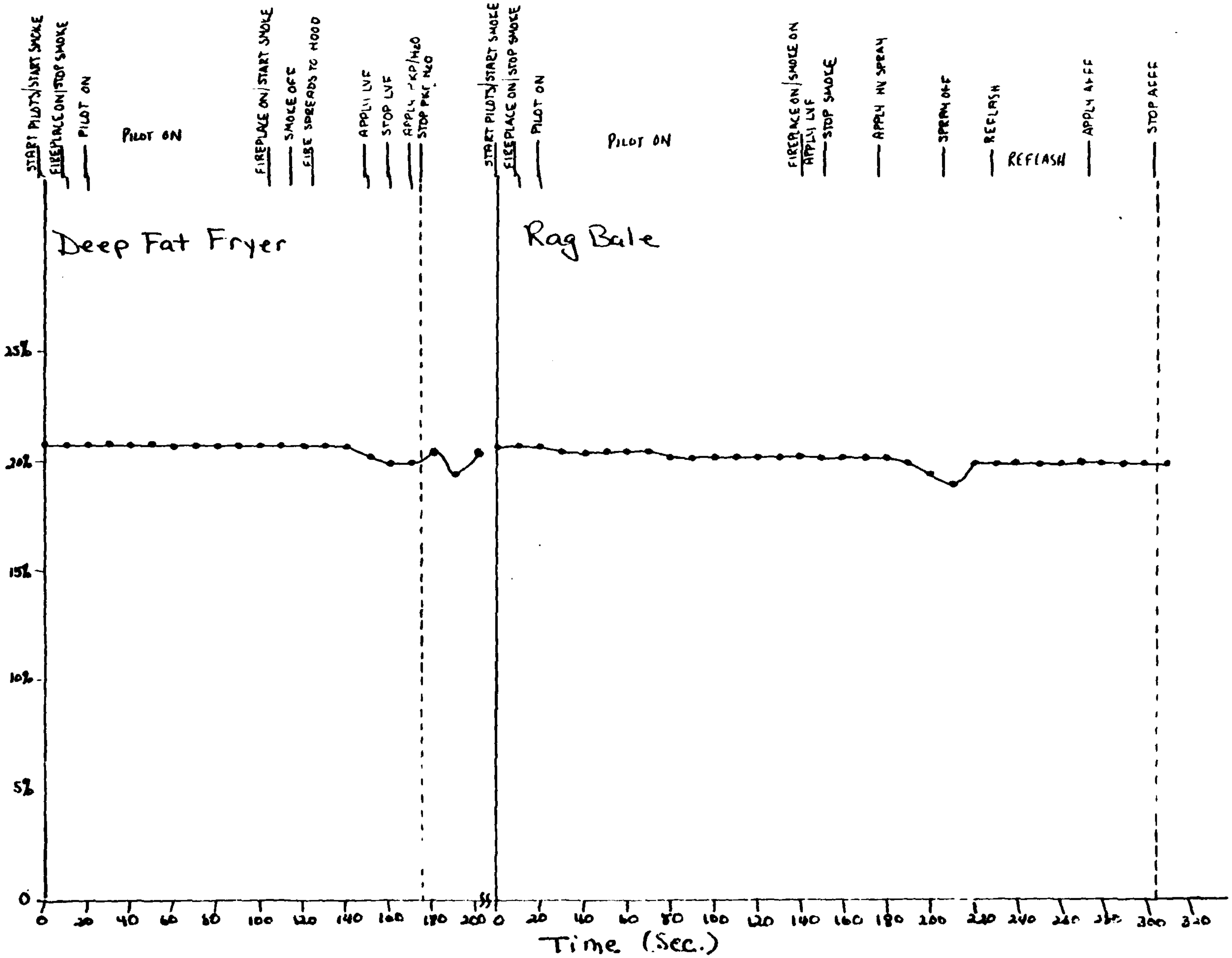
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	20.75	160	80	0.9	1,700
10	20.75	140	90	0.9	2,100
20	20.75	170	80	1.0	2,000
30	20.75	160	100	1.0	2,200
40	20.75	190	100	1.0	2,400
50	20.75	270	80	1.0	2,000
60	20.75	130	85	1.0	1,900
70	20.75	150	80	1.0	2,000
80	20.75	220	100	1.0	2,400
90	20.75	220	100	1.0	2,400
100	20.75	210	105	1.0	2,500
110	20.75	205	105	1.0	2,600
120	20.75	200	105	1.0	2,400
130	20.75	200	300 (peak 320 ≈ 131 sec.)	1.0	2,800
140	20.75	210	135	4.75	6,000
150	20.25	220	160	4.5	9,000
160	20.0	240	140	4.5	9,800
170	20.0	220	960 (off chart at ≈ 170 sec.) (on chart at ≈ 173 sec.)	4.75	4,800
180	20.5	450	600	10.5	12,800
190	19.5	290	300	9.5	4,800
200	20.5	210	260	6.25	3,400

TABLE F-8. UDQII SCENARIO FOR RAG BALE - RUN 3

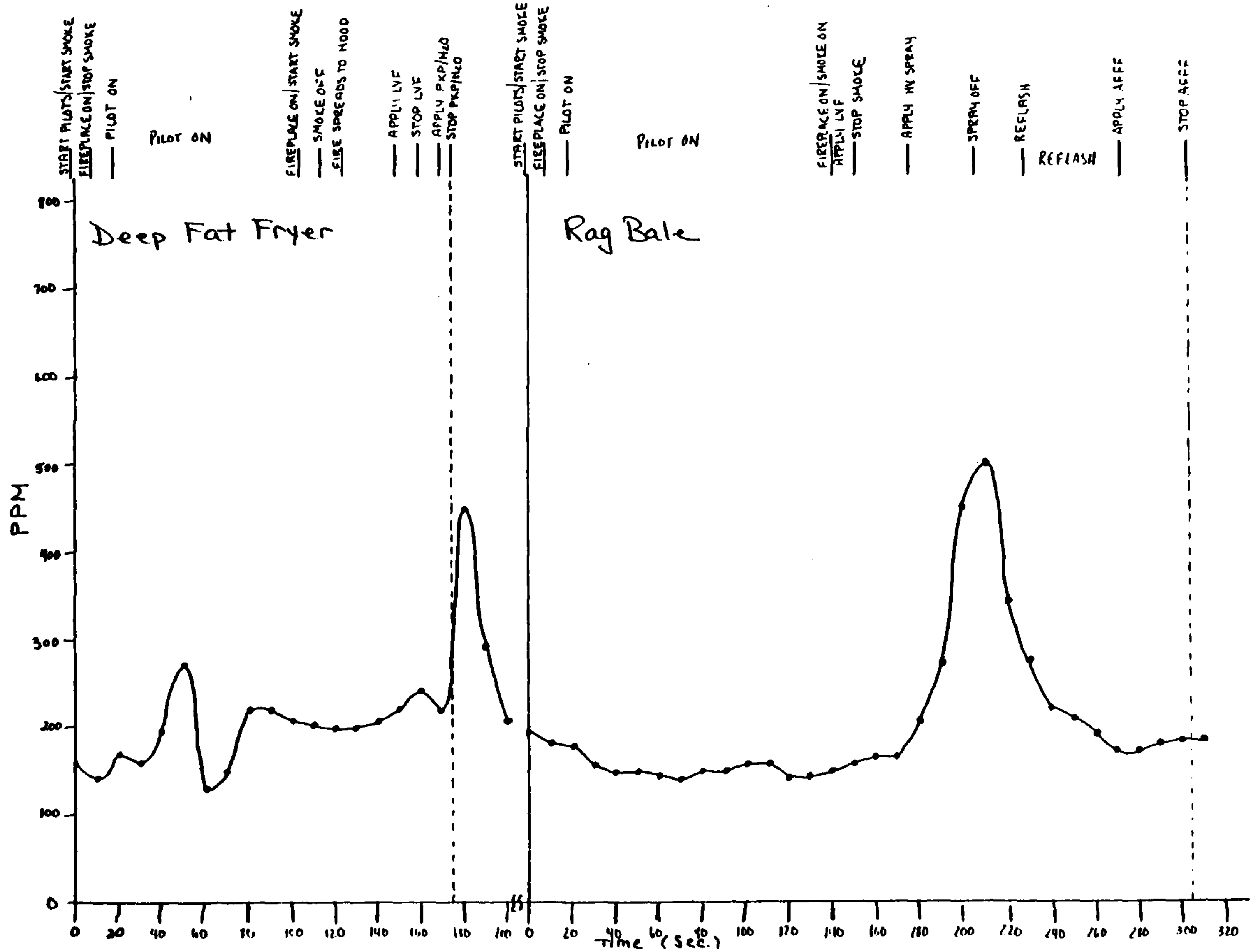
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	20.75	195	110	1.5	2,000
10	20.75	185	110	1.5	2,800
20	20.75	180	100	1.75	5,500
30	20.5	160	100	2.0	6,000
40	20.5	150	100	2.0	6,000
50	20.5	150	100	2.0	6,300
60	20.5	145	95	1.75	5,800
70	20.5	140	95	1.75	6,200 (6,600 at ≈ 75 sec.)
80	20.25	150	95	1.75	6,400
90	20.25	150	95	1.75	6,400
100	20.25	160	95	2.0	6,800
110	20.25	160	90	2.0	6,900
120	20.25	140	85	1.75	6,000
130	20.25	140	85	2.0	6,800
140	20.25	150	85	2.0	7,000
150	20.25	160	85	2.0	6,800
160	20.25	170	80	2.0	6,700 (6,000 at ≈ 165 sec.)
170	20.25	170	85	2.0	6,600
180	20.25	210	100	2.25	9,000
190	20.0	270	160	2.0	9,600
200	19.5	450 (525 at ≈ 206 sec.)	320	2.5	12,800
210	19.0	500	220	3.0	8,800
220	20.0	340	140	2.5	7,900

TABLE F-8 (Continued)

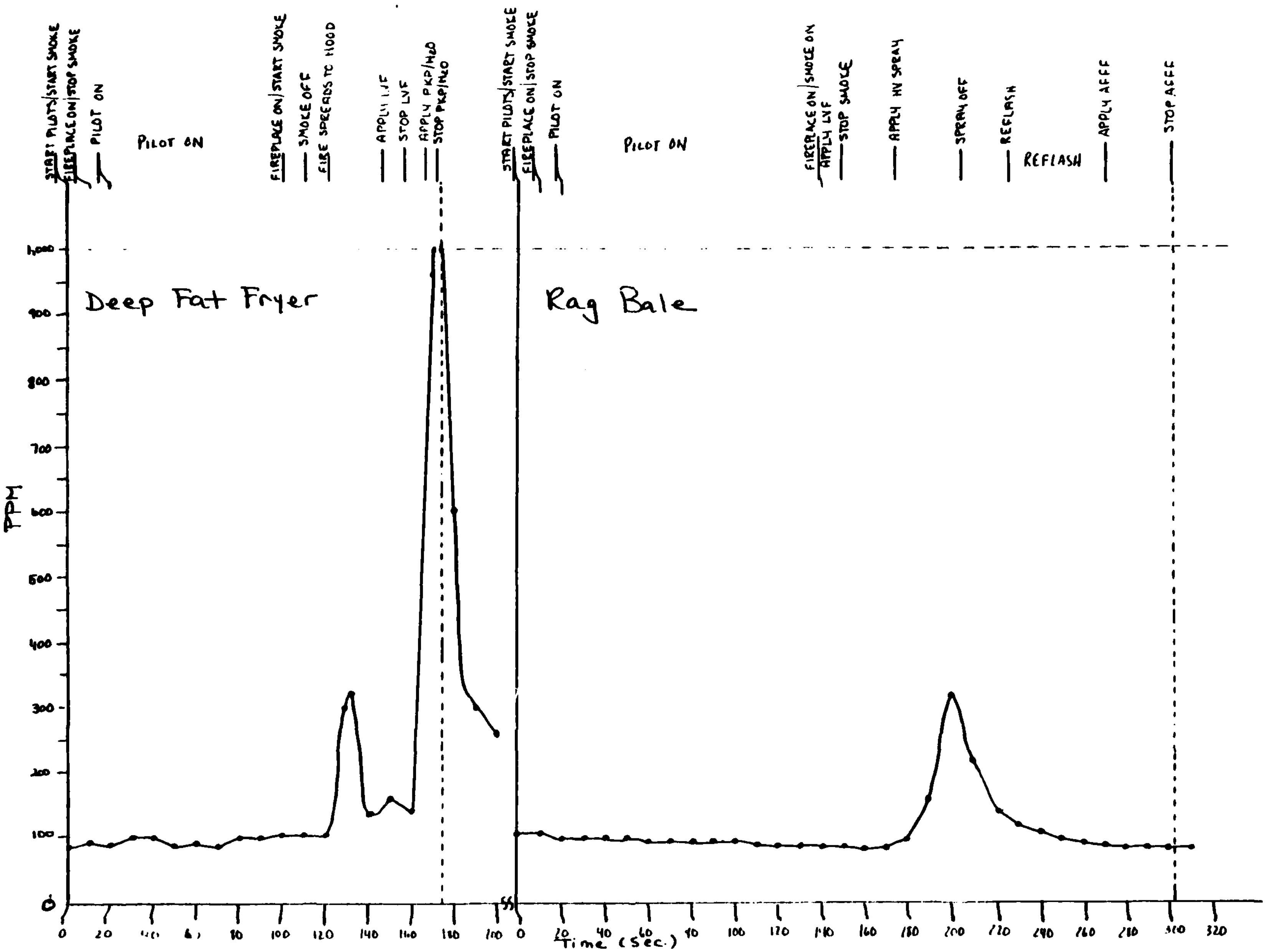
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
230	20.0	275	120	2.25	8,300
240	20.0	220	110	2.25	8,700
250	20.0	210	100	2.5	9,000
260	20.0	190	95	2.25	8,400
270	20.0	170	90	2.25	8,400
280	20.0	170	85	2.0	7,700
290	20.0	180	85	2.0	7,600
300	20.0	185	85	2.0	8,000
310	20.0	185	85	1.75	7,200
					(4,700 at ≈ 320 sec.)



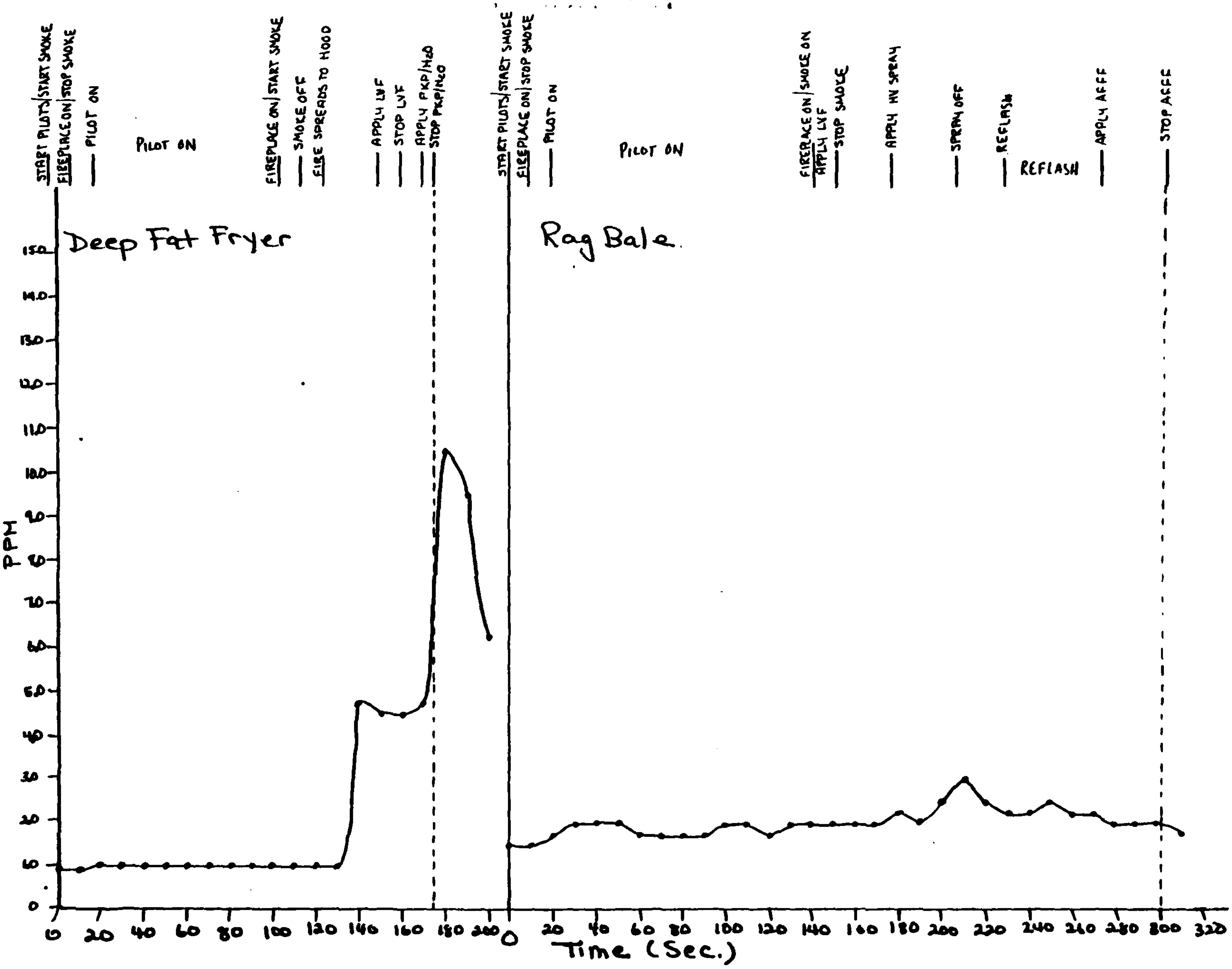
UDOII RUN 3 - O_2 LEVELS



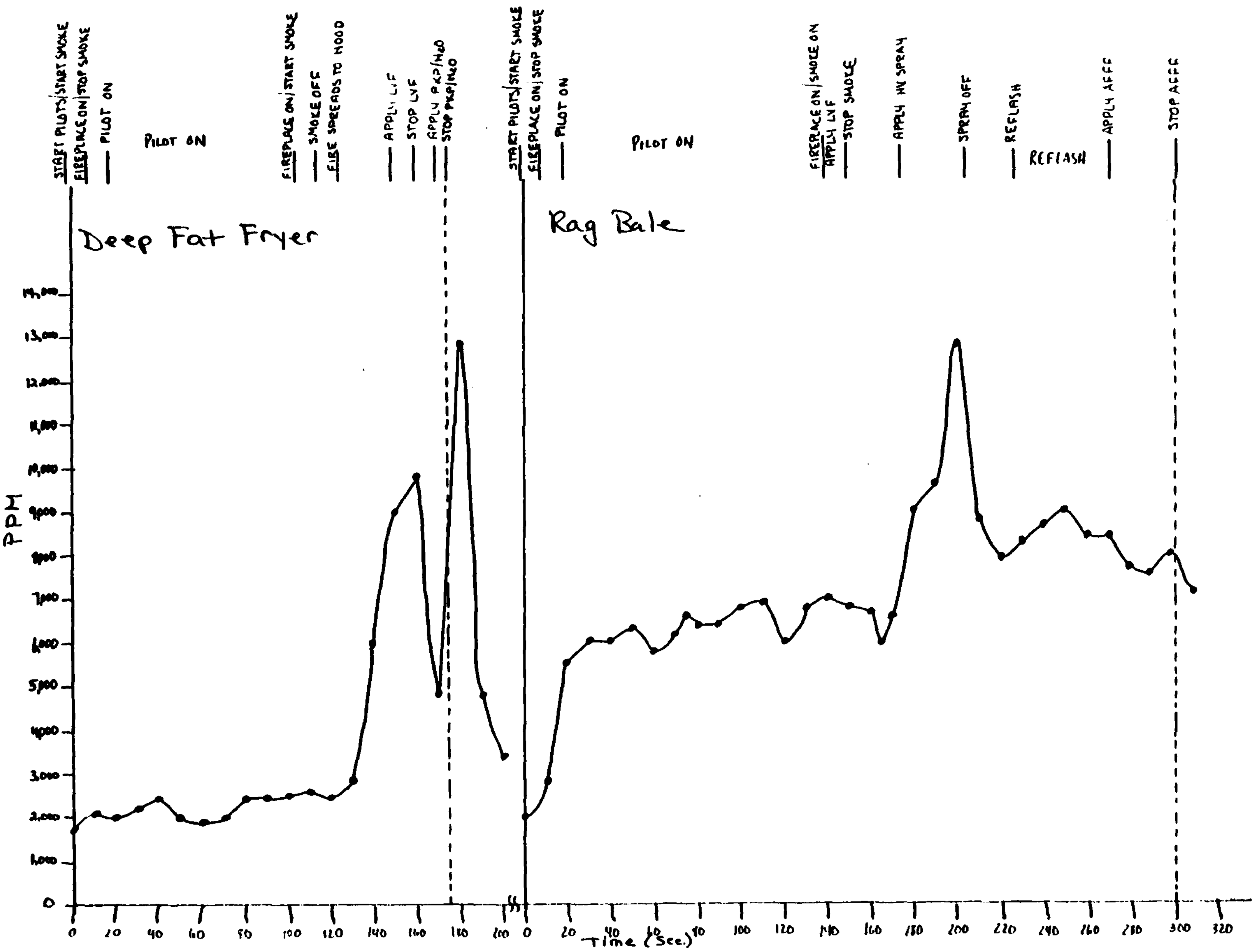
UDQII RUN 3 - CO LEVELS



UPPER RUN 2 - HC LEVELS



UDOII RUN 3. - NO. LEVELS



UDQII RUN 3 - CO_2 LEVELS

TABLE F-9. UDOII SCENARIO FOR DEEP FAT - RUN 4

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	20.75	160	100	1.5	2,000
10	20.75	190	110	1.5	2,300
20	20.75	190	120	1.5	2,200
30	20.75	180	120	1.5	2,400
40	20.75	170	115	1.5	2,200
50	20.75	160	110	1.5	2,000
60	20.75	170	110	1.5	2,200
70	20.75	195	110	1.5	2,400
80	20.75	200	105	1.5	2,400
90	20.75	200	105	1.5	2,400
100	20.75	180	105	1.5	2,200
110	20.75	160	100	1.5	2,000
120	20.75	145	100	1.5	2,000
130	20.75	160	105	1.5	2,400
140	20.75	175	110	1.5	2,400
150	20.75	185	110	1.5	2,400
160	20.75	185	110	1.5	2,400
170	20.75	180	300 (170 at ≈ 177 sec.)	1.75	4,000
180	20.5	190	185	3.2	5,800
190	20.25	240	240	2.75	6,000 (8,800 at ≈ 197 sec.)
200	20.5	220	700 (off chart at ≈ 201 sec.)	3.0	3,200

TABLE F-9 (Continued)

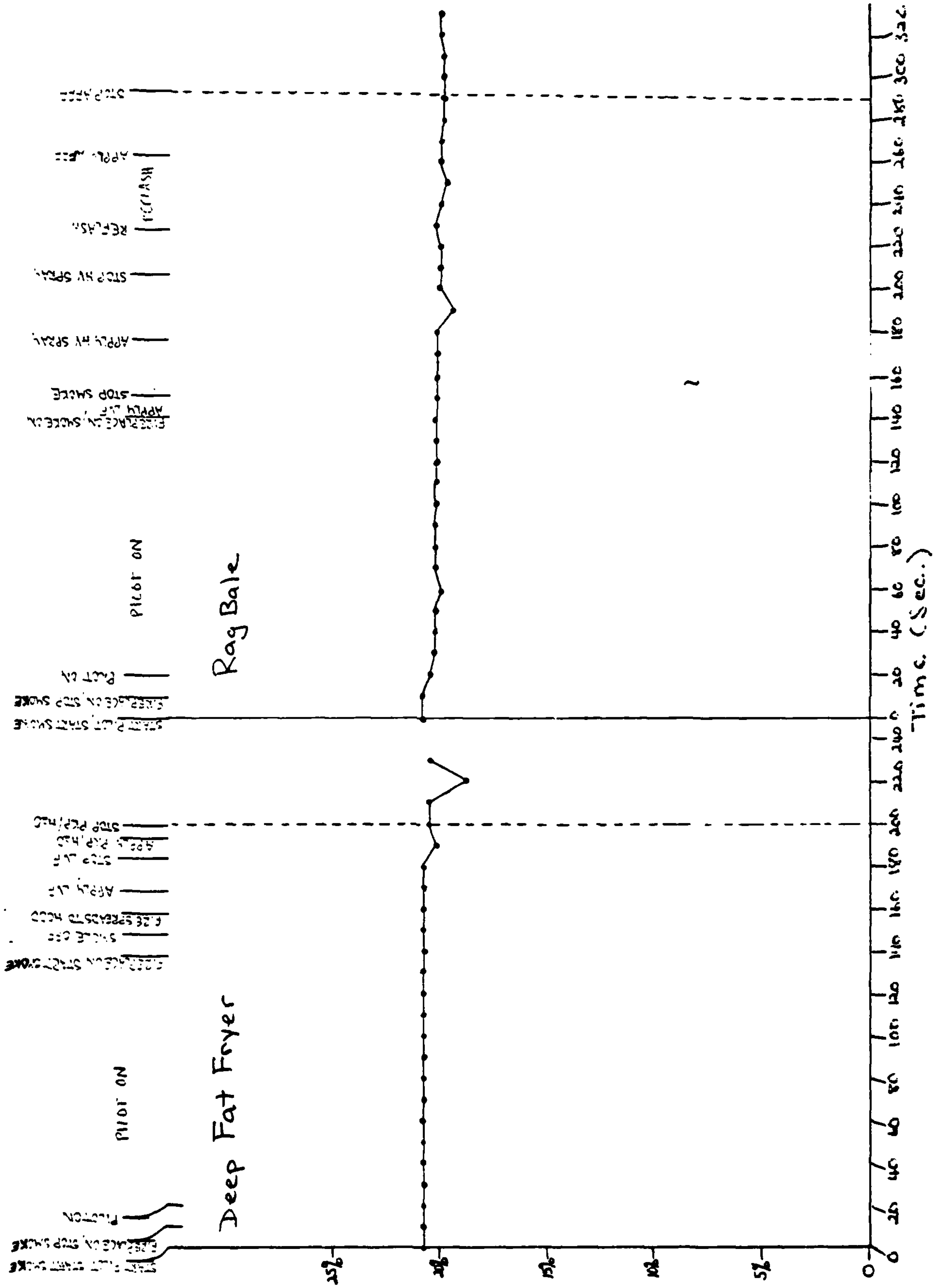
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
210	20.5	480 (510 at ≈ 213 sec.)	off chart (on chart at ≈ 213 sec.)	6.5 (7.0 at ≈ 215 sec.)	14,000 (16,000 at ≈ 212 sec.)
220	18.75	400	480 (520 at ≈ 228 sec.)	6.25	6,000
230	20.5	260	480	5.0	4,000

TABLE F-10. UDOII SCENARIO FOR RAG BALE - RUN 4

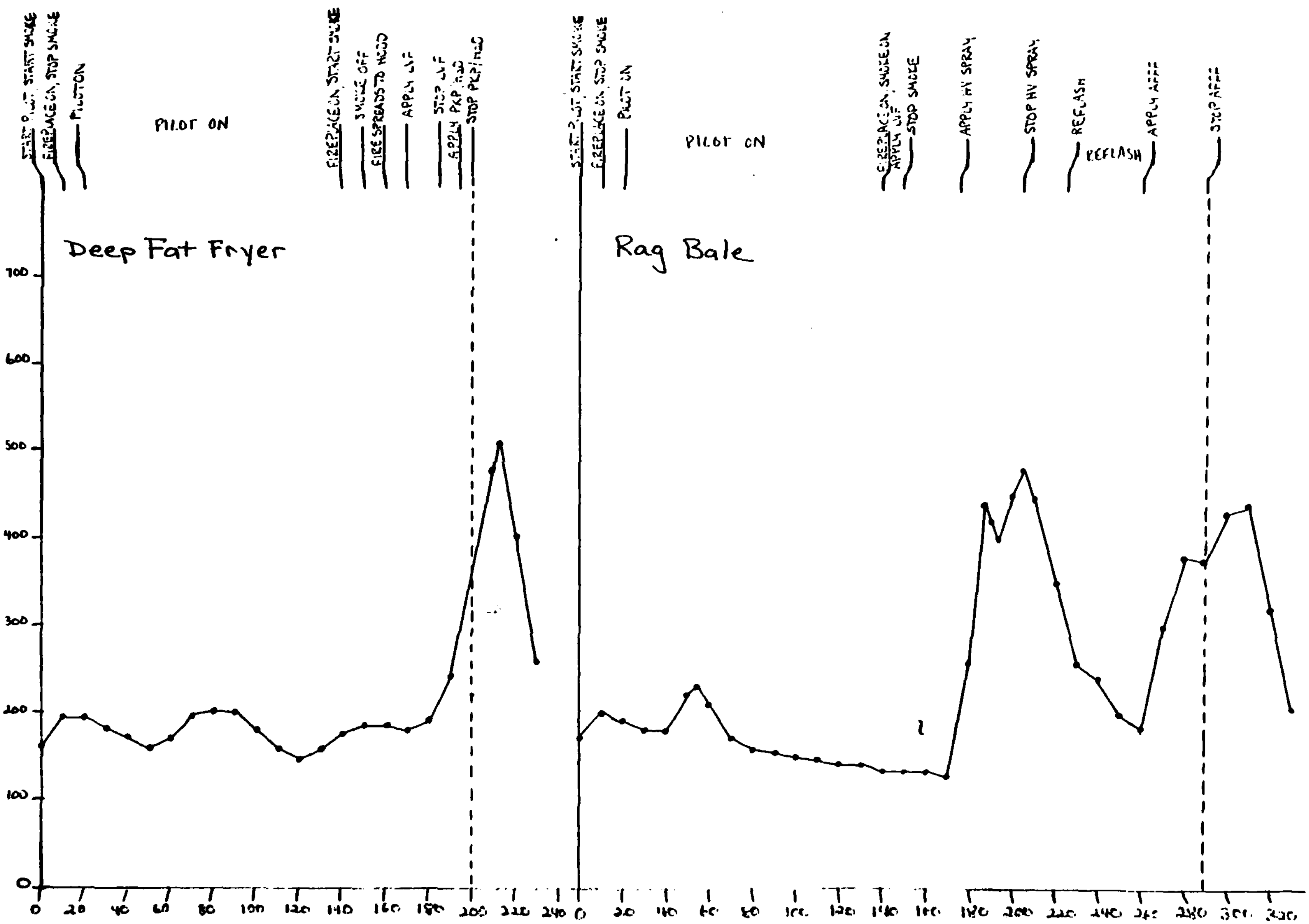
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	20.75	170	110	2.0	2,000
10	20.75	200	125	2.0	2,800
20	20.5	190	110	2.25	5,600
30	20.3	180	110	2.5	6,000
40	20.3	180	110	2.5	6,000
50	20.3	220 (230 at ≈ 55 sec.)	120	2.5	7,300
60	20.0	210	115	2.25	6,000
70	20.3	170	115	2.25	5,700
80	20.3	160	115	2.25	6,000
90	20.3	155	115	2.25	6,200 (6,400 at ≈ 93 sec.)
100	20.25	150	110	2.25	6,000 (6,300 at ≈ 105 sec.)
110	20.25	145	110	2.25	6,000 (6,300 at ~ 115 sec.)
120	20.25	140	105	2.0	5,800 (6,400 at ≈ 127 sec.)
130	20.25	140	105	2.1	6,000
140	20.25	135	100	2.1	6,100
150	20.25	135	100	2.2	6,400
160	20.25	135	100	2.25	6,600
170	20.25	130	100	2.1	6,000 (10,100 at ≈182 sec.)

TABLE F-10 (Continued)

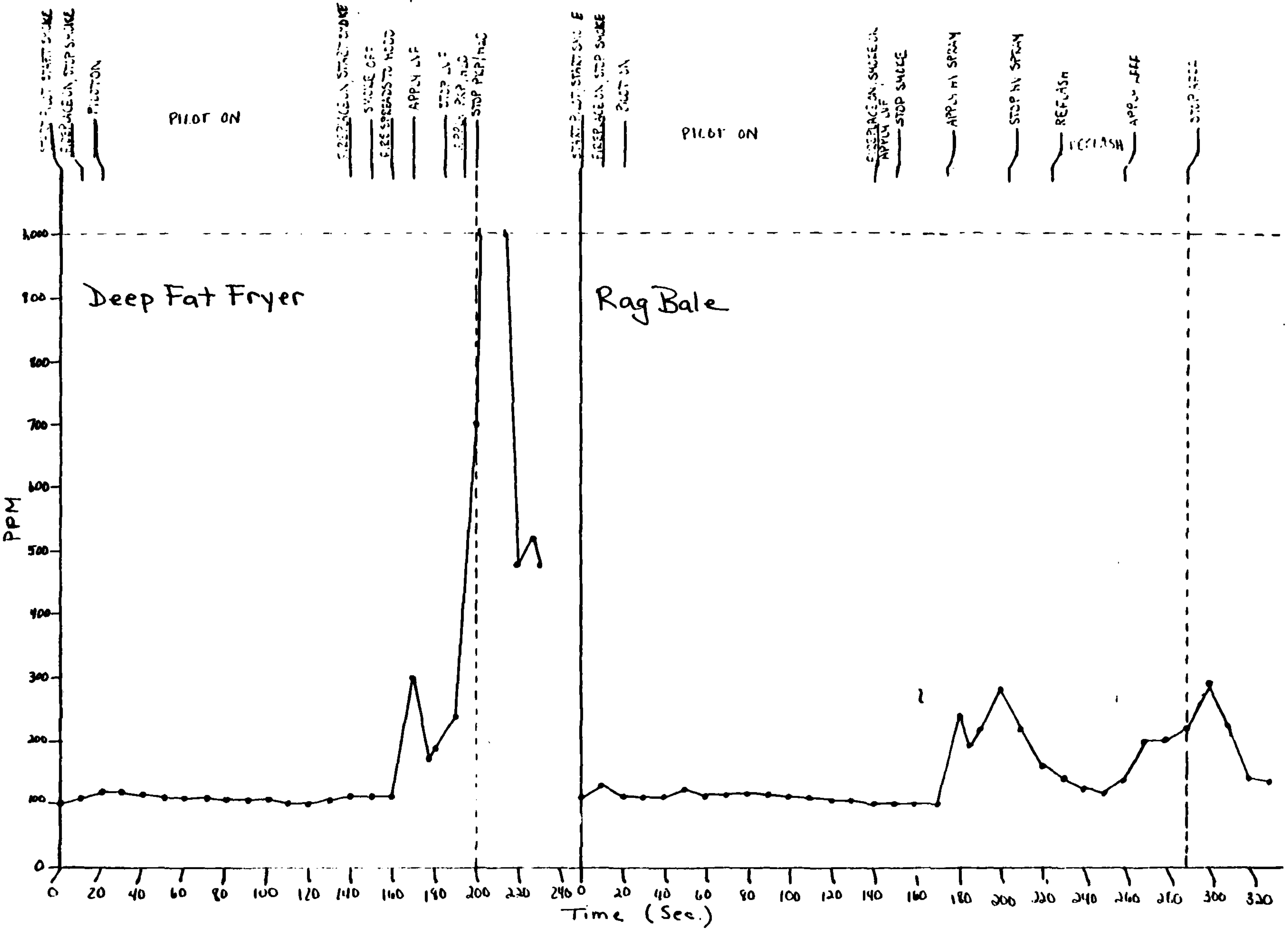
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
180	20.25	260 (440 at ≈ 187 sec.)	240 (190 at ≈ 185 sec.)	2.5	9,400
190	19.5	420 (400 at ≈ 193 sec.)	220	2.5	7,200
200	20.0	450 (480 at ≈ 205 sec.)	280	2.5	8,000 (8,400 at ≈ 203 sec.)
210	20.0	445	220	2.8	7,800
220	20.0	350	160	2.6	6,800 (6,500 at ≈ 225 sec.)
230	20.25	260	140	2.5	7,200
240	20.0	240	125	2.75	9,200
250	19.85	200	120	2.5	8,000 (7,200 at ≈ 255 sec.)
260	20.0	185	140	2.5	7,600
270	20.0	300	200	2.5	8,800
280	19.9	380	200	2.5	9,500
290	10.0	375	220	2.5	9,000
300	19.9	430	290	2.9	9,200
310	19.9	440	225	3.0	9,000
320	20.0	320	140	2.75	8,200
330	20.0	210	135	2.5	5,800



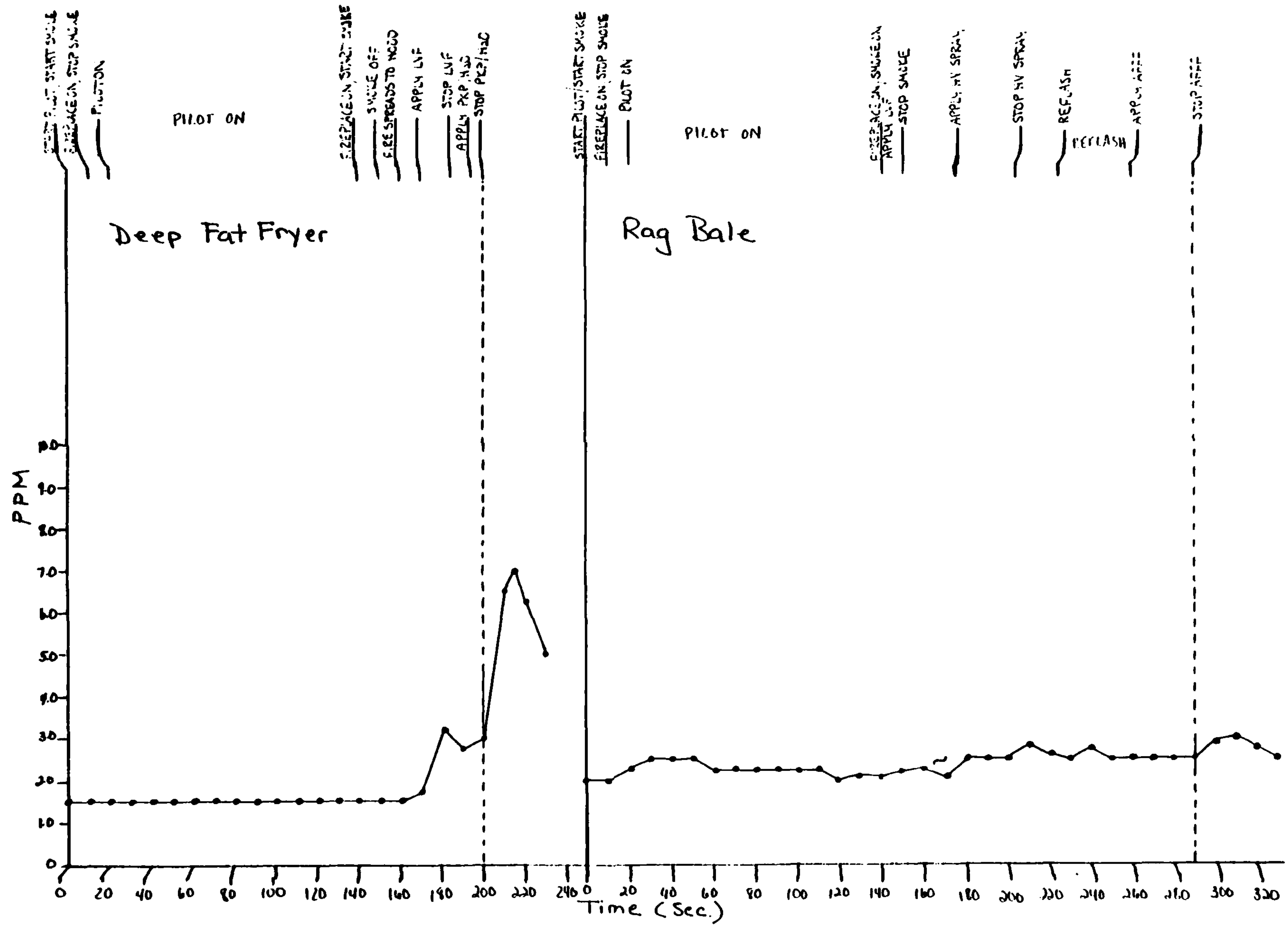
UDOII RUN 4 - O_2 LEVELS



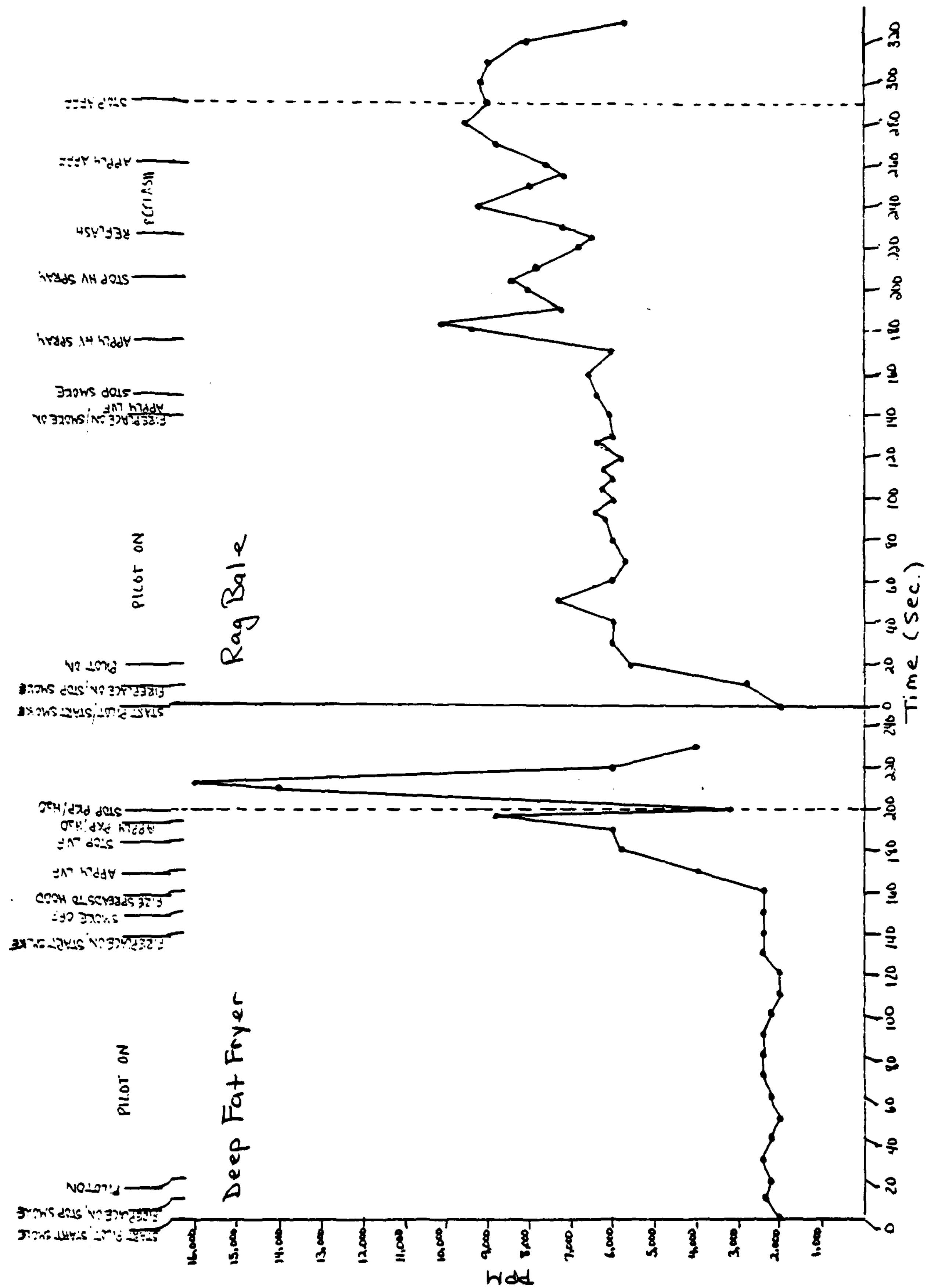
UDQII RUN 4 - CO LEVELS



UDOII RUN 4 - HC LEVELS



UDQII RUN 4 - NO_x LEVELS



UDQII RUN 4 - CO_2 LEVELS
Time (Sec.)
PPM
Deep Fat Fryer
Rag Bale
PILOT ON
PILOT ON
STOP HV SPRAY
APPLY HV SPRAY
REFLASH
STOP SMOKE
STOP PKP/H_2O

TABLE F-11. UDOII SCENARIO FOR DEEP FAT - RUN 5

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	20.75	220	100	1.5	2,000
10	20.75	195	100	1.5	2,200
20	20.75	200	100	1.5	2,400
30	20.75	200	100	1.5	2,400
40	20.75	190	100	1.5	2,400
50	20.75	180	100	1.5	2,400
60	20.75	180	100	1.5	2,400
70	20.75	180	100	1.5	2,400
80	20.75	175	100	1.5	2,400
90	20.75	170	100	1.5	2,400
100	20.75	165	100	1.5	2,400
110	20.75	180	100	1.5	2,500
120	20.75	185	100	1.5	2,400
130	20.75	195	100	1.5	2,400
140	20.75	200	105	1.5	2,400
150	20.75	210	110	1.5	2,400
			(110 at ≈ 155 sec.)		(2,400 at ≈ 158 sec.)
160	20.75	225	350	1.75	3,400
170	20.5	230	140	2.75	5,500
			(190 at ≈ 174 sec.)		
180	20.4	240	160	2.5	9,000
190	20.0	280	520	2.75	4,200
			(930 at ≈ 193 sec.)		
			(500 at ≈ 199 sec.)		

