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16. Abstract

The gaseous and particulate emissions from 14 cutters and boats in the First Coast Guard District have been measured under typical operating conditions. These measurements were performed on 57 diesel engines and boilers configured as main propulsion units, ship-service generators and hotel-service boilers. The diesel engines varied in size from two-cylinder, naturally aspirated, 35 h.p. units to 3600 h.p. turbo-charged units. The gaseous emission concentrations measured were carbon monoxide, carbon dioxide, total hydrocarbons, and oxides of nitrogen. Particulate emission rates by the gravimetric technique as well as smoke levels were also documented. These measured concentrations were reduced to mass emission notes by appropriate computer programs.

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PREFACE

The work described in this report was directed by the Environmental Measurements Branch of the DOT/Transportation Systems Center under the auspices of the United States Coast Guard, Office of Research and Development, Pollution Prevention Projects Branch, Cdr. W. E. Lehr, Chief and Cdr. R. J. Ketchel, Project Officer.

The contributions of the Coast Guard personnel in the 1st Coast Guard District were invaluable. Special acknowledgement must be made to the Engineering Division of the 1st District, Capt. N. L. Scherer, Chief, and the Boston, Portland, and Woods Hole Groups. Without the efforts of the Commanding Officers and crews of the cutters and boats involved in this program, these measurements could not have been completed. The cooperation and assistance of the Engineering Officers on each cutter was especially appreciated.

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1.0 INTRODUCTION

This report describes the work performed by Scott Research Laboratories, Inc. on Department of Transportation Contract No. DOT-TSC-429. The aim of this program was the documentation of the stack emissions of selected Coast Guard vessels in the 1st Coast Guard District (Boston area). Emission rates of carbon dioxide, carbon monoxide, unburned hydrocarbons, nitrogen oxides, particulates, and sulfur dioxide were measured in order to obtain meaningful emission indices for marine diesel engines and marine boilers. These data are needed to assess the impact of Coast Guard vessels on ambient air quality.

Exhaust-gas analysis equipment was assembled into several modules capable of being hand-carried aboard ship. The modules were located as close as possible to selected sampling points in the exhaust stacks of the cutter being tested. Exhaust emissions from marine diesel engines and marine boilers were sampled during normal operation over the complete range of normal use. Fuel flowmeters were inserted in the engine and boiler fuel lines to measure fuel flow rates.

The data were recorded on strip charts and log sheets. The strip charts were read manually, and the readings were keypunched on cards and converted to concentration data through appropriate computer programs. The concentration data were converted, by means of additional computer programs, to mass emission rates of pounds per hour and pounds per quantity of fuel consumed.

The report is divided into four sections:

Section 2 describes the test fleet and the types of engines tested. Section 3 describes the test equipment and procedures used and the special preparations required for shipboard use. Section 4 describes the data-reduction techniques and calculations performed. Section 5 discusses the data acquired.

This preliminary report illustrates the complexity of the field measurement of emissions from ships under typical operating conditions, and presents the initial results of these measurements. A detailed data analysis will yield more extensive conclusions and recommendations based on these results.

2.0 DESCRIPTION OF TEST VESSELS AND ENGINES

The Coast Guard fleet ranges in size from 378-foot-long cutters to small boats powered by outboard engines. A representative sample of engines and ship sizes was tested, with emphasis on those classes of vessels which consume the most fuel. Table 2-1 lists the test vessels in the order in which measurements were made. The vessel number is used to identify the measurement data presented in later sections. The number associated with the vessel class is the vessel's length overall.

The Coast Guard fleet on which measurements were made consists of patrol craft, work boats, search and rescue craft, and a lightship. The fleet contains diesel-powered cutters which use Navy Distillate fuel and steam-boiler-powered cutters which use Navy Special fuel. Diesel engines tested during this program ranged from 3500 hp main-propulsion units on the 378 foot-class cutters down to 34 hp units which power auxiliary electrical generators.

Most of the cutters tested had two diesel propulsion engines, two auxiliary diesel-powered electrical generators, and two hotel-service boilers. Generally each diesel engine had its own vertical stack, which exhausted above deck level. On the larger vessels, the exhaust stacks were usually clustered in a funnel. The exceptions were the WMEC 210, the WPB 82, and the small boats; these employed horizontal tubes that exhausted at the stern or sides slightly above water level. Cooling water was mixed with exhaust in the tubes on these vessels.

TABLE 2-1 COAST GUARD VESSELS TESTED DURING THE PROGRAM

Vessel No.	Type	Class	Name	Hull No.	Year Built	Description	Home Port	Number Tested		
								Main Engines	Aux. Engines	Boilers (Hotel Service)
1	WYTM	110A	Yankton	72	1943	Harbor Tug, Medium	Portland, ME	2	2	-
2	WLB	180A	Cowslip	277	1942	Buoy Tender, Seagoing	Portland, ME	2	2	1
3	WHEC	327	Campbell	32	1936	High Endurance Cutter	Portland, ME	2*	-	-
4	WMEC	210A	Active	618	1965	Medium Endurance Cutter	Portsmouth, NH	2	2	2
5	WLV	128	Relief	613	1952	Lightship	Boston, MA	-	2	1
6	UTB	40	-	40538	-	Utility Boat	Boston, MA	2	-	-
7	WLM	133	White Heath	545	1942	Buoy Tender, Coastal	Boston, MA	2	1	1
8	WHEC	378	Chase	718	1968	High-Endurance Cutter	Boston, MA	2	2	2
9	WLB	180C	Spar	403	1944	Buoy Tender, Seagoing	Boston, MA	2	2	-
10	WPB	95C	Cape Horn	95322	1958	Patrol Craft, Large	Woods Hole, MA	4	2	-
11	WPB	82D	Point Jackson	82378	1970	Patrol Craft, Small	Woods Hole, MA	2	2	1
12	WYTL	65B	Shackle	65609	1963	Harbor Tug, Small	Portland, ME	1	2	1
13	WMEC	210B	Decisive	629	1967	Medium Endurance Cutter	Portsmouth, NH	2	2	1
14	MLB	44	-	44318	1953	Motor Lifeboat	Scituate, MA	2	-	-

*Oil-fired steam turbine.

3.0 TEST EQUIPMENT AND PROCEDURES

The test equipment for exhaust-gas and particulate analysis and smoke measurement was assembled into several modules fitted with carrying handles. Figure 3-1 illustrates the equipment as used aboard the Cutter Yankton. Due to unique problems aboard each ship, the modules sometimes had to be reconfigured. The test equipment was moved from ship to ship during the course of the test program. Almost all handling involved hand carrying the equipment through narrow passageways and up and down steep ladders and stairs. When available, shore based cranes were used to transfer the equipment and the high pressure cylinders containing calibration standards from the pier to the cutter deck.

The gas analysis instrumentation consisted of an MSA Model 300 NDIR analyzer for carbon dioxide (CO_2), a Beckman Model 315 NDIR analyzer for carbon monoxide (CO), a Scott Model 125 chemiluminescence analyzer and thermal converter for nitric oxide and oxides of nitrogen (NO and NO_x), and a Scott Model 215 total hydrocarbon (THC) analyzer which incorporates a heated flame ionization detector. The gas analysis system utilized a heated sample line and heated prefilter.

The particulate analysis system was a specially modified sampling train built according to EPA stack-sampling specifications. A short, heated probe had to be fabricated for use in the diesel stacks, which are smaller in diameter than the industrial stacks normally sampled with this type of equipment.

An EPA-specified sampling train and heated glass probe were used to measure SO_2 concentrations by the barium perchlorate-thorin titration method.

Smoke level was measured with a Von Brand smokemeter.

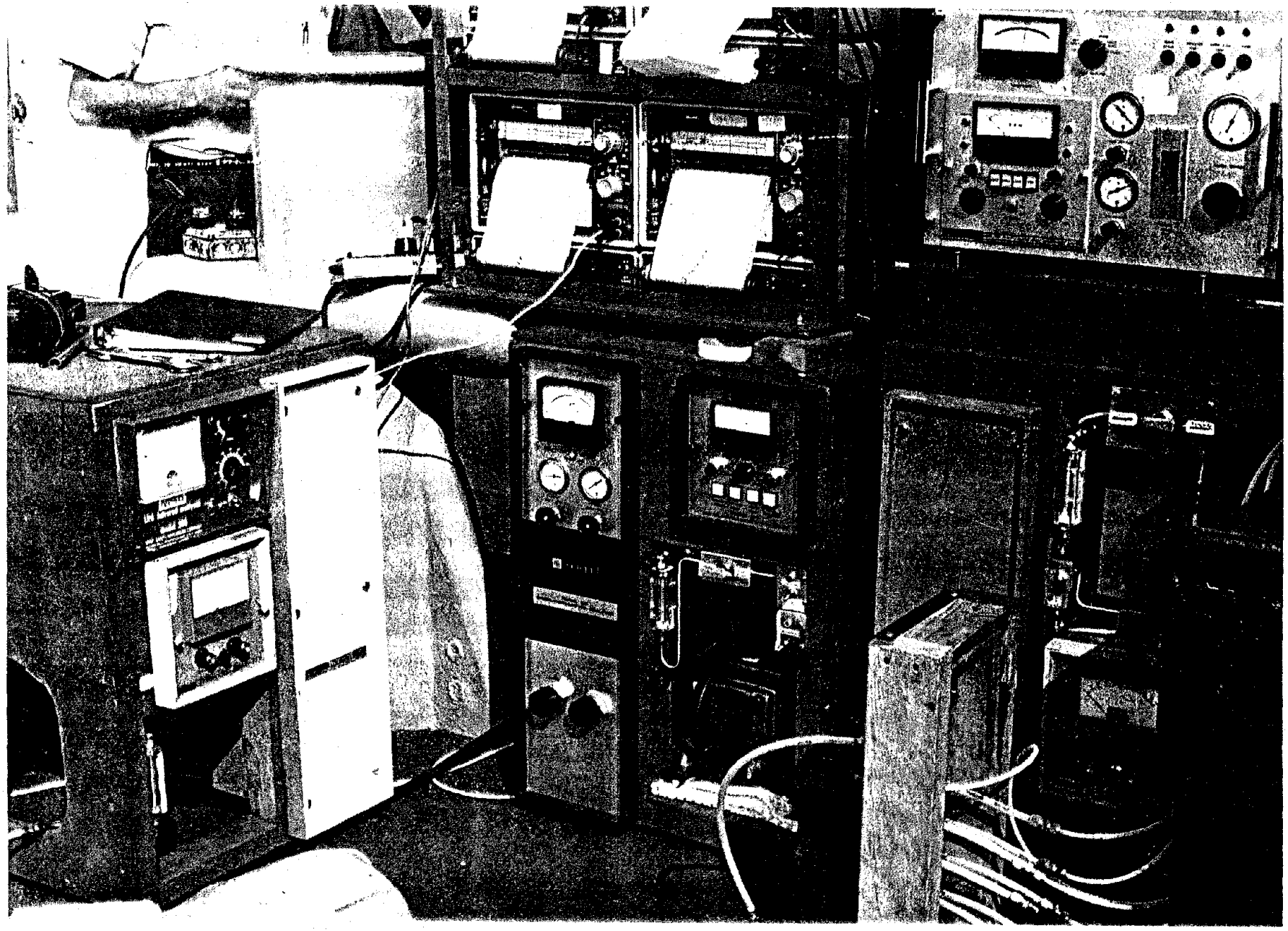

Figure 3—1 ANALYSIS EQUIPMENT ABOARD THE CUTTER YANKTON

3.1 DESCRIPTION OF SAMPLING AND ANALYTICAL EQUIPMENT

3.1.1 Gas Analysis System

A flow schematic of the gas analysis system is shown in Figure 3-2. Stainless steel and Teflon plumbing was used throughout the sampling system. Stainless steel valves and fittings controlled the flow path and rate of both the sample gas and calibration gases. Sample conditioning was performed by a particulate filter and a two-coil refrigerator which removed water vapor from the sample before it entered the CO_2, CO, and NO analyzers. Heated sample lines carried the gas sample to the hydrocarbon analyzer and the NO_x thermal converter.

A heated prefilter and a heated stainless steel pump were mounted on a wooden rack which also contained an autotransformer to control the voltage to the pump heaters. This prefilter module, located close to the exhaust sample probe, removed particulate matter from the gas sample and drove the sample through the analyzers at a pressure above ambient so as to eliminate the possibility of ambient air leaking into the system.

Zero and span gases were admitted to the analyzers at the heated prefilter through a remotely controlled selector valve and a patch panel at the operator's position. In this procedure, the calibration gases pass through the system just as an exhaust sample does. This technique allow for quick diagnosis of such sampling-line problems as leaks or hydrocarbon hangup.

The gas analyzers were assembled into three modules. The analyzers which require heated lines were grouped into the first module. This module contained the Scott Model 215 heated hydrocarbon analyzer, and the thermal converter associated with the Scott Model 125 chemiluminescence NO analyzer. It also contained the two-coil refrigerator to remove water vapor, which would interfere with the NDIR analysis of CO and CO_2, and could contaminate the gas detectors through condensation. Initially, the first module also contained a Beckman Model 255A NDUV analyzer for nitrogen dioxide (NO_2). It was to be used as a cross-check on the thermal conversion technique of

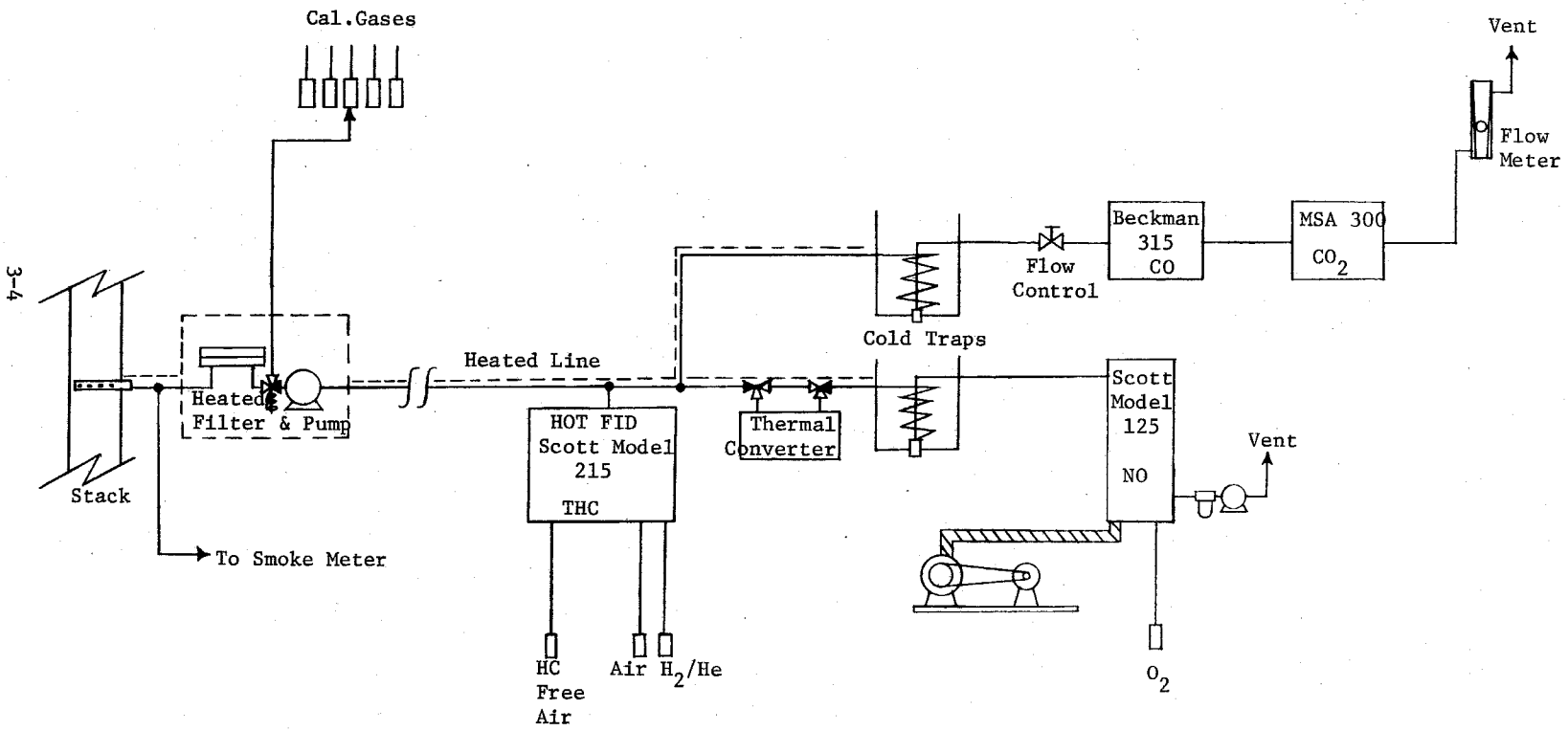

FIGURE 3-2 FLOW SCHEMATIC OF EXHAUST GAS ANALYSIS SYSTEM

determining NO_x level. However, the NDUV instrument was extremely sensitive to the severe operating conditions aboard Coast Guard cutters, and it required almost constant adjustment to overcome the effects of temperature, vibration, and changes in sampling conditions. Because of these difficulties with the NDUV analyzer, and the success of the thermal-converter chemiluminescence technique, the NDUV instrument was removed early in the test program.

A second module contained the CO and CO_2 analyzers. A Beckman Model 315 NDIR analyzer was used for carbon monoxide and the MSA Model 300 NDIR analyzer for carbon dioxide. The third module contained the chemiluminescence analyzer for nitric oxide and total oxides of nitrogen. Each of the three modules contained sample flowmeter and flow-control valves to monitor the sample flow through the analyzers in that module. Selector valves allowed the introduction of zero and span gases to calibrate the instruments. The electrical output signals from the instruments were recorded on five Esterline-Angus strip-chart recorders that were mounted in an aluminum rack.

3.1.2 Particulate-Sampling System

The equipment used for particulate analyses conformed to the Environmental Protection Agency specification for stack sampling of stationary sources as published in the Federal Register, Volume 36, No. 247, December 23, 1971. The particulate-sampling train, which is shown schematically in Figure 3-3, corresponds to the system specified in Method 5 of the above reference.

The sampling train consists of a heated probe which conducts the sample to a heated filter where the particulate is collected. The sample gas then passes through a train of glass impingers packed in ice where water is removed, and then through a pump, dry-test meter, and a calibrated orifice which is used to set the system flow rate so that the inlet flow velocity at the sampling nozzle is equal to the stack velocity at the sampling point (isokinetic sampling).

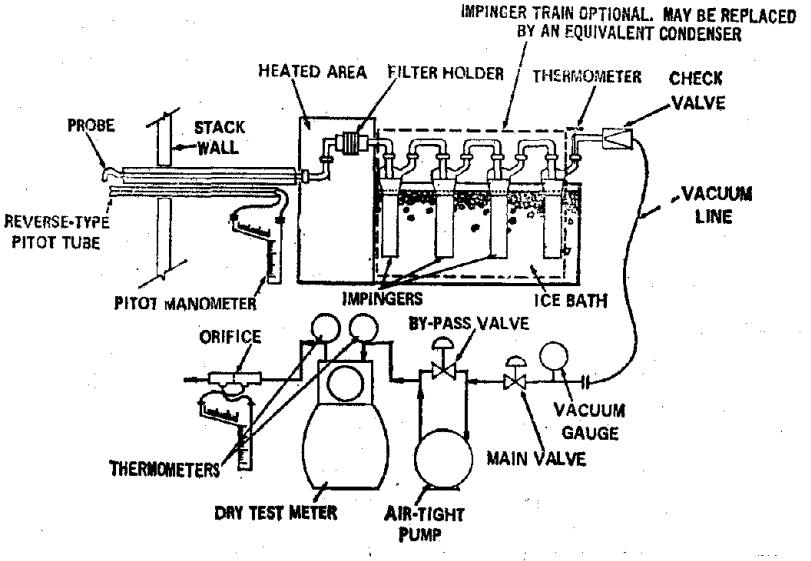

FIGURE 3-3 PARTICULATE SAMPLING TRAIN

The special short heated probe fabricated for use in the diesel stacks made the sampling apparatus compact, a necessity in shipboard use. Tight spaces around shipboard diesel stacks sometimes made it impossible to locate the filter and water inpinger train at the end of the sample probe. When this problem arose, the filter holder was clamped to the probe, wrapped with heating tape and covered with insulation. The outlet of the filter holder and the inlet to the remotely located impinger train were connected by flexible tubing.

3.1.3 Smokemeter

Particulate density in the exhaust stack was measured with a Von Brand portable smokemeter. This instrument is basically the same as the smokemeter specified in the proposed EPA standards for aircraft gas-turbine exhaust, which were published in the Federal Register, Volume 36, No. 238, December 12, 1972.

The Von Brand smokemeter samples particulate matter on a continuous filter-paper tape for subsequent photoelectric comparison. The exhaust is sampled at a uniform rate by means of a pump which pulls the exhaust through the continuously progressing filter paper tape. The trace on the paper tape is a time history of the smoke densities in the exhaust stack. An impinger train removed liquid water from the sample gas and a heated sampling head prevented condensation on the filter paper tape.

3.1.4 Fuel Flowmeters

Fuel flowmeters were obtained by the Department of Transportation from the U.S. Navy. These meters were of the positive-displacement type like domestic water meters. The amount of fuel which has passed through the meter during a given period is determined by reading the dial at the beginning and end of the period. Meters were selected according to the size of the engine; they were installed by the DOT and Coast Guard personnel.

These meters measure the volume of whatever fluid passes through them. Some problems were encountered with air leaking into the fuel systems upstream of the fuel meter causing erroneous fuel flow-readings. The most frequent source of leaks was the fuel filter.

3.2 GENERAL TEST PROCEDURES

Engine test procedures were modified as necessary to fit the situation; the basic approach was similar for all cutters, however. The definition of the test procedure for an individual cutter began with a visit by the sampling team and DOT representatives to the cutter. During a meeting with the cutter's captain and engineering officer, the cutter's normal engine settings and generator and boiler loads were determined. The sailing plan for the test period was discussed and the exhaust sampling scheduled so that it would interfere with the sailing plan as little as possible. The locations for sampling ports were then selected on the basis of accessibility. Existing sample ports, if adequate in size, were used where possible. Any other ports needed were cut by the ship's engineering officer. The fuelmeters were supplied by DOT to the cutter for installation before the test period.

3.2.1 Location of Analysis Equipment Aboard Ship

The equipment was loaded aboard the cutter a day or two in advance of the sailing date. The analyzers were arranged according to the space available.

The analysis equipment was located as close as possible to the stacks. A location on decks higher than the engine deck was preferred because of temperature and vibration considerations. (This also minimized direct interference with the normal engine-room functions.) The sampling points were in the vertical run of diesel exhaust stacks. The module containing the heated analyzers was put closest to the stacks. A 20-foot heated flexible sample line connected this hot module to the exhaust probe. With this line, all exhaust sampling points could be reached from one central equipment location. The gas-analysis modules were grouped so as to be within easy reach of a single operator. The particulate-sampling equipment was positioned on temporary tables or shelving so that the heated probe could be inserted into the stack sampling point with ease.

The Von Brand smokemeter was normally located on the deck close to the stack being sampled. A "T" connector at the sample probe made it possible to measure smoke at the same time that the exhaust gas was being analyzed.

Calibration and auxiliary high-pressure gas cylinders were usually located on the open deck, chained either with load binders to the rail or the superstructure. A network of ¼-inch diameter nylon and Teflon tubes, approximately 30 feet long, transferred the calibration and operating gases from the cylinders to the exhaust-analysis equipment.

3.2.2 Power Settings During Tests

Main engines were tested under a range of loads typical of their normal operation. Generally the engines were loaded to speed regimes of idle, 1/3 ahead, standard, and full speed. On most cutters the electrical requirement to operate the ship when it is underway can be met by one generator. Special activities, such as buoy handling or winch operation require the combined capacity of both generators. The generators are not usually operated under more than half load. On the larger cutters, which have versatile electrical control panels, the ship's electrical load can be split between the two generators. On these ships the generator undergoing emission measurements could be loaded over its entire operating range. On smaller cutters which lacked this capability, only a limited operating range was possible, and on some cutters emissions measurements could be made only at "normal" load. In general, we attempted to document the emissions from diesel-powered generators at no load, 1/4, 1/2, 3/4 and full load.

Some auxiliary diesels drive more than one generator; in the diesel-electric buoy tenders and tugs, each auxiliary diesel runs three generators: one ac generator for ship's service, one dc generator which supplies field excitation to the main propulsion motor, and another dc generator which powers the electrical steering system. On some cutters tested, the output of the dc generators was not monitored; it was thus impossible to record the actual load on the auxiliary diesel under test. In many cases the ac load provided the only indication of generator output.

