94-218

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service
Centers for Disease Control

Memorandum

Date July 15, 1994

From General Engineer, Certification and Quality Assurance Branch
Division of Safety Research

Subject Meeting with Bill Lambert of MSA, Bill Newcomb of North Safety, and Don Wilmes of 3M

To The Record

A meeting was held on July 7, 1994, at the request of Messrs. Lambert, Newcomb, and Wilmes. The purpose of the meeting was to further discuss the round-robin testing discussed at the public meeting and NIOSH's testing experience in achieving test-instrument correlations.

The manufacturers' concerns resulted from differing results obtained at five different manufacturers' test sites in round-robin testing using both ATI and TSI instruments. A copy of the test protocol used in the round-robin testing was provided to NIOSH. While very good correlation was achieved with mechanical filter media, varying results were obtained with electrostatic filter media. The experience of the Institute with varying results with electrostatic filter media and the associated chemical changes to dioctyl phthalate (DOP) from aging or heating was described. Mr. Wilmes related recent 3M testing experience that confirmed different results between "old" and "new" DOP; with the same results obtained between the TSI and ATI instruments using new DOP with electrostatic filter media. Differing results with the ATI instrument were noted in as little as 4 hours of operation. Further, he characterized 3M's correlation experience (semi-annual round-robin testing) with all their instruments in 27 locations around the world as excellent. The Institute will provide information on the chemical breakdown of the DOP and the latest draft test protocol.

The three manufacturers' representatives stated that a second series of round-robin testing was being planned with increased participation. Several of the original participants had recently (estimated at a month or less) received their TSI instruments prior to the initial series of testing. As many as ten Industrial Safety Equipment Association (ISEA) member companies have expressed an interest and are expected to participate. Other ISEA members, predominately, are not manufacturers of air-purifying respirators. The Institute indicated that it would consider its invitation to participate. The manufacturers' representatives indicated that any non-ISEA members expressing an interest, including ATI and TSI, would be welcomed to participate.

Another concern, the basis for the filter-loading limit during the proposed tests was discussed during the meeting. The Institute explained that the levels were considered

to be consistent with the loading levels of the current Part 11 tests that are considered severe.

In regard to fit testing, a comment to require an applicant to submit results of performed fit testing with an application was made. The Institute could accept or reject the results, according to this suggestion, under the provisions of § 84.63(c).

The manufacturers indicated that further comments would be submitted to the NIOSH Docket Office.

Roland J. Berry Ann

Roland J. Berry Ann

Attachments:
Round-robin protocol
Analysis of DOP
NIOSH-test protocol

cc:
Bill Newcomb
Bill Lambert
Don Wilmes
Docket Office

ISEA fax

Industrial Safety Equipment Association
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Arlington, VA 22209
(703)525-1695
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Date/Time: July 6, 1994

To: Roland BerryAnn, NIOSH-CQAB

Fax No. (304) 284-5877

Originator: Bill Erny

Number of pages, including cover sheet: 18

Included is the test protocol used for the ISEA ROUND ROBIN TEST as discussed and presented at the public hearings. Three ~~members~~ manufacturers will be meeting with you tomorrow at 8:00 a.m.

Bill Newcomb North Safety
Don Wilmes 3M
Bill Lambert MSA.

Please distribute copies to Ernie & Don Campbell and the 3 manufacturers. They left here before I could give them a copy. It may be used in your discussion tomorrow. Any questions, give me a call.

Yours Truely
Bill Erny

3M Occupational Health and
Environmental Safety Division

3M Center
St. Paul, Minnesota 55144-1000
612/733 1110

3M

May 17, 1994

Dear Round Robin Participants:

Enclosed with this letter are materials for participating in the DOP Loading Round Robin Test. You should find the following materials:

- Four bags of filters (2 each of green-line fiberglass and 3M BMF filters)
- A copy of the round robin test protocol entitled, "Round Robin of DOP Load Tests
- Documentation for the AFTLOAD.EXE program.
- A program diskette containing AFTLOAD.EXE and BROWSE.COM.

If any of these items are missing or damaged, please contact me or Don Wilmes immediately.

The test protocol is thoroughly described in the enclosed documents; however, please call if there are any questions. We look forward to receiving your test results as soon as possible.

Andrew S. Viner

Andrew S. Viner
Senior Quality Engineer
Phone: (612) 733-8097
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asv
Enclosure
c: D.P. Wilmes

Round Robin of DOP Load Tests

Please review this document carefully before initiating tests. portions may have changed since the last draft.