TABLE F-11 (Continued)

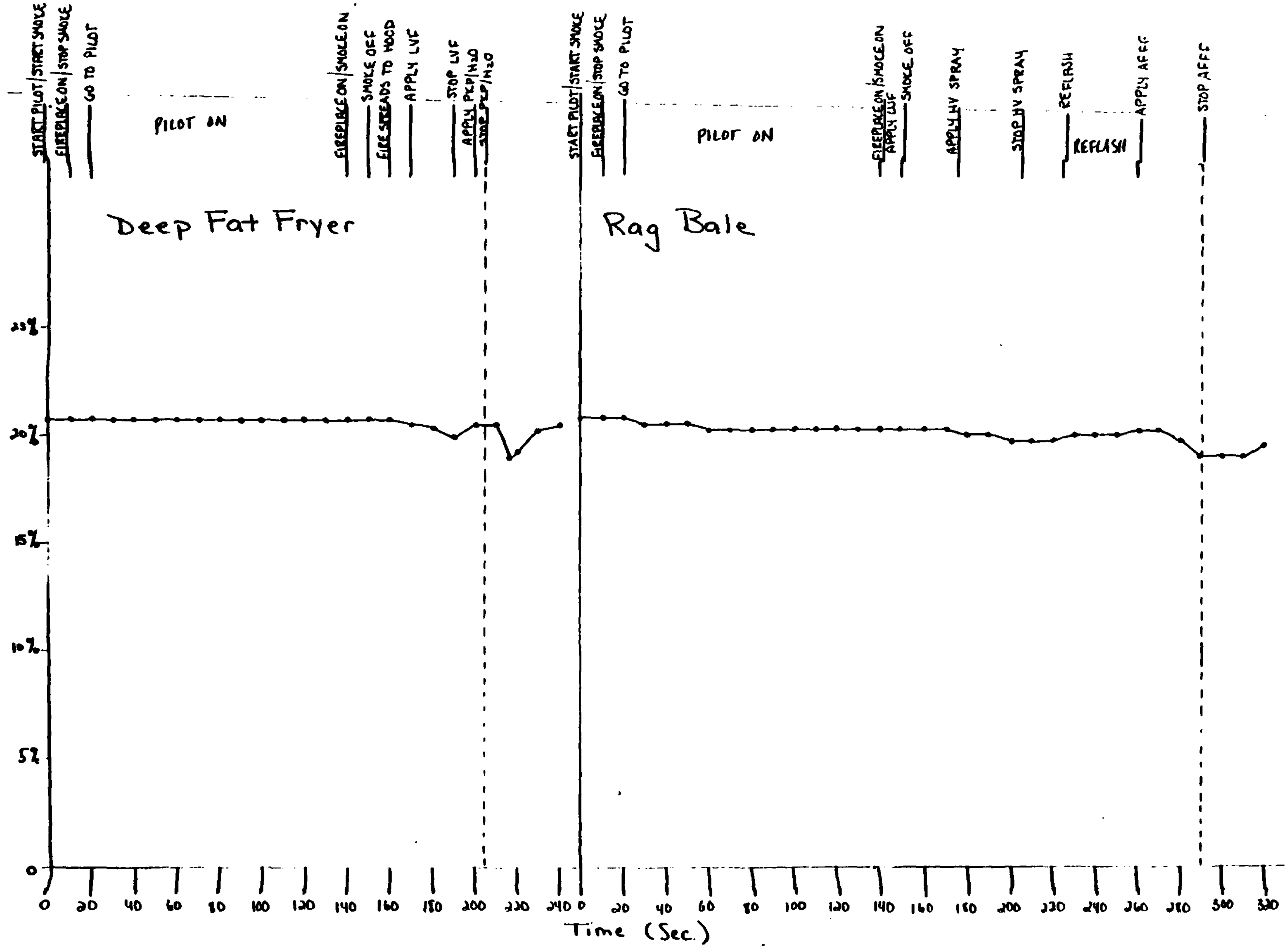
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
200	20.5	340 (330 at ≈ 203 sec.)	700 (500 at ≈ 199 sec.) (off chart at ≈ 201 sec.)	5.0 (5.0 at ≈ 205 sec.)	3,600 (14,000 at ≈ 209 sec.)
210	20.5 (19.0 at ≈ 217 sec.)	550 (640 at ≈ 214 sec.)	off chart (1,000 at ≈ 215 sec.) (730 at ≈ 217 sec.) (off chart at ≈ 219 sec.)	7.5 (8.5 at ≈ 215 sec.)	13,200
220	19.25	450 (430 at ≈ 221 sec.)	off chart	7.5	5,200 (6,200 at ≈ 222 sec.)
230	20.25	460	off chart (on chart at ≈ 232 sec.) (490 at ≈ 236 sec.)	7.25	5,500
240	20.5	340	620	6.0	3,400

TABLE F-12. UDQII SCENARIO FOR RAG BALE - RUN 5

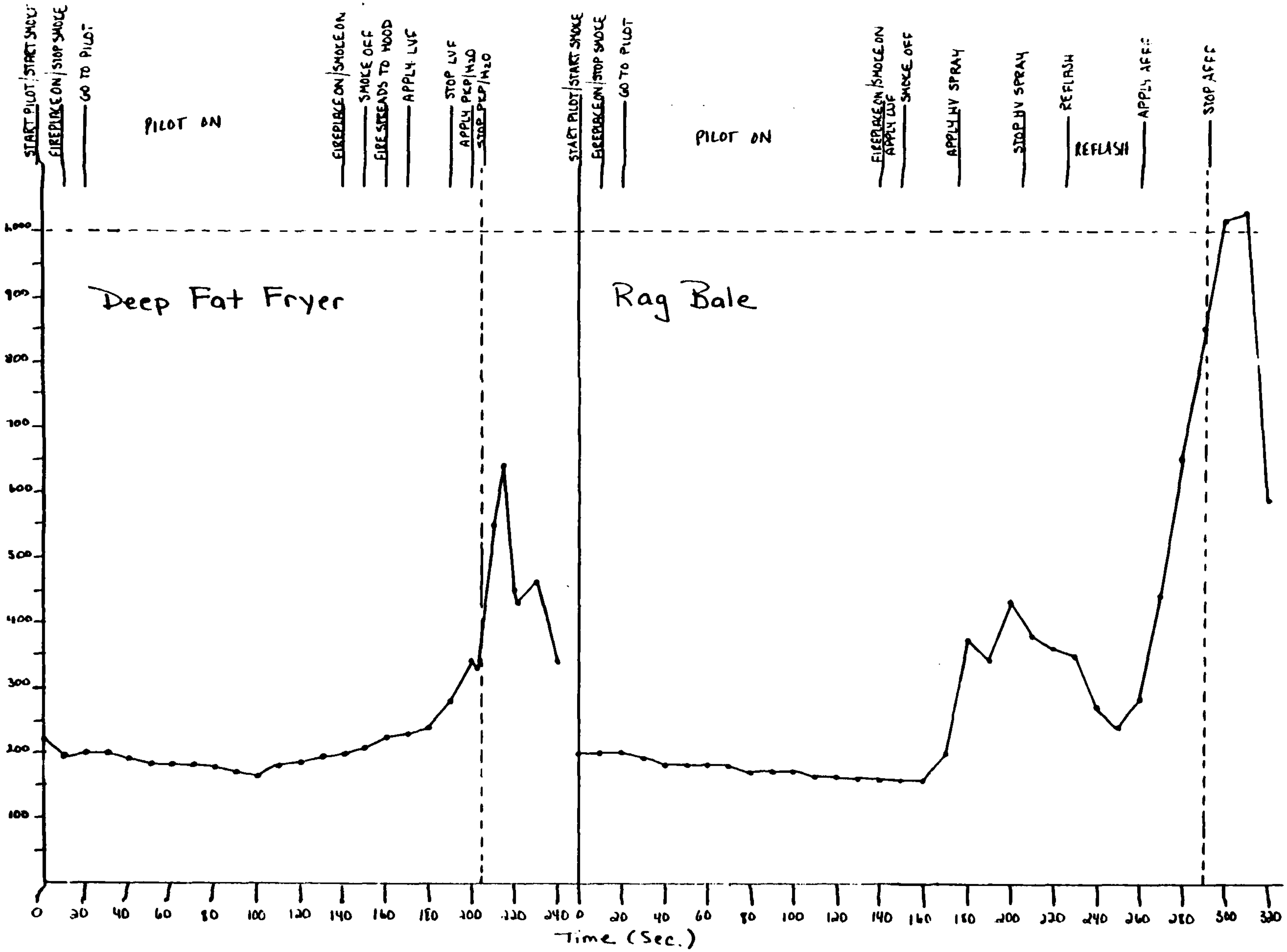
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	20.75	200	130	2.5	2,000
10	20.75	200	130	2.5	2,800
20	20.75	200	120	2.75	5,800
30	20.5	190	110	2.75	5,400
40	20.5	180	100	2.75	6,000
50	20.5	180	100	2.75	6,200
60	20.25	180	90	2.5	5,600
70	20.25	180	90	2.5	6,000
					(5,600 at ≈ 77 sec.)
80	20.25	170	85	2.5	5,800
90	20.25	170	80	2.5	6,200
100	20.25	170	80	2.5	6,000
110	20.25	165	80	2.25	6,200
120	20.25	165	80	2.25	6,000
					(6,600 at ≈ 128 sec.)
130	20.25	165	80	2.25	6,000
140	20.25	160	80	2.25	6,400
150	20.25	160	80	2.25	6,200
160	20.25	160	80	2.5	6,400
170	20.25	200	160	2.5	6,600
180	20.0	370	150	2.5	7,900
190	20.0	340	170	2.5	9,000
			(335 at ≈ 193 sec.)		
200	19.75	430	220	3.0	9,000
210	19.75	375	190	3.0	9,000
220	19.75	360	180	2.5	8,300
230	20.0	350	140	2.5	8,400

TABLE F-12 (Continued)

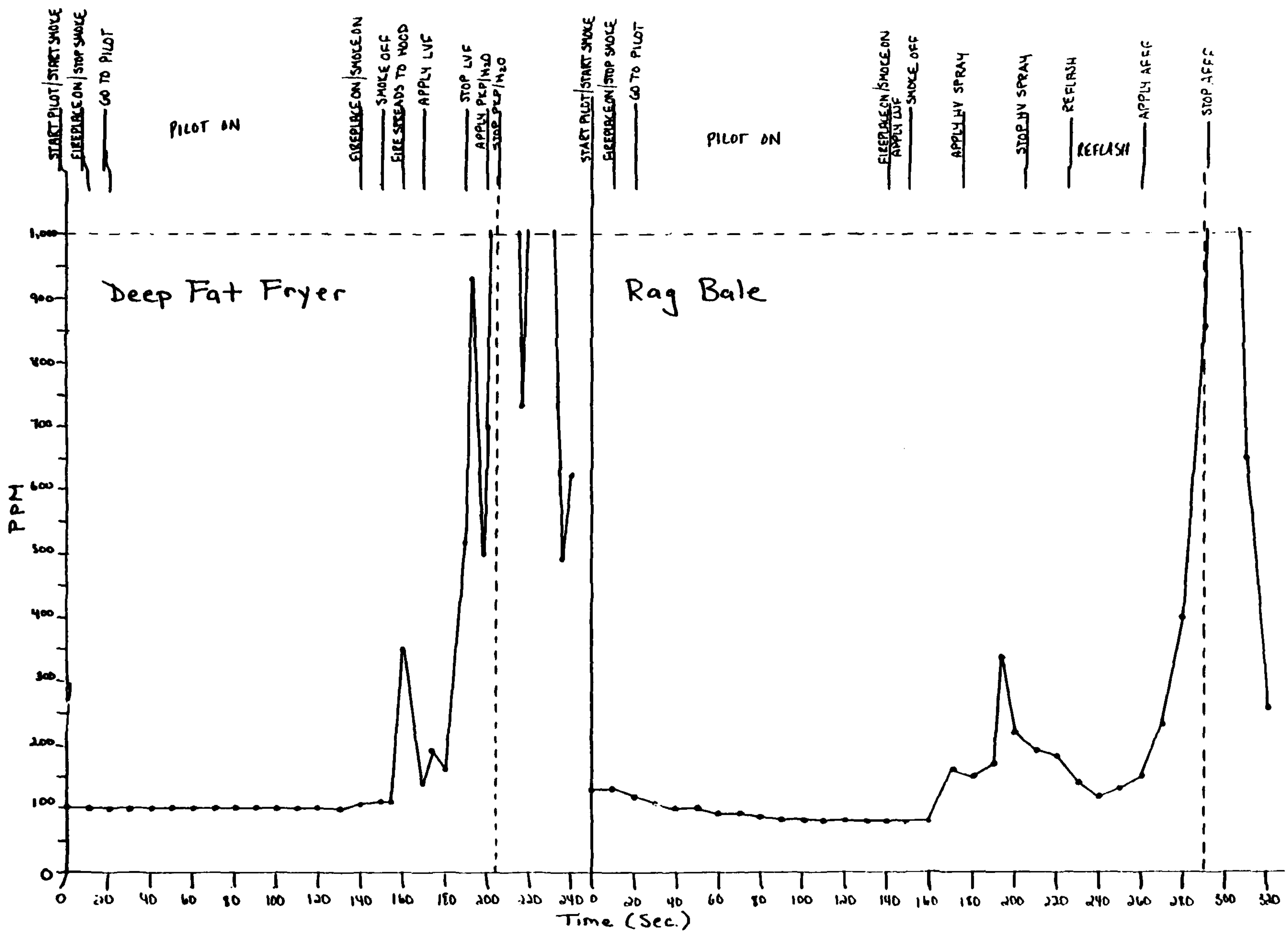
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
240	20.0	270	120	2.5	8,000
250	20.0	240	130	2.5	6,800
260	20.25	280	150	2.0	6,000
270	20.25	440	230	2.5	9,200
280	19.75	650	400	3.0	12,400 (13,000 at ≈ 283 sec.)
290	19.0	850	850 (at ≈ 291 sec.)	4.0	12,400
300	19.0	(1,020)	off chart (on chart at ≈ 307 sec.)	5.75	12,200
310	19.0	(1,030)	650	5.75	12,400
320	19.5	590	260	4.25	8,600



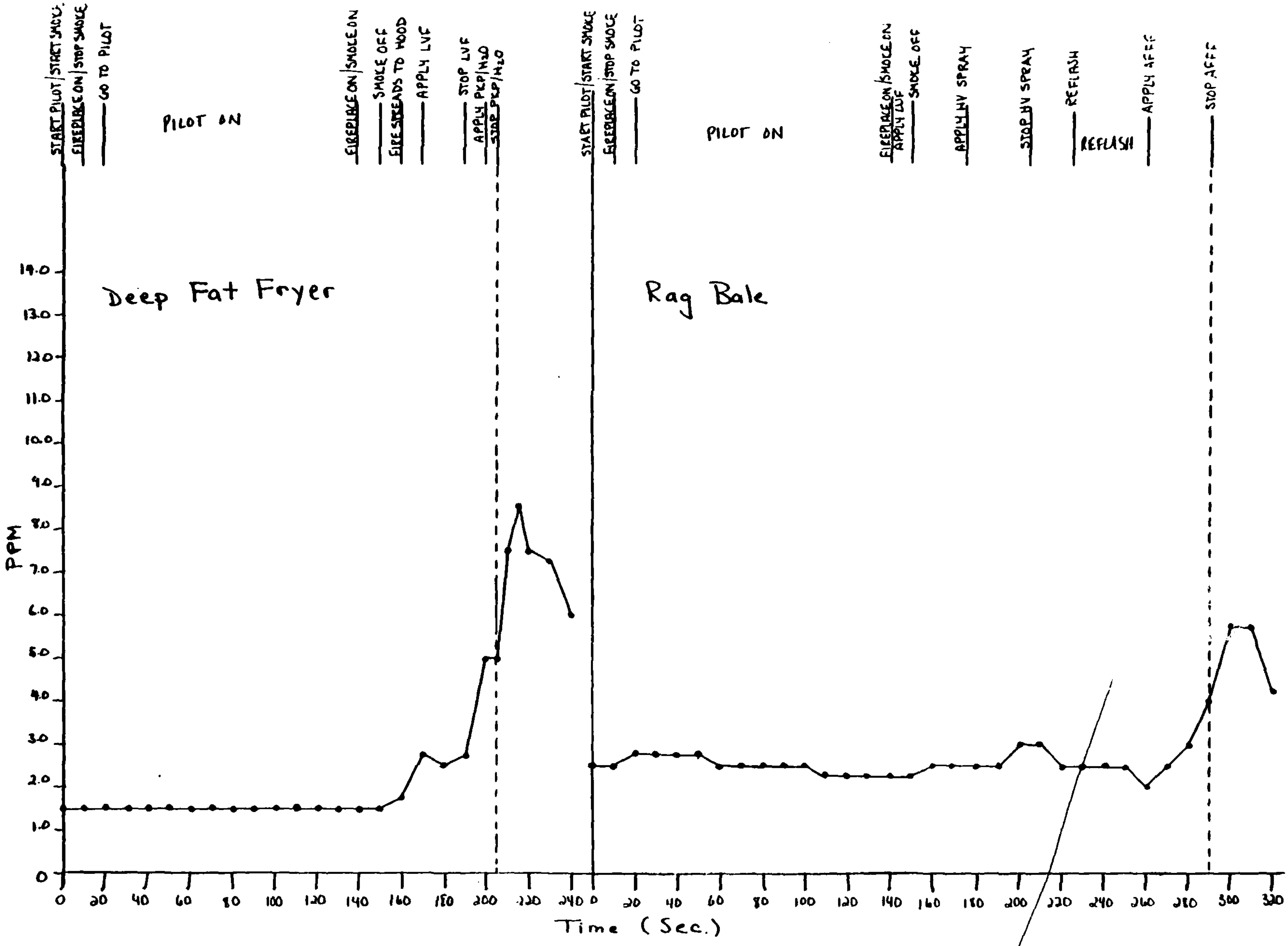
UDQII RUN 5 - O_2 LEVELS



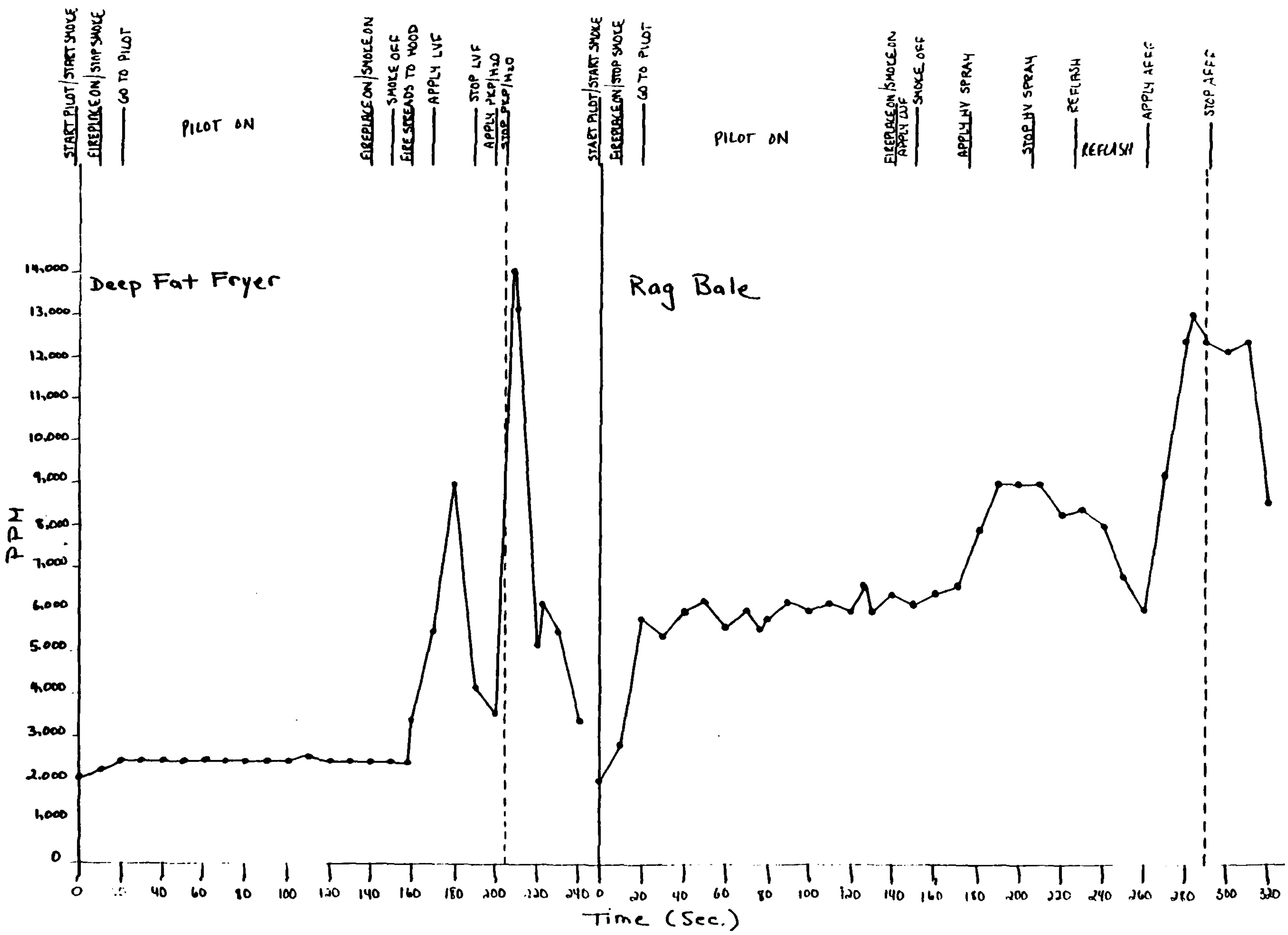
UDQII RUN 5 - CO LEVELS



UDQII RUN 5 - HC LEVELS



UDQII RUN 5 - NO_x LEVELS



UDQII RUN 5 - CO_2 LEVELS

TABLE F-13. UDQII SCENARIO FOR DEEP FAT - RUN 6

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	21.0	50	80	1.0	1,400
10	21.0	60	110	1.0	1,800
20	20.75	125	120	1.25	1,800
30	20.75	160	120	1.25	2,000
40	20.75	190	120	1.3	2,200
50	20.75	210	130	1.5	2,400
60	20.75	220	140	1.5	2,200
70	20.75	210	150	1.5	2,100
80	20.75	205	140	1.5	2,400
90	20.75	200	140	1.5	2,400
100	20.75	200	130	1.5	2,400
110	20.75	210	120	1.5	2,600
120	20.75	200	120	1.5	2,400
130	20.75	180	120	1.5	2,500
140	20.75	160	120	1.5	2,200
150	20.75	150	135	1.5	2,200
160	20.75	140	155 (300 at ≈ 163 sec.)	1.5	2,200
170	20.75	140	160	2.0	5,200
180	20.5	160	170	2.0	7,000 (7,600 at ≈182 sec.)
190	20.25	220	420 (920 at ≈ 199 sec.)	2.5	4,000
200	20.5	380	800 (off chart at ≈ 202 sec.)	5.0	5,100

TABLE F-13 (Continued)

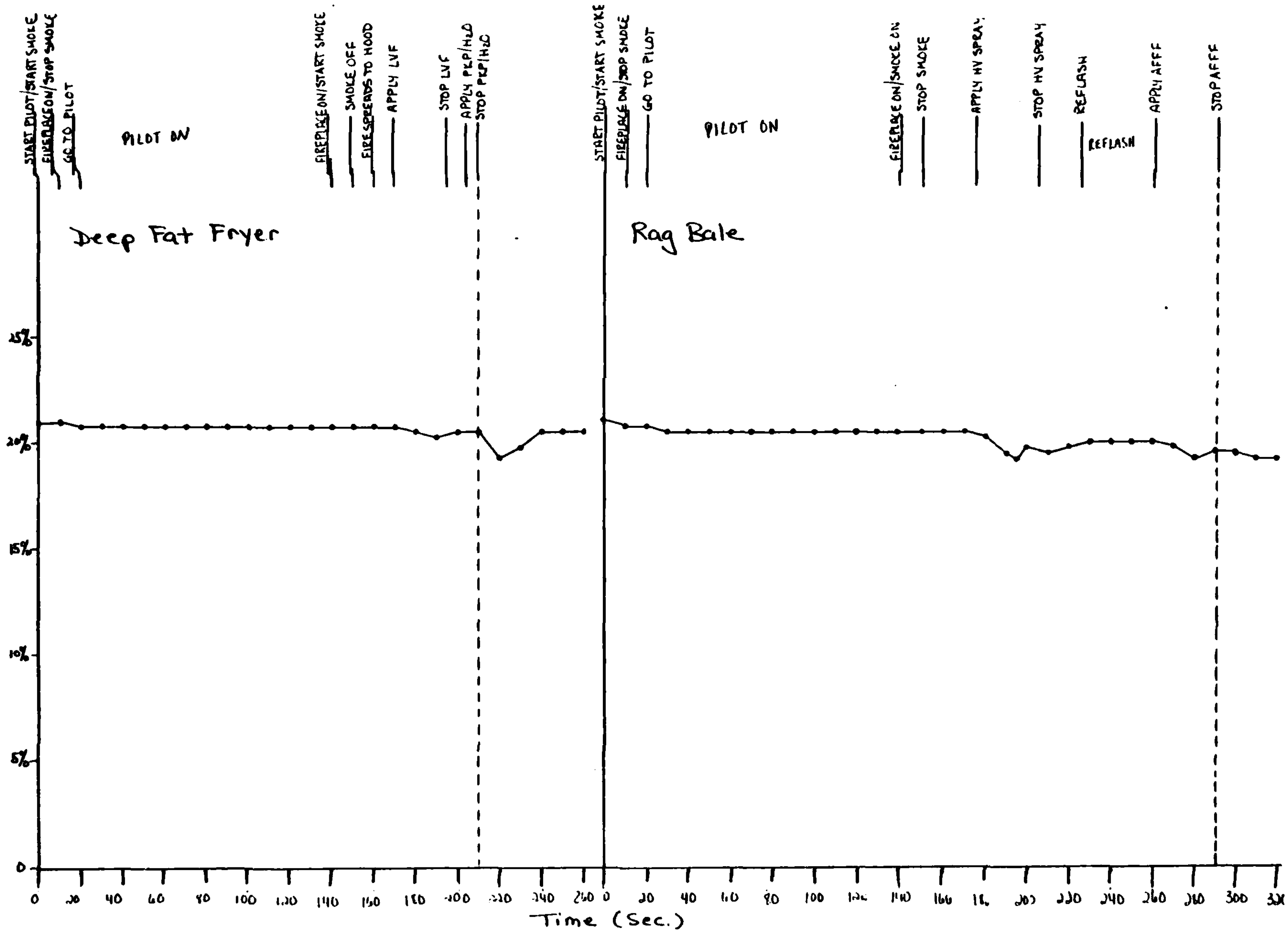
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
210	20.5	560 (700 at ≈ 216 sec.)	off chart	7.25	10,000 (12,800 at ≈ 213 sec.)
220	19.25	670	off chart (750 at ≈ 225 sec.)	8.75	10,000
230	19.75	500 (430 at ≈ 234 sec.)	880 (off chart at ≈ 231 sec.)	7.5 (6.5 at ≈ 235 sec.)	5,000
240	20.5	460 (480 at ≈ 245 sec.)	off chart	7.5	5,200
250	20.5	440	off chart (on chart at ≈256 sec.)	8.0	4,400
260	20.5	360	610	7.25	3,400

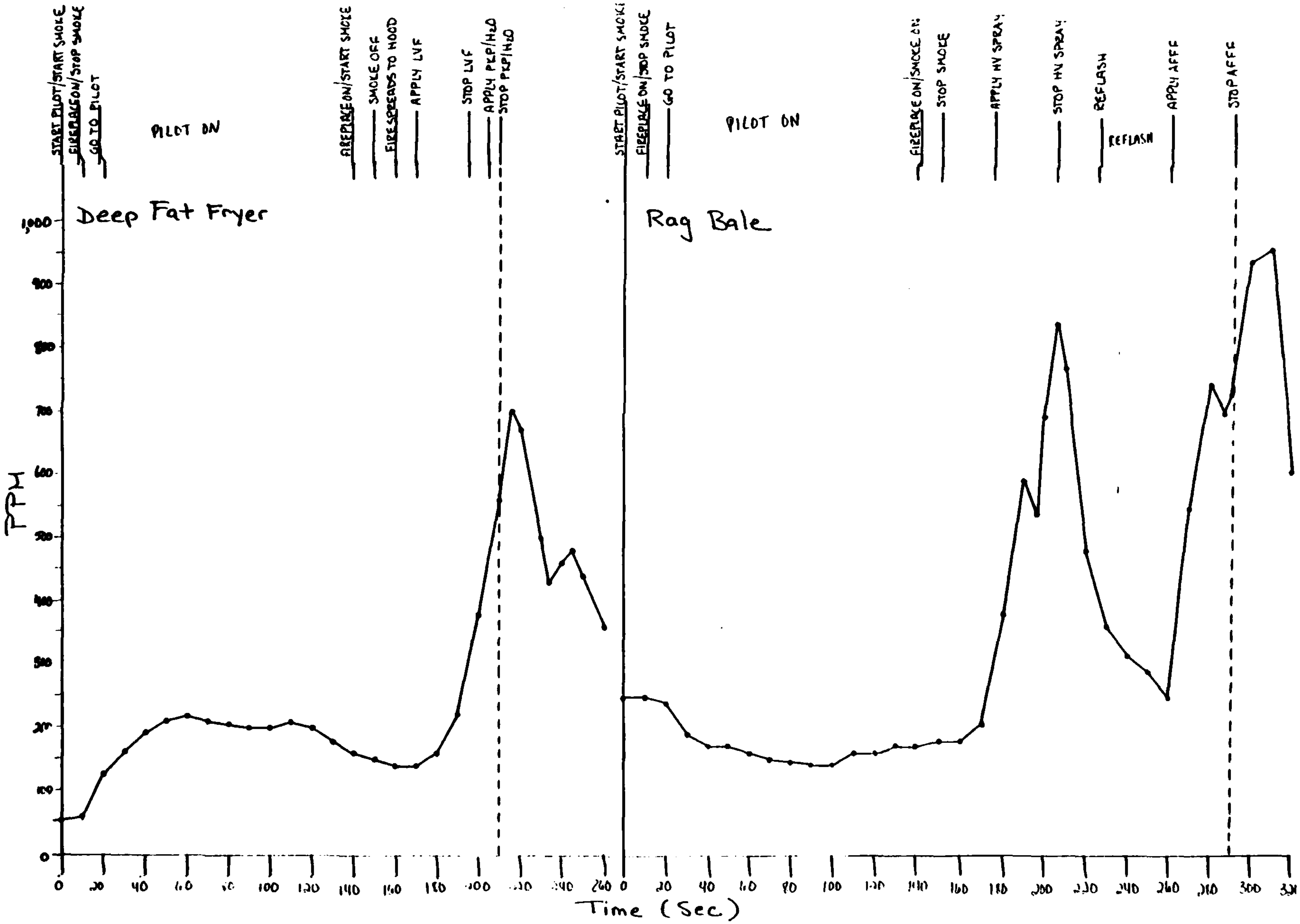
TABLE F-14. UDOII SCENARIO FOR RAG BALE - RUN 6

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	21.0	250	160	2.5	1,800
10	20.75	250	150	2.5	2,800
20	20.75	240	140	2.75	5,000
30	20.5	190	120	2.75	5,600
40	20.5	170	120	2.75	5,600
50	20.5	170	110	2.5	6,200
60	20.5	160	110	2.5	5,600
70	20.5	150	110	2.5	5,900
80	20.5	145	105	2.5	5,400
90	20.5	140	105	2.5	5,800
100	20.5	140	105	2.3	5,600 (5,300 at ≈ 104 sec.)
110	20.5	160	115	2.25	5,600
120	20.5	160	125	2.25	5,600 (5,100 at ≈ 128 sec.)
130	20.5	170	130	2.25	5,400
140	20.5	170	130	2.25	6,000
150	20.5	180	130	2.25	6,000 (5,500 at ≈ 154 sec.)
160	20.5	180	120	2.25	6,000 (5,600 at ≈ 165 sec.)
170	20.5	210	140	2.3	6,800
180	20.25	380	270 (300 at ≈ 183 sec.)	2.75	10,600 (11,900 at ≈ 188 sec.)

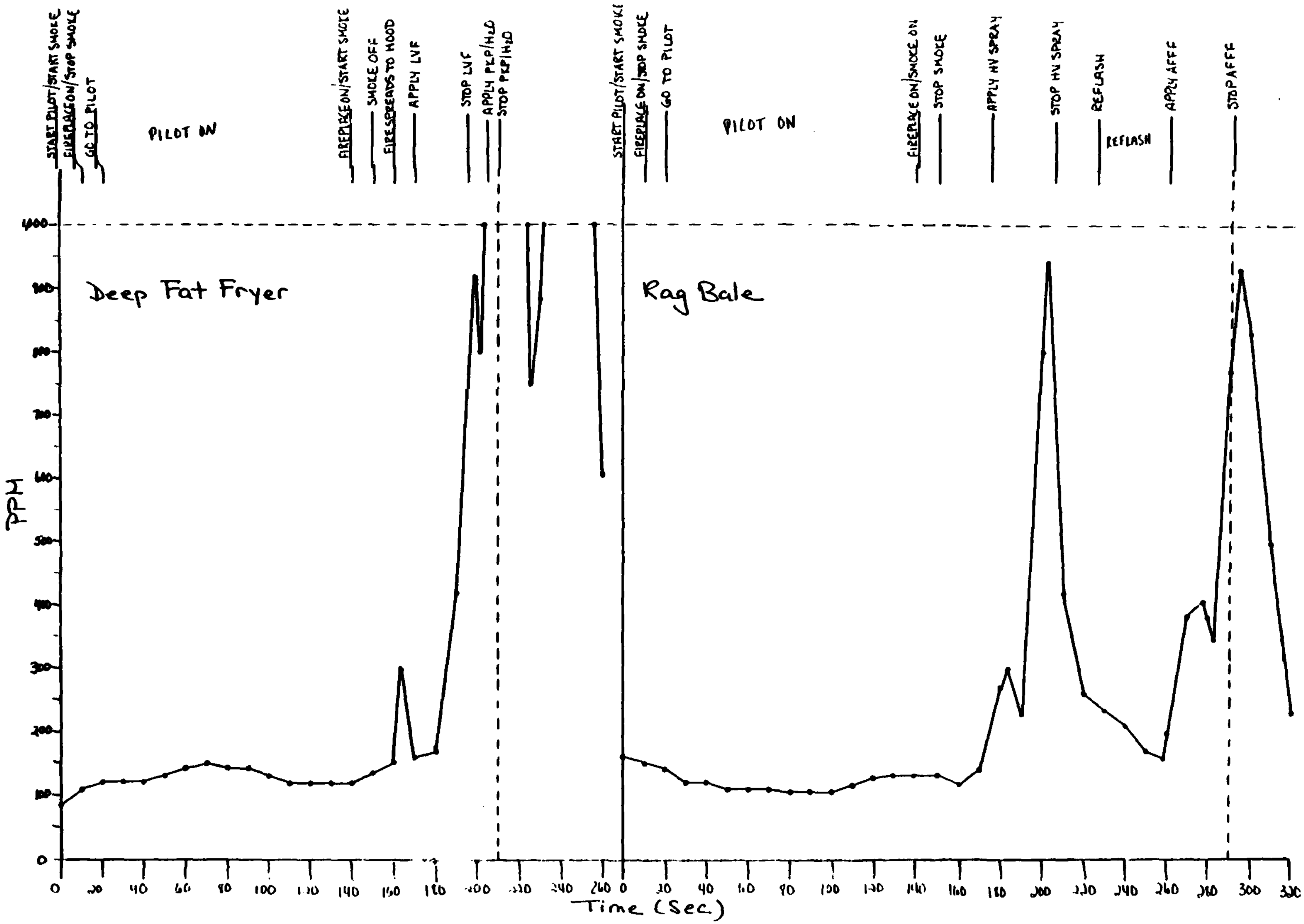
TABLE F-14 (Continued)

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
190	19.5 (19.25 at ≈ 195 sec.)	590 (540 at ≈ 196 sec.)	225	3.0	10,800
200	19.75	660 (840 at ≈ 206 sec.)	800 (940 at ≈ 202 sec.)	4.0 (5.2 at ≈ 207 sec.)	9,200 (10,400 at ≈ 205 sec.)
210	19.5	770	420	4.75	9,500
220	19.75	480	260	3.8	9,000
230	20.0	365	235	3.5	8,400
240	20.0	320	210	3.5	9,300
250	20.0	290	170 (160 at ≈ 258 sec.)	3.25	8,500
260	20.0	250	200	3.25	8,800
270	19.75	550	380 (405 at ≈ 278 sec.)	3.5	11,800
280	19.25	745 (700 at ≈ 287 sec.)	380 (350 at ≈ 282 sec.)	3.7	12,400 (9,200 at ≈ 287 sec.)
290	19.5	730	770 (930 at ≈ 294 sec.)	3.9	9,600
300	19.5	940	830	4.8	11,100
310	19.25	960	500	4.8	12,800
320	19.25	610	230	4.0	8,200

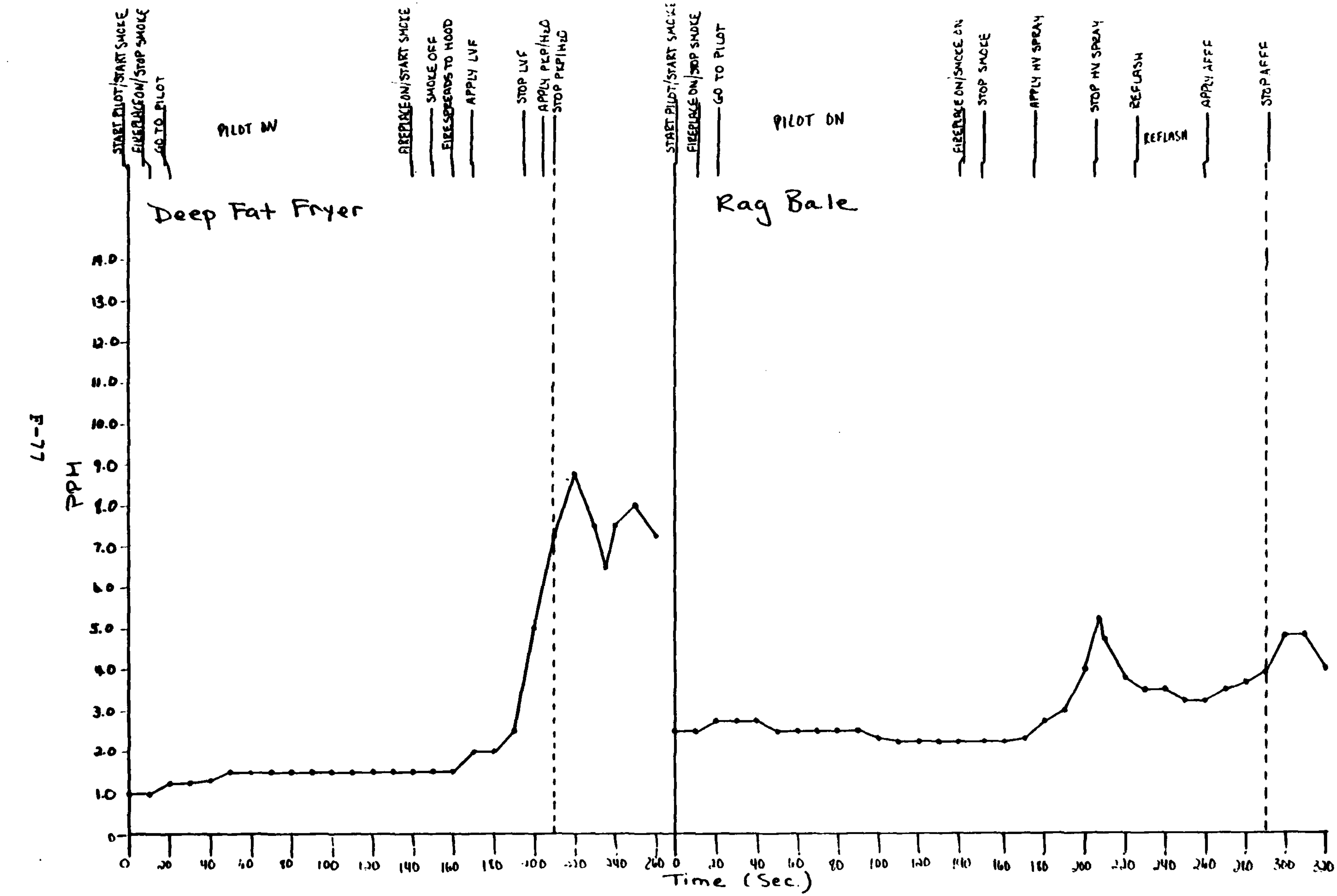

START PILOT/START SMOKE
FIREPLACE ON/STOP SMOKE
GO TO PILOT
PILOT ON
FIREPLACE ON/START SMOKE
SMOKE OFF
FIRE SPREADS TO HOOD
APPLY LVF
STOP LVF
APPLY PKP/H2O
STOP PKP/H2O
Deep Fat Fryer
START PILOT/START SMOKE
FIREPLACE ON/STOP SMOKE
GO TO PILOT
PILOT ON
FIREPLACE ON/SMOKE ON
STOP SMOKE
APPLY HV SPRAY
STOP HV SPRAY
REFLASH
REFLASH
APPLY AFFF
STOP AFFF
Rag Bale
25%
20%
15%
10%
5%
0
Time (Sec.)



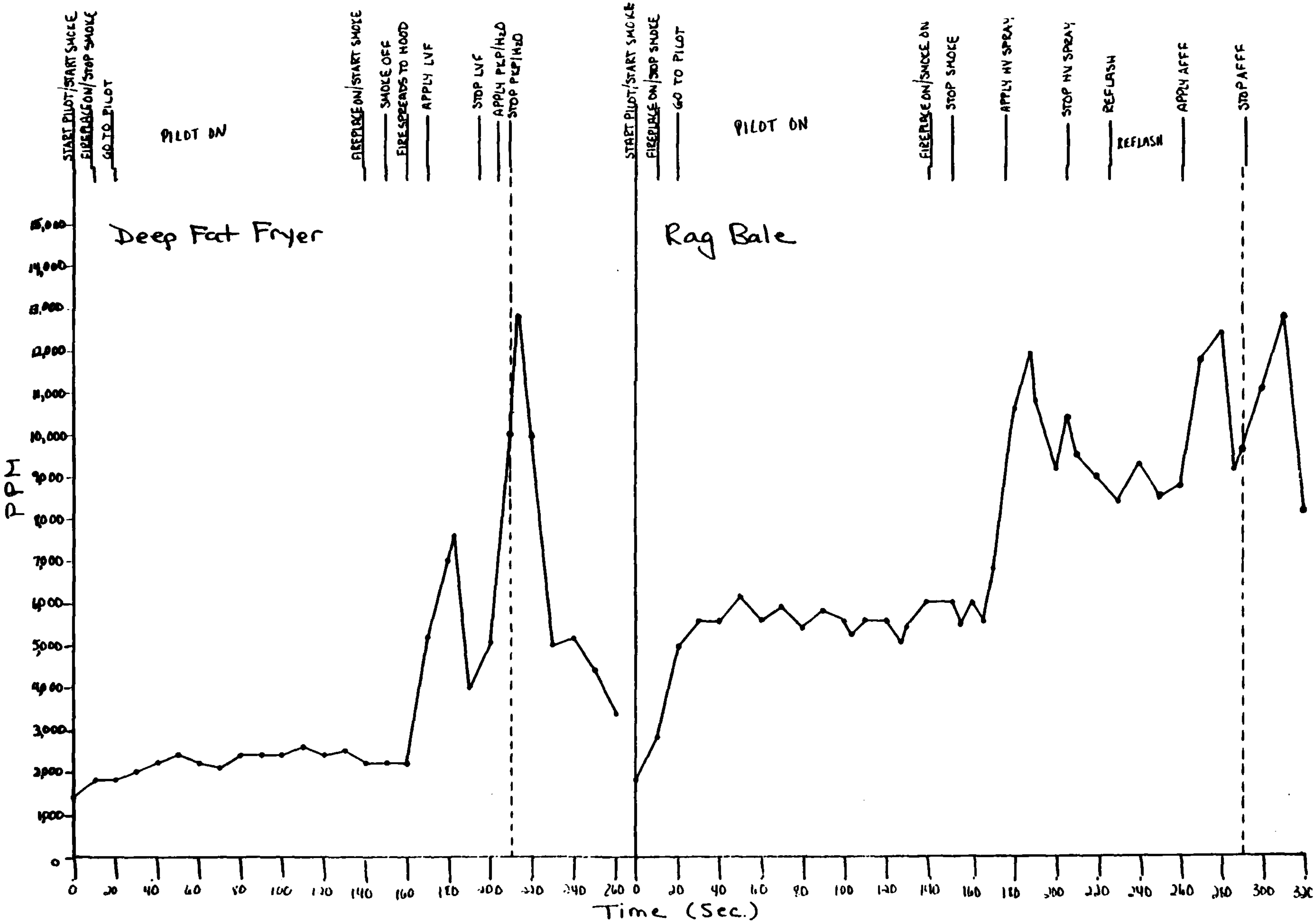
UDQII RUN 6 - CO LEVELS



UDQII RUN 6 - HC LEVELS



UDQII RUN 6 - NO_x LEVELS



UDOTT RUN 6 - CO_2 LEVELS

TABLE F-15. UDQII SCENARIO FOR DEEP FAT - RUN 7

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	21.0	160	135	1.75	2,000
10	21.0	145	140	1.75	2,300
20	21.0	150	130	1.75	2,400
30	21.0	150	140	1.75	2,600
			(215 at ≈ 35 sec.)		(3,600 at ≈ 35 sec.)
40	20.75	160	140	2.0	2,900
50	20.75	145	130	1.9	2,400
60	20.75	140	120	1.75	2,400
70	20.75	145	120	1.75	2,400
80	20.75	150	120	1.75	2,300
					(2,500 at ≈ 85 sec.)
90	20.75	155	120	1.75	2,200
100	20.75	160	120	1.75	2,200
110	20.75	170	120	1.75	2,200
					(2,900 at ≈ 115 sec.)
120	20.75	160	120	1.75	2,300
130	20.75	160	120	1.7	2,300
140	20.75	160	120	1.6	2,200
150	20.75	160	120	1.6	2,400
			(120 at ≈ 157 sec.)		
160	20.75	160	150	1.5	2,200
			(350 at ≈ 165 sec.)		
170	20.5	220	240	3.25	7,400
			(200 at ≈ 173 sec.)		(9,200 at ≈ 177 sec.)

