FINAL REPORT

DETERMINATION OF PARTICULATE& DUST CONCENTRATION DURING SHIPYARD DRYDOCK SANDBLASTING OPERATIONS

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1.0 INTRODUCTION

Testing was performed to determine the concentrations of total suspended particulate (TSP) and particulate matter smaller than 10 microns (PM_{10}) during a typical sandblasting operation. Testing was conducted at the Norfolk Shipbuilding and Drydock Corporation (Norshipco) located in Norfolk, Virginia, on July 14-15, 1992 under the direction of Thomas Beacham of Norshipco. Sampling was conducted by Patrick Slater and Everett Poore of Industrial & Environmental Analysts, Inc. (IEA) Research Triangle Park, North Carolina. Testing was observed by Ms. Lural Driver and Mr. Roy Huntley of the U.S. Environmental Protection Agency (EPA). Gravirmetric analysis was performed by Clean Air Engineering (CAE) Analytical Services. Polarized Light Microscopy (PLM and Scanning Electron Microscopy with Energy Dispersive X-Ray Spectroscopy (SEM-EDX) analyses were performed by IEA, Inc., North Billerica, Massachusetts.

A discussion of the project and sandblasting process is presented in Section 2. A summary and discussion of sampling results is included in Section 3. Sampling and analytical procedures are discussed in Section 4. Quality assurance/quality control (QA/QC) procedures are presented in Section 5. All field data, chain-of-custody forms, laboratory data, field logs, and equipment calibrations are included in the appendices.

2.0 PROJECT DESCRIPTION

The U.S. Environmental Protection Agency (EPA) is in the process of developing a control technology guidance document (CTG) for the shipbuilding and repair industry. This document is to address the control of particulate matter smaller than 10 microns (PM_{10}) generated during the sandblasting of ships while in drydock.

The purpose of the test program was to determine: l)whether PM_{10} dust is generated during a sandblasting operation, 2) if so, what concentrations exist, and 3) the major constituents of the dust.

2.1 Drydock Area

Testing was performed at locations in a large floating drydock, approximately 950 feet long, 192 feet wide, and 55 feet deep. The U. S.N.S. Humphreys was placed in the drydock, supported by concrete/wood pillars. The ship was supported approximately 4-5 feet above the drydock floor, and approximately 10-15 feet from each of the two drydock walls. The two ends of the drydock were open.

Large tarps, constructed of 100% fire retardant polypropylene, were draped from the walls of the drydock to the sides of the ship. Tarps also covered the open ends of the drydock. Photos 2.1A and 2.lB shows the U. S.N.S. Humphreys in drydock with the dust control tarps in place.

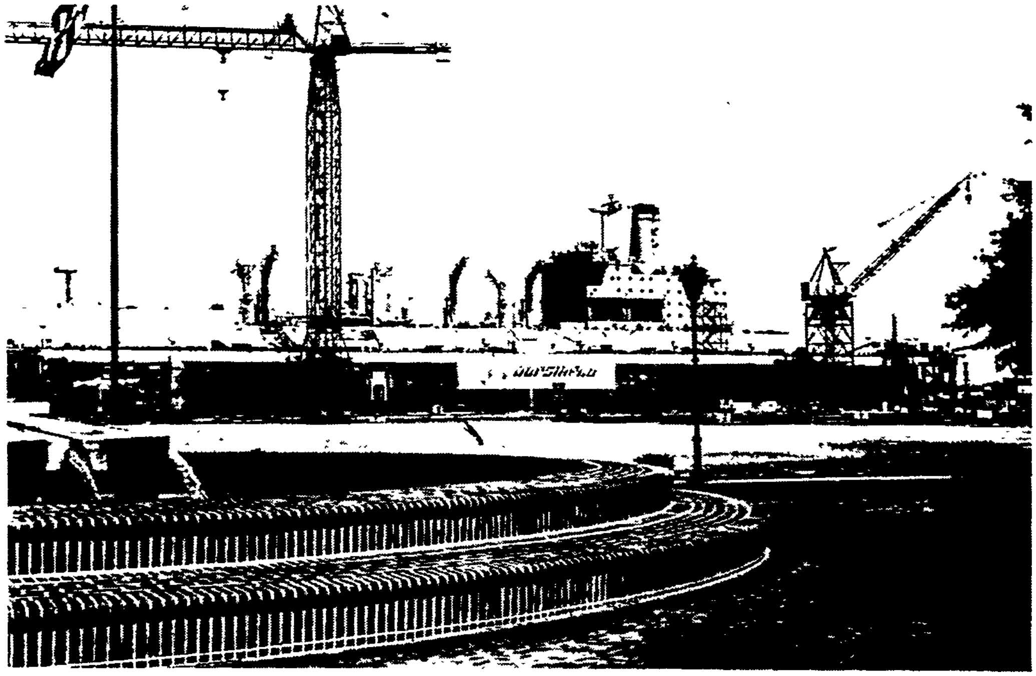
2.2 Sandblasting Operation

Sandblasting of the ship was performed between 18:00 July 14 and 06:30 July 15, 1992. Testing was performed from 22:00 July 14 to 03:00 July 15. An average of 32 sandblasters were working during the sampling period. An average of 32,340 pounds of blasting material per hour was consumed during the monitoring period, resulting in approximately 8,600 square feet of paint removed. Table 2.2.1 summarizes the number of blasting nozzles in use and pounds of blasting material used during the test period.

Sandblasters were supported by hydraulic man-lifts to within 2 feet of the ship (Photo 2.2A). The pressure at the blasting nozzle was an average 99 pounds per square inch (p.s.i.). **Two blasting agents were utilized, labelled 'Norshipco' and 'ACC'. Both** blasting agents were virtually identical, showing major amounts of aluminum, silicon, and iron, with smaller amounts of potassium and calcium. Both agents appear to be a glass product, having both characteristic optical properties and particle morphology.

Particle sizing on the virgin balsting grits was performed. Table 2.2.2 presents the results of this analysis. The highest percentage (by weight) of both grits have effective diameters of 1 millimeter or greater.

Photograph 2.1A
U. S.N.S Humphreys in drydock with dust control tarps in place.



Photograph 2.1B
U.S.N.SHumphreys in drydock with dust control tarps in place.

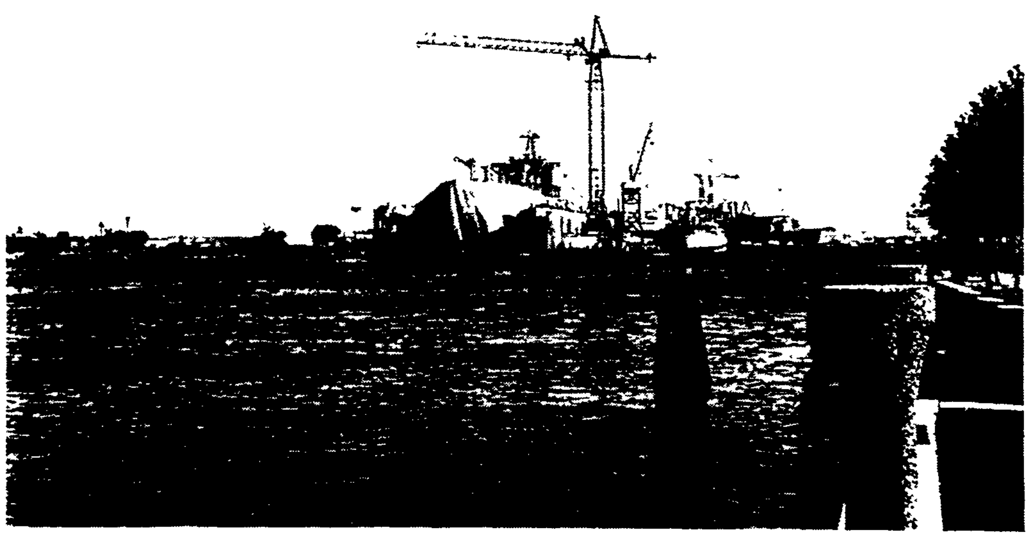


TABLE 2.2.1
Summary of Blasting Operation Conditions
Norfolk Shipbuilding and Repair Corporation
Norfolk, Virginia

Time	**Number of sandblasters**	**Pounds of Blast Grit used (lbs)**	Average **Pressure at Select Blasting Nozzles (p.s.i.)**
18:00	**28**	**16,968**	
20:00	35	16,954	90
20:30	35	14,700	
21:00	32	14,700	95
21:30	32	14,700	
22:00	32	14,700	110
22:30	32	14,700	
23:00	32	14,700	105
23:30	0	0	
24:00	32	14,700	85
00:30	32	14,700	
01:00	32	14,700	100
01:30	32	14,700	
02:00	32	14,700	105
02:30	32	14,700	
03:00	32	14,700	95
03:30	32	14,700	
0400	32	14,700	90
04:30	32	14,700	
05:00	32	14,700	100
05:30	32	14,700	
06:00	32	14,700	110
06:30	32	14,700	

Photograph 2.2A
Sandblaster on Man-Lift
U. S.N.S. Humphreys

TABLE 2.2.2
Particle Size Analysis of Blasting Grits
Norfolk Shipbuilding and Repair Corporation
Norfolk, Virginia

Equivalent ParticIe Diameter	ACC Blasting Grit (Weight %)	Norshipco Blasting Grit (Weight %)
> lmm	46.9	86.1
0.5mm to lmm	25.8	11.2
250µ to 0.5MM	8.3	1.6
105µ to 250µ	11.3	0.9
48µ to 105µ	6.1	0.2
Less than 48µ	1.6	0.1

2.3 Sample Locations

A total of five(5) sample locations were chosen to evaluate the sandblasting operation based on recommendations from the U.S. EPA, Norshipco, and IEA. One additional location was chosen to determine the ambient background concentration of both TSP and PM_{10}. A description of the sample locations is presented in Table 2.3.1. Figure 2.3.1 presents a schematic representation of the sample locations surrounding the sandblasting operation.

The background samples were collected from 18:30 July 13 to 18:30 July 14, 1992 (24 hour samples). Sampling at the five locations surrounding the drydock area varied from 5 minutes to 15 minutes, depending upon the anticipated particulate loading.

TABLE 2.3.1
Description of Sample Locations
Norfolk Shipbuilding and Repair Corporation
Norfolk, Virginia

Sample Location	Description
1	Ambient Background Sample - collected at Norshipco Warehouse approximately 1 mile northeast of drydock area.
2	Located on north side of wing wall, outside the dust-control tarp, approximately 3-4 feet from the tarp.
3	Located on middle landing of stairway leading to the top of the north wing wall. Approximately 12 feet above drydock floor. Shielded from the east by the drydock wall. North and south sides of landing open to atmosphere. No dust control tarp between landing and ship.
4	On drydock floor, within blasting area. Approximately 10 feet from drydock wall, and 15 feet from ship.
5	On drydock floor, within blasting area. Approximately 10 feet from drydock wall, and 15 feet from ship.
6	On drydock floor, midships. Appnximately 5 feet tim drydock wall and 6-8 feet from ship.

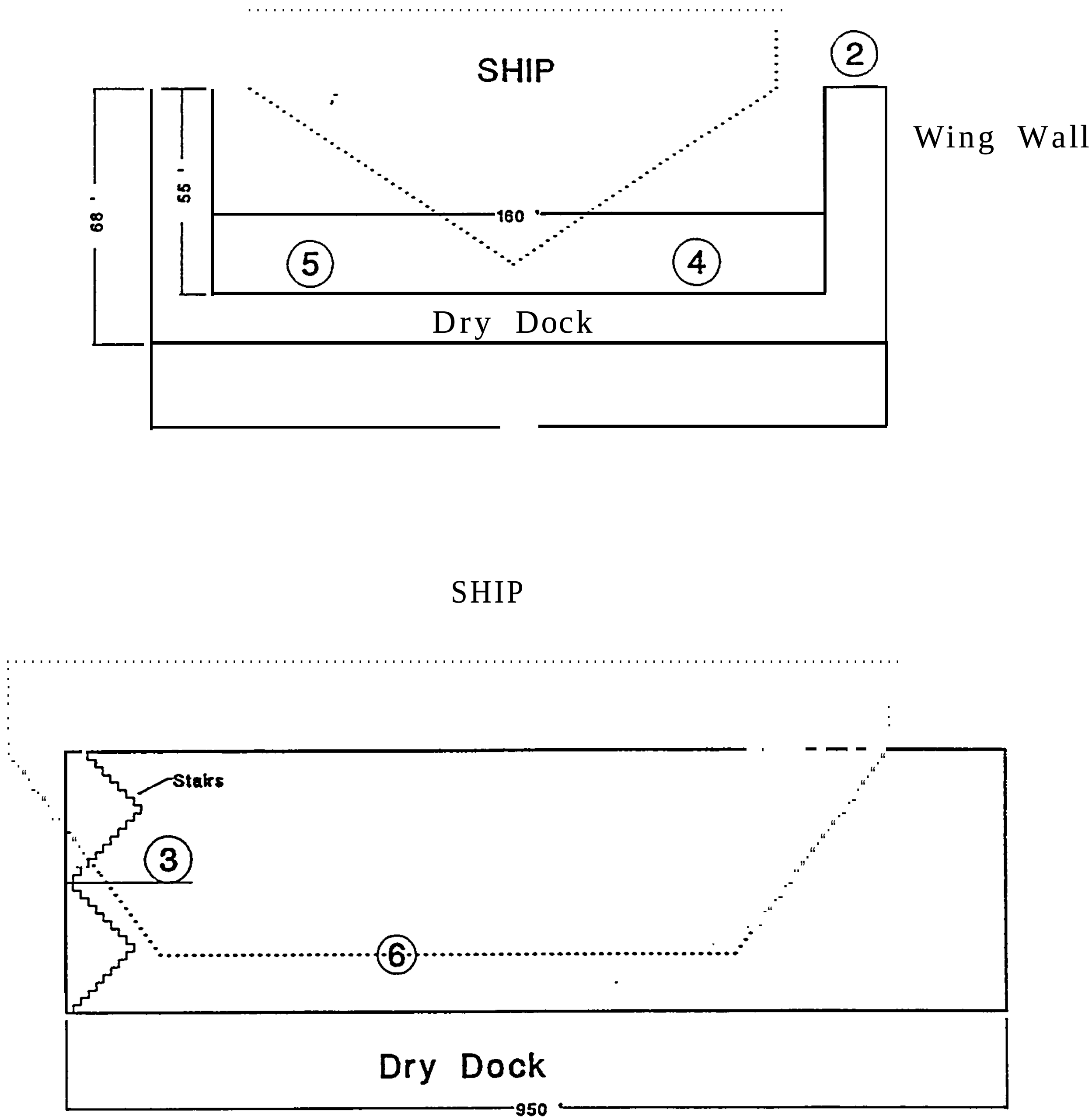


Figure 2.3.1
Sample Locations
U.S.N.S. Humphreys

3.0 SUMMARY AND DISCUSSION OF RESULTS

3.1 Gravimetric Results

Table 3.1.1 presents a summary of the gravirnetric results of all samples collected. Table 3.1.2 presents a summary of all laboratory and field trip blank falters. Table 3.1.3 summarizes the TSP and PM_{10} concentrations observed at each of the locations.

TSP concentrations ranged from a low of 6.42 mg/m^3 at location 2 (11 :55pm) to a high of 110 mg/m3, also at location 2 (10:23pm). PM_{10} concentrations ranged from 1.99 mg/m^3 at Location 2 (11 :55pm) to 52.0 mg/m^3 at Location 4 (2: OOam). The low dust concentration at 11:55pm can be attributed to the reduced number of sandblasters working at that time (see Table 2.2.1). The percentage of PM_{10} dust present ranged from a low of 18 % at Locations 2 and 3 (10:30pm and 12:OOam respectively) to a high of 93 % at Location 2 (10:45pm). The low percentage of PM_{10} at Location 6 (29 %) could be due to the close proximity of the sandblasters. It would be expected that the larger particles would settle in this short distance, while the PM_{10} particles would tend to stay airborne for a longer period of time, and thus be carried past the sampling locations by the air currents.

Filter contamination (field trip blanks) ranged from 0.0038g to 0.0250g. This was due to the extremely high concentration of dust in the areas. Because of the variability of this filter contamination samples were not blank corrected. This contamination also contributed to the variability in %PM_{10} concentrations at the various locations, possibly higher PM_{10} measurements than were actually present.

TABLE 3.1.1
Particulate Matter Concentrations
Norfolk Shipbuilding and Repair Corporation
Norfolk, Virginia

Sample Location	Run ID	Sample Type	Time o n	Total Sample Time (min)	Total grams collected (g)	Sample Flow Rate (m^3/min]	Sample Conc. (mg/m^3)
1	**A**	TSP	18:00	1,505	0.1877	1.251	0.10
1	B	PM_{IO}	18:03	1,499	0.1354	1.443	0.06
2	A	TSP	22:00	15	1.2766	1.303	65.8
2	B	PM_{IO}	22:02	15	0.3607	1.443	16.4
2	c	TSP	22:23	11	1.426	1.303	110
2	D	PM_{IO}	22:21	10	0.2778	1.443	19.8
2	E	TSP	22:35	10	0.2789	1.303	21.4
2	F	PM_{IO}	22:33	10	0.2789	1.416	19.9
2	G	TSP	—	–-	VOID	—	Tom Filter
2	H	PM_{IO}	—	—	VOID	- -	Tom Filter
2	I	TSP	23:55	10	0.0835	1.303	6.42
2	J	PM_{IO}	23:55	10	0.0278	1.416	1.99
3	A	TSP	23:41	10	0.4436	0.971	44.4
3	B	PM_{IO}	23:37	10	0.4192	1.521	28.0
3	C	TSP	23:54	10	0.4320	0.971	43.2
3	D	PM_{IO}	23:53	10	0.1240	1.567	7.75
4	A	TSP	—	—	VOID	—	Torn Filter
4	B	PM_{IO}		—	VOID	—	Tom Filter
4	C	TSP	02:08	5	0.6563	1.361	93.8
4	D	PM_{IO}	02:09	5	0.3639	1.331	52.0
5	A	TSP	02:20	5	0.2858	1.521	35.7
5	B	PM_{IO}	02:21	5	0.1124	0.971	22.5
6	A	TSP	02:45	5	0.2447	1.361	35.0
6	B	PM_{IO}	02:45	5	0.0715	1.490	10.2

TABLE 3.1.2
Laboratory and Field Blank Filter Analysis
Norfolk Shipbuilding and Repair Corporation
Norfolk, Virginia

Sample Location	Blank Type	Total Grams Present (g)
2	Field	0.0038
4	Field	0.0194
5	Field	0.0250
6	Field	0.0072
66-205	Lab	0.0010
66-215	Lab	0.0001
66-216	Lab	-0.0001
66-217	Lab	0.0000

TABLE 3.1.3
Comparison of TSP and PM_{10} Particulate Concentrations
Norfolk Shipbuilding and Repair Corporation
Norfolk, Virginia

Sample Location	TSP Concentration (mg/m^3)	PM_{10} Concentration (mg/m^3)	% PM_{10}
1	0.10	0.06	60%
2	65.8	16.4	25%
2	110	19.8	18%
2	21.4	19.9	93%
2	6.42	1.99	31%
3	44.4	28.0	63%
3	43.2	7.75	18%
4	93.8	52.0	55%
5	35.7	22.5	63%
6	35.0	10.2	29%

3.2 Microscopy Analysis Results

Table 3.2.1 presents summary of the PLM analysis of select PM_{10} falters. Table 3.2.2 presents a summary of the PLM analysis of select TSP falters.

The results from the microscopic analysis indicate that the majority of both the TSP and PM_{10} particulate generated during the sandblasting operation can be attributed to the blasting grit, and not the paint or metal from the ship. This conclusion is also supported by the SEM-EDX analysis which shows that the major chemical components are aluminum and silicon, both present only in the blasting grits.

A comparison of the 'Mean Diameter' field of Tables 3.2.1 and 3.2.2 indicates that the size selective inlet (SSI) of the PM_{10} sampler was able to effectively restrict the particles greater than 10 microns from reaching the falter. Table 3.2.3 shows an average partticle analysis of three PM_{10} falters. The average mean diameter of these three filters was 10.7 microns.

In-field verification of the effectiveness of the PM_{10} SSI can be seen on the greased shim plate. (See Section 4.2.2 for description of the PM_{10} sampler.) Photograph 3.2A shows a PM_{10} greased shim plate with regular circular patterns, which indicates no entrainment of particles greater than PM_{10}.

Photograph 3.2B, however, shows a PM_{10} greased shim plate with obvious streaking of the larger particles, indicating possible entrainment of these larger particles onto the PM_{10} falter. This effect would bias the weight of the PM_{10} filter high, since particles larger than PM_{10} would be present.

Photograph 3.2B is of the PM_{10} sampler used at Location 5. This would indicate a higher PM1O filter weight, as well as a higher average mean diameter of particles on the falter. This is supported by the PLM analysis of the Location 5 PM1O filter which did show a higher average mean diameter of particles present (see Table 3.2.1).

TABLE 3.2.1
Polarized Light Microscopy Analysis - PM_{10} Filters
Norfolk Shipbuilding and Repair Corporation
Norfolk, Virginia

Sample Location	Particle Type	Weight %	Number %	Mean Diameter (μ)	Density
lB	Minerals	36	44	7	2.6
	Opaques	21	29	7	1.5
	Blast Grit	8	6	8	2.6
	Biologicals	36	21	8	1.5
2B	Minerals	1	3	8	2.6
	Opaques	5	25	7	1.5
	Blast Grit	93	70	10	2.6
	Biological	<1	2	6	1.5
2D	Minerals	o	0	0	2.6
	Opaques	12	32	8	1.5
	Blast Grit	87	67	10	2.6
	Biological	1	1	10	1.5
3D	Minerals	2	2	9	2.6
	Opaques	11	36	7	1.5
	Blast Grit	86	61	9	2.6
	Biological	2	1	15	1.5
4D	Minerals	1	3	6	2.6
	Opaques	15	35	8	1.5
	Blast Grit	85	62	8	2.6
	Biological	o	0	0	1.5
5B	Minerals	4	4	14	2.6
	Opaques	24	39	12	1.5
	Blast Grit	72	57	13	2.6
	Biological	o	0	0	1.5
6B	Minerals	11	8	9	2.6
	Opaques	27	49	8	1.5
	Blast Grit	58	40	10	2.6
	Biologicals	4	3	10	1.5

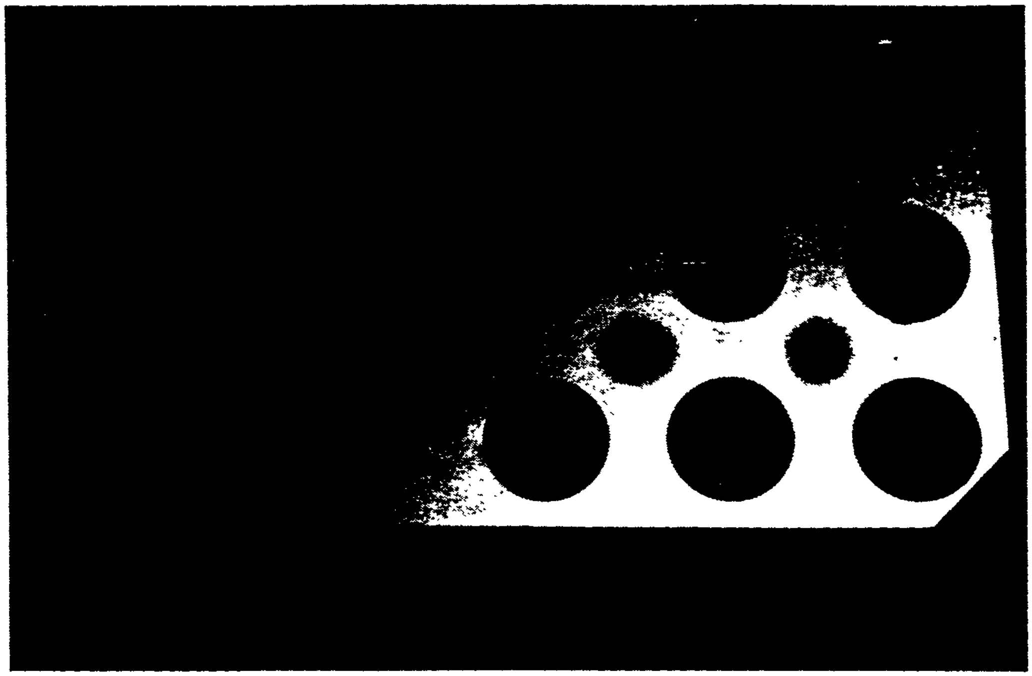
TABLE 3.2.2
Polarized -Light Microscopy Analysis - TSP Filters
Norfolk Shipbuilding and Repair Corporation
Norfolk, Virginia

Sample Location	Particle Type	Weight %	Number %	Mean Diameter (µ)	Density
2C	Minerals	<1	3	10	2.6
	Opaques	27	46	15	1.5
	Blast Grit	72	51	18	2.6
	Biological	o	0	10	1.5
3C	Minerals	<1	3	11	2.6
	Opaques	7	37	12	1.5
	Blast Grit	91	59	17	2.6
	Biological	1	1	25	1.5
4C	Minerals	<1	1	20	2.6
	Opaques	13	22	53	1.5
	Blast Grit	87	77	60	2.6
	Biological	o	0	0	1.5
5A	Minerals	1	2	19	2.6
	Opaques	5	18	16	1.5
	Blast Grit	90	78	20	2.6
	Biological	3	2	33	1.5
6A	Minerals	<1	5	9	2.6
	Opaques	10	17	15	1.5
	Blast Grit	89	78	18	2.6
	Biological	o	0	0	1.5

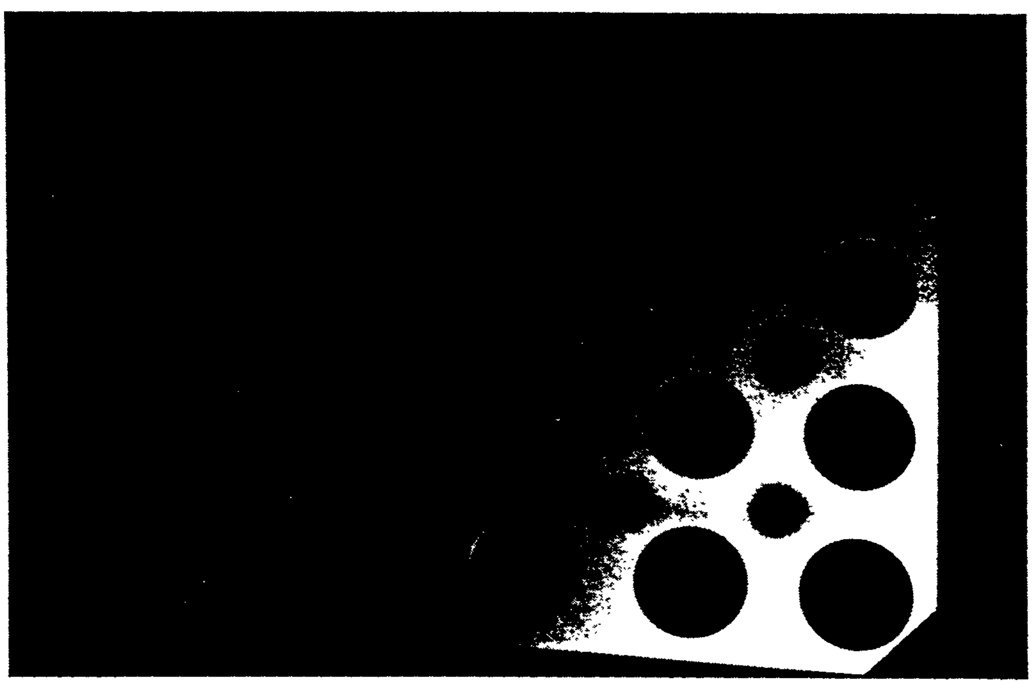
Table 3.2.3
PLM Particle Size Analysis - PM_{10} Filters
Norfolk Shipbuilding and Repair Corporation
Norfolk, Virginia

Sample Location	Mean Particle Diameter (P)
2F	11
3B	12
n	9

Photograph 3.2A
PM1O Greased Shim Plate - No Particle Trailing



Photograph 3.2B
PM1O Greased Shim Plate - Particle Trailing



3.3 Meteorological Results

Meteorological conditions during sampling were recorded by Norshipco. A comparison of sample concentrations and meteorological conditions is presented in Table 3.3.1. Since the required sampling time varied from 5 to 15 minutes (due to rapid filter loading), a definitive effect on sample concentrations by Changing meteorological renditions can not be determined.