Purpose

The question has been raised, "Do the ATI TDA-100 (Q127) DOP penetrometer and the TSI Model 8110 Automated Filter Tester (AFT) yield the same results for DOP loading tests?" The purpose of this round robin test is to gather data to address this question. DOP penetration of standard filter media will be measured using both instruments (Q127 and AFT) at different test sites. Two kinds of filter media will be tested: fiberglass and electrostatically-charged BMF (blown micro fiber) media. It has been observed that these two types of media behave differently during DOP loading tests. DOP penetration through fiberglass filters does not change significantly with loading, whereas electrostatic filters exhibit increasing penetration. The goal of this round robin test is to determine how much, if any, difference exists between DOP load tests for these media on the two instruments.

Overview

DOP penetration tests will be conducted at three levels of performance that correspond to the respirator classes proposed under 42 CFR 84 - A, B, and C (99.97%, 99%, & 95% efficiency). Tests should be conducted on one AFT and on one Q127 at each round robin site. Reproducibility will be assessed by measuring 5 samples in each class on each instrument. Given that penetration through fiberglass media does not increase significantly with DOP loading, the test can be simplified somewhat by running only initial (i.e., instantaneous) DOP tests on fiberglass filters. Complete load tests will be required for the BMF samples. Therefore, fifteen load tests (3 classes x 5 replicates) and fifteen instantaneous tests will be run on each instrument. Table 1 summarizes the tests to be conducted. All filter media will be supplied by 3M to ensure uniformity among test sites.

Table 1. A total of 60 tests are required at each site: 15 load tests and 15 instantaneous tests on an AFT and a Q127

Instantaneous Tests (Fiberglass) Day Two Q127	Day One AFT	Load Tests (BMF) Day Two Q127	Day One AFT
Class 'A' × 5	Class 'A' × 5	Class 'A' × 5	Class 'A' × 5
Class 'B' × 5	Class 'B' × 5	Class 'B' × 5	Class 'B' × 5
Class 'C' × 5	Class 'C' × 5	Class 'C' × 5	Class 'C' × 5

Procedure

The basic test procedure is described in the NIOSH protocol of December 15, 1993 ("Particulate Filter Instantaneous-Penetration Procedure To Test Negative Pressure Respirators Against Liquid Particulates"). Additional steps are necessary to ensure uniformity across test sites:

- [redacted] During load tests, filters will be tested until total exposure is 100 mg.
- Filters will be placed directly in the chucks of the instrument - do NOT use any filter holder that would reduce the filter area exposed to flow. An earlier draft of this document called for the use of a TSI gravimetric sample holder, but that holder restricts the filter area too much. Instead, measure and record the diameter of the chucks so the data can be adjusted, if necessary.
- Each filter will be weighed before preconditioning and after loading tests. The net weight gain of each filter will be used as a check on the accuracy and stability of the measured gravimetric concentration. (It has been verified that preconditioning has no discernable effect on the weight of the samples.)
- Each test site should have an ionizer for neutralizing the DOP aerosol. The ionizer should be balanced prior to testing (see Chapter XI, "Checking system performance," in the AFT manual for a detailed procedure).
- Five filters of each type of media will be tested in each performance class.
- Data collection software is provided to facilitate load testing on the AFTs. Review the enclosed documentation for AFTLOAD.EXE and make a practice run to familiarize yourself with the program.
- When testing is complete, return all data sheets and/or data diskettes to:

  Don Wilmes
  3M Center
  Building 260-3A-07
  St. Paul, MN 55144-1000

  Data will be analyzed at 3M and copies of the data and results will be delivered to each participant.

Sample Preparation

Four stacks of filters are provided with this test method. There are two stacks of Hollingsworth and Vose HE-1074 ("green-line") fiberglass media, each containing 50 filters. The other two stacks each contain 65 filters of electrostatically charged blown micro fiber (BMF) media from 3M. The samples for round robin testing are to be constructed by layering different numbers of filters to achieve the three classes of performance stipulated in the NIOSH test method (i.e, 99.97, 99, and 95% efficiency). The exact number of layers required for each type and class of filter are listed in Table 2.

All of the filters are marked with a colored line on one side. The fiberglass filters all have one or more green stripes and the BMF filters all have a single purple stripe. When stacking the filters, they should all be layered with the striped surface visible. (Remove the paper circle that separates BMF filters from each other.) When placing the samples in the chucks, the striped surface should always face away from the flow. That is, the challenge aerosol should always strike the unstriped surface first.