TABLE F-15 (Continued)

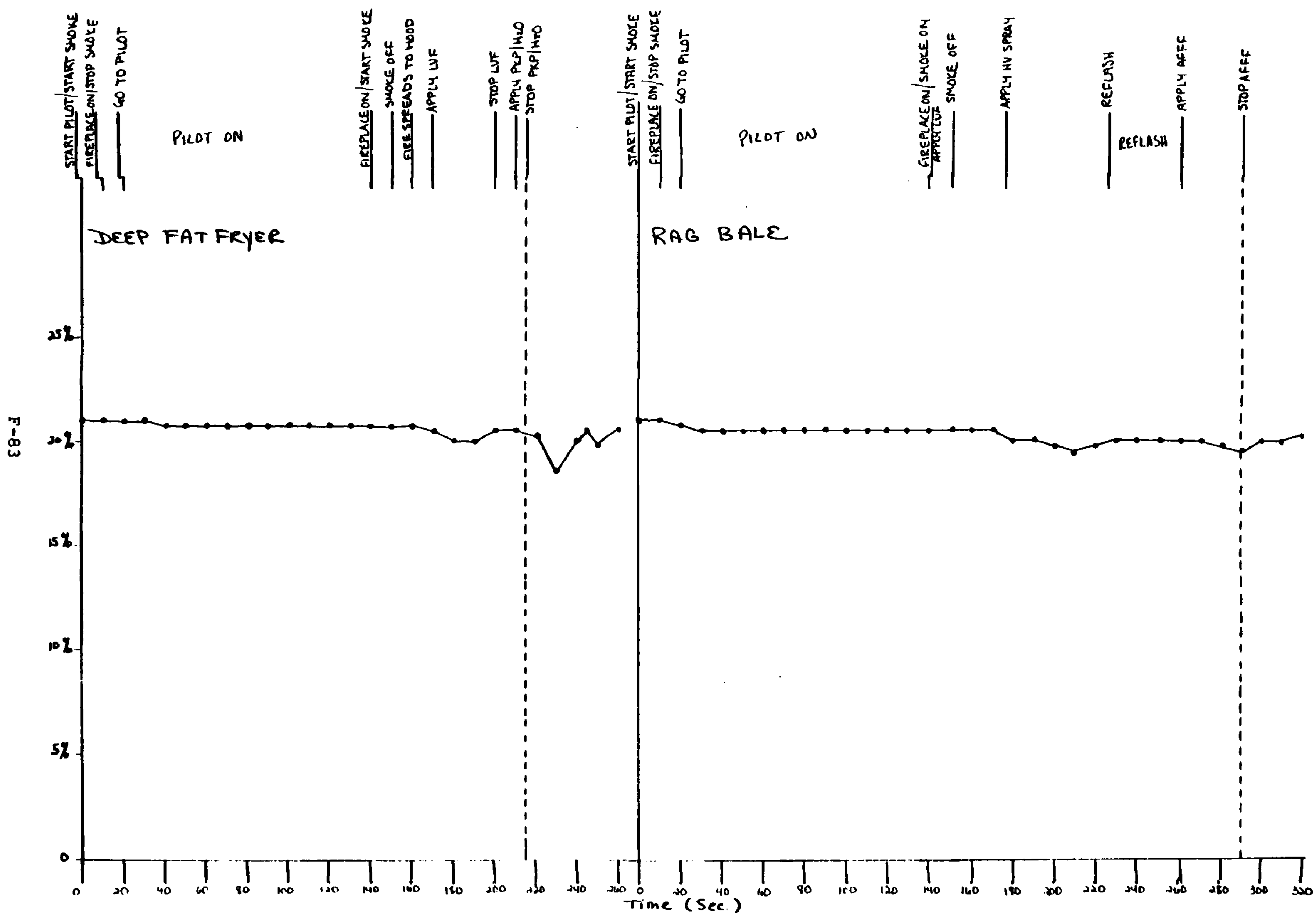
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
180	20.0	240	175 (210 at ≈ 176 sec.)	4.25	8,800 (9,200 at 185 sec.)
190	20.0	220	520 (off chart at ≈ 196 sec.)	3.0	5,500
200	20.5	300	off chart	5.0	4,500
210	20.5	470	off chart	7.75	6,800
220	20.25	760 (820 at ≈ 224 sec.)	off chart	10.5 (10.9 at 225 sec.)	14,500 (15,200 at 223 sec.)
230	18.5	680 (400 at ≈ 237 sec.)	1,000 (600 at 233 sec.) (off chart at ≈ 235 sec.)	9.75 (7.0 at 238 sec.)	10,000 (4,800 at 237 sec.)
240	20.0 (20.5 at ≈ 245 sec.)	620 (970 at ≈ 245 sec.)	off chart (on chart at ≈ 248 sec.)	7.5 (9.5 at 245 sec.)	9,200 (9,600 at 242 sec.)
250	19.75	650	850	8.0	6,200
260	20.5	310	560	6.2	4,200

TABLE F-16. UDQII SCENARIO FOR RAG BALE - RUN 7

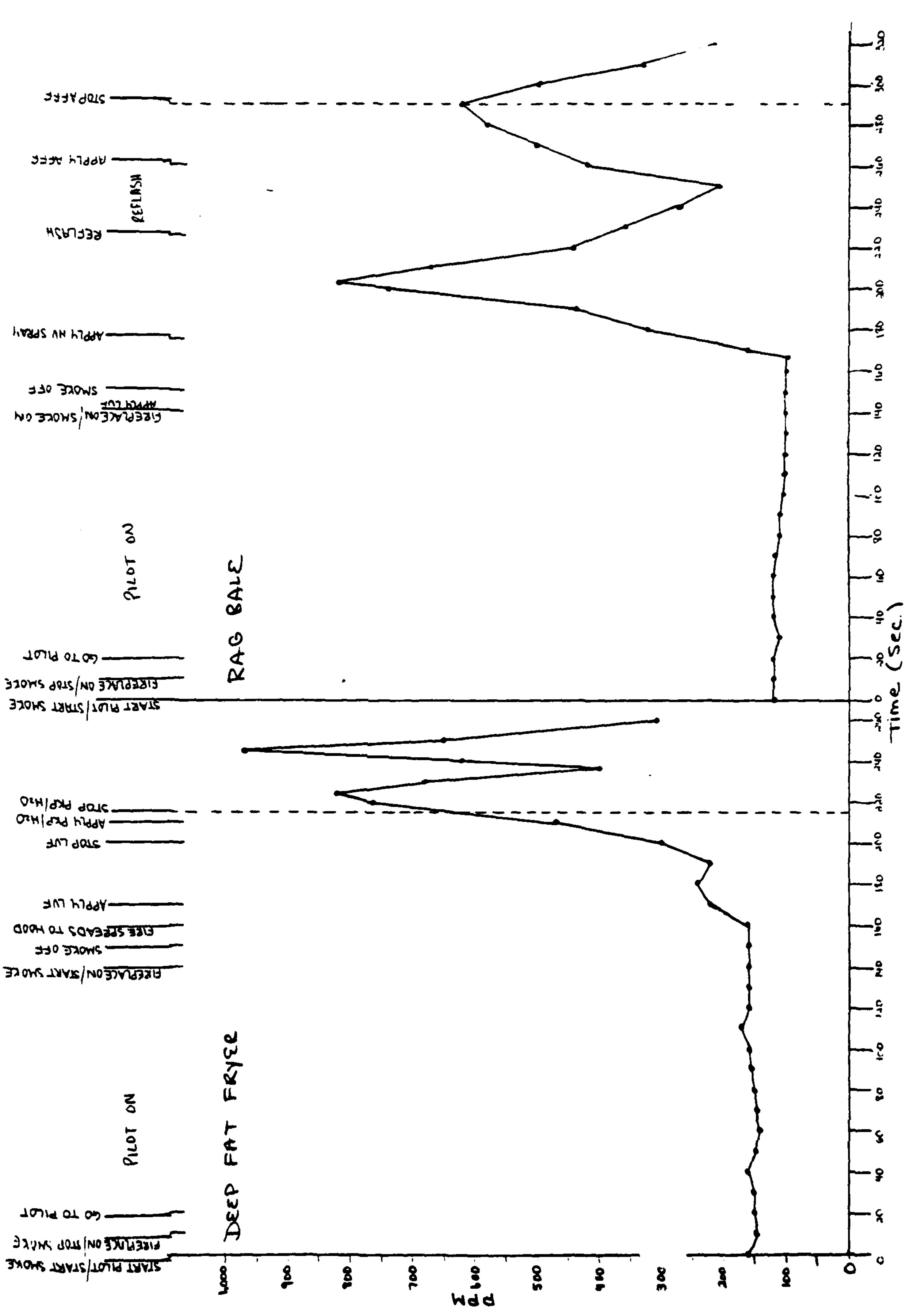
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	21.0	120	180	2.9	1,700
10	21.0	120	175	3.0	3,000
20	20.75	120	160	3.0	4,600
30	20.5	110	150	3.0	5,000
40	20.5	120	140	3.0	5,800
50	20.5	120	135	3.0	5,600
60	20.5	120	130	3.0	5,700
70	20.5	115	125	3.0	5,900
80	20.5	110	120	2.75	5,700 (6,000 at 86 sec.)
90	20.5	110	120	2.75	5,600 (6,000 at 97 sec.)
100	20.5	105	115	2.75	5,800
110	20.5	100	115	2.6	5,400 (6,000 at 115 sec.)
120	20.5	100	115	2.6	5,600
130	20.5	100	110	2.5	5,600
140	20.5	100	110	2.5	5,600 (6,100 at 145 sec.)
150	20.5	100	115	2.5	5,600
160	20.5	100 (100 at 167 sec.)	120	2.5	5,300
170	20.5	160	180 (170 at 174 sec.)	2.7	8,000

TABLE F-16 (Continued)

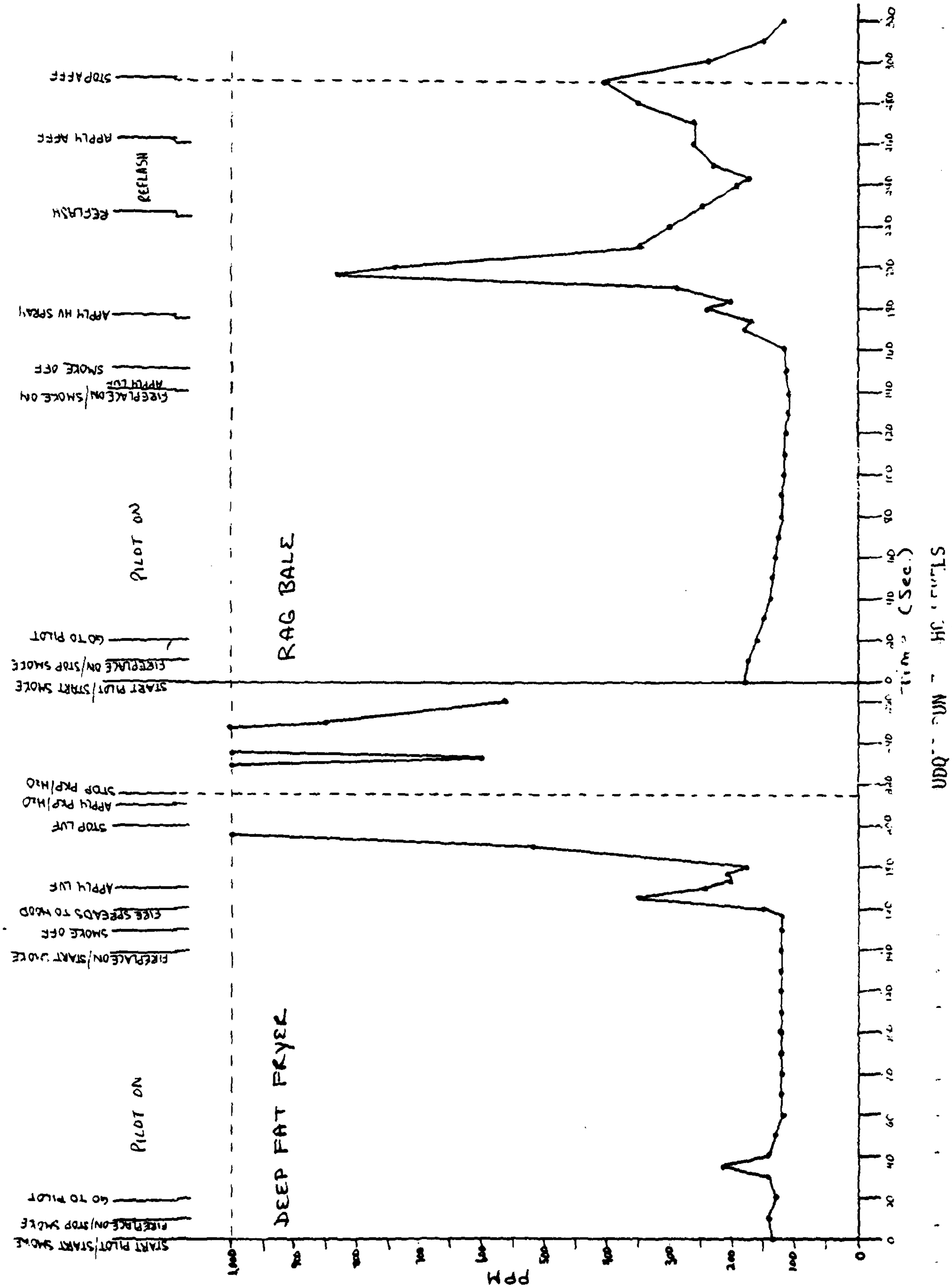
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
180	20.0	320	240 (205 at 184 sec.)	2.75	9,000 (10,600 at 185 sec.)
190	20.0	435	290 (825 at 197 sec.)	3.0	10,000
200	19.75	740 (820 at 203 sec.)	740	4.5 (5.2 at 205 sec.)	11,000 (10,200 at 205 sec.)
210	19.5	670	350	4.5	10,600 (9,100 at 215 sec.)
220	19.75	440	300	4.0	9,300
230	20.0	360	250	3.75	9,400
240	20.0	275	190 (175 at 244 sec.)	3.6	8,400 (8,000 at 245 sec.)
250	20.0	210	230	3.5	8,800
260	20.0	420	260	3.25	8,900
270	20.0	500	260	3.5	10,000
280	19.75	580	350	3.5	11,000
290	19.5	620	405	3.75	9,300
300	20.0	500	240	4.0	9,200
310	20.0	330	150	3.5	8,000
320	20.25	215	120	3.0	5,800


START PILOT/START SMOKE
FIREPLACE ON/STOP SMOKE
GO TO PILOT
PILOT ON
FIREPLACE ON/START SMOKE
SMOKE OFF
FIRE SPREADS TO HOOD
APPLY LVF
STOP LVF
APPLY PKP/H2O
STOP PKP/H2O
DEEP FAT FRYER
START PILOT/START SMOKE
FIREPLACE ON/STOP SMOKE
GO TO PILOT
PILOT ON
FIREPLACE ON/SMOKE ON
APPLY LVF
SMOKE OFF
APPLY HV SPRAY
REFLASH
REFLASH
APPLY AFFF
STOP AFFF
RAG BALE
25%
20%
15%
10%
5%
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
Time (Sec.)

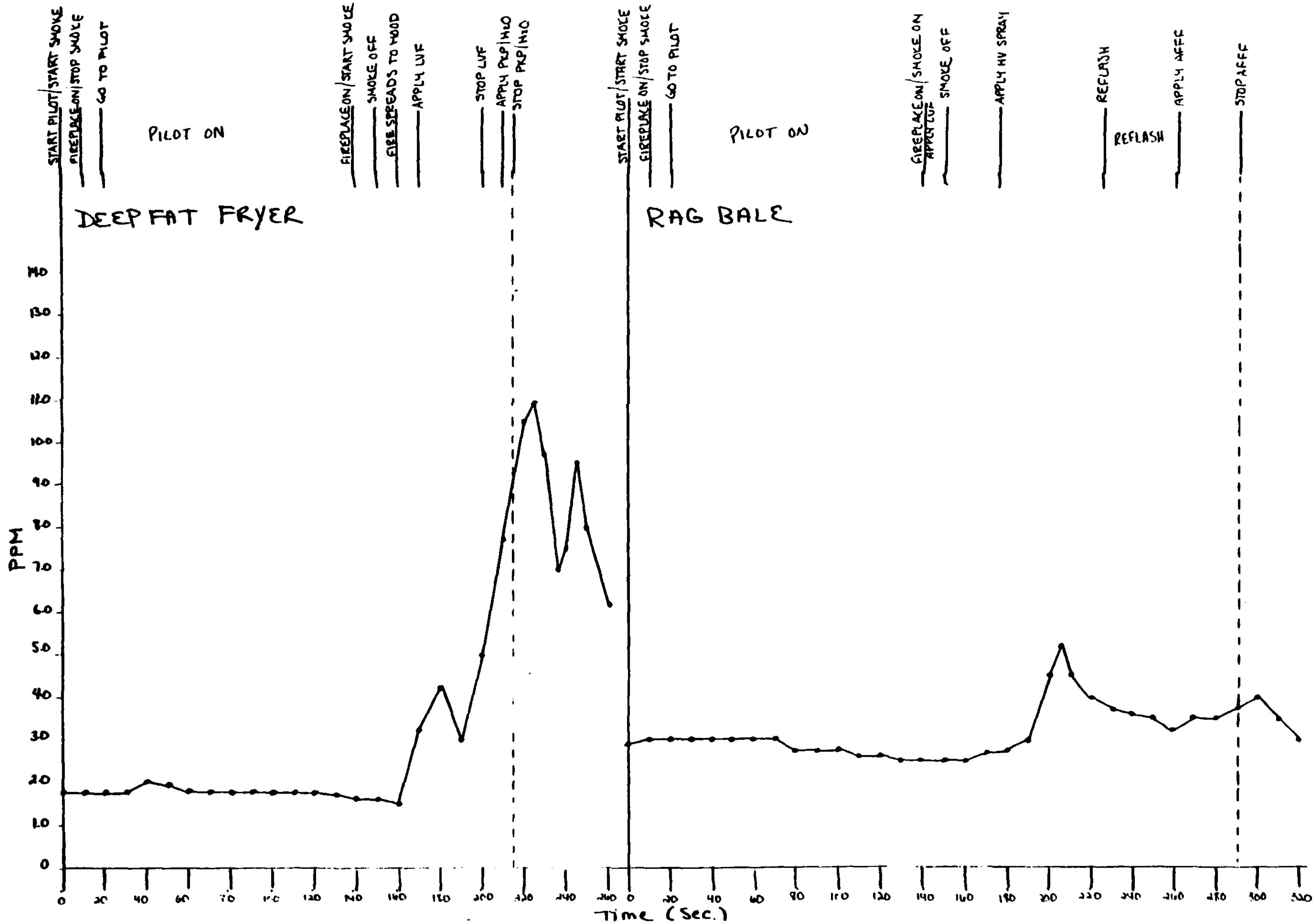
DQI[illegible] N 7 O_2 L[illegible]S



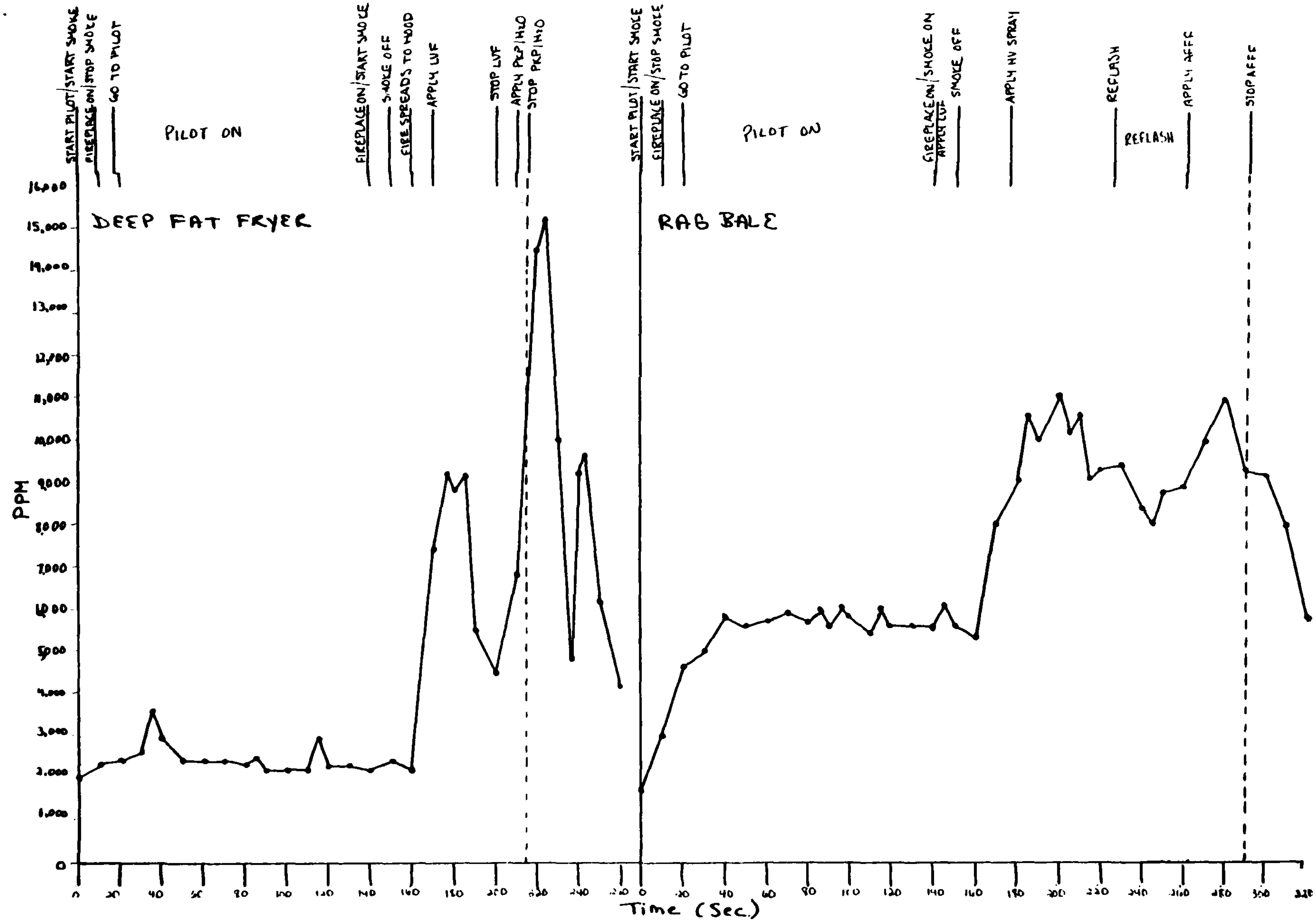
UD011 RUN 7 - CO LEVELS



DEEP FAT FRYER
RAG BALE
PILOT ON
PILOT ON
PPM
(Sec.)
START PILOT/START SMOKE
GO TO PILOT
SMOKE OFF
APPLY LUF
STOP LUF
APPLY PKP/H2O
STOP PKP/H2O
APPLY HV SPRAY
REFLASH
REFLASH
APPLY AFFF
STOP AFFF



UDQII RUN 7 - NO_x LEVELS



UDOTT RUN 7 - CO LEVELS

TABLE F-17. UDQII SCENARIO FOR DEEP FAT - RUN 8

Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	20.75	140	95	1.25	2,100
10	20.75	140	95	1.3	2,400
20	20.75	150	95	1.3	2,400
30	20.75	160	95	1.4	2,600
40	20.75	160	100	1.5	2,600
50	20.75	160	100	1.5	2,600
60	20.75	170	100	1.5	2,500
70	20.75	170	100	1.5	2,600
80	20.75	160	100	1.5	2,600
90	20.75	160	100	1.5	2,700
100	20.75	155	100	1.5	2,800
110	20.75	150	100	1.5	2,600
120	20.75	150	100	1.5	2,600
130	20.75	150	100	1.5	2,600
140	20.75	145	100	1.5	2,600
150	20.75	155	100 (100 at 156 sec.)	1.5	2,600
160	20.75	170	310	1.5	2,800
170	20.75	170	130	2.25	6,000
180	20.5	185	170	2.1	10,000
190	19.9	220	500 (off chart at ≈ 197 sec.)	2.5	4,700
200	20.5	290	off chart	4.5	4,400 (5,800 at 208 sec.)
210	20.5	490	off chart	7.75	5,600
220	20.5	840 (940 at 224 sec.)	off chart	11.5 (12.7 at 224 sec.)	13,800 (14,000 at 222 sec.)

TABLE F-17 (Continued)

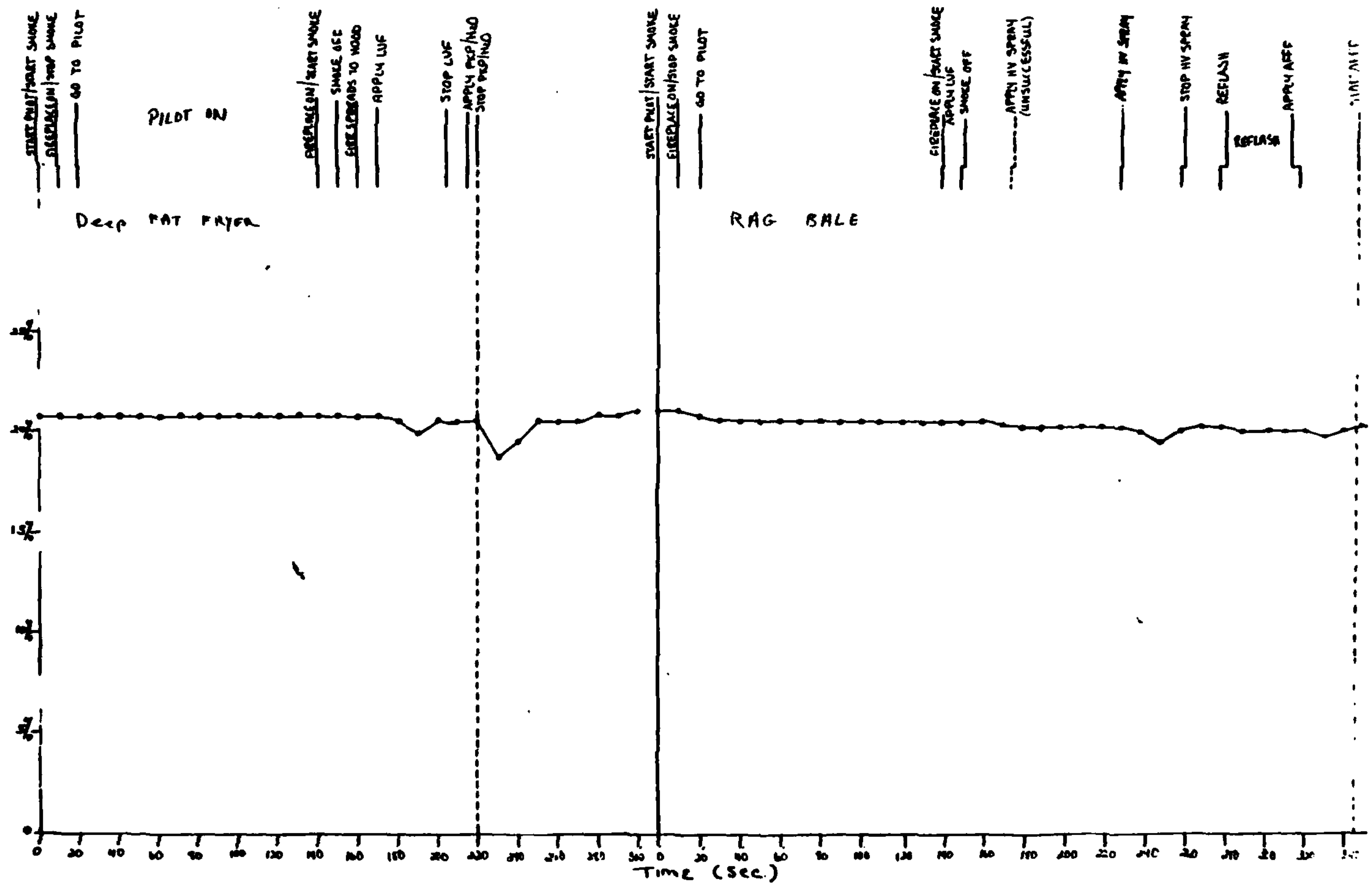
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
230	18.75	750	off chart (on chart at 239 sec.)	11.0	12,000
240	19.5	520	860 (1,020 at 241 sec.) (780 at 243 sec.) (off chart at 247 sec.)	8.25	6,800
250	20.5	360	off chart	6.9	4,600
260	20.5	325	off chart (1,020 at 266 sec.)	7.2 (7.75 at 267 sec.)	5,300 (5,700 at 263 sec.)
270	20.5	280	off chart (on chart at 273 sec.)	7.25	4,000
280	20.75	230	420 (470 at 281 sec.) (380 at 283 sec.)	6.5	2,800
290	20.75	180	650 (320 at 294 sec.)	5.75	2,500 (2,800 at 295 sec.)
300	21.0	175	360	5.5	2,200

TABLE F-18. UDQII SCENARIO FOR RAG BALE - RUN 8

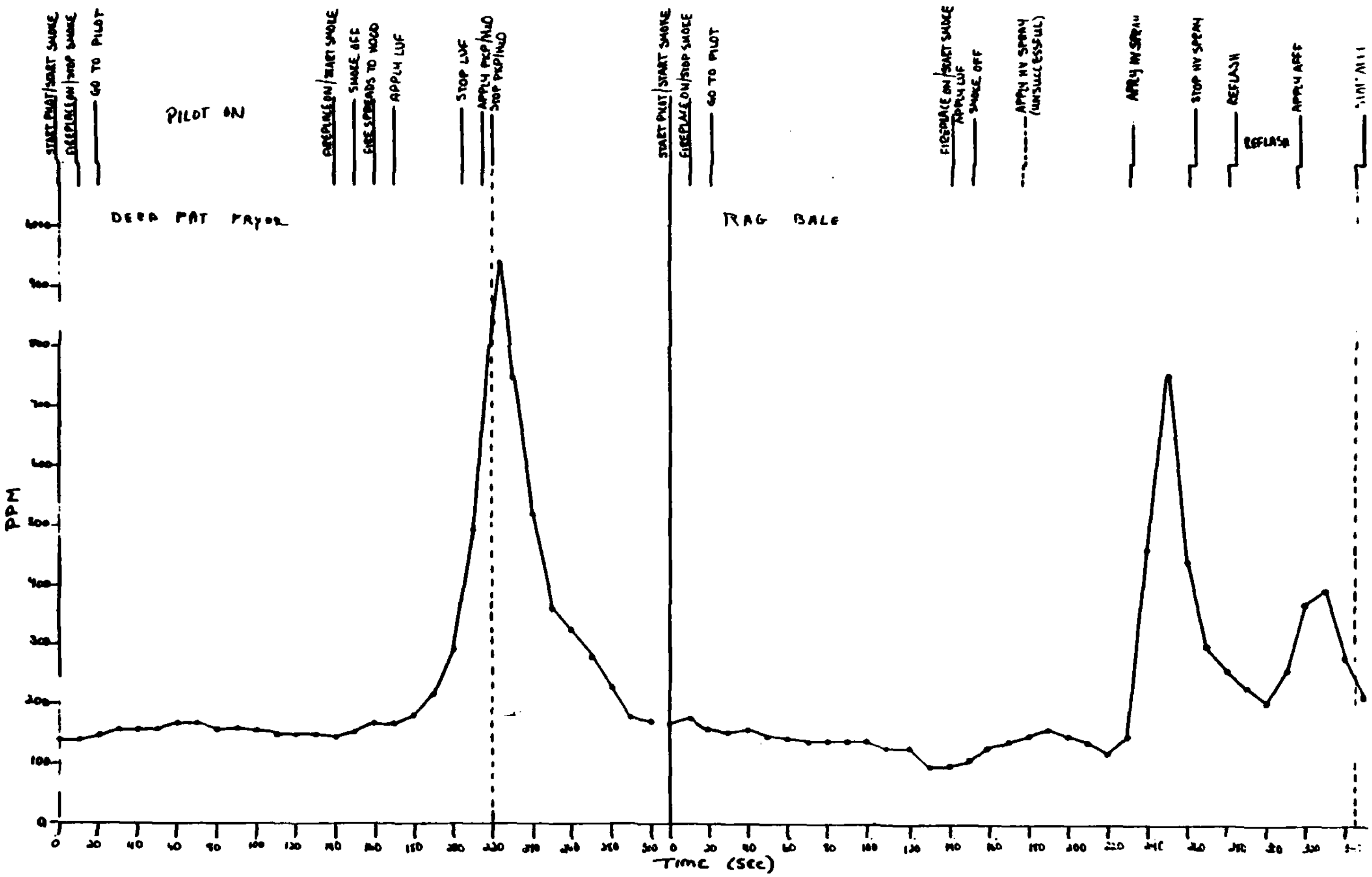
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
0	21.0	170	100	2.0	1,600
10	21.0	180	100	2.2	3,000
20	20.75	160	95	2.5	4,900
30	20.5	155	95	2.5	5,200
40	20.5	160	95	2.6	6,000 (5,200 at 46 sec.)
50	20.5	150	95	2.5	5,400
60	20.5	145	95	2.25	5,500
70	20.5	140	95	2.25	5,600 (6,000 at 76 sec.)
80	20.5	140	95	2.25	5,500
90	20.5	140	95	2.25	5,800
100	20.5	140	90	2.25	6,000
110	20.5	130	90	2.25	5,600 (6,000 at 112 sec.)
120	20.5	130	80	2.25	5,600
130	20.5	100	80	2.25	5,200
140	20.5	100	85	2.25	5,600
150	20.5	110	90	2.25	5,600
160	20.5	130	95	2.4	6,500
170	20.3	140	100	2.5	7,000
180	20.25	150	100	2.4	7,000 (7,500 at 186 sec.)
190	20.25	160	100	2.25	6,600
200	20.25	150	100	2.25	6,400

TABLE F-18 (Continued)

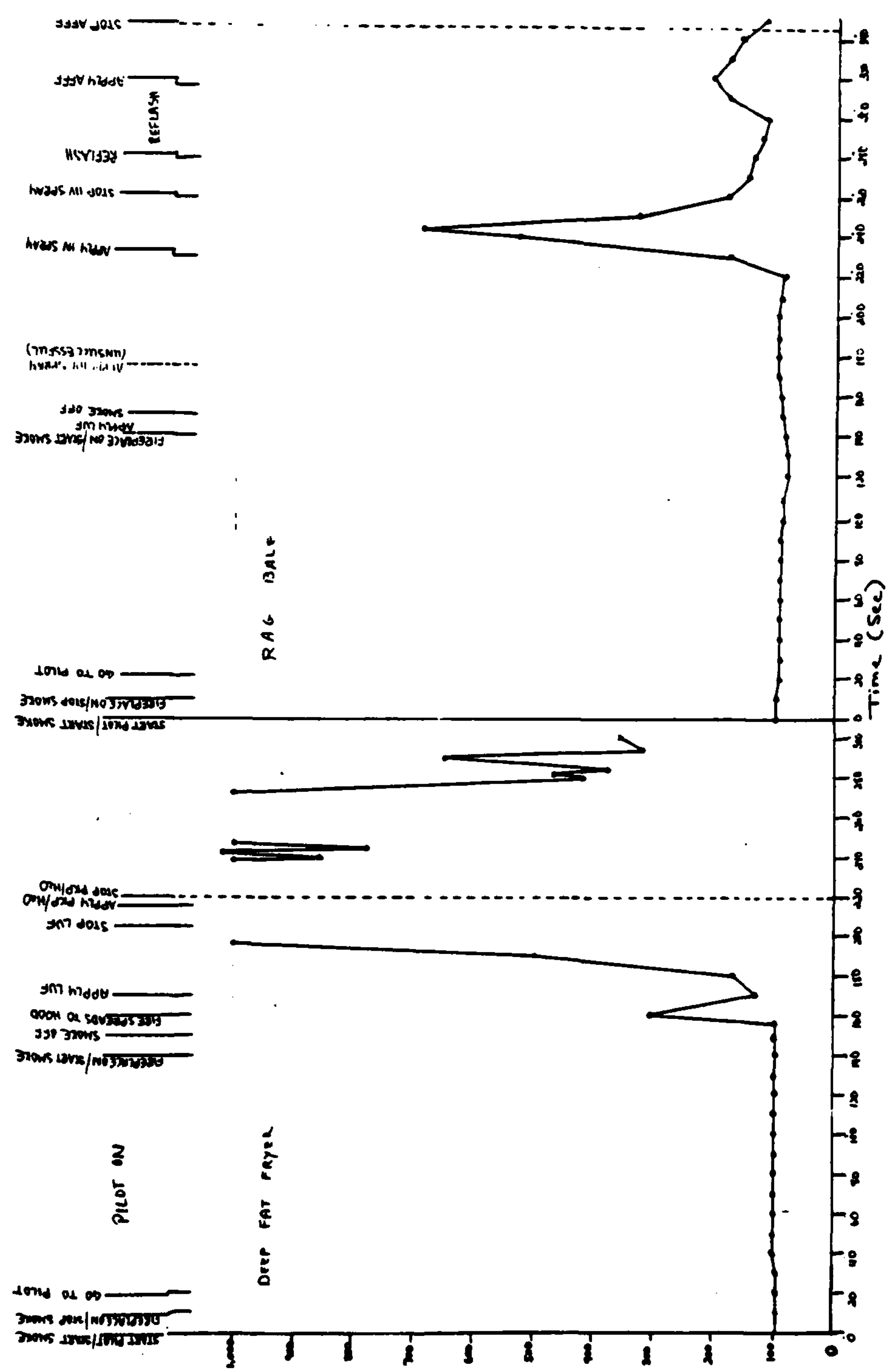
Time/Sec.	O_2 (percent)	CO (ppm)	HC (ppm)	NO_x (ppm)	CO_2 (ppm)
210	20.25	140	95	2.25	6,800 (7,200 at 215 sec.)
220	20.25	125	90	2.25	6,800
230	20.25	150	175	2.3	8,000 (10,400 at 237 sec.)
240	20.0	460	530 (690 at 243 sec.)	2.75	10,200 (10,800 at 247 sec.)
250	19.5	750	330	4.0	9,100
260	20.0	440	180	3.0	6,800 (7,600 at 268 sec.)
270	20.26	300	150	2.75	7,200
280	20.25	260	140	2.75	8,800
290	20.0	230	125	3.0	9,100
300	20.0	205	120	2.75	8,300
310	20.0	260	180	2.6	8,800
320	20.0	370	210	3.0	9,600 (10,000 at 323 sec.)
330	19.75	390	180	3.0	9,500
340	20.0	280	160	2.75	7,200
350	20.25	215	120	2.75	6,800



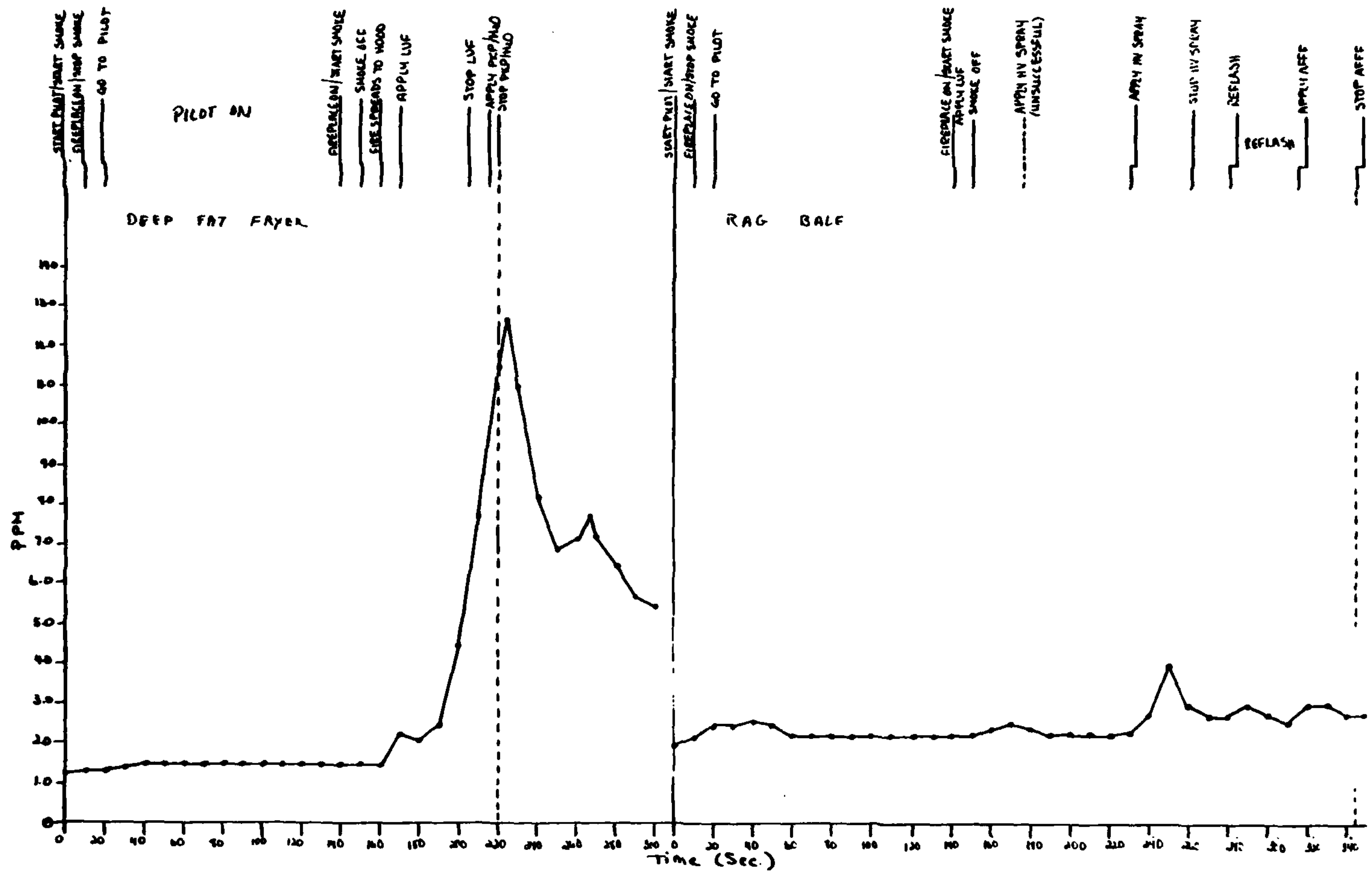
UDQII RUN 8 - O_2 LEVELS



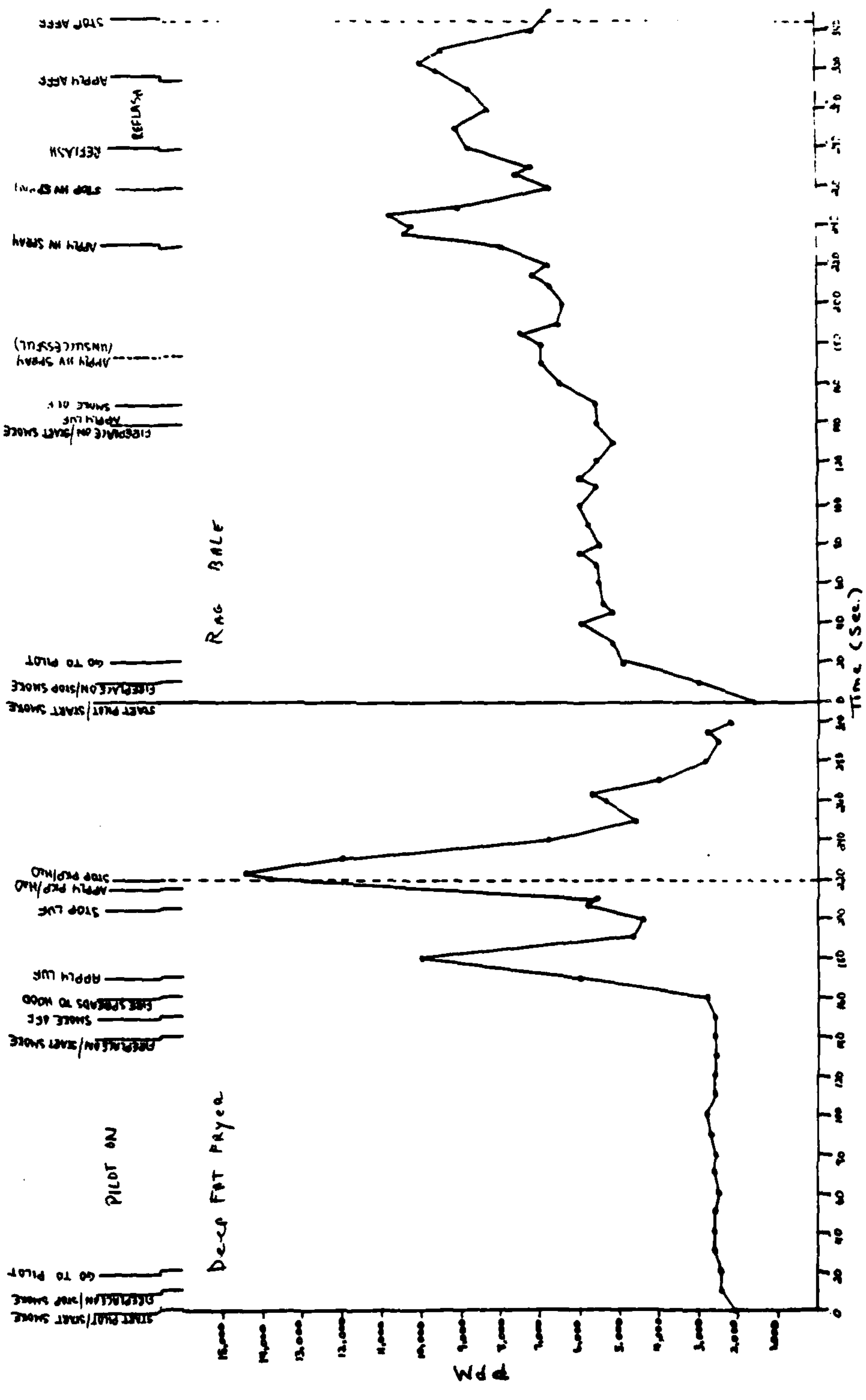
UDQII RUN 8 - CO LEVELS



UDQII RUN 8 - HC LEVELS



UDQII RUN 8 - NO_x LEVELS



UDQII RUN 8 - CO_2 LEVELS

LDQI INTERNAL ATMOSPHERE

(As Measured by Case
Consulting Equipment)

KEY

Activity	Abbreviation
Start Pilot, Start Smoke	Start
Flame On, Stop Smoke	On
Go to Pilot	Pilot
Flame On, Apply Low-Velocity Fog	LVF
Apply PKP Surrogate	PKP
Stop Applying PKP Surrogate	PKP Off
Apply Solid Stream Water	Solid Stream
Stop Applying Solid Stream, Apply High-Velocity Water Spray	HV
Stop Applying High-Velocity Spray	HV Off
Apply AFFF Surrogate	AFFF
Stop Applying AFFF Surrogate	AFFF Off

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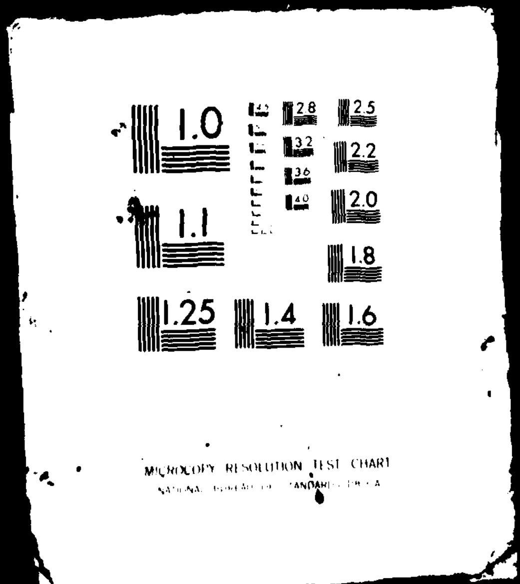
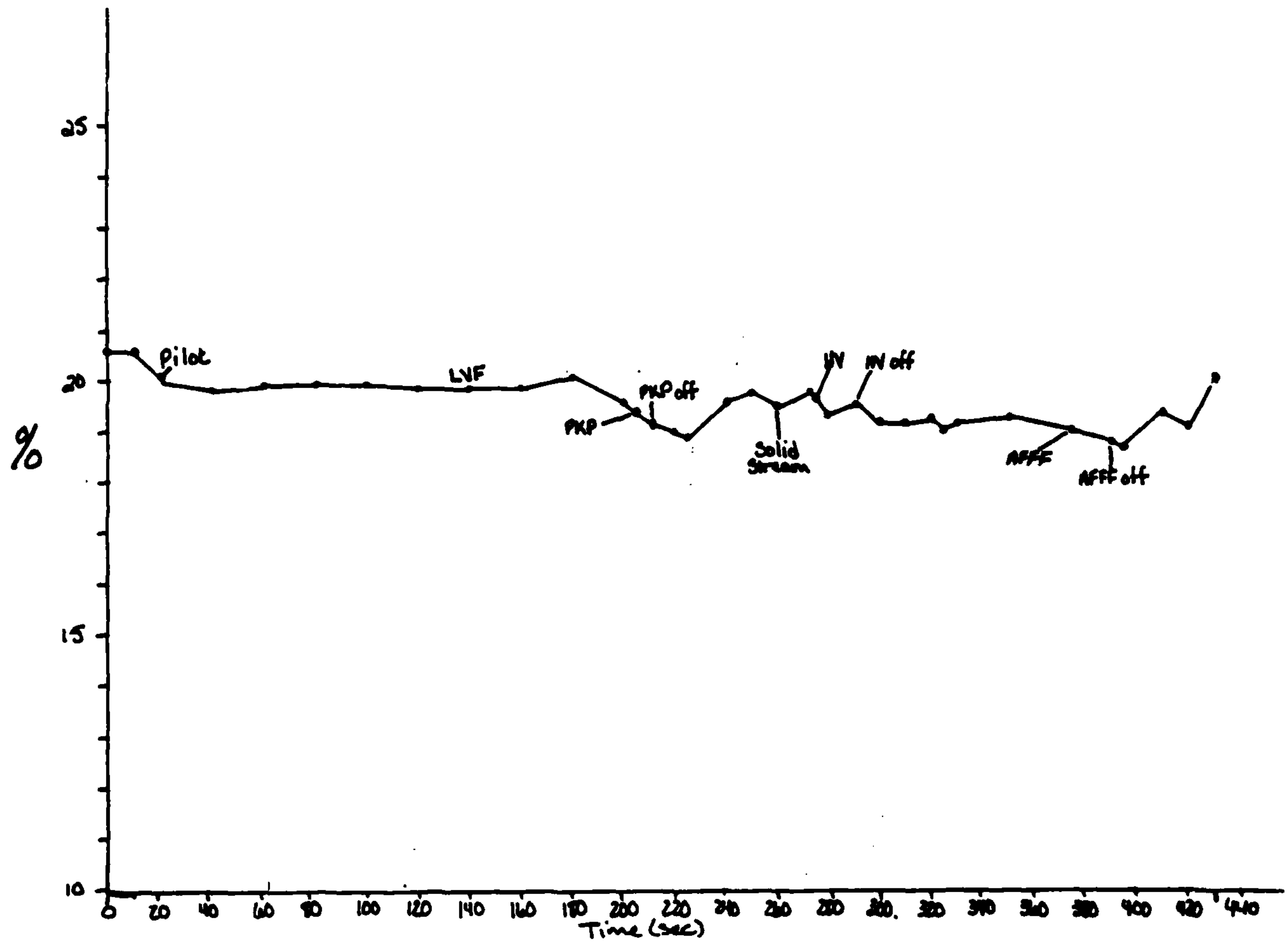


TABLE F-19. LDQI - RUN 3 (BILGE)

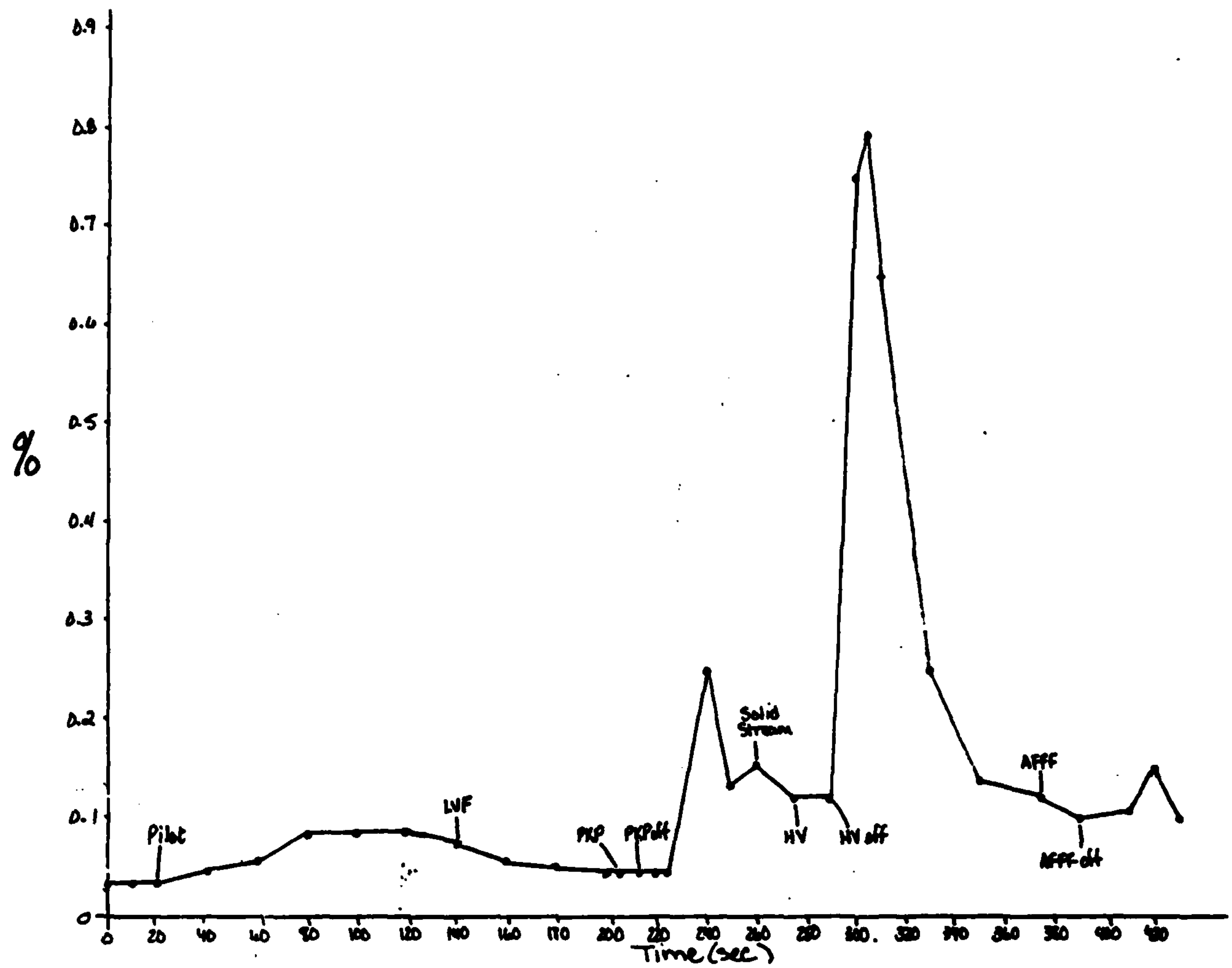
Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.6	0.03	0	0.08
10	20.6	0.03	0	0.25
15	-	-	-	0.55
20	20.1	0.03	0	0.20
40	19.85	0.04	0.02	0.35
50	-	-	-	0.59
60	19.95	0.06	0.03	0.45
80	19.95	0.08	0.02	0.41
100	19.9	0.08	0.02	0.61
120	19.8	0.08	0.01	0.52
140	19.8	0.07	0	0.71
160	19.8	0.06	0	0.63
180	20.1	0.05	0	0.40
200	19.65	0.04	0	0.81
205	19.4	0.04	0	0.55
212	19.25	0.04	0	0.80
220	19.0	0.04	0	1.2
225	18.9	0.04	0.09	0.75
230	-	-	0	1.2
240	19.6	0.25	0.05	0.82
250	19.75	0.13	0.02	0.95
260	19.5	0.16	0.01	0.50
272	19.85	-	-	-
275	19.75	0.12	0.01	0.52
280	19.4	-	-	1.5
290	19.55	0.12	0.4	1.0
300	19.25	0.75	0.25	1.0
305	-	0.79	-	-
310	19.25	0.65	-	-
320	19.35	-	0.03	1.55
325	19.1	-	-	-
330	19.2	0.25	0.02	0.75
350	19.3	0.14	0.05	0.90
375	19.1	0.12	0.01	1.25
390	18.85	0.10	0	1.4
395	18.75	-	-	-
410	19.45	0.11	0.07	1.65
420	19.15	0.15	0	0.55
430	20.15	0.10	0	0.37

NOTE: Data were obtained from the Case Consulting Labs.