3.2.3 Sampling Schedule

The gas-sampling probe was connected to the first stack to be sampled. Sampling was begun when engine steady-state conditions were reached. In cutters having more than one main engine, particulate analysis was done on one engine while gas and smoke were simultaneously analyzed on another main engine. Cutters are operated at steady power settings for long periods of time when cruising from point to point; almost no speed changes are made once the cutter is clear of the harbor except during periods of reduced visibility or when manuevering to avoid other shipping. Where possible, more than one measurement of gas concentrations and smoke levels was made. In testing main power plants, the operating parameters of engine rpm, propeller pitch, propeller-shaft rpm, engine temperature, fuel pressure, fuel temperature, and engine load or hp were recorded when known. The time of day and the cutter speed or bell signal were recorded to identify the operating conditions.

When diesel generator sets were tested, the generator electrical load was recorded, in addition, when available. Auxiliary generator installations had as many as three generators driven by one diesel engine. The main output of the ac generator was instrumented but the outputs of the other generators were not, so that only a part of the load could be determined.

Before and after each day's measurements the wet and dry-bulb temperatures and barometric pressure were measured and logged.

In testing boilers, the steam pressure, water exit temperature, and draft were recorded in addition to the fuel pressure and operating mode.

The total engine or boiler time, time since major overhaul, model number, serial number, and rated output were obtained from the main-power-plant, auxiliary-generator, and boiler log books and recorded.

3.2.4 Particulate Analysis Procedure

After the gas and smoke analyses had been made, the gas-sampling probe was removed and particulate analysis was performed.

First, the stack gas velocity and temperature were measured by traversing the stack with a type-S pitot tube and a thermocouple. The oil-filled manometer was aligned fore and aft so as to be affected only by the ship's pitching motion, which was generally much less than its rolling motion. The excursions were noted and an average value used for the manometer reading.

The stack-gas velcoity was calculated from the velocity-pressure profile and the gas density. A sampling nozzle was then chosen which would permit isokinetic sampling at the nozzle inlet within the flow capability of the sample pump. The system sampling rate was adjusted to the isokinetic value by maintaining the pressure drop across a reference orifice at a predetermined value. In the large stacks such as those on the cutter Cambell, several traverse points were used. The stack cross-sectional area was divided into a number of equal rectangular areas, and the traverse points were located at the centers of these areas. In the smaller diesel stacks, one sampling point in the center of the stack was used. Electrical heaters kept the temperature of the probe and filter holder assembly above the stack-gas dew point.

A sample adequate for weighing could be collected in one hour. After the sample had been collected, the filter was removed from the holder and sealed in a plastic container. The water extracted from the sample was measured in a graduated flask. The probe assembly, filter holder, and all glassware between the probe nozzle and filter holder were rinsed with acetone, which was collected in a jar and sealed. (A significant quantity of particulates are deposited on the interior walls of the sampling apparatus and must be collected by this technique.) All containers were labeled with a test code-number, the date, the name of the cutter, the engine being tested, and the engine operating mode.

The filters and probe washings were subsequently dried and weighed at Scott's Plumsteadville Laboratory. The filter and loose particulate matter collected were transferred from the sealed container to a tared glass weighing dish, desiccated, and weighed to the nearest 0.5 mg.

The acetone washings were transferred to a tared beaker and evaporated to dryness in a laboratory hood, then desiccated and weighed to the nearest 0.5 mg. The pre-weighed silica gel was also weighed to determine its water uptake.

3.2.5 Sulfur Dioxide Analysis

The cutter Campbell, the only steam-turbine-driven cutter tested, used Navy Special fuel which contains a significant percentage of sulfur. The concentration of sulfur dioxide in the exhaust was measured using the EPA standard procedure for stationary sources described as Method 6 in Volume 36, No. 247 of the Federal Register, published December 23, 1971. In this method a gas sample was extracted from the sampling point in the stack. The acid mist, including sulfur trioxide, was separated from the sulfur dioxide. The sulfur dioxide was then measured by the barium perchlorate-thorin titration method.

The apparatus consisted of a heated Pyrex glass probe inserted into the stack, which was connected to a train composed of a midget bubbler and three midget impingers. The midget bubbler contained 15 ml. of 80% isopropanol solution. This removed the SO_3 and sulfuric-acid mist. The first two midget impingers each contained 15 ml. of 3% hydrogen peroxide; the third impinger was empty. The exhaust end of the final impinger was connected to a pump and a wet-test meter. A pitot tube and manometer were used to measure the stack velocity. The sampling rate through the SO_2 train was set to be proportional to the stack velocity. The samples collected in the three midget impingers were transferred to a storage container and diluted with deionized water.

The contents of the midget impingers were transferred to Scott's Plumsteadville Laboratory, where they were diluted to a total volume of 50 ml. A 10-ml. aliquot of each sample was taken, 40 ml. of isopropanol and a few drops of thorin indicator were added, and the resulting solution was titrated with 0.01 N barium perchlorate to a pink endpoint.

3.2.6 Fuel-Flow-Rate Measurement

Fuel-flowmeters were inserted in the fuel lines of all engines under test, and were read at regular intervals by the DOT/TSC representative. The interval used varied between 10 minutes and 30 minutes. The fuel flow during the interval was obtained by subtracting the value observed at the beginning of the interval from the value observed at the end of the interval.

3.2.7 Fuel Analysis

One-pint fuel samples were collected from the fuel tank in use aboard each cutter during testing and submitted to a commercial laboratory for analysis. The carbon, hydrogen, water, sulfur, and ash content were determined by ASTM methods. Carbon and hydrogen content were determined by combustion of an aliquot in a furnace in the presence of catalysts. The resulting carbon dioxide was absorbed in Ascarite and the uptake determined by weighing. The resulting water was absorbed in magnesium perchlorate and its quantity determined by weight. The measured water and CO_2 quantities were used to calculate the initial hydrogen and carbon contents of the fuel sample. The sulfur content of the fuel was determined by combustion of a fuel sample in a bomb and precipitation of bomb washings with barium chloride. Ash was determined by the residual weight left from a fuel sample burned in a dish. Water was determined by distillation. The percentages by mass of the above constituents were then calculated for each fuel sample.

3.3 TEST PROCEDURES FOR SPECIFIC SHIPS

Each ship required different modifications to the procedures to obtain the desired emission data, because of differences in engine and stack configuration, power availability, and type of operation during which the measurements were to be made. Relevant notes on each ship are presented below.

3.3.1 Test Vessel No. 1 - Cutter Yankton

The emission analysis equipment was located on the open deck of the Yankton. The gaseous emissions of the ship-service generator were

measured while the ship was tied to the pier. Main-engine gaseous emissions were measured during a short harbor cruise. An attempt to measure particulate emissions was cut short when fuses blew in the cutter's electrical distribution panel. (The system had worked without difficulty during a full-dress rehearsal before the harbor cruise.) Only about a half load could be put on the generators because of this cutter's restricted electrical control panel.

3.3.2 Test Vessel No. 2 - Cutter Cowslip

The analysis equipment was located on the emergency generator deck just above the engine room. The Cowslip sailed on a tightly scheduled three-day mission of buoy work and lighthouse refueling in the vicinity of Rockland, Maine. Gaseous-emission measurements were made while underway on both main propulsion engines at idle, slow-cruise, and cruise power settings. (When lighthouses are being refueled, the buoy tender's main engines are operated at idle for four hours or more. Thick fog on the third day presented an opportunity to sample a slow-cruise mode.) The Cowslip's main engines would not operate properly with the fuel flowmeters installed in the fuel-return line, and the meters had to be removed at sea on the first day. A ship-service-generator repair occupied the crew on the first night in Rockland, but on the second night the fuel return lines were modified to allow us to collect and weigh the quantity of fuel being returned from each main engine at slow-cruise and cruise power settings. Emissions from the Cowslip's two ship-service generators and one steam generator were measured at normal loads while underway.

3.3.3 Test Vessel No. 3 - Cutter Campbell

Emissions from the cutter Campbell were measured during a three-day trip from Portland, Maine to Baltimore, Maryland where the Campbell entered the Coast Guard Yard for overhaul, and during the stopover at the Prudence Island, Rhode Island Naval Ordnance Depot. The Campbell is powered by oil-fired boilers and steam turbines. Gas-analysis equipment was placed in the machine-shop area just aft of the blower room through which the boiler stacks pass. Four evenly spaced ports were provided in each stack for sampling. The ports were located on a horizontal line midway between the floor and the inverted Y where the two stacks join

before entering the funnel. Emission measurements were made at standard speed and full speed while the ship was underway, and at a mode corresponding to station-keeping on an ocean patrol while the ship was off-loading ammunition onto the pier at Prudence Island.

3.3.4 Vessel No. 4 - Cutter Active

Emissions from the main diesel engines on the Active were measured during a dependents' cruise, an annual outing for the crew's families. Very thick fog dampened the holiday spirit and also limited the time during which the ship could be operated at high cruise speeds.

The Active has a water-cooled exhaust system. Dual exhaust tubes, 25 inches in diameter, carry exhaust horizontally through the ship to the stern, where the exhaust gases are vented just above water level. Eleven water-spray nozzles, located along the length of the exhaust tube, spray sea water into the exhaust gases to cool them. Exhaust stacks from one main diesel, one main-propulsion gas turbine, and one ship-service generator are connected into each exhaust tube in the engine-room area. Upstream of the connection point, butterfly valves in each exhaust stack can be closed to prevent sea water from going upstream and reaching an inoperative engine.

The exhaust was sampled just downstream of the manifolding point in each exhaust tube and at a point in the after steerage area downstream of the last water-spray nozzle. Only main propulsion diesel engine exhaust was measured during this one-day cruise. When the port main engine was being sampled, the ship's electrical power was provided by the starboard generator and the butterfly exhaust valve on the port generator was closed. For sampling the starboard engine, the procedure was reversed. First both generators were activated, then the electrical load was shifted to the port generator, and the starboard generator was secured and its butterfly valve closed. This insured that only exhaust from the propulsion engines would be sampled.

An unheated Teflon line was used to convey the exhaust sample from the after steerage area up to the engine room where the analysis equipment was located. The exahust-gas temperature at the aft sampling

points was approximately 100°F. As a check, the heated hydrocarbon detector was operated in the after steerage area and the cooled exhaust gases were sampled both with and without a heated sample line. No difference in hydrocarbon concentration was noted, which indicated that the condensible hydrocarbon had already been removed by the water, and unheated sample line could be used without biasing the data.

Measurements of gaseous emissions, smoke density, and particulate loading were made on both main diesel engines at two sampling locations while underway. Generators and boilers were measured the following day at dockside.

3.3.5 Vessel No. 5 - Cutter Relief

Since the cutter Relief uses its main engine sparingly going to and from light station, emission measurements on this ship were limited to the ship-service generators and hotel-service boilers. The measurements were made while the Relief was tied to the pier in Boston.

Fluctuating load levels on the generators complicated the data reduction. The data points used in the analysis were taken from times where five-minute equilibrated levels were available.

The heated FID, sample refrigerator, NO_x converter, and smokemeter were located on deck just above the engine room. After passing through these the dried gas sample was directed up to the gas analyzers which were located on the pier.

3.3.6 Vessel No. 6 - 40-Ft. Boat 40538

Due to a lack of shipboard power and space, the emissions from the 40-foot boat were measured while the boat was tied stern-on to the pier. Analysis equipment was located on the pier. An exhaust probe was inserted approximately two feet up the exhaust pipe and held in place about one inch from the top of the exhaust pipe. Measurements were made at three power settings on each engine with the propellers engaged. Full power cannot be achieved with a stationary boat since the propeller is inefficient in this condition; only 1000 rpm could be attained on the engines although they were rated at 2000 rpm.

3.3.7 Vessel No. 7 - Cutter White Heath

The cutter White Heath was tested during a three-day buoy-tending and lighthouse-refueling mission in the Massachusetts Bay area. The analysis equipment was located on the open deck with the exception of the hot FID, smokemeter, NO_x converter, and the sample refrigerator which were located in the engine room. Particulate analysis could not be performed because the particulate sampling port had not yet been cut in the main-engine exhaust stacks. Emissions from ship-service generators and hotel-service boilers were also measured while the ship was underway. A readout of electrical load was not available.

3.3.8 Vessel No. 8 - Cutter Chase

The Chase was first available for sampling two days before and during its annual dependents' cruise. A major mechanical problem prevented operation of the port main diesel engine. The starboard main-engine data listed as measured during test 02 therefore represents the emissions obtained while the vessel was powered by only that engine. Emissions from the generators and boilers were measured during this first set of tests.

The emissions from the cutter Chase's main diesel engines were measured a second time during a three-day cruise to Norfolk, Va. from Boston, Mass. Particulate emissions analyses were made at slow, standard and full speed on the main diesel engines and 30% load on one generator. Gas analyses were performed at one-third, two-thirds, standard, and full speed on both engines, and also at flank speed on the port engine. The instruments were located on the engine deck and in the main mess, one deck above the engine control room. The heated hydrocarbon analyzer, NO_x converter, refrigerator, smokemeter, and particulate train were on the engine deck. The carbon monoxide, carbon dioxide, and nitric oxide analyzers were located on the upper deck along with the calibration-gas cylinders.

3.3.9 Vessel No. 9 - Cutter Spar

Emissions from the cutter Spar were measured during a three-day cruise of buoy tending and lighthouse maintenance. The equipment locations and sampling procedure were similar to those used earlier on the cutter Cowslip, except that particulate measurements were added.

3.3.10 Vessel No. 10 - Cutter Cape Horn

The cutter Cape Horn has four main diesel engines. The exhaust stacks from the main diesels, two diesel-powered generators, and the boiler are exhausted through a single funnel. The gas analysis equipment was located on deck near the funnel. Exhaust gas concentrations were measured by lowering a probe into the stacks. Particulate loading was measured on the aft port main diesel running at cruise power. The person operating the particulate probe positioned himself inside the funnel. The particulate sampling port was located 39 inches below the stack mouth. The Cape Horn left Woods Hole, Massachusetts at dawn, passed through the Cape Cod Canal and arrived at Provincetown, Massachusetts at about noon the same day. Emission measurements on the two diesel generators and the boiler were made while the cutter was tied up to the pier at Provincetown.

3.3.11 Vessel No. 11 - Cutter Point Jackson

The Point Jackson has a water-cooled exhaust system for its main engines and ship-service generators. Measurements were made on the main engines at sample points upstream and downstream of the cooling water spray. In the data printouts, M1 and M3 indicate the data obtained from the starboard engine at the forward and aft sampling ports, respectively. M2 and M4 similarly refer to data from the forward and aft ports on the port engine.

3.3.12 Vessel No. 12 - Cutter Shackle

The analysis equipment was located on deck and measurements were made by lowering a sample probe into the exhaust stacks. Emissions from the auxiliary engines and the boiler were sampled under normal loads.

3.3.13 Vessel No. 13 - Cutter Decisive

The exhaust emissions from the cutter Decisive were measured during a two-day cruise from Portsmouth, New Hampshire to Newport, Rhode Island. As in the Active, exhaust from the main diesels and ship-service generators is ducted through tubes to the stern. Cooling water-spray nozzles along the length of the tubes decrease the exhaust temperature. Emissions from the main diesel and ship-service generators were measured at sampling points in the exhaust tubes both upstream and downstream of the water spray. Particulate emissions were measured at the forward sampling point on the port main engine at two thirds and full speed. Gaseous emissions and smoke were

measured at one-third, two-thirds, and full speed from both engines, and from both upstream and downstream sampling ports. Ship-service generator emissions were documented over a range of loads, and emissions from one hotel-service boiler were measured.

3.3.14 Vessel No. 14 - 44 Ft. Boat MLB 44318

The 44-foot motor lifeboat is used by the Coast Guard for search and rescue work under heavy sea conditions. Electrical power for the instrumentation was provided by two gasoline-engine-driven ac electrical generators. The instruments were located in the forward main cabin and in the aft survivor's cabin. The calibration-gas cylinders were lashed down to the boat pier. A tubing bundle, approximately 30 feet long, was connected to individual cylinders at one end and to a patch panel at the other end. When calibrations were to be performed, the boat was brought alongside the pier, the patch panel put aboard, and the calibration performed by connecting the gas-analysis system to the patch panel and selecting the appropriate calibration gases. Three "B"-size gas cylinders were carried aboard the boat and lashed to a stanchion at the helmsman's position. These were oxygen for the chemiluminescence analyzer, hydrogen/helium for the total-hydrocarbon (THC) analyzer, and hydrocarbon-free air which served both as combustion air and zero gas for the total-hydrocarbon analyzer.

A heated sample line carried the prefiltered exhaust sample from the exhaust-sample probe in the engine room up to the heated THC analyzer and the NO_x converter in the forward cabin. The sample was then passed through a refrigerated coil to remove the water vapor. The sample was then carried back to the aft cabin where the carbon dioxide, carbon monoxide, and nitric oxide analyzers were located.

The 44-foot boat tested, hull number 44318, was powered by two Cummins V6-200 diesels. Each engine installation had a cylindrical chamber aft of the engine where the hot exhaust and sea-water coolant were mixed. Two exhaust pipes, one from each bank of cylinders, brought exhaust gases into the mixer, and two pipes conducted the mixed water and exhaust gases out of the mixer aft to a transverse exhaust pipe with exhaust ports on both sides of the boat. On the assumption that the two exhaust pipes had similar outputs, only one of them from each engine was sampled. A ¼-inch

diameter hole was drilled on one exhaust pipe from each engine and a sample probe inserted in each. The two sample probes were connected through a selector valve to the gas-analysis and smoke-measuring instruments. A water trap in the sample line separated cooling water from the exhaust-gas sample.

Due to excessive air in the fuel lines, the return fuel meters did not give accurate results and were removed. Return fuel was measured by collecting a measured volume against time. Full engine rpm could not be attained with the supply fuel meter in place. In one test, the fuel meter from the starboard engine was removed to allow the engine to develop full power. This run is labeled M1 Full.

4.0 DATA REDUCTION AND CALCULATIONS

The data-reduction system used to process the emission data from Coast Guard vessels was an integrated, manual and computerized processing system in which all the validation, calculation, conversion, and reporting functions were performed by the computer. Diagrams of the manual and computerized segments of the system appear in Figure 4-1 and 4-2 respectively. The following paragraphs briefly describe the major segments of the system.

4.1 MANUAL PROCESSING SEGMENT

As shown in Figure 4-1, the manual portion of the data processing consisted of collecting data from the various sources, concentrating the information onto the run data sheets, and then having the data keypunched and keyverified for computer processing.

The continuously recorded analog strip charts indicating the concentrations of carbon monoxide, carbon dioxide, total hydrocarbon, nitric oxide, and total nitrogen oxides, and smoke were manually read and recorded in the appropriate column on the Test-Mode Data Sheet. Also recorded on this sheet were all the pertinent engine-parameters and environmental test data necessary to accurately describe the test run conditions for that specific engine-mode combination. The transitional segment at the start of each mode was disregarded. The average reading for each mode was recorded on a 0-100 scale. Where applicable, ranges and attenuations were also recorded. Similarly, the calibration data (time of calibration, zero reading, span reading, calibration standard gas concentration, and range and attenuation for each instrument) were read, checked against the operator's test log, and recorded on the Calibration Data Sheet for the test being processed. The fuel-rate data for the test engines, supplied by DOT, were inserted into the appropriate columns on the Test-Mode Data Sheet. The Engine Description Data Sheets which describe each power plant tested, the Test Mode Data Sheets, and the Calibration Data Sheets were then keypunched and keyverified to produce the following four type of data input cards: Engine data, test data, mode data, and calibration data.

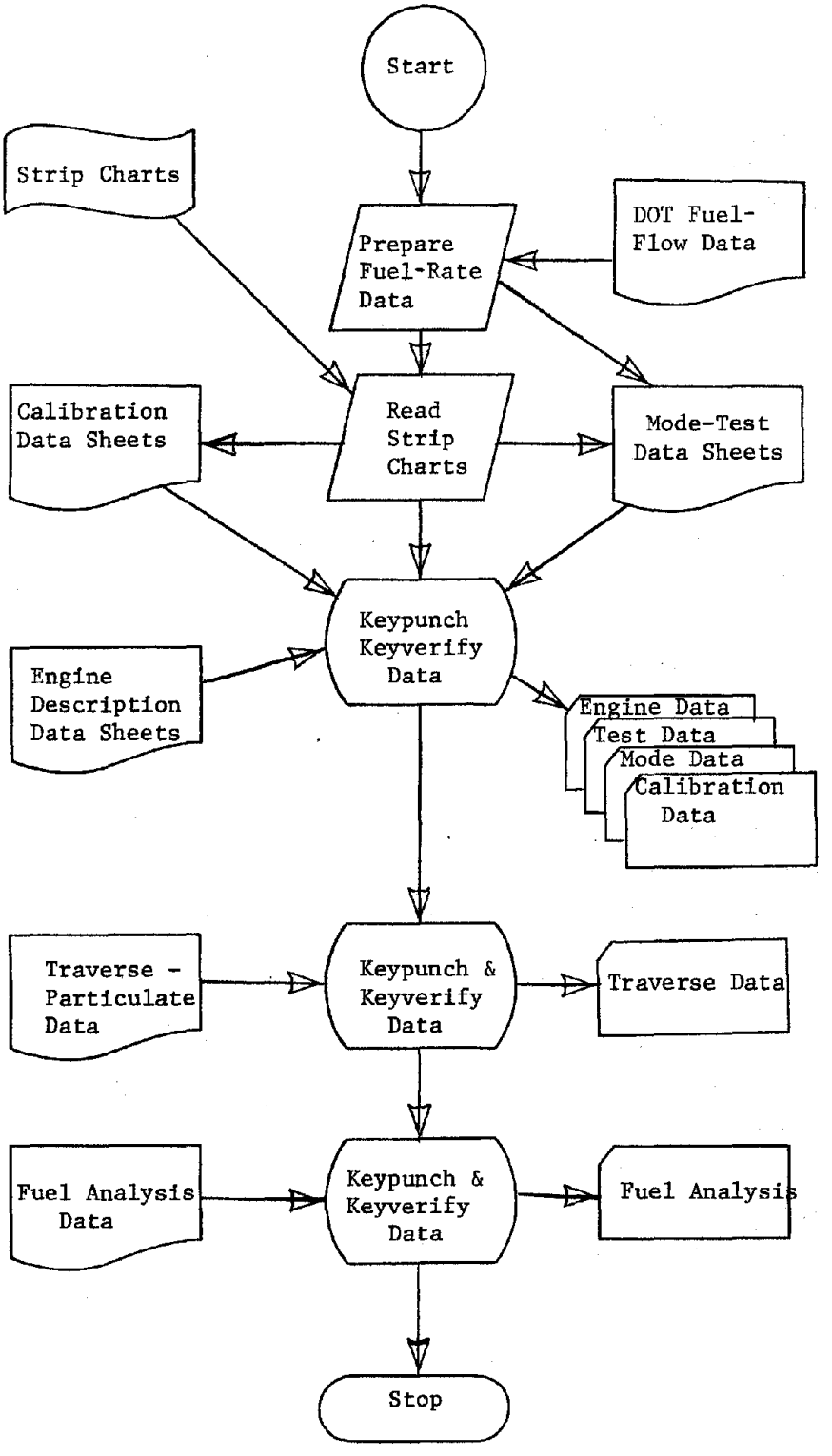

FIGURE 4-1 COAST GUARD VESSEL EMISSIONS DATA REDUCTION SYSTEM - MANUAL SEGMENT

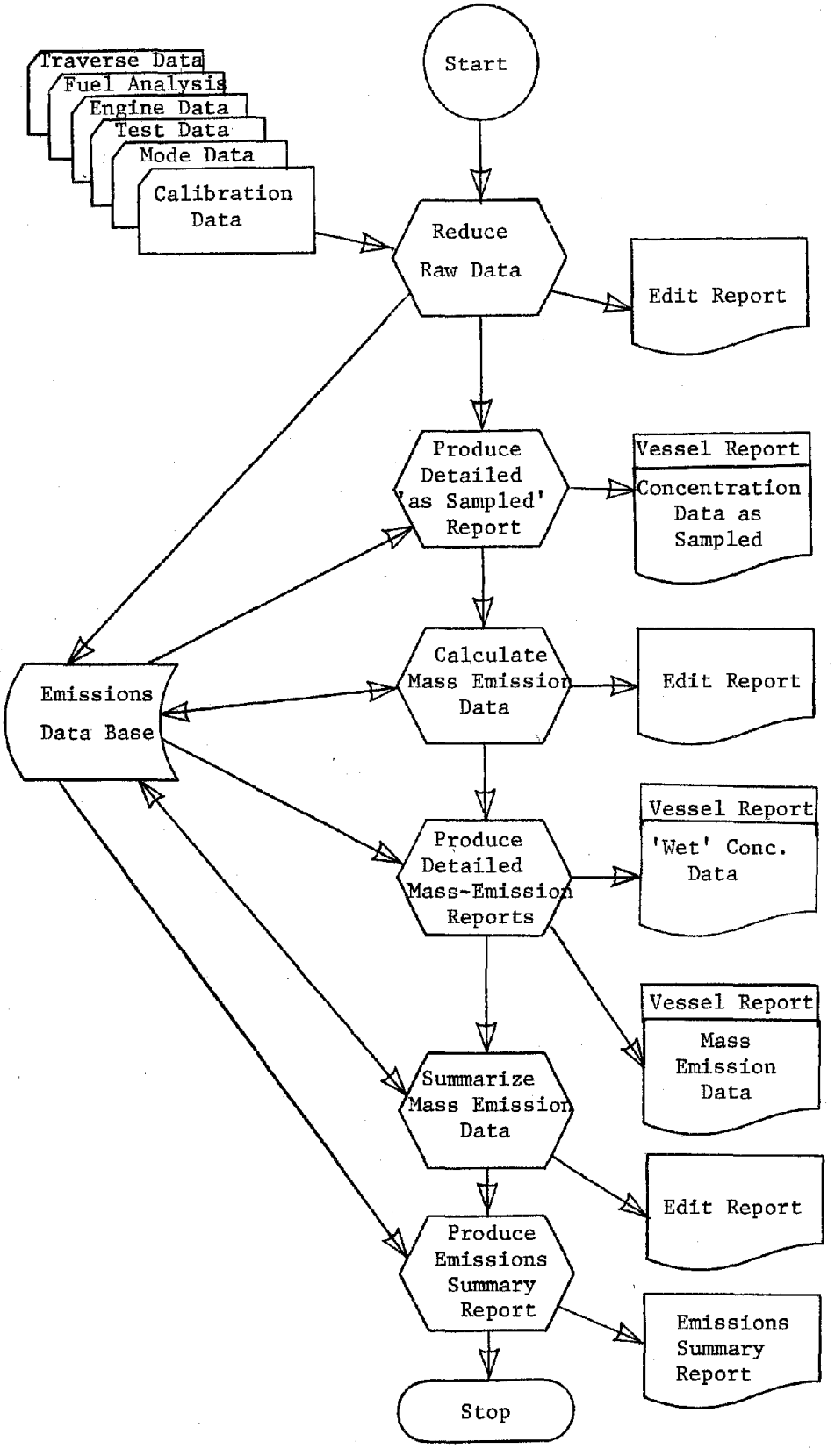

FIGURE 4-2 COAST GUARD VESSEL EMISSIONS DATA REDUCTION SYSTEM - COMPUTERIZED SEGMENT

The weights of the particulates collected were used in the EPA calculation procedure to determine both the particulate concentration at both stack condition (gr/CF) and standard conditions (gr/SCF) and the particulate mass-emission rate in pounds per hour. The sampling conditions were examined to determine conformance with the EPA specification that the sampling rate be between 90% and 110% of isokinetic flow.