TABLE 3.3.1
Comparison of Sample Concentrations and Meteorological Conditions
Norfolk Shipbuilding and Repair Corporation
Norfolk, **Virginia**

Sample Location	Run ID/ Sample Type	Time On	Sample Cone (mg/m^3)	Wind Direct.	Wind Speed (knots}	Temp (^0F)	% Re1. Humidity
1	A-TSP	18:00	0.10	w	10	95	40
1	B-PM_{IO}	18:03	0.06	w	10	95	40
2	A-TSP	22:00	65.8	w	10	89	48
2	B-PM_{IO}	22:02	16.4	w	10	89	48
2	C-TSP	22:23	110	w	11	88	67
2	D-PM_{IO}	22:21	19.8	w	11	88	67
2	E-TSP	22:35	21.4	w	11	88	67
2	F-PM_{IO}	22:33	19.9	w	11	88	67
2	I-TSP	23:55	6.42	w	10	87	66
2	J-PM_{IO}	23:55	1.99	w	10	87	66
3	A-TSP	23:41	29.6	w	8	88	67
3	B-PM_{IO}	23:37	41.9	w	8	88	67
3	C-TSP	23:54	27.0	w	10	87	66
3	D-PM_{IO}	23:53	12.4	w	10	87	66
4	C-TSP	02:08	93.8	w	10	84	76
4	D-PM_{IO}	02:09	52.0	w	10	84	76
5	A-TSP	02:20	35.7	w	10	84	76
5	B-PM_{IO}	02:21	22.5	w	10	84	76
6	A-TSP	02:45	35.0	w	13	84	80
6	B-PM_{IO}	02:45	10.2	w	13	84	80

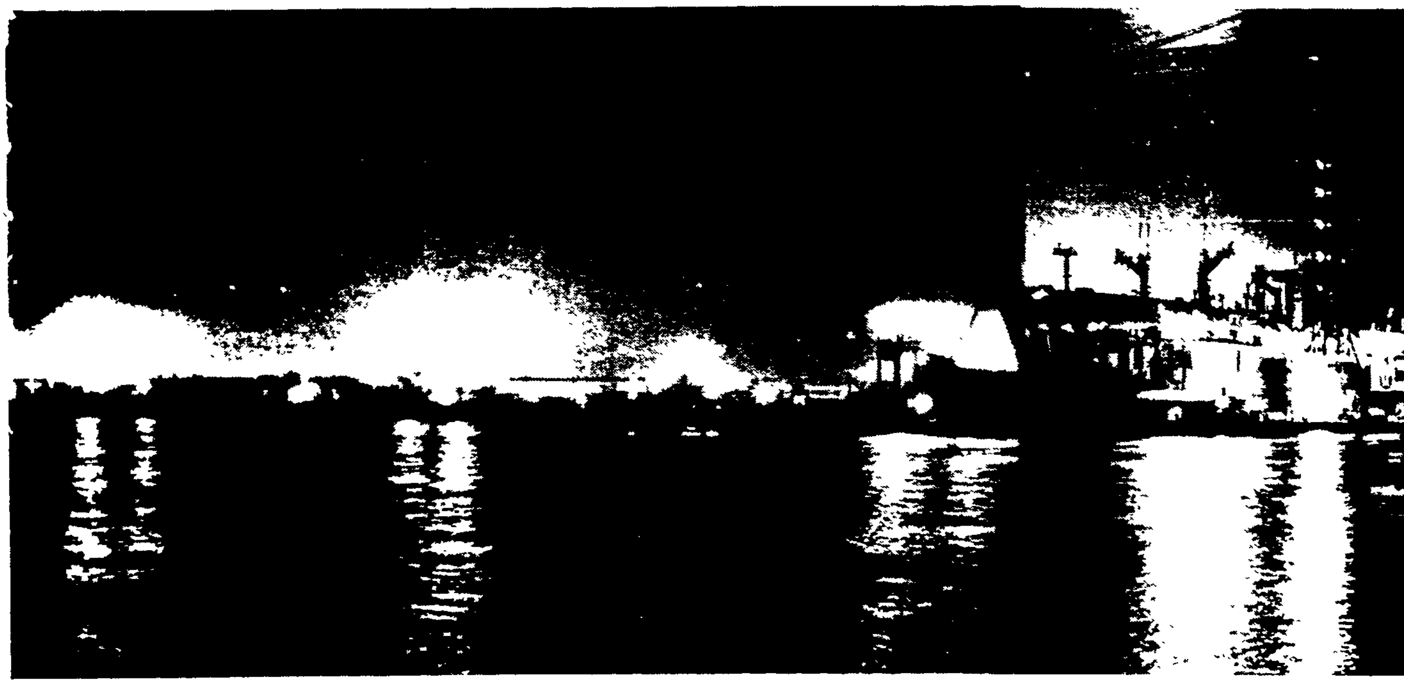
3.4 Summary

Due to the extremely high concentrations of total suspened particulate in the locations sampled, accurate TSP and PM_{10} results were difficult to obtain. A more accurate determination of the PM_{10} generated requires sampling for longer periods of time than was possible at the locations selected, due to rapid loading of the filters and > PM_{10} shim plate. In addition, the excessive contamination of falters due to the high area dust concentrations did not allow for accurate PM_{10} measurements.

The results of this study indicate that PM_{10} dust is generated during the sandblasting operation. The concentrations of PM_{10} dust found at the areas monitored ranged from 1.99 mg/m^3 to 52 mg/m^3, or from 18% to 93% of the total suspended particulate concentrations. The significant constituent of both the total and PM_{10} dusts was the blasting grit. The percentage of paint found in both the TSP and PM_{10} samples comprised only 5 to 27% (by weight) of the samples collected. Smaller amounts of minerals (e.g. ship metal, rust) were present.

PM_{10} emissions from the sandblasting operation would be more accurately measured by placing the samplers in the dust plume at locations further from the sandblasting operation. As can be seen in Photograph 3.4A, the dust plume created is capable of travelling a considerable distance. A comparison of the PM_{10} concentration present during and after a blasting event would provide a better estimate of the environmental impact, if any, of this type of blasting operation. The percentage of PM_{10} present in the samples collected in close proximtiy to the blasting operation were lower, on average, than the percent of PM_{10} found in the background sample.

Photograph 3.4A
Dus Plume Generated by Sandblasting Operation



4.0 SAMPLING AND ANALYTICAL PROCEDURES

4.1 Airborne Dust Concentrations

4.1.1 Total Suspended Particulate

Sampling and analytical procedures used in this project are contained in 40 CFR Part 50 Appendix B (7-l-89 Edition). Samples were collected using high-volume samplers manufactured by General Metal Works, Inc. (GMW). Figure 4.1.1 shows a schematic of the high volume sampler. The High Volume Air Sampler is the recommended instrument for sampling large volumes of air for the collection of suspended particulate matter. The physical design of the sampler is based on aerodynamic principles which result in the collection of particles of 100 microns (Stokes Equivalent Diameter) and less. The sampler consists of a supporting screen for the falter in front of the blower/motor unit. During operation, the sampler is supported in a protective shelter so that the 8“ x 10” surface of the filter is in a horizontal position approximately 3 feet above the floor. In its basic configuration, as used in this project, the sampler (Model GMWT 2200) is equipped with a flow meter connected to a pressure tap at the exhaust end of the motor. The sampler was modified to incorporate a programmable timer and continuous flow device for recording the flow rate over the entire sampling period.

4.1.2 PM_{10}

PM_{10} particles were collected using high-volume samplers manufactured by GMW equipped with a size selective inlet (SSI). Figure 4.1.2 shows a schematic of the high volume sampler equipped with the SSI. Particles enter the SSI through the symmetrical inlet, and are accelerated through multiple circular impactor nozzles. The base under the first set of nozzles is sprayed with Dow Silicone 361 grease. Particles greater than 10 microns impact with this greased impaction surface. The particles smaller than 10 microns are carried upward by the air flow, and then down through the multiple vent tubes to the 8" x 10' falter.

4.2 Filter Analysis

4.2.1 Gravimetric

The falters were standard glass fiber falters measuring 8" x 10". All falters were pre-tared by CAE Analytical Services. After sampling, the falters were put in foil pouches, replaced in their original envelopes, and post-weighed by CAE. The difference in the pre- and post-tare weights represents the mass of particulate collected.

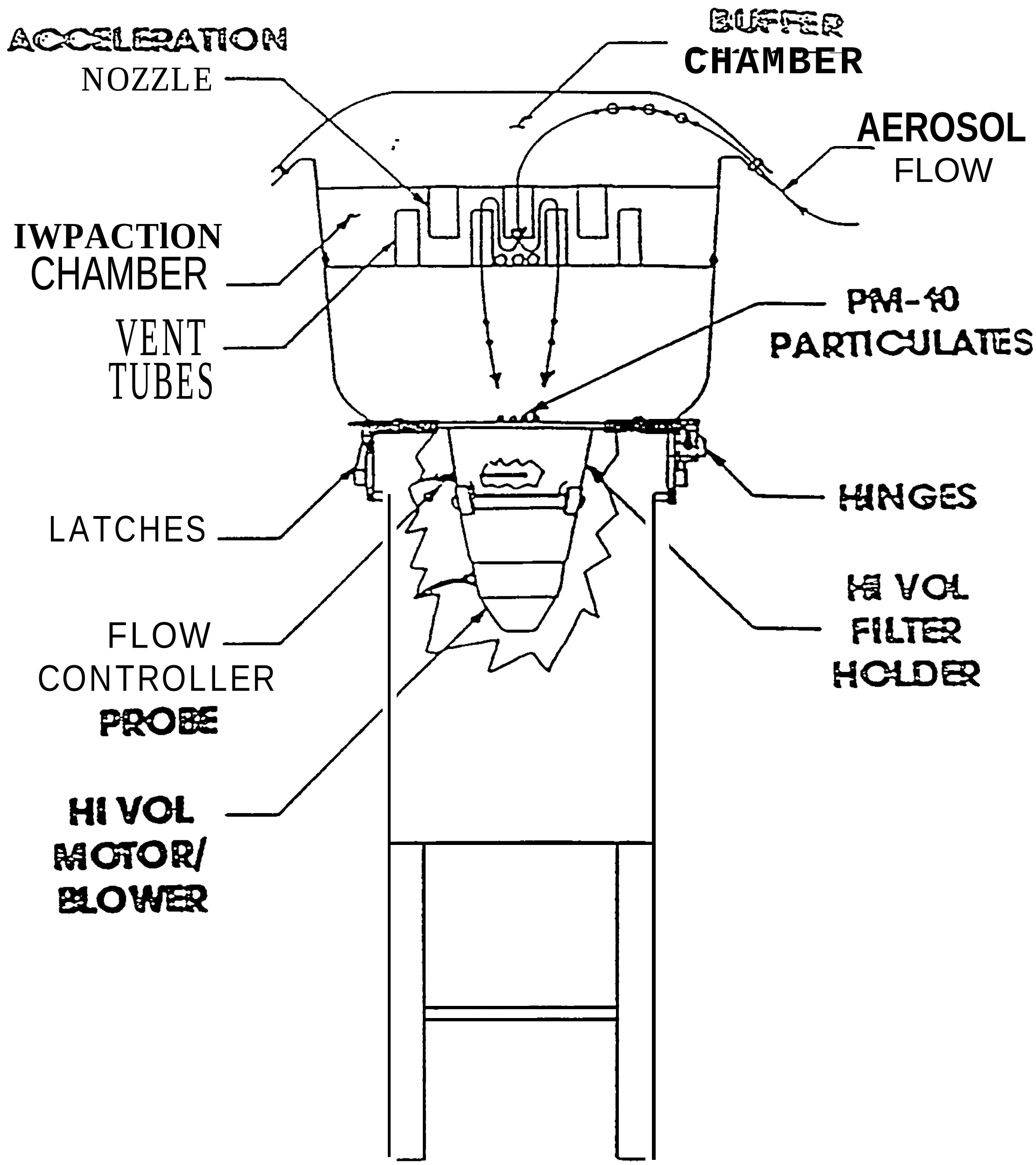


Figure 4.1.2
PM 10 High Volume Sampler

Several blank falters were also submitted for analysis. Laboratory blank falters were falters which were not-removed from their original envelope. Trip blank falters were falters placed in the filter cassettes, taken to the sample location, placed in the sampler, and then removed and placed back into the original envelope. Laboratory data is presented in Appendix C. The total mass collected (in milligrams, mg) divided by the **standard** sample volume (in standard cubic meters, m^3) represents the particulate concentration for the sample location (mg/m^3).

4.2.1 Polarized Light Microscopy (PLM)

For PLM analysis, a portion of the sample was transferred to a microscope slide, immersed in oil, and examined ushg standard PLM techniques.. This analysis was able to classify the dust collected into four categories: minerals, opaques, blast grit, and biologicals. The ‘minerals’ category included any birefringent angular to rounded particles. These particles could be tranparent, or colorless to strongly colored. The ‘opaques’ category included all opaque (black) particles, plus any translucent particles which were recognizable as paint or rust. The ‘blast grit’ category included particles which were transparent, isotropic, colorless to green-brown and always very angular. The blast grit particles occasionally exhibited inclusions and frequently showed conchoidal fractures. The ‘biological’ category include spores, pollens, and vegetable fibers.

4.2.2 Scanning Electron Microscopy with Energy Dispersive X-Ray Spectroscopy (SEM-EDX)

Select filters were analyzed by SEM-EDX in order to compare the dust composition with the composition of the blast grits and paint samples from the U. S.N.S. Humphreys. Samples were excited by a ban of incident radiation. The sample then emitted x-rays which were detected by a cryogenically coded lithium drifted silicon detector. The energy proportional signal for each individual x-ray which transmits the detector was digitized and stored in a multi-channel puke-height analyzer. A qualitative spectrogram is produced, which was used to identify the elements present. Spectrogams are presented in Appendix C.

5.0 QA/QC PROCEDURES

The objective of a quality assurance/quality control (QWQC) program is to assure that the precision and accuracy of all environmental data generated by IEA, Inc. is commensurate with the data quality objectives (DQOs) of Norshipco. DQOS are based on a common understanding of the intended end use(s) of the data, the measurement process, and the availability of resources. Once DQOS are established, formally or informally, QC protocol can be defined for the measurements. The data quality objectives in this project are to provide information to Norshipco and the U.S. EPA regarding the concentrations and composition of TSP and PM_{1O} dust generated during a sandblasting event.

The goal of a QA/QC progam is to ensure that data generated and used for decision-making are scientifically sound, of known quality, and documented to be "in control". To accomplish this goal, standardize methods or procedures are used whenever possible. They must be validated for their intended use, rigorously followed, and data reported with quality indicators (precision, accuracy, completeness, etc.).

Two basic concepts used in a QC progarn are to:

1. Control errors.
2. Verify that the entire sampling and analytical methods are operating within acceptable performance limits.

Use of qualified personnel, reliable and well-maintained equipment, appropriate calibrations and standards, and close supervision of all operations are important components of the QC system. QC in this test progam included the use and documentation of calibrated sampling and analytical instruments, use of EPA validated methods (EPA 40 CFR Part 50 Appendix B), adherence to established protocol, method blanks as a check against possible contamination, sample chain-of-custody documentation, and redundant data calculation with checking.

5.1 High-Volume Samplers

The Hi-Vol samplers were calibrated prior to sampling. The blower/motor unit of each sampler is designed to compensate for any additional pressure drop due to particulate collection and maintain a constant flow rate of 40 cubic feet per minute. A continuous chart recorder which monitored the pressure drop across the unit was added to each sampler. Calibration was confirmed in the field using a calibration orifice whenever the indicated flow rate varied by more than ten percent (10%). The actual sampling rate combined with the sample time allowed calculation of the total volume sampled. Barometric pressure, ambient temperature, and relative humidity were recorded constantly by the Norshipco meteorological station. The volume of air collected (m^3) at standard conditions (298 K, 760 mmHg) was calculated. Example calculations are provided in Appendix A. Calibration data are presented in Appendix E.

5.2 Filter Analysis

Gravimetric analysis was perforrned by clean Air Engineering (CAE) according to the analytical procedures defined in 40 CFR Part 50 Appendix B. Four laboratory filter blanks were provided for gravimetric analysis as a check against potential sample contamintion. In addition, four field trip blanks were also analyzed to determine if falter contamination was possible by simply transporting the falter to the sampler location. Chain-of-custody sheets are provided in Appendix C. No absolute accuracy for this method can be defined due to the inability to determine a “true” particulate matter concentration. Based upon collaborative testing, the relative standard deviation (coefficient of variation) for a single analyst’s precision (redatability) of the method is 3.0 percent. The corresponding value for interlaboratory precision is 3.7 percent.

Appendix A

Example Calculations

EXAMPLE CALCULATIONS

1. Sample Flow Rate

$$Q_{std} = \frac{1}{m}(Y - b)$$

Where	Q_{std}	=	Flow Rate at Standard Conditions, m^3/min
	m	=	Slope of Sampler Calibration Curve
	Y	=	Flow Rate Indicated on Sampler Chart Recorder
	b	=	Y Intercept of Sampler Calibration Curve

Example: Sample Run 1A

Q_{std} = (1/38.068) X (42 - (-5.191))
= 1.251 mg/m^3

2. Sample **Volume**

$$t \text{ X } Q_{std} = V_a$$

Where	t	=	Sample Time in Minutes
	Q_{std}	=	Sample Flow Rate (cubic meters per minute)
		=	Sample Volume (cubic meters)

Example: Sample Run 1A

V_a = 1505 min x 1.251 m^3/min
= 1,882 m^3

3. Sample Concentration

$$\text{Cone (mg/m3)} = \frac{\textit{WgX}\ 1{,}ooo\ \textit{Mg/g}}{V_a}$$

Where:	W_g	=	Total Particulate Weight, in grams
	v_a	=	Sample Volume, in cubic meters

Example: Sample Run 1A

Cone = (0.1877g x 1,000)/1,882 m^3
= 0.10 mg/m^3

Appendix B

FieId Data Summaries and Data Sheets

NORSHIPCO Project # 1512-001

Data Summary

Sample Number	Sampler ID	Indicated Flow (cfm)	Qstd (m3/min)	Sample Time (min)	Sample Volume (m3)	Total Weight (g)	Cone. (mg/m3)
1A	4	42	1.251	1505	1883	0.1877	0.10
1B	3	48	1.443	1499	2163	0.1354	0.06
2A	4	44	1.303	15	20	1.2766	63.83
2B	3	48	1.443	15	22	0.3607	16.40
2C	4	44	1.303	10	13	1.4260	109.69
2D	3	48	1.443	10	14	0.2778	19.84
2E	4	44	1.303	10	13	0.2789	21.45
2F	3	47	1.416	10	14	0.2789	19.92
2I	4	44	1.303	10	13	0.0835	6.42
2J	3	47	1.416	10	14	0.0278	1.99
3A	1	52	1.521	10	15	0.4436	29.57
3B	5	37	0.971	10	10	0.4192	41.92
3C	1	54	1.567	10	16	0.4320	27.00
3D	5	36	0.998	10	10	0.1240	12.40
4C	CAE	44	1.361	5	7	0.6563	93.76
4D	2	44	1.331	5	7	0.3639	51.99
5A	1	52	1.521	5	8	0.2858	35.73
5B	5	37	0.971	5	5	0.1124	22.48
6A	CAE	44	1.361	5	7	0.2447	34.96
6B	2	50	1.490	5	7	0.0715	10.21

HIGH VOLUME AMBIENT SAMPLER DATA SHEET

RH 78%

Sampling Site: warehouse 930
Sampler Location: Parking lot
Sample No.: 1

	Before	After
Barometric Pressure	29.58	29.57
Ambient Temperature	80.8	94

Site: Norco/Kingco Date: 7/13/92 Performed By: PS/EP

Sampler S/N	Sampling Location I.D.	Height Above Ground	Identification No. Filter	XAD-2 or PUF	Sampling Period 7/13/92 Start	7/14/92 Stop	Total Sampling Time (min)	Pump Timer (hr/min)	Sampler Flow Check* Manometer ΔH (in. H2O)	Qxs	M	Qms	Within +/-10%
4	1-A	36"	66-118	Total	18:00	19:05				42		42	✓
IEA-3 ~~80~~ smp 0111/ PM1538	1-B	52"	66-127	PM10	18:03	19:02				48		49	✓

Must Be Performed Before and After Each Sampling Period

Checked By
Date: 7/19/92

IEA - Temp : 9
Barometric : 29.79
Humidity : 58%

HIGH VOLUME AMBIENT SAMPLER DATA SHEET

→ Met. Station

Sampling Site: Norshipco
Sampler Location: Wingwall - ~~Port~~ Starboard
Sample No.: 2

	Before	After
Barometric Pressure		
Ambient Temperature		

Site: Midship - outside shroud Date: 7/14/92 Performed By: PS / EP

	Sampler S/N	Sampling Location I.D.	Height Above Ground	Identification No. Filter	Identification No. XAD-2 or PUF	Timer Sampling Period Start	Timer Sampling Period Stop	Total Sampling Time (min)	Pump Timer (hr/min)	Sampler Flow Check* Manometer ΔH (in. H2O)	Qxs	M	Qms	Within +/-10%	
(3)	IEA 4	2A	3.5	67-147	TSP	1303	13:18	15			44		44		22:00 22:15
IEA-3	1541-011	2B	4.5	67-148	PM10	20:00	20:15	15			48		48		22:02 22 17
(2)	IEA 4	2C	3.5	67-150	TSP	13:27	13:38	11			44		44		22:23 22:24
IEA-3	1541-011	2D	4.5	67-149	PM10	16:52	17:02	10			48		47		22:21 22:31
(1)	IEA 4	2E	3.5	67-145	TSP	13:39	13:44	10			44		44		22:35 22:45
IEA-3	1541-011	2F	4.5	67-144	PM10	17:03	17:13	10			47		47		22:33 22:43
	IEA 4	2G	3.5	66-121	TSP	VOID									
IEA-3	1541-011	2H	4.5	66-93	PM10	VOID		Tear in filter							
	IEA-4	2I	3.5	66-209	TSP	14:55	15:05	10			44		44		11:55 12:05
IEA-3	1541-011	2J	4.5	66-203	PM10	13:24	13:34	10			47		47		11 55 12:05
	—	2K	— EP	67-146 ~~66-146~~	Field Blank										

Must Be Performed Before and After Each Sampling Period

Checked By:
Date:

(1) slight tear in filter when removing
(2) " " " " before "
(3) Two Tears in filter when Removing

2I/2J - Plume ~~much~~ much lighter

HIGH VOLUME AMBIENT SAMPLER DATA SHEET

Sampling Site: Norshipco
Sampler Location:
Sample No.:

	Before	After
Barometric Pressure	—	—
Ambient Temperature	—	—

Site: Halfway Deck Date: 7/14/92 Performed By: PS / EP

	Sampler S/N	Sampling Location I.D.	Height Above Ground	Identification No. Filter	Identification No. XAD-2 or PUF	Sampling Period Start	Sampling Period Stop	Total Sampling Time (min)	Pump Timer (hr/min)	Sampler Flow Check* Manometer ΔH (in. H2O)	Sampler Flow Check* Qxs	Sampler Flow Check* M	Sampler Flow Check* Qms	Sampler Flow Check* Within +/-10%
IEA-1	C0574	3A	3'	66-201	TSP	2341	2351	10	6871		54		52	
IEA-5	0109	3B	4'	66-202	PM10	2337	2347	10	49:46		36		28	
IEA-1		3C	3'	66-199	TSP	2354	0:04	10	68:87		36		36	
IEA-5		3D	4'	66-200	PM10	2353	003	10	49:63		54		54	

* Must Be Performed Before and After Each Sampling Period

Checked By:
Date:

HIGH VOLUME AMBIENT SAMPLER DATA SHEET

Sample No.: ____________

Ambient Temperature — —

Site: ____________ Date: 7/14/92 Performed By: JS / EP

CAE 1945

EA-20112

Sampler S/N	Sampling Location I.D.	Height Above Ground	Identification No.		Sampling Period		Total Sampling Time (min)	Pump Timer (hr/min)	Sampler Flow Check*				
			Filter	XAD-2 or PUF	Start	Stop			Manometer Δ H (In. H2O)	Qxs	M	Qms	Within +/-10%
~~4A~~ K	4A	3'	66-126	TSP	1245	1256	~~[illegible]~~ 6.0	157/	VOID	40		40	
~~4B~~ K	4B	4'	~~66-125~~	PM-10		VOID							
			66-124										

Must Be Performed Before and After Each Sampling Period

Checked By ____________

Date: ____________

HIGH VOLUME AMBIENT SAMPLER DATA SHEET

Sampling Site: Norshipco
Sampler Location: Inside Bow
Sample No.:

	Before	After
Barometric Pressure		
Ambient Temperature	—	

Site: Date: 7/1/92 **Performed By:** JS / EP

	Sampler SIN	Sampling Location I.D.	Height Above Ground	Identification No. Filter	Identification No. XAD-2 or PUF	Sampling Period Start	Sampling Period stop	Total Sampling Time (mln)	Pump Timer (hr/mln)	Sampler Flow Check Manometer AH (In. H20)	Qxs	M	Qms	Within +/- 1 0%
CAE	2945	4C	3'	66-214	TSP	0205	0213	~~10~~ 5	1532		44		44	
IEA-2	0112	4D	4'	66-212	PM-10	0209	0214	~~10~~ 5			44		44	
(1)	2945	4S	Field Blank	66-211	TSP									

Must Be Performed Before and After Each Sampling Period

Checked By:
Date:

(1) Discoloration around edges

HIGH VOLUME AMBIENT SAMPLER DATA SHEET

Sampling Site: Norshipco
Sampler Location: Inside Bow (Rt.)
Sample No.:

	Before	After
Barometric Pressure	–	–
Ambient Temperature	–	–

Site: Date: 7/15/92 Performed By: PS/EP

Sampler SIN	Sampling Location I.D.	Height Above Ground	Identification No. Filter	Identification No. XAD-2 or PUF	Sampling Period Start	Sampling Period Stop	Total Sampling Time (min)	Pump Timer (hr/min)	Sampler Flow Check Manometer AH (In. H20)	Qxs	M	Qms	Within +/-10%
IEA-1	5A	3'	66-213	TSP	0220	0225	24 5			5 2		52	
IEA-5	5B	4'	66-210	PM-10	0221	0226	24 5			38		36	
(1)	5C	Field blank	66-209	TSP									

Must Be Performed Before and After Each Sampling Period

Checked By
Date:

(1) Discoloration around edges

HIGH VOLUME AMBIENT SAMPLER DATA SHEET

Sampling Site: Norshipco
Sampler Location: mid ship
Sample No.:

	Before	After
Barometric Pressure	—	—
Ambient Temperature	—	—

Site: Date: 7/15/92 Performed By: KB / EP

Sampler SIN	Sampling Location I.D.	Height Above Ground	Identification No. Filter	XAD-2 or PUF	Sampling Period Start	Sampling Period stop	Total Sampling Time (min)	Pump Timer (hr/min)	Sampler Flow Check Manometer AH (in. H20)	Qxs	M	Qms	Within +/-10%
CAE	6A	3'	66-208	734	0245	0250	~~13 10~~ 5			44		44	
2	6B	4'	66207	4M1-10	0245	0250	~~15 10~~ 5			50		50	
	6C	3'	66-206	Field blank									

Must Be Performed Before and After Each Sampling Period

Checked By
Date:

Appendix C

Laboratory Analysis Data and Chain-of-Custody Documentation

Particulate Testing Weight Sheet

Page 1 of 3

Client IEA	Project Number 1512-001	Analyst JRP
Plant Norshipco	Unit —	Balance GA200D
Test Date 7/14/92		

Description	Wt. No.	I.D. and Sample Description[1]	Sample volume (ml)[2]	Date/ Time	Gross Weight (g)	Tare Weight (g)	Date/ Time	Net Weight (g)
Type Filter	1	GC 137		7/23 1445	3.6331	3.4823	7/10 1600	
Run		Grey part. stain		7/24 1220	3.6179			
Location		Front Fwd		7/27 1100	3.6175			
		26119-01	T(F)B		3.6177			0.1354
Type Filter	2	66 198		7/23 1445	3.5086	3.3171	7/10 1220	
Run		Grey part stain		7/24 1210	3.5048			
Location				7/27 1055	3.5047			
		26119-02	T(F)B		3.5048			0.1877
Type Filter	3	66 199		7/23 1550	3.6805	3.2643	7/10 1215	
Run		Fine grey part. stain		7/24 1215	3.6665			
Location				7/27 1120	3.6860			
		26119-03	T(F)B		3.6863			0.4220
Type Filter	4	66 200		7/23 1600	3.4608	3.2766	7/10 1715	
Run		Grey part. stain		7/24 1230	3.4603			
Location		26119-04	T(F)B		3.4606			0.1840
Type Filter	5	66 201		7/23 1600	3.7187	3.2721	7/10 1715	
Run		Fine grey part stain		7/24 1210	3.7159			
Location				7/27 1105	3.7155			
		26119-05	T(F)B		3.7157			0.4436
Type Filter	6	66 202		7/23 1600	3.6772	3.2548	7/10 1215	
Run		Fine grey part stain		7/24 1222	3.6740			
Location				7/27 1100	3.6743			
		26119-06	T(F)B		3.6746			0.4198
Type Filter	7	66 203		7/23 1555	3.2951	3.2641	7/10 1715	
Run		Light grey part stain		7/24 1230	3.2916			
Location		Specks of fine blk. part						
		26119-07	T(F)B		3.2919			0.0278
Type Filter	8	66 204		7/23 1555	3.3386	3.2549	7/10 1615	
Run		Fine grey part stain		7/24 1245	3.3381			
Location		26119-08	T(F)B		3.3384			0.0835
Type Filter	9	66 205		7/23 1500	3.2800	3.2790	7/10 1615	
Run		Specks of fine blk part.		7/24 1225	3.2799			
Location		26119-09	T(F)B		3.2800		~~0.0010~~	0.0010
Type Filter	10	66 206		7/23 1510	3.3068	3.2976	7/10 1715	
Run		Specks of fine blk part		7/24 1215	3.3045			
vL@atim'1		Several specks of heavy blk part		7/27 1110	3.305			
		26119-10	T(F)B		3.3048			0.0072

Note appearance of particulate
[1]Two volumes e.g. (500/100) indicate an aliquot was taken
[2]Indicate (T)himble, (F)ilter, or (B)eaker in box below.

CAE F4 ver 1.0
D:\wpforms\weight

Particulate Testing
Weight Sheet

Client IER	Project Number 1512-001	Analyst JTP
Plant NORSHIPCO	Unit —	Balance GR200D
Test Date 7/14/92		

Description	Wt. No.	I.D. and Sample Description[1]	Sample volume (ml)[2]	Date/Time	Gross Weight (g)	Tare Weight (g)	Date/Time	Net Weight (g)
Type FILTER	1	66 207		7/23 1455	3.3659	3.2947	7/10 1710	
Run		Light grey stain		7/24 1150	3.3664			
Location		Fine blk part.						
		26119-11	T F B		3.3662			0.0715
Type FILTER	2	66 208		7/23 1510	3.5357	3.2887	7/10 1710	
Run		Heavy grey stain		7/24 1205	3.5338			
Location		Loose fine blk part.		7/27 1100	3.5334			
		26119-12	T F B		3.5336			0.2449
Type FILTER	3	66 209		7/23 1450	3.3185	3.2927	7/10 1715	
Run		Fine blk part.		7/24 1205	3.3174			
Location				7/27 1105	3.3179			
		26119-13	T F B		3.3177			0.0250
Type FILTER	4	66 210		7/23 1550	3.3946	3.2820	7/10 1725	
Run		Light grey part. stain		7/24 1200	3.3941			
Location								
		26119-14	T F B		3.3944			0.1124
Type FILTER	5	66 211		7/23 1540	3.2993	3.2797	7/10 1725	
Run		Specks of blk. part.		7/24 1245	3.2988			
Location								
		26119-15	T F B		3.2991			0.0194
Type FILTER	6	66 212		7/23 1540	3.4489	3.2860	7/10 1730	
Run		Fine grey part. stain		7/24 1250	3.4489			
Location								
		26119-16	T F B		3.4489			0.1639
Type FILTER	7	66 213		7/23 1530	3.5659	3.2804	7/10 1720	
Run		Light grey stain		7/24 1245	3.5663			
Location		Loose grey part.						
		26119-17	T F B		3.5662			0.2858
Type FILTER	8	66 214		7/23 1530	[illegible]	3.2829	7/10 1710	
Run		Light grey stain		7/24 1210	3.9394			
Location		Heavy loose blk part.		7/27 1110	3.9389			
		26119-18	T F B		3.9392			0.6563
Type FILTER	9	66 215		7/23 1605	3.2668	3.2669	7/10 1710	
Run		Clean		7/24 1150	3.2667			
Location								
		26119-19	T F B		3.2668			0.0001
Type FILTER	10	66 216		7/23 1605	3.2934	3.2932		
Run		Clean		7/24 1155	3.2929			
Location								
		26119-20	T F B		3.2931			-0.0001

[1] Note appearance of particulate
[2] Two volumes (e.g. 500/100) indicate an aliquot was taken.
Indicate (T)himble, (F)ilter, or (B)eaker in box below.

CAE P4 ver 1.0
D:\vpforms\weight

Particulate Testing
Weight Sheet

Client T-Lis	Project Number 1512-ccH	Analyst JLP	
Plant NORSHIPCO	unit	Balance GA 200D	
Test Date 7/14/92			

Description	Wt. No.	I.D. and Sample Description[1]	Sample volume (ml)[2]	Date/ Time	Gross Weight (g)	Tare Weight (g)	Date/ Time	Net Weight (g)
Type FILTER	1	66 217		7/23 1605	3.2879	3.2879	7/10 1705	
Run		CLEAN		7/24 1450	3.2879			
Location		26119-21	T (F) B		3.2879			0.0000
Type FILTER	2	67 150		7/23 1552	4.6609	3.5143	7/10 1645	
Run		HEAVY FINE GREY PART		7/24 1220	4.6571			
				7/27 1105	4.6566			
Location		26119-22	T (F) B		4.6569			1.1426
Type FILTER	3	67 149		7/23 1530	3.7578	3.5106	7/10 1650	
Run		HEAVY FINE GRAY PART		7/24 1230	3.7873			
Location		26119-23	T (F) B		3.7876			0.2770
Type FILTER	4	67 148		7/23 1515	3.8613	3.4975	7/10 1650	
Run		GREY PART. STRIK		7/24 1220	3.8584			
				7/25 1110	3.8580			
Location		26119-24	T (F) B		3.8582			0.3607
Type FILTER	5	67 147		7/23 1515	4.7435	3.4671	7/10 1650	
Run		HEAVY FINE GREY PART		7/24 1210	4.7438			
Location		26119-25	T (F) B		4.7437			1.2766
Type FILTER	6	67 146		7/23 1535	3.4722	3.4682	7/10 1655	
Run		SPECKS OF FINE BLK PART TORN FILTER		7/24 1220	3.4717			
Location		26119-26	T (F) B		3.47[illegible]			0.0038
Type FILTER	7	67 145		7/23 1535	4.6175	3.4469	7/10 1650	
Run		HEAVY FINE GREY PART FILTER TORN		7/24 1210	4.6141			
				7/27 1115	4.6138			
Location		26119-27	T (F) B					0.2789
Type FILTER	8	67 144		7/23 1535	3.7462	3.4671	7/10 1700	
Run		HEAVY FINE GREY PART.		7/24 1300	3.7458			
Location		FILTER TORN 26119.28	T F B		3.74[illegible]			0.2789
Type FILTER	9	66 173		7/23 1530	3.4923	3.4817	7/10 1645	
Run		LOOSE SPECKS OF BLK PART		7/24 1205	3.4902			
				7/27 1115	3.4900			
Location		26119-29	T F B		3.4901			0.0084
Type	10							
Run								
Location			T F B					

[1] Note appearance of particulate
[2] Two volumes (e.g. 500/100) indicate an aliquot was taken.
Indicate (T)himble, (F)ilter, or (B)eaker in box below.

CAE P4 ver 1.0
D:\vpforms\weight

Analytical
A Division of Clean Air Engineering
800-627-0033

Request for Analysis

Where Air Quality Analysis is Our Business

Chain of Custody

Please print. Instructions on reverse side correspond with circled numbers.

15087

1. Client: IEA Proj. #: 1512-001
Project Name: Norshipco Location: —
Project Manager: E. Poore P.O.#: —
Sampler: R. Slater / E. Poore Quote #: —

CAE Lab #	2 Sample Identification	Date Collected	Time Collected	# of Containers	Filter	5 Analyses Requested: Total wg	6 Remarks
	~~67-152~~						
	~~67-151~~						
	67-150	7/14/92		1	✓	✓	Retain filters for further Analyses
	67-149	7/14/92		1	✓	✓	
	67-148	7/14/92		1	✓	✓	
	67-147	7/14/92		1	✓	✓	
	67-146	7/14/92		1	✓	✓	
	67-145	7/14/92		1	✓	✓	
	67-144	7/14/92		1	✓	✓	
	~~66-93~~						
	~~66-121~~						
	66-123	7/14/92		1	✓	✓	
	~~66-124~~						
	~~66-125~~						
	~~66-126~~						

7. **Turnaround time requested** (check one only):
- [x] Normal 10-15 bus. days
- [ ] 6-9 bus. days (1.5x list fee)
- [ ] 3-5 bus. days (2x list fee)
- [ ] 2 bus. days or less (3x list fee)

This form was completed by:
Erict Poore 7/17/92
Client Signature Date
Incomplete forms will cause unnecessary delay and in some cases, a refusal to accept samples. A purchase order is required with the delivery of samples. All prices and work performed will be in accordance with CAE Analytical's fee schedule and terms and conditions.

9 Relinquished by	Date	Time	11 Received by
[signature]	7/10	1535	D. Chinane
Erict Poore	7/17	8:00	

Relinquished by	Date	Time	Received at CAE Analytical by

8. Rush results requested by (please circle): Fax or Phone
Fax #: 919-460-1785 Phone #:

10. Bill to address:

12. In case we have questions when samples arrive, CAE Analytical should call:
Name: E. Poore Phone: 919-460-0852
Send report to: E. Poore

500 West Wood Street, Palatine, IL 60067 (708) 991-3300 Copies: White→Lab/Project File Blue→Receipt Record Pink→Analyst Copy Gold→Customer Copy

CAE Analytical

A Division of Clean Air Engineering

800-627-0033

Request for Analysis

Where Air Quality Analysis is Our Business

Chain of Custody

Please print. Instructions on reverse side correspond with circled numbers.

15086

(1) Client: IEA   Proj. #: 1512-001

Project Name: Norshipco   Location: —

Project Manager: E. Poore   P.O.#: — FS1092

Sampler: P. Slater / E. Poore   Quote #: —

(4) Matrix   (5) Analyses Requested   (6) Remarks

CAE Lab #	(2) Sample Identification	Date Collected	Time Collected	(3) Grab	Composite	Total # of Containers	Filter	Liquid Blank/Wash	Liquid Sample Catch	Absorbent Tube	Bag Sample	Canister Sample	Cold Trap	PUF Plug	Other (Solid, etc.)	Total wg							Remarks
	66-212	7/14/92				1	✓									✓							Retain filters
	66-213	7/14/92				1	✓									✓							for further
	66-214	7/14/92				1	✓									✓							analyses
	66-215	7/14/92				1	✓									✓							
	66-216	7/14/92				1	✓									✓							
	66-217	7/14/92				1	✓									✓							
	~~66-218~~	~~7/14/92~~				~~1~~	~~✓~~									✓							
	~~66-219~~	~~7/14/92~~				~~1~~	~~✓~~									✓							
	~~66-220~~	~~7/14/92~~				~~1~~	~~✓~~									✓							
	~~66-221~~																						

(7) **Turnaround time requested** (check one only):

- [x] Normal 10-15 bus. days
- [ ] 6-9 bus. days (1.5x list fee)
- [ ] 3-5 bus. days (2x list fee)
- [ ] 2 bus. days or less (3x list fee)

This form was completed by: E. Poore 7/12/92

Client Signature   Date

Incomplete forms will cause unnecessary delay and in some cases, a refusal to accept samples. A purchase order is required with the delivery of samples. All prices and work performed will be in accordance with CAE Analytical's fee schedule and terms and conditions.

(9) Relinquished by	Date	Time	Received by (11)
[illegible]	7/10	17:35	P. Chimore
Errol Poore	7/12	8:00	

Relinquished by	Date	Time	Rec'd for CAE Analytical by

(8) **Rush results requested by** (please circle): Fax or Phone

Fax #: 919-460-1785   Phone #:

Bill to address: (10)

In case we have questions when samples arrive, CAE Analytical should call: (12)

Name: E. Poore   Phone: 919-460-0852

Send report to: E. Poore

IEA
An Aquarion Company

148 Rangeway Road
North Billerica, MA 01862

phone 617.272.5212
Fax 5080667.7871

September 4, 1992

Everett Poore
North Carolina Field Office
120 South Center Court
Suite 200
Morrisville NC 27560

Client Ref: Norshipco
IEA-MA Job #16853

Attn: Everett Poore

Dear Sir:

Please find enclosed results of analyses of sixteen filter and 5 bulk samples which you submitted. These samples were examined using SEM-EDX and PLM techniques to characterize airborne particulates from marine paint sandblasting operations.

METHODS :

portions of the three bulk paint chip samples were ground with a mortar and pestle. The fine particles from the two bulk blasting grit samples were separated by spreading the materials on a smooth plastic sheet. For SEM-EDX work, particles were supported on double-back tape and coated with evaporated graphite. For PLM, particles were immersed in oil of calibrated index of refraction (n=l.510). For PLM work, particles were identified into four categories. The “Minerals” category included any birefringent angular to rounded,transparent, colorless to strongly colored particies. The “Opaques” category included all opaque (black) particles, plus any translucent particles also recognizable as paint or rust. The “Blast Grit” is transparent, isotropic, colorless to green-brown and always very angular, occasionally with inclusions and frequently showing conchoidal fracture. The “biological” are chiefly spores/ plus occasional pollens and vegetable fibers.

IEA
An Aquarion Company

Should you have further questions, or need additional information, please feel free to contact me at any time.

Sincerely,

Drew Killius
Mgr. Microscopy Services

DK/ehs

IEA, INC.
Total Suspended Particulate Analysis by Polarized Light Microscopy
Version 4.2 (c) copyright 1989 by EAL, 1991 by IEA

CLIENT: N0RSHIPC0

SAMPLE: 66-212 TSP (Ug/cubic meter) = 0)

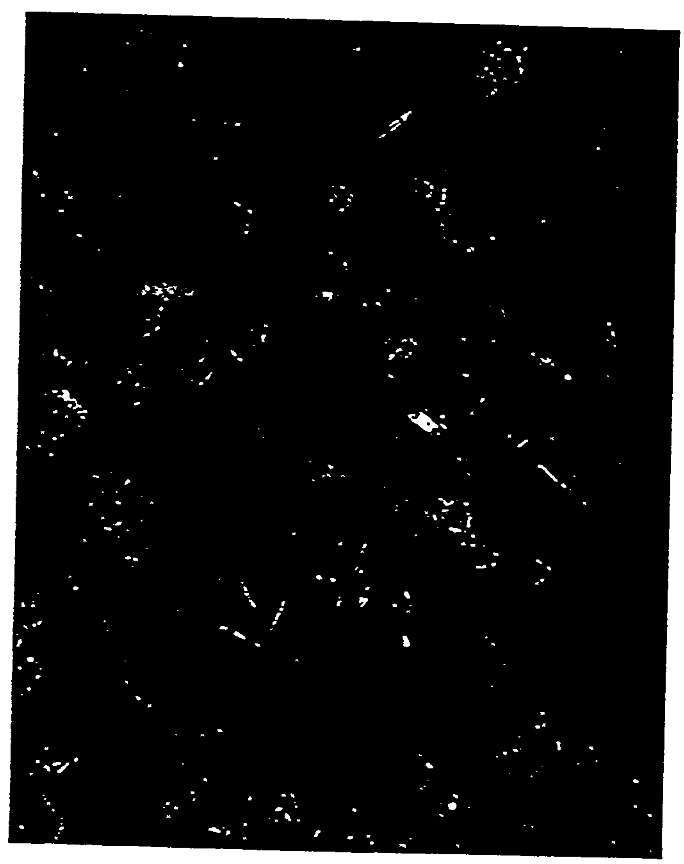
ANALYZED EY: DK 08-27-1992 EAL JOB NO.: 16853

TYPE	WEIGHT %	NUMBER %	MEAN DIAM. (uM)	DENSITY
MINERALS	1	3	6	G= 2.6
OPAQUES	15	35	8	G= 1.5
BLAST GRIT	85	62	8	G= 2.6
BIOLOGICALS	o	0	0	G= 1.5

TOTAL COUNT: 100

PHOTO A: 500X, PARTLY X-POLARS, TYPICAL
PHOTO H: 500X, PaRTLY X-POLARS, TYPICAL

--B-



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An Aquarion Company

FINDINGS :

Looking first at the bulk materials, the paint chips and blasting grit are readily distinguishable, both by PLM and EDX. The blasting grit appears to be a glass product, having characteristic optical properties, and particle morphology (see "methods" above). Chemically, it shows major amounts of aluminum, silicon, and iron, with smaller amounts of potassium and calcium. Spectra of both samples are virtually identical. The fine particles shown in the PLM micrograph of sample 17 (ACO) are a good representation of how the material appears in the PLM photos of the filter samples. The paints appear optically as opaque material of irregular to somewhat rounded outline, and as such, resemble many common soots. Occasional translucent particles are also present, including material recognizable as rust. Chemically we see two or three classes of material. The Freeboard sample shows high titanium, plus zinc, while the other two samples (boot-top, keel-bilge) show major copper, plus zinc, and a variable amount of iron. The elements copper, zinc, and titanium are unique to the paints and can be used as good tracers for airborne paint dust. Since iron is geochemically common, and occurs both as rust and as a constituent in the blasting grit, its usefulness as a chemical marker is somewhat more limited.

Turning to the filters, we can look first at the blank (66-217), where we see that the glass is a calcium-rich type and very inconspicuous in the PLM photo. The technique we use to remove particles from the filters is effective, and in the PLM work the glass fibers are also readily recognizable and do not constitute an interference.

After the blank, sample 66-127 appears to be the natural background in the area. Minerals, soots, and biological are present and typical in amount and appearance. Note in the EDX spectrogram the presence of a distinct peak for sulfur. This is a good indication that the soots are from combustion of high-sulfur fuels. The sulfur is also a good marker to help distinguish the soot fraction in the "opaques" category in the PLM analyses. The size of the particles shown in the photos is also typical of PM-10 type collection. (Note: at 500X, the scale is lmm=2um; e.g. a 10 micron particle will measure 5 millimeters). One filter (66-214) was apparently not a pm-10 type, and the very coarse particles present are readily apparent in the photos. Among the other samples given a full PLM analysis only one of the filters (66-210) showed mean sizes for the grit and opaques above the 10 UM level. It should be noted however that many filters showed mean sizes very close to the 10 micron level. Three filters were indicated as being of interest with regard to size only. I have done an abbreviated “one-category” PLM analysis on samples 66-203, 66-202, and 67-144 in order to obtain mean size information comparable to the mean size data given for the other (4-category) PLM analyses.

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An Aquarion Company

The last analyses conducted were particle size by sieving on the two bulk blasting grit samples. The table below gives weight percent in each size range:

	ACO	Norshipco
+ lmm	46.9	86.1
- 1 + 0.5mm	25.8	11.2
-0.5 + 60 mesh	8.3	1.6
-60 + 140	11.3	0.9
-140 + 300	6.1	0.2
- 300	1.6	0.1

DISCUSSION:

The overall picture which emerges here is that the fines from the blasting grit appear to be having the major impact on air quality. In the PLM analyses, the photos give a good qualitative appraisal. In using the weight percent data, keep in mind that the method may have one or two systematic biases. Firstly, particles are viewed lying flat on a microscope slide. Thin flakes or flattened chips may have a preferred orientation which presents their largest dimension, causing an overestimate of mass. Secondly, the mass calculation is based on a density value obtained from published data, which may not be exactly correct for the specific materials involved here. The number percent data, however, is less affected by preferred orientation. Likewise, the EDX data is obtained from a much larger population of more randomly oriented particles. None of the EDX analyses on the air filters show more than a few percent of copper, zinc, or titanium. This is also good evidence that the paint dust is not becoming airborne in large amounts. What does show in the EDX data is a variable amount of iron, which suggests that metal and rust particles may be more abundant than paint dust. This also agrees with the nature of the bulk paint samples; they are in the form of large flakes and chips. What I suspect is happening is that the greatest bulk of the paint is being removed by scraping or chipping, and that the sandblasting is being used to remove only the last vestiges of paint along with any rust, and even some fresh metal, as the final surface preparation step prio: to applying to the new finish.

IEA, INC.
Total Suspended Particulate Analysis by Polarixed Light Microscopy
version 4.2 (c) Copyright 1989 by EAL, 1991 by IEA

CLIENT: NORSHIPCO

SAMPLE: 67-148 TSP (ug/cubic meter) = 0

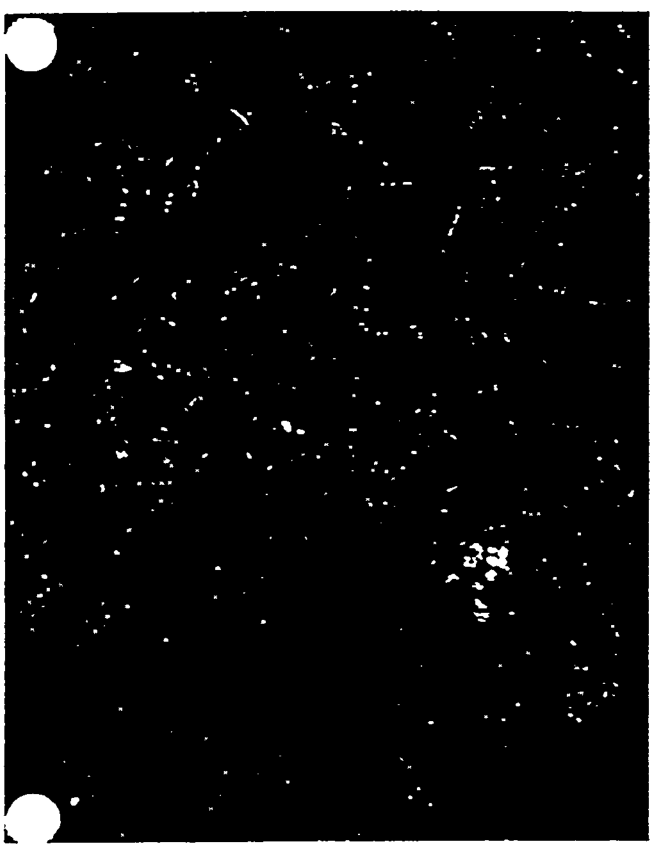
ANALYZED BY: DK 09-01-1992 EAL JOB NO.:

TYPE	WEIGHT %	NUMBER %	MEAN DIAM.(uM)	DENSITY
MINERALS	1	3	8	G= 2.6
OPAQUES	5	25	7	G= 1.5
BLAST GRIT	93	70	10	G= 2.6
BIOLOGICALS	<1	2	6	G= 1.5

TOTAL COUNT: 100

PHOTO A: 500X, PARTLY X-POLARS, TYPICAL
PHOTO B: 500X, PARTLY X–POLARS, TYPICAL

-A-



-B-

IEA, INC.