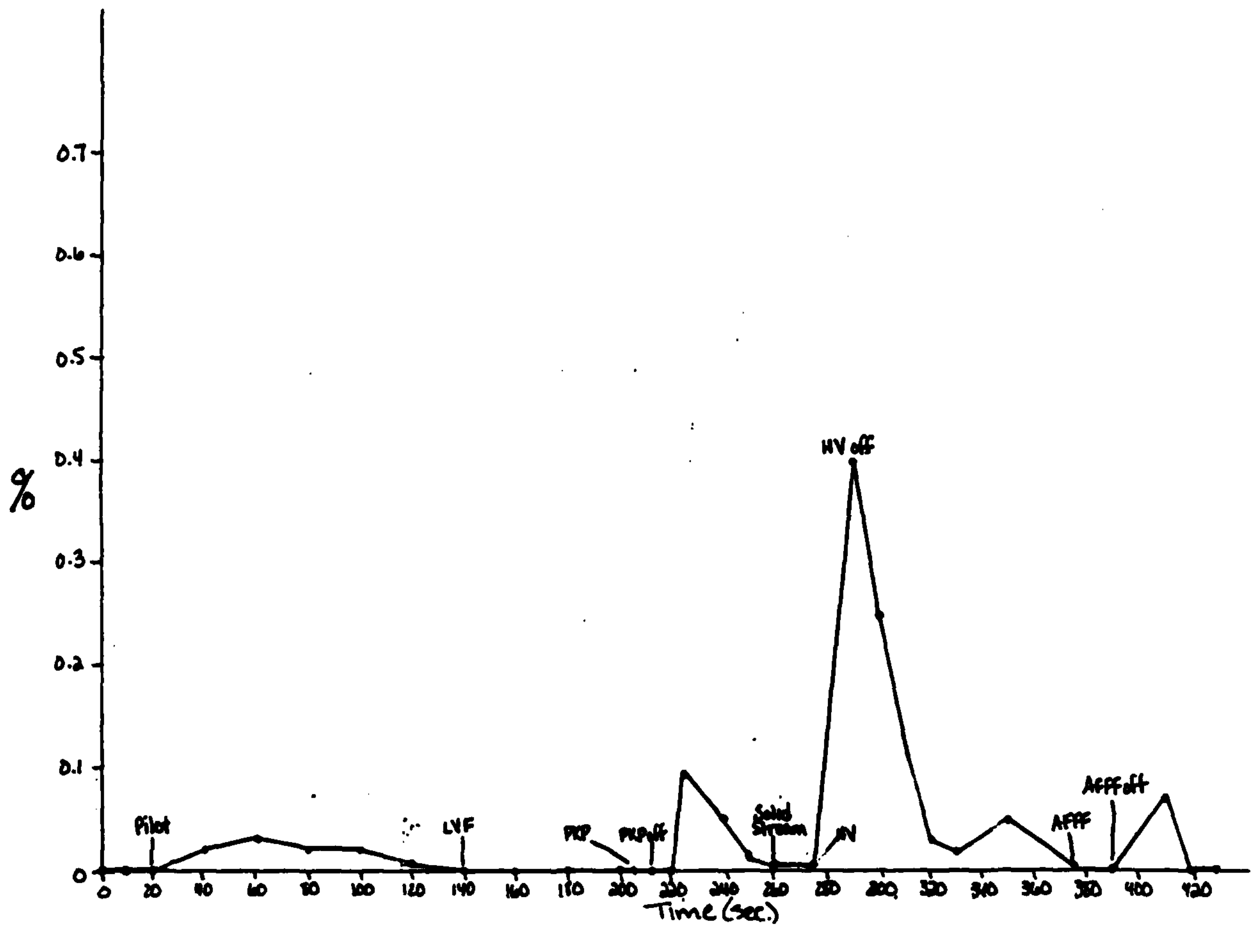
LDQI RUN 3 (CASE) - O_2 LEVELS



LDQI RUN 3 (CASE) - HC LEVELS



LDQI RUN 3 (CASE) - CO LEVELS



LDQI RUN 3 (CASE) - CO_2 LEVELS

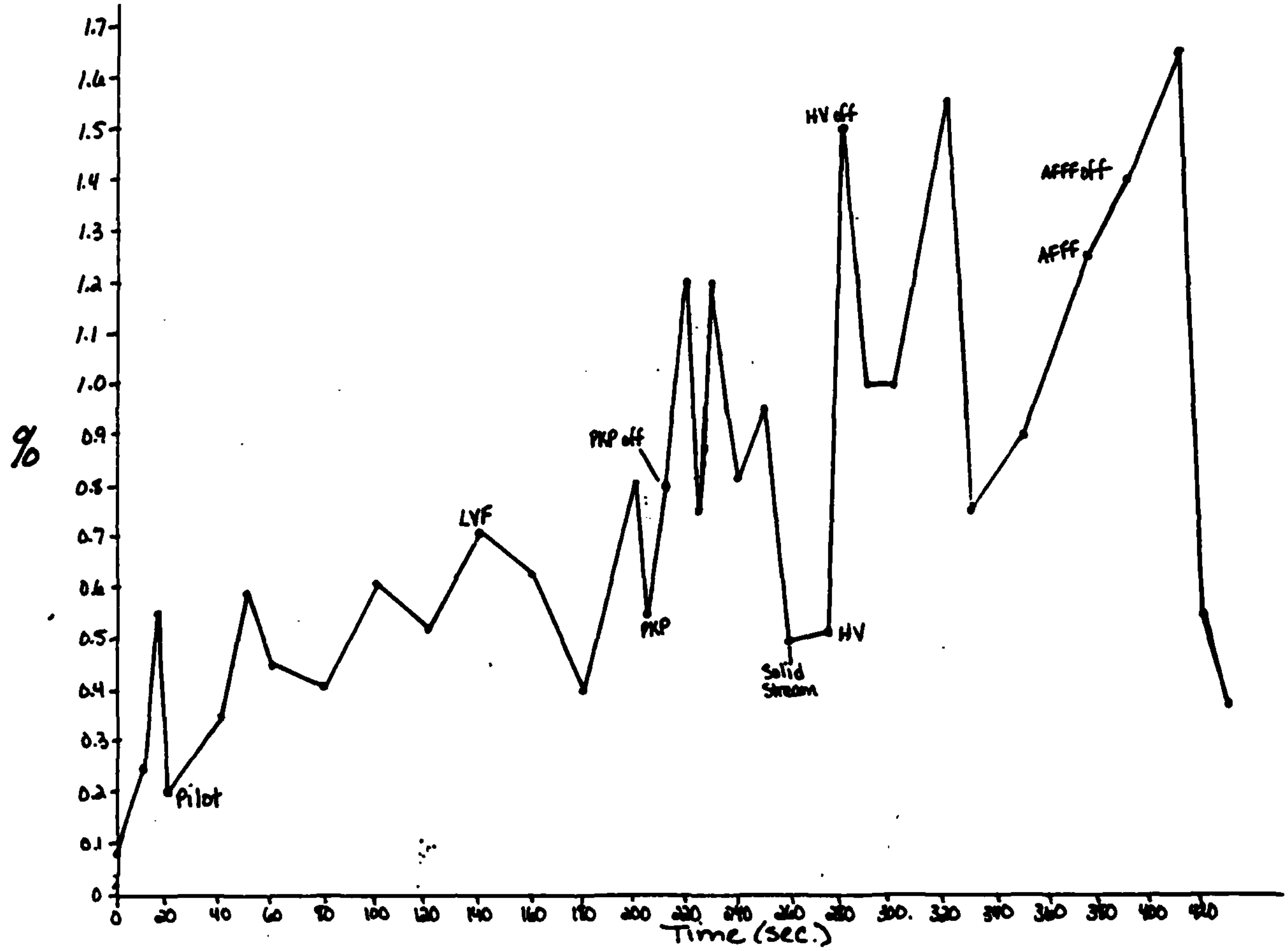
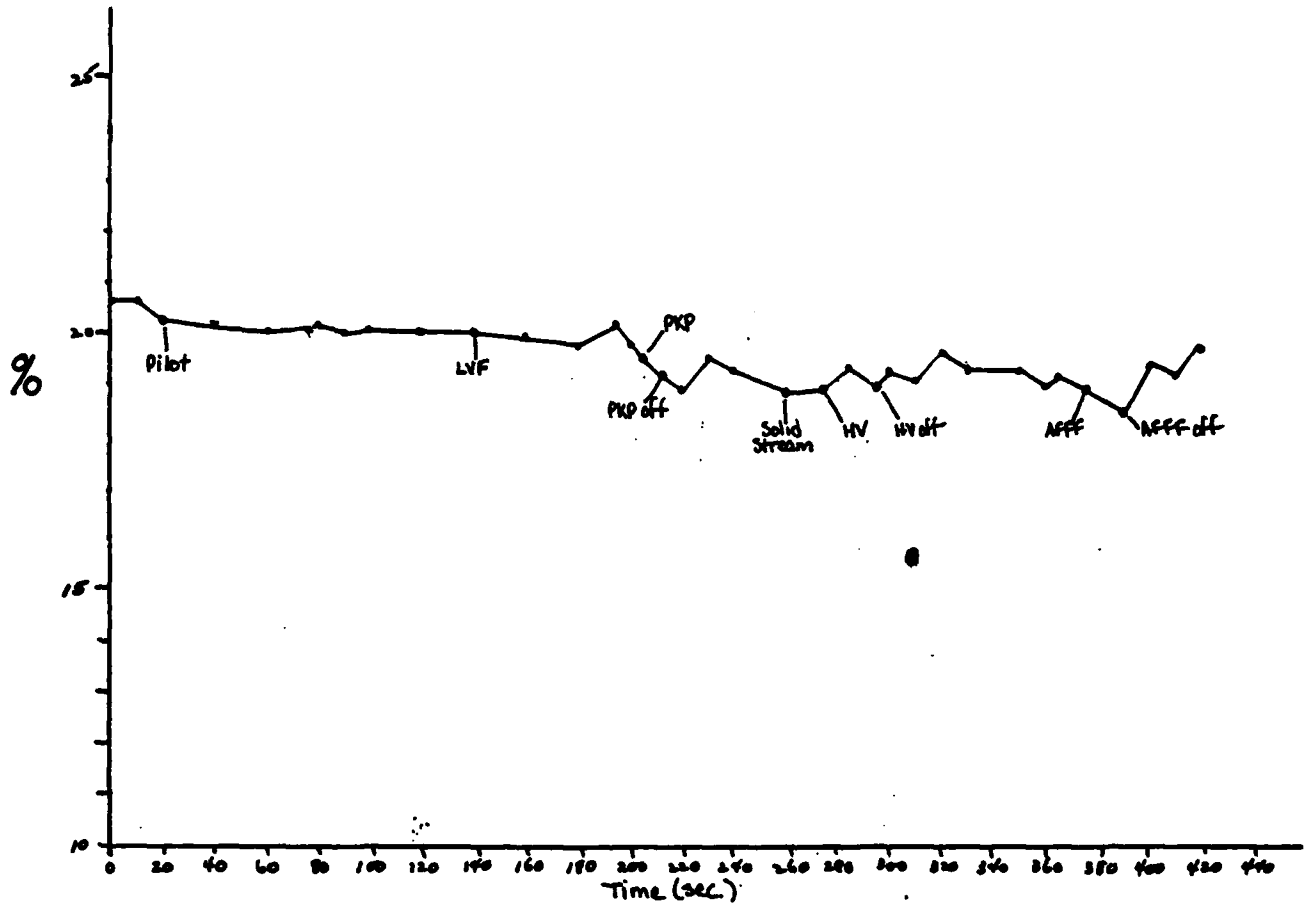


TABLE F-20. LDQI - RUN 4 (BILGE)

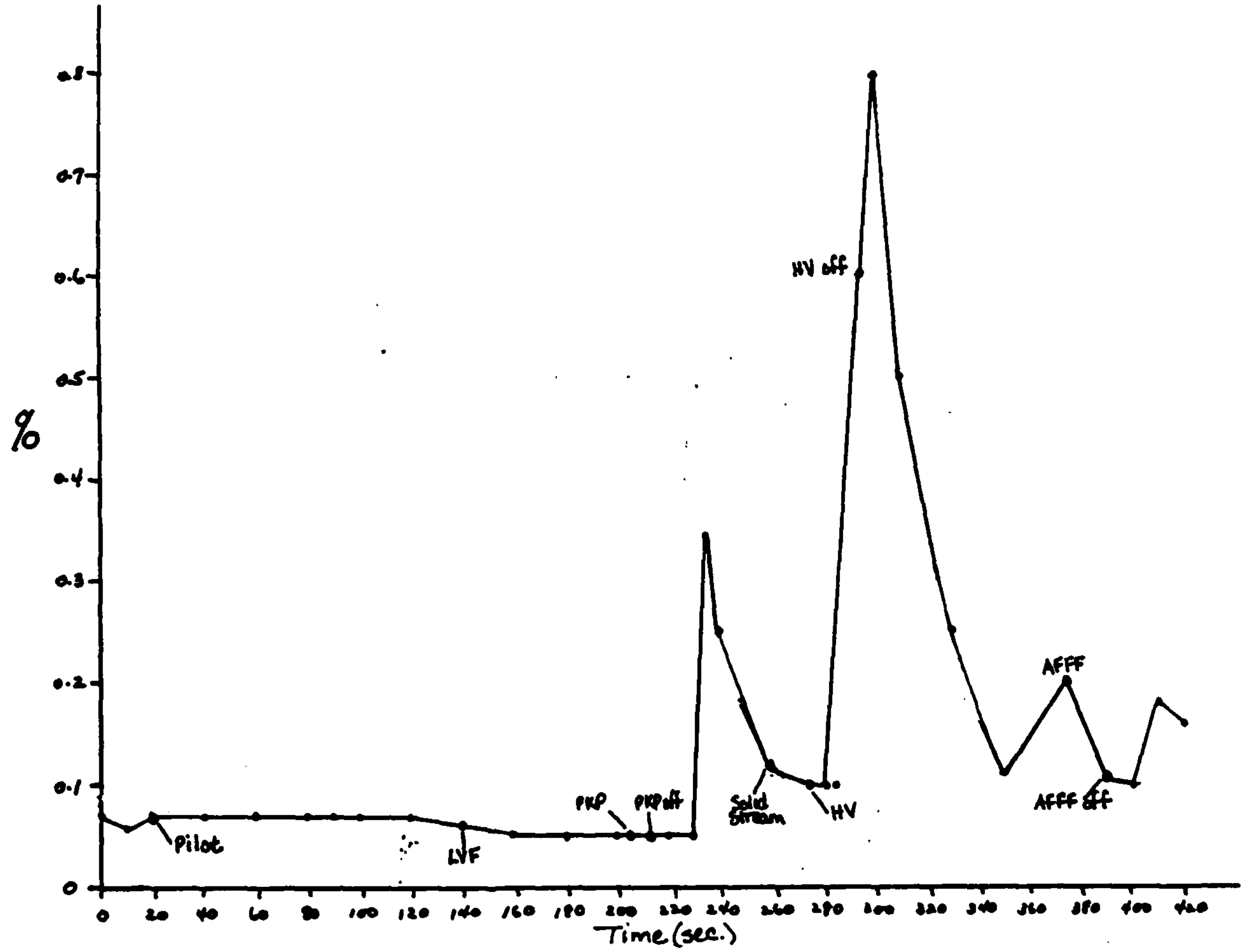
Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.6	0.07	0	0.1
10	20.6	0.06	0	0.28
20	20.25	0.07	0	0.20
40	20.15	0.07	0	0.51
60	20.05	0.07	0	0.21
75	-	-	-	0.60
80	20.2	0.07	0	0.25
90	20.0	0.07	0	-
100	20.1	0.07	0	0.50
110	-	-	-	0.68
120	20.0	0.07	0	0.31
140	20.0	0.06	0	0.31
160	19.95	0.05	0	0.55
180	19.7	0.05	0	0.40
195	20.2	-	-	-
200	19.75	0.05	0	0.68
205	19.5	0.05	0	0.82
215	19.2	0.05	0	1.03
220	18.9	0.05	0.27	1.2
230	19.5	0.05	0.01	1.77
235	-	0.34	-	-
240	19.25	0.25	0.03	0.7
250	-	-	-	1.04
260	18.8	0.12	0.02	0.68
275	18.9	0.10	0.01	0.75
285	19.3	0.10	0.25	-
295	19.0	0.60	0.13	1.41
300	19.3	0.79	0.27	1.40
305	-	-	-	1.9
310	19.15	0.50	0.09	1.25
320	19.6	-	-	-
330	19.25	0.25	0.05	0.80
340	-	-	-	1.21
350	19.25	0.12	0.01	0.70
360	19.0	-	-	-
365	19.2	-	0.12	1.81
375	18.9	0.20	0.01	0.75
390	18.5	0.11	0.01	1.70
400	19.4	0.10	0.12	1.10
410	19.15	0.18	0.02	1.72
420	19.75	0.16	0	0.45

NOTE: Data were obtained from the Case Consulting Labs.

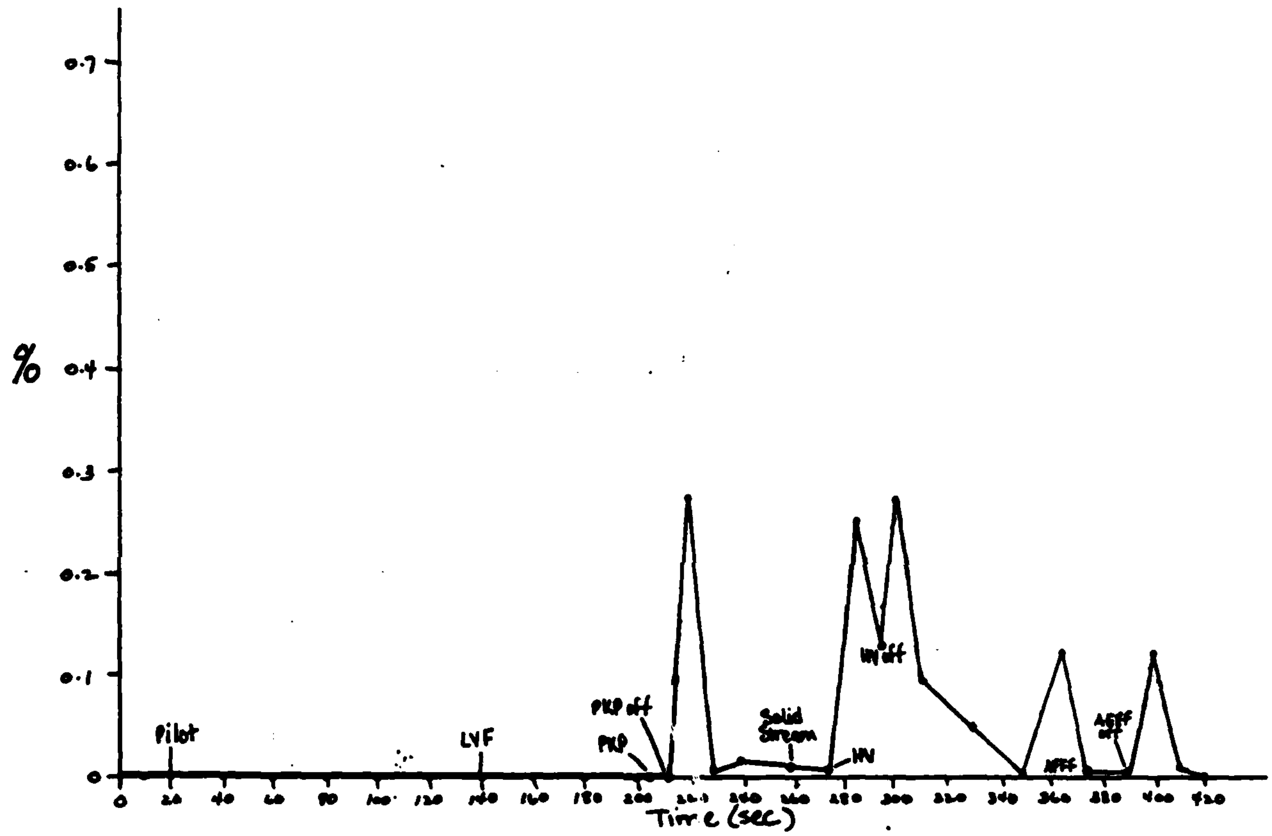
LDQI RUN 4 (CASE) - O_2 LEVELS



LDQI RUN 4 (CASE) - HC LEVELS



LDQI RUN 4 (CASE) - CO LEVELS



LDQI RUN 4 (CASE) - CO_2 LEVELS

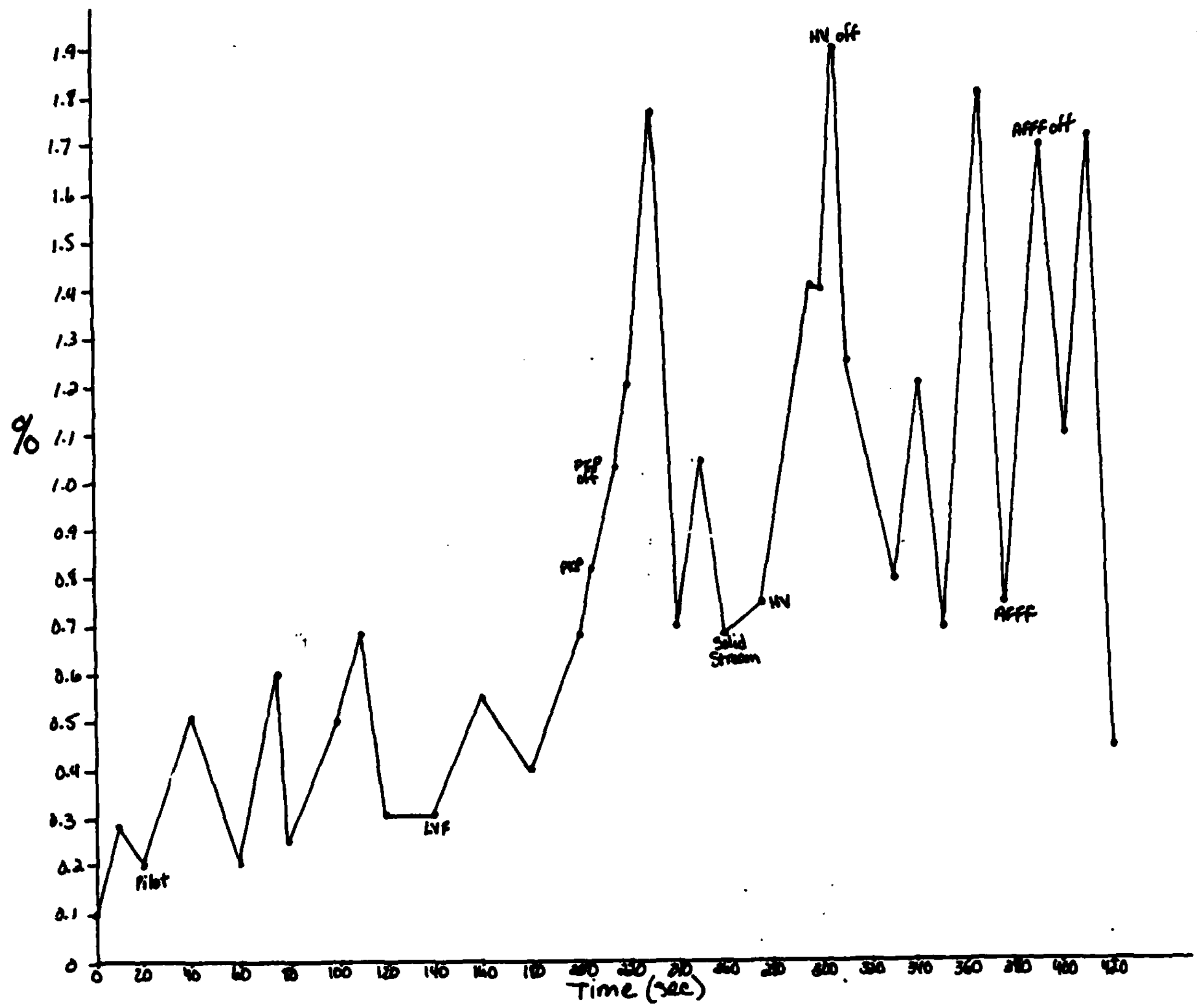
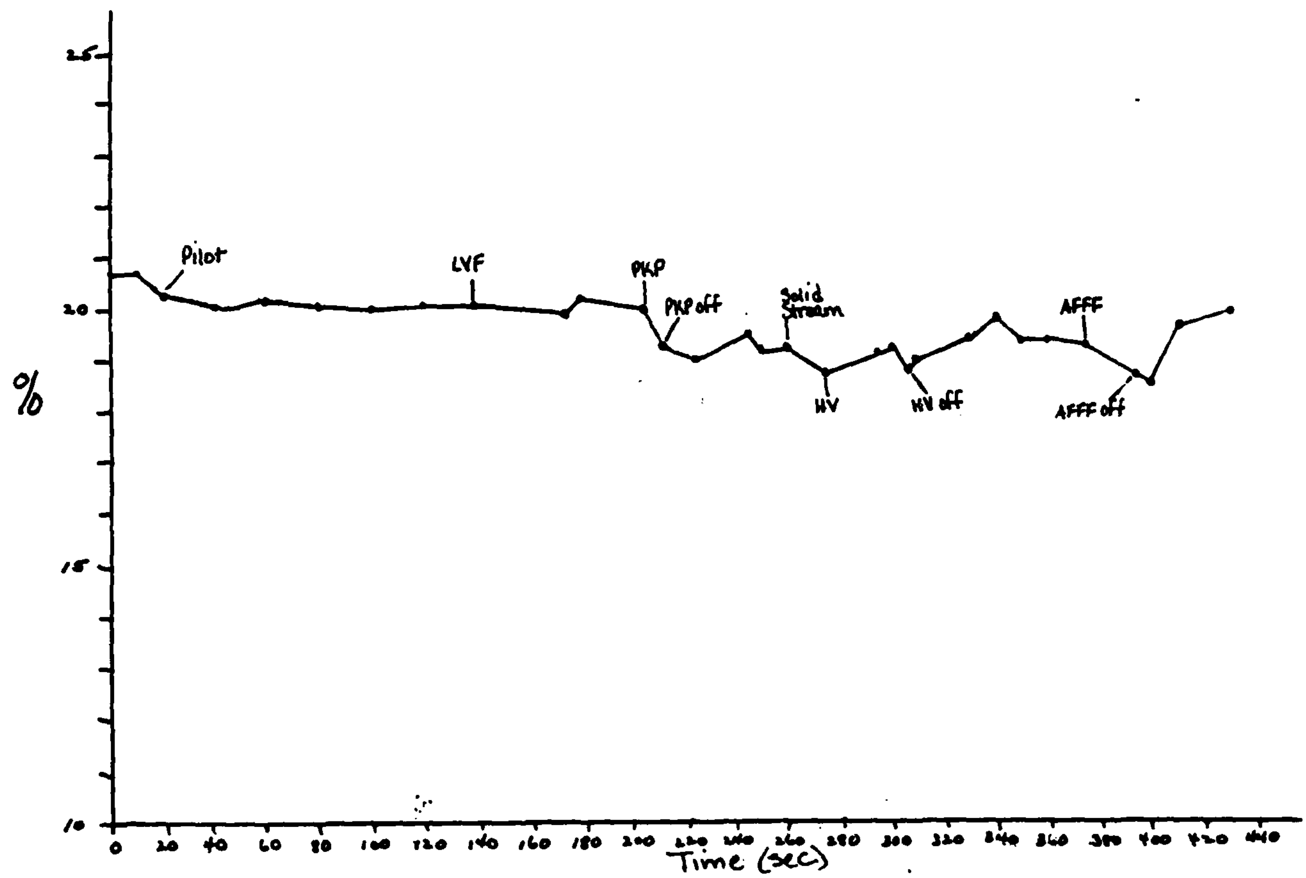


TABLE F-21. LDQI - RUN 5

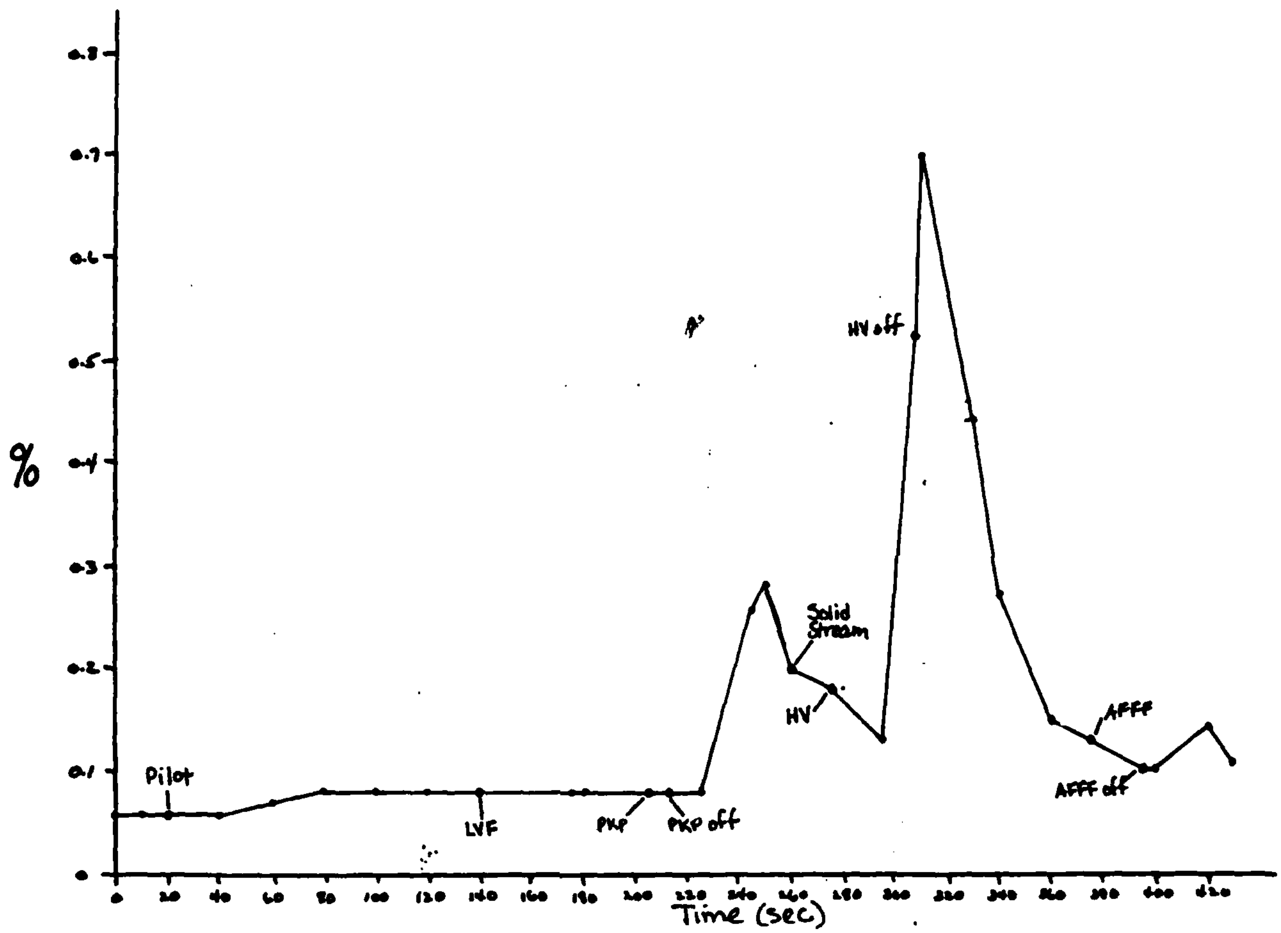
Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.65	0.06	0	0.18
10	20.65	0.06	0	0.22
20	20.25	0.06	0	0.22
30	-	-	-	0.48
40	20.1	0.06	0	0.28
60	20.2	0.07	0.02	0.14
70	-	-	-	0.43
80	20.1	0.09	0	0.22
100	20.0	0.08	0.01	0.30
105	-	-	-	0.60
120	20.1	0.08	0.02	0.43
140	20.1	0.08	0	0.37
150	-	-	-	0.53
175	19.95	0.08	0.1	0.25
180	20.15	0.08	-	-
205	20.0	0.08	0	0.80
212	19.25	0.08	0	0.97
225	19.0	0.08	0	1.31
240	-	-	0.16	-
245	19.5	0.26	0.09	1.20
250	19.25	0.28	0.05	1.60
260	19.3	0.20	0.13	0.78
275	18.65	0.18	0.06	1.40
290	-	-	-	1.86
295	19.25	0.13	0.16	1.21
300	19.35	-	0.60	-
308	18.75	0.55	0.25	2.32
310	19.0	0.70	-	-
330	19.45	0.44	0.10	1.12
340	19.7	0.27	0.08	1.37
350	19.3	-	0.02	0.75
360	19.3	0.15	0.02	1.0
375	19.25	0.13	0.03	1.25
395	18.65	0.10	0.01	1.98
400	18.5	0.10	0.02	1.5
405	-	-	0.08	-
420	19.65	0.14	0	0.63
430	19.9	0.11	0.02	0.92
440	-	-	0	0.48

NOTE: Data were obtained from the Case Consulting Labs.

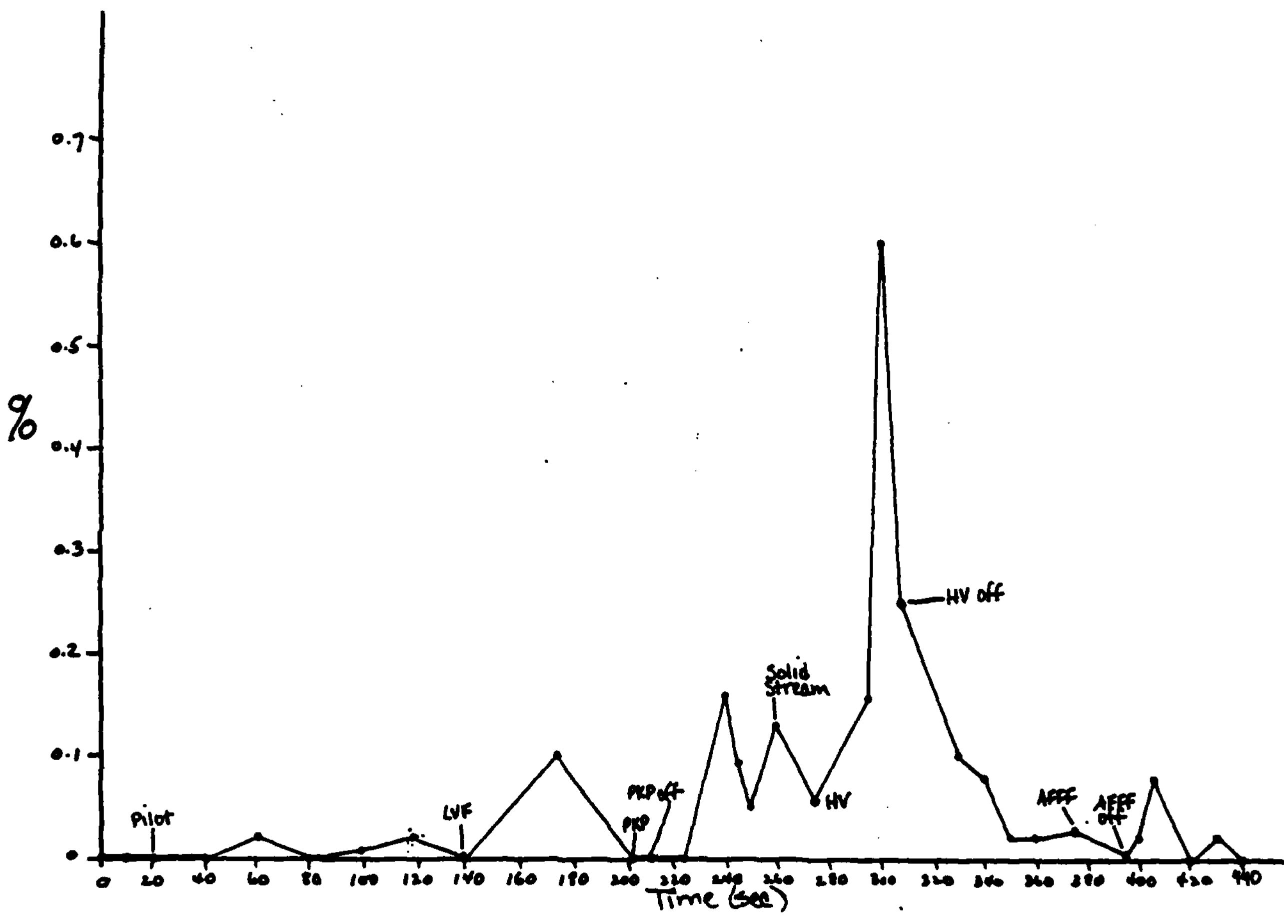
LDQI RUN 5 (CASE) - O_2 LEVELS



LDQI RUN 5 (CASE) - HC LEVELS



LDQI RUN 5 (CASE) - CO LEVELS



LDQI RUN 5 (CASE) - CO_2 LEVELS

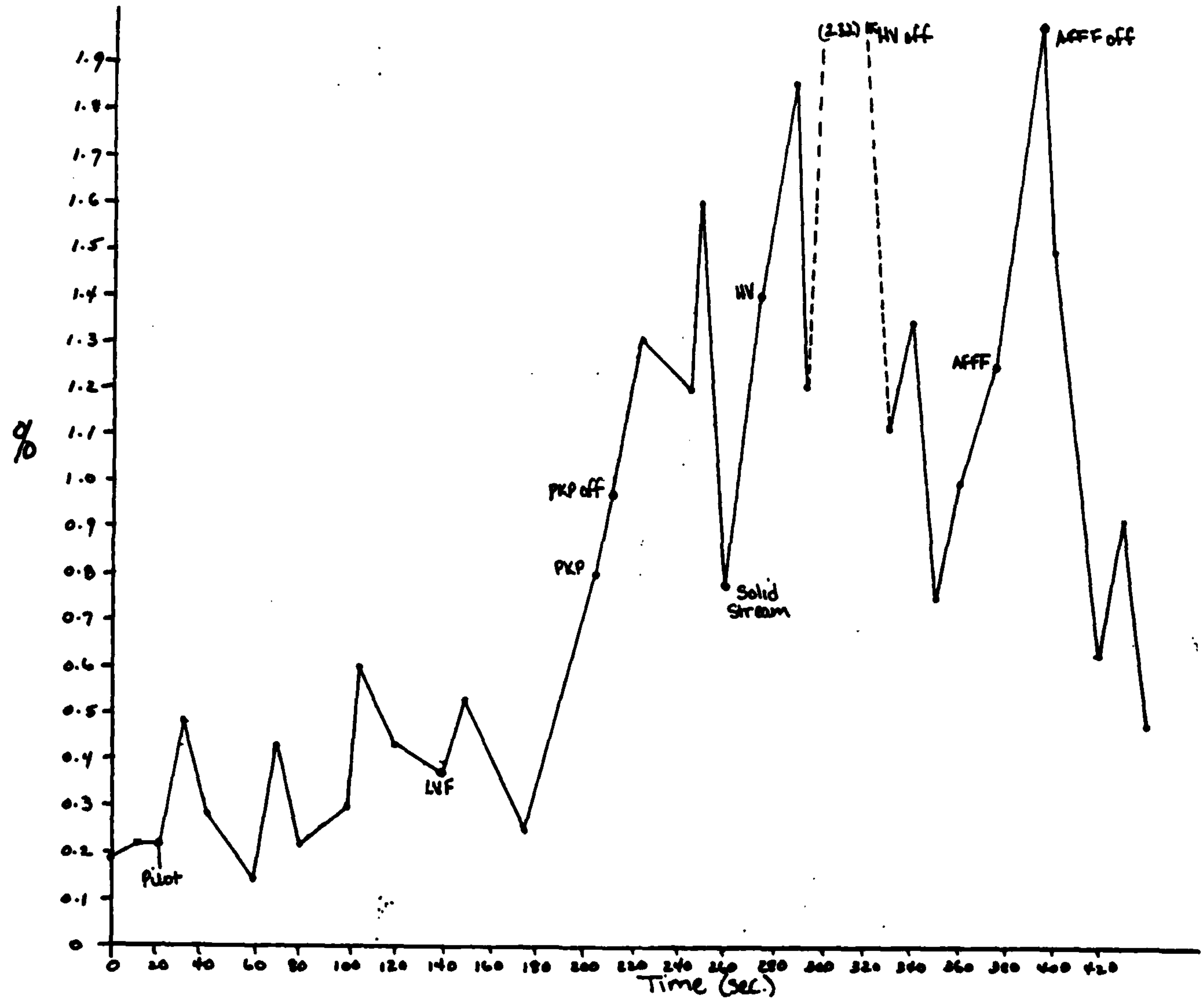
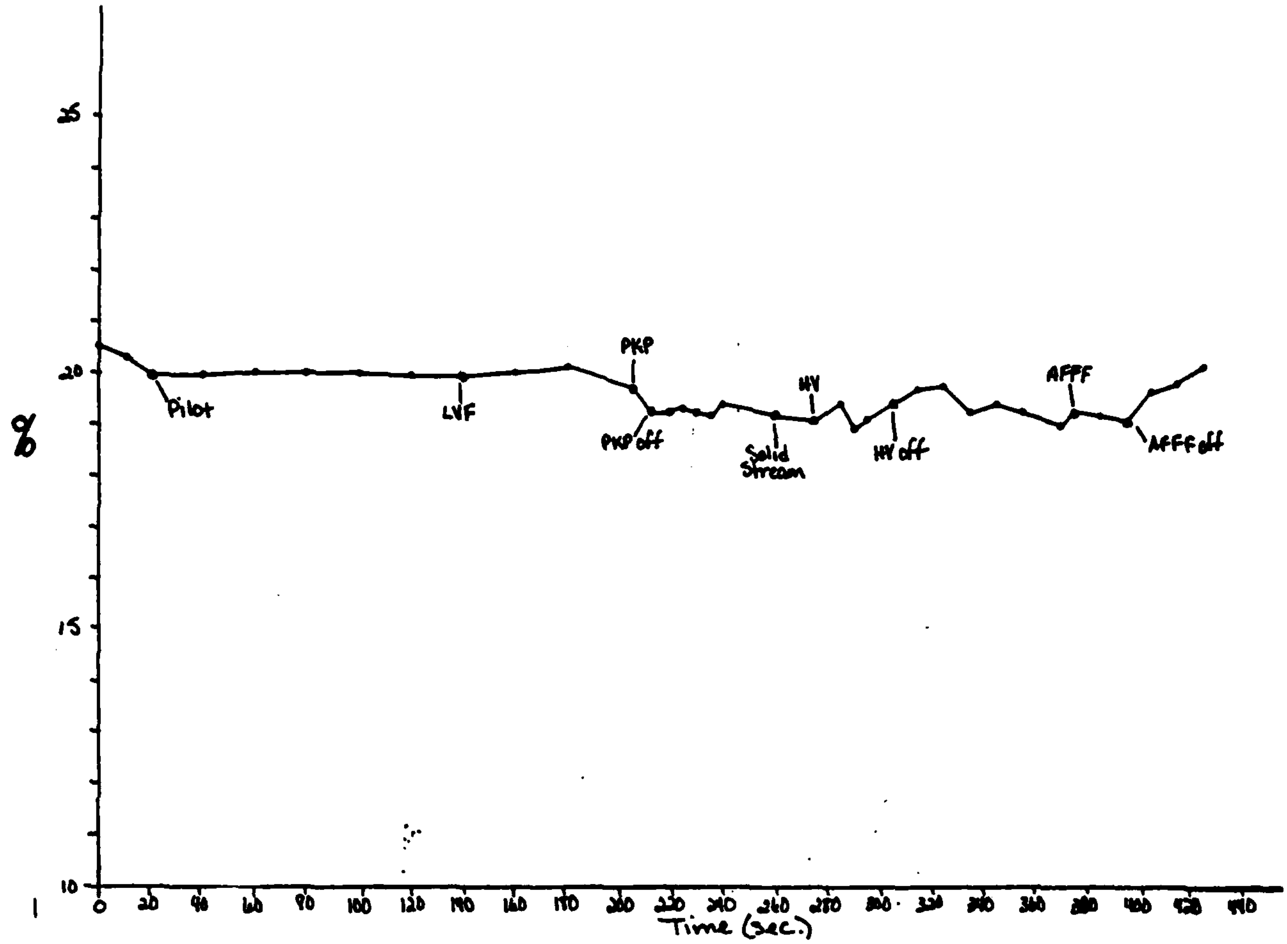


TABLE F-22. LDQI - RUN 6 (BILGE)

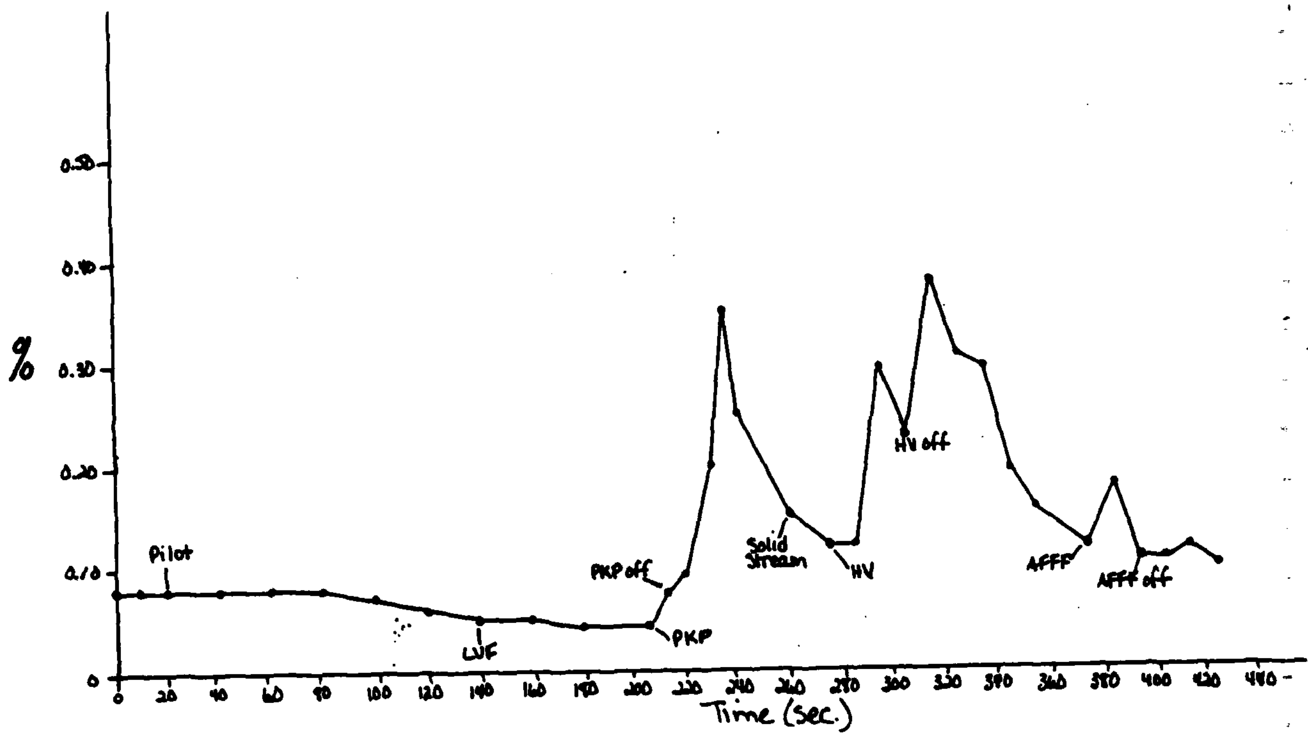
Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.55	0.08	0	0.08
10	20.3	0.08	0	0.10
20	19.95	0.08	0	0.40
40	19.95	0.08	0	0.21
60	20.0	0.08	0	0.03
80	20.0	0.08	0	0.40
85	-	-	-	0.71
100	20.0	0.07	0	0.33
120	19.95	0.06	0	0.45
140	19.95	0.05	0	0.48
155	-	-	-	0.70
160	20.0	0.05	0	0.40
180	20.15	0.04	0	0.62
190	-	-	-	0.09
205	19.7	0.04	0.02	1.18
212	19.25	.075	0	1.31
220	19.25	0.09	0.21	1.36
225	19.3	-	-	-
230	19.25	0.20	0.03	0.68
235	19.2	0.35	-	-
240	19.4	0.25	0.05	1.05
250	-	-	0.10	-
260	19.2	0.15	0.05	1.21
270	-	-	-	1.42
275	19.1	0.12	0.04	1.07
285	19.4	0.12	0.13	1.28
290	18.9	-	0.05	1.5
295	19.1	0.29	0.09	1.27
305	19.4	0.23	0.12	1.16
315	19.7	0.38	0.09	0.80
325	19.75	0.31	0.09	1.40
335	19.25	0.29	0.04	0.82
345	19.4	0.19	0.03	0.75
355	19.25	0.16	0.03	1.07
370	19.0	-	0.10	0.47
375	19.25	0.12	0.09	1.52
385	19.2	0.18	0.01	0.75
395	19.1	0.11	0.01	1.28
405	19.65	0.11	0.02	0.75
415	19.85	0.12	0.01	0.75
425	20.15	0.10	0	0.28

NOTE: Data were obtained from the Case Consulting Labs.