The measured volume of stack gas sampled thorugh the SO_2 train was corrected to standard conditions. The concentration of SO_2 in the stack gas was calculated from the correct sample volume and the titration parameters according to Method 6 of the EPA procedure.

Smoke data was reduced using the Bacharach Scale as specified in ASTM Method D2156-65, "Smoke Density In The Flue Gases From Distillate Fuels". The smoke scale used consists of ten spots, numbered 0 through 9, ranging in equal photometeric steps from white through neutral shades of grey to black. The smoke spot number is defined as the reduction (due to smoke) in reflected incident light from the filter paper, divided by 10. The filter paper on which the smoke sample was collected was backed with a piece of white paper and then compared to the smoke scale.

The particulate-traverse sampling and analysis data, SO_2 analysis data, smoke data, and fuel analysis data were also keypunched and key-verified onto the appropriate data cards.

4.2 COMPUTERIZED PROCESSING SEGMENT

The computerized segment of the data processing system is shown in Figure 4-2. Briefly, the raw data were input via the above-mentioned data cards, reduced and converted to engineering units, and stored in the Emissions Data Base in units of concentration as sampled. Once all the necessary data had been input into the Data Base, the concentration data were converted to a 'wet' basis where necessary, converted to mass units and stored in the Data Base. Using the measured fuel rate and generated load data, mass emission rates for each mode-engine combination were then calculated, summarized, and stored in the Emissions Data Base. Detailed edit-reports were produced at each calculation or conversion stage, and

data reports on a per-vessel basis were produced for the following: Concentration data as sampled, concentration data on a 'wet' basis, mass-emissions data, and mass-emission rate data summarized on a mode-engine basis.

4.3 RAW DATA REDUCTION

The raw input data were keypunched on six different types of data cards: Calibration data, engine data, test data, mode data, fuel-analysis data, and traverse (particulate analysis) data. The main processing program input the data cards, validated them according to contents and input order, determined the type of data card, processed it accordingly, and stored the resultant data in the appropriate data file in the Emissions Data Base. The flow of the data through this program is shown in Figure 4-3. The following paragraphs briefly describe the contents of, and the processing done, on each type of data card.

4.3.1 Engine

The Engine-Data Cards contained the descriptive data for the power plant being tested and the vessel on which it was located. They included such vessel data as type, class, name, and registration number, and such engine data as type, model, serial number, manufacturer, total engine time, time since last major overhaul, rated output, location and on-board function. These data were stored as read in the 'Engine' data file.

4.3.2 Test Data

The Test Data Card contained general environmental and test conditions such as: Start and end time, type of fuel used, date, barometric pressure, dry-bulb temperature, wet-bulb temperature, and (where applicable) sample-line temperature. Readings for the environmental conditions were averaged over the entire test period. With standard psychrometric equations and a stored temperature vapor-pressure table, the relative humidity and the absolute inlet-air humidity were calculated from the averaged values for barometric pressure and wet and dry-bulb temperatures. All of these data were then stored in the 'Test' data file.

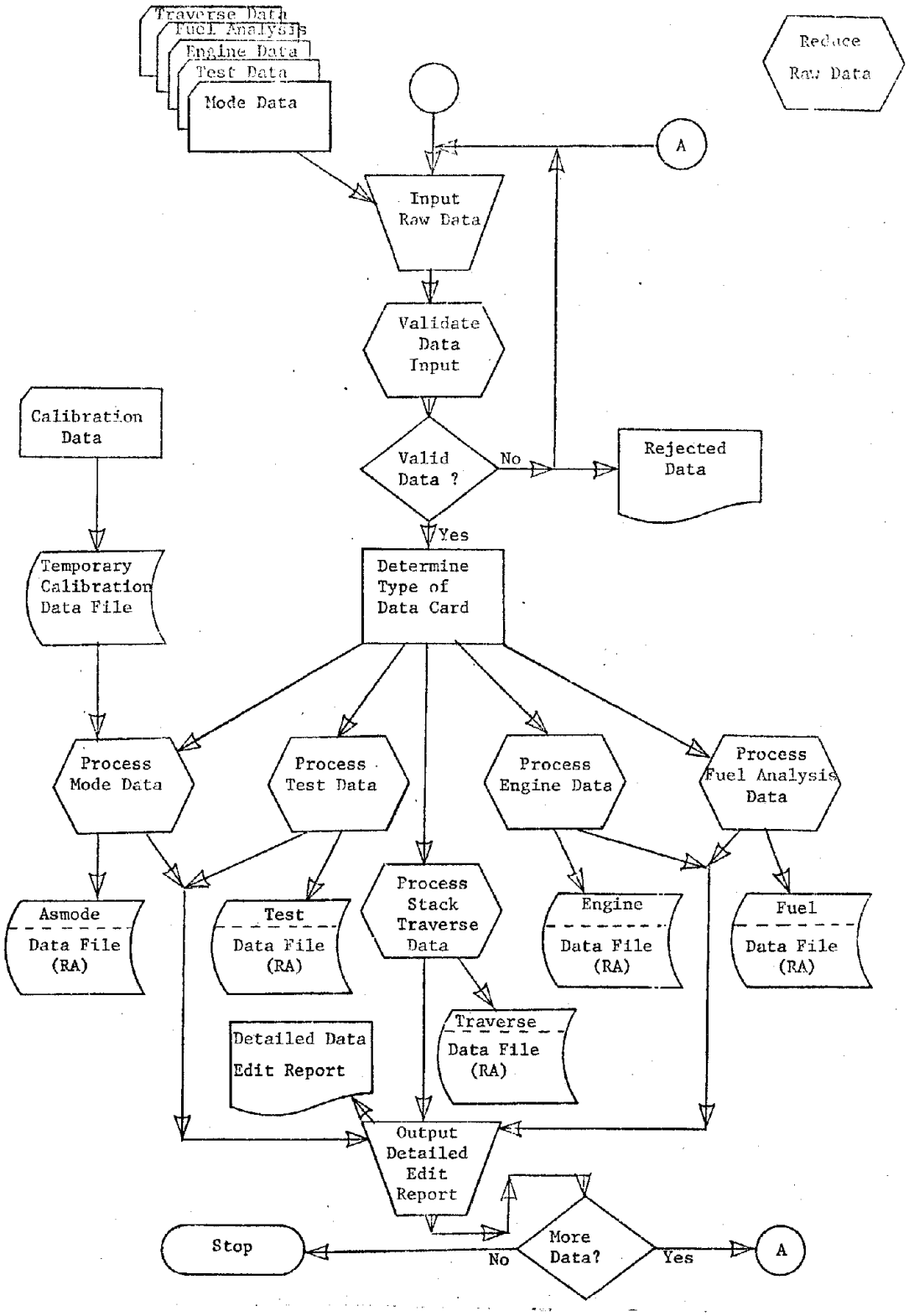

FIGURE 4-3 FLOW CHART OF RAW DATA REDUCTION MODULE

4.3.3 Mode Data

The Mode Data Cards contained the operating conditions for each mode and the raw average readings in each, and appropriate ranges or attenuations. The operating conditions covered the engine rpm, shaft rpm, propeller pitch, load, engine temperature, control setting, fuel pressure, input fuel reading, return fuel reading, time in mode, generator output (where applicable), and stack-boiler condition for steam boilers. Pollutants being measured were carbon dioxide, carbon monoxide, total hydrocarbons (as propane), total nitrogen oxides, nitric oxide, smoke, and sulfur oxides. The raw readings were corrected for zero shift and range change, and converted to concentration units using calculated calibration factors for the linear instruments and a combination of calculated calibration factors and normalized calibration curves for the nonlinear instruments. (The calculations of these factors and the normalized curve technique are described under 'Calibration Data'.) These data were then stored in the 'As Sampled Mode' data file. Where data were missing, blanks were inserted in the data file.

4.3.4 Fuel Analysis Data

The Fuel Analysis Data Card contained the type of fuel and the laboratory-performed fuel analysis, consisting of the percentages by weight of carbon, hydrogen, nitrogen, sulfur, ash, and water. From this analysis the atomic hydrogen-to-carbon ratio and the mass carbon-to-hydrogen ratio were calculated. All of these data were stored in the 'Fuel' data file.

4.3.5 Traverse-Particulate Data

The Traverse Data Cards contained the traverse sampling-point data taken during the test, the resultant sample and water volumes, and the particulate analysis. The volumetric flow rates and particulate-emission rate were calculated with standard EPA calculations and stored in the 'Traverse' data file.

4.3.6 Calibration Data

This card contained all the recorded calibration data for the carbon monoxide, carbon dioxide, total-hydrocarbons, and nitrogen-oxides

instruments, and the time at which the calibration was taken. These data were stored directly on a temporary file in chronological order, and were accessed whenever the mode sampling time required a new pair of bracketing calibrations. Upon access, the span readings for each parameter were corrected for zero shift and an average span value calculated over the period between the two contributing calibrations. From these average span values and the standard calibration concentrations, the calibration factors for each parameter were calculated and stored in memory. The calibration factors, average zero shifts, average span values, and standard ranges were printed out in an edit report for checking and verification. In the case of the CO and CO_2, where normalized curve functions were used, deviations from the standard calibration curve in excess of 5% were flagged with warning messages and appropriate diagnostic information. Missing calibrations were similarly flagged. This calibration edit report enabled the data analyst to see any discrepancies at a glance, yet permitted the calibration factors to be machine-calculated for each test with a high degree of accuracy and confidence. This method also permitted maximum utilization of equipment in the field, since the data conversion was not dependent on any specific instrument range or calibration standard.

4.4 MASS EMISSION CALCULATION

Once all of the necessary fuel, test, and mode data had been input into their respective data files, the concentrations data were converted to a 'wet' basis (where necessary) and then to a mass basis. The data flow through this phase of the processing is shown in Figure 4-4.

Basically, the gas concentrations of CO, CO_2, NO, and NO_x, measured by either NDIR or chemiluminescence instruments, were measured 'dry', since the sample-conditioning system used for these instruments removed the water vapor. In order to calculate mass emissions, it was first necessary to convert these 'dry' values to 'wet' values - that is, the ratio by volume of the specific gas to all of the exhaust gas, including water vapor. To do this, a conversion factor, K_w, was calculated using equations based on the carbon

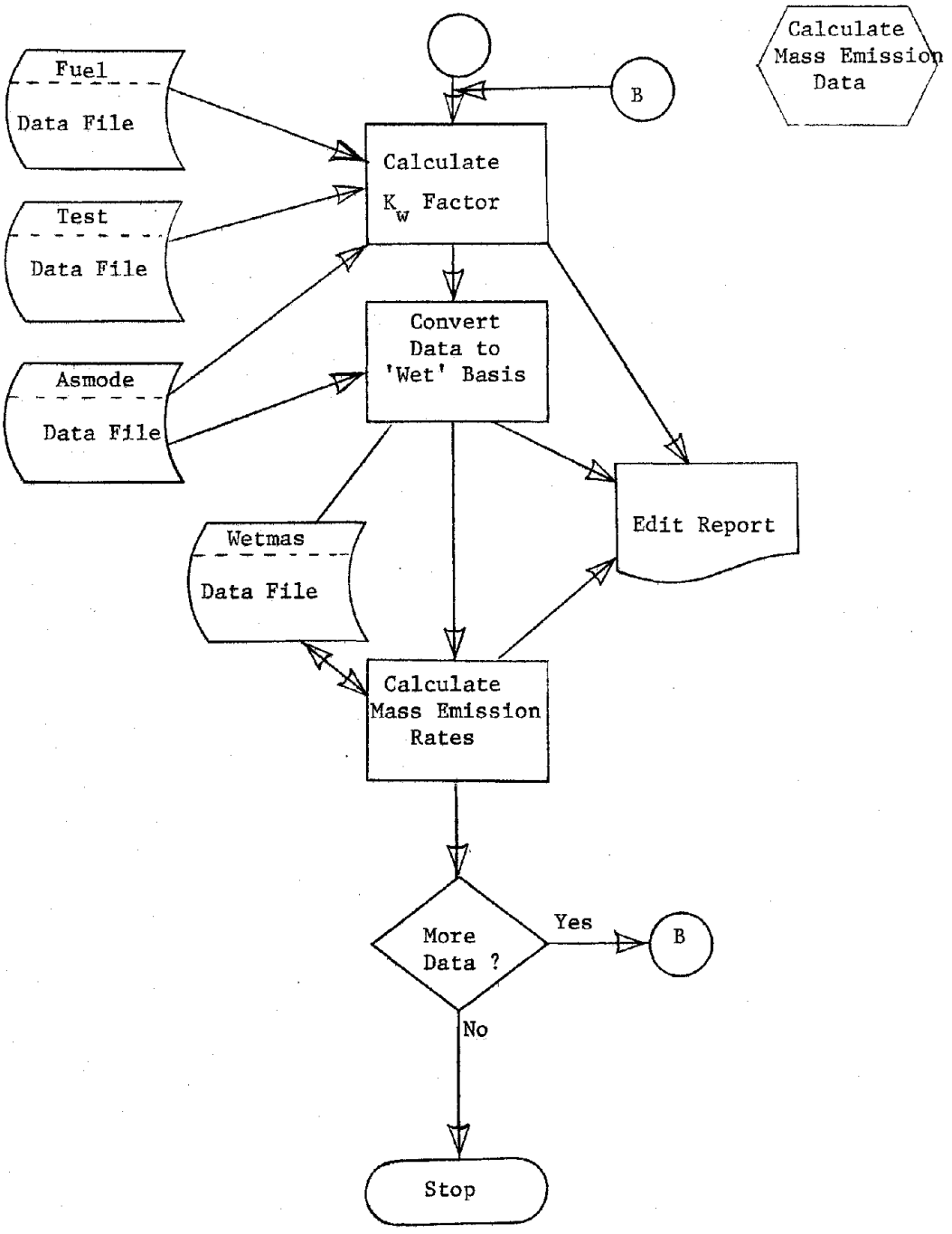

FIGURE 4-4 FLOW CHART OF MASS EMISSION DATA CALCULATION MODULE

balance and the hydrogen-to-carbon atomic ratio of the fuel used, as specified in SAE ARP 1256. The 'dry' concentration values were then multiplied by K_w to obtain the 'wet' concentration values.

The mass emissions were calculated using a carbon balance technique and stored in the Emissions Data Base as pounds of pollutant per pound of fuel. The requisites for using this technique were the hydrogen-to-carbon (mass) ratio of the fuel, and all carbon-bearing constituents of the exhaust. A mole of CO, CO_2 or hydrocarbons (measured as C) must have come from one mole of fuel of formula CH_y. The calculations are based on an empirical chemical formula normalized with respect to carbon. The number of moles of fuel used is the sum of the moles of CO, CO_2, and HC measured. Other carbon-bearing exhaust components, e.g., aldehydes, should of course be added if known. However, these are usually present only in small concentrations and can be neglected. The mass emission per pound of fuel is:

$$\frac{\text{lb X}}{\text{lb fuel}} = \frac{P_x \, (mw_x)}{(P_{CO} + P_{CO_2} + P_{HC-C}) \, (mw_{fuel})}$$

where: P_x = exhaust concentration of X expressed as a fraction

$$P_{CO} = \frac{\text{concentration of CO\%}}{100}$$

$$P_{CO_2} = \frac{\text{concentration of CO}_2\text{\%}}{100}$$

$$P_{HC-C} = \frac{\text{concentration of HC (ppm-C)}}{10^6}$$

$(mw)_x$ = molecular weight of X

molecular weights: CO = 28

CO_2 = 44

HC = 14

$(mw)_{fuel}$ is the empirical molecular weight of the fuel and is

$(mw)_f = 12 + y$,

where: $y = 12 \left(\frac{H}{C}\right)$ mass ratio

The hydrogen-to-carbon mass ratio was obtained from a fuel analysis.

The mass emission rate can now be calculated using the fuel-flow rate: $\frac{\text{lb X}}{\text{lb fuel}}$ (lb fuel/min.) = lb X/min.

No mass emission calculations could be made when either carbon dioxide or carbon monoxide data were missing. If the total hydrocarbon measurement was missing, the mass emissions could still be calculated for diesel engines, since the fraction of total carbon in the exhaust which appears as hydrocarbon is very small. Therefore, when a total-hydrocarbon measurement was missing, the emission rates of all but hydrocarbons were calculated.

5.0 RESULTS AND DISCUSSION

All of the data collected in the field program are tabulated in Apendices A through E. Appendix A contains engine background information. The measured pollutant concentrations are listed in Appendix B, grouped by cutter. Mass emission rates for gaseous pollutants are tabulated in Appendix C by cutter. Particulate emission rates are reported in Appendix D, and the exhaust flow-rate data for tests in which particulates were not collected are presented in Appendix E.

5.1 DISCUSSION OF EMISSION DATA

Many factors can contribute to variations in emission concentrations of exhaust from a number of diesel engines under similar conditions. These factors include engine design (two or four-stroke cycle, injector geometry, turbo-charged or naturally aspirated, and so on), the mechanical condition of the engine under test, and experimental error.

Engine design can have a considerable effect on the emissions from a diesel engine. Many areas of diesel engine design, such as the shape of the combustion chamber, the fuel injector pressure, and the engine timing specified, have a direct effect on the combustion process and therefore on the emissions. The Coast Guard fleet includes a large variety of two and four-stroke-cycle engines employing different injector geometries. These engines vary in age from twenty or thirty years old to new engines of improved design.

Although the Coast Guard has a well-developed program of engine maintenance, it is unreasonable to expect all engines to be operating at maximum efficiency at all times. The engines tested had operating times since major overhaul ranging from a few hours to thousands of hours. No definitive study has been done on emission-level changes with engine hours on marine-configured diesels.

Although every effort was made to obtain a representative exhaust sample through the judicious selection of sampling points and the use of special probes, space and time constraints sometimes limited the experimental configuration.

Other errors are introduced by inaccurate calibration gases, faulty instrumentation, and improper data handling and reduction. Many of these errors can be caught and corrected, or the data rejected by the computer processes previously described.

The intent of this program was to measure emissions from these engines and boilers under typical operation conditions. Measurements were therefore made at operating conditions set by the crew, and the opportunities to obtain replicate samples (i.e., same engine, same load) were limited. In this regard it was noted that once an engine had stabilized at a particular operating mode, the emission levels generally did not change over the time during which measurements were being performed.

When studying the data in the following tables it should be noted that because of ship and engine design, a speed condition in one ship did not mean that the engine load was the same as that in another ship being operated at the same speed. For instance, at cruise condition some main engines operated at little more than half the rated load, while others were at essentially full load. Since emissions from diesel engines are dependent on load, any analysis of the data must consider the actual load as measured or extrapolated from the carbon dioxide concentration (carbon dioxide concentrations increase with engine load).

5.2 GASEOUS EMISSIONS FROM COAST GUARD CUTTERS

Mass emission rates at cruise power for the main-propulsion diesel engines are listed in Table 5-1. Cruise power is defined as a ship's normal operating speed, clear of the harbor, while traveling from point to point. Ship-to-ship variations in the emission rates for the measured pollutants vary widely because of the reasons previously cited. However, it is interesting that generally good agreement in the emission rates exists between port and starboard engines operated under identical conditions. Wide variations are noted between the port and starboard engines of vessels No. 8, 10 and 14. In the case of vessels 8 and 14, these variations can be attributed to load differences due to propeller pitch and rpm. For cutter No. 10, there was no obvious explanation for

TABLE 5-1 DIESEL MAIN-ENGINE EMISSIONS AT CRUISE POWER

(Engine Ranked in Order of Increasing Horsepower)

Vessel No.	Engine	CO_2 %	Rated hp	Measured rpm	Fuel Flow lb/Hr.	lb/K lb Fuel			lb/Hr.		
						CO	THC	NO_x	CO	THC	NO_x
6	GM 6072-A-RH	1.94	200	800	17.3	17.09	29.74	-	.30	.51	-
6	GM 6072-A-LH[1]	2.83	200	800	17.3	18.40	18.35	59.39	.32	.32	1.03
14	Cummins V6-200M	10.12	200	2600	-	49.03	2.10	30.15	-	-	-
14	Cummins V6-200M[1]	5.06	200	2250	-	11.98	3.19	27.37	-	-	-
7	Union 06	6.00	300	200	43.2	7.68	8.45	53.86	.33	.36	2.33
7	Union 06	5.20	300	260	37.4	5.60	5.12	55.49	.21	.19	2.08
12	Waukesha 6LRDCSM	4.26	500	850	-	14.01	6.25	47.56	-	-	-
1	Ingersoll-Rand Type S	6.69	600	500	-	7.37	5.18	65.09	-	-	-
1	Ingersoll-Rand Type S	6.84	600	500	-	6.33	5.20	63.70	-	-	-
2	Cooper-Bessemer GND-8[2]	7.51	600	520	181.4	3.61	1.58	44.98	.65	.29	8.16
2	Cooper-Bessemer GND-8[3]	7.86	600	530	189.2	3.78	1.69	46.81	.72	.32	8.86
10	Cummins VT12M	7.42	600	1600	-	7.67	6.03	48.82	-	-	-
10	Cummins VT12M	7.83	600	1650	-	22.69	1.65	40.88	-	-	-
10	Cummins VT12M	7.66	600	1690	-	19.01	-	54.83	-	-	-
10	Cummins VT12M	8.00	600	1700	-	17.66	3.89	-	-	-	-
9	Cooper-Bessemer GN-8	6.27	700	595	-	4.40	1.08	63.90	-	-	-
9	Cooper-Bessemer GN-8	6.75	700	600	-	5.19	1.13	59.33	-	-	-
11	Cummins VT-12-900M	8.74	900	1900	224.6	12.06	3.71	65.40	2.71	.83	14.69
11	Cummins VT-12-900M	8.64	900	2000	224.6	11.99	1.09	48.31	2.74	.25	11.07
4	Cooper-Bessemer FVBM-12-T	5.13	1580	600	-	6.26	-	87.80	-	-	-
13	ALCO 16-251-B	8.95	2500	920	1005.5	9.80	1.70	54.67	9.85	1.71	54.97
8	Fairbanks-Morse 38TD-8-1/8	5.46	3600	742	768.2	5.04	3.58	43.36	3.87	2.75	33.31
8	Fairbanks-Morse 38TD-8-1/8	4.79	3600	720	779.0	2.93	6.77	49.80	2.28	5.28	38.80

1. Average of 2 runs.
2. Average of 6 runs.
3. Average of 5 runs.

the low CO reading on one engine. Since the NO_x reading on this engine is generally in good agreement with those of the other engines, the accuracy of this CO reading is in doubt.