Thirty samples should be constructed with each type of media for a total of sixty samples. There will be ten samples in each performance class (e.g., five Class C fiberglass for the Q127 and five for the AFT). Twenty-four hours prior to testing, weigh the filter samples to the nearest 0.1 mg, record the weights, and place them in a preconditioning oven at 85% RH and 37 °C.

Table 2. Number of layers of fiberglass and BMF required for each performance class

Fiberglass Samples (Green Line)		BMF Samples (Purple Stripe)	
Performance Class	Number of layers	Performance Class	Number of layers
A	5	A	6
B	3	B	4
C	2	C	3

Test Setup

1. Start up the test instrument, put fresh DOP in the aerosol generator and wait for the system to stabilize (at least ½ hr for Q127; at least 10 minutes for the AFT).

2. Run standard setup and calibration procedures. On the Q127 verify the particle size with a visual owl. For the AFT, use the procedure described in the Manual to verify particle size. Record the results (visual owl angle for Q127, standard filter penetration and pressure drop for the AFT) on the attached Daily Setup Data Sheet.

3. Set flow to 32 LPM. Use the orifice plate provided with the AFT to check flow. (Use the same plate on both the AFT and the Q127.) Each orifice plate is marked with a target pressure drop for 32 LPM. If the pressure drop across orifice plate is not within ±5% of the target, then check flow rate and/or pressure drop calibration. Adjust as necessary until the measured pressure drop is within ±5% of the target. Record the orifice plate pressure drop on the Daily Setup Data Sheet.

4. Set the flow to 42.5 LPM. Run a gravimetric test to determine the mass concentration of DOP aerosol (see Chapter XI, "Checking system performance," in the AFT manual for a detailed test procedure). Compute the *estimated* loading time as:

$t_{LOAD} = 2353 / C$

where C is DOP concentration in mg/m^3. For example, if you measure C=100 mg/m^3 then t_{LOAD} =23.53 minutes. (Typically, both the Q127 and the AFT generate 100 mg/m^3 of DOP aerosol. If the measured gravimetric concentration is outside the range 80-120 mg/m^3 it may be an indication of hardware problems.)

The above procedures should be performed at the beginning of each day of testing. Prior to testing, randomize the filter samples but alternate between load tests and instantaneous filter tests (e.g., Class 'C' load test #1 followed by Class 'A' instantaneous test #1 followed by Class 'B' load test #1,...).

Instantaneous Test Procedure (Fiberglass samples)

1. According to the NIOSH test protocol, the samples must be preconditioned 25 ± 1 hr prior to testing.

2. Verify that the flow is still at 42.5 LPM. Make two copies of the Instantaneous Penetration Test Data sheet to record the results (one for Q127 data and one for AFT data).

3. Put the sample in the instrument (AFT or Q127) with the colored stripe(s) away from the incoming flow. Run an instantaneous penetration test. On the Q127, keep the chucks closed until a stable penetration reading is obtained (~20 seconds). Test time on the AFT is controlled automatically. Record the date, time, operator, Filter ID, flow rate, pressure drop, and penetration on the data sheet.

4. Retain all samples in the original shipping carton in the event that additional information is needed.

> NOTE: For those familiar with the procedure, it would be helpful to capture the AFT data directly to a file. Any standard communications program can be used for this purpose (e.g., Crosstalk, Procomm, or the Terminal program that is included with Microsoft Windows). Data analysis will be faster if data is provided electronically.

Load Test Procedure (BMF samples)

1. According to the NIOSH test protocol, the samples must be preconditioned 25 ± 1 hr prior to testing.

2. Make 15 copies of the attached Q127 Loading Data sheet (a separate sheet for each sample).

3. For load tests on the AFT, use the software provided to collect the data. Also record summary information on the attached data sheet (AFT Load Test Summary). For load tests on the Q127, record penetration and pressure drop after 30 seconds and then again after 1 minute on the attached data sheet (Q127 Loading Data). Continue recording measurements at 1 minute intervals.

4. Run the loading test for at least t_{LOAD} minutes

5. At the end of a load test, remove the sample from the chucks, weigh it, and record the value on the appropriate data sheet. The difference between the final weight and the initial weight should be at least 100 mg. If not, recheck the gravimetric concentration.