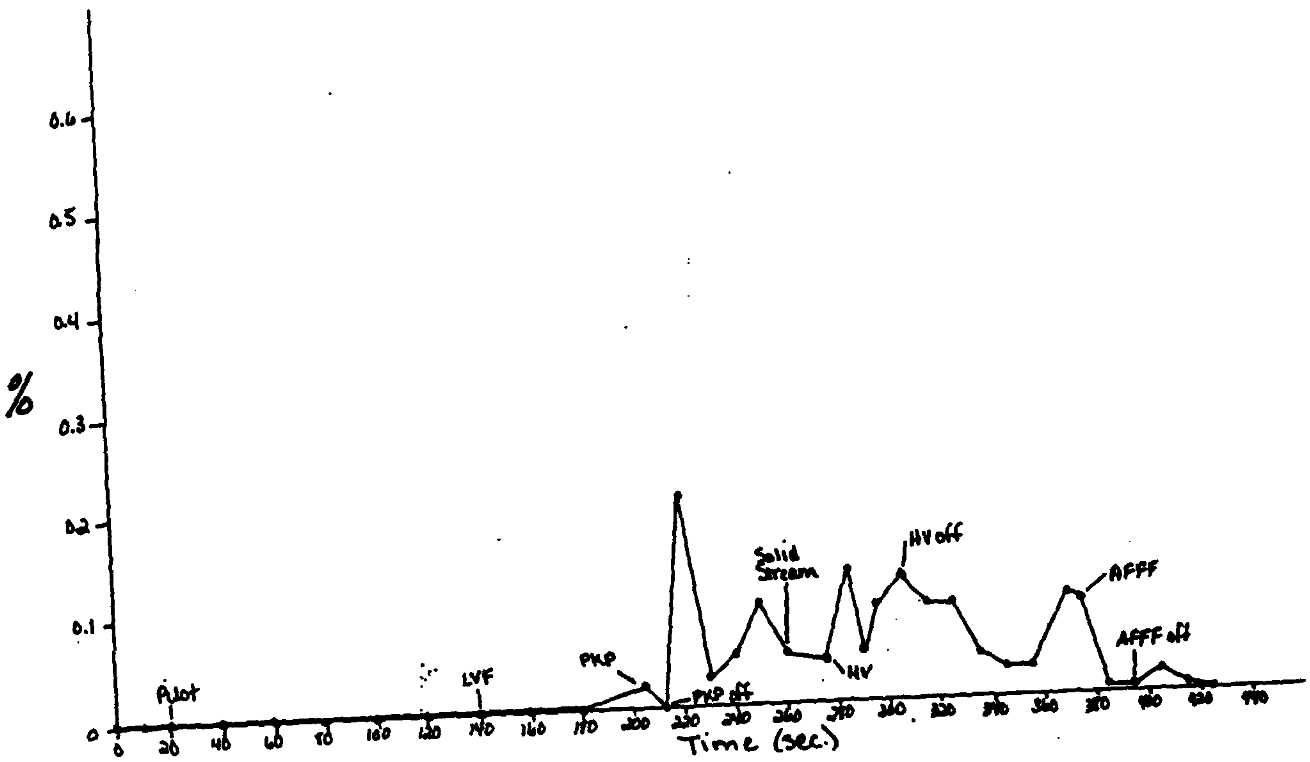
LDQI RUN 6 (CASE) - O_2 LEVELS



LDQI RUN 6 (CASE) - HC LEVELS



LDQI RUN 6 (CASE) - CO LEVELS



LDQI RUN 6 (CASE) - CO_2 LEVELS

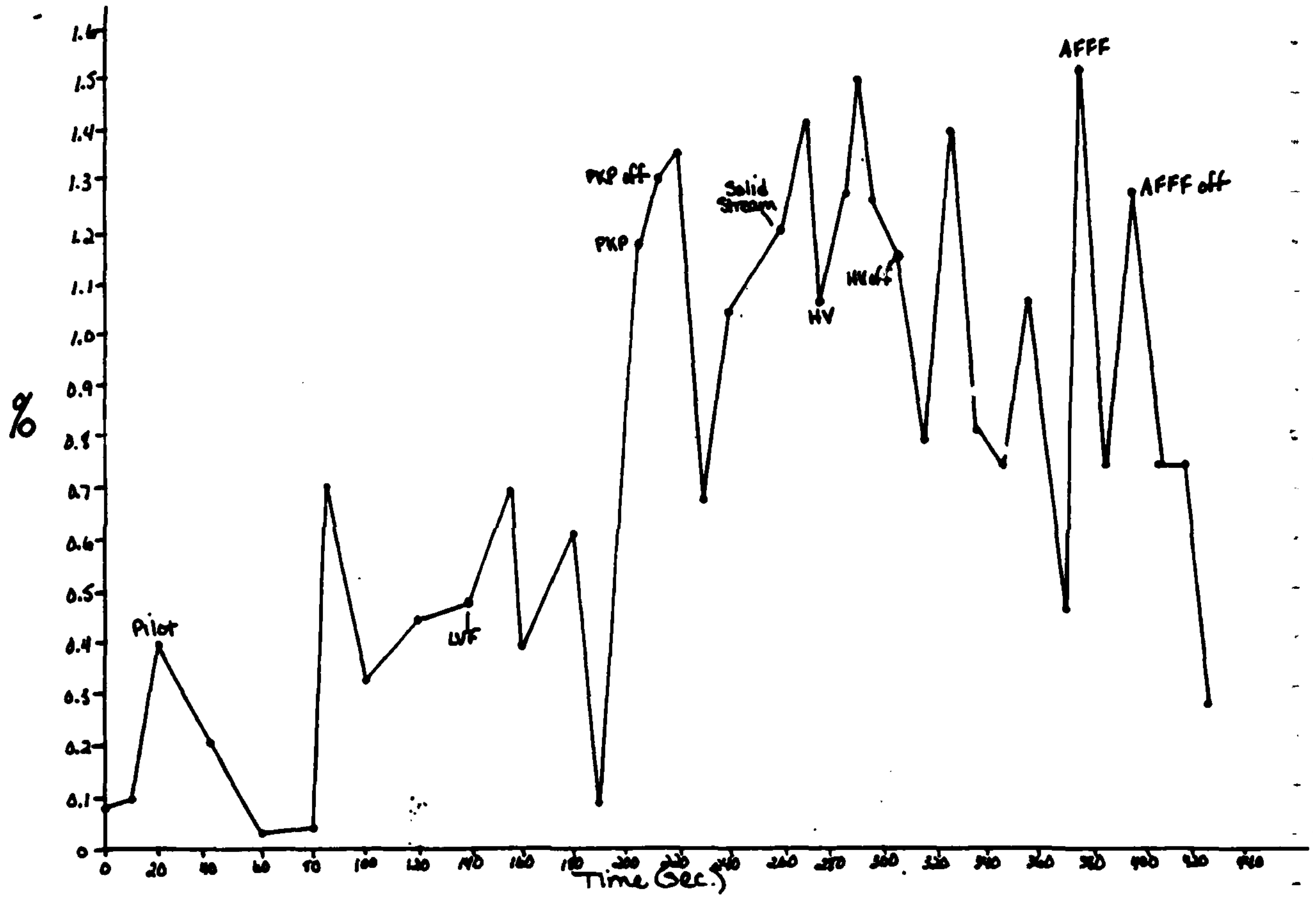
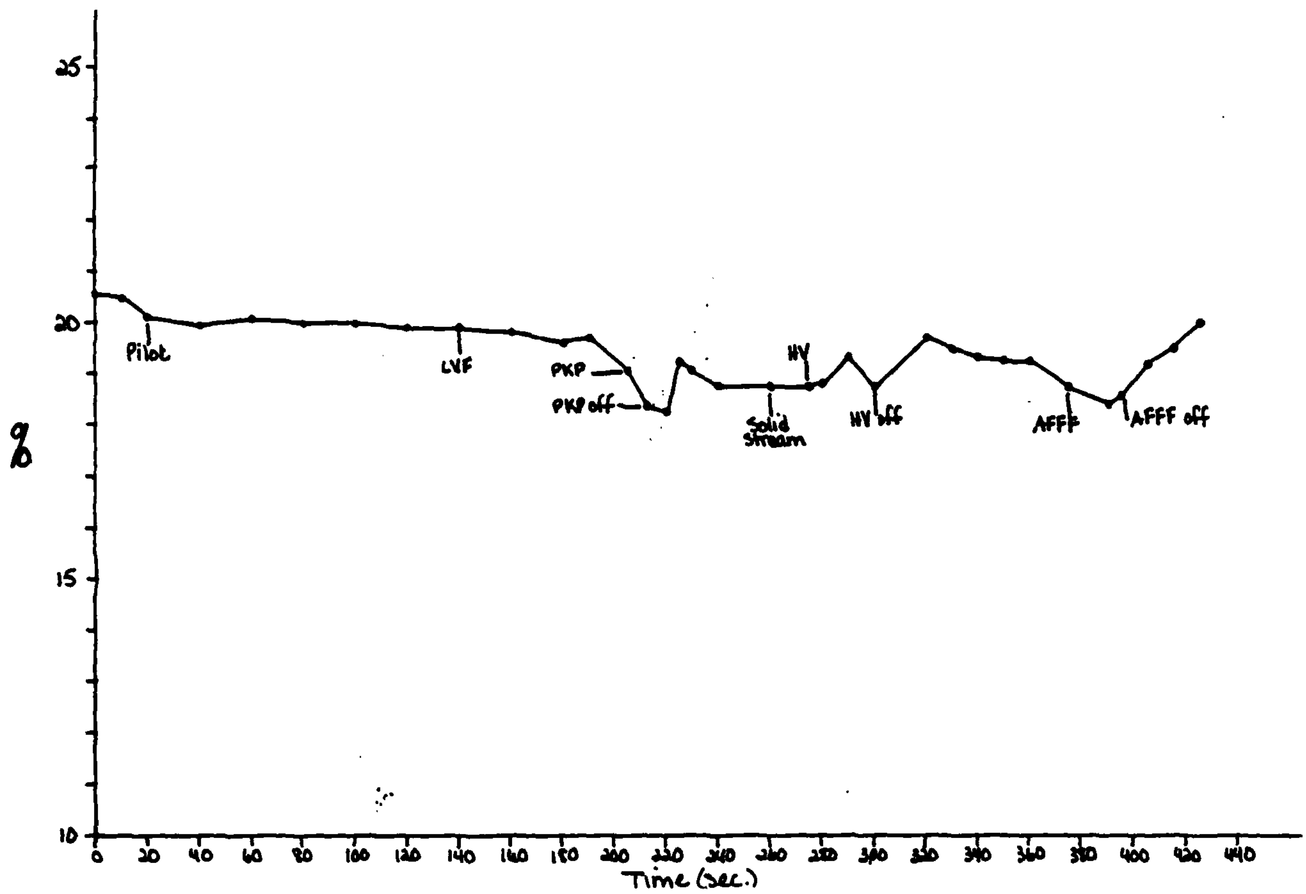


TABLE F-23. RUN 9 (BILGE)

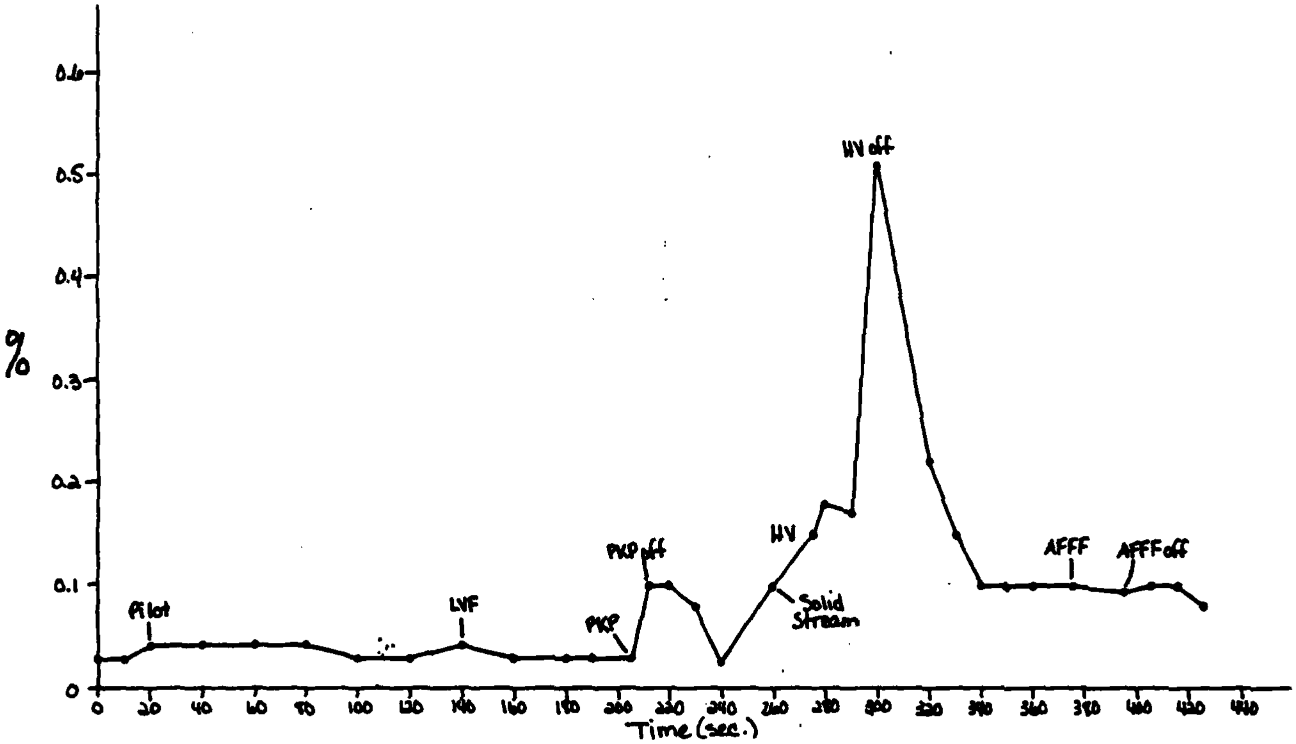
Time/Sec.	O_2 (percent)	HC (percent)	OC (percent)	CO_2 (percent)
0	20.6	0.03	0	0.07
10	20.5	0.03	0	0.12
20	20.15	0.04	0	0.21
40	19.95	0.04	0	0.40
60	20.1	0.04	0	0.15
80	20.0	0.04	0	0.15
100	20.0	0.03	0	0.20
120	19.9	0.03	0	0.50
140	19.9	0.04	0	0.18
160	19.8	0.03	0	0.83
180	19.65	0.03	0	0.57
190	19.7	0.03	0	0.60
205	19.1	0.03	0.10	1.35
212	18.4	0.10	0.02	2.52
220	18.3	0.10	0.04	1.72
225	19.25	-	0.53	0.50
230	19.1	0.08	0.40	1.88
235	-	-	-	2.1
240	18.75	0.26	0.08	0.45
260	18.75	0.10	0.01	1.05
275	18.75	0.15	-	-
280	18.8	0.18	0.12	2.18
290	19.35	0.17	0.58	0.65
300	18.75	0.51	0.08	1.70
310	-	-	0.13	0.43
320	19.7	0.22	0.05	1.38
330	19.5	0.15	0.01	0.95
340	19.35	0.10	0.03	1.1
350	19.25	0.10	0.04	1.3
360	19.25	0.10	0.02	1.32
375	18.75	0.10	0.01	1.8 (2.0 at 380)
390	18.4	-	-	-
395	18.6	0.09	0.06	1.6
405	19.2	0.10	0.04	1.58
415	19.5	0.10	0.01	1.15
425	20.0	0.08	0	0.50

NOTE: Data were obtained from the Case Consulting Labs.

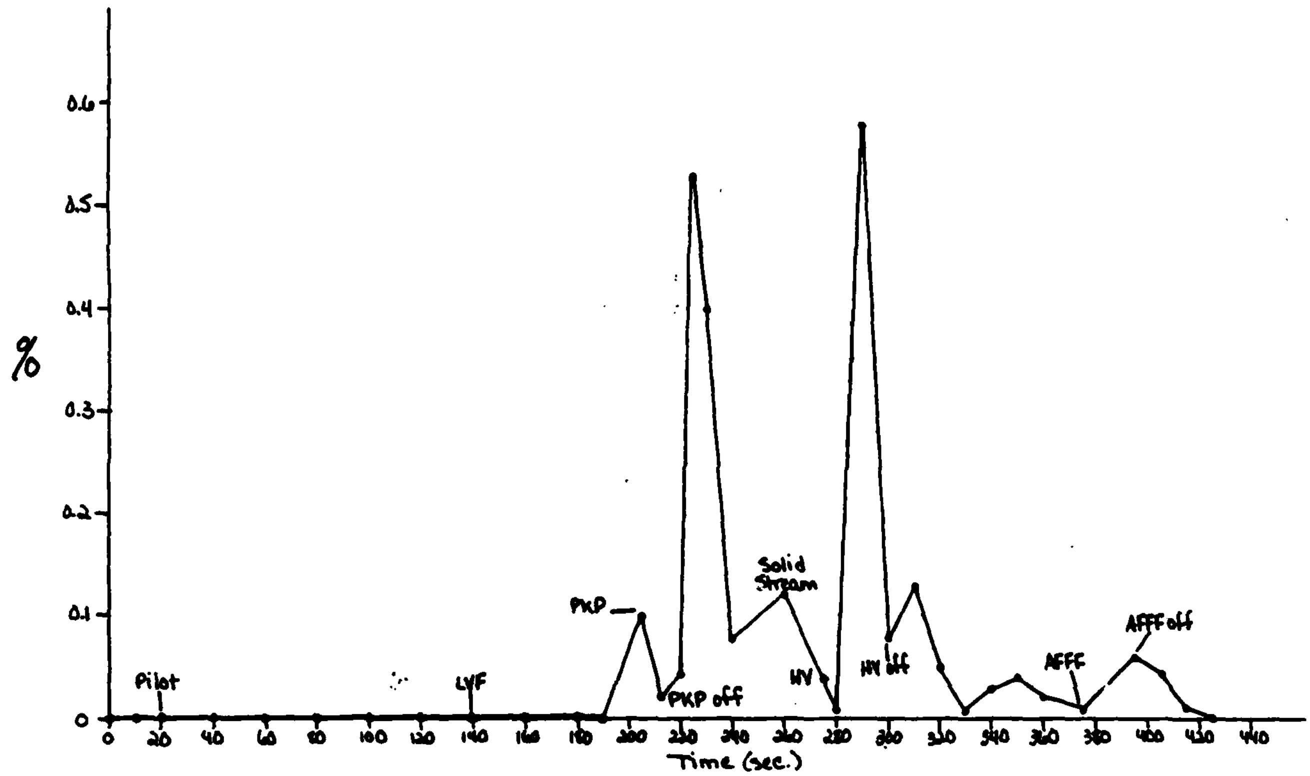
LDQI RUN 9 (CASE) - O_2 LEVELS



LDQI RUN 9 (CASE) - HC LEVELS



LDQI RUN 9 (CASE) - CO LEVELS



LDQI RUN 9 (CASE) - CO_2 LEVELS

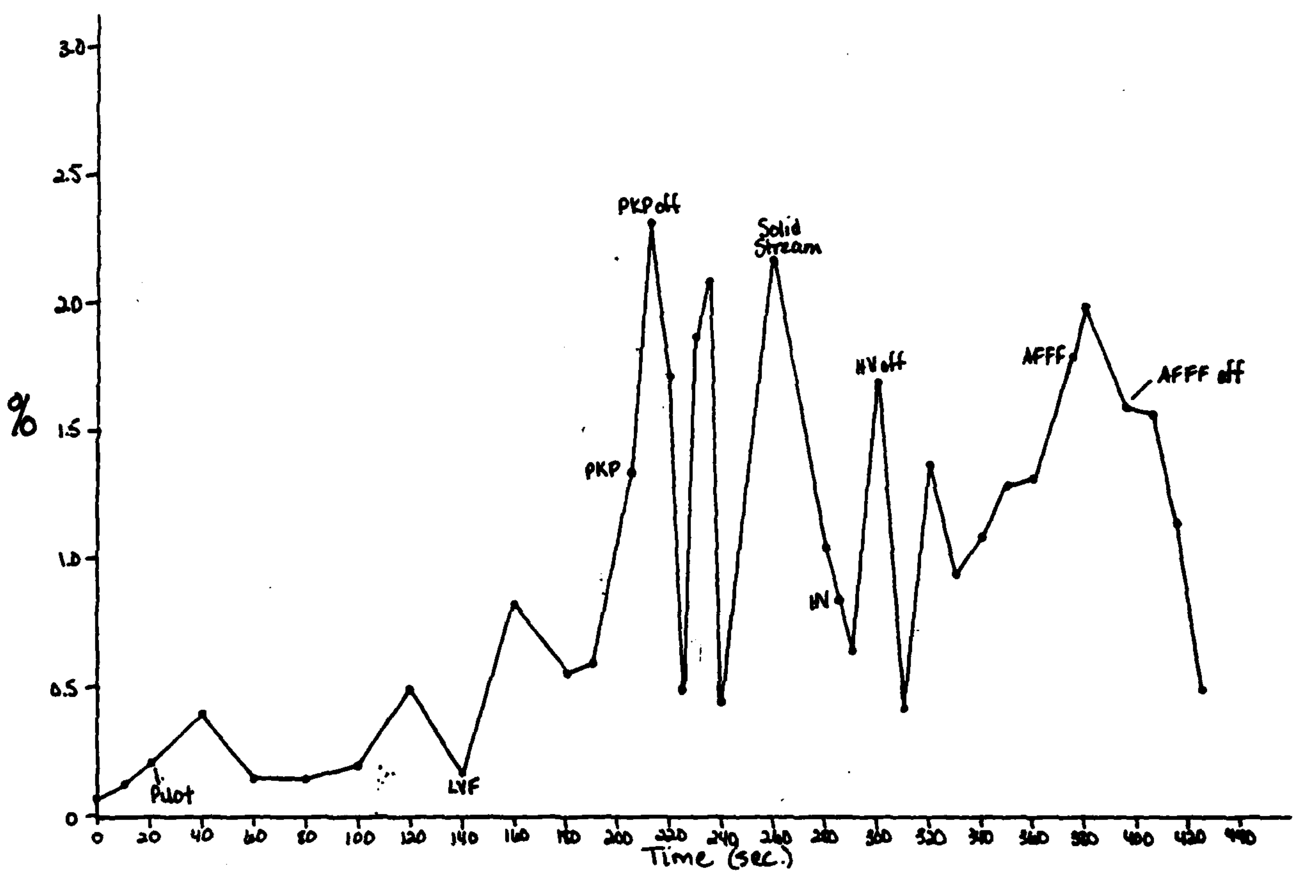
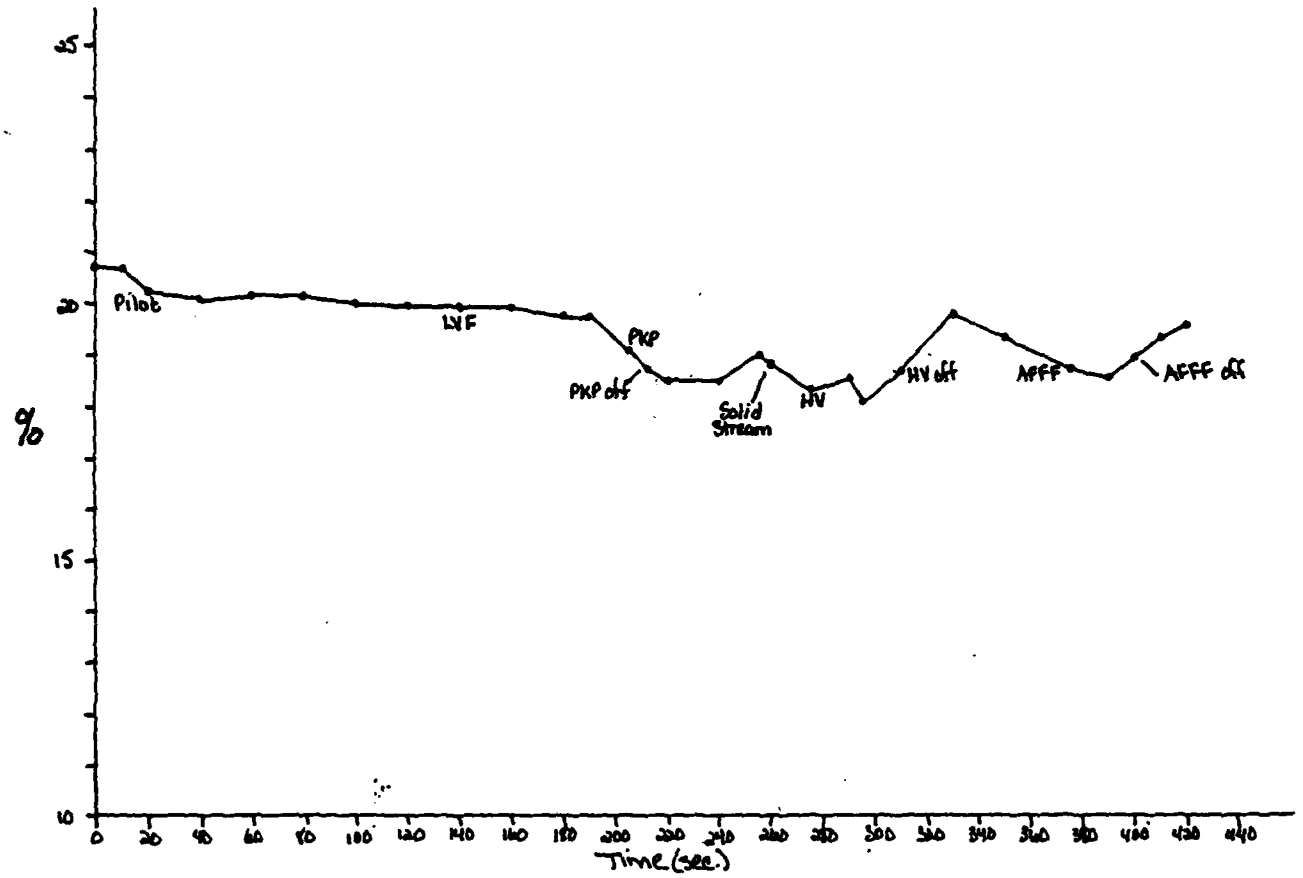


TABLE F-24. LDQI - RUN 10 (BILGE)

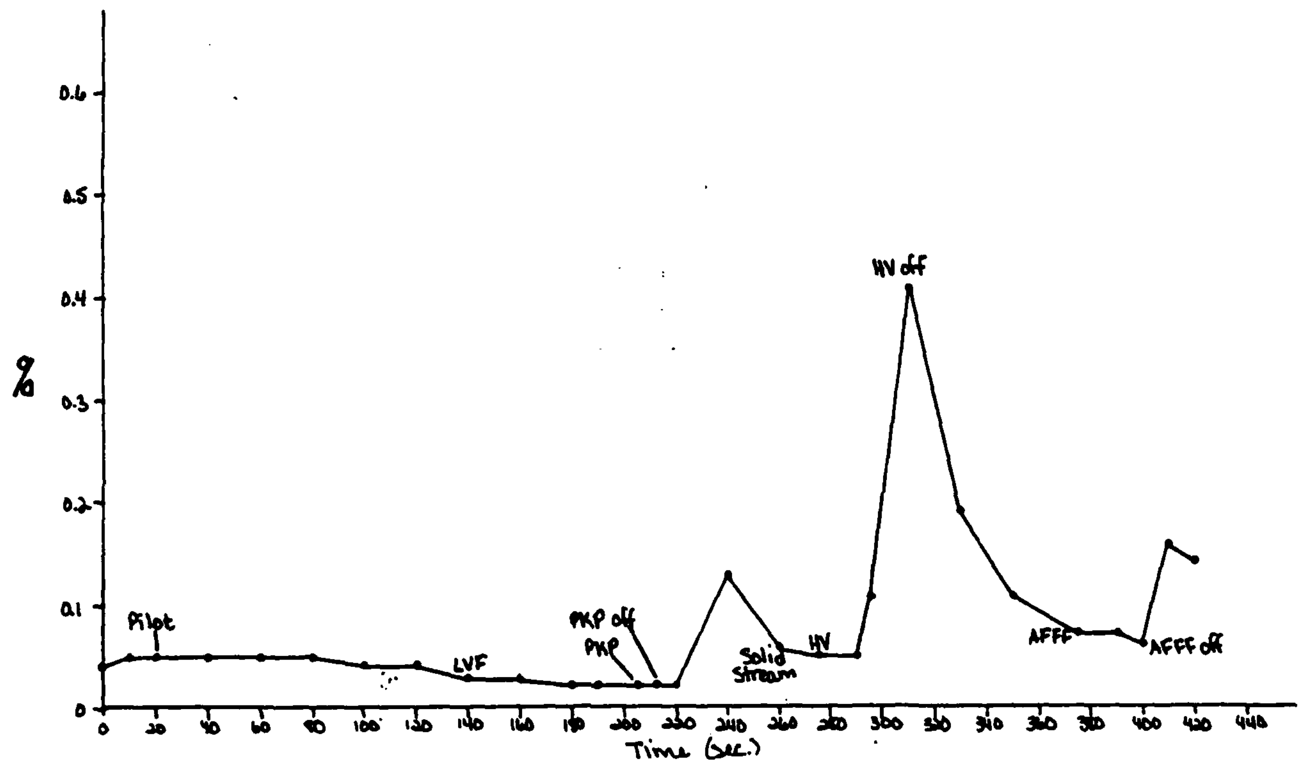
Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.75	0.04	0	0.18
10	20.7	0.05	0	0.41
20	20.25	0.05	0.02	0.20
40	20.1	0.05	0	0.43
60	20.2	0.05	0.02	0.57
80	20.2	0.05	0	0.70
100	20.0	0.04	0	0.72
120	19.95	0.04	0	0.60
140	19.95	0.03	0	0.70
160	19.9	0.03	0	0.85
180	19.25	0.02	0	0.75
190	19.75	0.02	0	0.70
205	19.1	0.02	0	1.70
212	18.75	0.02	0	1.38
220	18.5	0.02	0	2.14
230	-	-	0.19	2.2
240	18.5	0.13	0.05	1.45
255	19.0	-	-	-
260	18.85	0.06	0.03	1.90
275	18.35	0.05	0.03 (0.15 at 285)	2.12
290	18.55	0.05	0.05	2.3
295	18.1	0.11	0.25	-
310	18.7	0.41	0.15	2.1
325	-	-	0.03	0.60
330	19.8	0.19	0.09	1.42
350	19.35	0.11	0.02	0.86
375	18.75	0.07	0.02	1.72
390	18.6	0.07	0.02	2.0
400	18.95	0.06	0.11	0.9
405	-	-	-	1.55
410	19.35	0.16	0.03	1.23
420	19.6	0.14	0.01	0.75

NOTE: Data were obtained from the Case Consulting Labs.

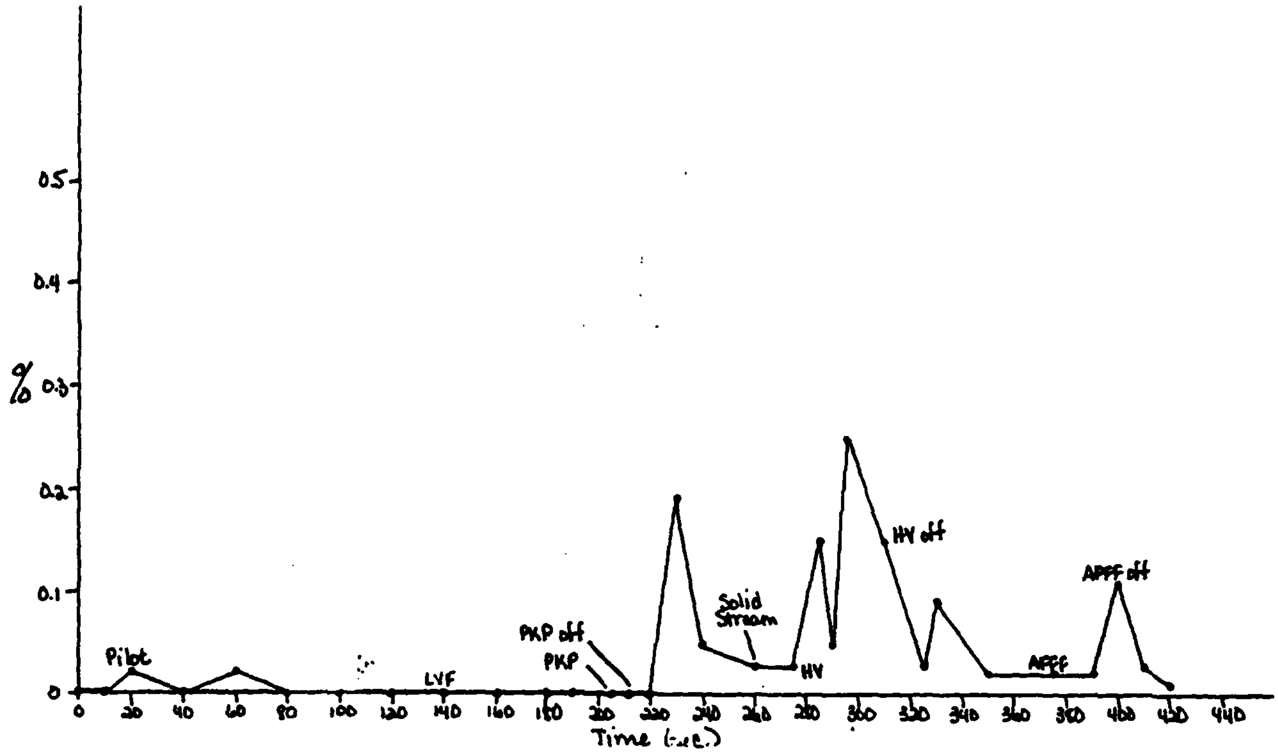
LDQI RUN 10 (CASE) - O_2 LEVELS



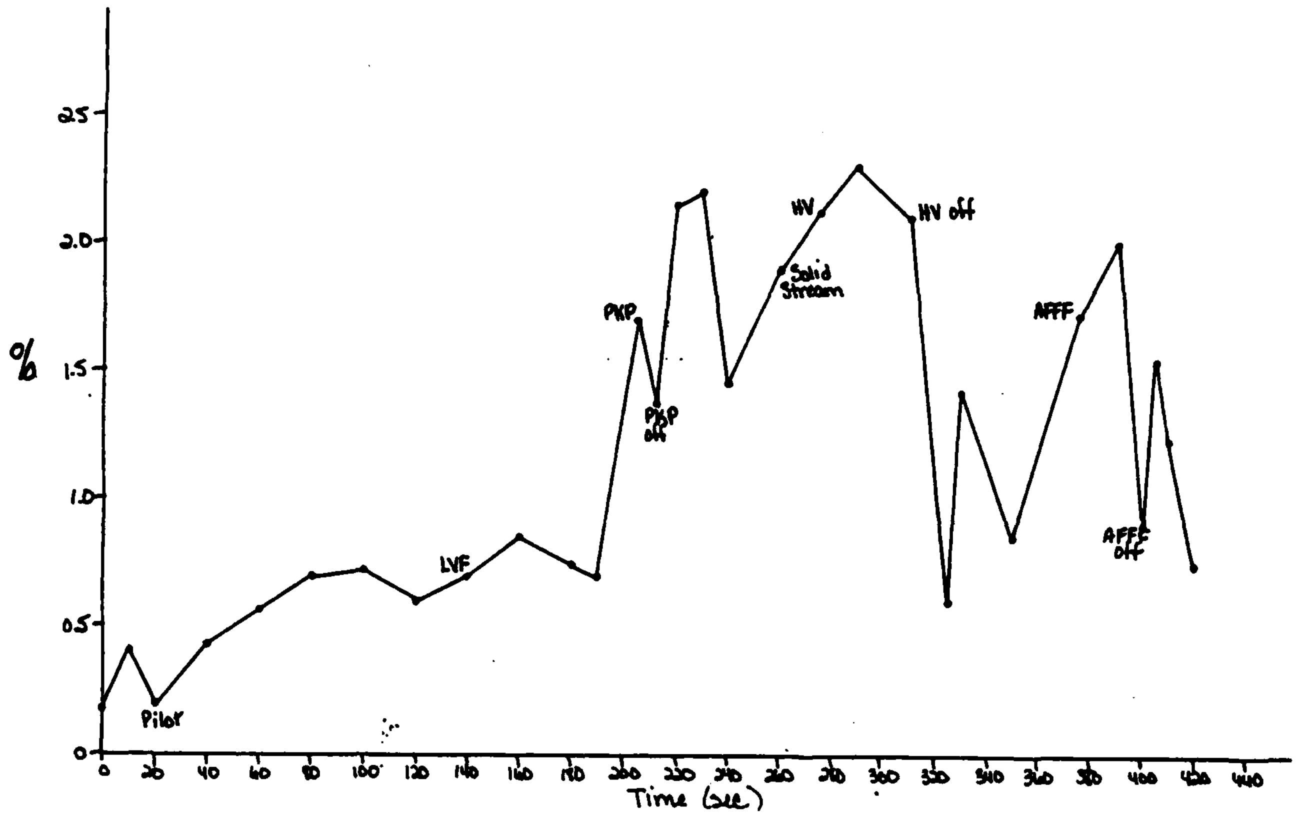
LDQI RUN 10 (CASE) - HC LEVELS



LDQI RUN 10 (CASE) - CO LEVELS



LDQI RUN 10 (CASE) - CO_2 LEVELS



LDQI INTERNAL ATMOSPHERE

(As Measured by Case
Consulting Equipment)

KEY

Activity	Abbreviation
Start Pilot, Start Smoke	Start
Flame On, Stop Smoke	On
Go to Pilot	Pilot
Flame On, Apply Low-Velocity Fog	LVF
Apply PKP Surrogate	PKP
Stop Applying PKP Surrogate	PKP Off
Apply Solid Stream Water	Solid Stream
Stop Applying Solid Stream, Apply High-Velocity Water Spray	HV
Stop Applying High-Velocity Spray	HV Off
Apply AFFF Surrogate	AFFF
Stop Applying AFFF Surrogate	AFFF Off

UDQII INTERNAL ATMOSPHERE

(As Measured by Case
Consulting Equipment)

KEY

Deep Fat

Activity	Abbreviation
Start Pilot, Start Smoke	Start
Flame On, Stop Smoke	On
Go to Pilot	Pilot
Flame On, Start Smoke	Smoke
Smoke Off	Smoke Off
Fire Spreads to Hood	Spread
Apply Low-Velocity Water Fog	LVF
Stop Applying Low-Velocity Water Fog	LVF Off
Apply PKP Surrogate/ H_2O Mixture	PKP
Stop Applying PKP Surrogate/H_2O Mixture	PKP Off

Rag Bale

Activity	Abbreviation
Start Pilot, Start Smoke	Start
Flame On, Stop Smoke	On
Go to Pilot	Pilot
Flame On, Start Smoke	Smoke
Stop Smoke	Smoke Off
Apply High-Velocity Spray	HV
Stop Applying High-Velocity Spray	HV Off
Reflash	Reflash
Apply AFFF Surrogate	AFFF
Stop Applying AFFF Surrogate	AFFF Off

TABLE F-25. UDQII FOR DEEP FAT - RUN 3

Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.25	0.09	0.01	0.10
10	20.2	0.10	0.01	0.25
20	20.2	0.09	0.025	0.10
40	20.2	0.08	0.03	0.32
60	20.1	0.07	0.035	0.10
80	20.1	0.08	0.06	0.18
105	20.1	0.10	0.05	0.18
115	20.1	0.09	0.05	0.18
125	20.1	0.09	0.10	0.85
130	20.1	0.09	0.10	0.95
145	-	-	-	1.75
150	19.4	0.10	0.17	1.60
160	18.45	0.12	0.24	0.50
170	19.15	0.13	0.15	2.80
175	19.8	0.15	0.13	0.80
185	19.85	0.18	0.13	0.62
195	19.9	0.19	0.12	0.30
205	20.1	0.11	0.12	0.25

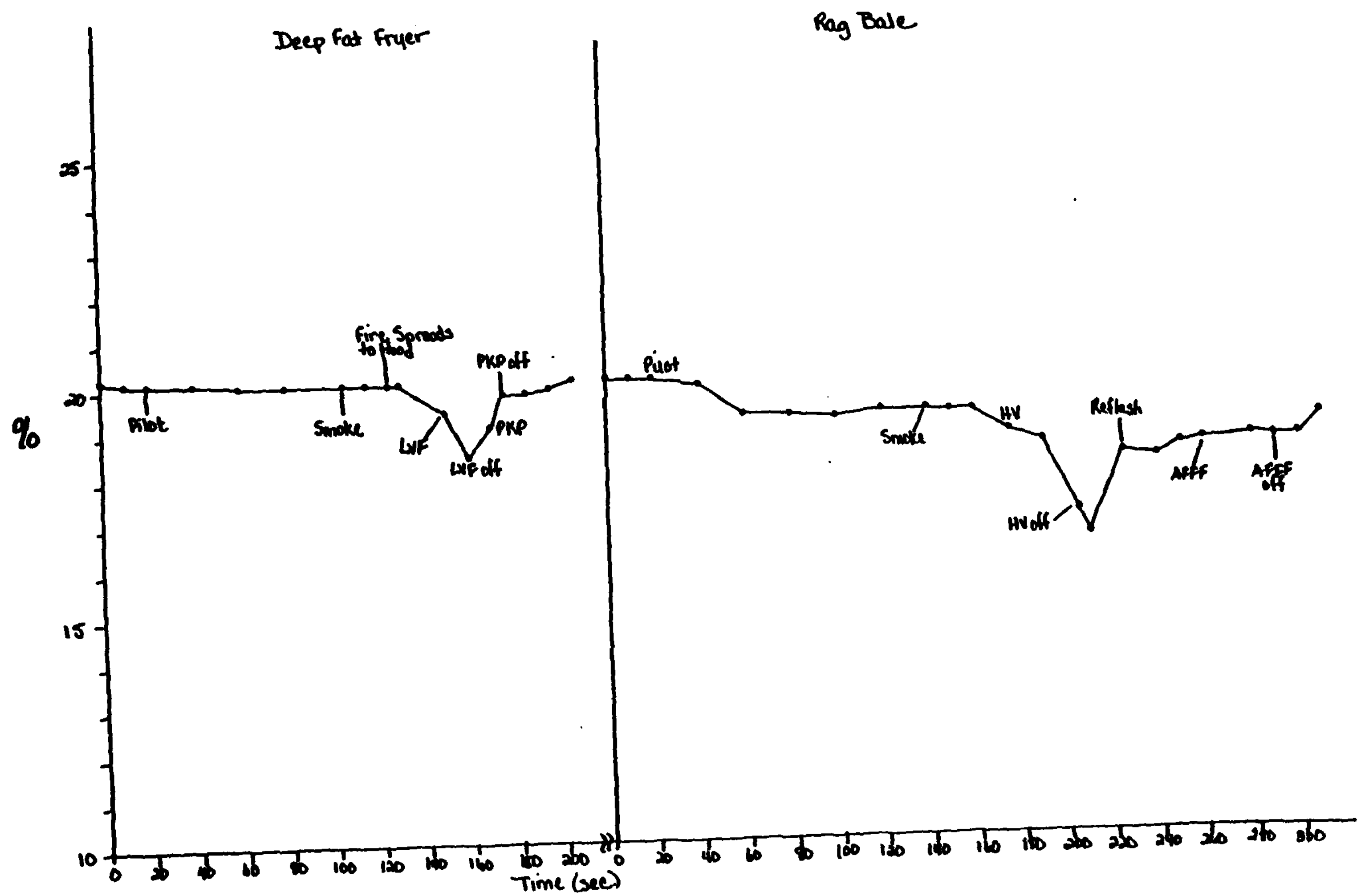
NOTE: Data were obtained from the Case Consulting Labs.