Measured carbon monoxide emissions varied from 2.93 to 49.03 lbs/1000 lb fuel (klb). The 49.03 lb/1000 lb fuel was measured under unusual load conditions in a twin-screw boat with one engine loaded more heavily than the other. Carbon monoxide production appears to correlate with rated engine rpm; the high-speed engines produce more carbon monoxide than the low-speed ones.

Hydrocarbons varied from 1 to 29.74 pounds per thousand pounds of fuel. Again, the two highest total-hydrocarbon values, 18.35 and 29.74, were measured in a twin-screw boat under simulated load while lashed to the dock. All other hydrocarbon values varied between 1.08 and 8.45 lbs/1000 lb of fuel. There was no obvious correlation between hydrocarbon emissions and engine type or rated rpm. The measured hydrocarbons can be indicative of the operating condition of the engine under test; that is worn pistons, piston rings or valves can allow lubricating oils to be introduced into the combustion process, which results in an increase in measured hydrocarbon levels.

Measured oxides of nitrogen varied between 23.37 and 87.80 lbs/1000 lb of fuel. Again, no correlation was evident between levels of oxides of nitrogen and engine type. However, the data indicates that for an individual engine the oxides of nitrogen increase with engine load. This is to be expected, since the formation of the oxides of nitrogen is a function of the peak flame temperature in the combustion process.

A DOT study of each engine design type and operating condition at time of test is currently underway in an effort to more fully explain the relationship between measured emission levels and engine design parameters. The results of this study will appear in a future DOT report.

5.3 EFFECT OF WATER-COOLED EXHAUST ON EMISSIONS

The effect of internally water-cooled exhaust stacks on emissions was studied by measuring exhaust-gas concentrations at exhaust-stack points upstream and downstream of the cooling water. The cooling water reduces the exhaust-gas temperature and adds water vapor. The water is added on the cutters Active and Decisive by eleven evenly spaced water-spray nozzles mounted in the centerline of the horizontal exhaust stacks, which run the length of those cutters from the engine room to the transom where they exhaust above the water line. In the cutter Point Jackson, a single spray nozzle injects engine-cooling water into the exhaust stack.

It was postulated that the cooling water might decrease smoke by precipitation washout and decrease total hydrocarbons by causing condensation of those hydrocarbons with boiling points above the temperature of the cooled exhaust gases.

The forward and aft exhaust measurements could not be made simultaneously, but were made consecutively while the engines were operated at constant power settings. The data is subject to engine-power variations, exhaust-gas dilution, and uncertainty in the representativeness of the sampling due to stratification. The data is also limited because time did not allow replicate measurements. Another uncertainty is the possible loss of CO_2 to the sea-water coolant. CO_2 is only slightly soluble in fresh water; it is more soluble in sea water, whose pH is 8.

The results of the tests conducted on the three cutters with water-cooled exhaust are listed in Table 5-2. The gas emission rates are compared on a mass-emission-rate basis. Mass emission rates are used for comparison instead of gas concentrations because it appears that the exhaust at the downstream sampling point had been diluted with air to a significant degree on two of the three vessels. This could have been caused by air entering through the exhaust exit, the butterfly valves, or non-metal connectors used to join the exhaust pipe sections. In any event, it seems more reasonable to assume that dilution occurred than that the decrease in concentrations from forward to aft resulted from the absorption

of nearly seventy percent of each pollutant into the cooling water. It must be noted that while carbon dioxide is somewhat soluble in sea water, carbon monoxide is not. Thus, the large decrease in carbon monoxide from forward to aft would most likely be indicative of dilution with ambient air.

The data in Table 5-2 show that in most cases the emission rates for carbon monoxide, hydrocarbons and nitrogen oxides were quite similar at the forward and aft sampling points. This indicates that the water spray has little effect on gaseous emission rates of any of the pollutants measured. In a few cases higher rates were found at the aft point. This, of course, is not possible, and this data must be subject to error resulting from experimental design constraints, such as the inability to make simultaneous measurements at the forward and aft points.

Examination of the smoke data from the three cutters indicates that mixing water with the exhaust has little effect on the smoke emitted to the air. The measurements crew observed significant smoke emerging from the exhaust pipes.

The preceding discussion points up the difficulty in performing the complex study of exhaust/water mixing under the constraints of a field-measurement program. Definitive results could be achieved more readily in a laboratory under controlled conditions.

TABLE 5-2 EFFECT OF WATER-COOLED EXHAUST ON EMISSIONS

Engine	Mode	Engine RPM	Shaft RPM	Mass Emissions, lb/1000 lb Fuel CO FWD	CO AFT	THC FWD	THC AFT	NO_x FWD	NO_x AFT	Smoke FWD	Smoke AFT
Cutter Active											
Stbd Main	Slow	530	160	19.05	15.32	-	-	51.49	52.81	4.5	4.5
	Cruise	600	185	6.26	6.27	-	-	87.80	87.23	-	5.0
	Full	890	265	30.0	31.79	2.67	3.19	-	73.54	8.0	-
Port Main	Full	900	265	35.93	35.74	1.87	1.86	63.18	62.15	-	9.5
Cutter Decisive											
Stbd Main	Slow	525	160	8.37	8.22	3.32	1.92	46.18	44.94	5.5	-
	2/3	640	195	15.92	15.21	3.25	2.09	41.44	42.67	8.5	-
	Full	1000	300	19.31	10.87	3.48	3.77	52.73	58.05	6.5	-
Port Main	Slow	500	160	9.13	8.23	5.07	2.34	66.48	78.15	5.0	-
	2/3	660	204	18.10	21.88	2.16	1.75	50.20	48.99	9.0	9.5
	Cruise	920	275	9.80	11.0	1.70	2.36	54.67	55.02	6.0	6.5
	Full	990	298	10.97	12.70	1.97	2.74	56.52	57.16	6.0	7.0
Cutter Point Jackson											
Stbd Main	2/3	1350	430	9.04	7.84	3.84	-	26.03	26.91	8.0	8.0
	Cruise	1900	640	12.06	10.61	3.71	-	65.40	49.23	8.0	7.5
Port Main	2/3	1350	420	8.93	9.25	.88	-	23.22	19.77	8.5	8.5
	Cruise	1900	620	11.99	10.79	1.09	-	48.31	39.18	9.0	9.0

APPENDIX A

ENGINE DESCRIPTION

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 1
PAGE 1

VESSEL NAME : USCGC YANKTON VESSEL REG # : 72
VESSEL TYPE & CLASS : WYTM - 110A

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT		
B1	BOILER	79230	WAY-WOLFF					@	
G1	STBD SS GENERATOR	6912	GENERAL MOTORS	GA-37165	18418	1825	52 KW	@	
G2	PORT SS GENERATOR	6911	GENERAL MOTORS	GA-37155	16557	3631	52 KW	@	
M1	STBD MAIN DIESEL ENG	TYPE S	INGERSOLL-RAND	44506	22815	5919	600 HP	@	720 RPM
M2	PORT MAIN DIESEL ENG	TYPE S	INGERSOLL-RAND	44507	22593	4991	600 HP	@	720 RPM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 2
PAGE 1

VESSEL NAME : USCGC COWSLIP VESSEL REG # : 277
VESSEL TYPE & CLASS : WLB - 180A

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT
B1	BOILER	FBM-4605BHM1	VAPOR CLARKSON	12525	125000		600000 BTU @
G1	STBD SS GENERATOR	6-71	GENERAL MOTORS	6-71-146-958	80231	4388	190 HP @
G2	PORT SS GENERATOR	6-71	GENERAL MOTORS	6-71-146-035	78658	1020	190 HP @
M1	STBD MAIN DIESEL ENGINE	GND-8	COOPER-BESSEMER	1890	37679	2040	600 HP @ 600 RPM
M2	PORT MAIN DIESEL ENGINE	GND-8	COOPER-BESSEMER	1891	37683	2317	600 HP @ 600 RPM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 3
PAGE 1

VESSEL NAME : USCGC CAMPBELL VESSEL REG # : 32
VESSEL TYPE & CLASS : WHEC - 327

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	BOILER MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT
M1	STBD MAIN ENG-SP E		BABCOCK & WILCOX				1550 HP @
M2	PORT MAIN ENG-SP A		BABCOCK & WILCOX				1550 HP @
M3	STBD MAIN ENG-SP F		BABCOCK & WILCOX				1550 HP @
M4	PORT MAIN ENG-SP B		BABCOCK & WILCOX				1550 HP @
M5	STBD MAIN ENG-SP G		BABCOCK & WILCOX				1550 HP @
M6	PORT MAIN ENG-SP C		BABCOCK & WILCOX				1550 HP @
M7	STBD MAIN ENG-SP H		BABCOCK & WILCOX				1550 HP @
M8	PORT MAIN ENG-SP D		BABCOCK & WILCOX				1550 HP @

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 4
PAGE 1

VESSEL NAME : USCGC ACTIVE VESSEL REG # : 618
VESSEL TYPE & CLASS : WMEC - 210A

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT	
B1	STBD BOILER	R0165Ø-S	VAPOR	1784	21ØØØ			@
B2	PORT BOILER	R0165Ø-S	VAPOR	1783	21ØØØ			@
G1	STBD SS GENERATOR	D343TA	CATERPILLAR	338639	11133		2ØØ KW	@
G2	PORT SS GENERATOR	D343TA	CATERPILLAR	338638	1Ø556		2ØØ KW	@
M1	STBD MAIN DIESEL-FWD SP	FVBM-12-T	COOPER-BESSEMER	6865	766Ø		158Ø HP	@
M2	PORT MAIN DIESEL-FWD SP	FVBM-12-T	COOPER-BESSEMER	6864	7656		158Ø HP	@
M3	STBD MAIN DIESEL-STRN SP	FVBM-12-T	COOPER-BESSEMER	6865	766Ø		158Ø HP	@
M4	PORT MAIN DIESEL-STRN SP	FVBM-12-T	COOPER-BESSEMER	6864	7656		158Ø HP	@

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 5
PAGE 1

VESSEL NAME : USCGC RELIEF VESSEL REG # : 613
VESSEL TYPE & CLASS : WLV - 128

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT
B1	STBD BOILER	N-193	YORK-SHIPLEY		11230		350000 BTU @
B2	PORT BOILER	N-193	YORK-SHIPLEY		13557		350000 BTU @
G1	STBD SS GENERATOR	4064B	GENERAL MOTORS	4A-18552	64005	4204	40 KW @
G2	PORT SS GENERATOR	4064B	GENERAL MOTORS	4A-18554	56543	3807	40 KW @
M1	MAIN DIESEL ENG	2400-B	GENERAL MOTORS				660 HP @

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 6
PAGE 1

VESSEL NAME : USCGC 40538 VESSEL REG # : 40538
VESSEL TYPE & CLASS : U/T - 40

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT
M1	STBD MAIN DIESEL ENG	6072-A-RH	GENERAL MOTORS	6A-17521	2243		200 HP @ 2000 RPM
M2	PORT MAIN DIESEL ENG	6071-A-LH	GENERAL MOTORS	6A-190616	2246		200 HP @ 2000 RPM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 7
PAGE 1

VESSEL NAME : USCGC WHITE HEATH VESSEL REG # : 545
VESSEL TYPE & CLASS : WLM - 133

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT
B1	BOILER	BS-B	BUCKLEY & SCOTT	19356			65000 BTU @
G1	FWD SS GENERATOR	H-10078	CUMMINS	875189	1004	1004	60 KW @ 1500 RPM
G2	AFT SS GENERATOR	6DTG-317	BUDA	156765	3798	3798	30 KW @ 1450 RPM
M1	STBD MAIN DIESEL ENG	06	UNION	43566	35060	3275	300 HP @ 350 RPM
M2	PORT MAIN DIESEL ENG	06	UNION	43565	35060	2821	300 HP @ 350 RPM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 8
PAGE 1

VESSEL NAME : USCGC CHASE VESSEL REG # : 718
VESSEL TYPE & CLASS : WHEC - 378

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT
B1	STBD BOILER	RO-110-CG	VAPOR CORP	18043	16000		@
B2	PORT BOILER	RO-110-CG	VAPOR CORP	18042	16000		@
G1	STBD SS GENERATOR	8-567EZ	GENERAL MOTORS	67-01-1097	15600	1000	500 KW @
G2	PORT SS GENERATOR	8-567EZ	GENERAL MOTORS	67-01-1122	14000	1000	500 KW @
M1	STBD MAIN DIESEL ENG	38TD-8-1/8	FAIRBANKS-MORSE	97083	6643	0	3600 HP @ 900 RPM
M2	PORT MAIN DIESEL ENG	38TD-8-1/8	FAIRBANKS-MORSE	97082	7300	5500	3600 HP @ 900 RPM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 9
PAGE 1

VESSEL NAME : USCGC SPAR VESSEL REG # : 403
VESSEL TYPE & CLASS : WLB - 180C

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT
B1	STBD BOILER	FBM-4605B	VAPOR	12183	440		600000 BTU @
B2	PORT BOILER	FBM-4605B	VAPOR	12184	60		600000 BTU @
G1	STBD SS GENERATOR	6-DTG-844	BUDA	84339	4414	4414	63 KW @ 1200 RPM
G2	PORT SS GENERATOR	6-DTG-844	BUDA	26423	62339	4101	63 KW @ 1200 RPM
M1	STBD MAIN DIESEL ENG	GN-8	COOPER-BESSEMER	2826	76616	2055	700 HP @ 700 RPM
M2	PORT MAIN DIESEL ENG	GN-8	COOPER-BESSEMER	2825	72903	747	700 HP @ 700 RPM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 10
PAGE 1

VESSEL NAME : USCGC CAPE HORN VESSEL REG # : 95322
VESSEL TYPE & CLASS : WPB - 95C

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT
B1	BOILER	3630-10E	WAY-WOLFF				@
G1	FWD SS GENERATOR	2-71	GENERAL MOTORS	2A2-3005	15335	4890	20 KW @
G2	AFT SS GENERATOR	2-71	GENERAL MOTORS	2A2-3620	14279	5210	20 KW @
M1	FWD STBD MAIN DIESEL	VT12M	CUMMINS	201336	3470	3470	600 HP @ 2100 RPM
M2	FWD PORT MAIN DIESEL	VT12M	CUMMINS	201339	10765	10765	600 HP @ 2100 RPM
M3	AFT STBD MAIN DIESEL	VT12M	CUMMINS	201337	10822	7718	600 HP @ 2100 RPM
M4	AFT PORT MAIN DIESEL	VT12M	CUMMINS	201338	10960	7717	600 HP @ 2100 RPM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 11
PAGE 1

VESSEL NAME : USCGC POINT JACKSON VESSEL REG # : 82378
VESSEL TYPE & CLASS : WPB - 82D

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT
B1	BOILER	M-120	REPCO	200-7			230000 BTU @
G1	FWD SS GENERATOR	2-71	GENERAL MOTORS	2A77870	1162		20 KW @
G2	AFT SS GENERATOR	2-71	GENERAL MOTORS	2A78216	844		20 KW @
M1	STBD MAIN DIESEL - FSP	VT-12-900M	CUMMINS	679763-3	1240		900 HP @ 2300 RPM
M2	PORT MAIN DIESEL - FSP	VT-12-900M	CUMMINS	681361-3	1238		900 HP @ 2300 RPM
M3	STBD MAIN DIESEL - ASP	VT-12-900M	CUMMINS	679763-3	1240		900 HP @ 2300 RPM
M4	PORT MAIN DIESEL - ASP	VT-12-900M	CUMMINS	681361-3	1238		900 HP @ 2300 RPM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 12
PAGE 1

VESSEL NAME : USCGC SHACKLE VESSEL REG # : 65609
VESSEL TYPE & CLASS : WYTL - 65B

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT
B1	BOILER	1924-8C	WAY-WOLFF	2200			105000 BTU @
G1	FWD SS GENERATOR	2-71	GENERAL MOTORS	2A52539	3526		20 KW @
G2	AFT SS GENERATOR	2-71	GENERAL MOTORS	2A52540	1994		20 KW @
M1	MAIN DIESEL ENGINE	6LRDCSM	WAUKESHA	20910	5183		500 HP @ 1200 RPM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 13
PAGE 1

VESSEL NAME : USCGC DECISIVE VESSEL REG # : 629
VESSEL TYPE & CLASS : WMEC - 210B

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT
B1	STBD BOILER	R0 1650-CG	VAPOR				@
B2	PORT BOILER	R0 1650-CG	VAPOR	18200	3444		@
G1	STBD SS GEN-MAN SP	D343TA	CATERPILLER	33B1547	7111		200 KW @ 1800 RPM
G2	PORT SS GEN-MAN SP	D343TA	CATERPILLER	33B1554	9928	107	200 KW @ 1800 RPM
G3	STBD SS GEN-JNCT SP	D343TA	CATERPILLER	33B1547	7111		200 KW @ 1800 RPM
G4	PORT SS GEN-JNCT SP	D343TA	CATERPILLER	33B1554	9928	107	200 KW @ 1800 RPM
M1	STBD MAIN DIESEL-MAN SP	16-251-B	ALCO	9386	9814		2500 HP @ 1000 RPM
M2	PORT MAIN DIESEL-MAN SP	16-251-B	ALCO	9384	7771		2500 HP @ 1000 RPM
M3	STBD MAIN DIESEL-JNCT SP	16-251-B	ALCO	9386	9814		2500 HP @ 1000 RPM
M4	PORT MAIN DIESEL-JNCT SP	16-251-B	ALCO	9384	7771		2500 HP @ 1000 RPM
M5	STBD MAIN DIESEL-STRN SP	16-251-B	ALCO	9386	9814		2500 HP @ 1000 RPM
M6	PORT MAIN DIESEL-STRN SP	16-251-B	ALCO	9384	7771		2500 HP @ 1000 RPM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 14
PAGE 1

VESSEL NAME : USCGC BOAT 44318 VESSEL REG # : 44318
VESSEL TYPE & CLASS : MLB - 44

POWERPLANT DESCRIPTION DATA FOR SAMPLED VESSEL :

CODE	POWERPLANT DESCRIPTION	ENG.MODEL	ENG. MFGR.	SERIAL #	TOT.ENG. TIME-HRS	TSMOH HRS	RATED OUTPUT
M1	STBD MAIN DIESEL ENG	V6-200M	CUMMINS	337642		2368	200 HP @ 3000 RPM
M2	PORT MAIN DIESEL ENG	V6-200M	CUMMINS	362082		387	200 HP @ 3000 RPM

APPENDIX B

EMISSIONS RAW DATA

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 1
PAGE 1

VESSEL NAME : USCGC YANKTON — VESSEL REG # : 72
VESSEL TYPE & CLASS : WYTM - 110A — FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	6/28/72	1000	1130	30.11	77.0	61.8	60	.0117	85.96	13.21	.20	1.85	6.51
2	6/29/72	0800	1030	30.11	58.0	56.3	94	.0096	85.96	13.21	.20	1.85	6.51
3	7/ 8/72	1000	1130	30.15	67.0	59.1	76	.0106	85.96	13.21	.20	1.85	6.51

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
G1	20 %	#1	1160		10 KW	200	47	0	0		1.67	151		153	129	24	5.5	
G1	45 %	#1	1160		24 KW	210	62	120	90		2.31	153		214	189	25	6.0	
G2	0 %	#2	1240		0 KW	0	0	0	0		.88	385	2020	117	81	36	4.0	
G2	35 %	#2	1230		18 KW	215	50	121	56		1.67	320	2281	272	226	46	4.5	
G2	35 %	#2	1230		17 KW	210	49	120	53		1.74	320	2447	267	221	46	4.5	
G2	45 %	#2	1230		23 KW	200	49	120	105		1.94	298	2281	301	262	39	4.5	
M1	CRUISE	#3	500	220							6.69	246	324	1323	1271	52	4.5	
M1	CRUISE	#3	550	230							6.65	250	340	1179	1100	79	4.5	
M2	CRUISE	#3	500	220							6.84	216	332	1323	1245	78	4.5	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 2
PAGE 1

VESSEL NAME : USCGC COWSLIP — VESSEL REG # : 277
VESSEL TYPE & CLASS : WLB - 180A — FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	7/10/72	0905	1615	30.16	81.5	62.0	52	.0118	86.24	13.12	.19	1.83	6.57
2	7/11/72	0820	1350	30.08	74.0	58.3	58	.0103	86.24	13.12	.19	1.83	6.57
3	7/12/72	0740	1430	30.12	74.8	60.1	60	.0110	86.24	13.12	.19	1.83	6.57

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
B1	NORMAL	03						125		6.00	8.54	153	82	58	57	1	6.5	
G1	25 %	01	1200		18 KW	215	64			2.82	3.35	139	2024	345	325	20	6.0	
G1	25 %	01	1200		18 KW	215	63			2.82	3.22	139	1977	350	320	30	6.0	
G2	25 %	01	1200		14 KW	212	50			2.65	2.70	203	2075	284	249	35	6.0	
G2	25 %	01	1200		16 KW	212	50			2.65	2.63	196	2015	294	254	40	6.5	
G2	25 %	01	1200		20 KW	215	49			2.65	2.70	199	2015	345	319	26	6.5	
G2	25 %	01	1200		20 KW	215	50			2.65	2.63	206	1863	329	294	35	6.0	
M1	IDLE	01	320	0	0 HP			0	0		1.05	142	74	144	99	45		
M1	IDLE	02	320	0	0 HP			0	0		1.06	142	136	127	96	31		
M1	SLOW	01	400	170	282 HP			150	1400	15.00	6.33	101	32	965	915	50		
M1	SLOW	03	400	160	281 HP			155	1350	15.00	5.69	82	77	933	909	24		
M1	SLOW	03	400	160	272 HP			150	1350	15.00	5.62	82	83	933	909	24		
M1	CRUISE	01	520	208	472 HP			220	1600	25.20	7.91	162	108	1065	1065	0	5.0	
M1	CRUISE	01	520	208	457 HP			220	1550	25.20	7.67	133	154	959	959	0	5.0	
M1	CRUISE	02	520	192	443 HP			220	1500	25.20	7.24	131	89	1003	1003	0		
M1	CRUISE	02	520	191	443 HP			220	1500	25.20	7.24	127	89	1003	1003	0		
M1	CRUISE	03	530	190	443 HP			220	1500	25.20	7.46	127	108	1041	1041	0		
M1	CRUISE	03	530	194	448 HP			220	1520	25.20	7.54	127	109	1041	1041	0		
M2	IDLE	01	320	0	0 HP			0	0		1.07	108	89		147		4.0	
M2	IDLE	02	320	0	0 HP			0	0		1.06	124	103	145	123	22		
M2	SLOW	03	400	120	272 HP			150	1350	16.15	6.07	97	110	1109	1085	24	5.0	
M2	CRUISE	02	520	192	472 HP			220	1600	26.28	8.29	177	129	1078	1078	0		
M2	CRUISE	02	530	192	478 HP			230	1550	26.28	8.11	153	131	1097	1097	0		
M2	CRUISE	02	530	194	469 HP			230	1520	26.28	7.61	135	119	1097	1097	0		
M2	CRUISE	03	540	194	448 HP			220	1520	26.28	7.65	138	118	1136	1115	21	5.5	
M2	CRUISE	03	540	194	448 HP			220	1520	26.28	7.65	136	115	1136	1136	0		

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 3
PAGE 1

VESSEL NAME : USCGC CAMPBELL — VESSEL REG # : 32
VESSEL TYPE & CLASS : WHEC - 327 — FUEL : NAVY SPECIAL

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	7/24/72	1940	2330	29.74	74.0	66.5	78	.0140	85.84	11.60	1.64	1.62	7.40
2	7/25/72	1200	2030	29.72	82.5	69.0	64	.0153	85.84	11.60	1.64	1.62	7.40

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
M1	IDLE	#2		0		230	475			80.70	4.98	10		83	83	0	1.0	
M1	CRUISE	#1		180		230	480			161.00	6.17	13	8	89	87	2	2.5	
M1	FULL	#2		220		230	630			282.00	6.29	55	10	91	89	2	2.5	
M2	IDLE	#2		0		230	435			80.70	4.80	30		90	87	3	2.5	
M2	CRUISE	#1		180		230	480			188.50	7.05	14	6	113	110	3	3.5	
M2	FULL	#2		220		230	640			282.00	9.71	17	3	161	161	0	3.0	
M3	IDLE	#2		0		230	475			80.70	4.83	11		78	77	1	1.0	
M3	CRUISE	#1		180		230	480			161.00	6.48	12	6	99	94	5	3.0	
M3	FULL	#2		220		230	630			282.00	6.90	70	7	99	99	0	2.5	
M4	IDLE	#2		0		230	435			80.70	4.93	43		75	74	1	1.0	
M4	CRUISE	#1		180		230	480			188.50	9.07	19	4	142	142	0	5.0	456
M4	FULL	#2		220		230	640			282.00	1.28	5	16	22	20	2	1.5	
M5	IDLE	#2		0		230	475			80.70	3.67	14		61	60	1	1.5	
M5	CRUISE	#1		180		230	480			161.00	7.20	10	6	126	124	2	3.5	514
M5	FULL	#2		220		230	630			282.00	9.21	49	2	133	131	2	2.0	491
M6	IDLE	#2		0		230	435			80.70	3.82	36		70	68	2	2.0	
M6	CRUISE	#1		180		230	480			188.50	7.55	16	7	118	118	0	5.0	
M6	FULL	#2		220		230	640			282.00	8.71	13	3	140	140	0	2.0	478
M7	IDLE	#2		0		230	475			80.70	6.03	19		96	95	1	2.0	