6. Retain all samples in the original shipping carton in the event that additional information is needed.

Q127 Loading Data

(BMF Media)

Date:_____
Operator:_____
Gravimetric Conc. _____mg/m³
t_{LOAD}:_____minutes

Q127 s/n:_____
Sample No.:_____
Final wt.:
Initial wt.: –_____
Net wt:

Test Time (min)	Pn (%)	ΔP (mm H_2O)
.5		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

Sample Class: ○ A
○ B
○ C

Instantaneous Penetration Test Data

(Fiberglass Media)

Instrument: O Q127
O AFT
Filename:_____
(optional)

Date	Time	Operator	Filter ID	Flow Rate (LPM)	ΔP (mm H_2O)	Pn (%)

Daily Setup Data Sheet

Check Diameter (measure both top and bottom chucks):

Q127: _____

AFT: _____

		Q127	AFT Particle Size Check			Flow Check	Gravimetric Measurement					
Date	Time	Visual Owl	Flow (LPM)	ΔP (mm H_2O)	Ps (%)	$\Delta P_{orifice}$ (mm H_2O)	Initial wt. (mg)	Final wt. (mg)	Net wt. (mg)	Test time (min)	Flow rate (LPM)	Grav. conc. (mg/m3)

AFT Load Test Summary

(BMF Media)

Date	Time	Operator	Filter ID	Initial ΔP (mm H_2O)	Max. Pn (%)	Initial wt. (mg)	Final wt. (mg)	Net wt. (mg)	Filename

AFTLOAD.EXE, v1.1

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Overview

This program was designed to simplify the collection of data from a TSI Model 8110 Automated Filter Tester (AFT) during filter load tests. The program monitors the output from the AFT (via RS-232), estimates the cumulative mass of aerosol that a sample has been exposed to, and alerts the test operator when a specified mass has been exceeded. The program permits the operator to enter information about the test and stores that information along with the test data in an ASCII data file. A summary table at the end of the file lists the total test time, the total air volume through the sample, the initial pressure drop, and the maximum penetration. The ASCII file is tab-delimited, thereby making it easy to read into a spreadsheet program (e.g., Microsoft Excel) for further calculations.

The program is DOS-based and should be compatible with almost any IBM PC-compatible computer. The program is relatively small (<100Kbytes), so memory requirements are modest. This software has been successfully operated on many different computers (including 8086, 80286, 80386, and 80486 processors) and on at least four different AFTs; however the program is provided "as-is" without warranty of any kind, including any guarantees of fitness for any given purpose. This program may be distributed free of charge with permission of the author. Comments and suggestions are welcome.

User Instructions

Hardware:

The physical connection between the AFT and the computer is straightforward. A standard RS-232 cable is required to connect between the PC and the AFT. A 25-pin male connector is required for the back of the AFT. On the PC side, a female connector with either 9 or 25 pins is required (depending on your PC).

It is assumed that the RS-232 port on the AFT is programmed to operate at 1200 baud, no parity, 7 data bits, and one stop bit. (These are the default settings for the 8110.) The AFTLOAD program will not operate unless these settings are in effect. Refer to Chapter VIII, "Serial Interface," of your AFT manual if you have any difficulty.

The program monitors the duration of a test by reading the computer's internal clock. The clock does not have to be set to the correct time, however it is essential that the clock measure time intervals accurately (i.e., the clock must be able to accurately measure an hour to within one minute).

Software

The AFTLOAD program is executed from the DOS prompt. The program should be compatible with the Microsoft Windows program; however I have very little experience running it in that environment. Once loaded, the program displays the main menu, which lists five menu choices as shown in Figure 1.

```
        AFT Data Collection Program

F1      Enter a filename
F2      Specify run parameters
F3      Begin data collection
F4      View data file
F10     Exit

        Press a Function key
```

Figure 1. The Main Menu of the AFTLOAD program.

The menu options are selected by pressing a function key (F1-F4 or F10). Each option is described below.

Enter a filename

When this option is selected, the screen shown in Figure 2 appears. The program always stores data in a file, so a DOS-compatible filename is required. The data file will be stored in the "current" directory (i.e., the directory you were in when you started up the AFTLOAD program), and the program displays that directory. For example, in Figure 2, the AFTLOAD program was started from the DATA directory on the C: drive, so the data file will be stored there. The program does not allow you to edit the path for the data file — it will always be stored in the current directory.

```
Please enter a filename for data storage.
It must be DOS-compatible (8 char name + 3 char ext)
C:\DATA\
```

Figure 2. The Main Menu of the AFTLOAD program.