TABLE F-26. UDQII FOR RAG BALE - RUN 3

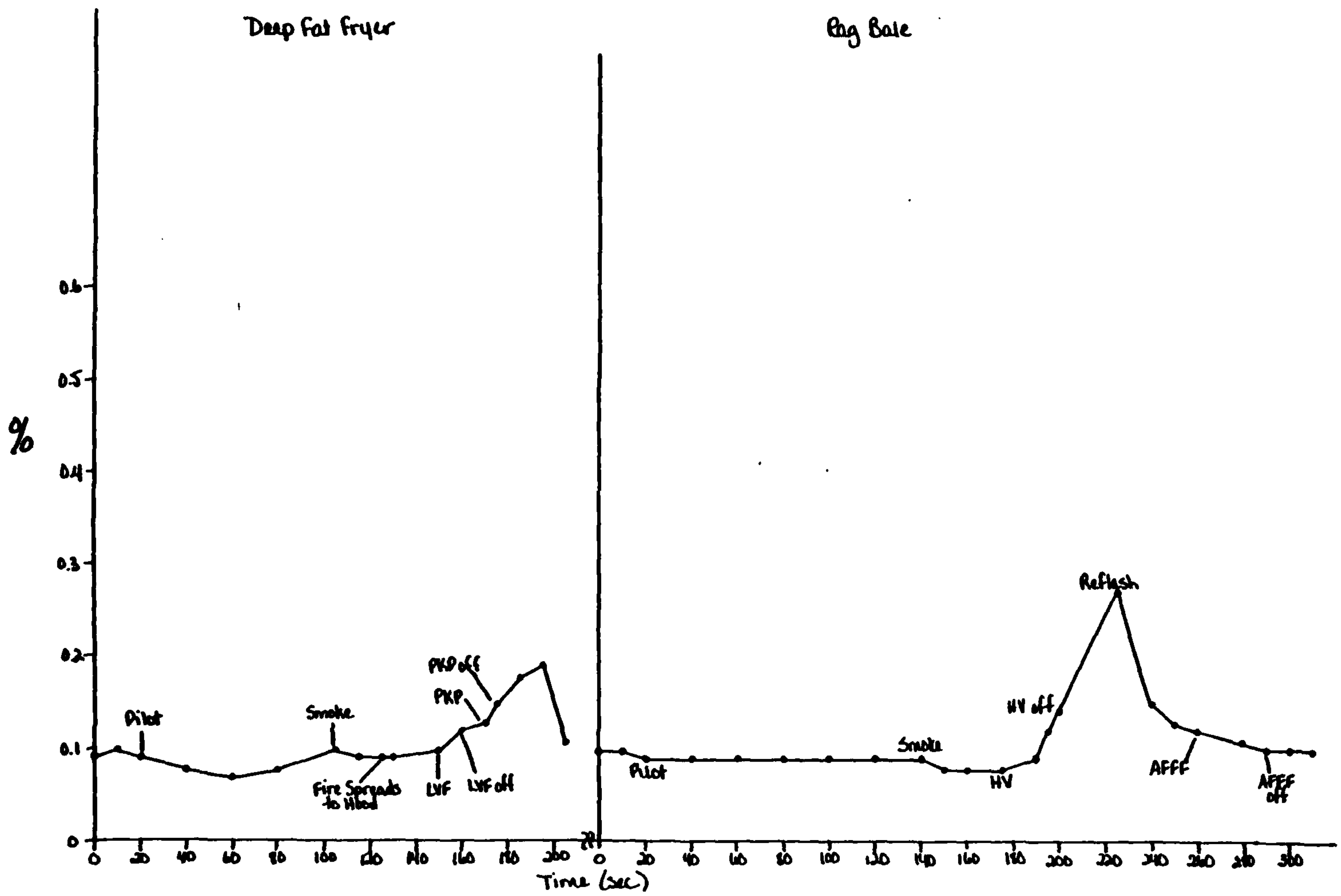
Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.15	0.10	0	0.18
10	20.15	0.10	0	0.70
20	20.15	0.09	0	1.50
40	19.9	0.09	0	1.40
60	19.25	0.09	0	1.40
80	19.25	0.09	0	1.60
100	19.2	0.09	0	1.60
120	19.3	0.09	0	1.50
140	19.3	0.09	0	1.45
150	19.25	0.08	0	1.40
160	19.25	0.08	0.01	1.50
175	18.8	0.08	0.06	1.75
190	18.55	0.09	0.89	4.0
200	-	-	-	4.45
205	17.0	0.12	0.07	1.70
210	16.5	0.14	0.07	1.28
225	18.25	0.27	0.07	2.30
240	18.2	0.15	0.05	1.68
250	18.4	0.13	0.04	1.54
260	18.5	0.12	0.03	1.65
280	18.6	0.11	0.02	1.50
290	18.55	0.10	0.02	1.00
295	-	-	-	1.70
300	18.6	0.10	0.01	0.80
310	19.0	0.10	0.01	0.26

NOTE: Data were obtained from the Case Consulting Labs.

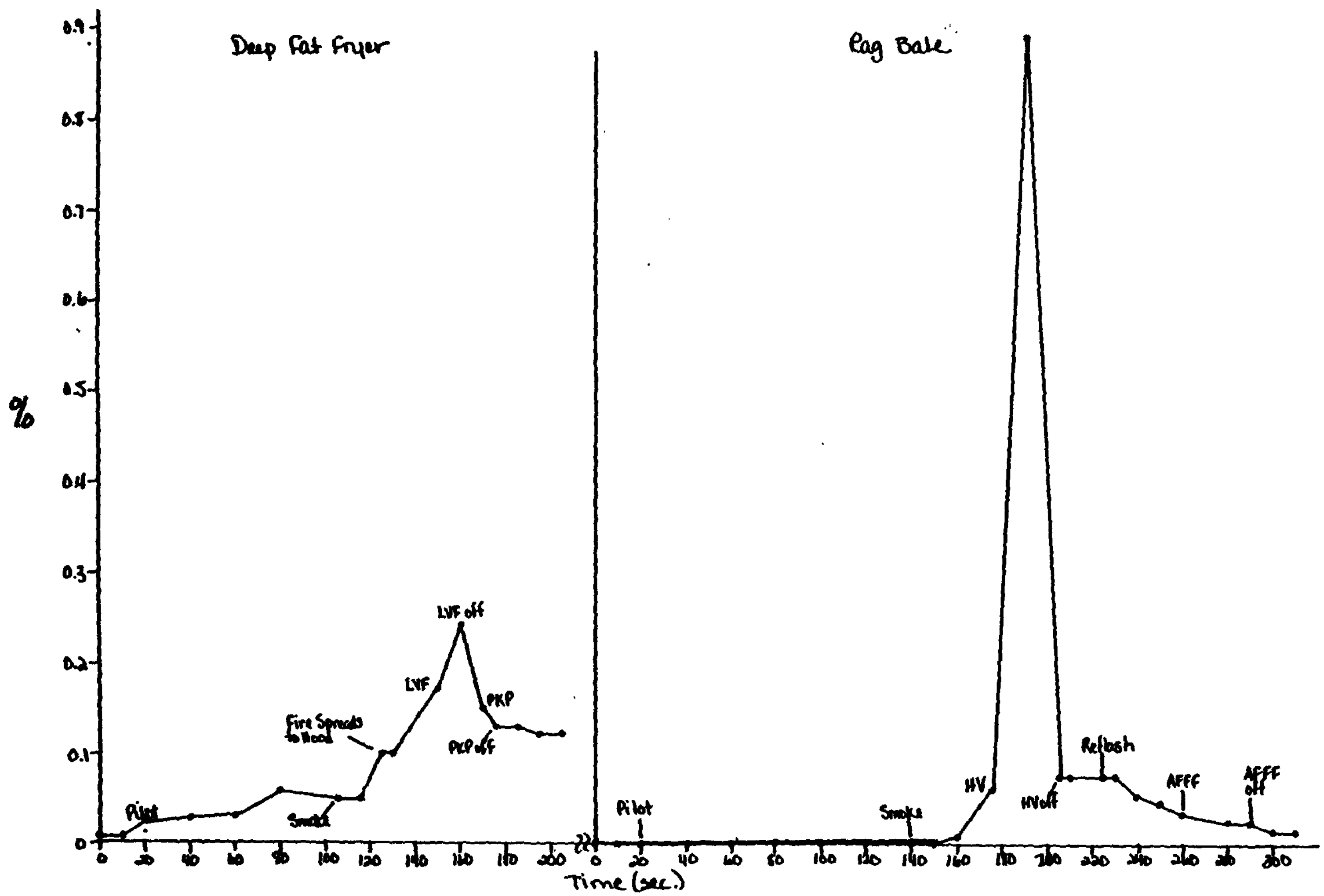
UDQII RUN 3 (CASE) - O_2 LEVELS



UDQII RUN 3 (CASE) - HC LEVELS



UDQII RUN 3 (CASE) - CO LEVELS



UDQII RUN 3 (CASE) - CO_2 LEVELS

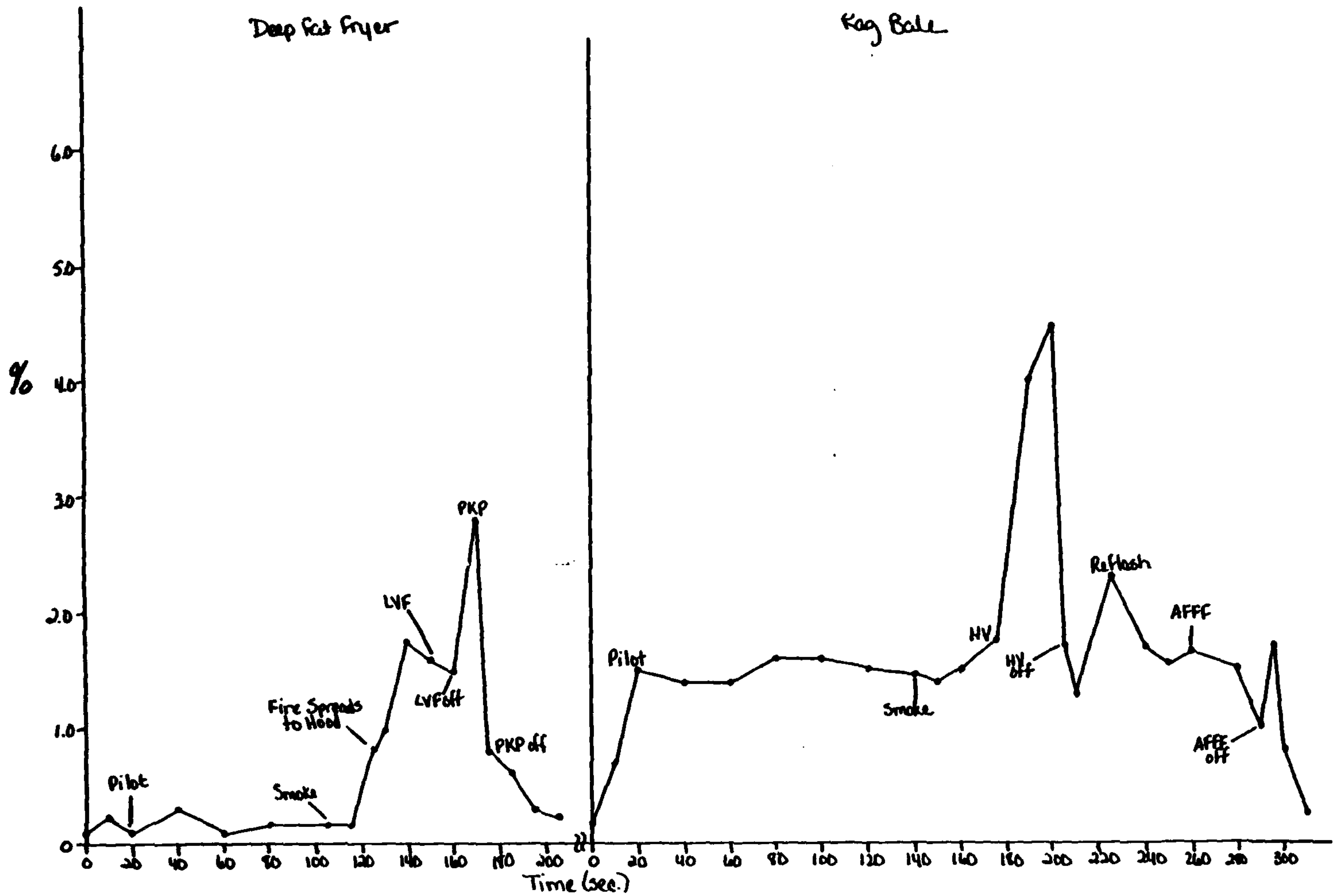


TABLE F-27. UDQII FOR DEEP FAT - RUN 4

Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.5	0.06	0	0
10	20.5	0.06	0.01	0
20	20.5	0.05	0.01	0
40	20.5	0.07	0.02	0.13
60	20.4	0.07	0.01	0
80	20.45	0.07	0	0
100	20.45	0.07	0.02	0.05
120	20.4	0.08	0	0
140	20.45	0.05	0	0.01
150	20.45	0.05	0	0.05
160	20.45	0.07	0.01	0.01
170	20.45	0.08	0.06	0.03
180	-	-	0.15	-
185	20.45	0.08	0.10	1.25
195	20.25	0.08	0.2	0.10
200	20.1	0.09	0.3	0.12
205	-	-	0.25	1.58
210	20.4	0.09	0.15	1.97
220	19.75	0.14	0.12	0.13
225	19.0	0.22	-	-
230	19.8	0.26	0.12	0.17
240	20.0	0.22	0.12	0.09
260	20.25	0.24	0.12	0.08

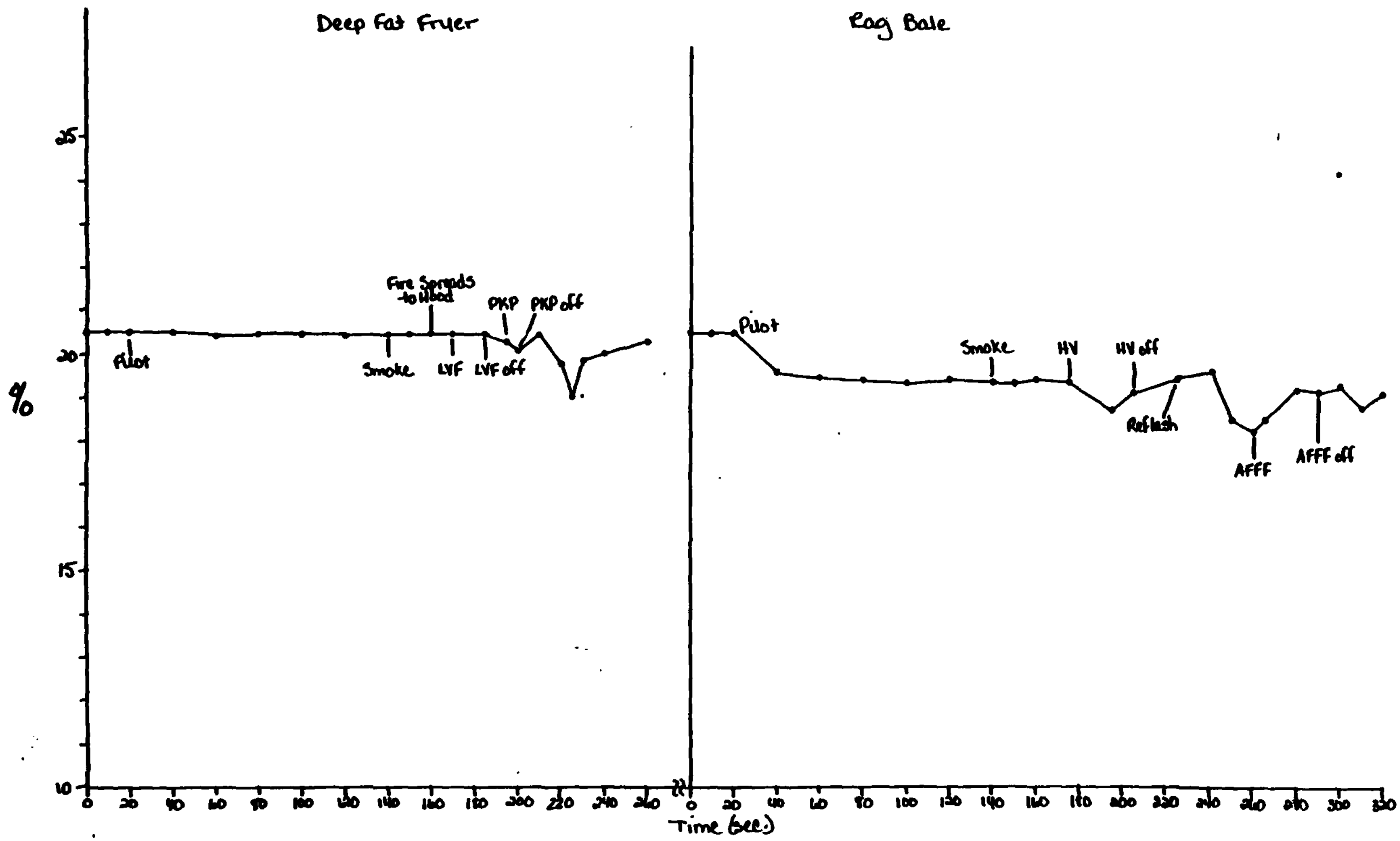
NOTE: Data were obtained from the Case Consulting Labs.

TABLE F-28. UDQII FOR RAG BALE - RUN 4

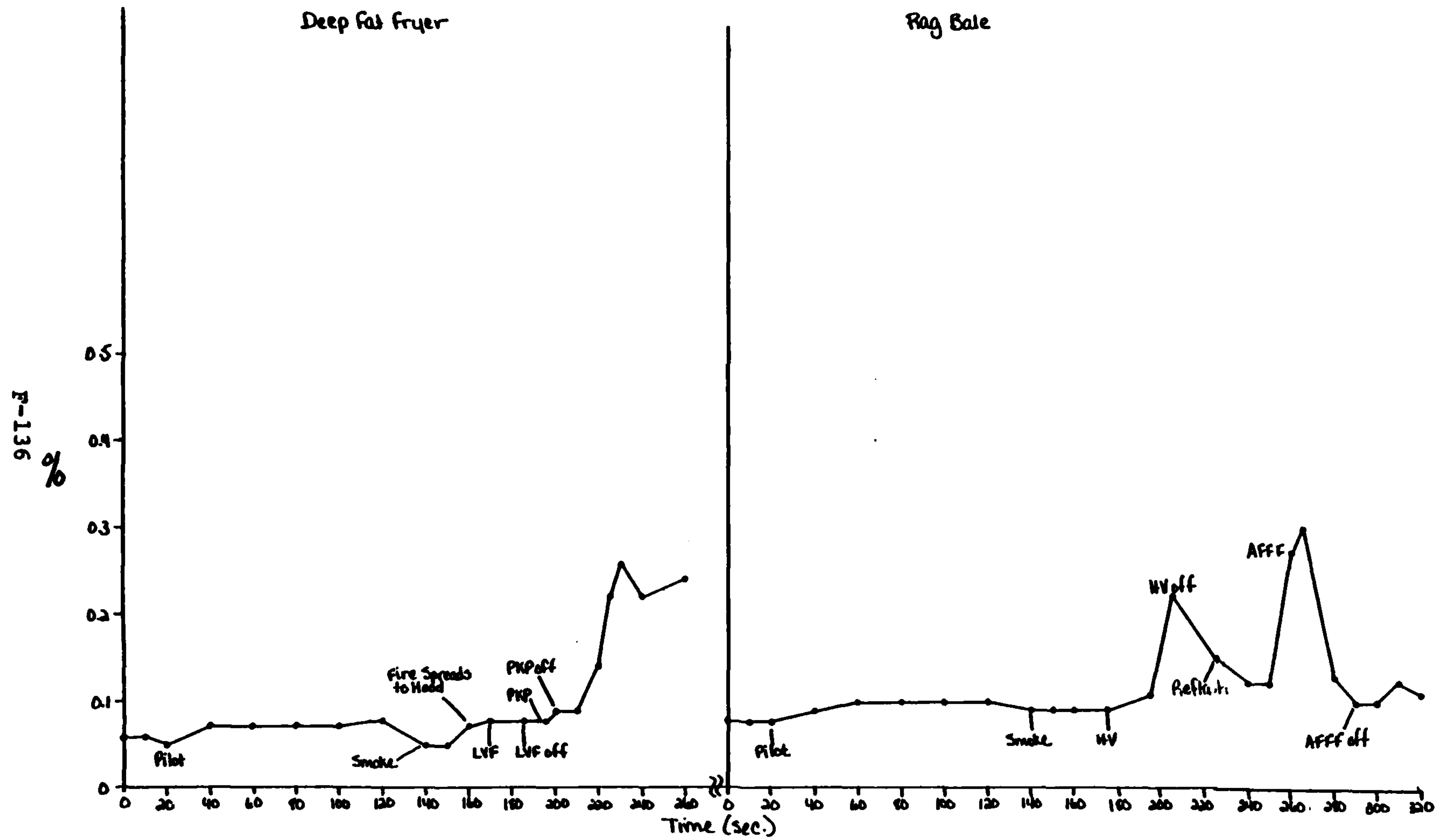
Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.5	0.08	0	0.05
10	20.5	0.08	0	0.80
20	20.5	0.08	0	1.12
40	19.6	0.09	0.01	1.17
60	19.45	0.10	0.01	1.12
80	19.4	0.10	0.01	1.10
100	19.3	0.10	0.01	1.12
120	19.4	0.10	0.01	1.0
140	19.3	0.09	0	1.02
150	19.3	0.09	0	1.09
160	19.4	0.09	0	1.15
175	19.35	0.09	0.15	2.58
185	-	-	0.45	-
195	18.7	0.11	0.05	1.7
205	19.15	0.22	0.02	0.93
225	19.4	0.15	0.01	1.31
240	19.65	0.12	0.01	0.9
250	18.5	0.12	0.01	1.12
260	18.25	0.27	0.01	1.0
265	18.5	0.30	-	-
280	19.2	0.13	0.02	1.0
290	19.15	0.10	0.05	1.95
295	-	-	-	2.5
300	19.25	0.10	0	1.1
310	18.75	0.12	0	1.35
320	19.1	0.11	0	0.3

NOTE: Data were obtained from the Case Consulting Labs.

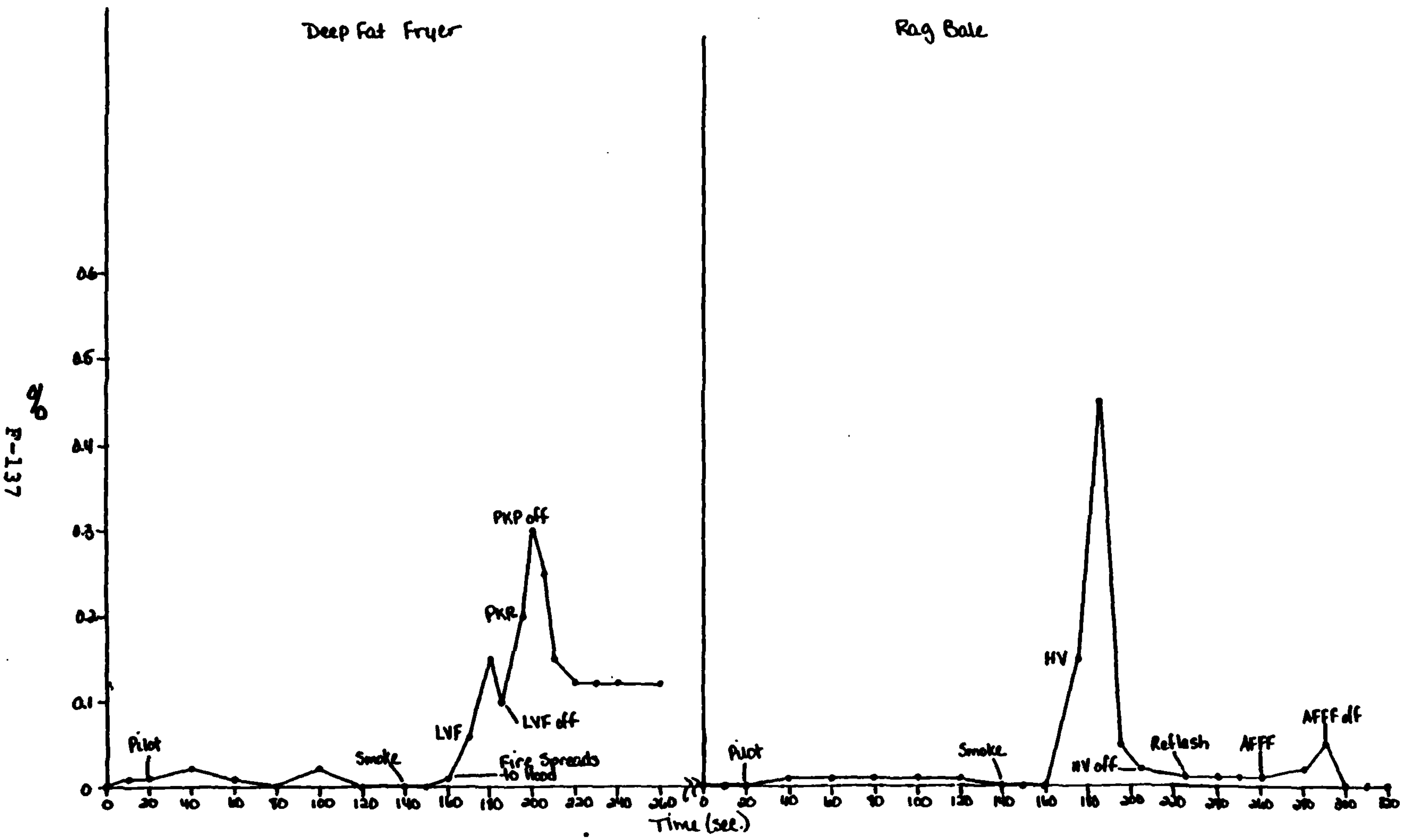
UDQII RUN 4 (CASE) - O_2 LEVELS



UDQII RUN 4 (CASE) - HC LEVELS



UDQII RUN 4 (CASE) - CO LEVELS



UDQII RUN 4 (CASE) - CO_2 LEVELS

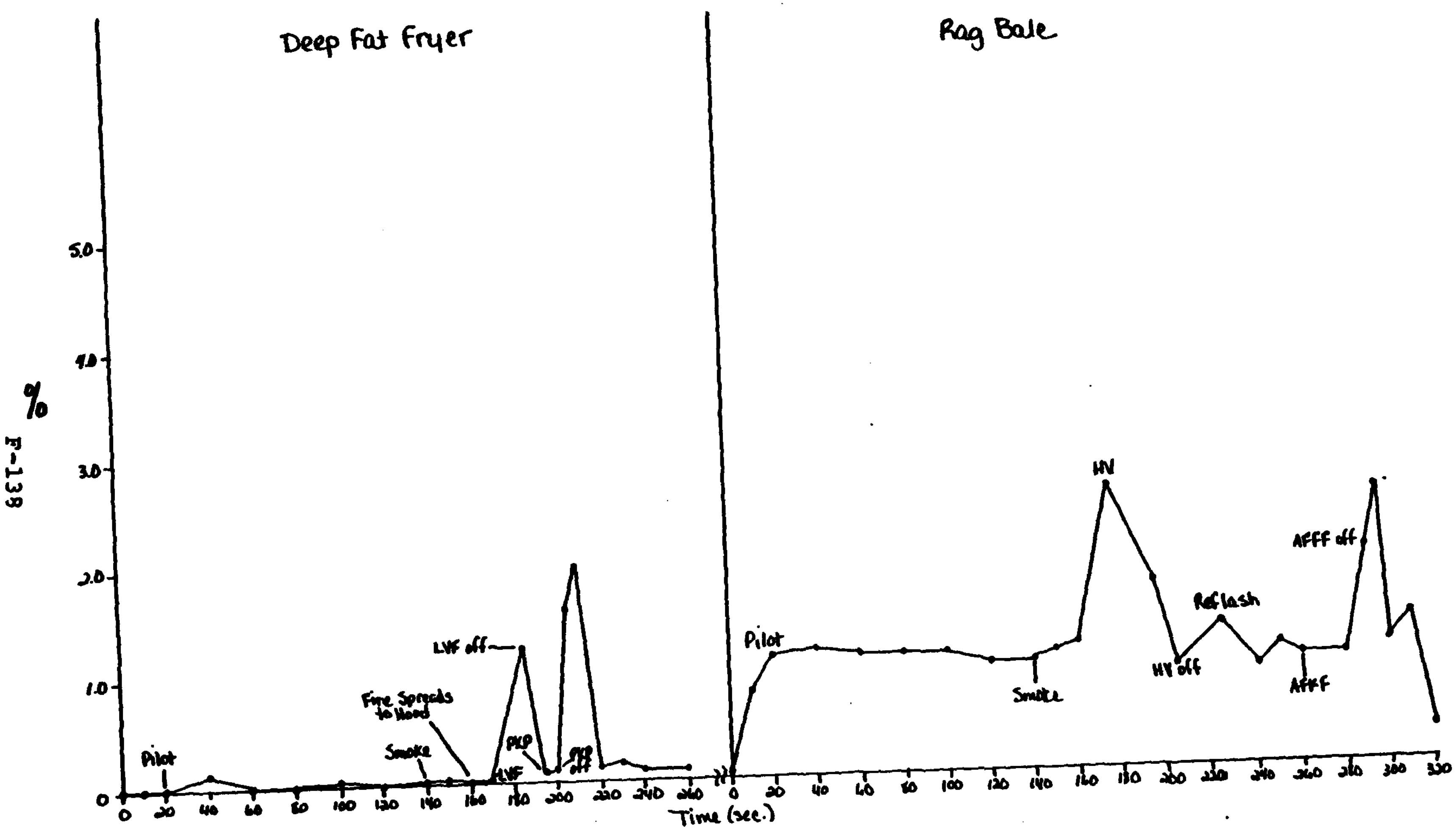


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TABLE F-29. UDQII FOR DEEP FAT - RUN 5

Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.35	0.08	0.025	0.07
10	20.35	0.08	0.025	0.07
20	20.35	0.08	0.02	0.08
40	20.35	0.09	0.01	0.08
60	20.3	0.09	0.01	0.12
80	20.3	0.08	0	0.28
100	20.35	0.08	0	0.22
120	20.35	0.08	0	0.12
140	20.25	0.08	0	0.09
150	20.25	0.08	0.01	0.10
160	20.3	0.08	0.025	0.08
170	20.25	0.08	0.05	0.91
180	19.95	0.10	0.15	1.9
190	19.6	0.10	0.125	0.5
195	19.1	0.10	-	-
200	19.25	0.11	0.17	0.68
205	19.75	0.20	0.33	3.4
210	-	-	0.11	-
215	19.4	0.31	0.44	0.75
220	-	-	-	1.6
225	18.3	0.45	0.13	0.4
230	19.0	0.50	-	-
240	19.6	0.33	0.125	0.28
260	20.0	0.25	0.11	0.20

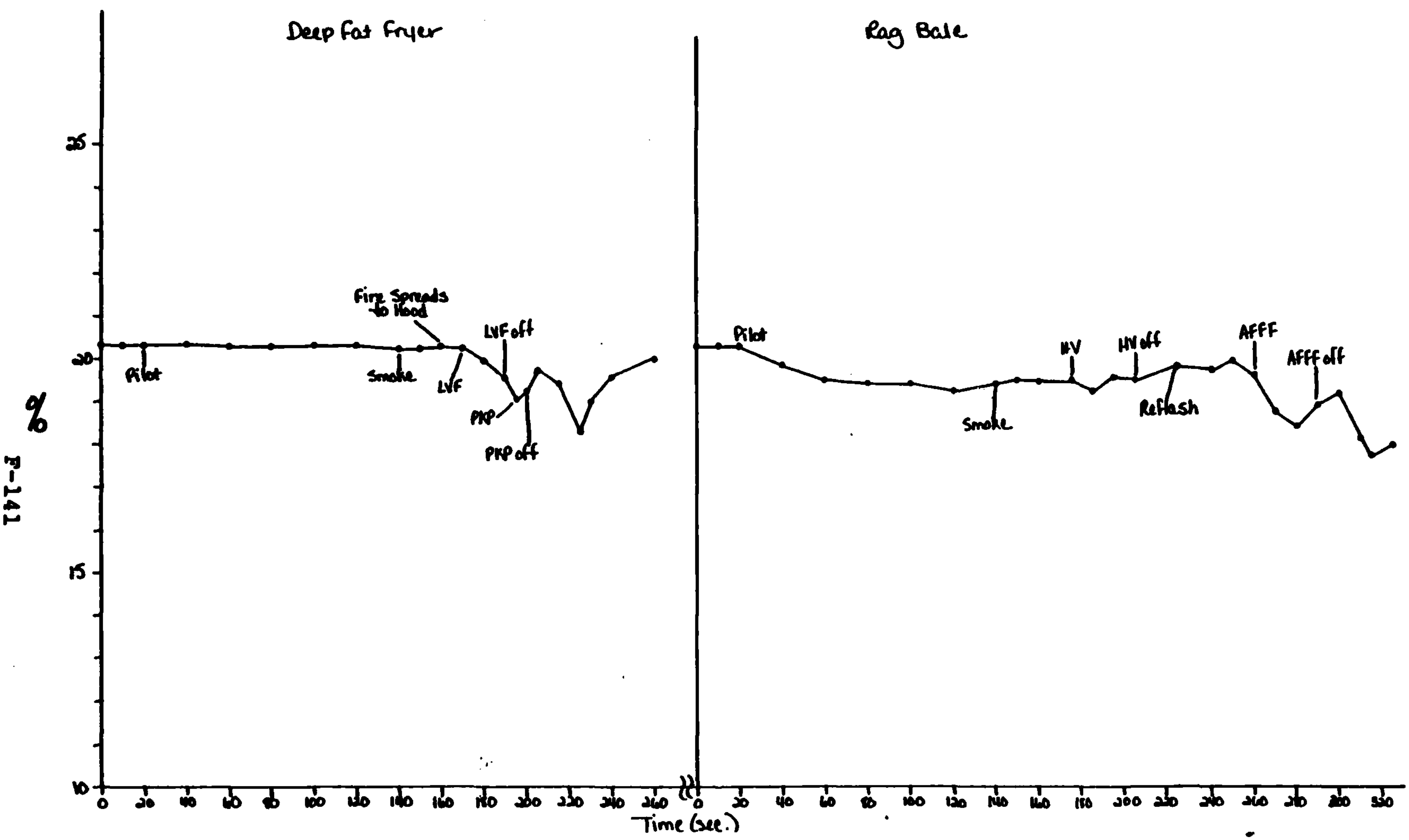
NOTE: Data were obtained from the Case Consulting Labs.

TABLE F-30. UDQII FOR RAG BALE - RUN 5

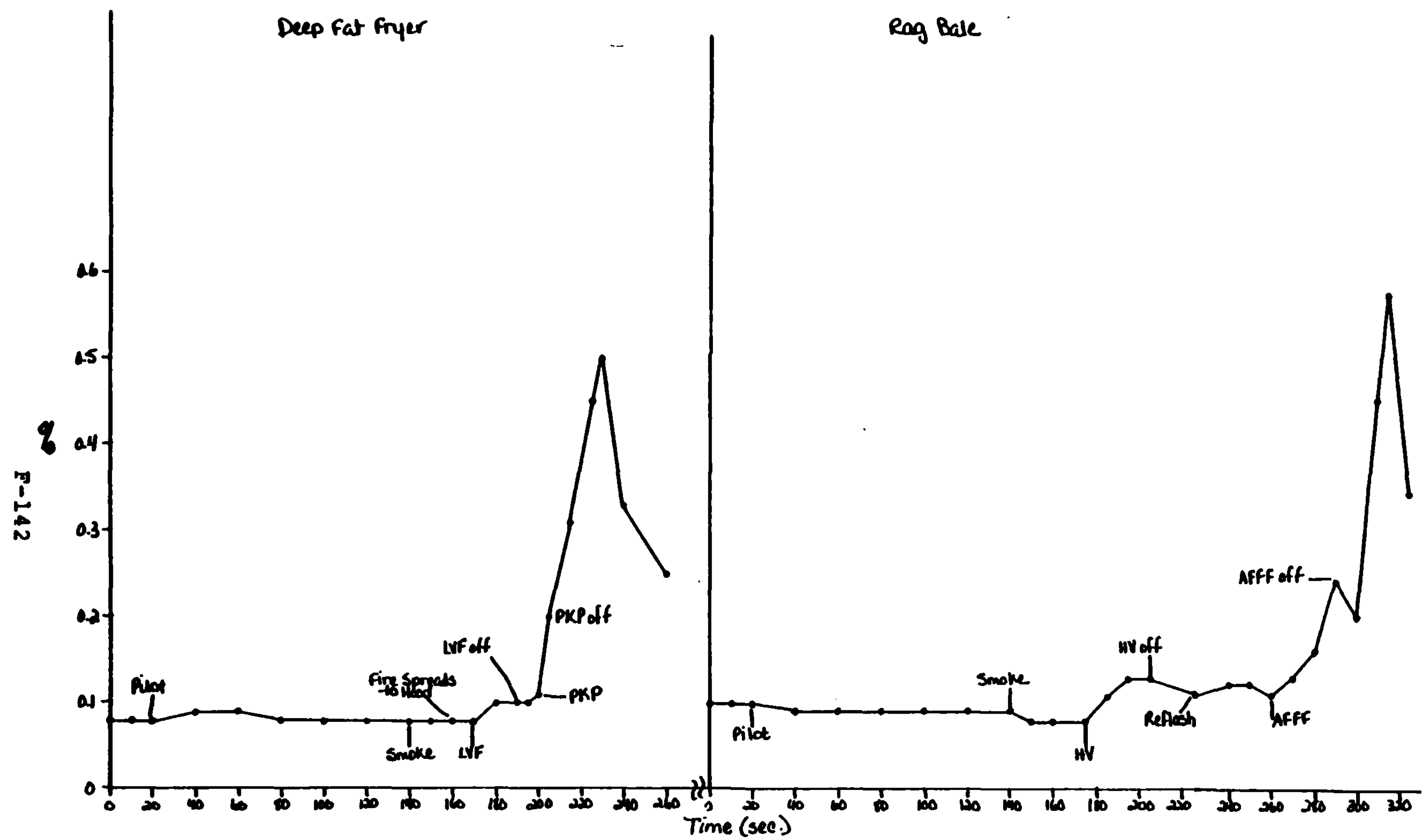
Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.3	0.10	0	0.10
10	20.3	0.10	0	1.15
20	20.3	0.10	0	1.35
40	19.7	0.09	0.01	1.53
60	19.5	0.09	0.01	1.38
80	19.4	0.09	0.01	1.55
100	19.9	0.09	0	1.6
120	19.25	0.09	0	1.6
140	19.4	0.09	0	1.6
150	19.5	0.08	0	1.68
160	19.45	0.08	0	1.58
170	-	-	0.125	-
175	19.5	0.08	0.04	3.18
185	19.25	0.11	0.10	2.25
190	-	-	0.46	-
195	19.6	0.13	0.04	0.55
200	-	-	-	3.8
205	19.5	0.13	0.05	1.85
215	-	-	0.25	1.4
225	19.8	0.11	0.02	3.45
240	19.75	0.12	0.02	1.4
250	19.9	0.12	0.05	1.1
260	19.65	0.11	0.07	2.82
270	18.75	0.13	0.16	3.3
280	18.4	0.16	0.75	3.9
290	18.9	0.24	0.6	4.1
295	-	-	0.3	4.25
300	19.2	0.20	0.08	3.18
310	18.2	0.45	0.025	1.7
315	17.75	0.57	0.025	1.4
325	18.0	0.34	0.01	0.3

NOTE: Data were obtained from the Case Consulting Labs.

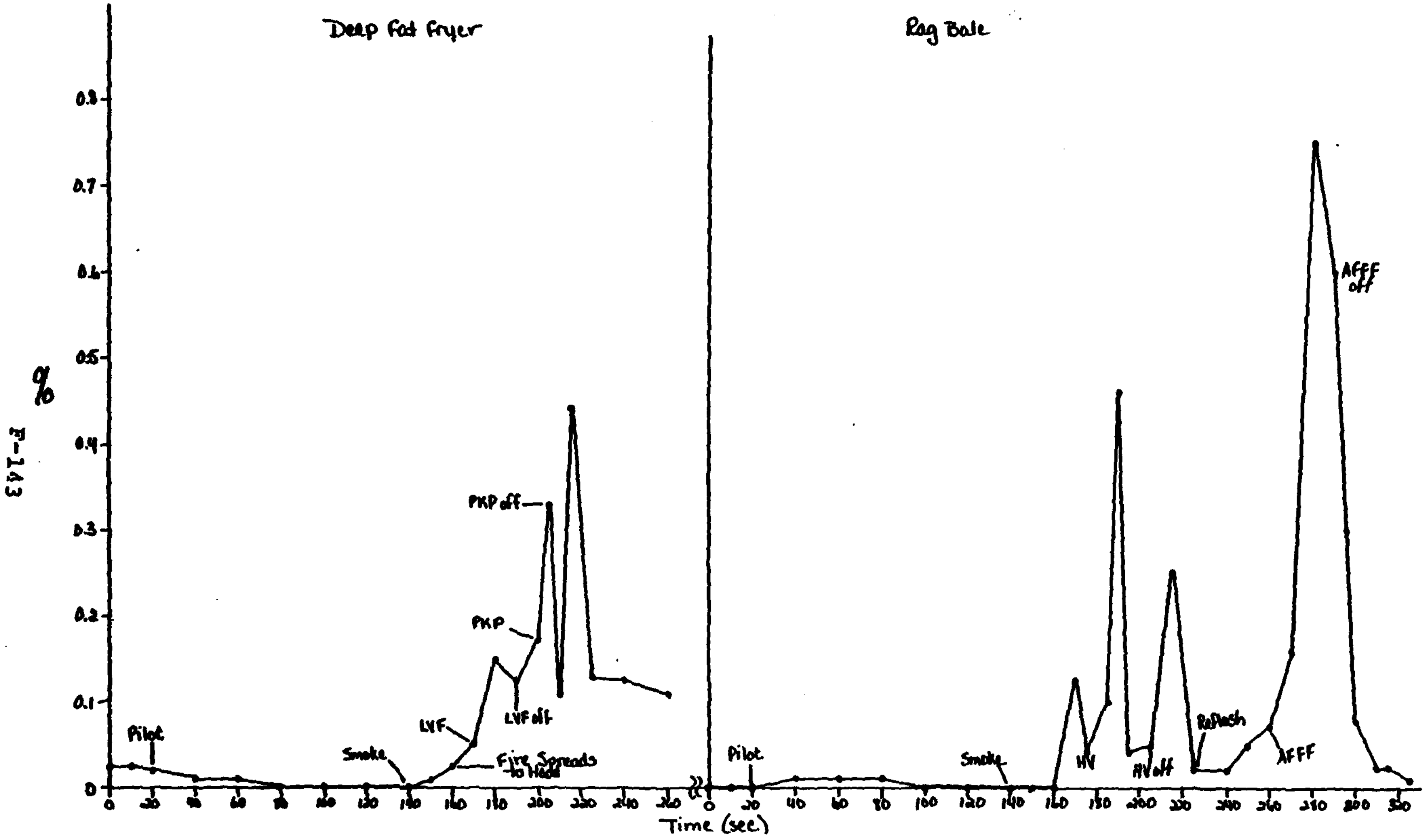
UDQII RUN 5 (CASE) - O_2 LEVELS



UDQII RUN 5 (CASE) - HC LEVELS



UDQII RUN 5 (CASE) - CO LEVELS



UDQII RUN 5 (CASE) - CO_2 LEVELS

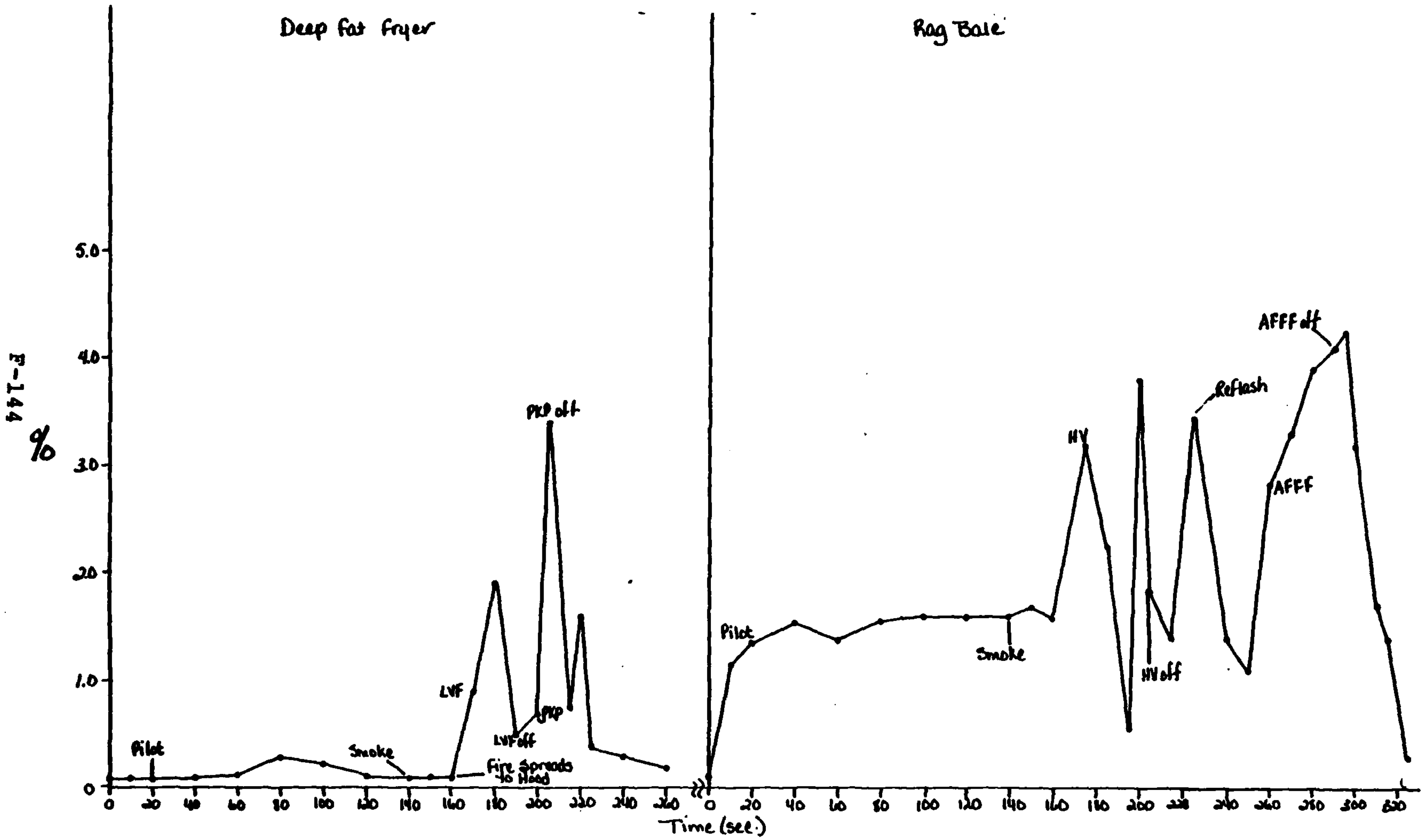


TABLE F-31. UDQII FOR DEEP FAT - RUN 6

Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.5	0.03	0	0.02
10	20.5	0.03	0.01	0.27
20	20.3	0.03	0.01	0.08
40	20.4	0.05	0.02	0.07
60	20.4	0.07	0.02	0.13
80	20.35	0.08	0.025	0.17
100	20.35	0.09	0.025	0.26
120	20.35	0.09	0.025	0.15
140	20.3	0.09	0.025	0.15
150	20.3	0.09	0.025	0.2
160	20.3	0.08	0.025	0.2
170	20.35	0.08	0.03	0.41
180	20.25	0.08	0.05	1.0
190	20.45	0.05	0.1	1.41
195	20.4	0.06	0.14	0.51
205	20.2	0.12	0.33	0.75
210	20.1	0.19	0.17	1.6
215	-	-	-	2.67
220	20.0	0.26	0.125	1.35
230	19.65	0.40	0.3	0.53
240	19.7	0.42	0.175	0.7
245	19.7	0.50	-	1.1
250	19.95	0.48	0.15	0.8
260	20.1	0.30	0.125	0.45

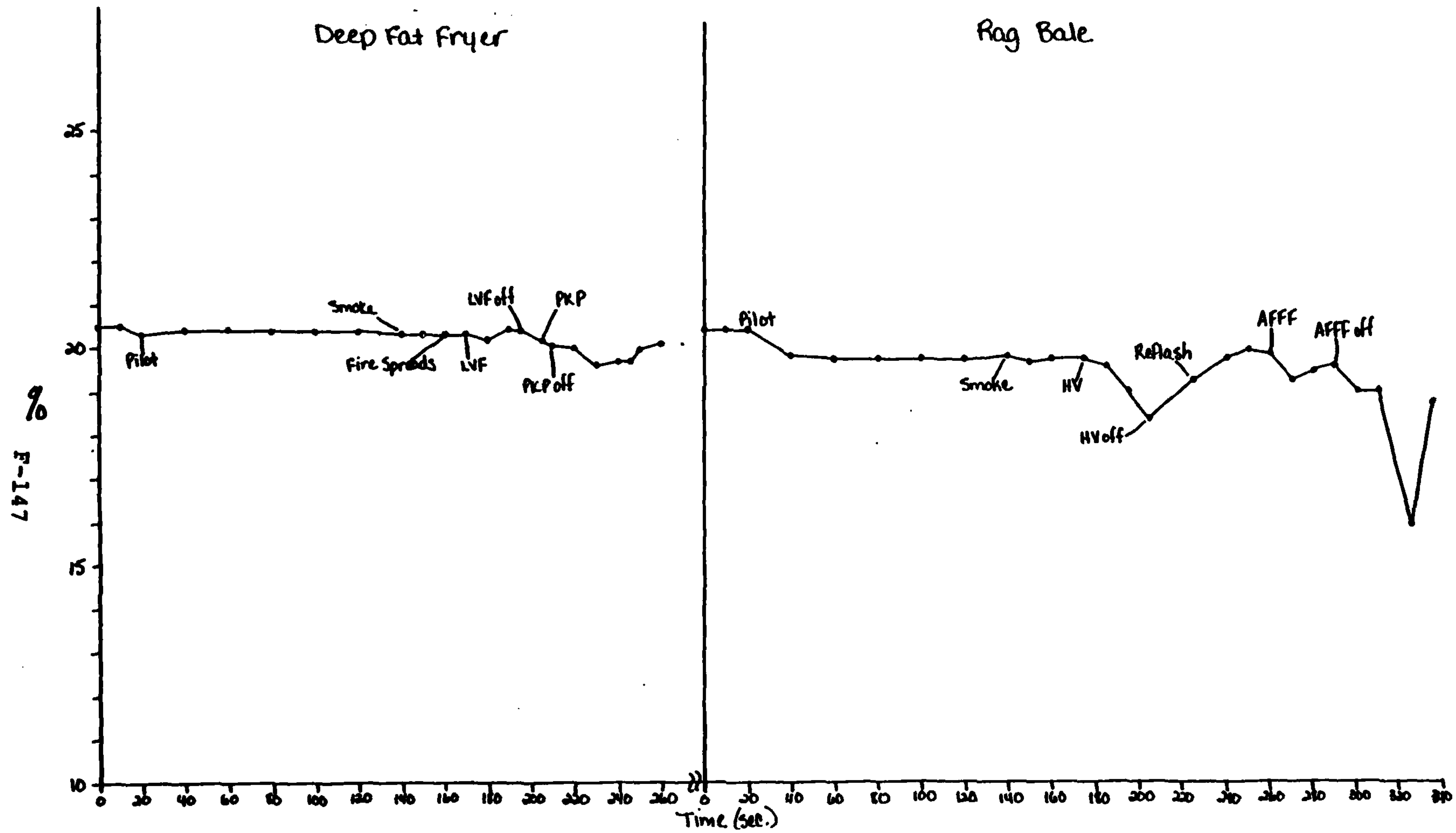
NOTE: Data were obtained from the Case Consulting Labs.