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 3
PAGE 2

VESSEL NAME : USCGC CAMPBELL VESSEL REG # : 32
VESSEL TYPE & CLASS : WHEC - 327 FUEL : NAVY SPECIAL

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
M7	CRUISE	#1		180		230	480			161.00	7.44	10	4	119	119	0		
M7	FULL	#2		220		230	630			282.00	10.31	52	10	155	153	2	3.0	
M8	IDLE	#2		0		230	435			80.70	2.84	89		43	43	0	2.5	
M8	CRUISE	#1		180		230	480			188.50	6.89	34	7	83	81	2	4.5	
M8	FULL	#2		220		230	640			282.00	9.54	16	3	148	148	0	2.0	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 4
PAGE 1

VESSEL NAME : USCGC ACTIVE — VESSEL REG # : 618
VESSEL TYPE & CLASS : WMEC - 210A — FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	8/ 3/72	0800	1720	29.62	78.0	64.7	64	.0132	86.55	13.03	.17	1.81	6.64
2	8/ 4/72	0900	1426	29.63	92.0	55.5	29	.0095	86.55	13.03	.17	1.81	6.64

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
B2	NORMAL	02					150				3.00	140	1297	15	15	0	6.0	
B2	LO FLM	02					140				3.07	153	1026	15	15	0	6.0	
G1	0 %	02	1800		0 KW	440	0				3.13	189	26	223	200	23	7.0	
G1	40 %	02	1800		80 KW	440	110				6.01	120	110	416	398	18	9.0	
G1	63 %	02	1800		125 KW	440	195				8.19	561	220	411	411	0	9.5	
G2	0 %	02	1800		0 KW	440	0				1.44	124	64	86	72	14	6.0	
G2	30 %	02	1800		60 KW	440	80				2.90	115	58	191	180	11	8.0	
G2	55 %	02	1800		110 KW	440	180				1.81	55	48	90	88	2	7.0	
M1	SLOW	01	530	160							.98	93		153			4.5	
M1	CRUISE	01	600	185							5.13	159		1357	1309	48		
M1	FULL	01	890	265							7.09	1068	177		1532		8.0	
M2	FULL	01	900	265							6.04	1092	107	1169	1145	24		
M3	SLOW	01	530	160							3.06	233		489			4.5	
M3	CRUISE	01	600	185							4.06	126		1067	994	73	5.0	
M3	FULL	01	890	265							7.25	1159	216	1632	1582	50		
M4	FULL	01	900	265							6.64	1194	116	1264	1240	24	9.5	

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 5
PAGE 1

VESSEL NAME : USCGC RELIEF VESSEL REG # : 613
VESSEL TYPE & CLASS : WLV - 128 FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	8/ 8/72	1400	1815	29.73	87.0	62.5	44	.0122	86.40	13.15	.19	1.83	6.57

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
B2	NORMAL	#1					15			3.50	10.52	119		266	234	32	1.0	
G1	0 %	#1	1200		0 KW	440	0				1.26	154	903	138	116	22	5.0	
G1	50 %	#1	1200		19 KW	440	32				3.15	158	1203	329	295	34	6.0	
G1	75 %	#1	1200		30 KW	450	44				4.07	174	1147	447	426	21	7.0	
G2	0 %	#1	1200		0 KW	440	0				1.32	132	1338	114	101	13	6.0	
G2	50 %	#1	1200		20 KW	450	34				3.51	181	1393	355	341	14		
G2	50 %	#1	1200		16 KW	440	32				3.16	158	1347	296	286	10	6.5	
G2	75 %	#1	1200		27 KW	440	47				4.16	210	1486	397	365	32		
G2	75 %	#1	1200		34 KW	440	48				4.16	219	1393	431	408	23	7.5	

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 6
PAGE 1

VESSEL NAME : USCGC 40538 VESSEL REG # : 40538
VESSEL TYPE & CLASS : U/T - 40 FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	8/11/72	1420	1615	30.38	72.0	48.8	44	.0072	87.57	12.03	.25	1.65	7.28
2	8/14/72	1200	1300	30.35	70.0	50.4	50	.0076	87.57	12.03	.25	1.65	7.28

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
M1	IDLE	01	650	0						.20	1.09	431	624				5.5	
M1	CRUISE	01	800	400						2.40	1.94	168	576				3.0	
M1	FULL	01	1000	500						4.67	2.44	125	447				1.0	
M2	SLOW	01	600	300						1.14	1.69	341	350				7.0	
M2	SLOW	02	600	300						1.14	2.30	333	369	368	357	11		
M2	CRUISE	01	800	400						2.40	2.83	265	576				5.0	
M2	CRUISE	02	800	400						2.40	3.17	288	494	573	529	44		
M2	FULL	01	1000	500						4.80	4.15	172	640				4.0	
M2	FULL	02	1000	500						4.80	3.99	193	516	723	701	22		

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 7
PAGE 1

VESSEL NAME : USCGC WHITE HEATH — VESSEL REG # : 545
VESSEL TYPE & CLASS : WLM - 133 — FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	8/16/72	0915	1220	30.04	66.0	55.3	68	.0093	86.19	13.25	.24	1.85	6.50
2	8/17/72	1330	1420	30.26	72.0	58.6	63	.0104	86.19	13.25	.24	1.85	6.50
3	9/18/72	1200	1400	30.42	86.0	56.4	37	.0095	86.19	13.25	.24	1.85	6.50

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
B1	NORMAL	02					15			2.50	6.26	26	134	37	34	3	5.0	
G1	99 %	01	1500		60 KW			116	250	4.40	6.41	1296	1425	220	181	39	9.5	
M1	SLOW	01	120	120						1.80	2.00	83	156	289	269	20	6.0	
M1	CRUISE	01	200	200						6.00	3.69	142	301	606	553	53	5.5	
M1	FULL	01	310	310						15.40	7.24	220	128	795	769	26	7.0	
M1	FULL	02	320	320							7.22	421	218	659	644	15	8.5	
M2	CRUISE	01	260	260						5.20	4.12	115	202	694	667	27	5.0	
M2	FULL	01	330	330						12.80	6.37	209	162	886	866	20	6.0	
M2	FULL	02	340	340						13.80	6.58	278	241	846	820	26	7.0	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 8
PAGE 1

VESSEL NAME : USCGC CHASE — VESSEL REG # : 718
VESSEL TYPE & CLASS : WHEC - 378 — FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	8/23/72	0950	1630	30.01	87.0	65.2	48	.0133	85.90	13.60	.22	1.90	6.32
2	8/24/72	0820	1530	29.96	87.0	68.5	54	.0150	85.90	13.60	.22	1.90	6.32
3	10/31/72	1220	2330	30.36	84.5	49.8	30	.0075	86.32	13.37	.20	1.86	6.46

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
B1	NORMAL	#1					125			32.60	5.48	111	96	43	42	1	4.0	
B1	LO FLM	#1					120			29.90	5.87	102	52	54	52	2	4.0	
B2	NORMAL	#2					130			32.60	7.29	89	169	53	52	1	4.0	
B2	LO FLM	#2					121			29.90	7.61	88	192	52	51	1	4.5	
G1	0 %	#1	750		0 KW	450	0			8.57	1.15	35	408	75	73	2	7.0	
G1	80 %	#1	750		400 KW	450	570			28.32	4.20		535	720	710	10	7.0	
G1	80 %	#1	750		400 KW	450	570			28.32	3.85	253	336	663	663	0	6.5	
G1	80 %	#1	750		435 KW	450	620				4.35	385	290	838	833	5	6.0	
G1	90 %	#1	750		450 KW	450	680			35.45	4.78	511	267	951	946	5	7.0	
G2	0 %	#2	740		0 KW	450	0			7.20	1.07	58	253	72	71	1	6.0	
G2	50 %	#2	740		230 KW	450	375			19.78	2.76	77	276	265	260	5	7.0	
G2	80 %	#2	740		380 KW	450	700			31.60	4.42	161	284		641		7.5	
M1	SLOW	#3	460	76						26.70	1.72	190	157	299	256	43	1.0	
M1	2/3	#3	560	94						61.60	3.46	85	127	522	512	10	2.0	
M1	CRUISE	#3	742	123						106.70	5.46	137	185	718	718	0	5.0	
M1	FULL	#3	820	135						146.70	6.35	310	208	802	797	5	9.0	
M1	FULL	#3	840	135						146.70	6.55	316	239	805	805	0	6.0	
M2	COLD	#3	0	0							1.87	221		379				
M2	SLOW	#2	450	78						26.70	2.10	211	160	301	278	23	1.5	
M2	2/3	#2	550	95						56.60	5.57	82	175	863	863	0	6.0	
M2	CRUISE	#2	600	100						108.20	6.83	350	283	1131	1106	25	8.5	

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 8
PAGE 2

VESSEL NAME : USCGC CHASE VESSEL REG # : 718
VESSEL TYPE & CLASS : WHEC - 378 FUEL : NAVY DISTILLATE

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
M2	CRUISE	03	720	125						108.20	4.79	70	310	725	720	5	6.0	
M2	FULL	03	800	140						153.20	6.35	218	303	915			7.5	
M2	FLANK	03	840	150						183.20	7.13	408	283	1042			9.0	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 9
PAGE 1

VESSEL NAME : USCGC SPAR — VESSEL REG # : 403
VESSEL TYPE & CLASS : WLB - 180C — FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	8/29/72	1110	1455	29.85	87.8	62.1	42	.0119	86.15	13.28	.17	1.85	6.49
2	8/30/72	1000	1140	30.10	76.0	58.9	55	.0105	86.15	13.28	.17	1.85	6.49
3	8/31/72	0820	0930	30.23	82.0	58.9	46	.0105	86.15	13.28	.17	1.85	6.49

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
G1	20 %	03	1250		11 KW	200	50				3.57	453	898	116	96	20	7.5	
G2	20 %	03	1350		15 KW	200	75				2.88	298	423	201	181	20	7.0	
M1	IDLE	02	320	0							.94	175	121	111	92	19	2.0	
M1	CRUISE	01	595	180							6.27	137	63	1211	1187	24	5.0	
M1	CRUISE	02	510	185							6.69	93	75	1300	1275	25	5.0	
M2	IDLE	02	320	0							1.09	257	156	106	82	24	1.5	
M2	CRUISE	01	600	190							6.41	390	90				7.0	
M2	CRUISE	01	600	190							6.75	174	71	1211	1187	24	6.0	
M2	CRUISE	02	515	184							6.53	72	84	1350	1325	25	5.5	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 10
PAGE 1

VESSEL NAME : USCGC CAPE HORN
VESSEL TYPE & CLASS : WPB - 95C
VESSEL REG # : 95322
FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	9/ 6/72	0745	1155	30.03	71.3	55.0	56	.0092	86.10	13.08	.10	1.82	6.58

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
G1	60 %	01	1250		12 KW	450	22				3.35	141	1038	625	555	70	6.0	
G2	0 %	01	900		0 KW	0	0				1.16	102	492	160	125	35	6.0	
G2	50 %	01	1250		10 KW	450	18				2.44	75	886	420	365	55	5.5	
M1	SLOW	01	1140	400							4.07	157	71	308	288	20	7.5	
M1	CRUISE	01	1600	550							7.42	284	417	1100	1075	25	7.5	
M2	SLOW	01	1200	400							3.71	181	105	283	260	23	8.0	
M2	CRUISE	01	1650	550							7.83	889	120	975	975	0	8.5	
M3	SLOW	01	1190	400							4.81	366	201	373	348	25	6.5	
M3	CRUISE	01	1690	550							7.66	726		1275	1275	0	7.5	
M4	SLOW	01	1100	400							5.27	257	101	358	348	10	8.0	
M4	CRUISE	01	1700	550							8.08	714	292	395	378	17	9.0	
M4	CRUISE	01	1600	550							8.00	633	50	1075	1075	0	8.5	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 11
PAGE 1

VESSEL NAME : USCGC POINT JACKSON — VESSEL REG # : 82378
VESSEL TYPE & CLASS : WPB - 82D — FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	9/11/72	1400	1650	30.05	74.0	53.5	49	.0087	86.47	13.06	.12	1.81	6.62
2	9/12/72	1015	1420	29.94	88.8	65.6	47	.0135	86.47	13.06	.12	1.81	6.62

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
B1	NORMAL	02						125		2.30	10.38	23	22	63	61	2	3.5	
G1	0 %	01	1250		0 KW	450	0			.60	1.81	124	156	291	265	26	2.0	
G1	30 %	01	1250		6 KW	450	10			.80	2.81	84	215	559	545	14	2.5	
G1	80 %	01	1250		17 KW	450	27			1.50	5.37	71	245	1071	1047	24	5.0	
G2	0 %	01	1250		0 KW	400	0			.40	1.53	113	365	423	382	41	2.5	
G2	30 %	01	1250		7 KW	450	10			.60	2.28	67	293	574	544	30	3.0	
G2	70 %	01	1250		14 KW	450	24			1.20	3.47	75	224	811	786	25	4.0	
M1	IDLE	02	650	0							1.76	112	487	93	62	31	6.0	
M1	2/3	02	1350	430							5.87	264	211	463	449	14	8.0	
M1	CRUISE	02	1900	640						31.20	8.77	527	298	1740	1692	48	8.0	
M2	IDLE	02	680	0							1.55	413	676	66	45	21	5.5	
M2	2/3	02	1380	420							5.69	252	47	399	389	10	8.5	
M2	CRUISE	02	2000	630						31.80	8.64	515	86	1263	1238	25	9.0	
M3	2/3	02	1350	430							2.60	101		211	191	20	8.0	
M3	CRUISE	02	1900	620						31.20	1.52	80		226	226	0	7.5	
M4	2/3	02	1350	420							2.53	116		151	146	5	8.5	
M4	CRUISE	02	2000	620						31.80	2.67	143		316	311	5	9.0	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 12

VESSEL NAME : USCGC SHACKLE — VESSEL REG # : 65609
VESSEL TYPE & CLASS : WYTL - 65B — FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	9/14/72	1400	1600	29.68	79.0	65.8	64	.0137	86.70	13.58	.09	1.88	6.38
2	9/15/72	0810	1030	30.06	83.5	55.0	38	.0091	86.70	13.58	.09	1.88	6.38

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
B1	NORMAL	02						190			6.13	421	222	42	35	7	1.5	
G1	0 %	02	900		0 KW	440	0				1.09	161	424	268	225	43	4.0	
G1	50 %	02	1320		10 KW	440	13				2.30	110	1276	405	368	37	4.5	
G2	0 %	02	900		0 KW	440	0				1.36	235	473	272	233	39	5.0	
G2	35 %	02	1320		7 KW	430	9				2.36	134	1213	363	354	9	5.5	
G2	40 %	02	1320		9 KW	430	12				2.89	158	1589	424	382	42	5.5	
M1	IDLE	01	550	0						2.20	1.44	294	240	63	5	58		
M1	CRUISE	01	850	295							4.26	300	255	620	520	100	4.5	
M1	FULL	01	1200	412						20.40	6.77	401	202	780	770	10		

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 13
PAGE 1

VESSEL NAME : USCGC DECISIVE — VESSEL REG # : 629
VESSEL TYPE & CLASS : WMEC - 210B — FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	10/ 3/72	0930	2120	30.32	75.5	53.4	46	.0086	86.00	13.28	.12	1.85	6.48
2	10/ 4/72	0840	1330	30.38	82.0	58.9	46	.0105	86.00	13.28	.12	1.85	6.48

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
B2	NORMAL	02					100			6.50	5.09	1570	98	38	37	1	7.5	
B2	LO FLM	02					50			4.50	3.51	175	97	21	19	2	3.0	
G1	0 %	01	1750		0 KW	440	0			2.64	2.79	378	373	148	121	27	6.0	
G1	73 %	01	1750		145 KW	440	190			10.93	7.45	366	287	456	456	0	8.0	
G4	85 %	02	1750		170 KW	440	260			22.50	8.97	104	30	527	527	0	7.5	
M2	SLOW	01	500	160						10.20	3.09	141	152	625	566	59	5.0	
M2	2/3	01	660	204						48.00	8.59	778	172	1314	1314	0	9.0	
M2	CRUISE	01	920	275						139.65	8.95	437	140	1484	1484	0	6.0	
M2	FULL	01	990	298						139.80	8.48	464	154	1455	1374	81	6.0	
M3	SLOW	01	525	160						17.76	3.21	134	103	450	417	33	5.5	
M3	2/3	01	640	195						39.60	4.72	376	147	596	596	0	8.5	
M3	FULL	01	1000	300						140.16	5.05	489	168	813	791	22	6.5	
M5	SLOW	01	525	160						17.76	1.27	52	24	173	168	5		
M5	2/3	01	660	200						39.60	1.71	130	35	222	217	5		
M5	FULL	01	1000	300						140.16	1.62	88	60	286	275	11		
M6	SLOW	01	500	160						10.20	1.00	41	23	237	216	21		
M6	2/3	01	660	200						48.00	2.99	328	51	447	436	11	9.5	
M6	CRUISE	01	950	270						139.65	1.64	90	38	274	269	5	6.5	
M6	FULL	01	990	298						139.80	3.09	196	82	537	495	42	7.0	

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 14
PAGE 1

VESSEL NAME : USCGC BOAT 44318 VESSEL REG # : 44318
VESSEL TYPE & CLASS : MLB - 44 FUEL : NAVY DISTILLATE

TEST	DATE	START TIME	STOP TIME	BAR.PRES. IN.HG	DB.TEMP DEG.F	DP.TEMP DEG.F	REL.HUM %	ABS.HUM # H2O/# DRY AIR	FUEL %C	FUEL %H	FUEL %S	FUEL H/C-(A)	FUEL C/H-(M)
1	10/12/72	1030	1430	30.10	59.5	50.3	71	.0077	86.62	13.04	.22	1.81	6.64

EXHAUST EMISSION CONCENTRATION DATA AS SAMPLED :

ENG	MODE	TEST	ENG RPM	SHAFT RPM	APPROX. LOAD	V-AC/ DRAFT	A-AC/ STM.PR	V-DC/ H2O TMP	A-DC	FUEL RATE GPH	CO2 % DRY	CO PPM DRY	THC PPM-C WET	NOX PPM DRY	NO PPM DRY	NO2 PPM DRY	SMOKE	SO2 PPM WET
M1	IDLE	01	740								.38	20	202	1	1	0	8.0	
M1	SLOW	01	1500								1.28	101	221	72	63	9	8.0	
M1	FULL	01	2600								10.12	2514	197	941	910	31	9.5	
M2	IDLE	01	740								.32	13	201	1	1	0	5.5	
M2	SLOW	01	1500								2.62	156	200	80	80	0	7.0	
M2	FULL	01	2250								5.06	331	148	410	410	0	9.5	
M2	FULL	01	2250								5.23	282	164	444	444	0	9.5	

APPENDIX C

MASS EMISSION RATES

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 1
PAGE 1

VESSEL NAME : USCGC YANKTON — VESSEL REG # : 72
VESSEL TYPE & CLASS : WYTM - 110A — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL					# / HOUR				
							CO	THC	NOX	SOX	SMOKE	PART	CO	THC	NOX	SOX
G1	20 %	1160			10 KW		18.12		30.15		5.5					
G1	45 %	1160			24 KW		13.30		30.56		6.0					
G2	0 %	1240			0 KW		69.13	184.30	34.51		4.0					
G2	35 %	1230			18 KW		33.40	121.35	46.63		4.5					
G2	35 %	1230			17 KW		31.96	124.65	43.80		4.5					
G2	45 %	1230			23 KW		27.32	106.84	45.33		4.5					
M1	CRUISE	500	220				7.37	5.18	65.09		4.5					
M1	CRUISE	550	230				7.53	5.46	58.34		4.5					
M2	CRUISE	500	220				6.33	5.20	63.70		4.5					

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 2
PAGE 1

VESSEL NAME : USCGC COWSLIP — VESSEL REG # : 277
VESSEL TYPE & CLASS : WLB - 180A — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL CO	THC	NOX	SOX	SMOKE	# / HOUR PART	CO	THC	NOX	SOX
B1	NORMAL					43.2	3.62	1.05	2.25		6.5		.16	.05	.10	
G1	25 %	1200			18 KW	20.3	7.87	59.43	32.08		6.0		.16	1.21	.65	
G1	25 %	1200			18 KW	20.3	8.18	60.26	33.82		6.0		.17	1.23	.69	
G2	25 %	1200			14 KW	19.0	13.99	73.78	32.16		6.0		.27	1.41	.61	
G2	25 %	1200			16 KW	19.0	13.87	73.53	34.18		6.5		.26	1.40	.65	
G2	25 %	1200			20 KW	19.0	13.75	71.81	39.15		6.5		.26	1.37	.75	
G2	25 %	1200			20 KW	19.0	14.66	68.34	38.45		6.0		.28	1.30	.73	
M1	IDLE	320	0		0 HP		26.82	7.10	44.67							
M1	IDLE	320	0		0 HP		26.41	12.83	38.81							
M1	SLOW	400	170		282 HP	100.0	3.22	.54	50.58				.35	.06	5.46	
M1	SLOW	400	160		281 HP	100.0	2.91	1.44	54.36				.31	.16	5.87	
M1	SLOW	400	160		272 HP	100.0	2.94	1.58	55.03				.32	.17	5.94	
M1	CRUISE	520	200		472 HP	181.4	4.13	1.49	44.61		5.0		.75	.27	8.09	
M1	CRUISE	520	200		457 HP	181.4	3.50	2.18	41.41		5.0		.63	.40	7.51	
M1	CRUISE	520	192		443 HP	181.4	3.65	1.33	45.92				.66	.24	8.33	
M1	CRUISE	520	191		443 HP	181.4	3.54	1.33	45.92				.64	.24	8.33	
M1	CRUISE	530	190		443 HP	181.4	3.43	1.57	46.25				.62	.28	8.39	
M1	CRUISE	530	194		448 HP	181.4	3.40	1.57	45.76				.62	.28	8.30	
M2	IDLE	320	0		0 HP		20.00	8.40			4.0					
M2	IDLE	320	0		0 HP		23.18	9.76	44.52							
M2	SLOW	400	120		272 HP	116.2	3.22	1.94	60.53		5.0		.37	.23	7.04	
M2	CRUISE	520	192		472 HP	189.2	4.31	1.70	43.07				.81	.32	8.15	
M2	CRUISE	530	192		478 HP	189.2	3.80	1.76	44.81				.72	.33	8.48	
M2	CRUISE	530	194		469 HP	189.2	3.58	1.69	47.76				.68	.32	9.04	
M2	CRUISE	540	194		448 HP	189.2	3.64	1.67	49.20		5.5		.69	.32	9.31	
M2	CRUISE	540	194		448 HP	189.2	3.59	1.63	49.21				.68	.31	9.31	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 3
PAGE 1

VESSEL NAME : USCGC CAMPBELL — VESSEL REG # : 32
VESSEL TYPE & CLASS : WHEC - 327 — FUEL : NAVY SPECIAL

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL					# / HOUR				
							CO	THC	NOX	SOX	SMOKE	PART	CO	THC	NOX	SOX
M1	IDLE		0			604.4	.41		5.62		1.0		.25		3.40	
M1	CRUISE		180			1205.9	.43	.14	4.87		2.5		.52	.17	5.87	
M1	FULL		220			2112.2	1.79	.17	4.88		2.5		3.79	.37	10.30	
M2	IDLE		0			604.4	1.28		6.32		2.5		.78		3.82	
M2	CRUISE		180			1411.9	.41	.09	5.41		3.5		.58	.13	7.64	
M2	FULL		220			2112.2	.36	.03	5.59		3.0		.76	.07	11.82	
M3	IDLE		0			604.4	.47		5.45		1.0		.28		3.29	
M3	CRUISE		180			1205.9	.38	.10	5.15		3.0		.46	.12	6.22	
M3	FULL		220			2112.2	2.08	.11	4.84		2.5		4.40	.23	10.22	
M4	IDLE		0			604.4	1.79		5.13		1.0		1.08		3.10	
M4	CRUISE		180			1411.9	.43	.05	5.28	25.80	5.0		.61	.07	7.46	36.42
M4	FULL		220			2112.2	.80	1.31	5.79		1.5		1.69	2.76	12.23	
M5	IDLE		0			604.4	.78		5.61		1.5		.47		3.39	
M5	CRUISE		180			1205.9	.29	.09	5.90	36.12	3.5		.34	.11	7.12	43.56
M5	FULL		220			2112.2	1.09	.02	4.87	27.42	2.0		2.31	.05	10.29	57.92
M6	IDLE		0			604.4	1.93		6.18		2.0		1.17		3.73	
M6	CRUISE		180			1411.9	.44	.10	5.27		5.0		.61	.14	7.44	
M6	FULL		220			2112.2	.31	.04	5.42	28.13	2.0		.65	.08	11.46	59.42
M7	IDLE		0			604.4	.65		5.37		2.0		.39		3.25	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 3
PAGE 2

VESSEL NAME : USCGC CAMPBELL — VESSEL REG # : 32
VESSEL TYPE & CLASS : WHEC - 327 — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL CO	THC	NOX	SOX	SMOKE	# / HOUR PART	CO	THC	NOX	SOX
M7	CRUISE		180			1205.9	.28	.06	5.40				.33	.07	6.51	
M7	FULL		220			2112.2	1.04	.11	5.07		3.0		2.19	.23	10.71	
M8	IDLE		0			604.4	6.42		5.09		2.5		3.88		3.08	
M8	CRUISE		180			1411.9	1.01	.11	4.06		4.5		1.43	.16	5.74	
M8	FULL		220			2112.2	.34	.04	5.23		2.0		.73	.07	11.06	

AVERAGE EMISSION RATES

	MODE	FUEL RATE #/HR	# / 1000 # FUEL CO	THC	NO_X	SO_X	# / HOUR PART	CO	THC	NO_X	SO_X
STARBOARD BOILER	IDLE	604.4	.58	-	5.51	-		.35	-	3.33	-
	CRUISE	1205.9	.34	.094	5.36	37.64	3.283	.44	.11	6.46	45.39
	FULL	2112.2	1.49	.101	4.92	29.02	17.121	3.15	.21	10.39	61.29
PORT BOILER	IDLE	604.4	2.85	-	5.68			1.72	-	3.43	
	CRUISE	1411.9	.58	.088	4.98	24.65	3.690	.82	.12	7.03	34.80
	FULL	2112.2	.45	.35	5.50	29.67	14.720	.95	.74	11.62	62.67

NOTES: CRUISE AND FULL VALUES ARE STACK VELOCITY WEIGHTED AVERAGES.
IDLE VALUES ARE AREA WEIGHTED AVERAGES.