Total Suspended Particulate Analysis by Polarized Light Microscopy
-sion 4.2 (c) Copyright 1989 by EAL, 1991 by IEA

CLIENT: NORSHIPCO

SAMPLE: 67-149 TSF (ug/cubic meter) = 0

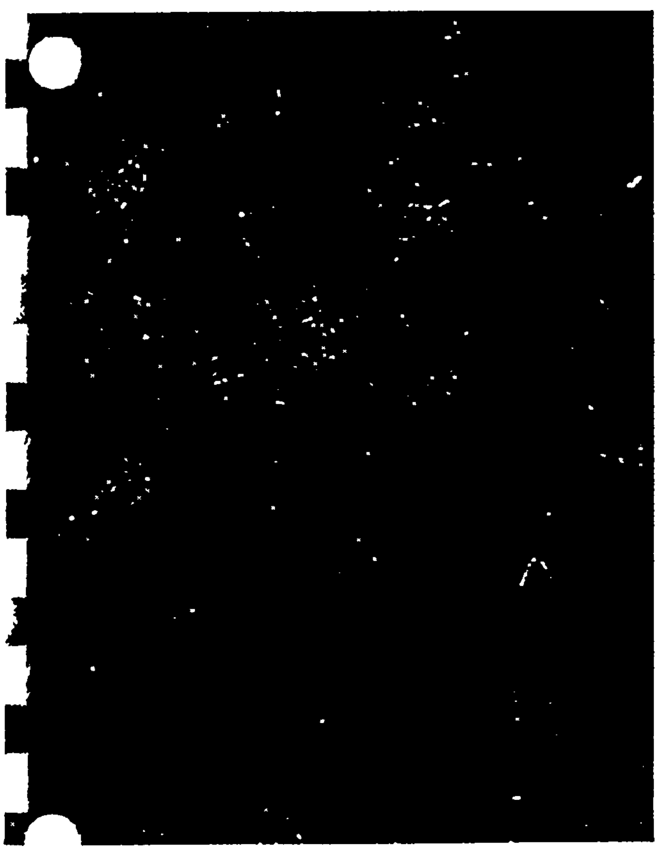
ANALYZED BY: DK 09-01-1992 EAL JOB NO.:

TYPE	WEIGHT %	NUMBER %	MEAN DIAM.CUM)	DENSITY
MINERALS	0	0	0	G= 2.6
OPAQUES	12	32	8	G= 1.5
BLAST GRIT	87	67	10	G= 2.6
BIOLOGICALS	1	1	10	G= 1.5

TOTAL COUNT: C1100

PHOTO A: 500X, PARTLY X-POLARS, TYPICAL
PHOTO H: 500X, PARTLY X-POLARS, TYPICAL

-A-



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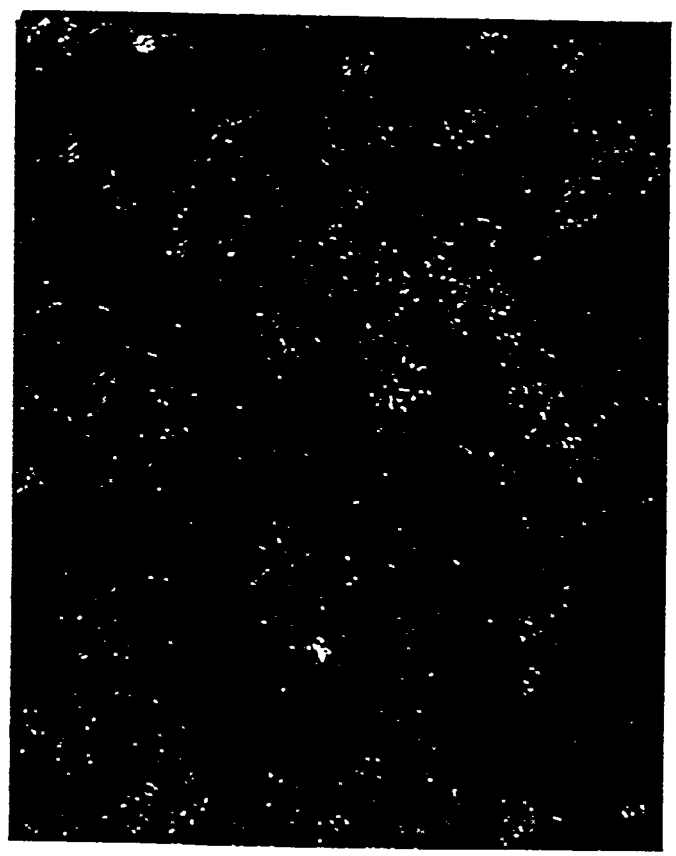


IEA, INC.

TOtal Suspended Particulate Analysis by Polarized Light Micrcoscopy
version 4.2 (c) Copyright 1989 by EAL, 1991 by IEA

CLIENT: NORSHIPCO

SAMPLE: 66–200 TSP (ug/cubic meter) = O

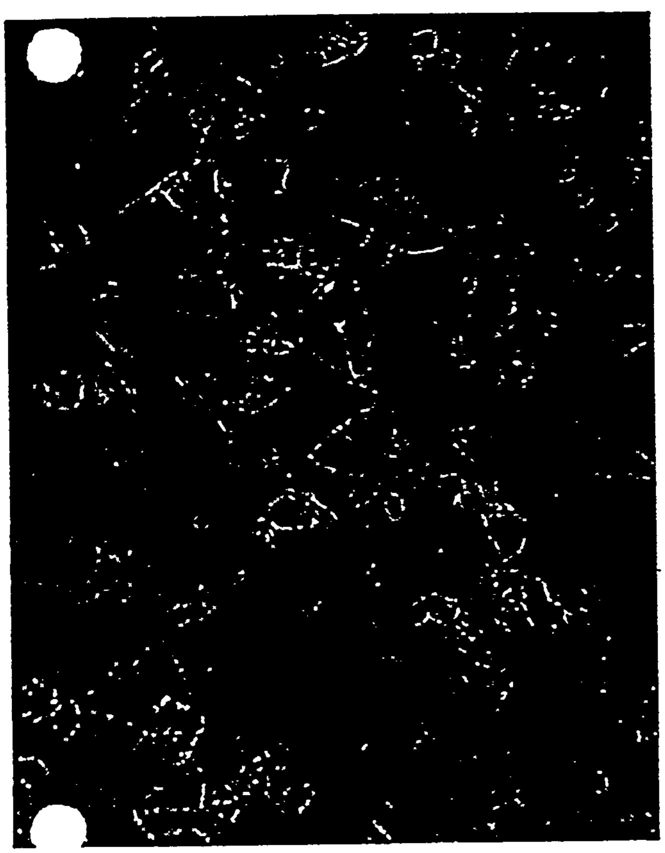
ANALYZED BY: DK 08-27-1992 EAL JOB NO.: 16853

TYPE	WEIGHT %	NUMBER %	MEAN DIAM.CUM>	DENSITY
MINERALS	2	2	'9	G= 2.6
OPAQUES	11	36	7	G= 1.5
BLAST GRIT	86	61	'9	G= 2.6
BIOLOGICALS	2	1	1.5	G= 1.5

TOTAL COUNT: 100

PHOTO A: 500X, PARTLY X-POLARS, TYPICAL
PHOTO H: 500X, PARTLY X-POLARS, TYPICAL

-A-



-B-

IEA, INC.
Total Suspended particulate Analysis by Polarized Light Microscopy
rsion, 4.2 (c) Copyright l989 by EAL, 1991 by IEA

CLIENT: NORSHIPCO

SAMPLE: 66-127 TSP (ug/cubic meter) = (0)

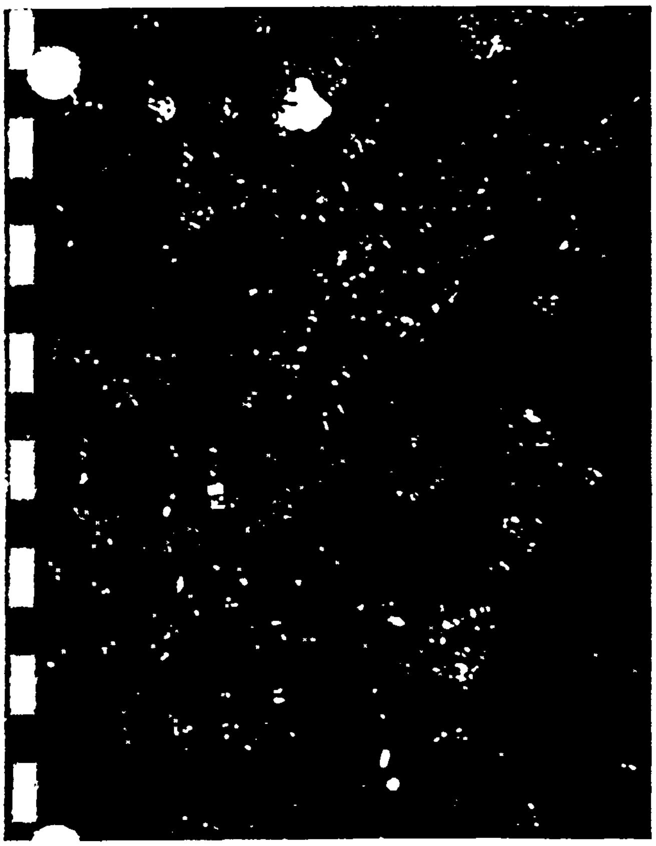
ANALYZED BY: DK 09-01-1992 EAL JOB NO.:

TYPE	WEIGHT %	NUMBER %	MEAN DIAM.(uM)	DENSITY
MINERALS	36	44	7	G= 2.6
OPAQUES	21	29	7	G= 1.5
ELAST GRIT	8	6	8	G= 2.6
BIOLOGICALS	36	21	8	G= 1.5

TOTAL COUNT: 100

PHOTO A: 500X, PARTLY X-POLARS, TYPICAL
PHOTO B: 500X, PARTLY X-POLARS, TYPICAL

-A-



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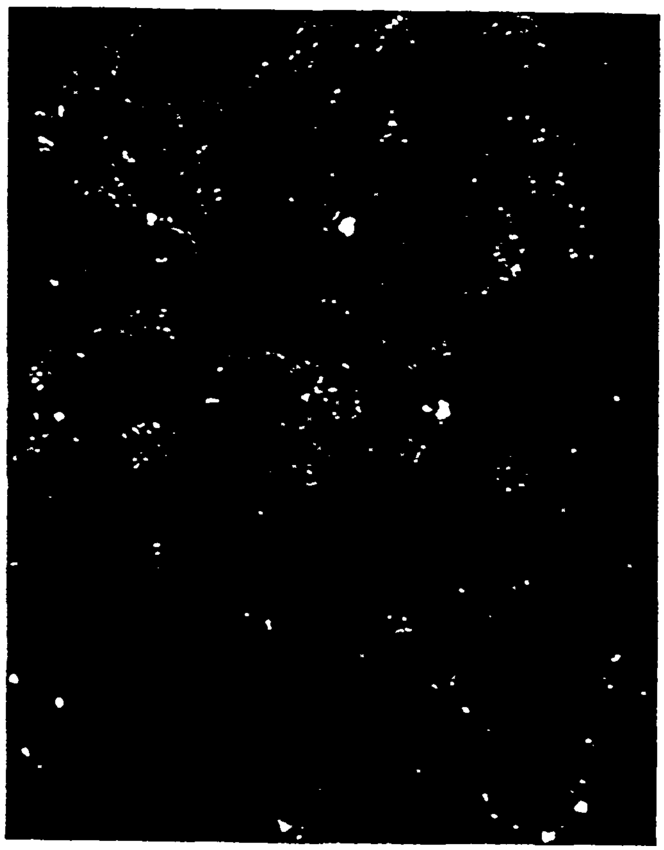

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TOtal Suspended Particulate Analysis by Polarized Light Microscopy
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CLIENT: NORSHIPCO

SAMPLE: 66-207 TSP (ug/cubic meter) = 0

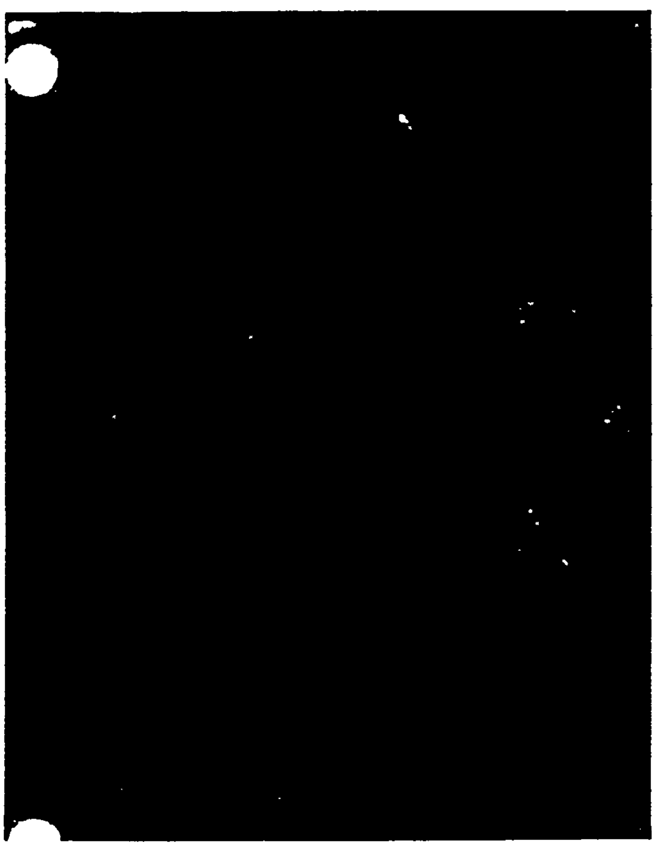
ANALYZED BY: DK 08-27-1992 EAL JOB NO.: 16853

TYPE	WEIGHT %	NUMBER %	MEAN DIAM.(uM>	DENSITY
MINERALS	11	8	9	G= 2.6
OPAQUES	27	49	8	G= 1.5
BLAST GRIT	58	40	10	G= 2.6
BIOLOGICALS	4	3	10	G= 1.5

TOTAL COUNT: 100

PHOTO A: 500X, PARTLY X-POLARS, TYPICAL
PHOTO B: 500X, PARTLY X-POLARS, TYPICAL

-A-



-B-

IEA, INC.
Total Suspended Particulate Analysis by Polarized Light Microscopy
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CLIENT: NORSHIPCO

SAMPLE : 66-210 TSp (ug/cubic meter:) = 0

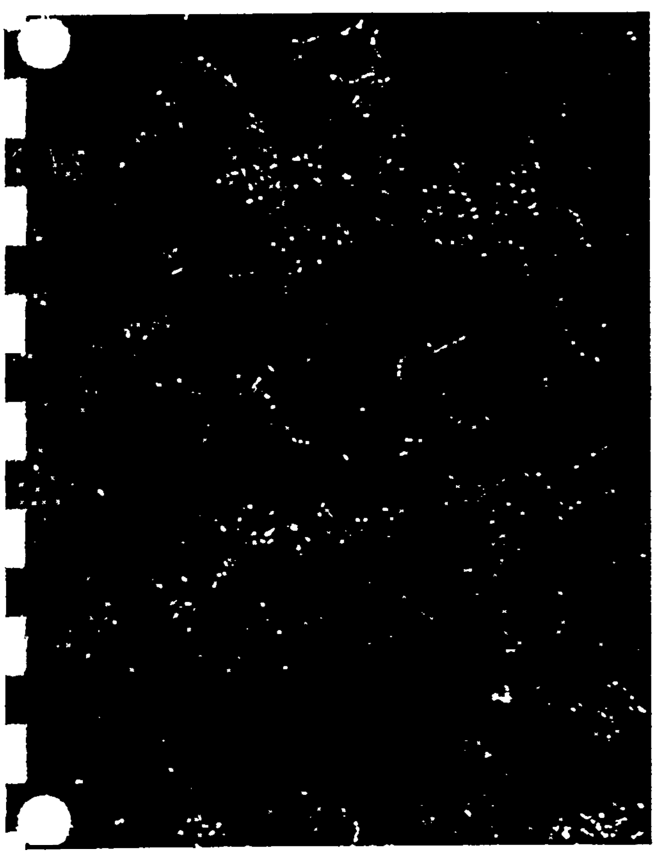
ANALYZED BY: DK 09-01-1992 EAL JOB NO.:

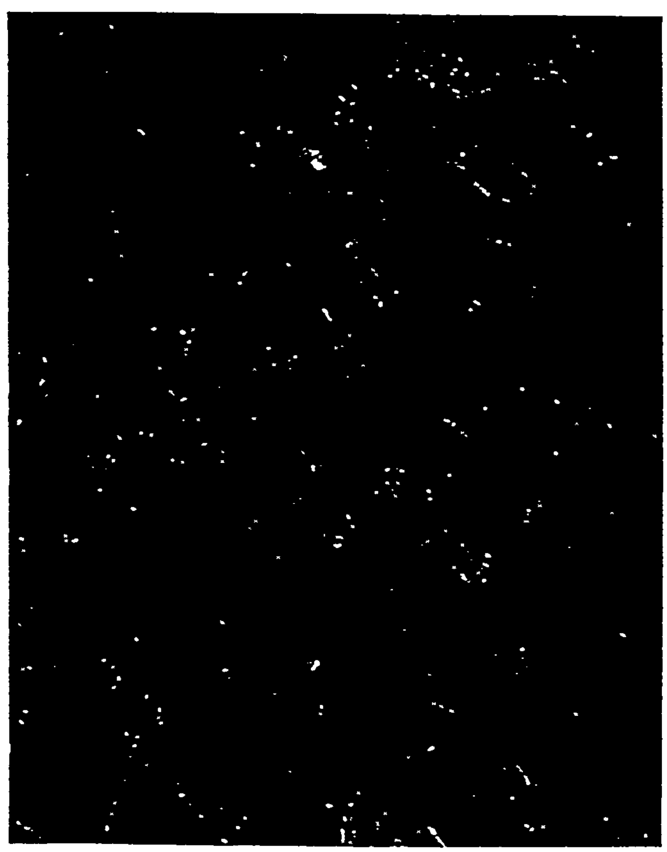
TYPE	WEIGHT %	NUMBER %	MEAN DIAM.(uM)	DENSITY
MINERALS	4	4	14	G= 2.6
OPAQUES	24	39	12	G= 1.5
BLAST GRIT	72	57	13	G= 2.6
BIOLOGICAL	0	0	0	G= 1.5

TOTAL COUNT: 100

PHOTO A: 500X, PARTLY X-POLARS, TYPICAL
PHOTO B: 5OOX, PARTLY X-POLARS, TYPICAL

-B-





IEA, INC.
TOtal Suspended Particulate Analysis by Polarized Light Microscopy
version 4.2 (Cl) Copyright 1989 by EAL, 1991 by IEA

CLIENT: NORSHIPCO

SAMPLE : 56-208 TSP (ug/cubic meter) = 0

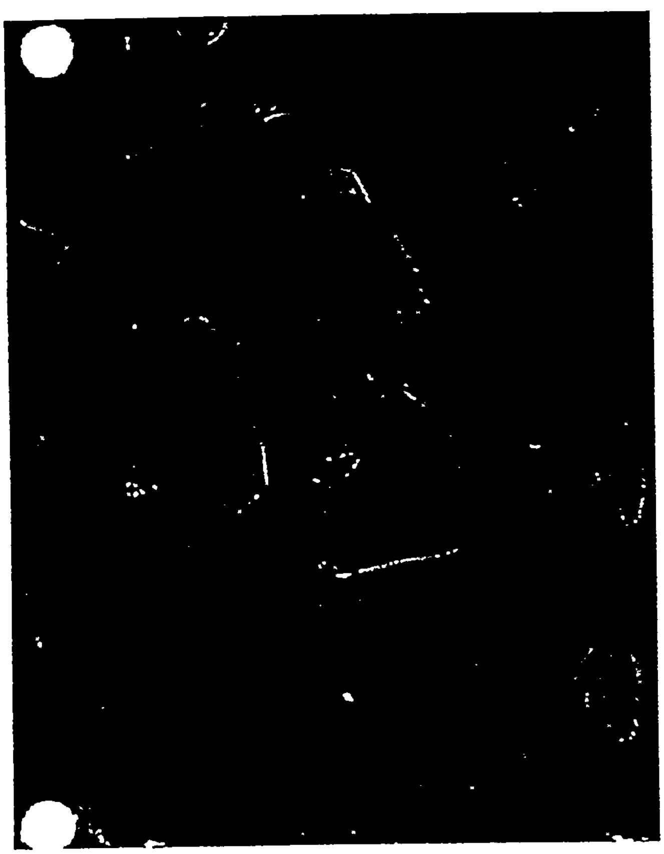
ANALYZED BY: DK 08-27-1992 EAL JOB NO.: 16853

TYPE	WEIGHT %	NUMBER %	MEAN DIAM.(uM	DENSITY
MINERALS	<1	5	9	G= 2.6
OPAQUES	10	17	15	G= 1.5
BLAST GRIT	89	78	18	G= 2.6
BI0LOGICALS	0	0	0	G= 1.5

TOTAL COUNT: 100

PHOTO A: 500X, PARTLY X-POLARS, TYPICAL
PHOTO B: 500X, PARTLY X-POLARS, TYPICAL

-A-



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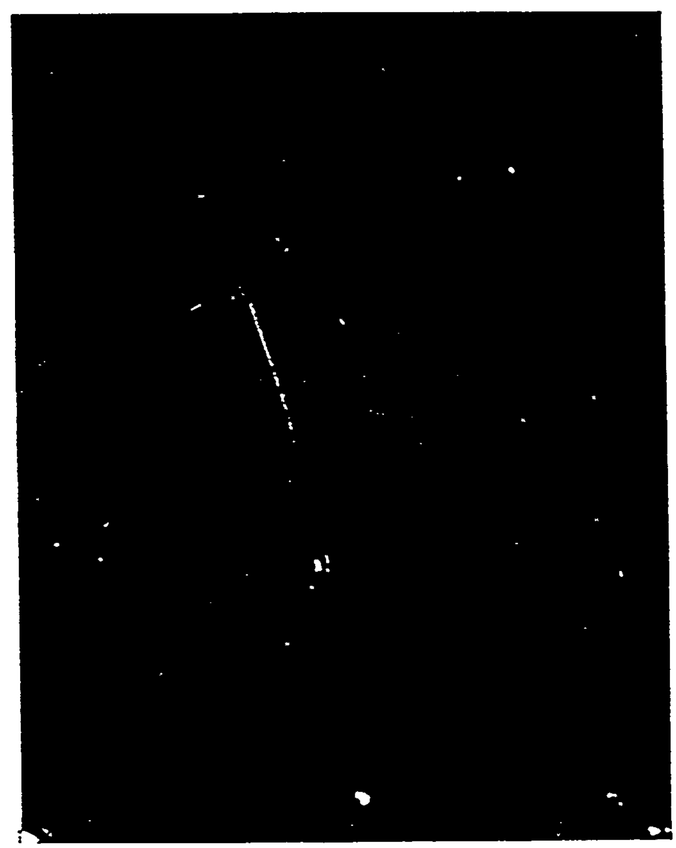

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Total Suspended Particulate Analysis by Polarized Light Microscopy
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CLIENT: NORSHIPCO

SAMPLE: 66-199 TSP (ug/cubic meter:) = 0

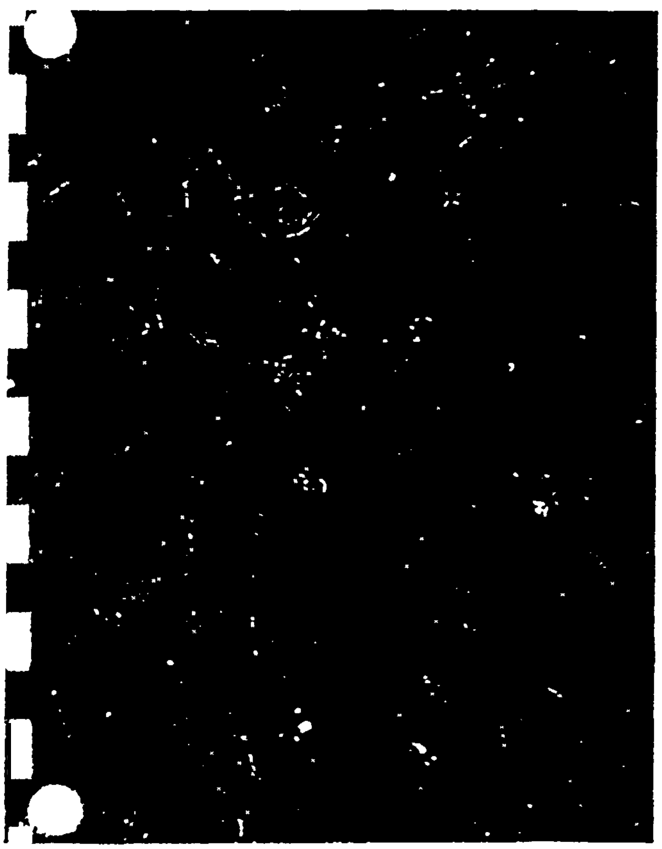
ANALYZED BY: DK 09-01-1992 EAL JOB NO.:

TYPE	WEIGHT %	NUMBER %	MEAN DIAM. (uM)	DENSITY
MINERALS	<1	3	11	G= 2.6
OPAQUES	7	37	12	G= 1.5
BLAST GRIT	91	59	17	G= 2.6
BIOLOGICALS	1	1	25	G= 1.5

TOTAL COUNT: 100

PHOTO A: 500X, PARTLY X-POLARS, TYPICAL
PHOTO B: 500X, PARTLY X-POLARS, TYPICAL

-A-



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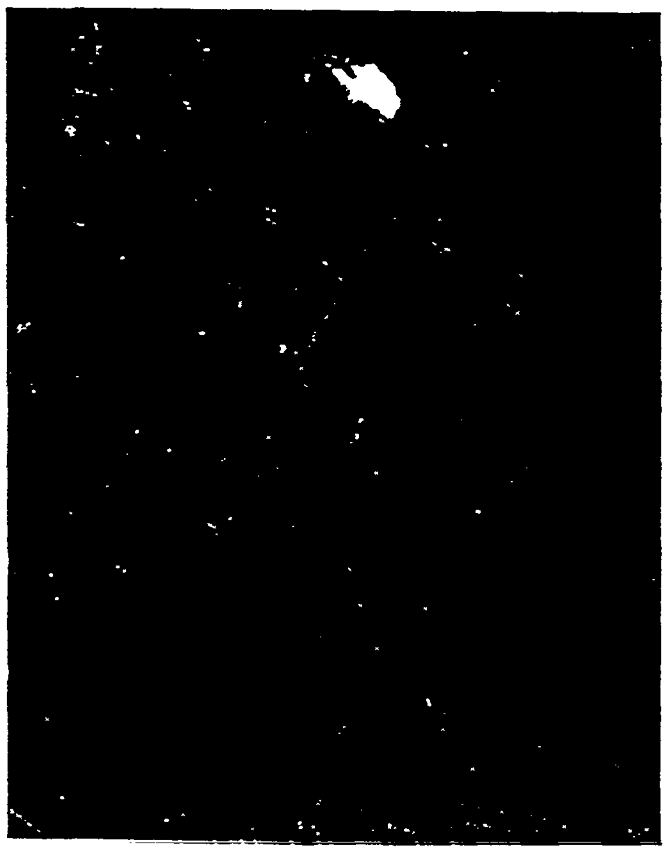

IEA, INC.
Total Suspended Particulate Analysis by Polarized Light Microscopy
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CLIENT: NORSHIPCO

SAMFPLE: 67-150 TSP (ug/cubic meter:) = 0

ANALYZED BY: DK 09-01-1992 EAL JOB NO.:

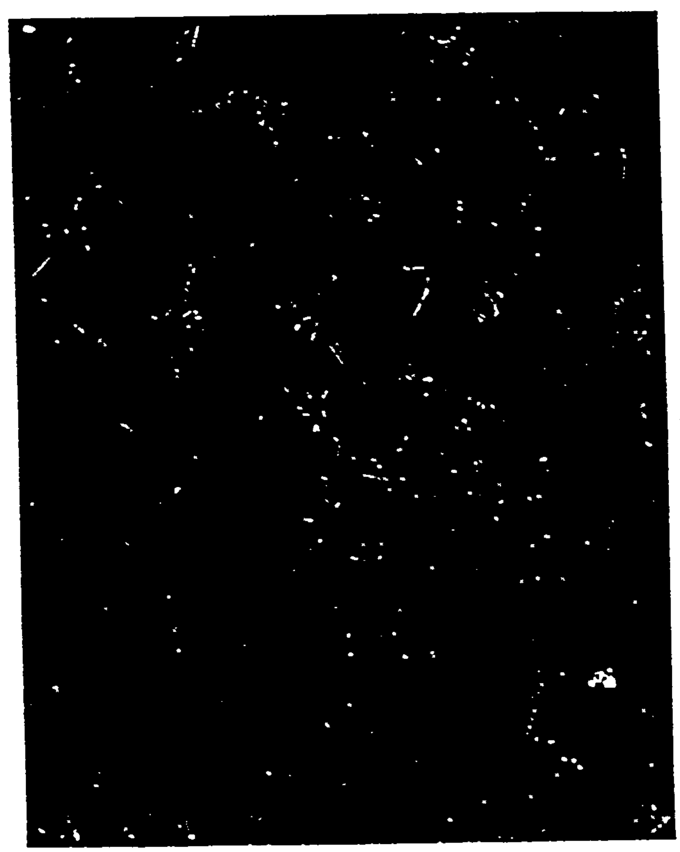
TYPE	WEIGHT %	NUMBER %	MEAN DIAM. (uM)	DENSITY
MINERALS	<1	3	10	G= 2.6
OPAQUES	27	46	15	G= 1.5
BLAST GRIT	72	51	18	G= 2.6
BIOLOGICALS	0	0	0	G= 1.5

TOTAL COUNT: 100

PHOTO A: 500X, PARTLY X-P0LARS, TYPICAL
PHOTO B: 500X, PARTLY X-POLARS, TYPICAL

-A-

-B-



IEA, INC.
Total Suspended Particulate Analysis by Polarized Light Microscopy
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CLIENT: NORSHIPCO

SAMPLE: 66-213 TSP (ug/cubic meter) = 0

ANALYZED BY: DK 09-01-1992 EAL JOB NO.:

TYPE	WEIGHT %	NUMBER %	MEAN DIAM.(uM)	DENSITY
MINERALS	1	2	19	G= 2.6
OPAQUES	5	18	16	G= 1.5
BLAST GRIT	90	78	20	G= 2.6
BI0LOGICALS	3	2	33	G= 1.5

TOTAL COUNT: 100

PHOTO A: 500X, PARTLY X-POLARS, TYPICAL
PHOTO B: 500X, PARTLY X-POLARS, TYPICAL

-A-

-B-

IEA, INC.
Total Suspended Particulate Analysis by Polarized Light Microscopy

CLIENT: NORSHIPCO

SAMPLE: 66-214 TSP (ug/cubic meter = 0

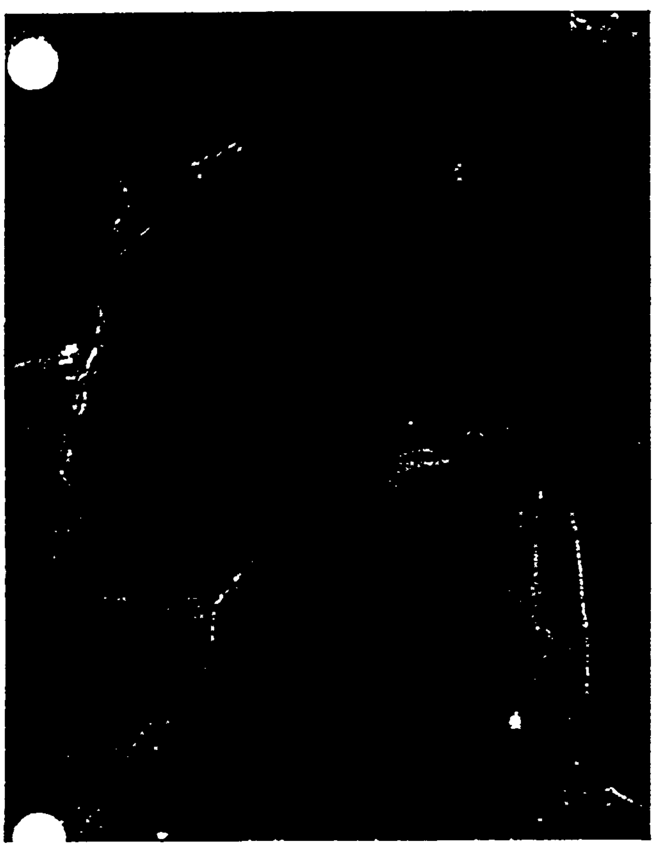
ANALYZED BY: DK 08-27-1992 EAL JOB NO.: 16853

TYPE	WEIGHT %	NUMBER %	MEAN DIAM-(uM)	DENSITY
MINERALS	<1	1	20	G= 2.6
OPAQUES	13	22	53	G= 1.5
BLAST GRIT	87	77	60	G= 2.6
BIOLOGICALS	0	0	0	G= 1.5

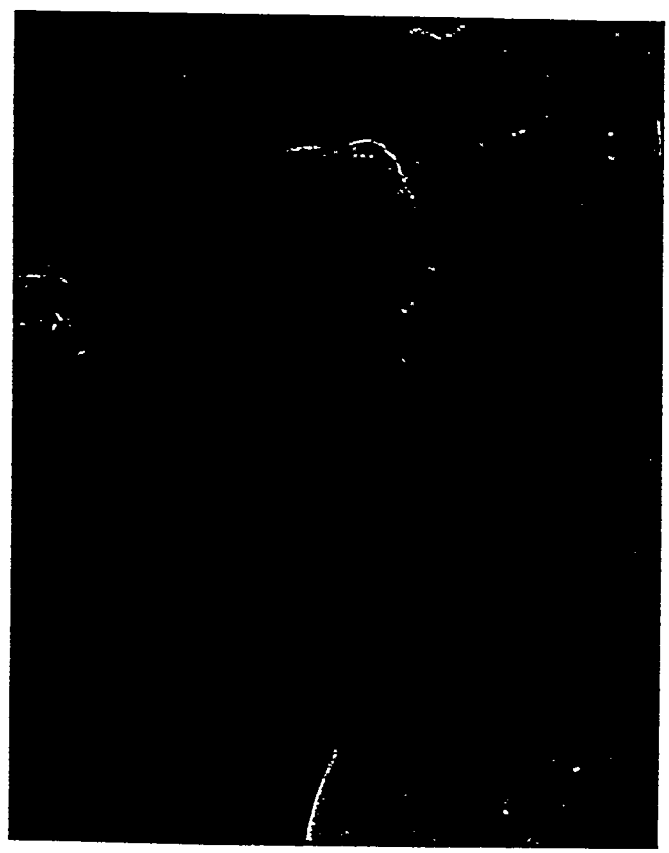
TOTAL COUNT: 100

PHOTO A: 500X, PARTLY X-POLARS, TYPICAL
PHOTO B: 500X, PARTLY X-POLARS, TYPICAL

-A-



-B-



IEA, INC.
Total Suspended Particulate Analysis by Polarized Light Microscopy
Version 4.2 (c) copyright 1989 by EAL, 1991 by IEA

CLIENT: NORSHIPCO

SAMPLE: 66-203 TSP (ug/cubic meter) = 0

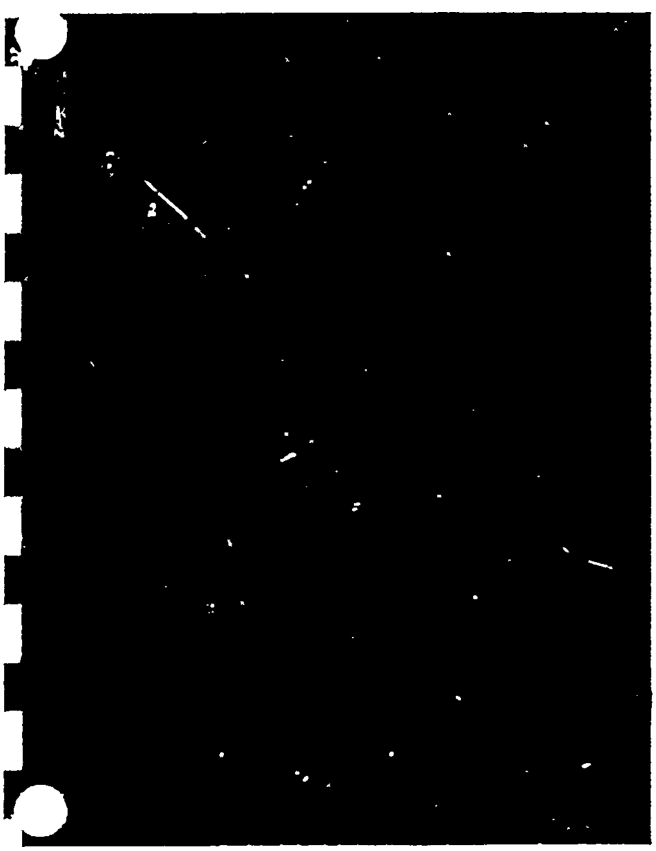
ANALYZED BY: DK 09-02-1992 EAL JOB NO.:

TYPE	WEIGHT %	NUMBER %	MEAN DIAM. (uM)	DENSITY
AVER.PART.	100	100		G= 2

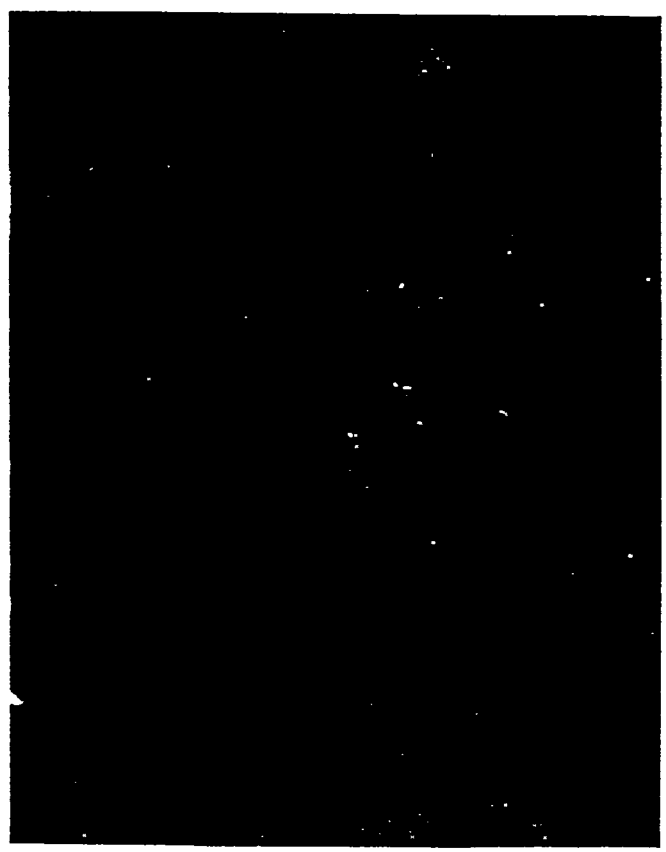
TOTAL COUNT: 50

PHOT0 A: 500X, PARTLY X-POLARS, TYPICAL
PHOTO B: 500X, PARTLY X-POLARS, TYPICAL

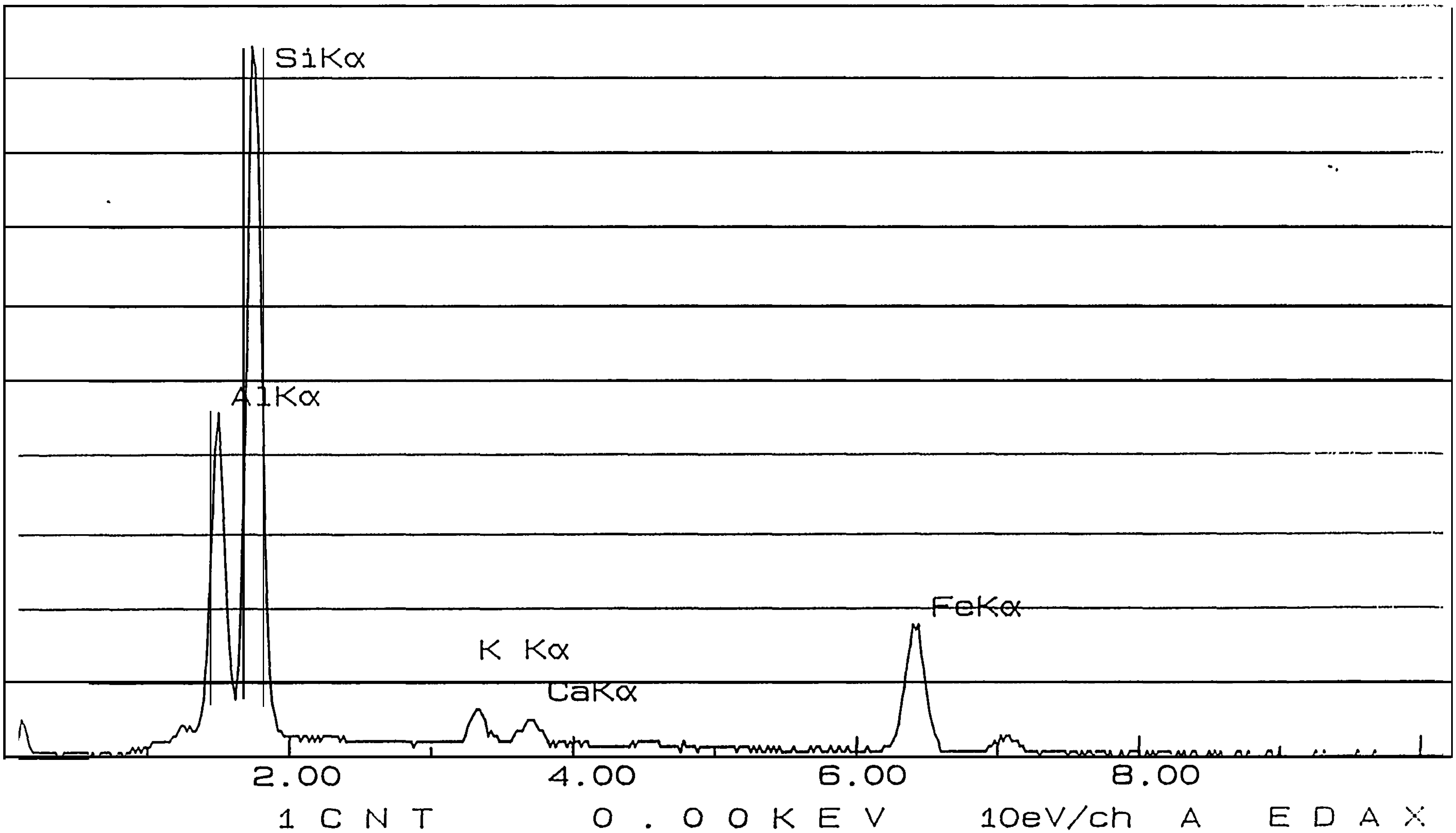
-A-



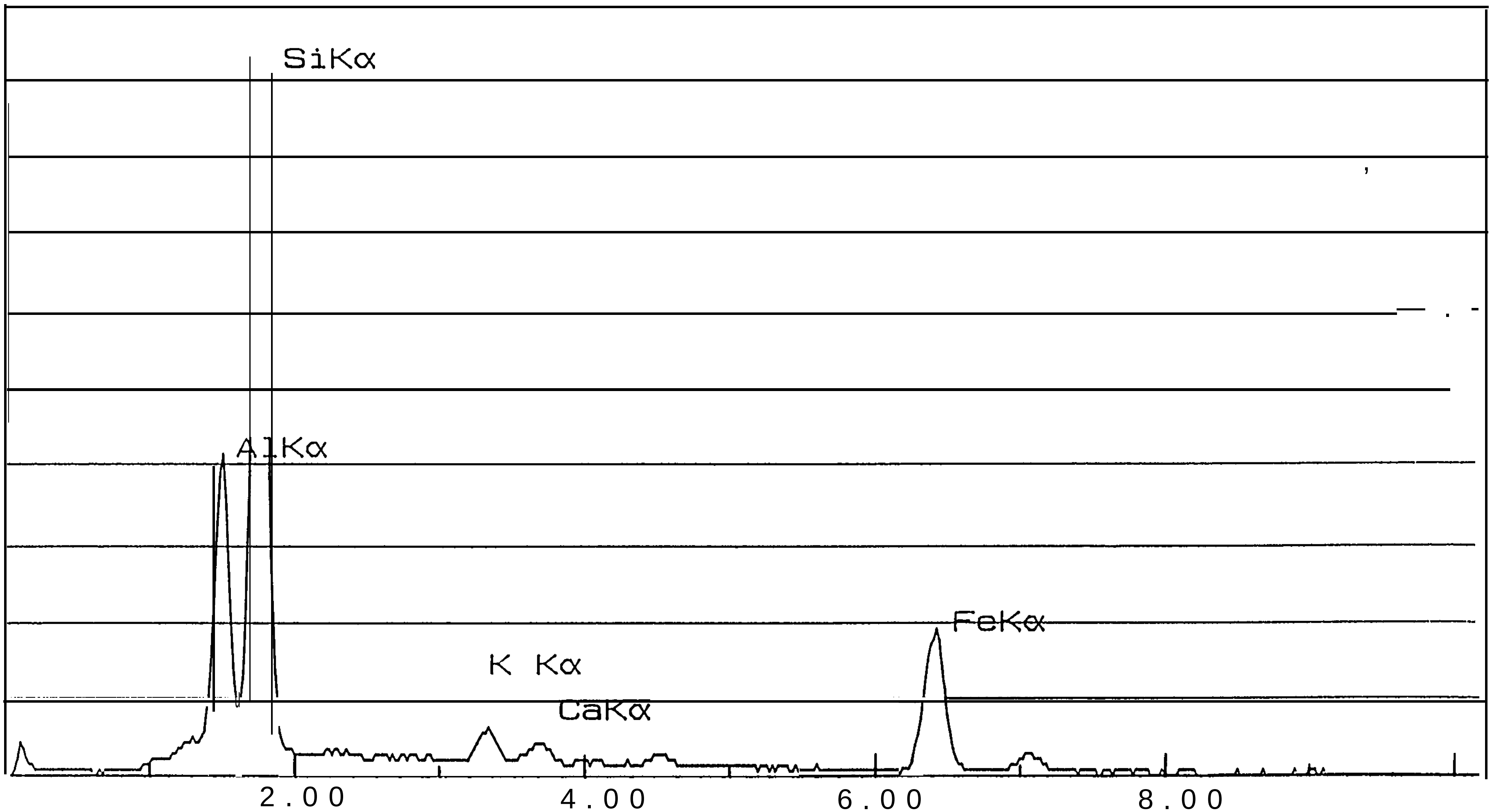
-B-



21-AUG-92 15:17:33 EDAX READY
RATE = 4CPS TIME = 148LSEC
FS = 4598CNT PRST = 200LSEC
A =SANDBLAST MAT"L NORSHIPCO

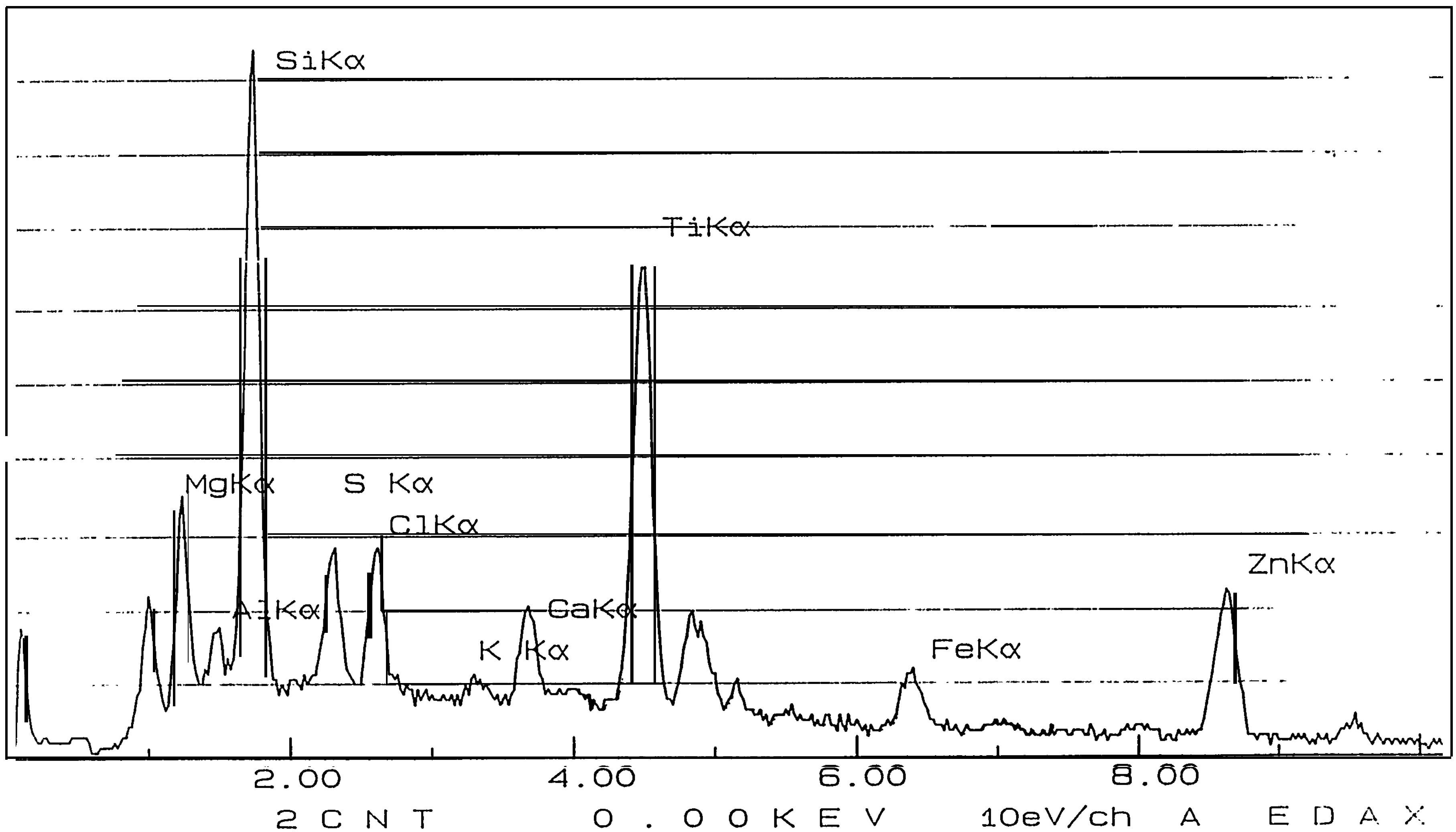


21,– AUG– 921 5:27:43 EDAX READY
RATE = OCPS TIME = 150 LSEC
FS = 10457CNT PRST = 150 LSEC
A = SANDBLAST MAT'L AC0

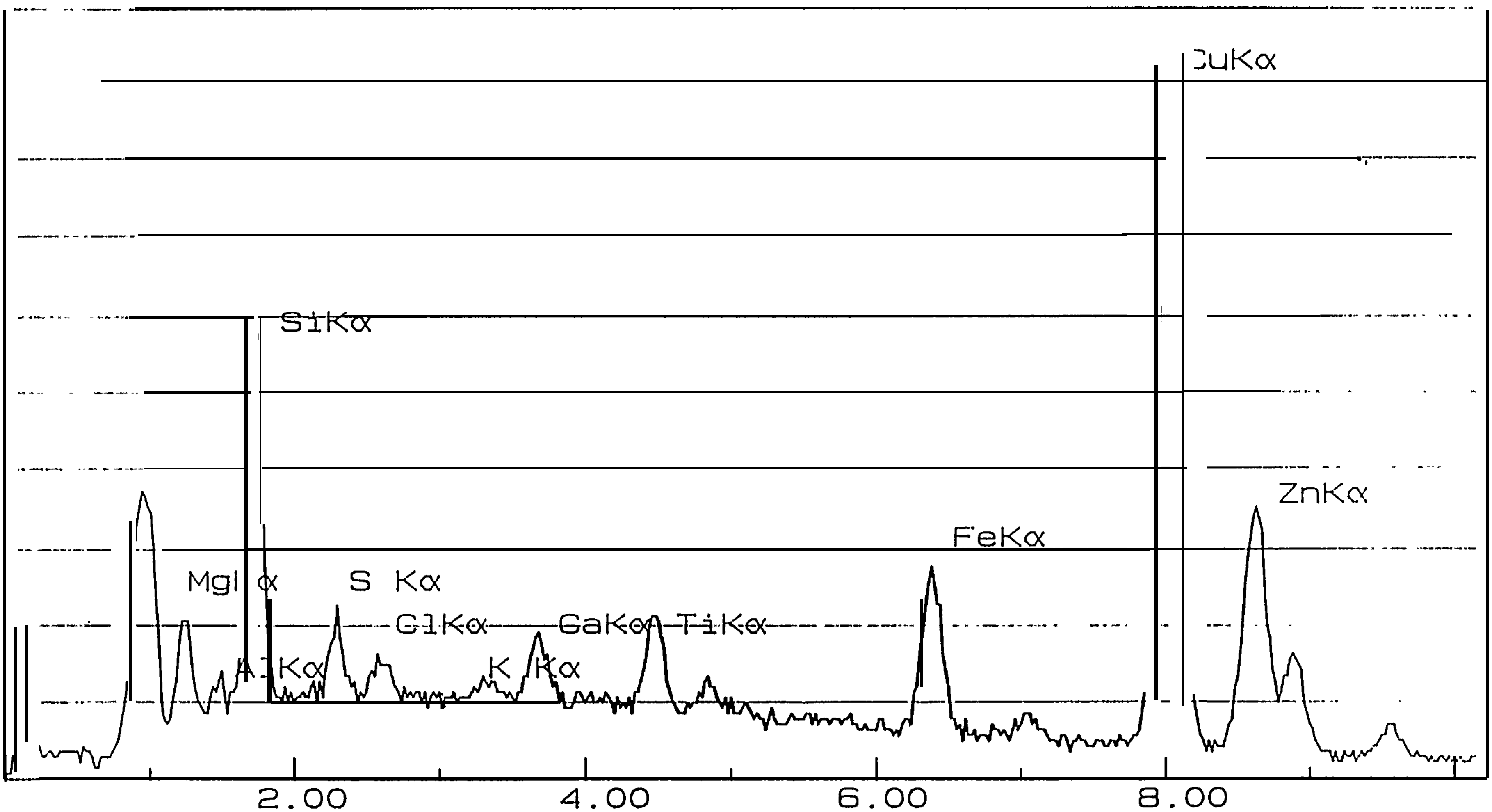


OCNT 0.OOKEV 10eV/ch A EDAX

27-AUG-92 13:46:02 EDAX READY
RATE= 6CPS TIME= 150LSEC
FS= 1867CNT PRST= 150LSEC
A =USNS FREE BOARD

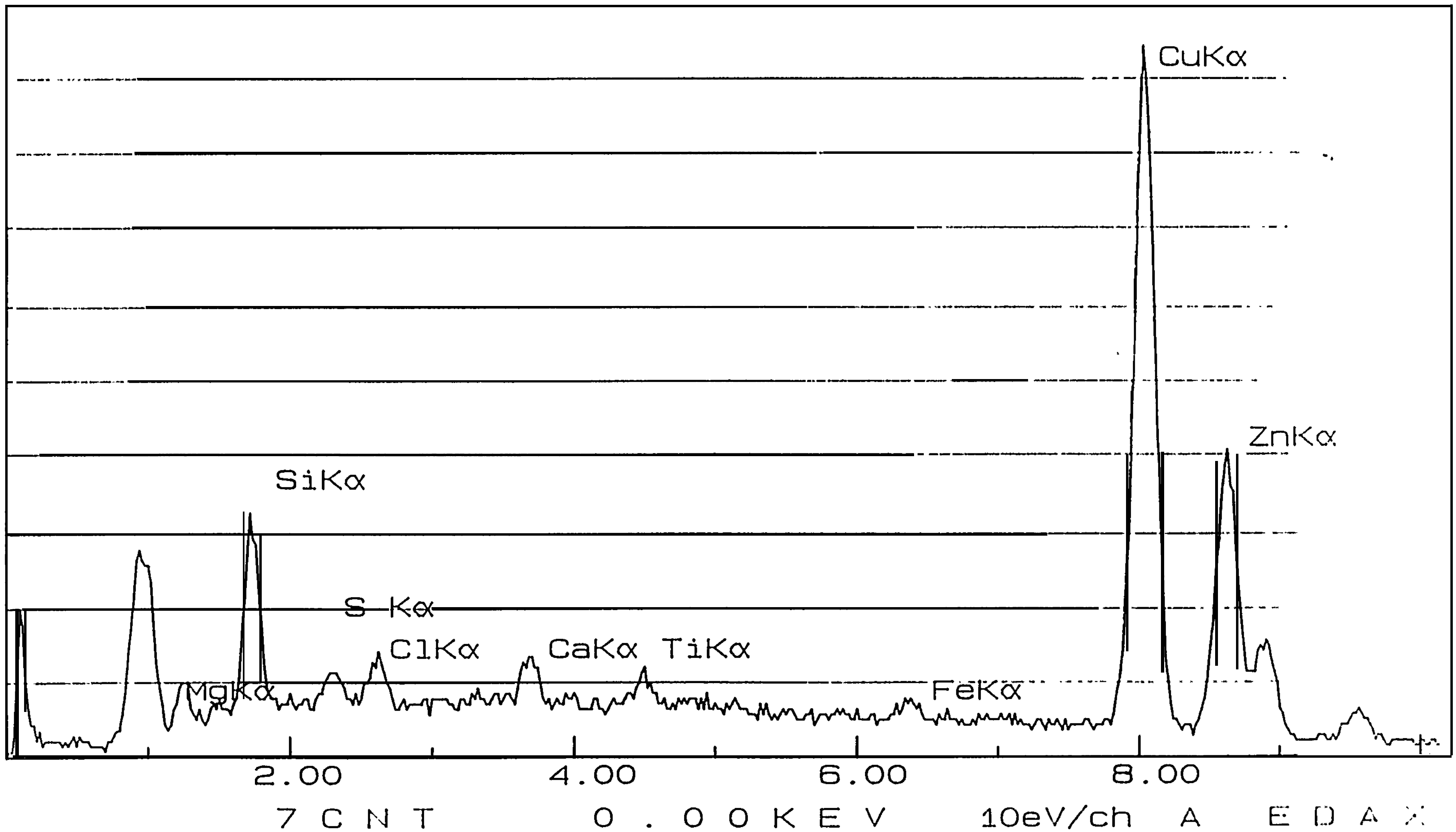


27-AUG-92 13:54:28 EDAX READY
RATE = 4CPS TIME = 150LSEC
FS = 1963CNT PRST = 150LSEC
A =USNS KEEL TO TURN OF BILGE

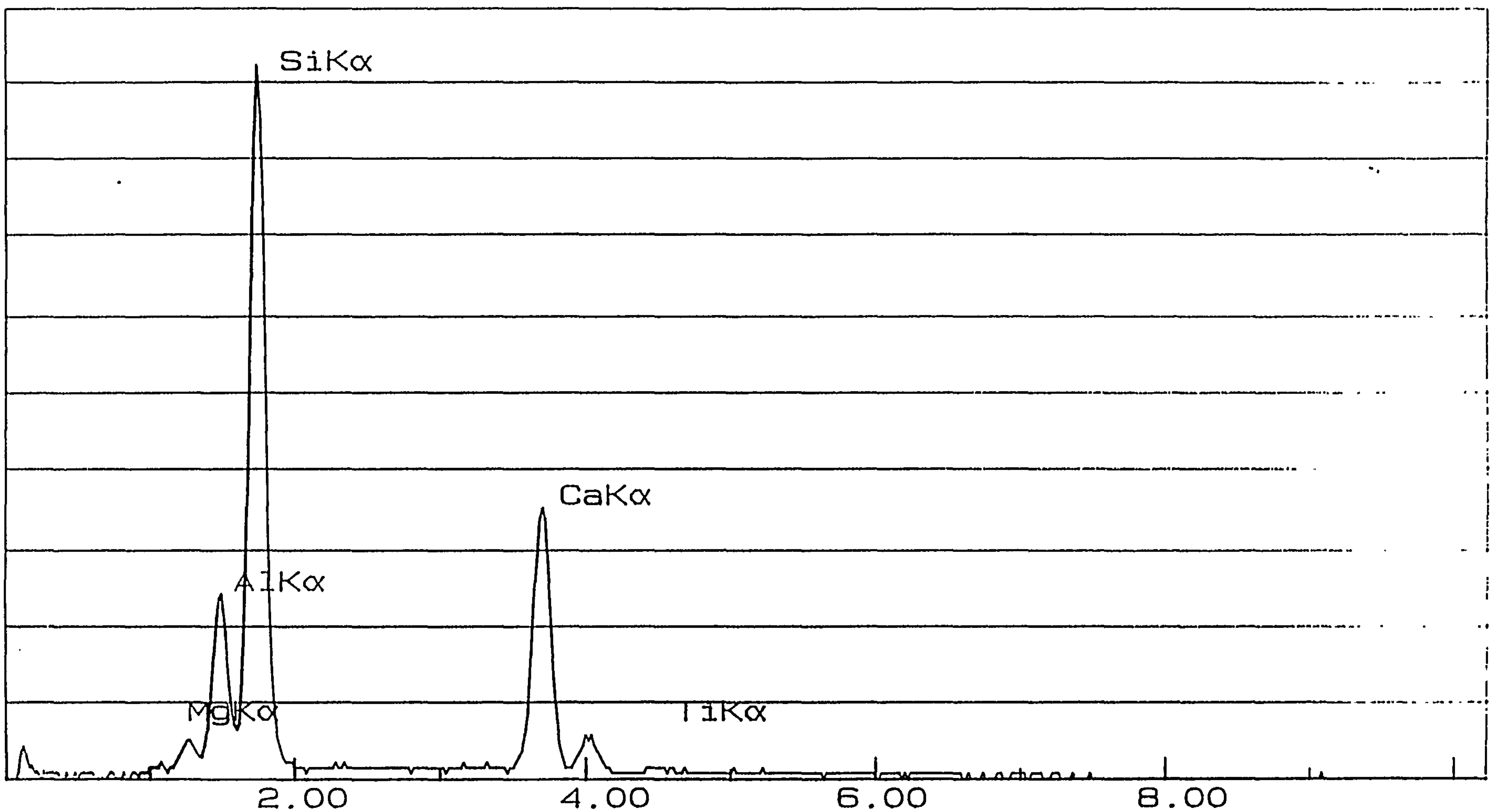


6CNT 0.00KEV 10eV/ch A EDAX

27-AUG-92 13:33:57 EDAX READY
RATE= 21CPS TIME= 150LSEC
FS= 1880CNT PRST= 150LSEC
A =USNS LT.LOAD TO DEEP BOOTOP

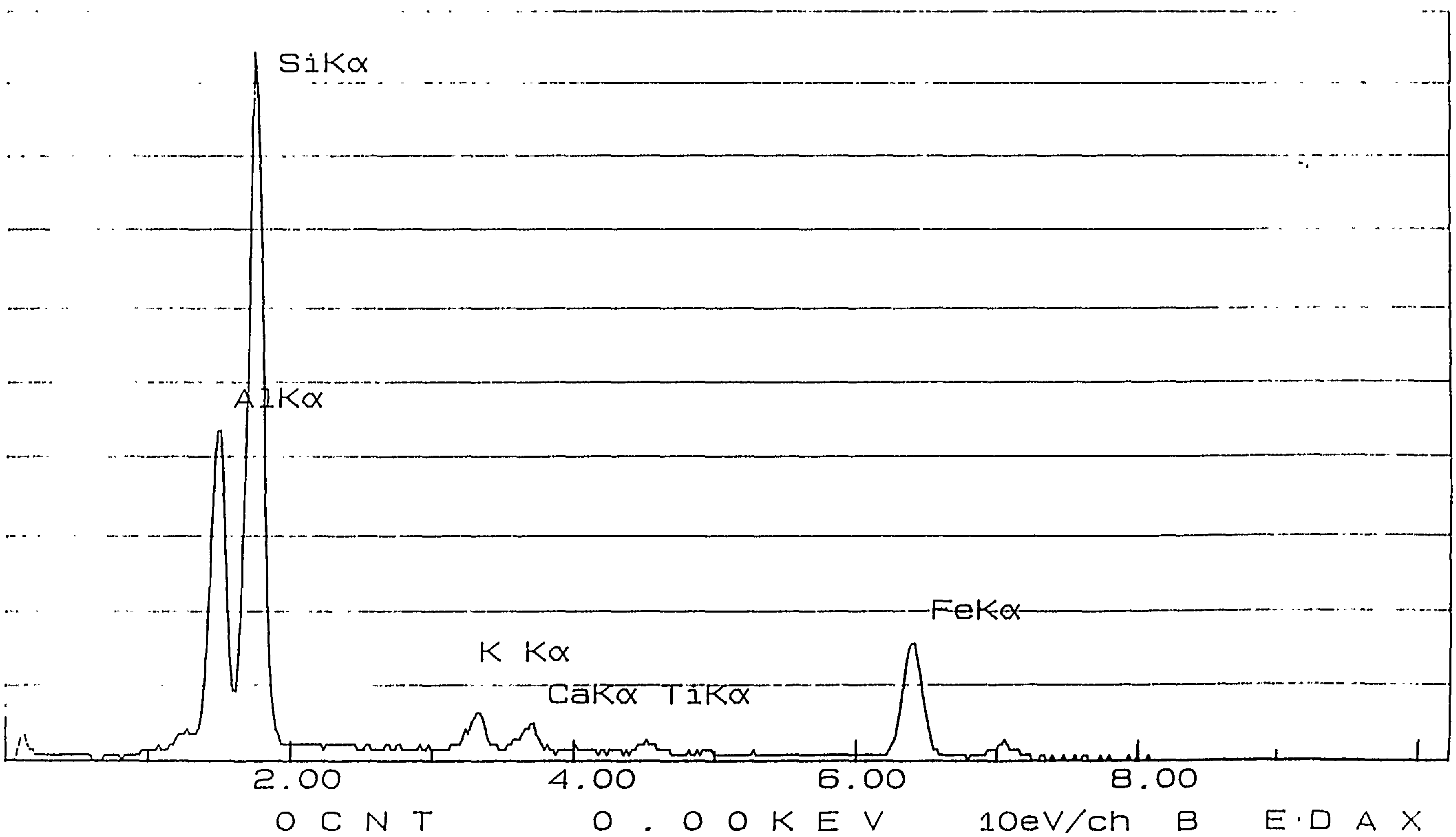


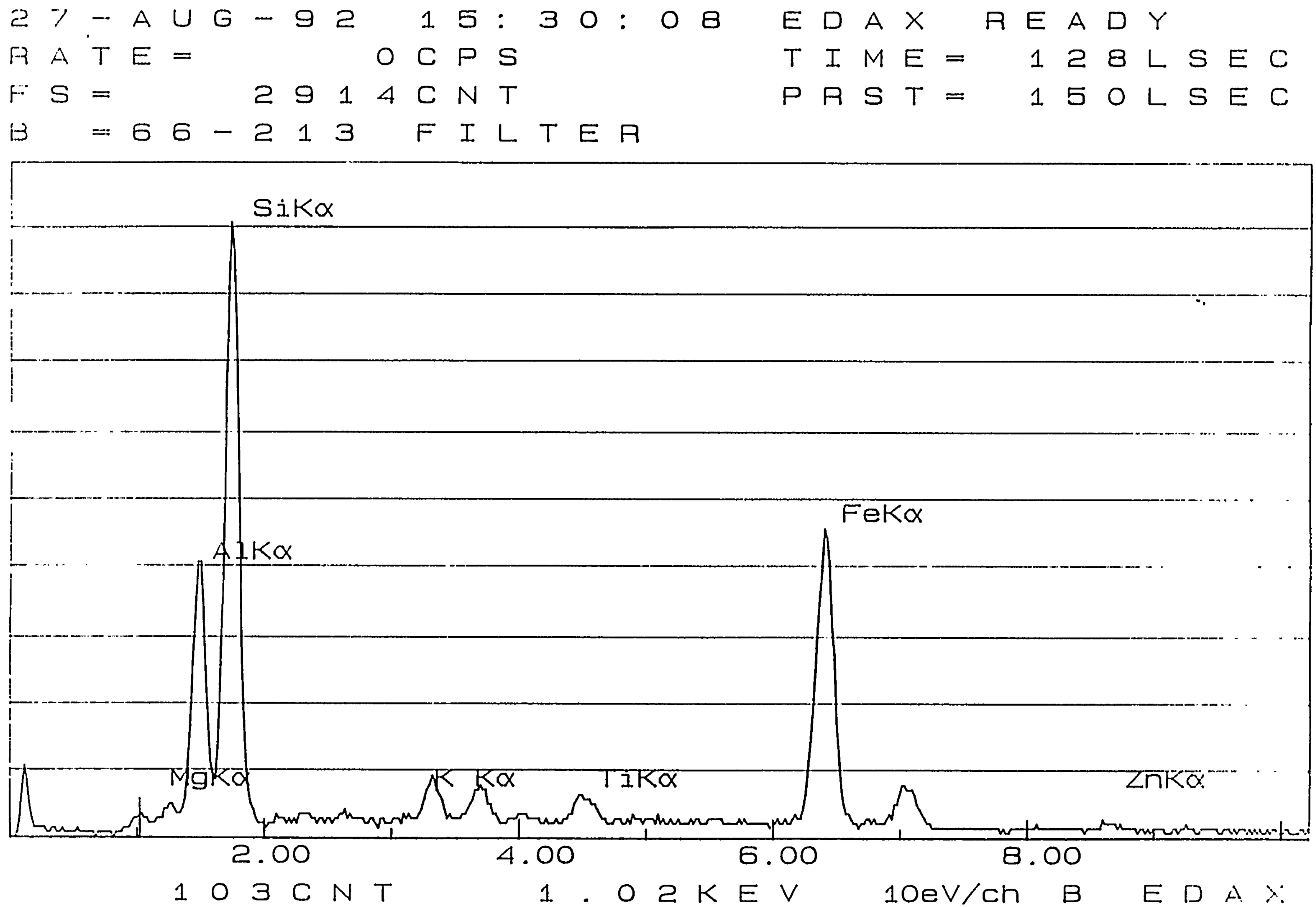
26-AUG-92 11:48:22 EDAX READY
RATE= 0CPS TIME= 123LSEC
FS= 4965CNT PRST= 150LSEC
B =66-217 FILTER



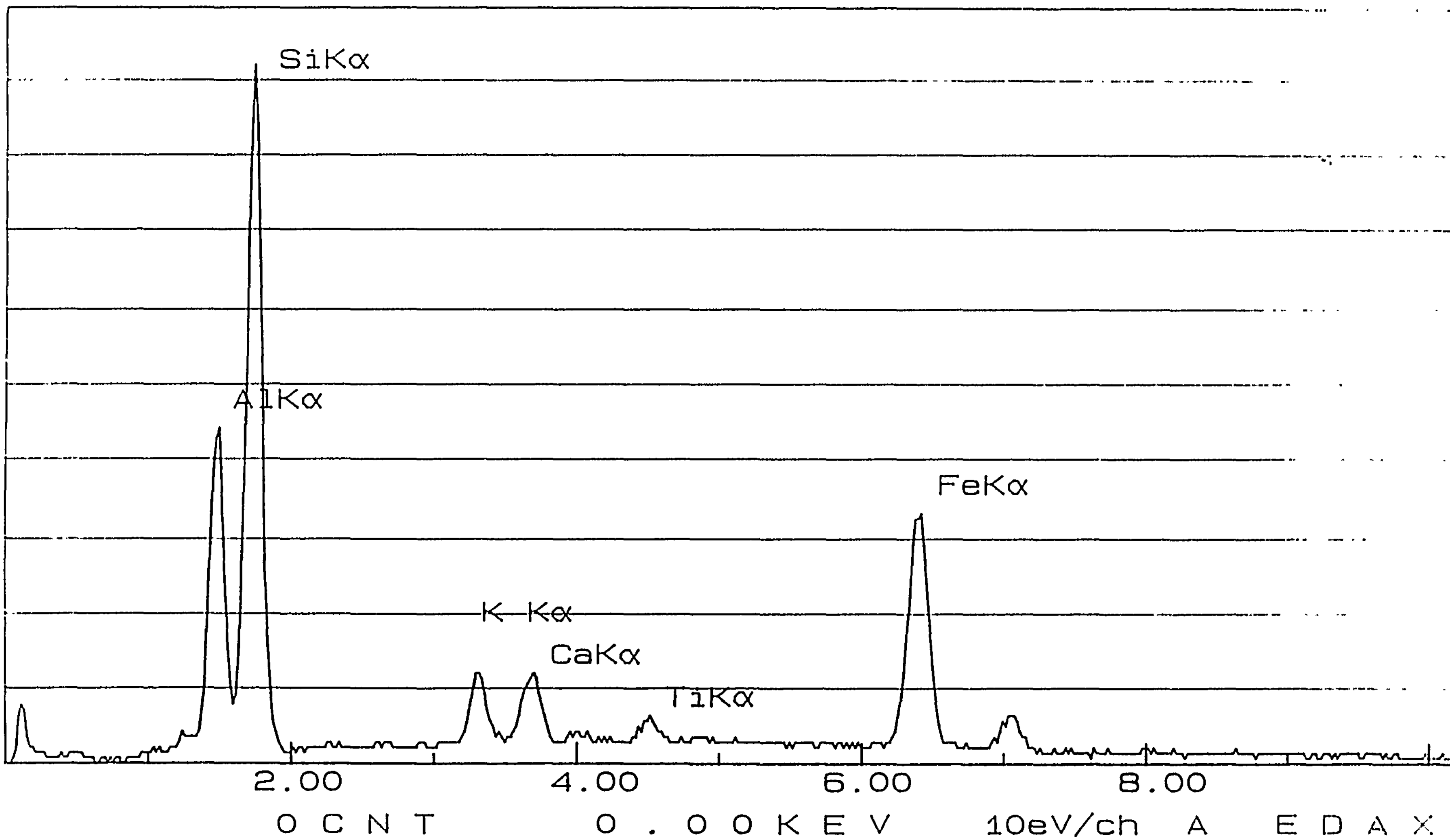
0CNT 0.00KEV 10eV/ch B EDAX

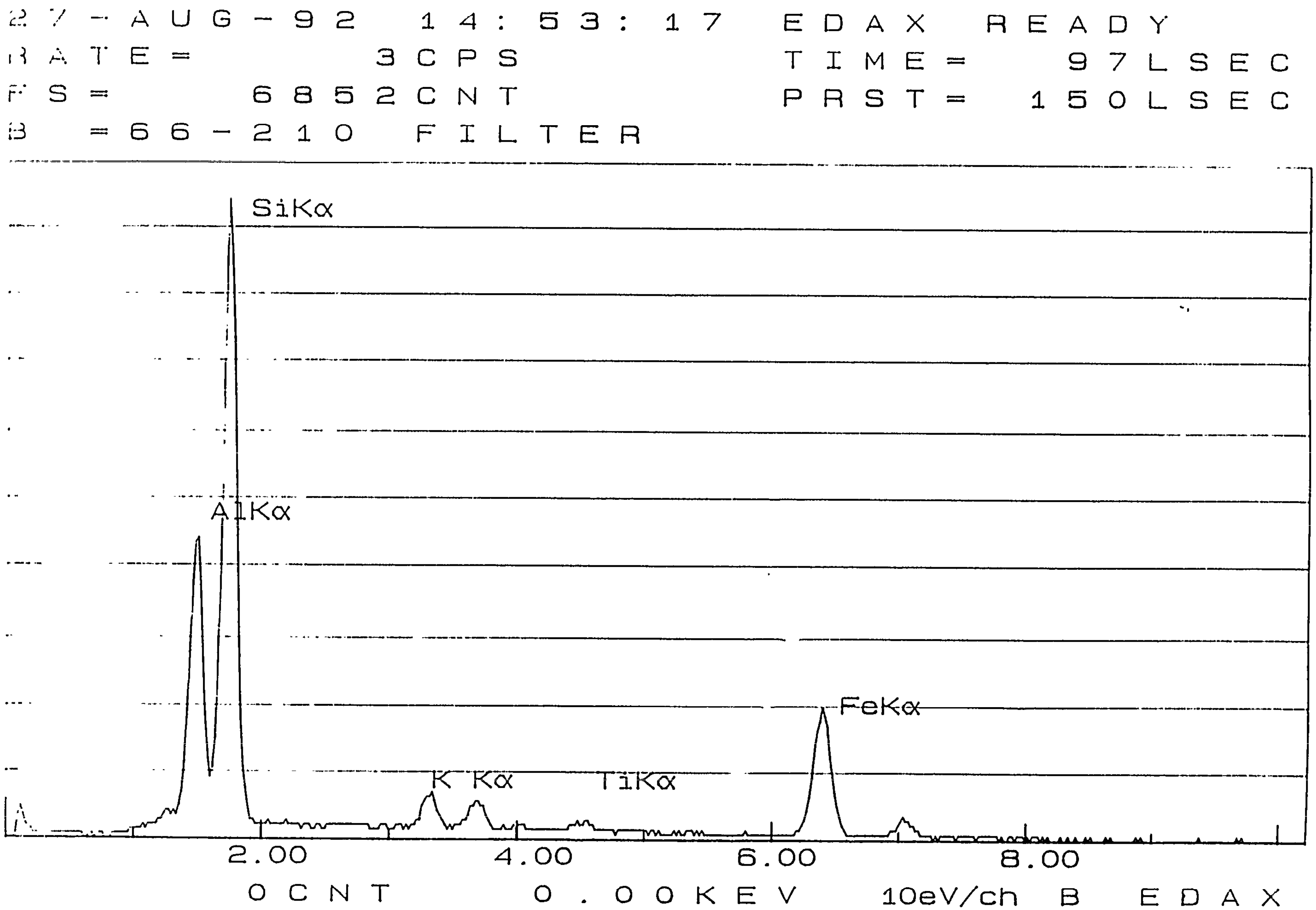
27-AUG-92 15:46:47 EDAX READY
RATE= 0CPS TIME= 100LSEC
FS= 9233CNT PRST= 150LSEC
B =66-214 FILTER



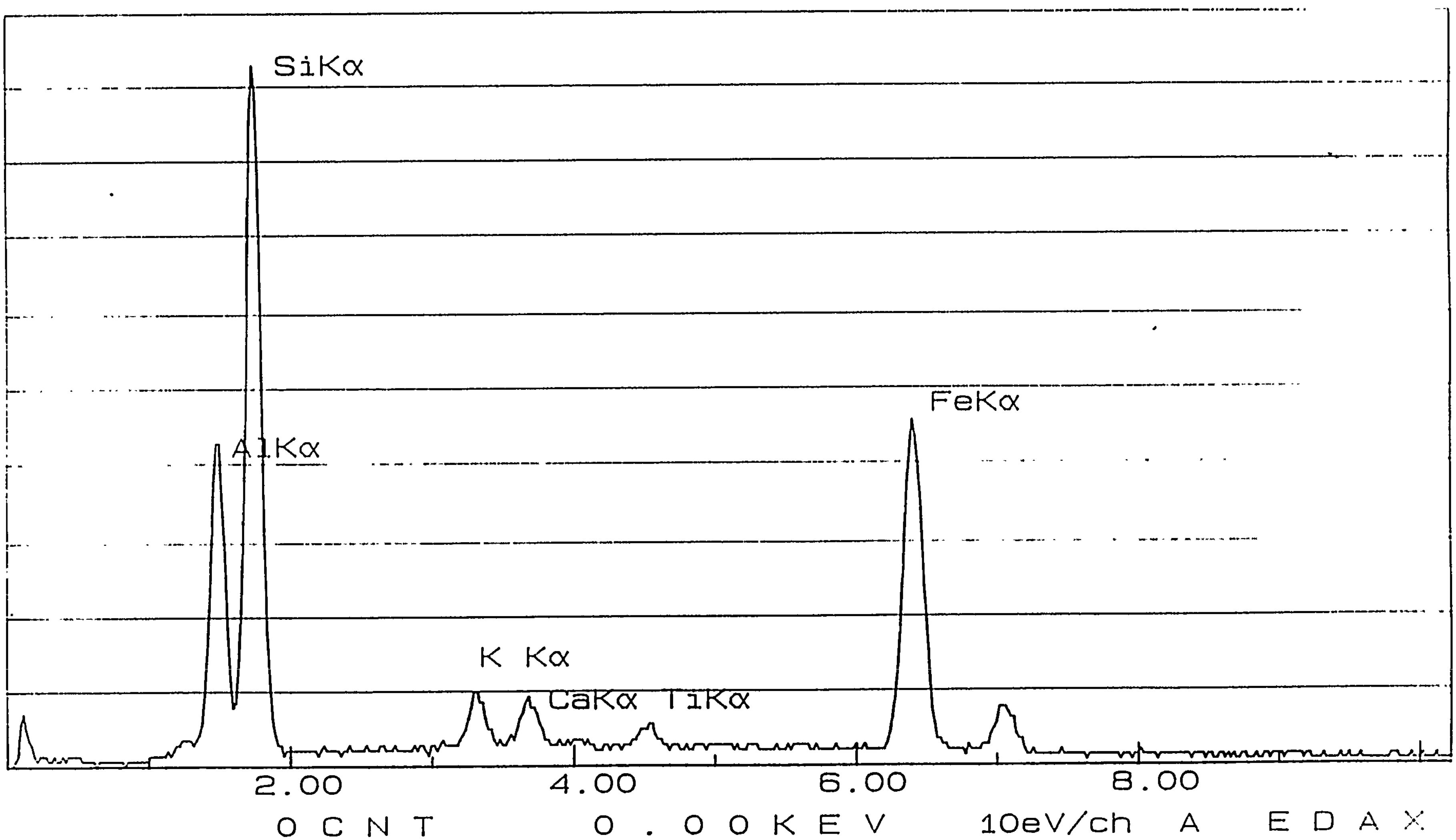

27-AUG-92 15:30:08 EDAX READY
RATE= 0CPS TIME= 128LSEC
FS= 2914CNT PRST= 150LSEC
B =66-213 FILTER
SiKα
AlKα
FeKα
MgKα
K Kα
TiKα
ZnKα
2.00
4.00
6.00
8.00
103CNT 1.02KEV 10eV/ch B EDAX