TABLE F-32. UDQII FOR RAG BALE - RUN 6

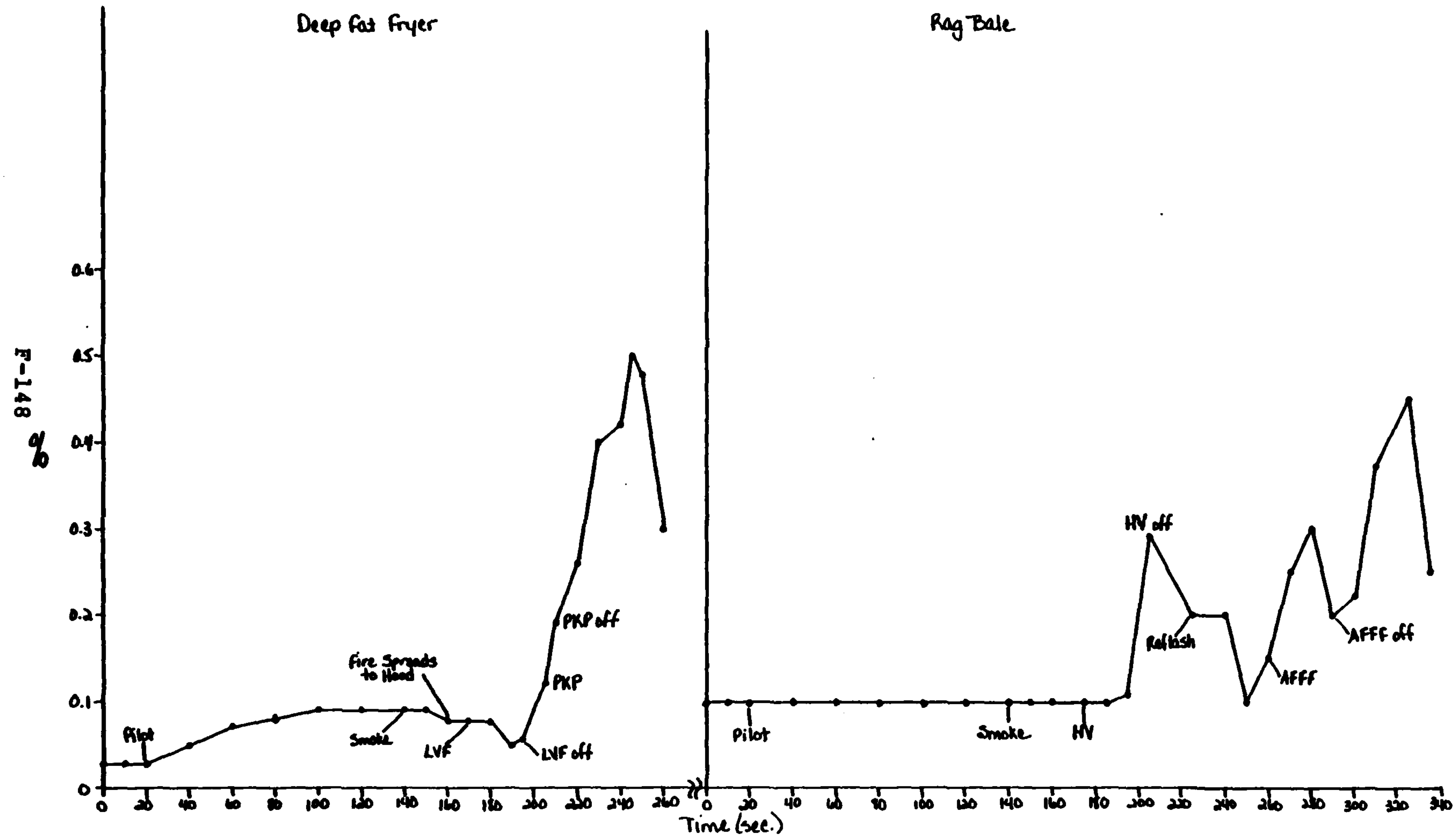
Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.4	0.10	0.03	0.1
10	20.4	0.10	0.025	0.12
20	20.4	0.10	0.025	1.35
40	19.8	0.10	0.02	1.13
60	19.75	0.10	0.02	1.35
80	19.75	0.10	0.02	1.25
100	19.75	0.10	0.02	1.47
120	19.75	0.10	0.02	1.5
140	19.8	0.10	0.02	1.32
150	19.7	0.10	0.01	1.35
160	19.75	0.10	0.01	1.37
175	19.75	0.10	0.05	1.78
185	19.6	0.10	0.05	3.49
195	19.0	0.11	0.25	2.9
200	-	-	0.40	0.55
205	18.35	0.29	0.09	2.63
225	19 25	0.20	0.01	0.4
230	-	-	-	2.15
240	19.75	0.20	0	1.61
250	19.9	0.10	0	1.4
260	19.8	0.15	0	1.51
270	19.25	0.25	0.07	2.75
280	19.4	0.30	0.875	3.7
290	19.55	0.20	0.575	4.46
300	19.0	0.22	0.73	2.65
310	19.0	0.37	0.125	5.62
325	15.9	0.45	0	1.42
335	18.75	0.25	0	0.27

NOTE: Data were obtained from the Case Consulting Labs.

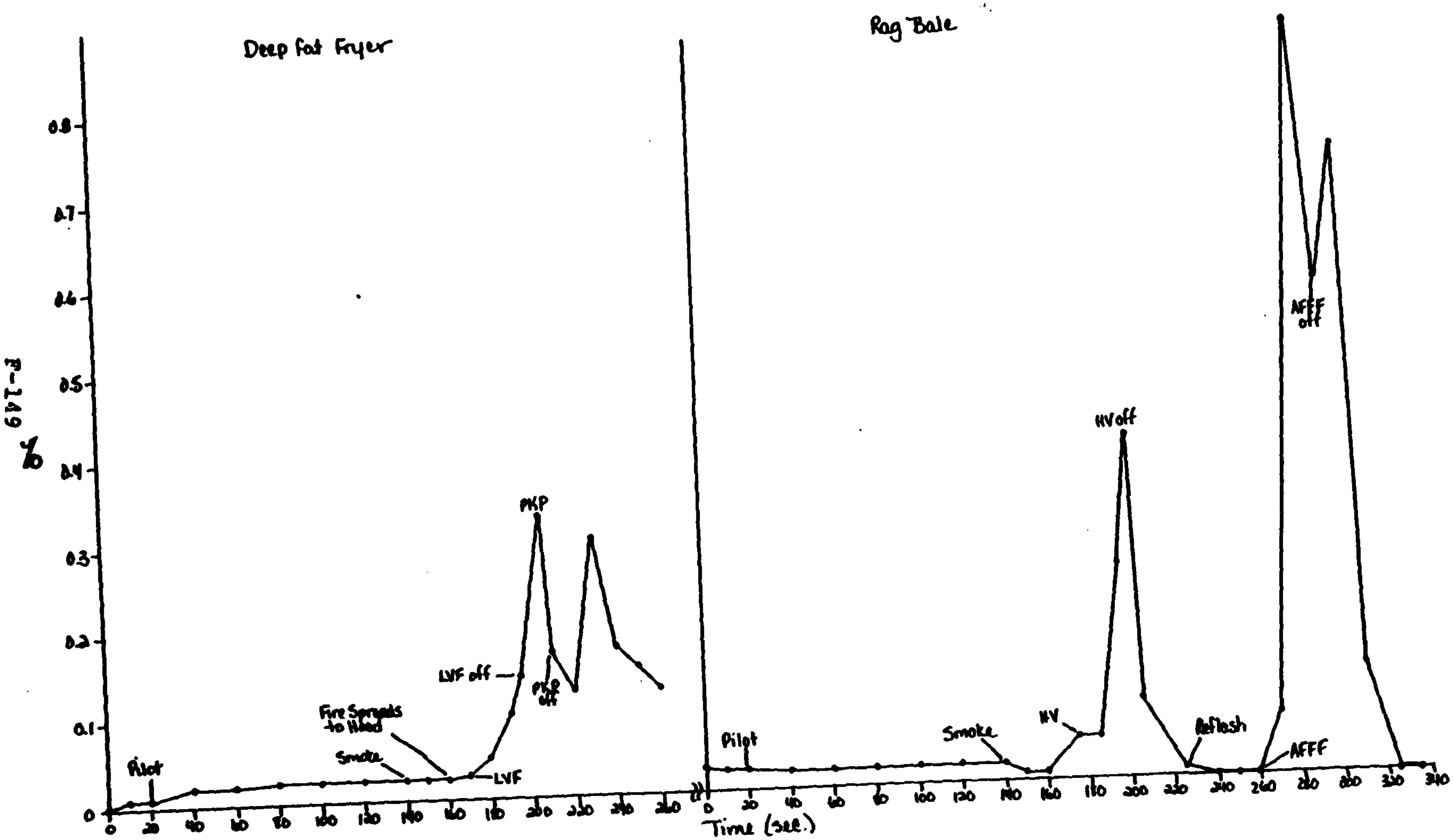
UDQII RUN 6 (CASE) - O_2 LEVELS



UDQII RUN 6 (CASE) - HC LEVELS



UDQII RUN 6 (CASE) - CO LEVELS



UDQII RUN 6 (CASE) - CO_2 LEVELS

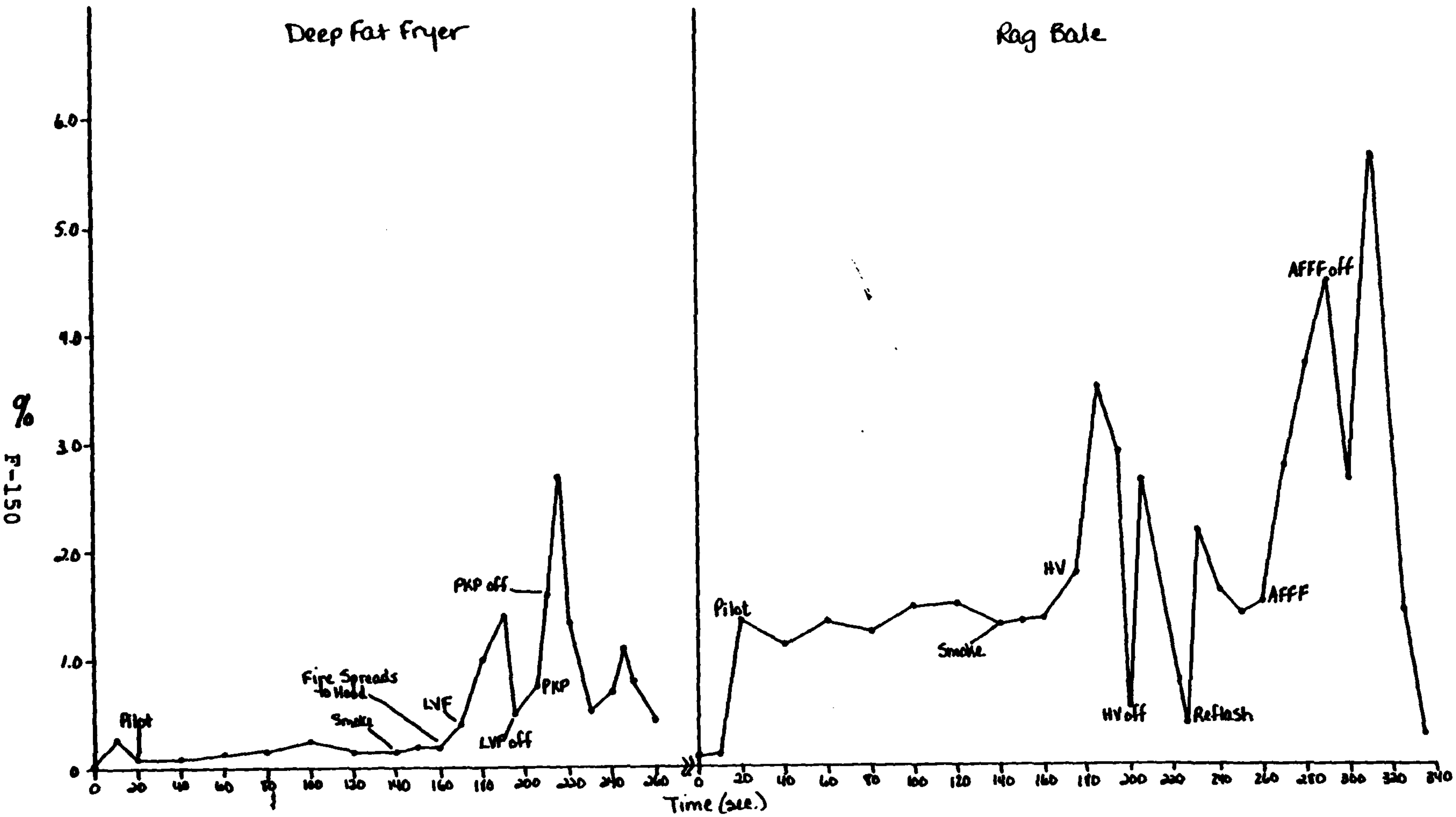


TABLE F-33. UDQII FOR DEEP FAT - RUN 7

Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.4	0.08	0	0.1
10	20.4	0.08	0	0.25
20	20.4	0.08	0	0.2
40	20.25	0.08	0.01	0.35
60	20.25	0.08	0.01	0.2
80	20.35	0.08	0.01	0.3
100	20.35	0.07	0.01	0.25
120	20.35	0.07	0.01	0.35
140	20.35	0.07	0.01	0.15
150	20.35	0.08	0.01	0.25
160	20.35	0.08	0.05	0.5
170	20.25	0.08	0.04	1.7
175	19.65	0.09	0.075	1.88
180	20.0	0.10	0.17	1.4
185	-	-	-	0.5
190	20.35	0.09	0.225	1.1
200	20.35	0.09	0.18	1.5
210	20.0	0.20	0.26	1.25
215	19.75	0.28	0.10	3.13
225	19.5	0.40	0.075	1.4
230	-	-	0.74	0.6
235	19.65	0.39	0.10	2.55
245	18.95	0.25	0.07	0.67
260	19.75	0.25	0.07	0.35

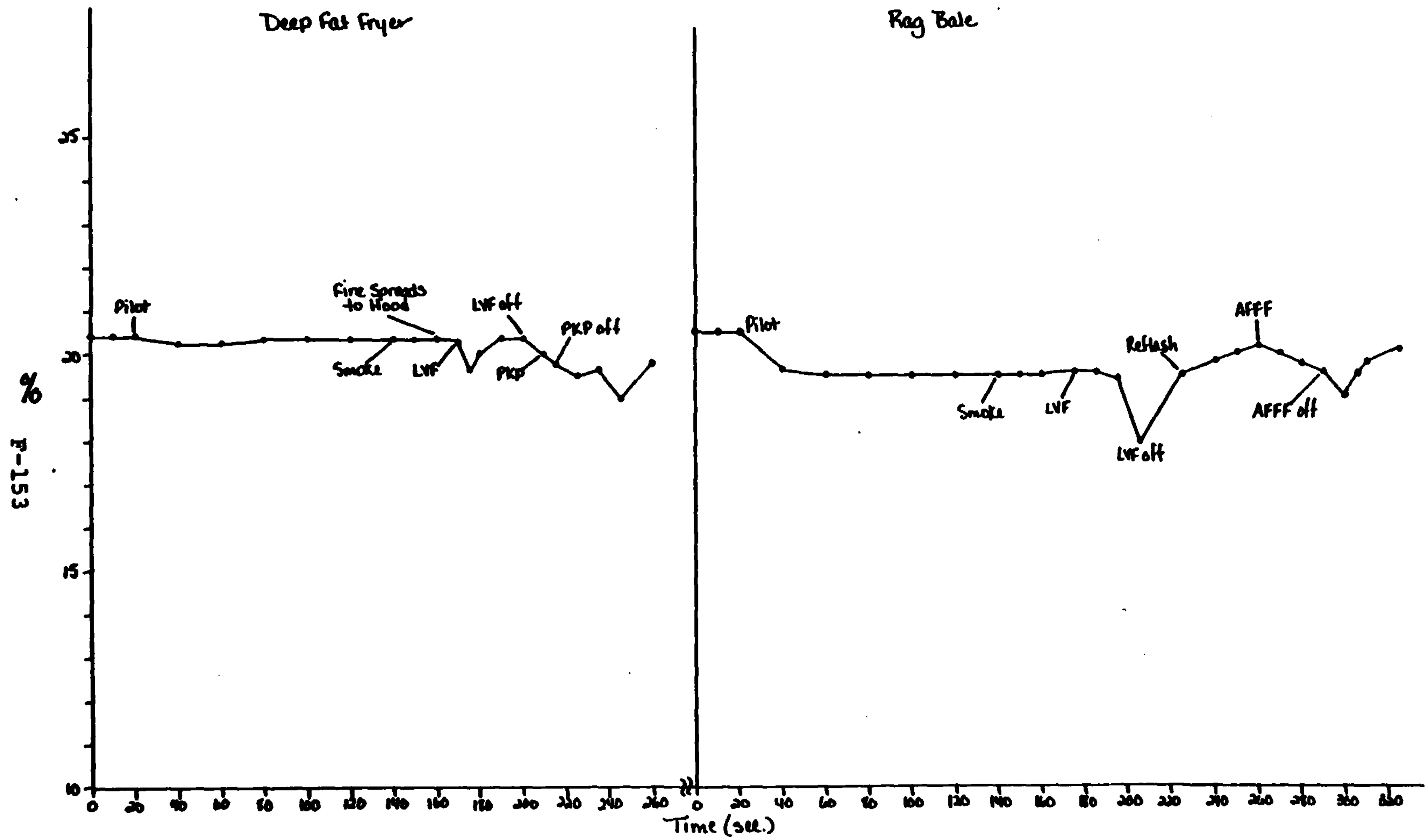
NOTE: Data were obtained from the Case Consulting Labs.

TABLE F-34. UDQII FOR RAG BALE - RUN 7

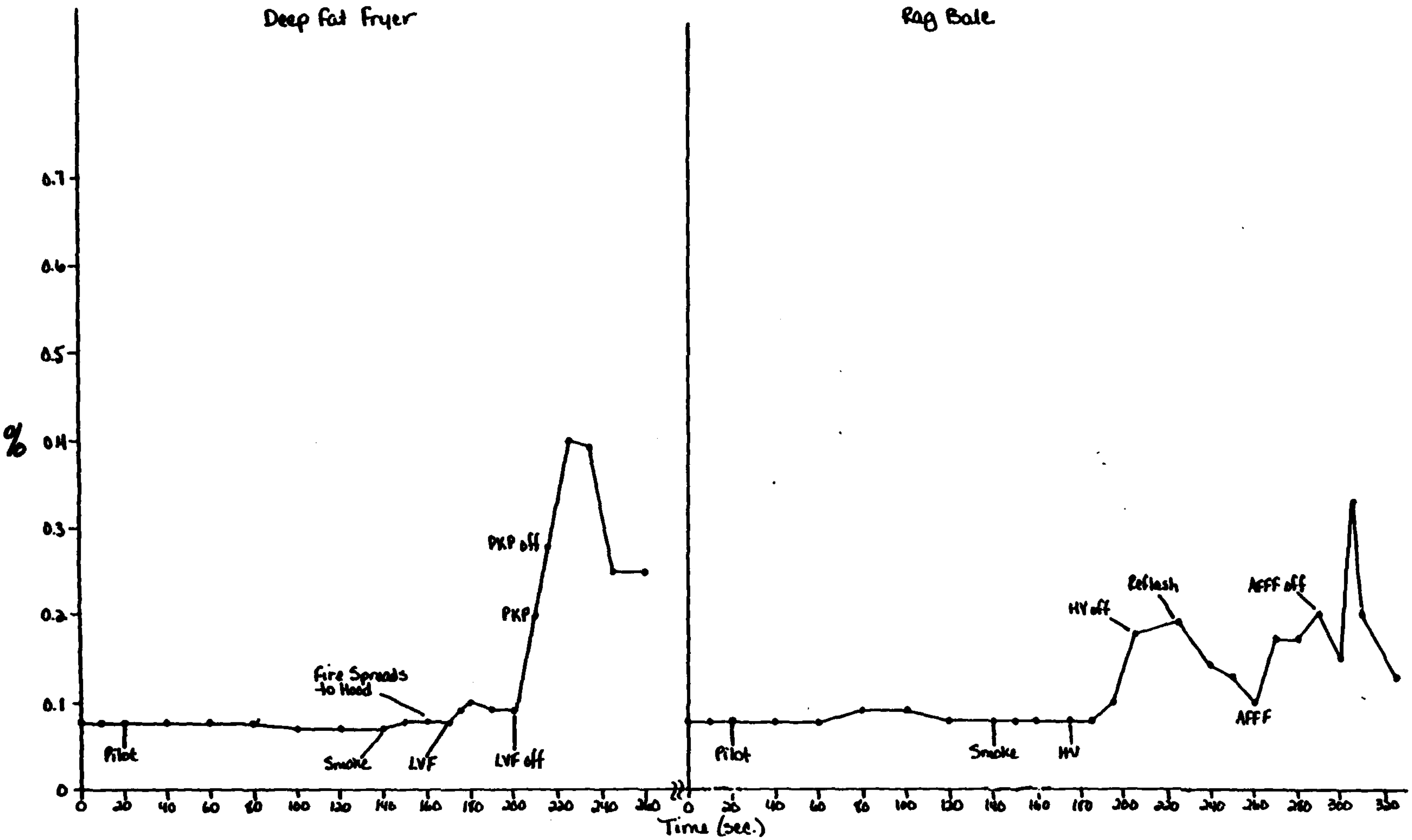
Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.5	0.08	0	0.10
10	20.5	0.08	0	1.12
20	20.5	0.08	0	1.45
40	19.65	0.08	0.01	1.55
60	19.5	0.08	0.01	1.47
80	19.5	0.09	0.01	1.53
100	19.5	0.09	0.01	1.45
120	19.5	0.08	0.01	1.4
140	19.5	0.08	0	1.3
150	19.5	0.08	0	1.5
160	19.5	0.08	0	1.4
175	19.6	0.08	0.06	1.9
180	-	-	0.125	-
185	19.6	0.08	0.06	3.65
195	19.4	0.10	0.73	1.3
200	-	-	-	4.33
205	17.9	0.18	0.03	1.2
210	-	-	-	1.55
225	19.5	0.19	0.02	3.1
240	19.8	0.14	0	1.5
250	20.0	0.13	0.05	1.5
260	20.2	0.10	0.09	3.35
270	20.0	0.17	0.16	2.8
275	-	-	0.51	3.73
280	19.75	0.17	0.34	1.72
290	19.55	0.20	0.15	2.32
300	19.0	0.15	0.03	1.25
305	19.5	0.33	0.03	2.82
310	19.75	0.20	0.02	2.52
325	20.1	0.13	0.01	1.35

NOTE: Data were obtained from the Case Consulting Labs.

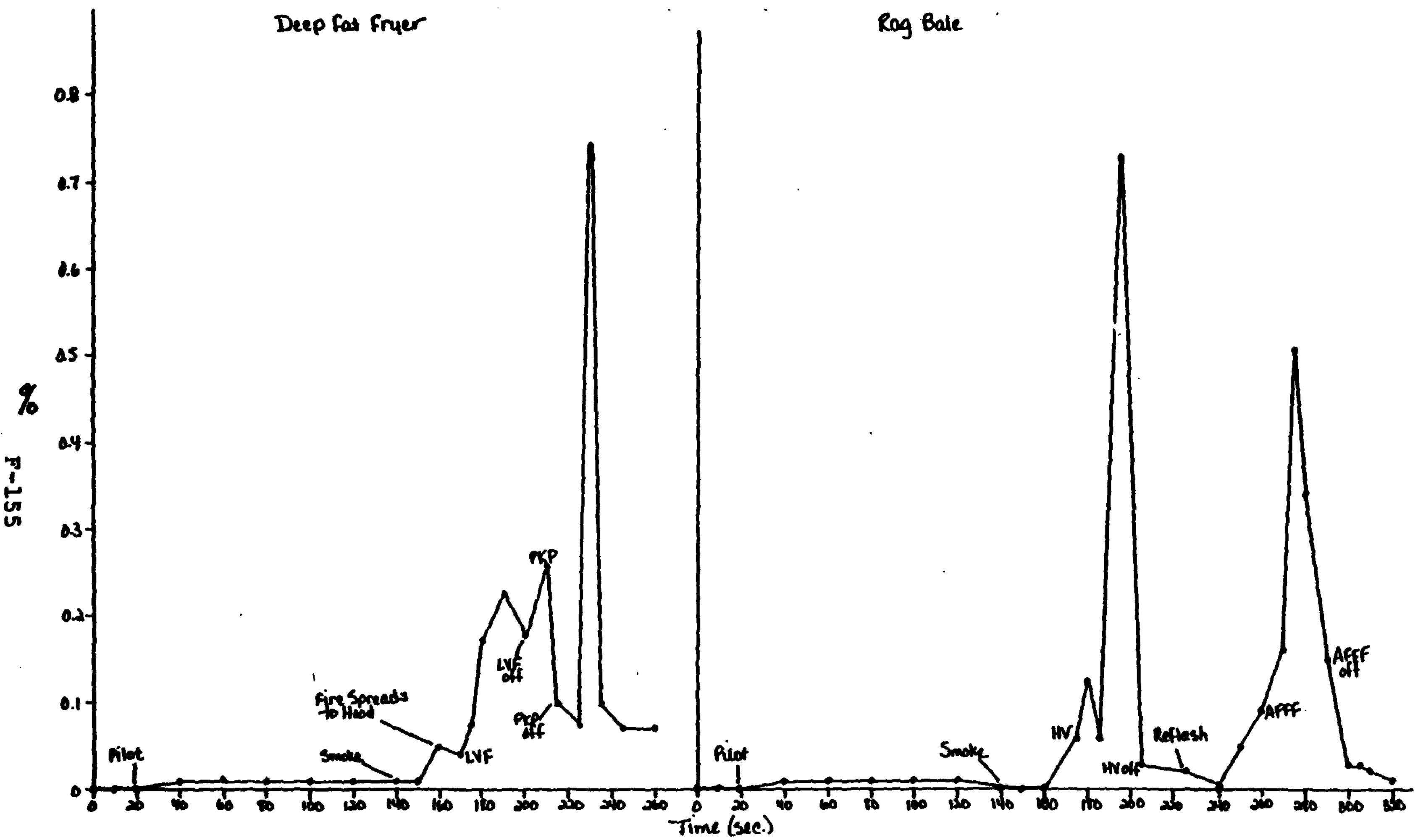
UDQII RUN 7 (CASE) - O_2 LEVELS



UDQII RUN 7 (CASE) - HC LEVELS



UDQII RUN 7 (CASE) - CO LEVELS



UDQII RUN 7 (CASE) - CO_2 LEVELS

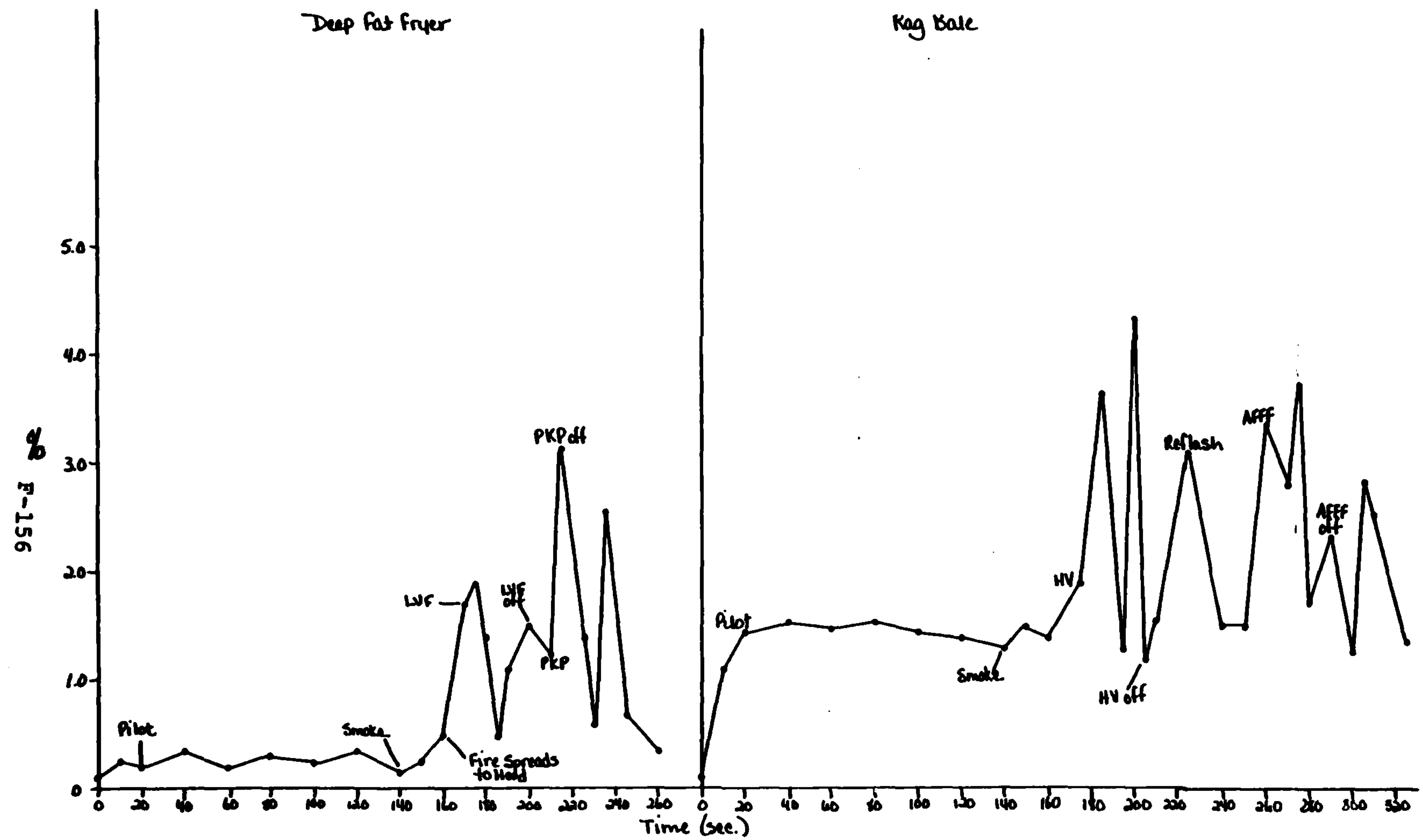


TABLE F-35. UDQII FOR DEEP FAT - RUN 8

Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.5	0.06	0	0.15
10	20.5	0.07	0	0.31
20	20.5	0.07	0	0.15
40	20.5	0.07	0	0.35
60	20.5	0.08	0	0.32
80	20.5	0.08	0	0.18
100	20.5	0.08	0	0.18
120	20.45	0.09	0	0.2
140	20.5	0.09	0	0.3
150	20.4	0.09	0	0.35
160	20.45	0.09	0.01	0.2
170	20.5	0.09	0.01	1.15
180	20.0	0.09	0.025	0.93
185	-	-	-	3.32
190	20.45	0.10	0.075	0.5
205	20.25	0.09	0.2	0.5
210	-	-	0.1	-
215	19.8	0.38	0.225	1.53
220	19.8	0.43	0.17	0.9
225	-	-	-	2.95
230	19.8	0.40	0.075	1.8
240	19.5	0.45	0.05	1.75
245	19.5	0.54	0.18	0.5
255	19.8	0.40	0.07	1.45
260	19.8	0.56	0.05	1.14
270	19.95	0.50	0.03	0.7

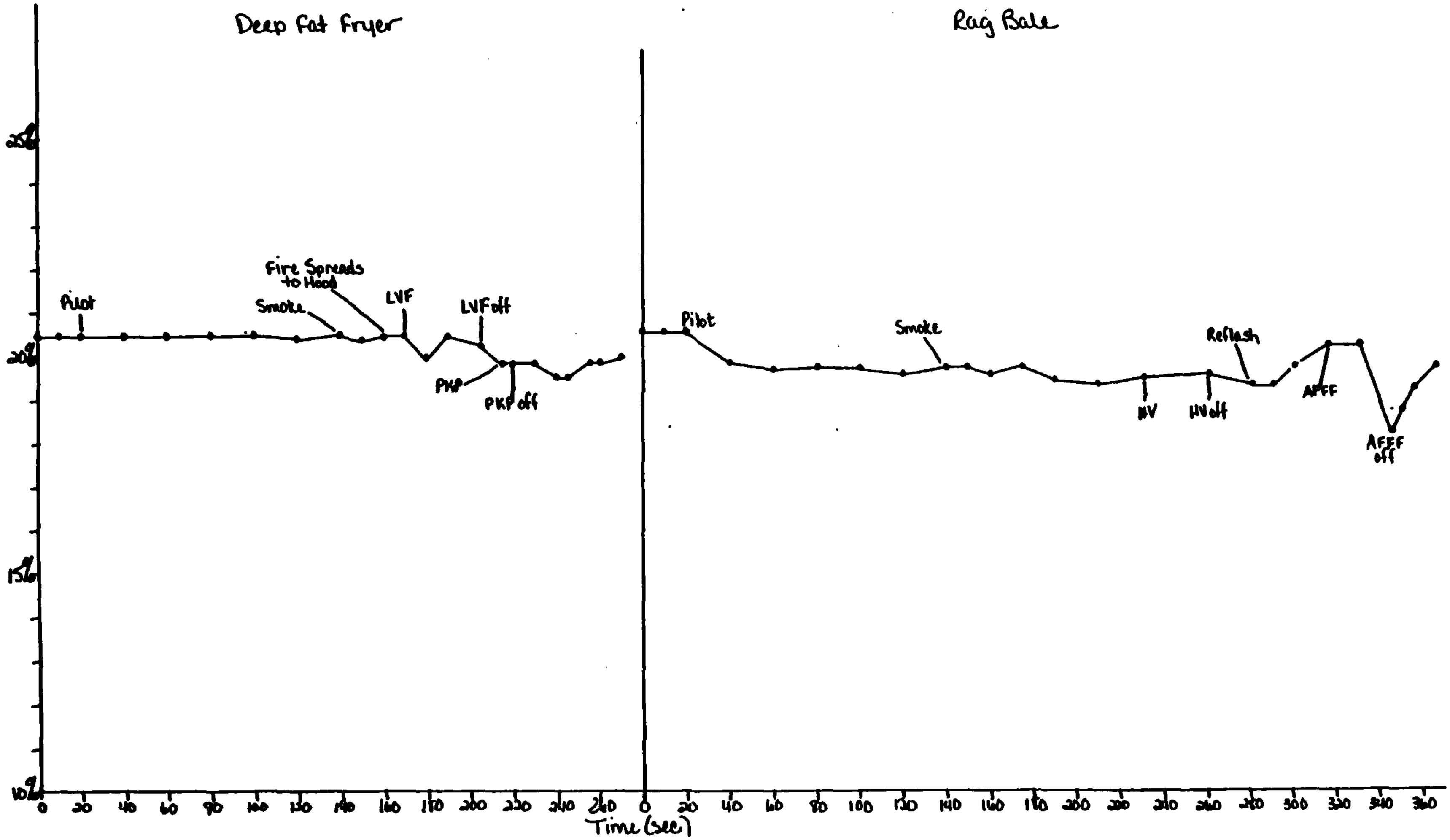
NOTE: Data were obtained from the Case Consulting Labs.

TABLE F-36. UDQII FOR RAG BALE - RUN 8

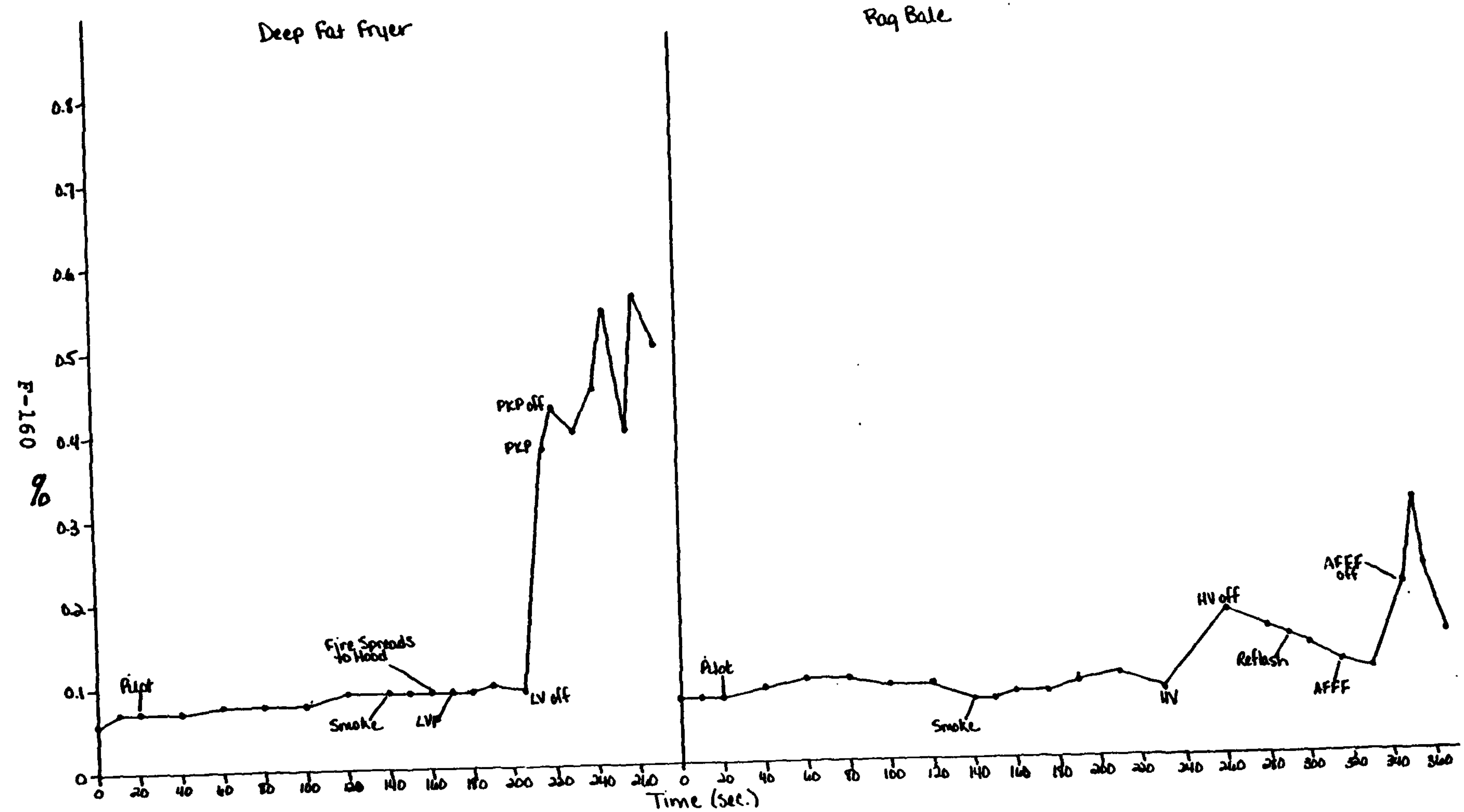
Time/Sec.	O_2 (percent)	HC (percent)	CO (percent)	CO_2 (percent)
0	20.51	0.08	0	0.1
10	20.51	0.08	0.01	1.4
20	20.51	0.08	0.01	1.4
40	19.85	0.09	0.01	1.6
60	19.70	0.10	0.01	1.45
80	19.75	0.10	0.01	1.42
100	19.7	0.09	0.01	1.68
120	19.65	0.09	0.01	1.4
140	19.75	0.07	0.01	1.4
150	19.75	0.07	0	1.1
160	19.6	0.08	0	1.55
175	19.75	0.08	0.01	1.22
190	19.4	0.09	0.01	0.48
195	-	-	-	2.38
210	19.35	0.10	0.01	1.7
230	19.5	0.08	0.11	1.95
235	-	-	0.48	3.88
260	19.6	0.17	0	0.82
275	-	-	-	4.05
280	19.35	0.15	0	3.5
290	19.35	0.14	0	3.05
300	19.75	0.13	0.02	1.45
315	20.25	0.11	0.01	1.3
330	20.25	0.10	0.1	1.25
340	-	-	-	2.85
345	18.25	0.20	0.01	0.55
350	18.75	0.30	0.01	1.62
355	19.25	0.22	0.01	-
365	19.75	0.14	0	0.23

NOTE: Data were obtained from the Case Consulting Labs.