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 4
PAGE 1

VESSEL NAME : USCGC ACTIVE — VESSEL REG # : 618
VESSEL TYPE & CLASS : WMEC - 210A — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL					# / HOUR				
							CO	THC	NOX	SOX	SMOKE	PART	CO	THC	NOX	SOX
B2	NORMAL						9.01	43.02	1.59		6.0					
B2	LO FLM						9.72	33.59	1.56		6.0					
G1	0 %	1800			0 KW		12.16	.86	23.56		7.0					
G1	40 %	1800			80 KW		4.03	1.95	22.96		9.0					
G1	63 %	1800			125 KW		13.75	2.91	16.55		9.5					
G2	0 %	1800			0 KW		17.23	4.52	19.63		6.0					
G2	30 %	1800			60 KW		7.99	2.07	21.80		8.0					
G2	55 %	1800			110 KW		6.12	2.72	16.46		7.0					
M1	SLOW	530	160	.2			19.05		51.49		4.5					
M1	CRUISE	600	185	.8			6.26		87.80			1.180				
M1	FULL	890	265	.8			30.00	2.67			8.0	3.616				
M2	FULL	900	265	.8			35.93	1.87	63.18							
M3	SLOW	530	160	.2			15.32		52.81		4.5					
M3	CRUISE	600	185	.8			6.27		87.23		5.0					
M3	FULL	890	265	.8			31.79	3.19	73.54							
M4	FULL	900	265	.8			35.74	1.86	62.15		9.5					

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 5
PAGE 1

VESSEL NAME : USCGC RELIEF — VESSEL REG # : 613
VESSEL TYPE & CLASS : WLV - 128 — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL					# / HOUR				
							CO	THC	NOX	SOX	SMOKE	PART	CO	THC	NOX	SOX
B2	NORMAL					25.2	2.29		8.40		1.0		.06		.21	
G1	0 %	1200			0 KW		22.78	68.06	33.53		5.0					
G1	50 %	1200			19 KW		9.72	38.33	33.23		6.0					
G1	75 %	1200			30 KW		8.37	28.82	35.32		7.0					
G2	0 %	1200			0 KW		18.16	93.85	25.77		6.0					
G2	50 %	1200			20 KW		9.97	39.89	32.12							
G2	50 %	1200			16 KW		9.64	42.60	29.67		6.5					
G2	75 %	1200			27 KW		9.80	36.25	30.43							
G2	75 %	1200			34 KW		10.24	34.05	33.10		7.5					

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BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 6
PAGE 1

VESSEL NAME : USCGC 40538 — VESSEL REG # : 40538
VESSEL TYPE & CLASS : U/T - 40 — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL					# / HOUR				
							CO	THC	NOX	SOX	SMOKE	PART	CO	THC	NOX	SOX
M1	IDLE	650	0			1.4	73.85	53.91			5.5		.11	.08		
M1	CRUISE	800	400			17.3	17.09	29.74			3.0		.30	.51		
M1	FULL	1000	500			33.6	10.26	18.69			1.0		.34	.63		
M2	SLOW	600	300			8.2	39.73	20.66			7.0		.33	.17		
M2	SLOW	600	300			8.2	28.80	16.25	52.27				.24	.13	.43	
M2	CRUISE	800	400			17.3	18.63	20.71			5.0		.32	.36		
M2	CRUISE	800	400			17.3	18.17	15.99	59.39				.31	.28	1.03	
M2	FULL	1000	500			34.6	8.33	16.01			4.0		.29	.55		
M2	FULL	1000	500			34.6	9.74	13.44	59.94				.34	.46	2.07	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 7
PAGE 1

VESSEL NAME : USCGC WHITE HEATH — VESSEL REG # : 545
VESSEL TYPE & CLASS : WLM - 133 — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL					# / HOUR				
							CO	THC	NOX	SOX	SMOKE	PART	CO	THC	NOX	SOX
B1	NORMAL					18.0	.84	2.29	1.96		5.0		.02	.04	.04	
G1	99 %	1500			60 KW	31.7	39.14	22.89	10.91		9.5		1.24	.73	.35	
M1	SLOW	120	120			13.0	8.29	7.96	47.40		6.0		.11	.10	.61	
M1	CRUISE	200	200			43.2	7.68	8.45	53.86		5.5		.33	.36	2.33	
M1	FULL	310	310			110.9	6.11	1.90	36.28		7.0		.68	.21	4.02	
M1	FULL	320	320				11.68	3.24	30.03		8.5					
M2	CRUISE	260	260			37.4	5.60	5.12	55.49		5.0		.21	.19	2.08	
M2	FULL	330	330			92.2	6.59	2.71	45.90		6.0		.61	.25	4.23	
M2	FULL	340	340			99.4	8.47	3.91	42.34		7.0		.84	.39	4.21	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 8
PAGE 1

VESSEL NAME : USCGC CHASE — VESSEL REG # : 718
VESSEL TYPE & CLASS : WHEC - 378 — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL				SMOKE	# / HOUR				
							CO	THC	NOX	SOX		PART	CO	THC	NOX	SOX
B1	NORMAL					234.7	4.06	1.87	2.59		4.0		.95	.44	.61	
B1	LO FLM					215.3	3.49	.95	3.03		4.0		.75	.20	.65	
B2	NORMAL					234.7	2.45	2.52	2.40		4.0		.57	.59	.56	
B2	LO FLM					215.3	2.32	2.74	2.25		4.5		.50	.59	.48	
G1	0 %	750			0 KW	61.7	5.89	35.07	20.75		7.0		.36	2.16	1.28	
G1	80 %	750			400 KW	203.9					7.0	.932				
G1	80 %	750			400 KW	203.9	13.03	9.05	56.07		6.5	.932	2.66	1.85	11.43	
G1	80 %	750			435 KW		17.54	6.95	62.72		6.0	.932				
G1	90 %	750			450 KW	255.3	21.17	5.84	64.73		7.0		5.41	1.49	16.52	
G2	0 %	740			0 KW	51.8	10.60	23.64	21.61		6.0		.55	1.23	1.12	
G2	50 %	740			230 KW	142.4	5.54	10.32	31.34		7.0		.79	1.47	4.46	
G2	80 %	740			380 KW	227.5	7.26	6.75			7.5		1.65	1.54		
M1	SLOW	460	76	.5		192.2	21.86	9.18	56.52		1.0		4.20	1.77	10.86	
M1	2/3	560	94	1.1		443.5	4.93	3.80	49.74		2.0		2.19	1.69	22.06	
M1	CRUISE	742	123	1.1		768.2	5.04	3.58	43.36		5.0		3.87	2.75	33.31	
M1	FULL	820	135	1.1		1056.2	9.78	3.48	41.55		9.0	5.832	10.33	3.67	43.89	
M1	FULL	840	135	1.0		1056.2	9.66	3.88	40.42		6.0	5.832	10.20	4.10	42.69	
M2	COLD	IDLE	0	.98			23.59		66.45							
M2	SLOW	450	78	.5		192.2	19.87	7.78	46.57		1.5	1.921	3.82	1.50	8.95	
M2	2/3	550	95	1		407.5	2.95	3.35	51.00		6.0		1.20	1.37	20.78	
M2	CRUISE	600	100	1		779.0	10.22	4.45	54.25		8.5	3.288	7.96	3.47	42.26	

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS VESSEL # : 8
PAGE 2

VESSEL NAME : USCGC CHASE VESSEL REG # : 718
VESSEL TYPE & CLASS : WHEC - 378 FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL					# / HOUR				
							CO	THC	NOX	SOX	SMOKE	PART	CO	THC	NOX	SOX
M2	CRUISE	720	125	.98		779.0	2.93	6.77	49.80		6.0		2.28	5.28	38.80	
M2	FULL	800	140	.98		1103.0	6.87	5.06	47.40		7.5	11.244	7.58	5.58	52.28	
M2	FLANK	840	150	.98		1319.0	11.44	4.23	48.00		9.0		15.09	5.59	63.32	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 9
PAGE 1

VESSEL NAME : USCGC SPAR — VESSEL REG # : 403
VESSEL TYPE & CLASS : WLB - 180C — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL					# / HOUR				
							CO	THC	NOX	SOX	SMOKE	PART	CO	THC	NOX	SOX
G1	20 %	1250			11 KW		24.68	25.40	10.38		7.5					
G2	20 %	1350			15 KW		20.39	14.93	22.59		7.0					
M1	IDLE	320	0				36.46	12.78	37.99		2.0					
M1	CRUISE	595	180				4.40	1.08	63.90		5.0					
M1	CRUISE	510	185				2.80	1.21	64.34		5.0					
M2	IDLE	320	0				45.89	14.14	31.09		1.5					
M2	CRUISE	600	190				12.20	1.50			7.0	.179				
M2	CRUISE	600	190				5.19	1.13	59.33		6.0	.179				
M2	CRUISE	515	184				2.22	1.38	68.46		5.5					

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 10
PAGE 1

VESSEL NAME : USCGC CAPE HORN — VESSEL REG # : 95322
VESSEL TYPE & CLASS : WPB - 95C — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL CO	THC	NOX	SOX	SMOKE	# / HOUR PART	CO	THC	NOX	SOX
G1	60 %	1250			12 KW		8.22	31.27	59.86		6.0					
G2	0 %	900			0 KW		16.92	41.36	43.59		6.0					
G2	50 %	1250			10 KW		5.98	36.21	55.01		5.5					
M1	SLOW	1140	400				7.77	1.83	25.02		7.5					
M1	CRUISE	1600	550				7.67	6.03	48.82		7.5					
M2	SLOW	1200	400				9.80	2.95	25.17		8.0					
M2	CRUISE	1650	550				22.69	1.65	40.88		8.5					
M3	SLOW	1190	400				15.22	4.38	25.48		6.5					
M3	CRUISE	1690	550				19.01		54.83		7.5					
M4	SLOW	1100	400				9.81	2.02	22.44		8.0					
M4	CRUISE	1700	550				17.66	3.89	16.05		9.0	.302				
M4	CRUISE	1600	550				15.88	.67	44.31		8.5	.302				

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 11
PAGE 1

VESSEL NAME : USCGC POINT JACKSON — VESSEL REG # : 82378
VESSEL TYPE & CLASS : WPB - 82D — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL					# / HOUR				
							CO	THC	NOX	SOX	SMOKE	PART	CO	THC	NOX	SOX
B1	NORMAL					16.6	.45	.24	2.02		3.5		.01	.00	.03	
G1	0 %	1250			0 KW	4.3	13.67	8.76	52.68		2.0		.06	.04	.23	
G1	30 %	1250			6 KW	5.8	5.99	7.88	65.49		2.5		.03	.05	.38	
G1	80 %	1250			17 KW	10.8	2.66	4.83	65.97		5.0		.03	.05	.71	
G2	0 %	1250			0 KW	2.9	14.50	23.80	89.17		2.5		.04	.07	.26	
G2	30 %	1250			7 KW	4.3	5.86	13.10	82.45		3.0		.03	.06	.36	
G2	70 %	1250			14 KW	8.6	4.34	6.70	77.10		4.0		.04	.06	.67	
M1	IDLE	650	0				12.46	27.76	16.99		6.0					
M1	2/3	1350	430				9.04	3.84	26.03		8.0					
M1	CRUISE	1900	640			224.6	12.06	3.71	65.40		8.0		2.71	.83	14.69	
M2	IDLE	680	0				50.37	42.19	13.22		5.5					
M2	2/3	1380	420				8.93	.88	23.22		8.5					
M2	CRUISE	2000	630			229.0	11.99	1.09	48.31		9.0		2.74	.25	11.07	
M3	2/3	1350	430				7.84		26.91		8.0					
M3	CRUISE	1900	620			224.6	10.61		49.23		7.5		2.38		11.05	
M4	2/3	1350	420				9.25		19.77		8.5					
M4	CRUISE	2000	620			229.0	10.79		39.18		9.0		2.47		8.97	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 12

VESSEL NAME : USCGC SHACKLE — VESSEL REG # : 65609
VESSEL TYPE & CLASS : WYTL - 65B — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL				SMOKE	# / HOUR				
							CO	THC	NOX	SOX		PART	CO	THC	NOX	SOX
B1	NORMAL						13.70	3.83	2.25		1.5					
G1	0 %	900			0 KW		28.24	37.69	77.21		4.0					
G1	50 %	1320			10 KW		9.08	53.96	54.90		4.5					
G2	0 %	900			0 KW		33.09	33.84	62.90		5.0					
G2	35 %	1320			7 KW		10.81	50.18	48.11		5.5					
G2	40 %	1320			9 KW		10.37	53.75	45.72		5.5					
M1	IDLE	550	0			15.8	39.67	16.58	13.96				.63	.26	.22	
M1	CRUISE	850	295				14.01	6.25	47.56		4.5					
M1	FULL	1200	412			146.9	11.83	3.20	37.81				1.74	.47	5.55	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 13
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VESSEL NAME : USCGC DECISIVE — VESSEL REG # : 629
VESSEL TYPE & CLASS : WMEC - 210B — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL					# / HOUR				
							CO	THC	NOX	SOX	SMOKE	PART	CO	THC	NOX	SOX
B2	NORMAL					46.8	60.34	1.98	2.40		7.5		2.82	.09	.11	
B2	LO FLM					32.4	9.99	2.87	1.97		3.0		.32	.09	.06	
G1	0 %	1750			0 KW	19.0	26.64	13.52	17.13		6.0		.51	.26	.33	
G1	73 %	1750			145 KW	78.7	9.84	4.13	20.13		8.0		.77	.33	1.58	
G4	85 %	1750			170 KW	162.0	2.34	.37	19.47		7.5		.38	.06	3.15	
M2	SLOW	500	160	53		73.4	9.13	5.07	66.48		5.0		.67	.37	4.88	
M2	2/3	660	204	85		345.6	18.10	2.16	50.20		9.0		6.25	.75	17.35	
M2	CRUISE	920	275	85		1005.5	9.80	1.70	54.67		6.0		9.85	1.71	54.97	
M2	FULL	990	298	85		1006.6	10.97	1.97	56.52		6.0		11.05	1.98	56.89	
M3	SLOW	525	160	64		127.9	8.37	3.32	46.18		5.5		1.07	.42	5.90	
M3	2/3	640	195	85		285.1	15.92	3.25	41.44		8.5		4.54	.93	11.82	
M3	FULL	1000	300	84		1009.2	19.31	3.48	52.73		6.5		19.49	3.51	53.22	
M5	SLOW	525	160	64		127.9	8.22	1.92	44.94				1.05	.25	5.75	
M5	2/3	660	200	84		285.1	15.21	2.09	42.67				4.34	.59	12.17	
M5	FULL	1000	300	84		1009.2	10.87	3.77	58.05				10.97	3.81	58.59	
M6	SLOW	500	160	53		73.4	8.23	2.34	78.15				.60	.17	5.74	
M6	2/3	660	200	85		345.6	21.88	1.75	48.99		9.5		7.56	.61	16.93	
M6	CRUISE	950	270	86		1005.5	11.00	2.36	55.02		6.5		11.06	2.38	55.32	
M6	FULL	990	298	85		1006.6	12.70	2.74	57.16		7.0		12.78	2.76	57.53	

SCOTT RESEARCH LABORATORIES — SRL 1302-016-0373 — DATE 03/05/73
BASELINE STACK EMISSION DATA - COAST GUARD VESSELS — VESSEL # : 14
PAGE 1

VESSEL NAME : USCGC BOAT 44318 — VESSEL REG # : 44318
VESSEL TYPE & CLASS : MLB - 44 — FUEL : NAVY DISTILLATE

EXHAUST EMISSION DATA ON A MASS BASIS :

ENG	MODE	ENG RPM	SHAFT RPM	PROP PITCH	APPROX. LOAD	FUEL RATE #/HR	# / 1000 # FUEL					# / HOUR				
							CO	THC	NOX	SOX	SMOKE	PART	CO	THC	NOX	SOX
M1	IDLE	740					10.07	51.08	.83		8.0					
M1	SLOW	1500					15.60	17.27	18.26		8.0					
M1	FULL	2600					49.03	2.10	30.15		9.5					
M2	IDLE	740					7.71	59.84	.97		5.5					
M2	SLOW	1500					11.90	7.82	10.03		7.0					
M2	FULL	2250					13.13	3.07	26.72		9.5					
M2	FULL	2250					10.83	3.30	28.02		9.5					

APPENDIX D

PARTICULATE EMISSION ANALYSIS

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 1 TEST # : 3
ENGINE : M2 MODE : 30
SAMPLE POINT : 50.0 % OF STACK DIAM.
STACK TYPE : CIRCULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :

STACK AREA : 81.71 SQ.IN.	NOZZLE DIAM.: 250. MILS
C-FACTOR : .855	SAMPLING TIME : 7. MIN.
AVG.STACK PRESS.: 30.40 IN.HG.ABS.	B.P.: 30.26 IN.HG.ABS.
AVG.STACK TEMP.: 612.0 DEG.F	AVG.GAS METER TEMP.: 100. DEG.F
AVG.STACK VEL.HEAD : .45 IN.H2O	AVG.ORIFICE PRESS.DROP : .81 IN.H2O
VOL.OF DRY GAS SAMPLED : 3.63 SCF	

WATER COLLECTED :

IMPINGERS : 6.0 MLS	
SILICA GEL : .0 GMS	
TOTAL : 6.0 MLS	

PARTICULATE COLLECTED :

FILTER : .0 MG	
WASHINGS : .0 MG	
TOTAL : .0 MG	

STACK CONDITIONS :

AVG.STACK VELOCITY : 3246.0 FPM	STACK GAS MOLECULAR WT.: 28.96
PERCENT MOISTURE BY VOL.: 7.27 %	MOLE FRACTION OF DRY STACK GAS : .927
Q @ STND.COND.: 858.0 SCFM	Q @ STACK COND.: 1842.0 CFM
PERCENT ISOKINETIC : 100.19 %	

PARTICULATES :

LOADING @ STND.COND.: .00000 GR/SCF	LOADING @ STACK COND.: .00000 GR/CF
MASS EMISSION RATE : .000 #/HR	

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 1
ENGINE : M1 MODE : 30
SAMPLE POINT : .0 % OF STACK DIAM.
STACK TYPE : RECTANGULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 1548.00 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 29.94 IN.HG.ABS.
- AVG.STACK TEMP.: 427.0 DEG.F
- AVG.STACK VEL.HEAD : .11 IN.H20
- VOL.OF DRY GAS SAMPLED : 51.57 SCF
- NOZZLE DIAM.: 250. MILS
- SAMPLING TIME : 60. MIN.
- B.P.: 29.91 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : 2.18 IN.H20

WATER COLLECTED :
- IMPINGERS : 89.0 MLS
- SILICA GEL : 17.8 GMS
- TOTAL : 106.8 MLS

PARTICULATE COLLECTED :
- FILTER : 108.5 MG
- WASHINGS : 40.5 MG
- TOTAL : 149.0 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 1471.0 FPM
- PERCENT MOISTURE BY VOL.: 8.94 %
- Q @ STND.COND.: 8609.8 SCFM
- PERCENT ISOKINETIC : 313.86 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .911
- Q @ STACK COND.: 15813.3 CFM

PARTICULATES :
- LOADING @ STND.COND.: .04450 GR/SCF
- MASS EMISSION RATE : 3.283 #/HR
- LOADING @ STACK COND.: .02421 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 2
ENGINE : M1 MODE : 40
SAMPLE POINT : .0 % OF STACK DIAM.
STACK TYPE : RECTANGULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 1548.00 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 30.12 IN.HG.ABS.
- AVG.STACK TEMP.: 462.0 DEG.F
- AVG.STACK VEL.HEAD : .17 IN.H20
- VOL.OF DRY GAS SAMPLED : 31.97 SCF
- NOZZLE DIAM.: 370. MILS
- SAMPLING TIME : 45. MIN.
- B.P.: 29.90 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : 1.45 IN.H20

WATER COLLECTED :
- IMPINGERS : 72.0 MLS
- SILICA GEL : 13.2 GMS
- TOTAL : 85.2 MLS

PARTICULATE COLLECTED :
- FILTER : 215.0 MG
- WASHINGS : 189.0 MG
- TOTAL : 404.0 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 1858.9 FPM
- PERCENT MOISTURE BY VOL.: 11.21 %
- Q @ STND.COND.: 10266.8 SCFM
- PERCENT ISOKINETIC : 99.35 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .888
- Q @ STACK COND.: 19982.7 CFM

PARTICULATES :
- LOADING @ STND.COND.: .19458 GR/SCF
- MASS EMISSION RATE : 17.121 #/HR
- LOADING @ STACK COND.: .09990 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 1
ENGINE : M2 MODE : 30
SAMPLE POINT : .0 % OF STACK DIAM.
STACK TYPE : RECTANGULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 1548.00 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 29.93 IN.HG.ABS.
- AVG.STACK TEMP.: 432.0 DEG.F
- AVG.STACK VEL.HEAD : .09 IN.H2O
- VOL.OF DRY GAS SAMPLED : 45.97 SCF
- NOZZLE DIAM.: 250. MILS
- SAMPLING TIME : 60. MIN.
- B.P.: 29.92 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : 1.77 IN.H2O

WATER COLLECTED :
- IMPINGERS : 71.0 MLS
- SILICA GEL : 14.2 GMS
- TOTAL : 85.2 MLS

PARTICULATE COLLECTED :
- FILTER : 111.5 MG
- WASHINGS : 52.5 MG
- TOTAL : 164.0 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 1334.5 FPM
- PERCENT MOISTURE BY VOL.: 8.08 %
- Q @ STND.COND.: 7838.5 SCFM
- PERCENT ISOKINETIC : 307.36 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .919
- Q @ STACK COND.: 14346.3 CFM

PARTICULATES :
- LOADING @ STND.COND.: .05494 GR/SCF
- MASS EMISSION RATE : 3.690 #/HR
- LOADING @ STACK COND.: .02999 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 2
ENGINE : M2 MODE : 40
SAMPLE POINT : .0 % OF STACK DIAM.
STACK TYPE : RECTANGULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 1548.00 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 30.07 IN.HG.ABS.
- AVG.STACK TEMP.: 462.0 DEG.F
- AVG.STACK VEL.HEAD : .13 IN.H20
- VOL.OF DRY GAS SAMPLED : 38.77 SCF
- NOZZLE DIAM.: 370. MILS
- SAMPLING TIME : 60. MIN.
- B.P.: 29.85 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : 1.15 IN.H20