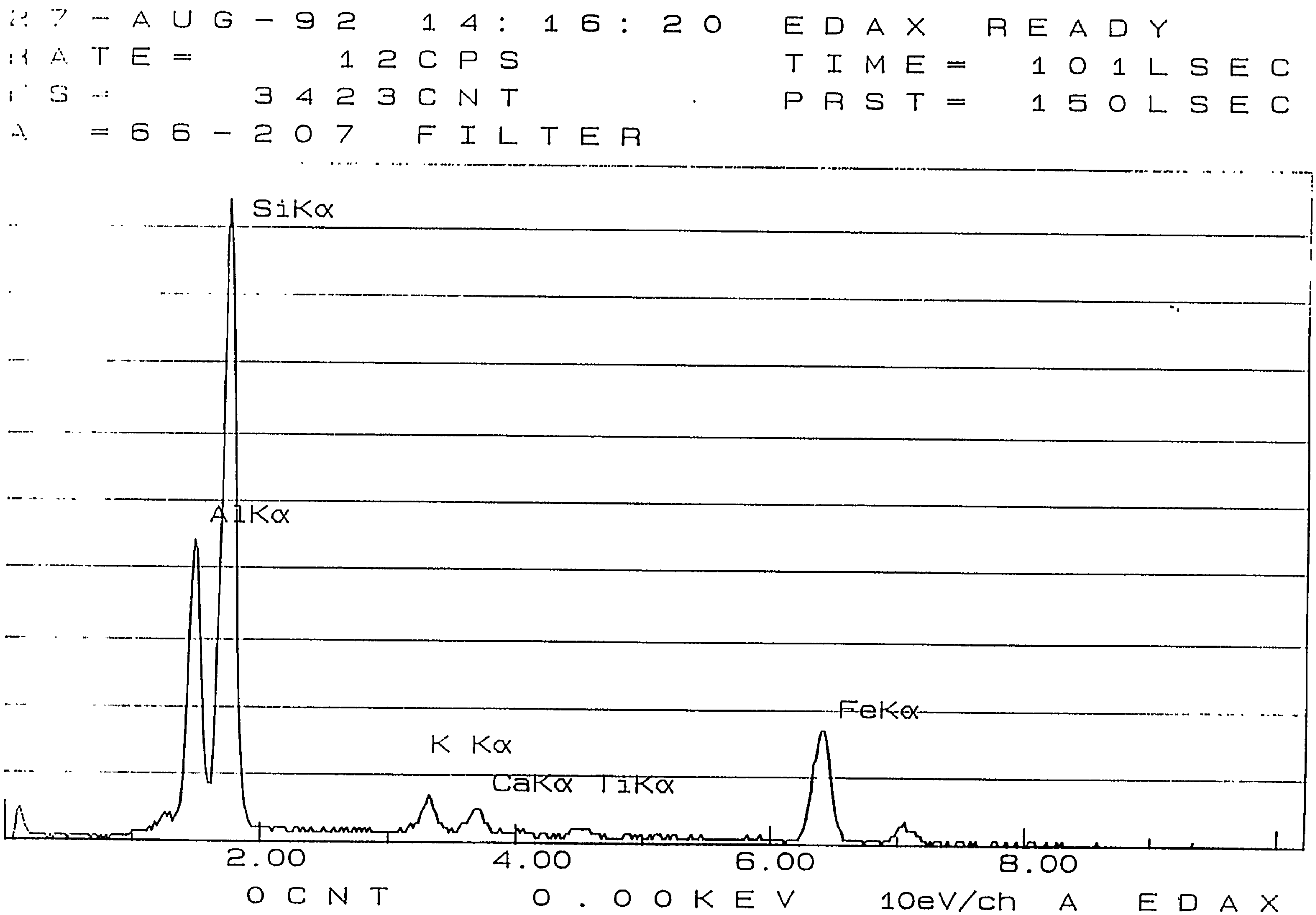
27-AUG-92 14:26:24 EDAX READY
RATE = 2CPS TIME = 150LSEC
FS = 4316CNT PRST = 150LSEC
A =66-212 FILTER

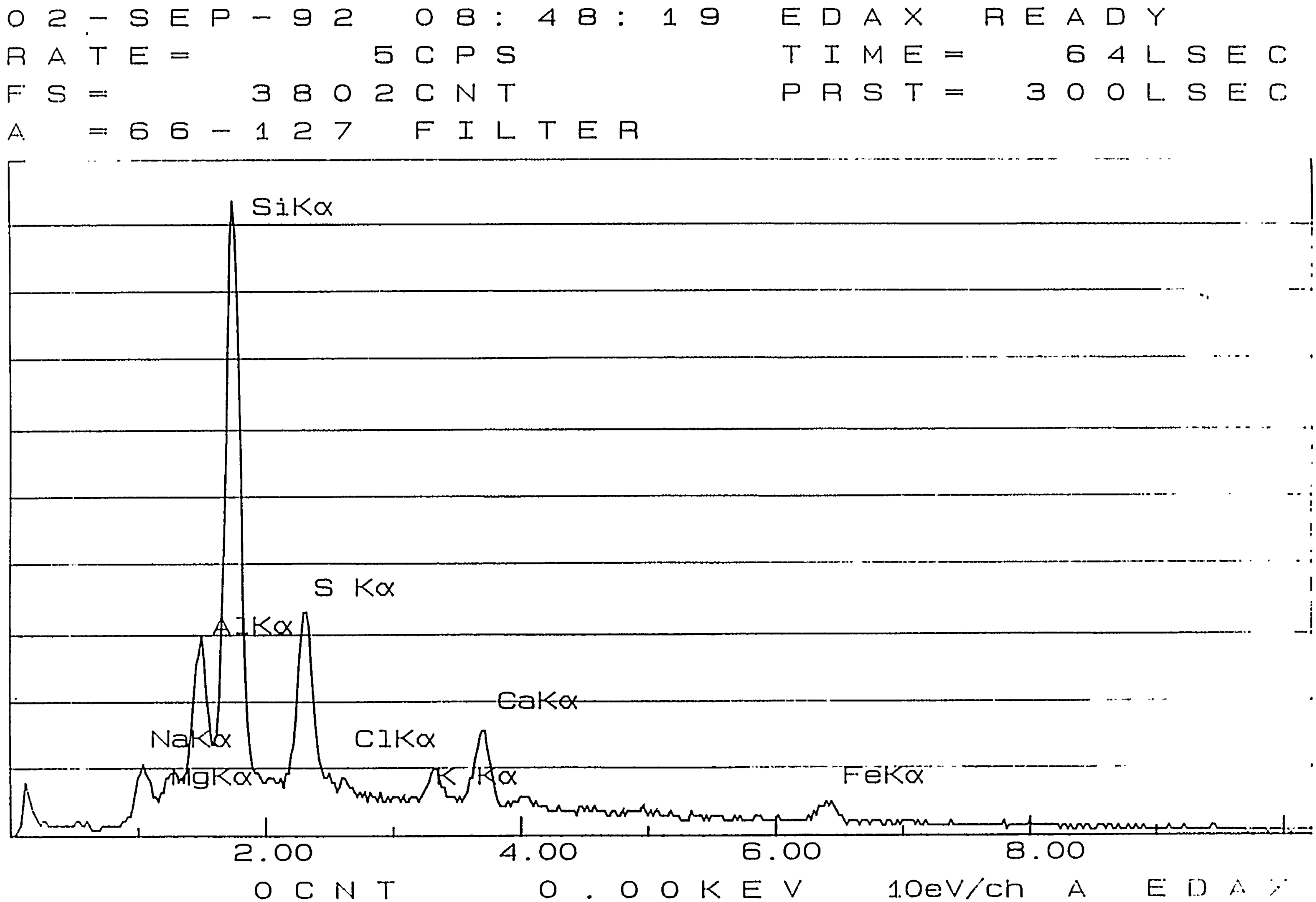



27-AUG-92 14:53:17 EDAX READY
RATE= 3CPS
TIME= 97LSEC
FS= 6852CNT
PRST= 150LSEC
B =66-210 FILTER
SiKα
AlKα
FeKα
K Kα
TiKα
2.00
4.00
6.00
8.00
0CNT 0.00KEV 10eV/ch B EDAX

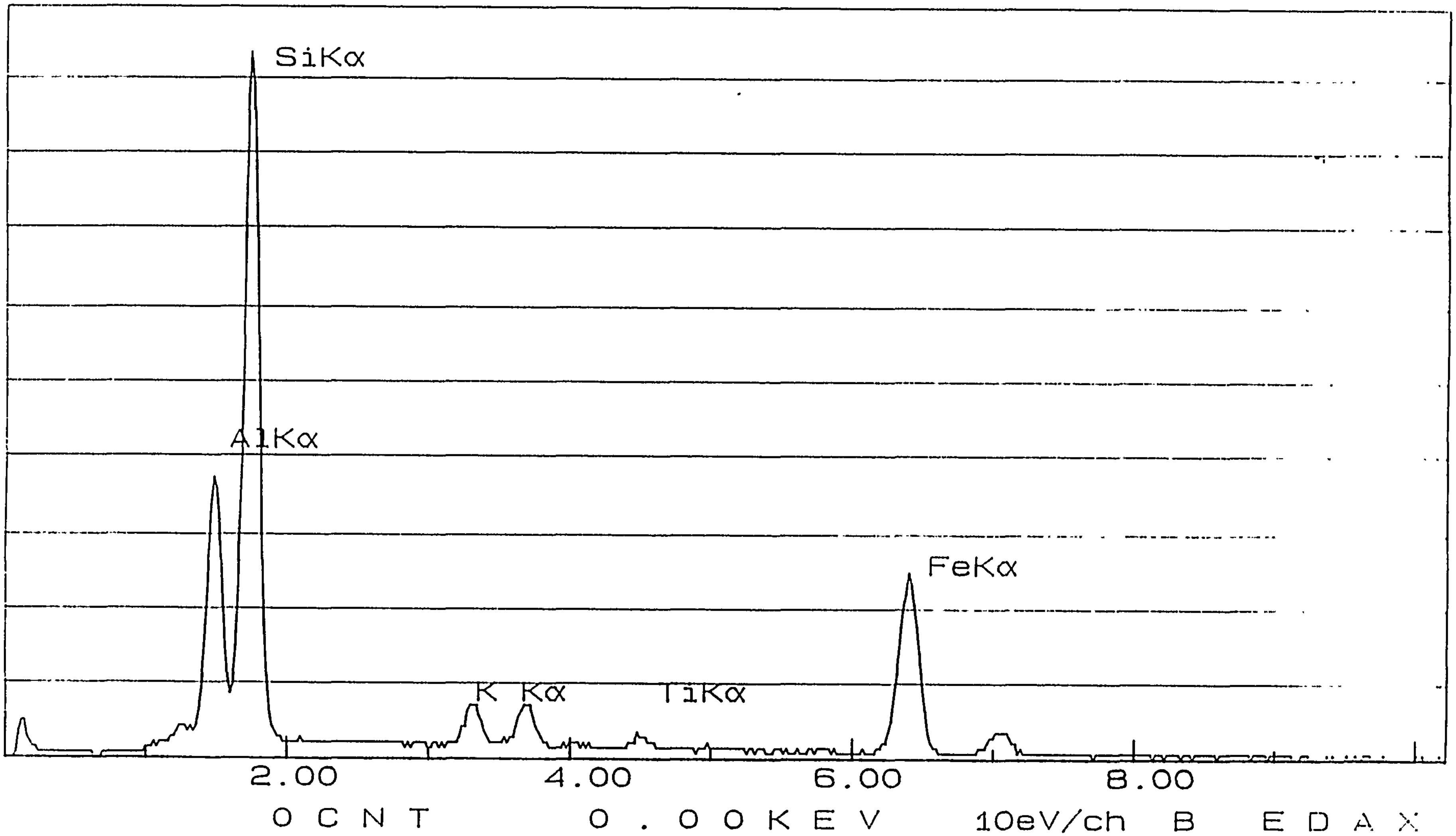
27-AUG-92 14:20:59 EDAX READY
RATE = 3CPS TIME= 103LSEC
FS= 3284CNT PRST= 150LSEC
A =66-208 FILTER




7-AUG-92 14:16:20 EDAX READY
ATE = 12CPS
TIME= 101LSEC
S= 3423CNT
PRST= 150LSEC
=66-207 FILTER
SiKα
AlKα
K Kα
CaKα
TiKα
FeKα
2.00
4.00
6.00
8.00
0CNT
0.00KEV
10eV/ch
A
EDAX


02-SEP-92 08:48:19 EDAX READY
RATE= 5CPS TIME= 64LSEC
FS= 3802CNT PRST= 300LSEC
A =66-127 FILTER
SiKα
S Kα
AlKα
CaKα
NaKα
ClKα
MgKα
K Kα
FeKα
2.00
4.00
6.00
8.00
0CNT 0.00KEV 10eV/ch A EDAX

27-AUG-92 14:37:21 EDAX READY
RATE= 6CPS TIME= 100LSEC
FS= 6505CNT PRST= 150LSEC
B =66-200 FILTER

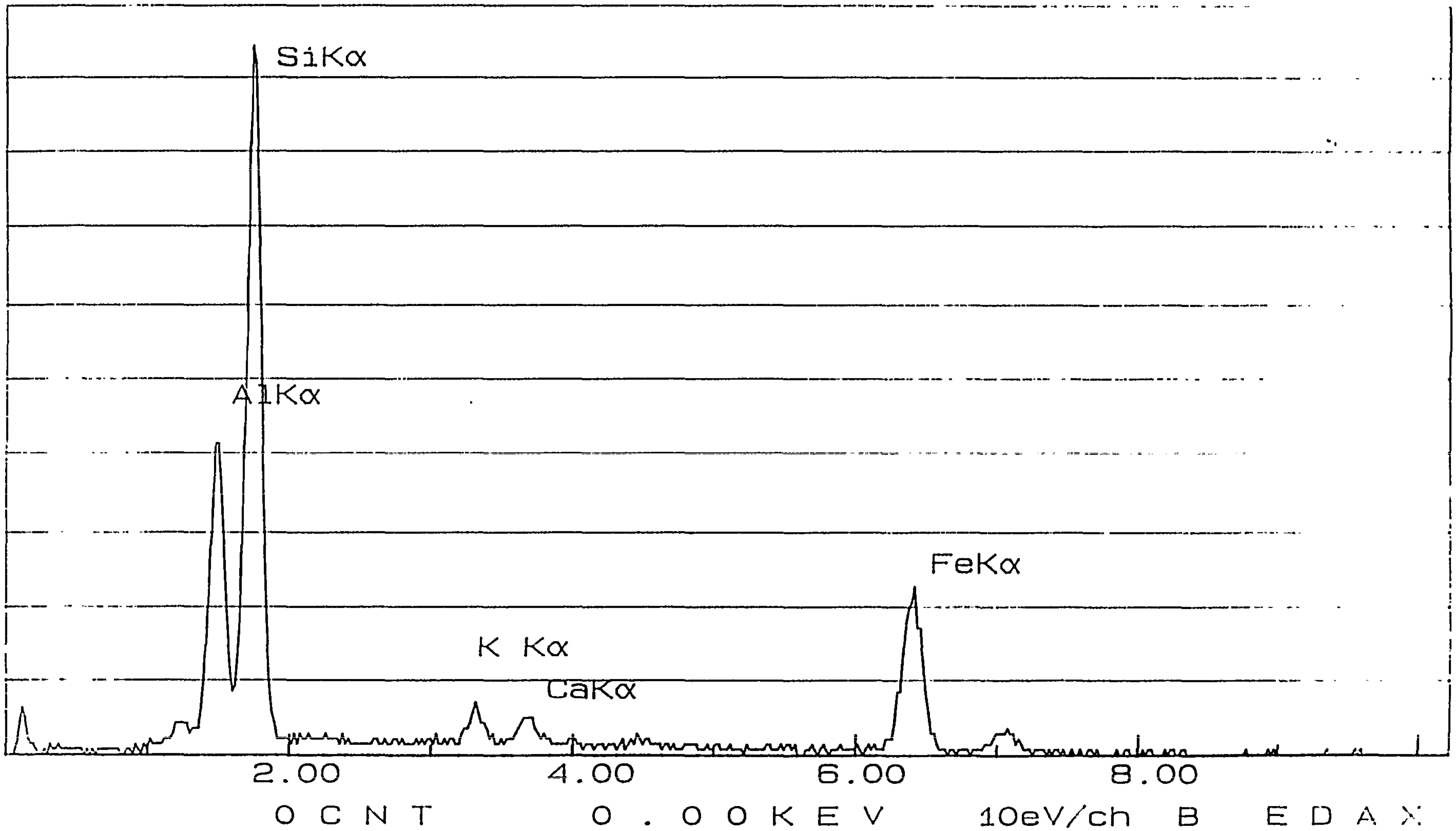


27-AUG-92 15:52:10 EDAX READY

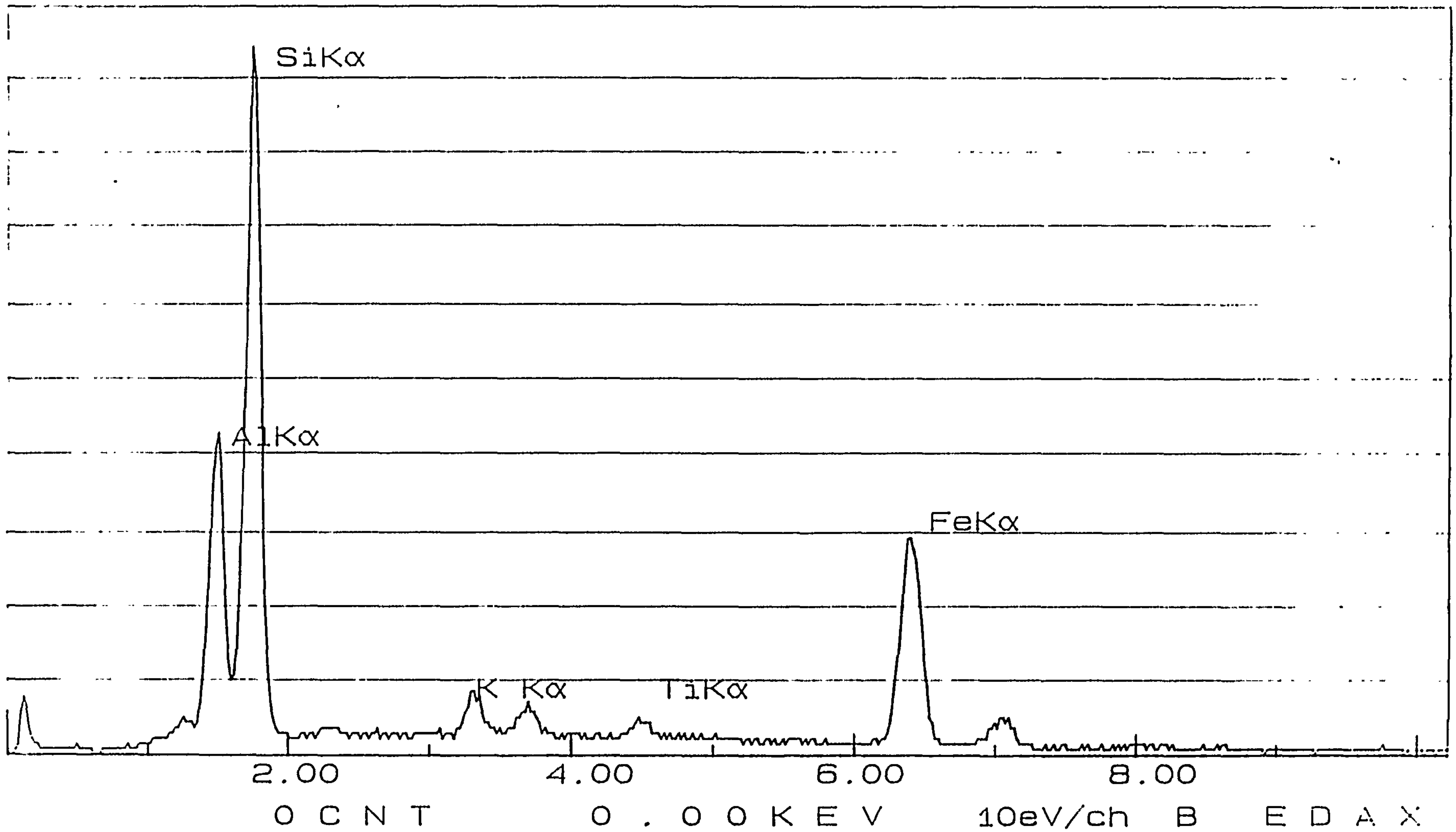
RATE = 3CPS TIME = 37LSEC

FS = 1353CNT PRST = 150LSEC

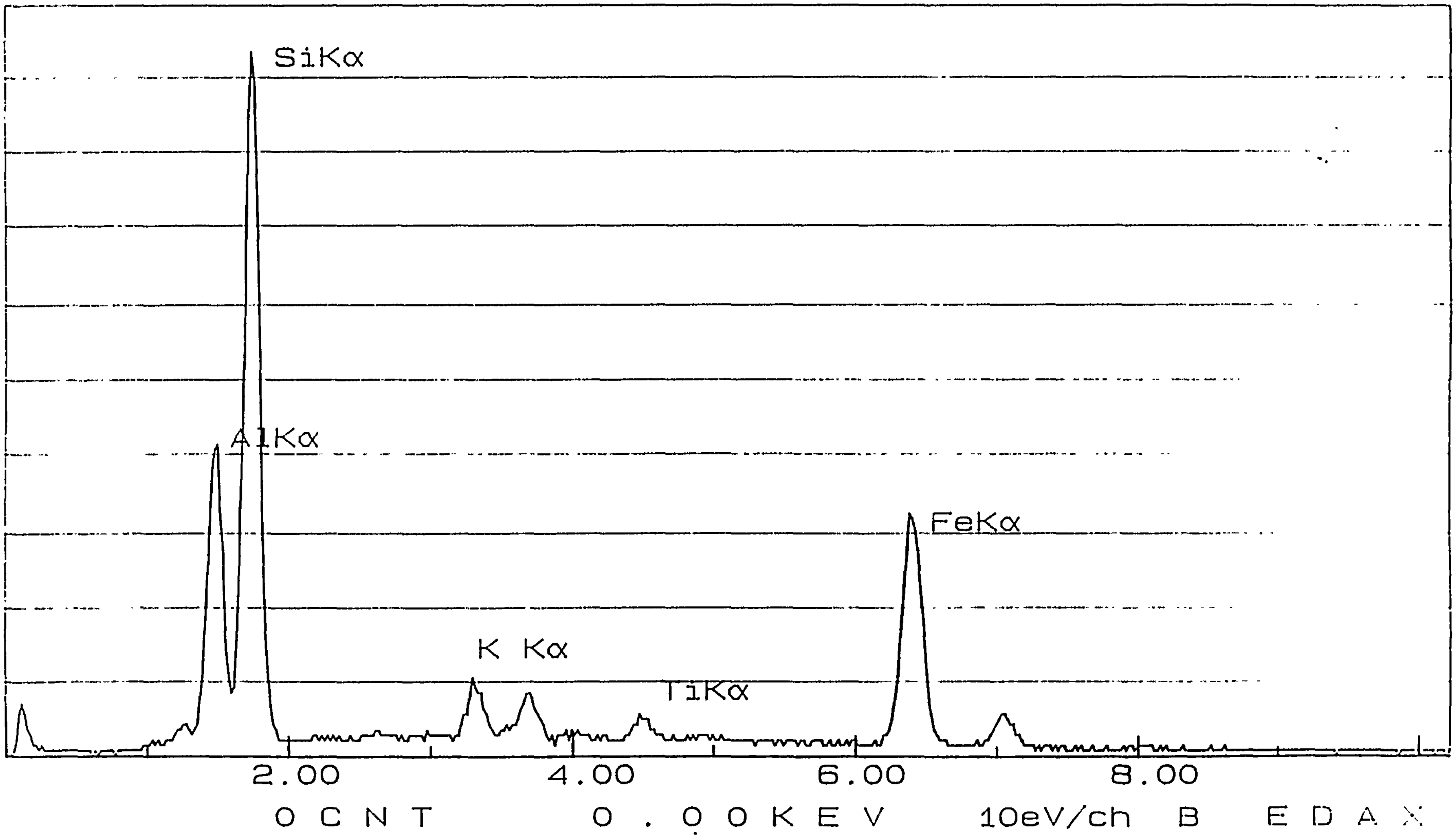
B = 66-199 FILTER



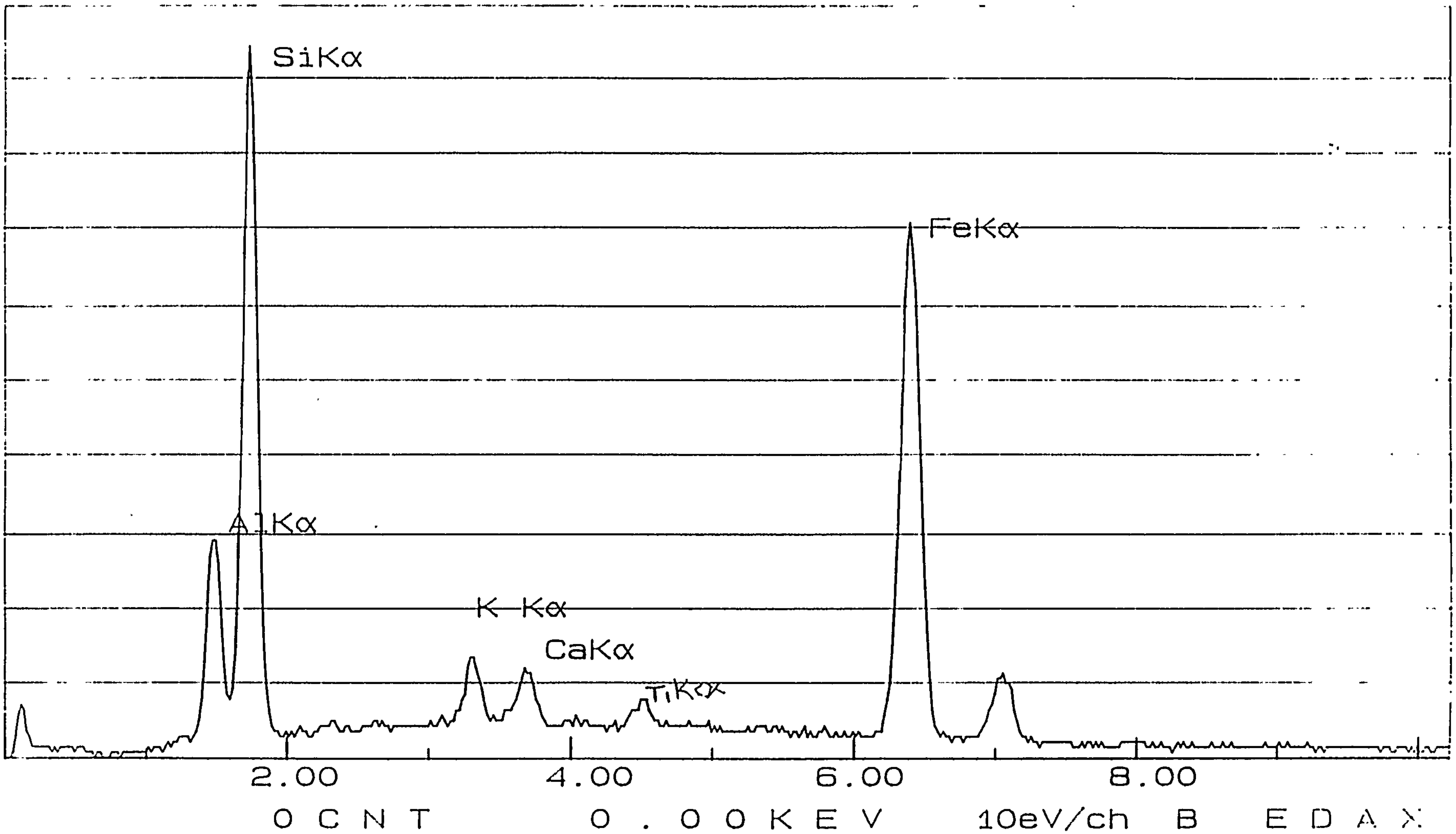
27-AUG-92 14:48:44 EDAX READY
RATE= 0CPS TIME= 83LSEC
FS= 3097CNT PRST= 150LSEC
B =67-150 FILTER



27-AUG-92 14:44:16 EDAX READY
RATE = 5CPS TIME = 79LSEC
FS = 3665CNT PRST = 150LSEC
B = 67-149 FILTER



27-AUG-92 15:41:42 EDAX READY
RATE= 0CPS TIME= 124LSEC
FS= 3750CNT PRST= 150LSEC
B =67-148 FILTER CATEGORY



memo

Volume Sandblast Material Used
Date: 7-14-92
Location: Titan Drydock
Purpose: PM-10 Study

Objective: Calculate on the half hour the number of pounds sanblast used during that half hour. Start at 2000 at end at shift completion.