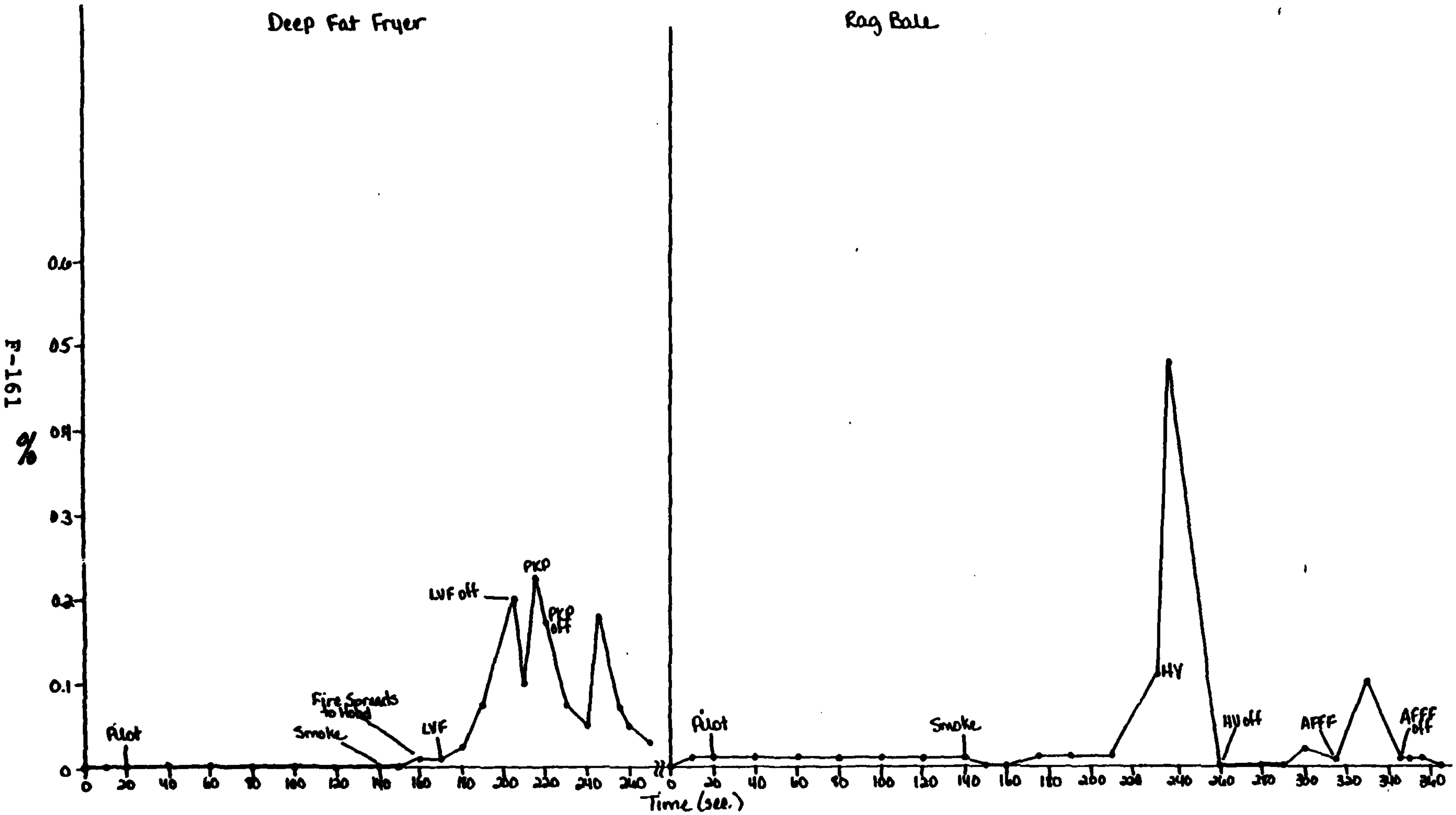
UDQII RUN 8 (CASE) - O_2 LEVELS



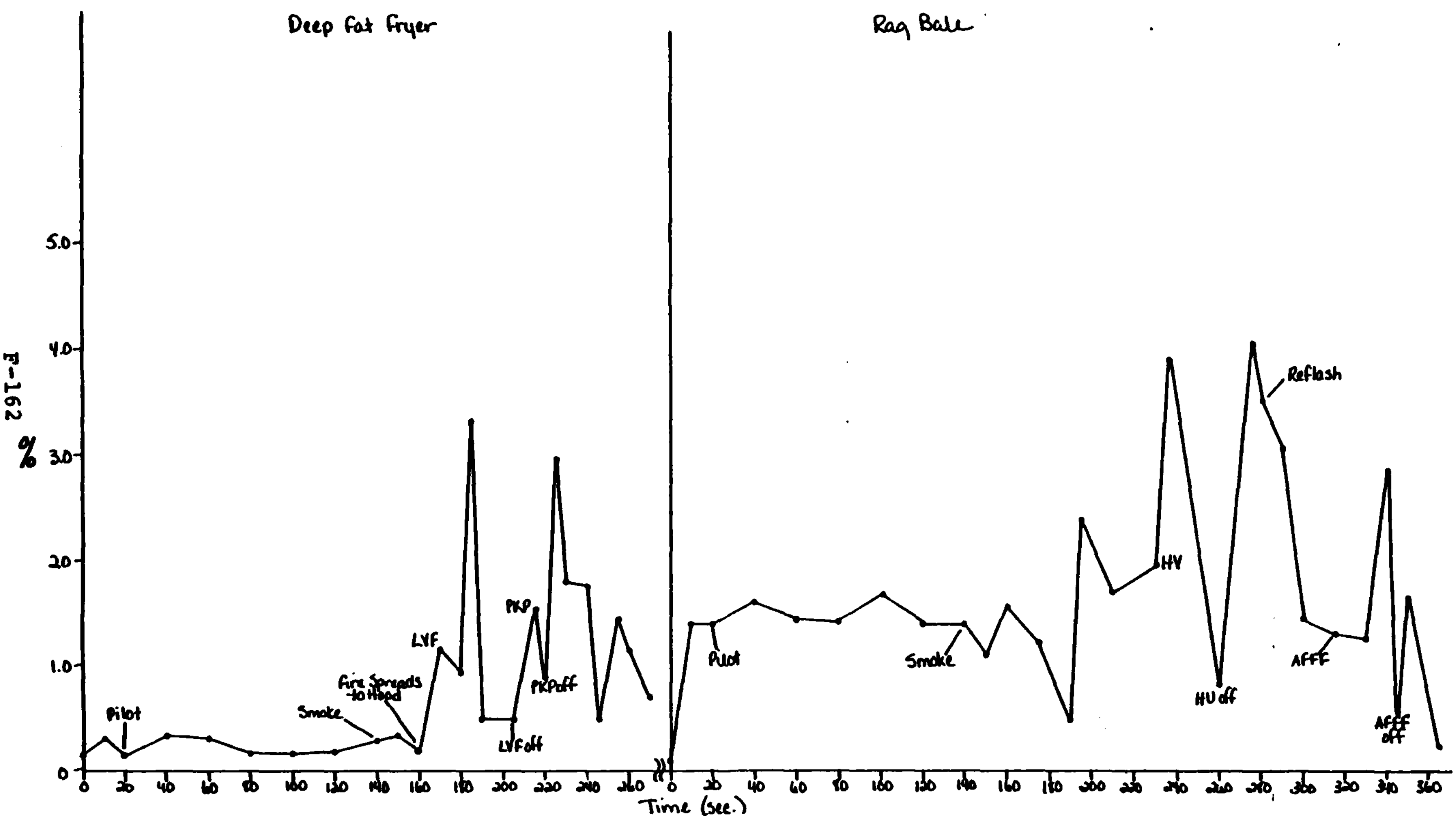
UDQII RUN 8 (CASE) - HC LEVELS



UDQII RUN 8 (CASE) - CO LEVELS



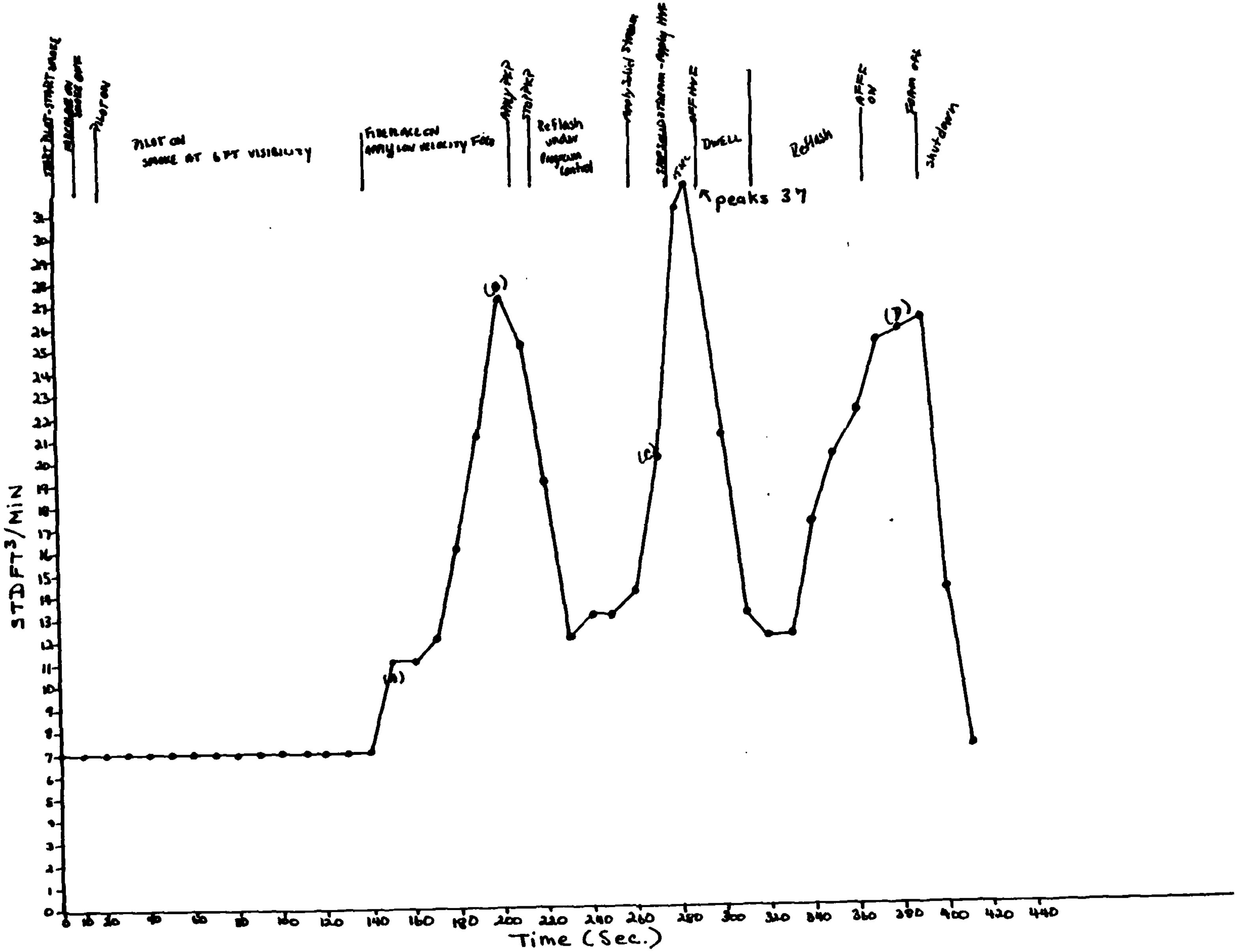
UDQII RUN 8 (CASE) - CO_2 LEVELS



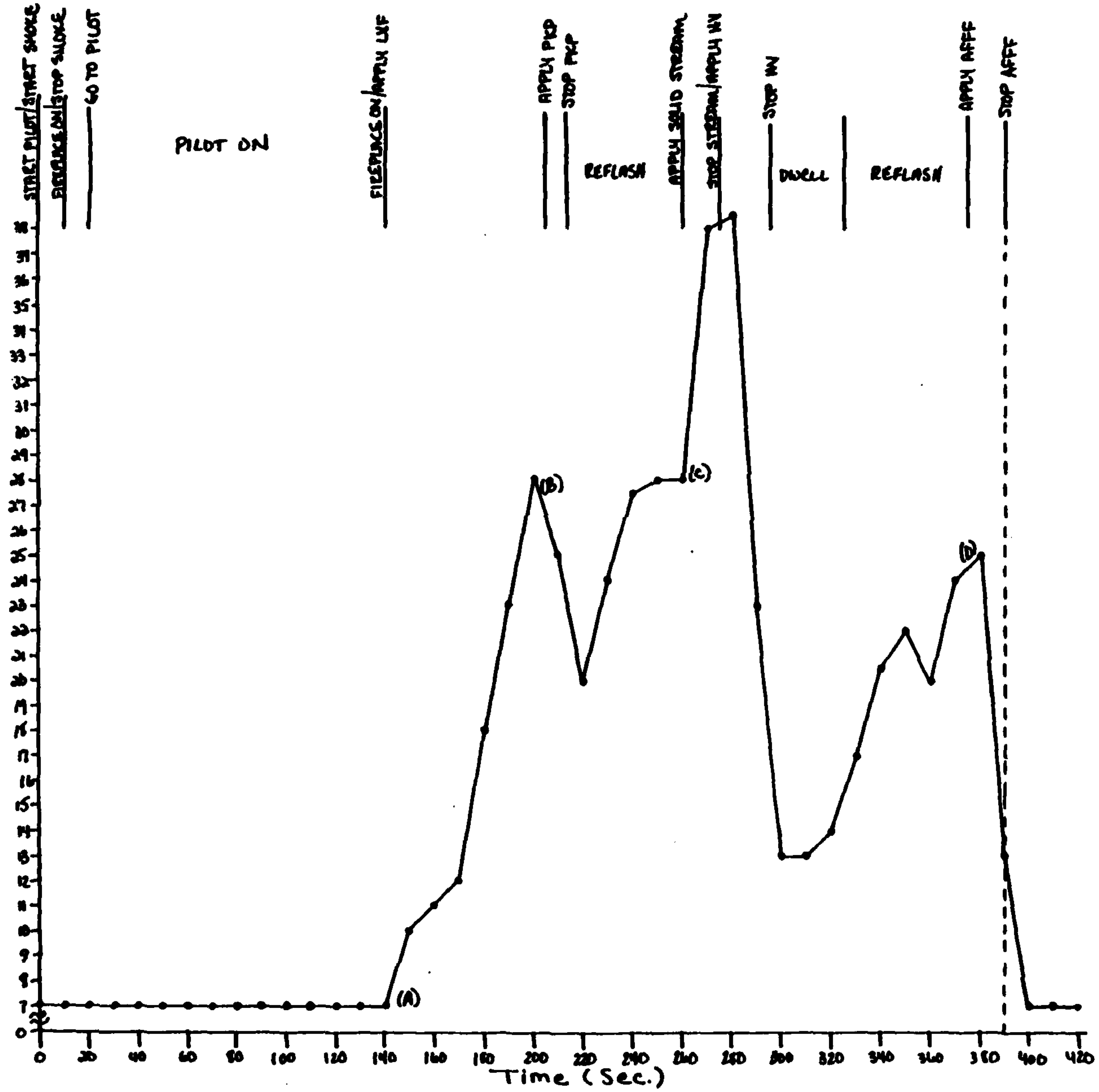
LDQI GAS FLOWS

TABLE F-37. LDQI GAS FLOWS
(STD. FT^3/MIN.)

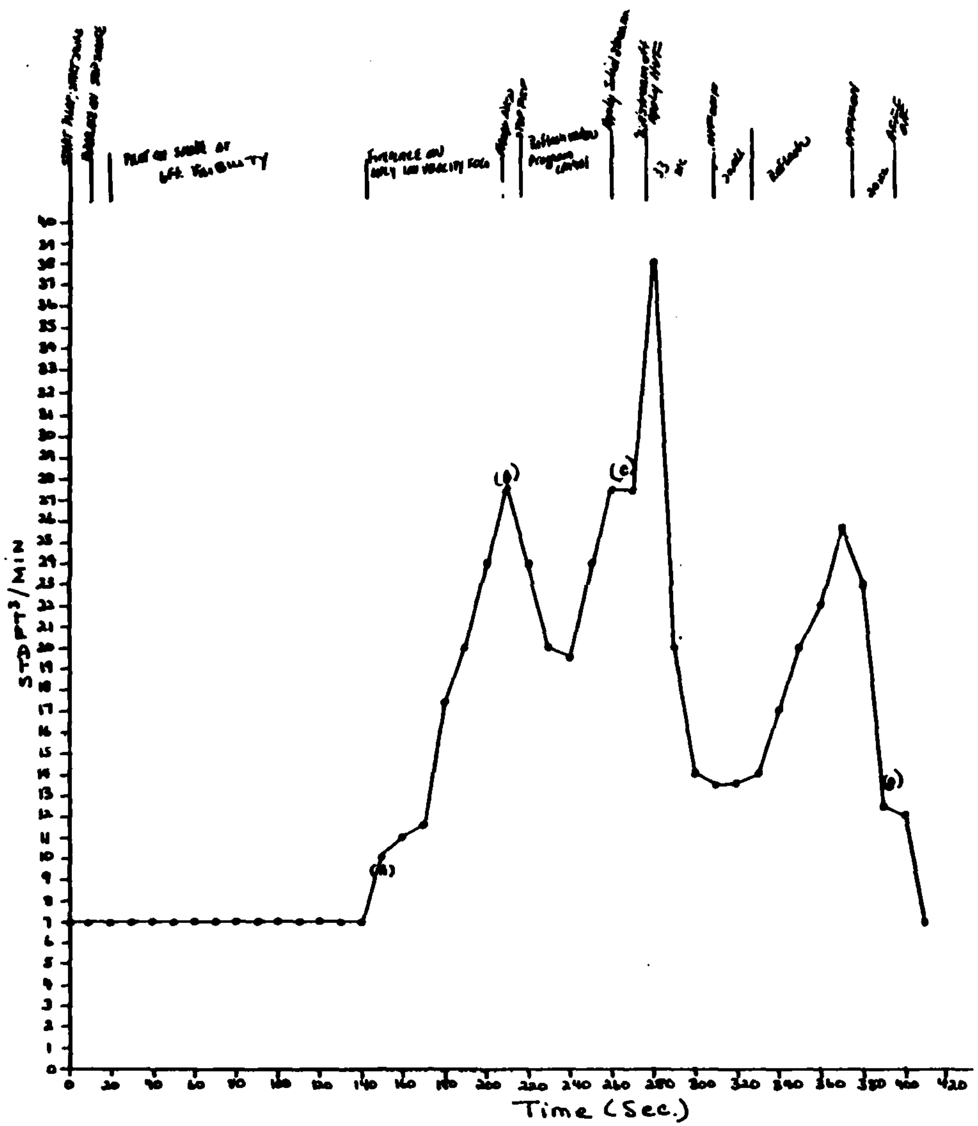
Time/Sec.	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
0	<5	7	7	7	7	7	8	8	7	8
10	<5	7	7	7	7	7	8	8	7	8
20	7	7	7	7	7	7	8	8	7	8
30	7	7	7	7	7	7	8	8	7	8
40	7	7	7	7	7	7	8	8	7	8
50	7	7	7	7	7	7	8	(Abort)	7	8
60	7	7	7	7	7	7	8		7	8
70	7	7	7	7	7	7	8		7	8
80	7	7	7	7	7	7	8		7	8
90	7	7	7	7	7	7	8		7	8
100	7	7	7	7	7	7	8		7	8
110	7	7	7	7	7	7	8		7	8
120	7	7	7	7	7	7	8		7	8
130	7	7	7	7	7	7	(Abort)		7	8
140	7	11	7	7	7	7			7	8
150	10	11	11	10	10	7			10	10
160	12	12	11	11	11	10			11	12
170	14	17	12	12	11.5	12			13	13
180	14.5	23	16	18	17.5	15			19	20
190	14.5	27.5	21	23	20	19			23	23
200	14.5	27.5	27	28	24	20			27	28
210	14.5	25	25	25	27.5	14			22.5	28
220	17	19	19	20	24	14			13	22
230	13	25.5	12	24	20	17			21	18
240	13	27.5	13	27.5	19.5	20			25	21
250	13	27.5	13	28	24	20			27	24
260	13	26	14	28	27.5	20			22	22.5
270	22	25	20	38	27.5	22.5			23	28
280	25	27.5	31	38.5	38	24			25.5	38.5
290	23	27.5	37	23	20	23			21	26
300	12	27.5	21	13	14	12.5			14	18
310	10	17	13	13	13.5	12.5			13	16
320	7	12	12	14	13.5	12.5			13	14
330	7	7	12	17	14	12.5			15	15
340		7	17	20.5	17	14			18	18
350		7	20	22	20	18			19	21
360		7	22	20	22	18			22	25
370		7	25	24.0	25.5	17	(Abort)	(Abort)	25.5	26
380			25	25	23	18			26	26
390			26	13	12.5	15			18	18
400			14	7	12	12			12	12
410			7	7	7	7				
420				7	7	7				
430				7	7	7				
440				7	7	7				



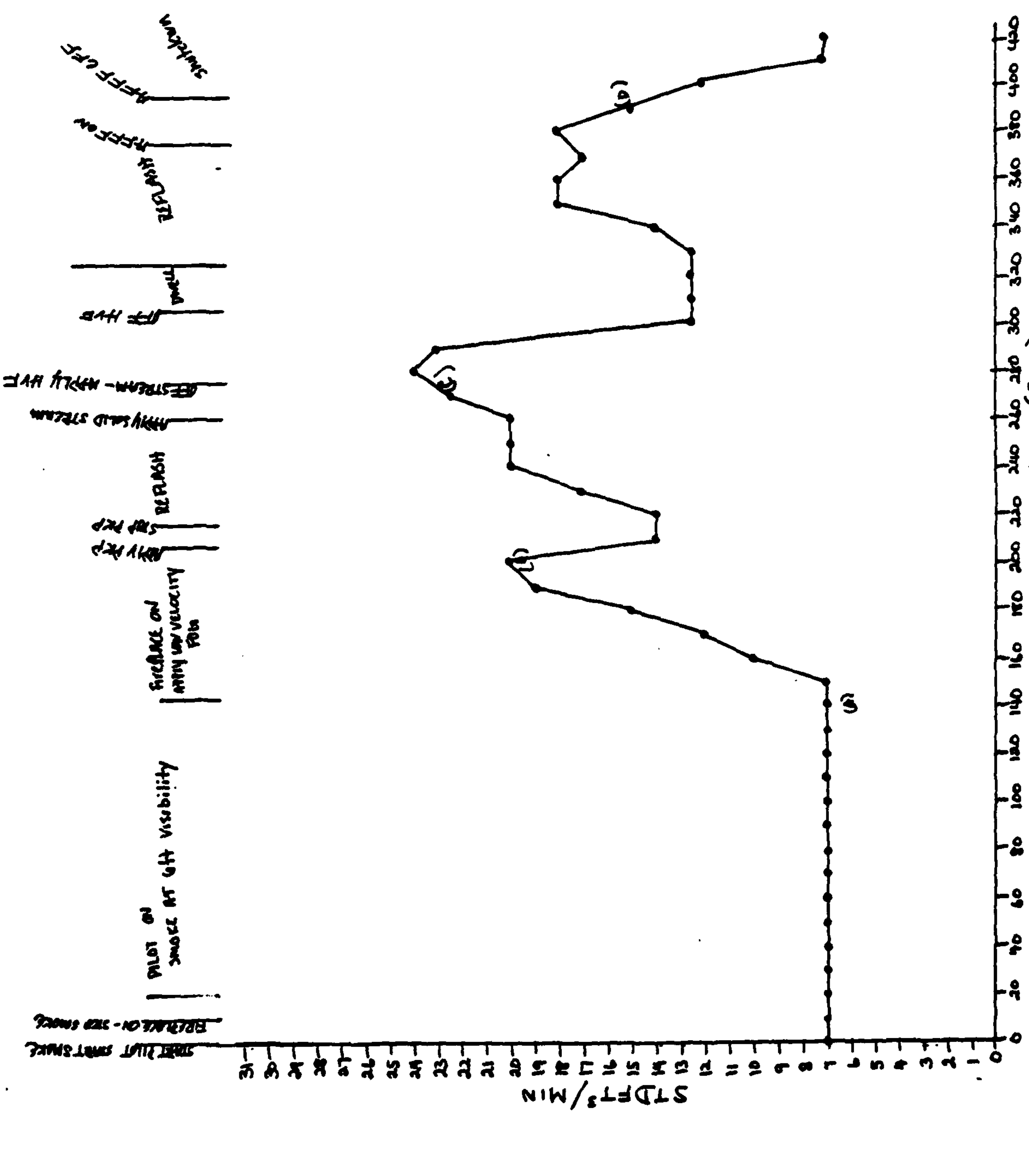
LDQI RUN 3 - GAS FLOW



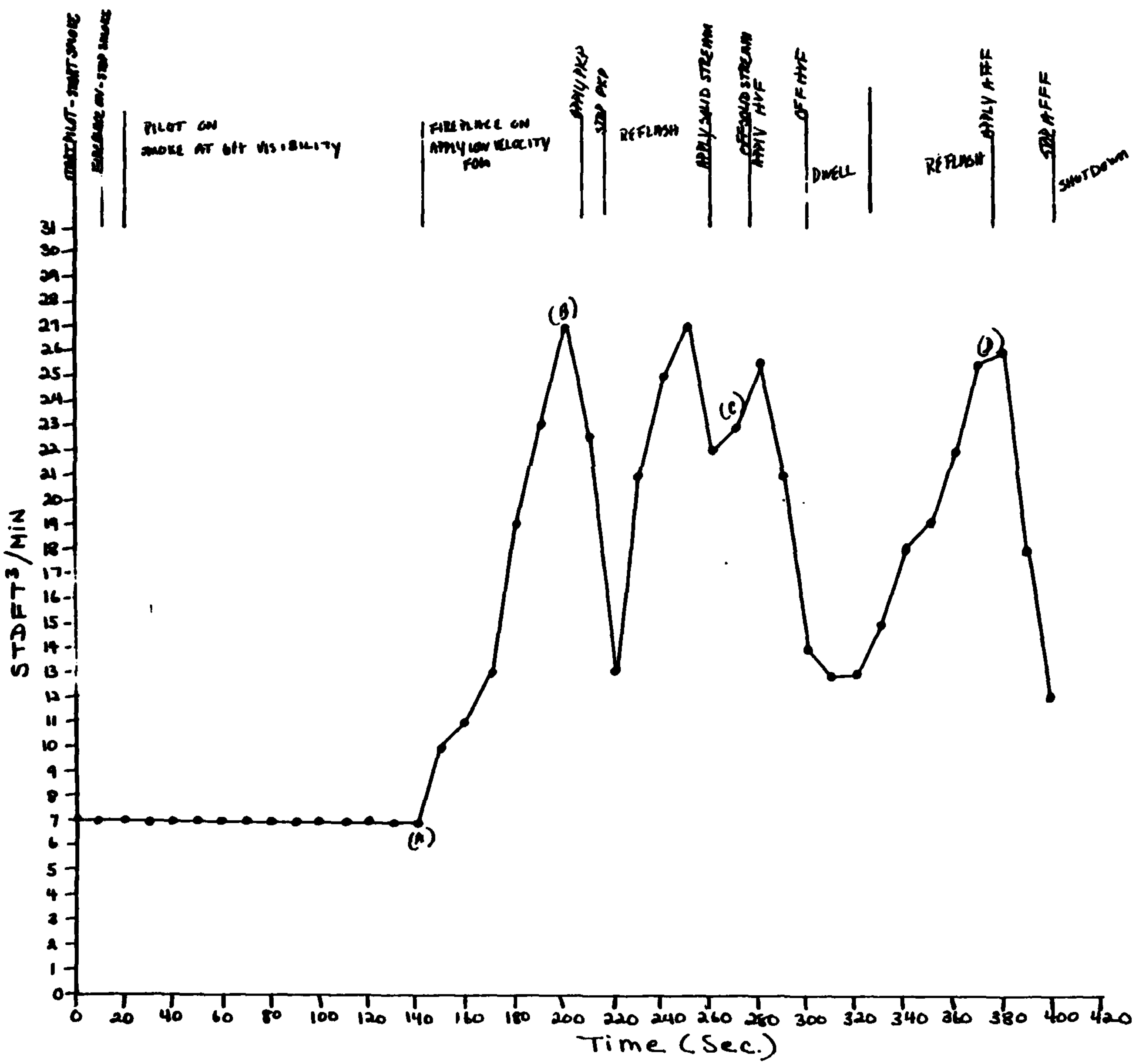
LDQI RUN 4 - GAS FLOW



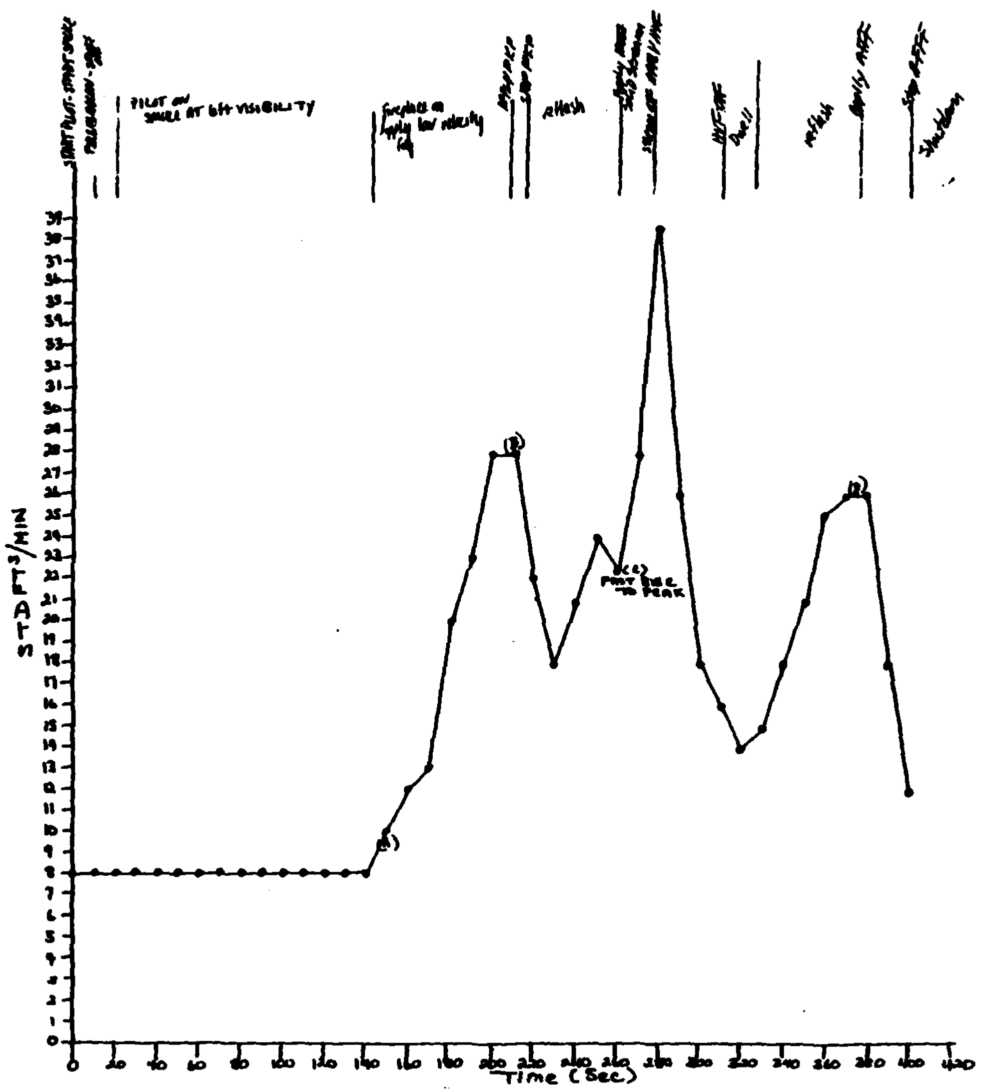
LDQI RUN 5 - GAS FLOW



LDQI RUN 6 - GAS FLOW



LDQI RUN 9 - GAS FLOW



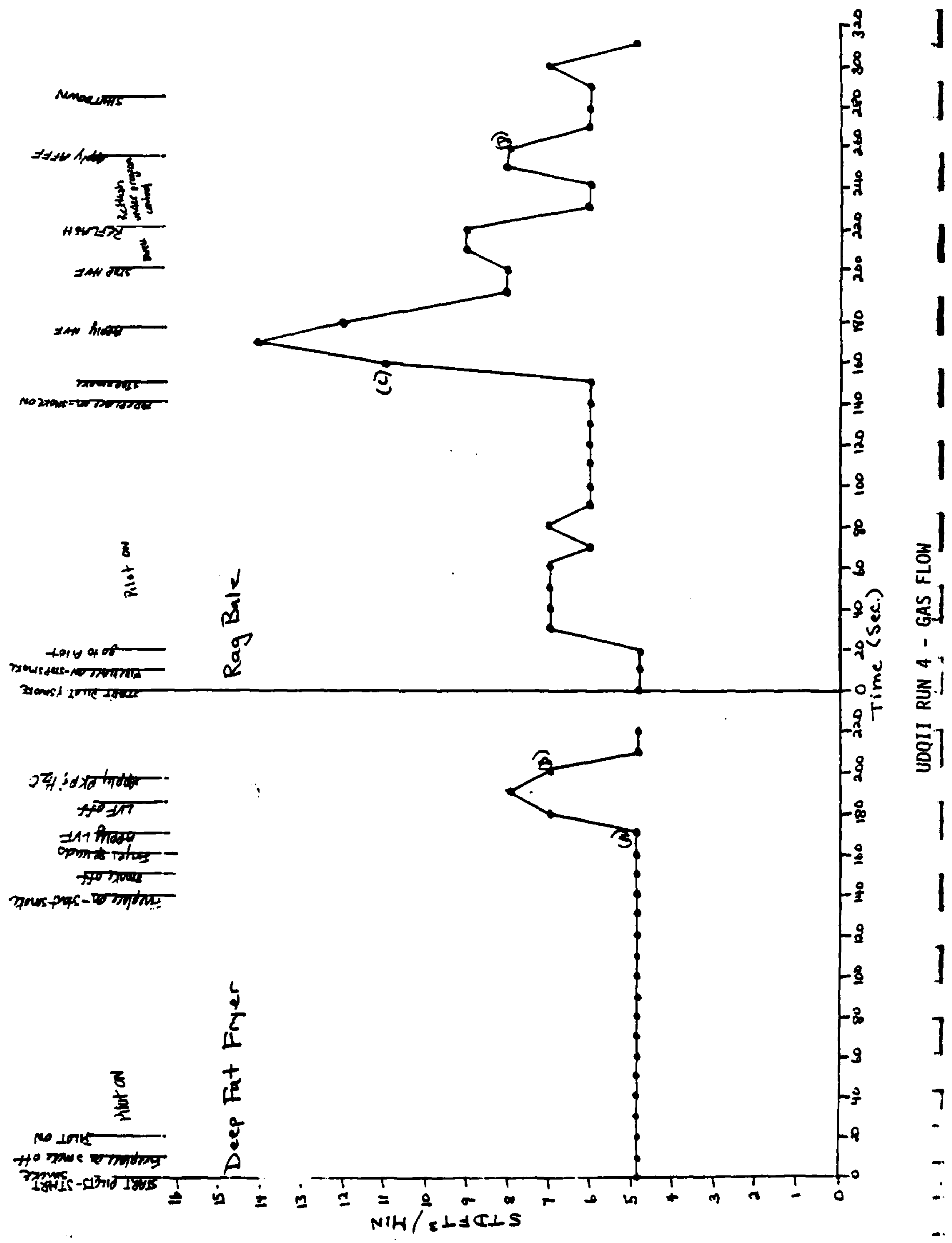
LDQI RUN 10 - GAS FLOW

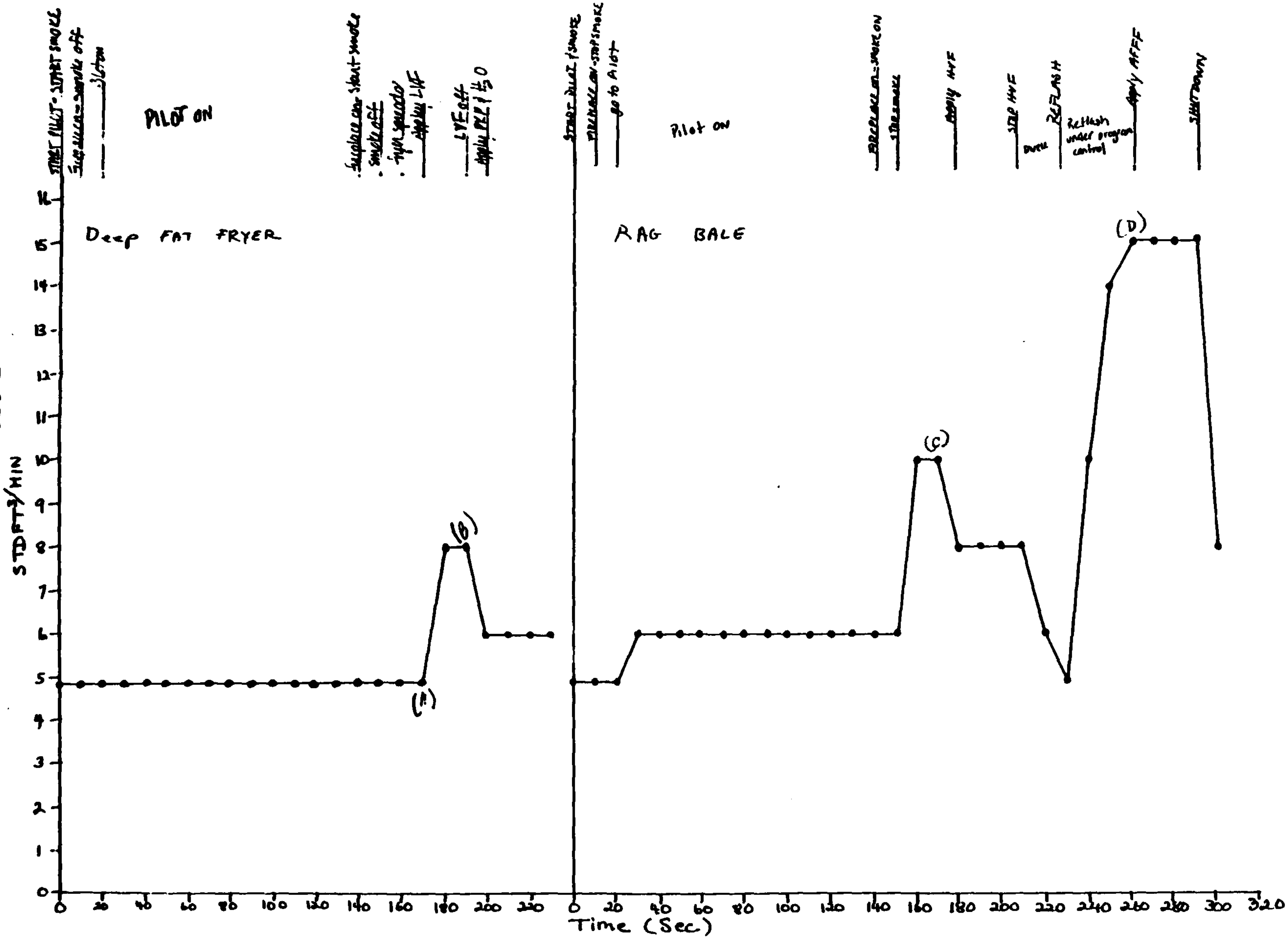
UDQII GAS FLOWS

TABLE F-38. UDQII GAS FLOWS (STD. FT^3/MIN.)

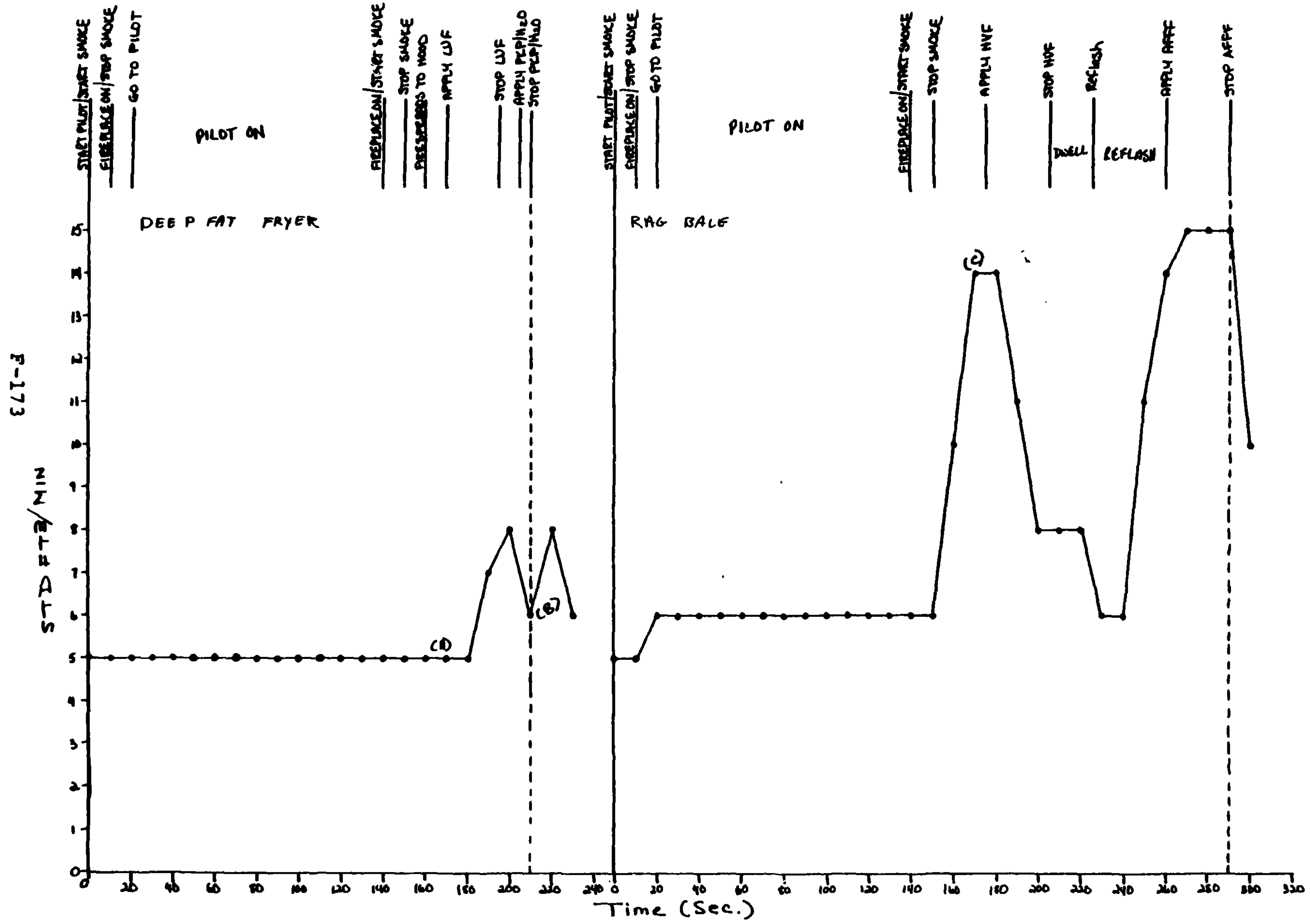
Time/Sec.	Run 1	Run 1(B)	Run 2	Run 2(B)	Run 3[1]	Run 3(B)	Run 4[1]	Run 4(B)	Run 5[1]	Run 5(B)	Run 6[1]	Run 6(B)	Run 7[1]	Run 7(B)	Run 8[1]	Run 8(B)
0	<5	<5	<5	<5	<5	7	<5	<5	<5	<5	<5	<5	6	6	<5	<5
10	<5	<5	<5	<5	<5	7	<5	<5	<5	<5	<5	<5	<5	6	<5	<5
20	<5	<5	<5	<5	<5	7	<5	<5	<5	<5	<5	6	6	6	<5	6
30	<5	<5	<5	<5	<5	<5	<5	7	<5	6	<5	6	6	7	<5	7
40	<5	<5	<5	<5	<5	<5	<5	7	<5	6	<5	6	<5	7	<5	7
50	<5	7	<5	<5	<5	<5	<5	7	<5	6	<5	6	<5	7	<5	7
60	<5	6	<5	<5	<5	<5	<5	7	<5	6	<5	6	<5	7	6	7
70	<5	6	<5	<5	<5	<5	<5	6	<5	6	<5	6	<5	7	6	7
80	<5	6	<5	<5	<5	(End)	<5	7	<5	6	<5	6	<5	7	<5	7
90	<5	7	<5	<5	<5		<5	6	<5	6	<5	6	<5	7	<5	7
100	<5	7	<5	<5	<5		<5	6	<5	6	<5	6	<5	7	<5	7
110	<5	6	<5	<5	<5		<5	6	<5	6	<5	6	<5	7	<5	7
120	<5	7	<5	<5	<5		<5	6	<5	6	<5	6	<5	7	<5	6
130	<5	6	<5	8	<5		<5	6	<5	6	<5	6	<5	7	<5	7
140	7	8	<5	9	<5		<5	6	<5	6	<5	6	<5	7	<5	6
150	8	6	7	8	8		<5	6	<5	6	<5	6	<5	7	6	7
160	8	6	7	8	<5		<5	11	<5	10	<5	10	6	10	5	7
170	10	6	7	8	<5		<5	14	<5	10	<5	14	6	14	8	7
180	<5	6	6	8	<5		7	12	8	8	<5	14	8	15	7	6
190	<5	7	6	8			8	8	8	8	7	11	8	12	8	7
200	7	8	5	6			7	8	6	8	8	8	9	8	7	7
210	6	7	5	6			<5	9	6	8	6	8	7	9	8	7
220	<5	8	5	6			<5	9	6	6	8	8	7	6	7	10
230	<5	7	<5					6	6	<5	6	6		6	7	14
240	<5	7	<5					6	6	10		6		10	5	12
250	<5	10	5					8	<5	14		11		15		8
260	<5	15	5					8	<5	15		14		15		8
270	<5	12	5					6		15		15		14		8
280	<5	7	5					6		15		15		9		6
290	<5	<5	5					6		15		15		8		7
300		<5	5					7		8		10				7
310		<5	<5					<5								7
320		<5	<5													7
330		<5	<5													6
340		<5	<5													7
350		<5	<5													6

[1] "Good" run.

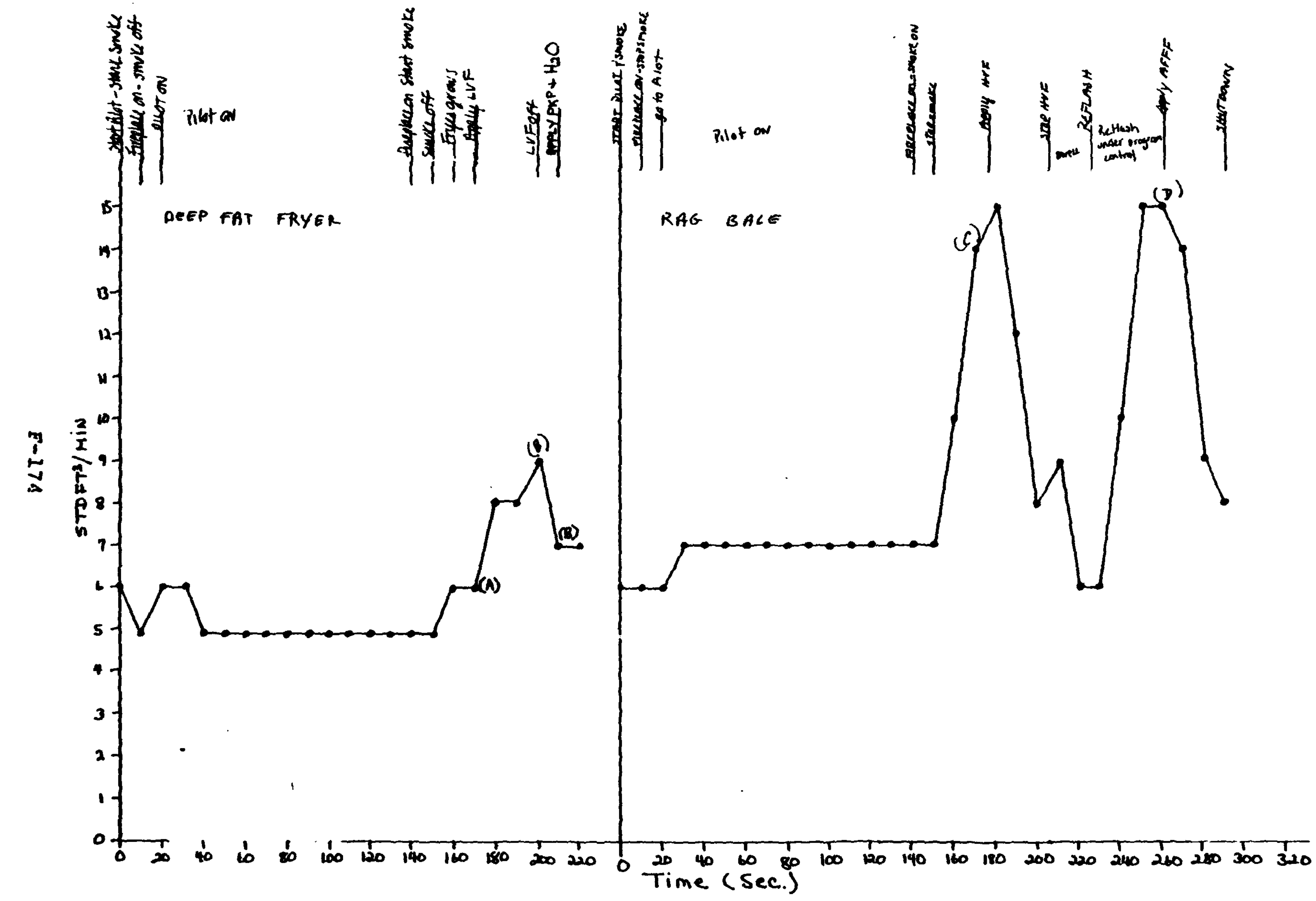

UDOIT RUN 4 - GAS FLOW
Time (Sec.)
STDFT3/MIN
Deep Fat Fryer
Rag Bale
Pilot on
SHUTDOWN
REFLASH



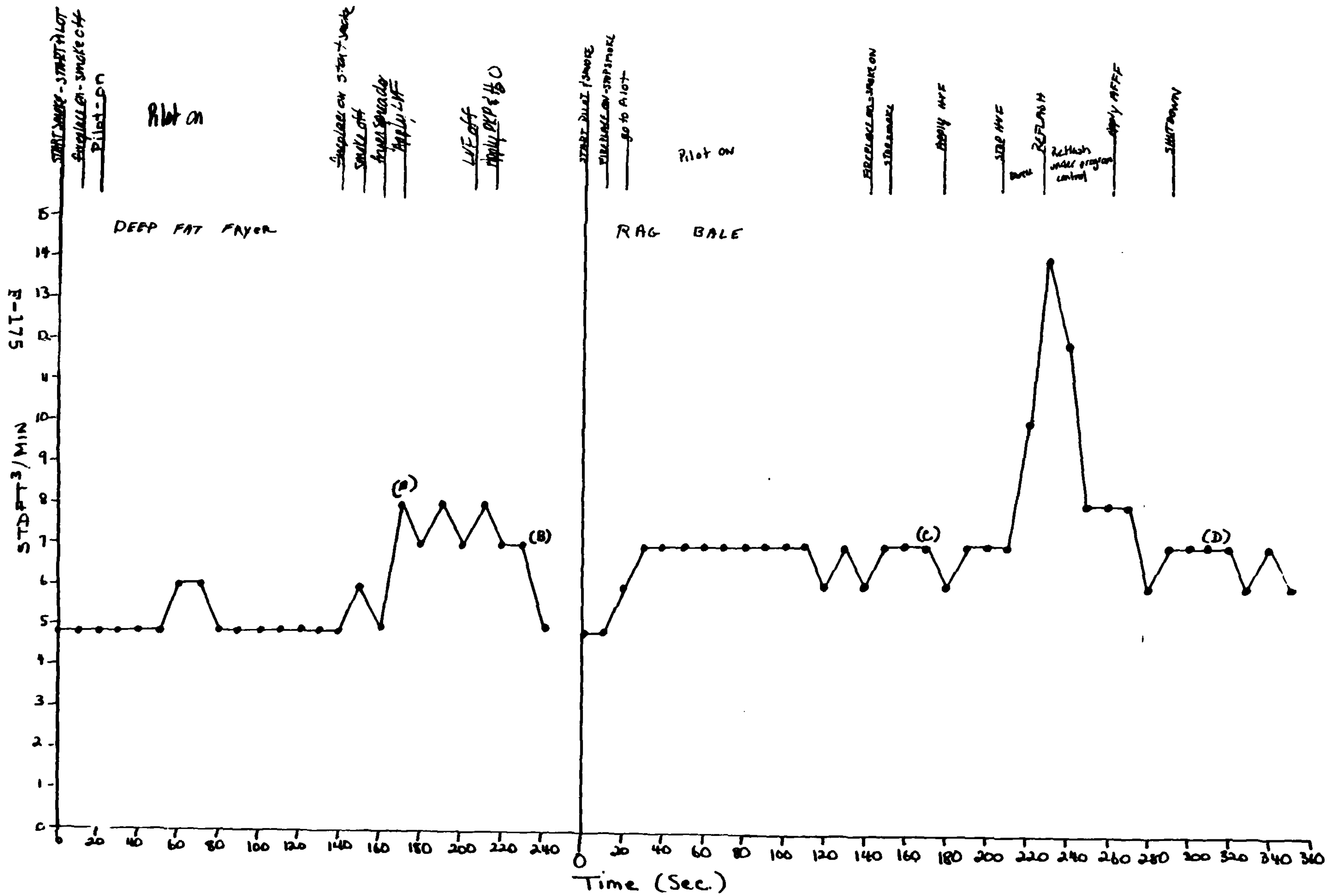
UDQII RUN 5 - GAS FLOW



UDQII RUN 6 · GAS FLOW



UDQII RUN 7 - GAS FLOW



UDQII RUN 8 - GAS FLOW

APPENDIX G

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