WATER COLLECTED :
- IMPINGERS : -2.0 MLS
- SILICA GEL : 18.3 GMS
- TOTAL : 16.3 MLS

PARTICULATE COLLECTED :
- FILTER : 193.0 MG
- WASHINGS : 243.5 MG
- TOTAL : 436.5 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 1626.9 FPM
- PERCENT MOISTURE BY VOL.: 1.95 %
- Q @ STND.COND.: 9906.2 SCFM
- PERCENT ISOKINETIC : 93.63 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .980
- Q @ STACK COND.: 17488.9 CFM

PARTICULATES :
- LOADING @ STND.COND.: .17338 GR/SCF
- MASS EMISSION RATE : 14.720 #/HR
- LOADING @ STACK COND.: .09813 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 4 TEST # : 1
ENGINE : M1 MODE : 30
SAMPLE POINT : 80.8 % OF STACK DIAM.
STACK TYPE : CIRCULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 481.11 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 29.55 IN.HG.ABS.
- AVG.STACK TEMP.: 544.0 DEG.F
- AVG.STACK VEL.HEAD : .78 IN.H2O
- VOL.OF DRY GAS SAMPLED : 14.34 SCF
- NOZZLE DIAM.: 250. MILS
- SAMPLING TIME : 50. MIN.
- B.P.: 29.55 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : .15 IN.H2O

WATER COLLECTED :
- IMPINGERS : 12.0 MLS
- SILICA GEL : 4.4 GMS
- TOTAL : 16.4 MLS

PARTICULATE COLLECTED :
- FILTER : 8.0 MG
- WASHINGS : 10.5 MG
- TOTAL : 18.5 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 4194.9 FPM
- PERCENT MOISTURE BY VOL.: 5.14 %
- Q @ STND.COND.: 6931.2 SCFM
- PERCENT ISOKINETIC : 40.43 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .949
- Q @ STACK COND.: 14015.1 CFM

PARTICULATES :
- LOADING @ STND.COND.: .01987 GR/SCF
- MASS EMISSION RATE : 1.180 #/HR
- LOADING @ STACK COND.: .00982 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 4 TEST # : 1
ENGINE : M1 MODE : 40
SAMPLE POINT : 80.8 % OF STACK DIAM.
STACK TYPE : CIRCULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 481.11 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 29.72 IN.HG.ABS.
- AVG.STACK TEMP.: 919.0 DEG.F
- AVG.STACK VEL.HEAD : .52 IN.H2O
- VOL.OF DRY GAS SAMPLED : 15.67 SCF
- NOZZLE DIAM.: 250. MILS
- SAMPLING TIME : 30. MIN.
- B.P.: 29.72 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : .71 IN.H2O

WATER COLLECTED :
- IMPINGERS : 22.0 MLS
- SILICA GEL : 9.1 GMS
- TOTAL : 31.1 MLS

PARTICULATE COLLECTED :
- FILTER : 51.5 MG
- WASHINGS : 40.5 MG
- TOTAL : 92.0 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 4002.6 FPM
- PERCENT MOISTURE BY VOL.: 8.60 %
- Q @ STND.COND.: 4666.3 SCFM
- PERCENT ISOKINETIC : 109.38 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .914
- Q @ STACK COND.: 13372.8 CFM

PARTICULATES :
- LOADING @ STND.COND.: .09042 GR/SCF
- MASS EMISSION RATE : 3.616 #/HR
- LOADING @ STACK COND.: .03153 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 8 TEST # : 1
ENGINE : G1 MODE : 90
SAMPLE POINT : 50.0 % OF STACK DIAM.
STACK TYPE : CIRCULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 108.43 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 31.07 IN.HG.ABS.
- AVG.STACK TEMP.: 630.0 DEG.F
- AVG.STACK VEL.HEAD : 2.90 IN.H2O
- VOL.OF DRY GAS SAMPLED : 52.64 SCF
- NOZZLE DIAM.: 210. MILS
- SAMPLING TIME : 60. MIN.
- B.P.: 30.00 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : 2.30 IN.H2O

WATER COLLECTED :
- IMPINGERS : 32.0 MLS
- SILICA GEL : 24.7 GMS
- TOTAL : 56.7 MLS

PARTICULATE COLLECTED :
- FILTER : 62.0 MG
- WASHINGS : 63.0 MG
- TOTAL : 125.0 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 8219.1 FPM
- PERCENT MOISTURE BY VOL.: 4.86 %
- Q @ STND.COND.: 2973.3 SCFM
- PERCENT ISOKINETIC : 92.11 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .951
- Q @ STACK COND.: 6189.1 CFM

PARTICULATES :
- LOADING @ STND.COND.: .03657 GR/SCF
- MASS EMISSION RATE : .932 #/HR
- LOADING @ STACK COND.: .01755 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 8 TEST # : 3
ENGINE : M1 MODE : 40
SAMPLE POINT : 12.0 % OF STACK DIAM.
STACK TYPE : CIRCULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 572.56 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 30.62 IN.HG.ABS.
- AVG.STACK TEMP.: 850.0 DEG.F
- AVG.STACK VEL.HEAD : 3.30 IN.H2O
- VOL.OF DRY GAS SAMPLED : 57.25 SCF
- NOZZLE DIAM.: 210. MILS
- SAMPLING TIME : 63. MIN.
- B.P.: 30.36 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : 2.35 IN.H2O

WATER COLLECTED :
- IMPINGERS : 51.0 MLS
- SILICA GEL : 19.7 GMS
- TOTAL : 70.7 MLS

PARTICULATE COLLECTED :
- FILTER : 119.5 MG
- WASHINGS : 48.5 MG
- TOTAL : 168.0 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 9682.2 FPM
- PERCENT MOISTURE BY VOL.: 5.53 %
- Q @ STND.COND.: 15058.1 SCFM
- PERCENT ISOKINETIC : 99.46 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .945
- Q @ STACK COND.: 38497.1 CFM

PARTICULATES :
- LOADING @ STND.COND.: .04519 GR/SCF
- MASS EMISSION RATE : 5.832 #/HR
- LOADING @ STACK COND.: .01766 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 8 TEST # : 2
ENGINE : M2 MODE : 20
SAMPLE POINT : 88.2 % OF STACK DIAM.
STACK TYPE : CIRCULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 572.56 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 29.96 IN.HG.ABS.
- AVG.STACK TEMP.: 335.0 DEG.F
- AVG.STACK VEL.HEAD : .36 IN.H20
- VOL.OF DRY GAS SAMPLED : 71.19 SCF
- NOZZLE DIAM.: 388. MILS
- SAMPLING TIME : 60. MIN.
- B.P.: 29.96 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : 4.05 IN.H20

WATER COLLECTED :
- IMPINGERS : 35.0 MLS
- SILICA GEL : 18.1 GMS
- TOTAL : 53.1 MLS

PARTICULATE COLLECTED :
- FILTER : 108.0 MG
- WASHINGS : 52.5 MG
- TOTAL : 160.5 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 2518.5 FPM
- PERCENT MOISTURE BY VOL.: 3.41 %
- Q @ STND.COND.: 6456.6 SCFM
- PERCENT ISOKINETIC : 88.73 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .966
- Q @ STACK COND.: 10013.9 CFM

PARTICULATES :
- LOADING @ STND.COND.: .03472 GR/SCF
- MASS EMISSION RATE : 1.921 #/HR
- LOADING @ STACK COND.: .02237 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 8 TEST # : 2
ENGINE : M2 MODE : 30
SAMPLE POINT : 88.2 % OF STACK DIAM.
STACK TYPE : CIRCULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :

STACK AREA : 572.56 SQ.IN.	NOZZLE DIAM.: 250. MILS
C-FACTOR : .855	SAMPLING TIME : 60. MIN.
AVG.STACK PRESS.: 29.96 IN.HG.ABS.	B.P.: 29.96 IN.HG.ABS.
AVG.STACK TEMP.: 790.0 DEG.F	AVG.GAS METER TEMP.: 60. DEG.F
AVG.STACK VEL.HEAD : 1.00 IN.H20	AVG.ORIFICE PRESS.DROP : 1.40 IN.H20
VOL.OF DRY GAS SAMPLED : 42.23 SCF	

WATER COLLECTED :

IMPINGERS :	51.0 MLS
SILICA GEL :	17.4 GMS
TOTAL :	68.4 MLS

PARTICULATE COLLECTED :

FILTER :	69.0 MG
WASHINGS :	58.5 MG
TOTAL :	127.5 MG

STACK CONDITIONS :

AVG.STACK VELOCITY : 5263.4 FPM	STACK GAS MOLECULAR WT.: 28.96
PERCENT MOISTURE BY VOL.: 7.13 %	MOLE FRACTION OF DRY STACK GAS : .929
Q @ STND.COND.: 8251.8 SCFM	Q @ STACK COND.: 20927.8 CFM
PERCENT ISOKINETIC : 99.20 %	

PARTICULATES :

LOADING @ STND.COND.: .04649 GR/SCF	LOADING @ STACK COND.: .01832 GR/CF
MASS EMISSION RATE : 3.288 #/HR	

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 8 TEST # : 3
ENGINE : M2 MODE : 40
SAMPLE POINT : 12.0 % OF STACK DIAM.
STACK TYPE : CIRCULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 572.56 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 30.60 IN.HG.ABS.
- AVG.STACK TEMP.: 850.0 DEG.F
- AVG.STACK VEL.HEAD : 3.30 IN.H2O
- VOL.OF DRY GAS SAMPLED : 54.86 SCF
- NOZZLE DIAM.: 210. MILS
- SAMPLING TIME : 60. MIN.
- B.P.: 30.36 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : 2.35 IN.H2O

WATER COLLECTED :
- IMPINGERS : 21.0 MLS
- SILICA GEL : 19.3 GMS
- TOTAL : 40.3 MLS

PARTICULATE COLLECTED :
- FILTER : 6.0 MG
- WASHINGS : 297.5 MG
- TOTAL : 303.5 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 9685.3 FPM
- PERCENT MOISTURE BY VOL.: 3.37 %
- Q @ STND.COND.: 15398.2 SCFM
- PERCENT ISOKINETIC : 97.86 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .966
- Q @ STACK COND.: 38509.7 CFM

PARTICULATES :
- LOADING @ STND.COND.: .08520 GR/SCF
- MASS EMISSION RATE : 11.244 #/HR
- LOADING @ STACK COND.: .03404 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 9 TEST # : 1
ENGINE : M2 MODE : 30
SAMPLE POINT : 75.0 % OF STACK DIAM.
STACK TYPE : CIRCULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 78.54 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 32.83 IN.HG.ABS.
- AVG.STACK TEMP.: 774.0 DEG.F
- AVG.STACK VEL.HEAD : 1.75 IN.H2O
- VOL.OF DRY GAS SAMPLED : 52.44 SCF
- NOZZLE DIAM.: 250. MILS
- SAMPLING TIME : 55. MIN.
- B.P.: 29.85 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : 2.70 IN.H2O

WATER COLLECTED :
- IMPINGERS : 51.0 MLS
- SILICA GEL : 23.6 GMS
- TOTAL : 74.6 MLS

PARTICULATE COLLECTED :
- FILTER : 28.3 MG
- WASHINGS : 16.5 MG
- TOTAL : 44.8 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 6608.8 FPM
- PERCENT MOISTURE BY VOL.: 6.32 %
- Q @ STND.COND.: 1591.4 SCFM
- PERCENT ISOKINETIC : 95.58 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .937
- Q @ STACK COND.: 3604.6 CFM

PARTICULATES :
- LOADING @ STND.COND.: .01316 GR/SCF
- MASS EMISSION RATE : .179 #/HR
- LOADING @ STACK COND.: .00580 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 10 TEST # : 1
ENGINE : M4 MODE : 30
SAMPLE POINT : 70.0 % OF STACK DIAM.
STACK TYPE : CIRCULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 53.46 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 30.03 IN.HG.ABS.
- AVG.STACK TEMP.: 641.0 DEG.F
- AVG.STACK VEL.HEAD : .85 IN.H2O
- VOL.OF DRY GAS SAMPLED : 34.40 SCF
- NOZZLE DIAM.: 302. MILS
- SAMPLING TIME : 35. MIN.
- B.P.: 30.03 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : 2.64 IN.H2O

WATER COLLECTED :
- IMPINGERS : 20.0 MLS
- SILICA GEL : 14.8 GMS
- TOTAL : 34.8 MLS

PARTICULATE COLLECTED :
- FILTER : 60.5 MG
- WASHINGS : 40.5 MG
- TOTAL : 101.0 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 4548.9 FPM
- PERCENT MOISTURE BY VOL.: 4.58 %
- Q @ STND.COND.: 778.5 SCFM
- PERCENT ISOKINETIC : 93.93 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .954
- Q @ STACK COND.: 1688.7 CFM

PARTICULATES :
- LOADING @ STND.COND.: .04522 GR/SCF
- MASS EMISSION RATE : .302 #/HR
- LOADING @ STACK COND.: .02083 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 13 TEST # : 1
ENGINE : M4 MODE : 25
SAMPLE POINT : 29.5 % OF STACK DIAM.
STACK TYPE : CIRCULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :
- STACK AREA : 471.44 SQ.IN.
- C-FACTOR : .855
- AVG.STACK PRESS.: 30.31 IN.HG.ABS.
- AVG.STACK TEMP.: 790.0 DEG.F
- AVG.STACK VEL.HEAD : .12 IN.H2O
- VOL.OF DRY GAS SAMPLED : 47.72 SCF
- NOZZLE DIAM.: 500. MILS
- SAMPLING TIME : 60. MIN.
- B.P.: 30.31 IN.HG.ABS.
- AVG.GAS METER TEMP.: 60. DEG.F
- AVG.ORIFICE PRESS.DROP : 1.87 IN.H2O

WATER COLLECTED :
- IMPINGERS : 65.0 MLS
- SILICA GEL : 22.0 GMS
- TOTAL : 87.0 MLS

PARTICULATE COLLECTED :
- FILTER : 160.5 MG
- WASHINGS : 70.0 MG
- TOTAL : 230.5 MG

STACK CONDITIONS :
- AVG.STACK VELOCITY : 1812.7 FPM
- PERCENT MOISTURE BY VOL.: 7.95 %
- Q @ STND.COND.: 2346.3 SCFM
- PERCENT ISOKINETIC : 81.15 %
- STACK GAS MOLECULAR WT.: 28.96
- MOLE FRACTION OF DRY STACK GAS : .920
- Q @ STACK COND.: 5934.7 CFM

PARTICULATES :
- LOADING @ STND.COND.: .07438 GR/SCF
- MASS EMISSION RATE : 1.496 #/HR
- LOADING @ STACK COND.: .02939 GR/CF

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 13 TEST # : 1
ENGINE : M4 MODE : 40
SAMPLE POINT : 29.5 % OF STACK DIAM.
STACK TYPE : CIRCULAR

STACK PARTICULATE ANALYSIS

SAMPLING DATA :

STACK AREA : 471.44 SQ.IN.	NOZZLE DIAM.: 250. MILS
C-FACTOR : .855	SAMPLING TIME : 60. MIN.
AVG.STACK PRESS.: 30.34 IN.HG.ABS.	B.P.: 30.34 IN.HG.ABS.
AVG.STACK TEMP.: 1030.0 DEG.F	AVG.GAS METER TEMP.: 60. DEG.F
AVG.STACK VEL.HEAD : 2.20 IN.H2O	AVG.ORIFICE PRESS.DROP : 2.40 IN.H2O
VOL.OF DRY GAS SAMPLED : 54.73 SCF	

WATER COLLECTED :		PARTICULATE COLLECTED :	
IMPINGERS :	62.0 MLS	FILTER :	46.5 MG
SILICA GEL :	24.0 GMS	WASHINGS :	22.0 MG
TOTAL :	86.0 MLS	TOTAL :	68.5 MG

STACK CONDITIONS :

AVG.STACK VELOCITY : 8469.9 FPM	STACK GAS MOLECULAR WT.: 28.96
PERCENT MOISTURE BY VOL.: 6.93 %	MOLE FRACTION OF DRY STACK GAS : .931
Q @ STND.COND.: 9308.6 SCFM	Q @ STACK COND.: 27729.4 CFM
PERCENT ISOKINETIC : 93.84 %	

PARTICULATES :

LOADING @ STND.COND.: .01927 GR/SCF	LOADING @ STACK COND.: .00647 GR/CF
MASS EMISSION RATE : 1.538 #/HR	

NOTE STANDARD CONDITIONS @ 29.92 IN.HG. & 70 DEG.F.

APPENDIX E

STACK VELOCITY TRAVERSE DATA

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 1 TEST # : 1
ENGINE : G1 MODE : 20
APPROXIMATE TIME : 1100
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 11.00 IN. STACK PRESSURE: 30.11 IN.HG.ABS.
STACK AREA : 95.03 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.8	.75	.01	435.	444.3
2	25.0	2.75	.02	435.	628.3
3	50.0	5.50	.04	435.	888.5
4	75.0	8.25	.02	435.	628.3
5	93.0	10.23	.00	435.	.0
	AVERAGE :		.02	435.	517.9

AVERAGE Q @ STACK CONDITIONS: 341.8 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 1 TEST # : 1
ENGINE : G1 MODE : 45
APPROXIMATE TIME : 1010
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 11.00 IN. STACK PRESSURE: 30.11 IN.HG.ABS.
STACK AREA : 95.03 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POINT NO.	POSITION % ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.8	.75	.00	510.	.0
2	25.0	2.75	.03	510.	801.1
3	50.0	5.50	.06	510.	1132.9
4	75.0	8.25	.03	510.	801.1
5	93.0	10.23	.00	510.	.0
	AVERAGE :		.02	510.	547.0

AVERAGE Q @ STACK CONDITIONS: 361.0 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 1 TEST # : 2
ENGINE : G2 MODE : 0
APPROXIMATE TIME : 900
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 11.00 IN. STACK PRESSURE: 30.52 IN.HG.ABS.
STACK AREA : 95.03 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POINT NO.	% ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.8	.75	.02	310.	578.8
2	25.0	2.75	.03	315.	711.2
3	50.0	5.50	.04	315.	821.2
4	75.0	8.25	.03	315.	711.2
5	93.0	10.23	.02	312.	579.6
	AVERAGE :		.03	313.	680.4

AVERAGE Q @ STACK CONDITIONS: 449.0 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 1 TEST # : 2
ENGINE : G2 MODE : 35
APPROXIMATE TIME : 930
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 11.00 IN. STACK PRESSURE: 30.58 IN.HG.ABS.
STACK AREA : 95.03 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.8	.75	.00	430.	.0
2	25.0	2.75	.01	435.	440.8
3	50.0	5.50	.03	425.	759.3
4	75.0	8.25	.01	417.	436.4
5	93.0	10.23	.00	420.	.0
	AVERAGE :		.01	425.	327.3

AVERAGE Q @ STACK CONDITIONS: 216.0 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 1 TEST # : 2
ENGINE : G2 MODE : 45
APPROXIMATE TIME : 1000
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 11.00 IN. STACK PRESSURE: 30.58 IN.HG.ABS.
STACK AREA : 95.03 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.8	.75	.01	420.	437.1
2	25.0	2.75	.02	430.	621.7
3	50.0	5.50	.04	450.	889.0
4	75.0	8.25	.01	440.	442.1
5	93.0	10.23	.00	430.	.0
	AVERAGE :		.02	434.	478.0

AVERAGE Q @ STACK CONDITIONS: 315.4 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 1 TEST # : 4
ENGINE : M2 MODE : 30
APPROXIMATE TIME : 1000
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 10.19 IN. STACK PRESSURE: 30.26 IN.HG.ABS.
STACK AREA : 81.55 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	4.5	.46	.40	492.	2890.7
2	14.7	1.50	.65	600.	3888.3
3	29.5	3.01	.65	605.	3897.4
4	50.0	5.09	.76	612.	4228.2
5	70.5	7.18	.85	610.	4467.3
6	85.3	8.69	1.00	610.	4845.5
7	95.6	9.74	.90	610.	4596.9
	AVERAGE :		.74	591.	4116.3

AVERAGE Q @ STACK CONDITIONS: 2331.2 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 2 TEST # : 2
ENGINE : M1 MODE : 10
APPROXIMATE TIME : 1330
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 8.00 IN. STACK PRESSURE: 30.09 IN.HG.ABS.
STACK AREA : 50.27 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE NO.	POSITION % ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.54	.61	220.	3025.5
2	25.0	2.00	.69	220.	3217.7
3	50.0	4.00	.74	220.	3332.3
4	75.0	6.00	.79	220.	3443.0
5	93.3	7.46	.75	220.	3354.7
	AVERAGE :		.72	220.	3274.6

AVERAGE Q @ STACK CONDITIONS: 1143.1 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 2 TEST # : 3
ENGINE : M1 MODE : 20
APPROXIMATE TIME : 800
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 8.00 IN. STACK PRESSURE: 30.13 IN.HG.ABS.
STACK AREA : 50.27 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.54	1.60	550.	5967.7
2	25.0	2.00	1.70	600.	6301.7
3	50.0	4.00	1.80	600.	6484.4
4	75.0	6.00	2.05	600.	6920.1
5	93.3	7.46	1.90	595.	6646.4
	AVERAGE :		1.81	589.	6464.1

AVERAGE Q @ STACK CONDITIONS: 2256.4 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 2 TEST # : 1
ENGINE : M1 MODE : 30
APPROXIMATE TIME : 952
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 8.00 IN. STACK PRESSURE: 31.69 IN.HG.ABS.
STACK AREA : 50.27 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POINT NO.	% ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.54	3.10	770.	8938.3
2	25.0	2.00	3.60	785.	9690.7
3	50.0	4.00	3.75	785.	9890.6
4	75.0	6.00	3.80	785.	9956.3
5	93.3	7.46	3.20	780.	9118.2
	AVERAGE :		3.49	781.	9518.8

AVERAGE Q @ STACK CONDITIONS: 3322.7 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 2 TEST # : 2
ENGINE : M1 MODE : 30
APPROXIMATE TIME : 925
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 8.00 IN.
STACK AREA : 50.27 SQ.IN.
C-FACTOR : .855

STACK PRESSURE: 30.08 IN.HG.ABS.
STACK GAS MOLECULAR WEIGHT: 28.96

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.54	3.20	785.	9377.9
2	25.0	2.00	3.60	785.	9946.7
3	50.0	4.00	4.00	785.	10484.8
4	75.0	6.00	3.90	780.	10332.1
5	93.3	7.46	3.60	780.	9926.7
	AVERAGE :		3.66	783.	10013.6

AVERAGE Q @ STACK CONDITIONS: 3495.4 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 2 TEST # : 3
ENGINE : M1 MODE : 30
APPROXIMATE TIME : 1300
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 8.00 IN. STACK PRESSURE: 30.11 IN.HG.ABS.
STACK AREA : 50.27 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.54	3.50	805.	9881.1
2	25.0	2.00	3.60	800.	10001.5
3	50.0	4.00	3.80	800.	10275.5
4	75.0	6.00	3.80	795.	10255.1
5	93.3	7.46	3.60	800.	10001.5
	AVERAGE :		3.66	800.	10082.9

AVERAGE Q @ STACK CONDITIONS: 3519.6 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 2 TEST # : 2
ENGINE : M2 MODE : 10
APPROXIMATE TIME : 1315
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 8.00 IN. STACK PRESSURE: 30.09 IN.HG.ABS.
STACK AREA : 50.27 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.54	.68	90.	2872.8
2	25.0	2.00	.68	90.	2872.8
3	50.0	4.00	.72	90.	2956.1
4	75.0	6.00	.74	90.	2996.9
5	93.3	7.46	.75	95.	3030.7
	AVERAGE :		.71	91.	2945.9

AVERAGE Q @ STACK CONDITIONS: 1028.3 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 2 TEST # : 3
ENGINE : M2 MODE : 20
APPROXIMATE TIME : 810
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 8.00 IN. STACK PRESSURE: 30.13 IN.HG.ABS.
STACK AREA : 50.27 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H20	TEMP DEGF	VELOCITY FPM
1	6.7	.54	1.60	600.	6113.6
2	25.0	2.00	1.60	615.	6156.7
3	50.0	4.00	1.80	615.	6530.2
4	75.0	6.00	2.00	615.	6883.4
5	93.3	7.46	1.70	615.	6346.2
	AVERAGE :		1.74	612.	6406.0

AVERAGE Q @ STACK CONDITIONS: 2236.1 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 2 TEST # : 1
ENGINE : M2 MODE : 30
APPROXIMATE TIME : 1040
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 8.00 IN. STACK PRESSURE: 32.20 IN.HG.ABS.
STACK AREA : 50.27 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.54	3.20	800.	9118.3
2	25.0	2.00	3.30	795.	9241.3
3	50.0	4.00	3.50	795.	9517.2
4	75.0	6.00	3.70	795.	9785.4
5	93.3	7.46	3.40	790.	9361.6
	AVERAGE :		3.42	795.	9404.8