Time	# Nozzles	#lbs Blast Material Consumed
ex.1800to 1830	28	
2000	35	16,968 LBS.
2030	35	16,954 LBS.
2100	32	14,700 LBS.
2130	32	14,700 LBS.
2200	32	14,700 LBS.
2230	32	14,700 LBS.
2300	32	14,700 LBS.
2330	0	0
2400	32	14,700 LBS.
0030	32	14,700 LBS.
0100	32	14,700 LBS.
0130	32	14,700 LBS.
0200	32	14,700 LBS.
0230	32	14,700 LBS.
0300	32	14,700 LBS.
0330	32	14,700 LBS.
0400	32	14,700 LBS.
0430	32	14,700 LBS.
0500	32	14,700 LBS.
0530	32	14,700 LBS.
0600	32	14,700 LBS.
0630	32	14,700 LBS.
0700		14,700 LBS.

Total Estimated square footage removed during shift

22,373 Square Footage

memo

NORSHIPCO

Average Pressure Supplied to Blasting Head
Date: 7-14-92
Location: Titan Drydock
Purpose: PM-10 Study

Time	Average Pressure at Nozzles
2000	90 PSI
2100	95 PSI
2200	110 PSI
2300	105 PSI
2400	85 PSI
0100	100 PSI
0200	105 PSI
0300	95 PSI
0400	90 PSI
0500	100 PSI
0600	110 PSI
0700	

memo

Meteorological Conditions
Date: 7-25-92
Location: Titan Drydock
Purpose: PM-10 Study

Time	Wind Direction		Speed	Temp.	% Humidity
1800	W	240	10 kt.	95°	40%
1830	W	240	8 kt.	95°	42%
1900	W	240	8 kt.	94°	45%
1930	W	240	6 kt.	94°	48%
2000	W	240	8 kt.	93°	48%
2030	W	220	6 kt.	92°	53%
2100	W	250	6 kt.	91°	56%
2130	W	240	5 kt.	90°	65%
2200	W	220	10 kt.	89°	67%
2230	W	250	11 kt.	88°	67%
2300	W	255	12 kt.	88°	67%
2330	W	230	8 kt.	87°	67%
2400	W	230	10 kt.	86°	66%
0030	W	255	15 kt.	85°	70%
0100	W	230	8 kt.	85°	73%
0130	W	235	10 kt.	84°	73%
0200	W	230	10 kt.	84°	76%
0230	W	255	13 kt.	84°	76%
0300	W	245	16 kt.	84°	80%
0330	W	270	13 kt.	84°	80%
0400	W	240	12 kt.	83°	84%
0430	W	270	14 kt.	83°	88%
0500	W	270	10 kt.	82°	92%
0530	W	255	11 kt.	81°	88%
0600	W	240	12 kt.	82°	92%
0630	W	265	13 kt.	82°	72%
0700					65%
0730					
0800					

NORSHIPCO

NORFOLK SHIPBUILDING & DRYDOCK CORPORATION
PO BOX 2100
NORFOLK, VIRGINIA 23501-2100
Telex 823 613 Cable: NORSHIPCO
Telephone 804/494-4000

Meteorological Conditions
Date: 7-13-92
Purpose: PM-10 Background

Time	Wind	Direction	Speed, Knots
1800	W	240	5
1900	W	270	5
2000	W	270	4
2100	W	270	2
2200	W	260	2
2300	W	280	2
2400	W	240	4
July 14, 1992			
0100	W	250	4
0200	W	270	5
0300	W	250	8
0400	W	260	8
0500	W	260	8
0600	W	250	5
0700	W	260	8
0800	W	250	10
0900	W	270	10
1000	W	250	8
1100	W	250	8
1200	W	250	10
1300	W	250	10
1400	W	270	8
1500	W	270	8
1600	W	270	8
1700	W	270	8

[illegible signature]
7-30-92

Appendix D

Field Summary Logs

Indian Valley Industries, Inc.

[redacted]

DESERT STORM TAN/BLACK
(100% fire retardant polypropylene)

[illegible] [redacted]	
WEIGHT	5 oz/yd^2
SHADE PERCENTAGE	72%
AIR POROSITY	377 cfm
TENSILE STRENGTH Grab Method	Warp: 267 lbs Fill: 116 lbs
ELONGATION % Grab Method	Warp: 15% Fill: 13%
PUNCTURE	110 lbs
TEAR STRENGTH Trapezoid Method	Warp: 113 lbs Fill: 39 lbs
BURST STRENGTH Mullen	327 lbs/in^2

CONTAINMENT 80% to 85%

DISTRIBUTED BY:

ATLANTIC COAST EQUIPMENT CO., INC.
2601-B Trade St.
Chesapeake, VA 23323
(804) 487-1055

EMISSION TESTING
FIELD PROJECT SUMMARY LOG

CLIENT Norshipco PROJECT NO. 1512-001

PLANT Norshipco CITY Norfolk STATE VA

DATE/TIME	ACTION TAKEN
7/13/92	
4:30pm	Arrive on site. Met w/ T. Beachum
6:00pm	Arrive off-site warehouse. Set-up TSP and PM_{10}
	samplers (Runs 1A and 1B)
7/14/92	
9:00am	Arrive on site. Met w/ T. Beachum + blasting crew
	supervisor. Toured drydock area. Left site 10:30am
3:00pm	Arrive on site. Met w/ T. Beachum + Laurel Driver &
	Roy Huttley (EPA). Toured drydock area. Sample
	locations were discussed and selected with
	EPA. representatives
7:00pm	Arrive off-site warehouse. Collected filters for Runs
	1A and 1B
7:30pm	Arrive on-site. Assembled filter cassettes in drydock
	office. Assembled samplers.
8:30pm	Joined by T. Beachum and L. Driver/R. Huttley of EPA.
	Positioned samplers at positions 2 and 4

Page 1 of 3 SIGNATURE [signature]

EMISSION TESTING
FIELD PROJECT SUMMARY LOG

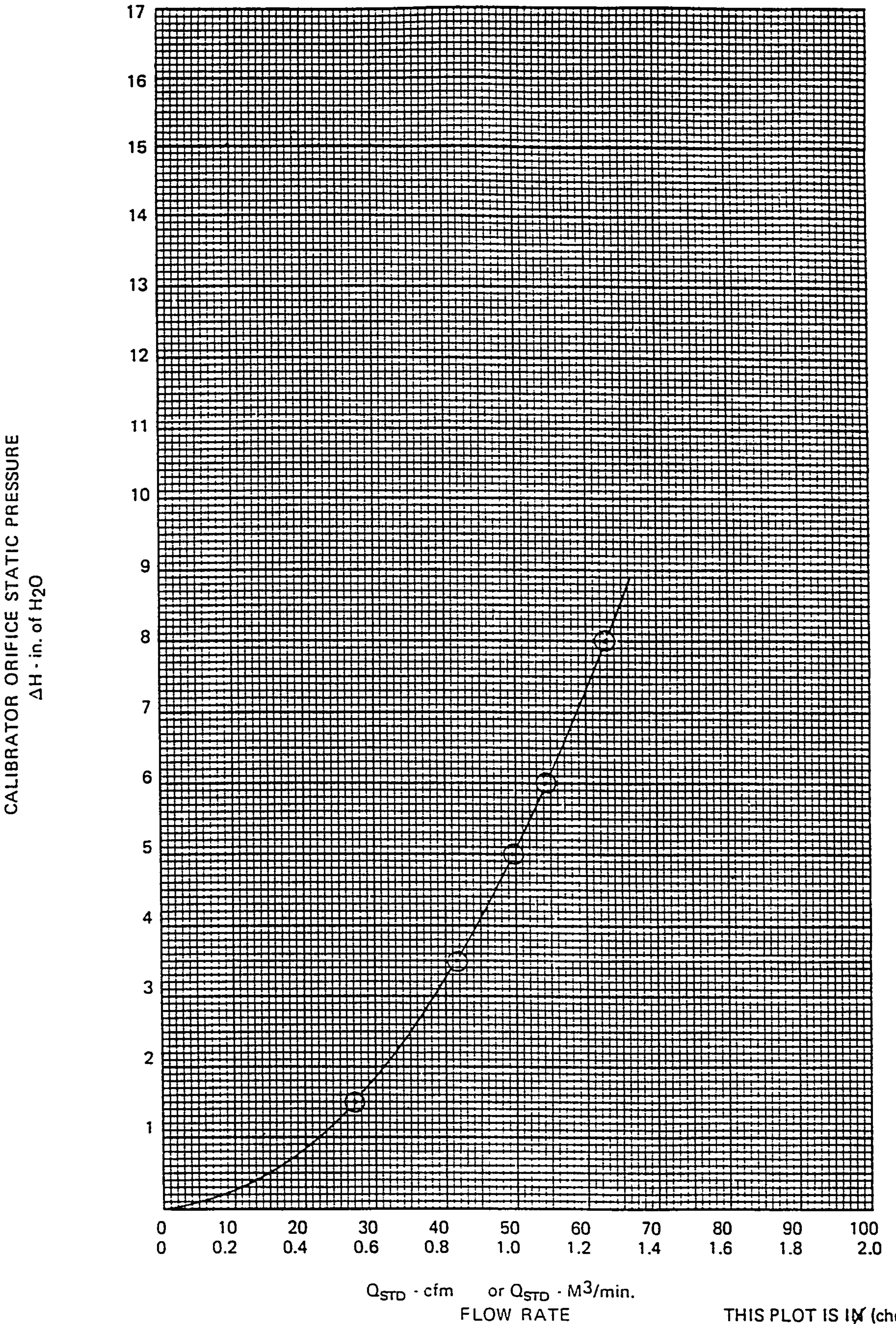
CLIENT Norshipco PROJECT NO. 1512-001
PLANT Norshipco CITY Norfolk STATE VA

DATE/TIME	ACTION TAKEN
7/14/92 10:00pm	Started runs 2A & 2B
10:15 pm	Completed runs 2A & 2B
10:23 pm	Started runs 2C & 2D
10:33pm	Completed runs 2C & 2D. Checked PM_{10} head for
	particle trailing.
10:35pm	Started runs 2E & 2F. EPA officials leave site with
	T. Beachum
10:45pm	Completed runs 2E & 2F. Noticed tears on filters
	2G & 2H.. Returned to dock office to ~~per~~ prepare
	more filter cassettes.
11:55pm	Started runs 2I and 2J while Pat Slater
	started runs 3A and 3B.
7/15/92 12:05am	Completed runs 2I and 2J, Pat Slater completed
	runs 3A, 3B, 3C and 3D. Moved to location 4
12:45am	Started runs 4A & 4B. Noticed tears in filters. Voided Runs.
	Moved samplers to new locations. Returned to
	dock office to assemble more filter cassettes

Page 2 of 3 SIGNATURE [signature]

Appendix E

Equipment Calibrations



THIS PLOT IS IN (check one)
cfm ✓
M^3/min.
They are NOT EQUIVALENT

HIGH VOLUME SAMPLER CALIBRATION WORKSHEET

Site location: Norshipco #1512-001

Date: 7/13/92 (1) Barometric pressure, P_2 (mm Hg or in.): 256

Calibrated by: P. Slater / E. Ponre (2) Temperature, T_2 (K): 295.2

Sampler No.: CAE 2945 Serial No.:

Transfer std type: Orifice Serial No.: U-2

Optional:

P_{std} = 760 mm Hg (or 29.92 in.)

Average barometric pressure: P_a = ______

Seasonal average temperature: T_a = ______

5 (Y):

- For specific pressure and temperature corrections (see Table 2.1): ☑ I or ☐ $\sqrt{I\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$ or ☐ $I\sqrt{\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$
- For incorporation of average pressure and seasonal average temperature (see Table 2.1): ☐ I or ☐ $\sqrt{I\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$ or ☐ $I\sqrt{\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$

No.	1 ΔH Pressure drop across orifice (in) or (cm)	$\sqrt{\Delta H\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$	(X) 3 Q_{std} (from orifice certification std. m³/min	4 I Sampler flow rate indication (arbitrary)	5 (Y) For specific pressure and temperature corrections	5 (Y) For incorporation of average pressure and seasonal average temperature
1	1.5		0.764	20		
2	3.5		1.172	34		
3	5.0		1.398	46		
4	6.0		1.536	52		
5	8.0		1.777			
6						

Least Aquares Calculations

Linear regression of Y on X: Y = mX + b; Y = appropriate expression from Table 2.1; X = Q_{std}

Slope (m) = 41.99606 Intercept (b) = -12.3032 Correlation Coefficient (r) = ______

To determine subsequent flow rate during use: X = 1/m (Y-b)

Q_{std} = 1/m (appropriate expression from Table 2) - b)

CALIBRATION WORK SHEET

QSTD

(1) Run Point No.	(2) Elapsed Time - Δt Min.	(3) Initial Volume V_M M^3	(4) Meter Inlet Static Pressure-ΔP mm of Hg	(5) Standard Volume V_{STD} M^3	(6) Calibrator Orifice Static Press. ΔH in. of H_2O	(7) Metric Flow Rate Q_{STD} M^3/min.	(8) English Flow Rate Q_{STD} ft^3/min.	For application ref. 1 (9) $\sqrt{\Delta H \left(\frac{Pa}{P_{STD}}\right)\left(\frac{298}{TA}\right)}$
1	1.338	1	4.0	1.022	1.5	0.764	27.0	
2	0.866	1	9.3	1.015	3.5	1.172	41.4	
3	0.722	1	13.2	1.009	5.0	1.398	49.4	
4	0.655	1	15.9	1.006	6.0	1.536	54.2	
5	0.562	1	21.2	0.999	8.0	1.777	62.8	
6								
7								

$$V_{STD} = V_m \frac{(Pa-\Delta P)\,T_{STD}}{P_{STD}\,Ta}$$

(7) and (8) are corrected to
760 mm of Hg
25° mm (298°K)

$$Q_{STD} = \frac{V_{STD}}{\Delta t}$$

$M^3 \times 35.31 = Ft^3$

Qa

(1) Run oint No.	(2) Elapsed Time - Δt Min.	(3) Initial Volume Vm M^3	(4) Meter Inlet Static Pressure-ΔP mm of Hg	(5a) Actual Volume Va M^3	(6) Calibrator Orifice Static Press. ΔH in. of H_2O	(7a) Metric Flow Rate Qa M^3/min.	For application see ref. 2 (8a) $\sqrt{\Delta H \left(\frac{TA}{PA}\right)}$
1	1.338	1	4.0		1.5		
2	0.866	1	9.3		3.5		
3	0.722	1	13.2		5.0		
4	0.655	1	15.9		6.0		
5	0.562	1	21.2		8.0		
6							
7							

$$Va = Vm \frac{(PA-\Delta P)}{PA} \qquad Qa = \frac{Va}{\Delta t}$$

(9) Pa 775.2 mm of Hg

(10) Ta 23 °C + 273 = °K

(11) RH: 54 %

Roots Meter No.: 7509364

Calibrator Orifice:

Model No.: VRC

Serial No.: V2

Calibration performed by: J. Lazaro

Calibration Code 30-3-2C1C

Date placed in service: 11-12-90

(To be noted by user) JCB

additional information consult:

1. The Federal Register, Vol. 47, No. 234, pp. 54896-54921, December 6, 1982
2. Quality Assurance Handbook, Vol. II (EPA 600/4-77-027a), Section 2.11

Notes:
1. EPA recommends calibrators should be recalibrated after one year of field use.
2. Copies of this calibration are not kept on file.

HIGH VOLUME SAMPLER CALIBRATION WORKSHEET

Site location: Narshipco #1512-001

Date: 7/13/92 (1) Barometric pressure, P_2 (mm Hg) (or in.) 756

Calibrated by: P. Slater / E. Poore (2) Temperature, T_2 (K) 295.2

Sampler No: 5 Serial No.

Transfer std type: Orifice Serial No. V-2

Optional

P_{std} = 760 mm Hg (or 29.92 in.)

Average barometric pressure: P_a =

Seasonal average temperature: T_a =

5 (Y)

For specific pressure and temperature corrections (see Table 2.1):

☑ 1 or

☐ $\sqrt{1\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$ or

☐ $1\sqrt{\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$

For incorporation of average pressure and seasonal average temperature (see Table 2.1):

☐ 1 or

☐ $\sqrt{1\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$ or

☐ $1\sqrt{\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$

No	1 ΔH Pressure drop across orifice (in) or (cm)	$\sqrt{\Delta H\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$	(X) 3 Q_{std} (from orifice certification std. m³/min	4 I Sampler flow rate indication (arbitrary)	5 (Y) For specific pressure and temperature corrections	5 (Y) For incorporation of average pressure and seasonal average temperature
1	1.5		0.764	30		
2	3.5		1.172	43		
3	5.0		1.398	53		
4	6.0		1.536	58		
5	8.0		1.777	67		
6						

Least Aquares Calculations

Linear regression of Y on X: Y = mX + b; Y = appropriate expression from Table 2.1; X = Q_{std}

Slope (m) = ~~42.75841~~ EP 37.03243 Intercept (b) = 1.560376 Correlation Coefficient (r) = ——

To determine subsequent flow rate during use: X = 1/m (Y-b)

Q_{std} = 1/m (appropriate expression from Table 2) - b)

HIGH VOLUME SAMPLER CALIBRATION WORKSHEET

Site location: Norshipco #1512-001

Date: 7/13/92 (1) Barometric pressure, P (mm Hg or in.) 756

Calibrated by: P. Slater / E. Poore (2) Temperature, T_2 (K) 295.2

Sampler No. 4 Serial No.

Transfer std type: orifice Serial No. V-2

Optional

P_{std} = 760 mm Hg (or 29.92 in.)

Average barometric pressure: P_a =

Seasonal average temperature: T_a =

5 (Y)

For specific pressure and temperature corrections (see Table 2.1):

☑ 1 or

☐ $\sqrt{1\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$ or

☐ $1\sqrt{\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$

For incorporation of average pressure and seasonal average temperature (see Table 2.1):

☐ 1 or

☐ $\sqrt{1\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$ or

☐ $1\sqrt{\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$

No	1 ΔH Pressure drop across orifice (in) or (cm)	$\sqrt{\Delta H\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$	(X) 3 Q_{std} (from orifice certification std. m³/min	4 I Sampler flow rate indication (arbitrary)	5 (Y) For specific pressure and temperature corrections	5 (Y) For incorporation of average pressure and seasonal average temperature
1	1.5		0.764	24		
2	3.5		1.102	38		
3	5.0		1.398	48		
4	6.0		1.536	53		
5	8.0		1.777	—		
6						

Least Aquares Calculations

Linear regression of Y on X: Y = mX + b; Y = appropriate expression from Table 2.1; X = Q_{std}

Slope (m) = 38.06825 Intercept (b) = -5.19079 Correlation Coefficient (r) = —

To determine subsequent flow rate during use: X = 1/m (Y-b)

Q_{std} = 1/m [appropriate expression from Table 2] - b)

HIGH VOLUME SAMPLER CALIBRATION WORKSHEET

Site location Norshipco #1512-001

Date 7/13/92 (1) Barometric pressure, P_2 mm Hg (or in.) 756

Calibrated by P. Slater / E. Poore (2) Temperature, T_2 (K) 295.2

Sampler No 3 Serial No.

Transfer std type Orifice Serial No. V-2

					5 (Y)	
Optional. P_{std} = 760 mm Hg (or 29.92 in.) Average barometric pressure: P_a = ______ Seasonal average temperature: T_a = ______					For specific pressure and temperature corrections (see Table 2.1)	For incorporation of average pressure and seasonal average temperature (see Table 2.1)
No	1 ΔH Pressure drop across orifice (in) or (cm)	$\sqrt{\Delta H\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$	(X) 3 Q_{std} (from orifice certification std. m³/min	4 I Sampler flow rate indication (arbitrary)	☒ I or ☐ $\sqrt{I\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$ or ☐ $I\sqrt{\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$	☐ I or ☐ $\sqrt{I\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$ or ☐ $I\sqrt{\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$
1	1.5		0.764	22		
2	3.5		1.172	38		
3	5.0		1.398	48		
4	6.0		1.536	50		
5	8.0		1.777	62		
6						

Least Aquares Calculations

Linear regression of Y on X: Y = mX + b; Y = appropriate expression from Table 2.1; X = Q_{std}

Slope (m) = 37.23434 Intercept (b) = -4.53625 Correlation Coefficient (r) = ______

To determine subsequent flow rate during use: X = 1/m (Y-b)

Q_{std} = 1/m [appropriate expression from Table 2] - b)

HIGH VOLUME SAMPLER CALIBRATION WORKSHEET

Site location: Norshipco #1512-001

Date: 7/13/92 (1) Barometric pressure, P_2 (mm Hg) (or in.) 754

Calibrated by: P. Slater / E. Poore (2) Temperature, T_2 (K) 295.2

Sampler No. 2 Serial No.

Transfer std type: Orifice Serial No. V-2

Optional. P_{std} = 760 mm Hg (or 29.92 in.)

Average barometric pressure: P_a =

Seasonal average temperature: T_a =

5 (Y)

For specific pressure and temperature corrections (see Table 2.1):

- ☑ I or
- ☐ $\sqrt{I\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$ or
- ☐ $I\sqrt{\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$

For incorporation of average pressure and seasonal average temperature (see Table 2.1):

- ☐ I or
- ☐ $\sqrt{I\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$ or
- ☐ $I\sqrt{\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$

No	1 ΔH Pressure drop across orifice (in) or (cm)	$\sqrt{\Delta H\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$	(X) 3 Q_{std} (from orifice certification std. m^3/min)	4 I Sampler flow rate indication (arbitrary)	5 (Y) For specific pressure and temperature corrections	5 (Y) For incorporation of average pressure and seasonal average temperature
1	1.5		0.764	22		
2	3.5		1.172	39		
3	5		1.398	48		
4	6		1.539	50		
5	8		1.777	—		
6						

Least Aquares Calculations

Linear regression of Y on X: Y = mX + b; Y = appropriate expression from Table 2.1; X = Q_{std}

Slope (m) = 37.24351 Intercept (b) = -4.29692 Correlation Coefficient (r) = —

To determine subsequent flow rate during use: X = 1/m (Y-b)

Q_{std} = 1/m (appropriate expression from Table 2) - b)

Summary of Sampler Calibrations

Orifice Qstd	Delta H	Sampler CAE-2945	Sampler 1	Sampler 2	Sampler 3	Sampler 4	5
0.764	1.5	20	20	22	22	24	30
1.172	3.5	34	36	39	38	38	43
1.398	5	46	47	48	48	48	53
1.536	6	52	53	50	50	53	58
1.777	8				62		67
	Y Intercept (b	-12.3032	-12.7681	-4.29697	-4.53625	-5.19079	1.560376
	Slope (m)	41.99606	42.75841	37.24351	37.23434	38.06825	37.03243

HIGH VOLUME SAMPLER CALIBRATION WORKSHEET

Site location Norshipco #1512-0a

Date 7/13/92 (1) Barometric pressure, P_2 (mm Hg (or in.) 756

Calibrated by: P. Slater /E. Poore (2) Temperature, T_2 (K) 295.2

Sampler No 1 Serial No.

Transfer std type Orifice Serial No. V-2

Optional. P_{std} = 760 mm Hg (or 29.92 in.)

Average barometric pressure: P_a =

Seasonal average temperature: T_a =

5 (Y)

For specific pressure and temperature corrections (see Table 2.1): ☑ I or ☐ $\sqrt{I\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$ or ☐ $I\sqrt{\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$

For incorporation of average pressure and seasonal average temperature (see Table 2.1): ☐ I or ☐ $\sqrt{I\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$ or ☐ $I\sqrt{\left(\frac{P_2}{P_a}\right)\left(\frac{T_a}{T_2}\right)}$

No	1 ΔH Pressure drop across orifice (in) or (cm)	$\sqrt{\Delta H\left(\frac{P_2}{P_{std}}\right)\left(\frac{298}{T_2}\right)}$	(X) 3 Q_{std} (from orifice certification std. m³/min	4 I Sampler flow rate indication (arbitrary)	5 (Y) For specific pressure and temperature corrections	5 (Y) For incorporation of average pressure and seasonal average temperature
1	1.5	1.22	0.764	20		
2	3.5	1.87	1.172	36		
3	5.0	2.24	1.398	47		
4	6.0	2.45	1.536	53		
5	8.0	2.83	1.777	—		
6						

Least Aquares Calculations

Linear regression of Y on X: Y = mX + b; Y = appropriate expression from Table 2.1; X = Q_{std}

Slope (m) = 42.75841 Intercept (b) = -12.7631 Correlation Coefficient (r) = —

To determine subsequent flow rate during use: X = 1/m (Y-b) Q_{std} = 1/m [appropriate expression from Table 2] - b)

EMISSION TESTING
FIELD PROJECT SUMMARY LOG

CLIENT Norshipco PROJECT NO. 1512-001

PLANT Norshipco CITY Norfolk STATE VA

DATE/TIME	ACTION TAKEN
7/15/92 2:00am	Returned to Location 4 and started runs 4C and
	4D.
2:10 am	Completed runs 4C & 4D. Check PM_{10} for
	particle trailing (none observed). Moved samplers
	to Location 6.
2:20 am	Started runs 5A & 5B
2:25am	Completed runs 5A & 5B
2:45am	Started runs 6A & 6A
2:50 am	Completed runs 6A & 6B
	Disassembled filter cassettes. Checked data sheets
	Chain of Custody log. Loaded equipment
4:00 am	Left site.

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