AVERAGE Q @ STACK CONDITIONS: 3282.9 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 2 TEST # : 2
ENGINE : M2 MODE : 30
APPROXIMATE TIME : 950
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 8.00 IN. STACK PRESSURE: 30.08 IN.HG.ABS.
STACK AREA : 50.27 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE NO.	POSITION % ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.54	2.00	800.	7458.4
2	25.0	2.00	2.60	805.	8520.7
3	50.0	4.00	3.40	805.	9743.8
4	75.0	6.00	3.40	805.	9743.8
5	93.3	7.46	3.50	800.	9866.5
	AVERAGE :		2.98	803.	9066.6

AVERAGE Q @ STACK CONDITIONS: 3164.9 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 2 TEST # : 3
ENGINE : M2 MODE : 30
APPROXIMATE TIME : 1220
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 8.00 IN. STACK PRESSURE: 30.11 IN.HG.ABS.
STACK AREA : 50.27 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.54	3.30	830.	9689.0
2	25.0	2.00	3.50	830.	9978.3
3	50.0	4.00	3.70	830.	10259.4
4	75.0	6.00	3.90	830.	10533.1
5	93.3	7.46	3.60	830.	10119.8
	AVERAGE :		3.60	830.	10115.9

AVERAGE Q @ STACK CONDITIONS: 3531.1 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 1
ENGINE : M1 MODE : 30
APPROXIMATE TIME : 2330
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 29.94 IN.HG.ABS.
STACK AREA : 423.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE NO.	% ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.03	345.	731.8
2	30.0	10.80	.06	360.	1044.6
3	50.0	18.00	.08	415.	1246.0
4	70.0	25.20	.10	450.	1420.6
5	90.0	32.40	.11	465.	1502.2
	AVERAGE :		.08	407.	1189.0

AVERAGE Q @ STACK CONDITIONS: 3492.8 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 1
ENGINE : M3 MODE : 30
APPROXIMATE TIME : 2330
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 29.93 IN.HG.ABS.
STACK AREA : 947.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.05	365.	956.6
2	30.0	10.80	.10	415.	1393.3
3	50.0	18.00	.13	432.	1603.9
4	70.0	25.20	.14	450.	1681.2
5	90.0	32.40	.15	460.	1749.7
	AVERAGE :		.11	424.	1476.9

AVERAGE Q @ STACK CONDITIONS: 3559.0 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 1
ENGINE : M5 MODE : 30
APPROXIMATE TIME : 2330
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN.
STACK AREA : 342.00 SQ.IN.
C-FACTOR : .855

STACK PRESSURE: 29.93 IN.HG.ABS.
STACK GAS MOLECULAR WEIGHT: 28.96

TRAVERSE POINT NO.	% ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.08	380.	1221.0
2	30.0	10.80	.09	407.	1315.7
3	50.0	18.00	.12	445.	1552.2
4	70.0	25.20	.14	456.	1686.7
5	90.0	32.40	.15	473.	1762.0
	AVERAGE :		.12	432.	1507.5

AVERAGE Q @ STACK CONDITIONS: 3580.4 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 1
ENGINE : M7 MODE : 30
APPROXIMATE TIME : 2330
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 29.93 IN.HG.ABS.
STACK AREA : 436.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.10	410.	1389.3
2	30.0	10.80	.12	425.	1534.9
3	50.0	18.00	.14	462.	1692.2
4	70.0	25.20	.15	466.	1755.4
5	90.0	32.40	.14	465.	1695.0
	AVERAGE :		.13	446.	1613.4

AVERAGE Q @ STACK CONDITIONS: 4884.9 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 2
ENGINE : M1 MODE : 40
APPROXIMATE TIME : 2000
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 30.12 IN.HG.ABS.
STACK AREA : 423.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.07	406.	1156.0
2	30.0	10.80	.14	430.	1657.3
3	50.0	18.00	.18	475.	1926.2
4	70.0	25.20	.20	488.	2044.4
5	90.0	32.40	.24	490.	2241.9
	AVERAGE :		.17	458.	1805.2

AVERAGE Q @ STACK CONDITIONS: 5302.7 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 2
ENGINE : M3 MODE : 40
APPROXIMATE TIME : 2000
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 30.12 IN.HG.ABS.
STACK AREA : 347.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.06	412.	1074.0
2	30.0	10.80	.13	445.	1610.5
3	50.0	18.00	.17	466.	1862.9
4	70.0	25.20	.19	482.	1986.4
5	90.0	32.40	.23	492.	2197.0
	AVERAGE :		.16	459.	1746.1

AVERAGE Q @ STACK CONDITIONS: 4207.7 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 2
ENGINE : M5 MODE : 40
APPROXIMATE TIME : 2000
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 30.12 IN.HG.ABS.
STACK AREA : 342.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.14	460.	1685.1
2	30.0	10.80	.16	450.	1791.6
3	50.0	18.00	.18	465.	1915.9
4	70.0	25.20	.20	485.	2041.2
5	90.0	32.40	.24	491.	2243.1
	AVERAGE :		.18	470.	1935.4

AVERAGE Q @ STACK CONDITIONS: 4596.5 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 1
ENGINE : M2 MODE : 30
APPROXIMATE TIME : 2300
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 29.92 IN.HG.ABS.
STACK AREA : 423.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE NO.	POSITION % ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.04	405.	876.3
2	30.0	10.80	.07	405.	1159.2
3	50.0	18.00	.09	405.	1314.4
4	70.0	25.20	.10	405.	1385.5
5	90.0	32.40	.11	405.	1453.1
	AVERAGE :		.08	405.	1237.7

AVERAGE Q @ STACK CONDITIONS: 3635.8 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 1
ENGINE : M4 MODE : 30
APPROXIMATE TIME : 2300
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 29.92 IN.HG.ABS.
STACK AREA : 347.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE NO.	% ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.03	405.	758.9
2	30.0	10.80	.08	440.	1264.1
3	50.0	18.00	.09	450.	1348.2
4	70.0	25.20	.10	460.	1428.9
5	90.0	32.40	.10	455.	1425.0
	AVERAGE :		.08	442.	1245.0

AVERAGE Q @ STACK CONDITIONS: 3000.1 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 1
ENGINE : M6 MODE : 30
APPROXIMATE TIME : 2300
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 29.91 IN.HG.ABS.
STACK AREA : 342.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.06	450.	1101.0
2	30.0	10.80	.08	450.	1271.3
3	50.0	18.00	.09	450.	1348.4
4	70.0	25.20	.11	450.	1490.7
5	90.0	32.40	.11	450.	1490.7
	AVERAGE :		.09	450.	1340.4

AVERAGE Q @ STACK CONDITIONS: 3183.5 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 1
ENGINE : M8 MODE : 30
APPROXIMATE TIME : 2300
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 29.92 IN.HG.ABS.
STACK AREA : 436.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.08	405.	1239.2
2	30.0	10.80	.08	430.	1257.0
3	50.0	18.00	.10	440.	1413.3
4	70.0	25.20	.11	440.	1482.2
5	90.0	32.40	.12	445.	1552.4
	AVERAGE :		.10	432.	1388.8

AVERAGE Q @ STACK CONDITIONS: 4205.1 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 2
ENGINE : M2 MODE : 40
APPROXIMATE TIME : 1900
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 30.07 IN.HG.ABS.
STACK AREA : 423.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.06	445.	1095.0
2	30.0	10.80	.10	460.	1425.3
3	50.0	18.00	.11	475.	1507.0
4	70.0	25.20	.13	480.	1642.7
5	90.0	32.40	.14	465.	1691.0
	AVERAGE :		.11	465.	1472.2

AVERAGE Q @ STACK CONDITIONS: 4324.6 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 2
ENGINE : M4 MODE : 40
APPROXIMATE TIME : 1900
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 30.07 IN.HG.ABS.
STACK AREA : 347.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POINT NO.	% ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.05	435.	994.1
2	30.0	10.80	.12	475.	1574.0
3	50.0	18.00	.12	480.	1578.2
4	70.0	25.20	.15	483.	1767.3
5	90.0	32.40	.20	485.	2042.9
	AVERAGE :		.13	472.	1591.3

AVERAGE Q @ STACK CONDITIONS: 3834.6 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 2
ENGINE : M6 MODE : 40
APPROXIMATE TIME : 1900
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 30.07 IN.HG.ABS.
STACK AREA : 342.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.14	420.	1649.4
2	30.0	10.80	.12	450.	1552.8
3	50.0	18.00	.14	470.	1695.6
4	70.0	25.20	.16	470.	1812.7
5	90.0	32.40	.17	465.	1863.4
	AVERAGE :		.15	455.	1714.8

AVERAGE Q @ STACK CONDITIONS: 4072.6 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 3 TEST # : 2
ENGINE : M8 MODE : 40
APPROXIMATE TIME : 1900
STACK TYPE : RECTANGULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 36.00 IN. STACK PRESSURE: 30.07 IN.HG.ABS.
STACK AREA : 436.00 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE NO.	POSITION % ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	3.60	.11	425.	1466.2
2	30.0	10.80	.14	445.	1672.6
3	50.0	18.00	.14	465.	1691.0
4	70.0	25.20	.17	475.	1873.5
5	90.0	32.40	.18	465.	1917.4
	AVERAGE :		.15	455.	1724.2

AVERAGE Q @ STACK CONDITIONS: 5220.3 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 4 TEST # : 2
ENGINE : B2 MODE : 10
APPROXIMATE TIME : 1350
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 14.50 IN. STACK PRESSURE: 29.11 IN.HG.ABS.
STACK AREA : 165.13 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	3.3	.48	.12	165.	1308.0
2	10.5	1.52	.20	230.	1774.2
3	19.4	2.81	.23	240.	1916.3
4	32.3	4.68	.16	245.	1604.0
5	50.0	7.25	.13	220.	1420.0
6	67.7	9.82	.09	234.	1193.6
7	80.6	11.69	.09	265.	1220.0
8	89.5	12.98	.10	235.	1259.1
9	96.7	14.02	.11	252.	1336.6
	AVERAGE :		.14	232.	1448.0

AVERAGE Q @ STACK CONDITIONS: 1660.5 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 4 TEST # : 2
ENGINE : B2 MODE : 20
APPROXIMATE TIME : 1330
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 14.50 IN. STACK PRESSURE: 29.09 IN.HG.ABS.
STACK AREA : 165.13 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	3.3	.48	.14	152.	1398.5
2	10.5	1.52	.20	224.	1767.1
3	19.4	2.81	.23	215.	1882.5
4	32.3	4.68	.17	225.	1630.3
5	50.0	7.25	.13	225.	1425.7
6	67.7	9.82	.09	225.	1186.3
7	80.6	11.69	.09	225.	1186.3
8	89.5	12.98	.09	240.	1199.2
	AVERAGE :		.14	216.	1459.5

AVERAGE Q @ STACK CONDITIONS: 1673.6 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 4 TEST # : 2
ENGINE : G1 MODE : 0
APPROXIMATE TIME : 945
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 24.75 IN. STACK PRESSURE: 29.61 IN.HG.ABS.
STACK AREA : 481.11 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE NO.	POSITION % ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	8.2	2.03	.02	195.	542.0
2	14.6	3.61	.02	215.	550.2
3	22.6	5.59	.00	225.	.0
4	34.2	8.46	.00	230.	.0
5	50.0	12.37	.00	238.	.0
6	65.8	16.29	.02	250.	564.3
7	77.4	19.16	.04	262.	804.8
8	85.4	21.14	.04	273.	810.9
9	91.5	22.65	.06	284.	1000.5
	AVERAGE :		.02	241.	474.7

AVERAGE Q @ STACK CONDITIONS: 1586.1 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 4 TEST # : 2
ENGINE : G1 MODE : 40
APPROXIMATE TIME : 1000
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 29.75 IN. STACK PRESSURE: 29.61 IN.HG.ABS.
STACK AREA : 695.13 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POINT NO.	POSITION % ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	8.2	2.44	.01	378.	433.5
2	14.6	4.34	.01	390.	436.6
3	22.6	6.72	.01	396.	438.1
4	34.2	10.17	.02	399.	620.7
5	50.0	14.87	.01	411.	441.9
6	65.8	19.58	.02	423.	629.3
7	77.4	23.03	.04	449.	903.0
8	85.4	25.41	.06	456.	1110.2
9	91.5	27.22	.09	468.	1368.5
	AVERAGE :		.03	419.	709.1

AVERAGE Q @ STACK CONDITIONS: 3423.0 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 4 TEST # : 2
ENGINE : G1 MODE : 65
APPROXIMATE TIME : 1045
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 29.75 IN. STACK PRESSURE: 29.61 IN.HG.ABS.
STACK AREA : 695.13 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	8.2	2.44	.01	476.	458.1
2	14.6	4.34	.01	540.	473.5
3	22.6	6.72	.02	573.	680.7
4	34.2	10.17	.01	582.	483.4
5	50.0	14.87	.02	584.	684.3
6	65.8	19.58	.02	600.	692.1
7	77.4	23.03	.03	614.	850.0
8	85.4	25.41	.05	629.	1105.0
9	91.5	27.22	.06	630.	1211.0
	AVERAGE :		.03	582.	737.6

AVERAGE Q @ STACK CONDITIONS: 3560.5 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 4 TEST # : 1
ENGINE : M1 MODE : 40
APPROXIMATE TIME : 1000
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 24.75 IN. STACK PRESSURE: 29.72 IN.HG.ABS.
STACK AREA : 481.11 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POINT NO.	% ID	POSITION INCHES	VEL.HEAD IN.H20	TEMP DEGF	VELOCITY FPM
1	8.2	2.03	.15	794.	2050.0
2	14.6	3.61	.15	832.	2080.8
3	22.6	5.59	.14	842.	2018.0
4	34.2	8.46	.13	845.	1946.9
5	50.0	12.37	.16	865.	2176.3
6	65.8	16.29	.30	875.	2991.3
7	77.4	19.16	.39	890.	3429.7
8	85.4	21.14	.42	885.	3552.6
9	91.5	22.65	.40	885.	3467.0
	AVERAGE :		.25	857.	2634.7

AVERAGE Q @ STACK CONDITIONS: 8802.7 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 8 TEST # : 1
ENGINE : G1 MODE : 80
APPROXIMATE TIME : 1630
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 11.75 IN. STACK PRESSURE: 30.00 IN.HG.ABS.
STACK AREA : 108.43 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	4.4	.52	3.00	630.	8507.4
2	14.7	1.73	2.80	630.	8218.9
3	29.5	3.47	2.90	630.	8364.4
4	50.0	5.87	2.80	630.	8218.9
5	70.5	8.28	2.80	630.	8218.9
6	85.3	10.02	3.00	630.	8507.4
7	95.6	11.23	3.00	630.	8507.4
	AVERAGE :		2.90	630.	8363.3

AVERAGE Q @ STACK CONDITIONS: 6297.7 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 7 TEST # : 3
ENGINE : M1 MODE : 40
APPROXIMATE TIME : 1200
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 5.75 IN. STACK PRESSURE: 30.42 IN.HG.ABS.
STACK AREA : 25.97 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.5	.37	1.10	124.	3744.6
2	30.4	1.75	4.30	130.	7441.5
3	50.0	2.87	3.00	134.	6236.7
4	73.9	4.25	2.90	134.	6131.9
5	93.5	5.38	3.40	129.	6611.5
AVERAGE :			2.94	130.	6033.3

AVERAGE Q @ STACK CONDITIONS: 1088.0 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 8 TEST # : 2
ENGINE : M2 MODE : 20
APPROXIMATE TIME : 1100
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 27.00 IN. STACK PRESSURE: 30.00 IN.HG.ABS.
STACK AREA : 572.56 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	2.1	.57	.08	355.	1201.3
2	6.7	1.81	.07	355.	1123.7
3	11.8	3.19	.02	355.	600.6
4	17.7	4.78	.00	355.	.0
5	25.0	6.75	.00	355.	.0
6	35.5	9.58	.00	355.	.0
7	50.0	13.50	.05	355.	949.7
8	64.5	17.41	.13	345.	1521.9
9	75.0	20.25	.24	340.	2061.4
10	82.3	22.22	.28	336.	2221.0
11	88.2	23.81	.36	335.	2516.8
12	93.3	25.19	.48	335.	2906.2
13	97.9	26.43	.51	330.	2986.2
	AVERAGE :		.17	347.	1391.5

AVERAGE Q @ STACK CONDITIONS: 5532.6 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 8 TEST # : 2
ENGINE : M2 MODE : 30
APPROXIMATE TIME : 1430
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 27.00 IN. STACK PRESSURE: 29.96 IN.HG.ABS.
STACK AREA : 572.56 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE NO.	POSITION % ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	2.1	.57	.35	790.	3113.9
2	6.7	1.81	.30	795.	2888.6
3	11.8	3.19	.13	800.	1905.3
4	17.7	4.78	.02	800.	747.3
5	25.0	6.75	.02	800.	747.3
6	35.5	9.58	.00	800.	.0
7	50.0	13.50	.13	800.	1905.3
8	64.5	17.41	.53	800.	3847.1
9	75.0	20.25	.88	800.	4957.2
10	82.3	22.22	.92	795.	5058.6
11	88.2	23.81	1.00	795.	5273.9
12	93.3	25.19	1.20	790.	5765.8
13	97.9	26.43	1.20	795.	5777.3
	AVERAGE :		.51	797.	3229.8

AVERAGE Q @ STACK CONDITIONS: 12842.1 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 8 TEST # : 3
ENGINE : M2 MODE : 40
APPROXIMATE TIME : 1925
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 27.00 IN. STACK PRESSURE: 30.60 IN.HG.ABS.
STACK AREA : 572.56 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE NO.	POSITION % ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	2.1	.57	.10	712.	1594.7
2	6.7	1.81	.01	775.	517.7
3	11.8	3.19	.01	775.	517.7
4	17.7	4.78	.00	775.	.0
5	25.0	6.75	.00	775.	.0
6	35.5	9.58	.00	775.	.0
7	50.0	13.50	.35	820.	3117.9
8	64.5	17.41	1.80	825.	7084.5
9	75.0	20.25	2.20	825.	7832.2
10	82.3	22.22	2.60	835.	8547.6
11	88.2	23.81	2.90	850.	9079.4
12	93.3	25.19	3.30	850.	9685.3
13	97.9	26.43	3.20	825.	9446.0
	AVERAGE :		1.27	801.	4417.2

AVERAGE Q @ STACK CONDITIONS: 17563.0 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 9 TEST # : 3
ENGINE : G1 MODE : 20
APPROXIMATE TIME : 820
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 4.50 IN. STACK PRESSURE: 30.23 IN.HG.ABS.
STACK AREA : 15.90 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE NO.	POSITION % ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	50.0	2.25	2.90	655.	8427.5
	AVERAGE :		2.90	655.	8427.5

AVERAGE Q @ STACK CONDITIONS: 930.8 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 9 TEST # : 3
ENGINE : G2 MODE : 20
APPROXIMATE TIME : 900
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 4.50 IN. STACK PRESSURE: 30.23 IN.HG.ABS.
STACK AREA : 15.90 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	50.0	2.25	2.60	445.	7189.1
	AVERAGE :		2.60	445.	7189.1

AVERAGE Q @ STACK CONDITIONS: 794.0 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 9 TEST # : 1
ENGINE : M2 MODE : 30
APPROXIMATE TIME : 1455
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 10.00 IN. STACK PRESSURE: 32.83 IN.HG.ABS.
STACK AREA : 78.54 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	5.0	.50	1.60	630.	5939.1
2	10.0	1.00	2.10	732.	7115.3
3	15.0	1.50	2.00	750.	6996.1
4	25.0	2.50	1.70	765.	6489.9
5	40.0	4.00	1.60	767.	6301.3
6	60.0	6.00	1.70	773.	6511.1
7	75.0	7.50	1.75	774.	6608.8
8	85.0	8.50	1.70	771.	6505.8
9	90.0	9.00	1.71	768.	6516.9
	AVERAGE :		1.76	748.	6553.8

AVERAGE Q @ STACK CONDITIONS: 3574.6 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 10 TEST # : 1
ENGINE : M4 MODE : 30
APPROXIMATE TIME : 945
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 8.25 IN. STACK PRESSURE: 30.03 IN.HG.ABS.
STACK AREA : 53.46 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POINT NO.	% ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	10.0	.82	.55	650.	3674.1
2	30.0	2.47	.53	650.	3606.7
3	50.0	4.12	.52	666.	3598.1
4	70.0	5.77	.60	642.	3823.6
5	90.0	7.42	.68	735.	4238.8
	AVERAGE :		.58	669.	3788.2

AVERAGE Q @ STACK CONDITIONS: 1406.3 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 11 TEST # : 2
ENGINE : M1 MODE : 25
APPROXIMATE TIME : 1215
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 7.00 IN. STACK PRESSURE: 29.93 IN.HG.ABS.
STACK AREA : 38.48 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.47	1.80	626.	6585.4
2	25.0	1.75	2.00	624.	6935.2
3	50.0	3.50	1.90	630.	6778.3
4	75.0	5.25	1.50	629.	6019.9
5	93.3	6.53	1.20	629.	5384.4
	AVERAGE :		1.68	628.	6340.6

AVERAGE Q @ STACK CONDITIONS: 1694.6 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 11 TEST # : 2
ENGINE : M1 MODE : 3Ø
APPROXIMATE TIME : 1145
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 7.ØØ IN. STACK PRESSURE: 29.93 IN.HG.ABS.
STACK AREA : 38.48 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.47	4.2Ø	885.	11194.8
2	25.Ø	1.75	6.9Ø	895.	14402.Ø
3	5Ø.Ø	3.5Ø	1Ø.ØØ	89Ø.	17306.Ø
4	75.Ø	5.25	8.1Ø	89Ø.	15575.4
5	93.3	6.53	3.2Ø	889.	9786.1
	AVERAGE :		6.48	89Ø.	13652.9

AVERAGE Q @ STACK CONDITIONS: 3648.8 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 11 TEST # : 2
ENGINE : M2 MODE : 25
APPROXIMATE TIME : 1045
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 7.00 IN. STACK PRESSURE: 29.96 IN.HG.ABS.
STACK AREA : 38.48 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.47	.94	618.	4739.0
2	25.0	1.75	1.70	624.	6390.7
3	50.0	3.50	2.00	630.	6950.9
4	75.0	5.25	1.40	624.	5799.5
5	93.3	6.53	1.10	628.	5150.2
	AVERAGE :		1.43	625.	5806.1

AVERAGE Q @ STACK CONDITIONS: 1551.7 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 11 TEST # : 2
ENGINE : M2 MODE : 30
APPROXIMATE TIME : 1110
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 7.00 IN. STACK PRESSURE: 29.96 IN.HG.ABS.
STACK AREA : 38.48 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE NO.	POSITION % ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	6.7	.47	4.60	916.	11844.0
2	25.0	1.75	5.10	916.	12471.1
3	50.0	3.50	8.10	914.	15705.3
4	75.0	5.25	6.50	904.	14017.7
5	93.3	6.53	3.90	911.	10885.9
	AVERAGE :		5.64	912.	12984.8

AVERAGE Q @ STACK CONDITIONS: 3470.2 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 13 TEST # : 1
ENGINE : M4 MODE : 25
APPROXIMATE TIME : 2130
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 24.50 IN. STACK PRESSURE: 30.31 IN.HG.ABS.
STACK AREA : 471.44 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE POSITION NO.	% ID	INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	4.4	1.08	.16	740.	2050.9
2	14.7	3.60	.12	785.	1809.1
3	29.5	7.23	.12	790.	1812.7
4	50.0	12.25	.11	795.	1739.0
5	70.5	17.27	.11	785.	1732.1
AVERAGE :			.12	779.	1828.8

AVERAGE Q @ STACK CONDITIONS: 5987.1 CFM

SCOTT RESEARCH LABORATORIES SRL 1302-016-0373 DATE 03/05/73
VESSEL # : 13 TEST # : 1
ENGINE : M4 MODE : 40
APPROXIMATE TIME : 1500
STACK TYPE : CIRCULAR

STACK TRAVERSE VELOCITY ANALYSIS

STACK ID : 24.50 IN. STACK PRESSURE: 30.34 IN.HG.ABS.
STACK AREA : 471.44 SQ.IN. STACK GAS MOLECULAR WEIGHT: 28.96
C-FACTOR : .855

TRAVERSE NO.	POSITION % ID	POSITION INCHES	VEL.HEAD IN.H2O	TEMP DEGF	VELOCITY FPM
1	4.4	1.08	1.80	1030.	7661.3
2	14.7	3.60	2.20	1035.	8484.1
3	29.5	7.23	2.10	1025.	8261.3
4	50.0	12.25	1.70	1026.	7435.5
5	70.5	17.27	1.40	1012.	6715.7
	AVERAGE :		1.84	1026.	7711.6

AVERAGE Q @ STACK CONDITIONS: 25246.7 CFM