Specify run parameters

When this option is selected, the menu shown in Figure 3 appears. This menu allows the test operator to enter information pertaining to the test.

> NOTE: The AFTLOAD program does NOT control any aspect of the test, it simply MONITORS the test. The program cannot turn on or off the aerosol neutralizer, nor can it control the aerosol type or any other parameter. The purpose of this menu is to permit the operator to supply information pertinent to the test. Furthermore, the program has no way to detect whether the information supplied is correct or not. That is up to the operator to verify.

The parameters on the menu are self-explanatory for the most part. The Header, AFT Serial No., and Operator are optional text entries. The Neutralizer, Aerosol Type, and Maximum load are toggles. Pressing F4 toggles the Neutralizer entry from Off to On and back again. Likewise, F5 toggles the Aerosol Type between NaCl and DOP while F6 toggles Maximum Load between 100 and 200 mg. The Maximum Load parameter is used to determine the end of a test: when the cumulative mass of aerosol challenge exceeds Maximum Load, the program alerts the operator that the test is over. Actually, the name Maximum Load is a misnomer. In a future version this parameter will be re-labeled "Target Exposure."

The last two entries in the menu are related to each other. The Run Mode is a toggle with two possible settings: Constant or Variable Challenge Concentration. When Constant Challenge Concentration is specified, the program assumes that the mass concentration is constant throughout the test and is equal to the value specified under option F8 (Gravimetric Concentration). To enter the gravimetric concentration, press F8 and enter a

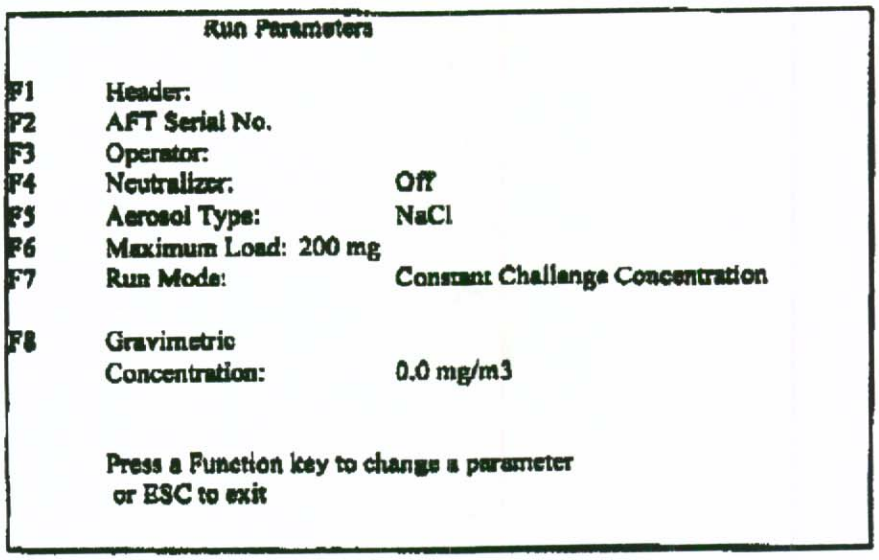


Figure 3. The Run parameters menu.

value.

If F7 is toggled to Variable Challenge Concentration then the definition of F8 is changed to Photometer Correlation and the menu displays two numeric values: a slope and intercept. The purpose of the Variable Challenge Concentration option is to make use of the photometer information that the AFT provides through the RS-232 port. Given appropriate calibration data, one should be able to calculate the DOP mass concentration in real time based on the photometer readings from the AFT. It is assumed that a linear relationship exists between mass concentration and photometer voltage. This option has not been thoroughly tested at this time.

Press the Escape key to exit from the Run Parameters menu back to the Main menu.

Begin data collection

To start a load test, activate the "Load Test" button on the front of the AFT, activate the data collection routine on the PC (press F3 from the Main menu), then close the chucks on the AFT. The data collection routine must be started before closing the chucks because the program expects to receive a blank line from the AFT when the chucks are closed. The blank line is a signal to start the timer for the test.

When the F3 key is pressed, the screen shown in Figure 4 appears. The screen displays information pertinent to the test (filename, header, aerosol type, and target load). The aerosol concentration displayed on the screen depends on the run mode selected from the Run Parameters menu. If Constant Challenge Concentration is specified for the run mode, then the aerosol concentration is the Gravimetric Concentration entered on the Run Parameters menu. If Variable Challenge Concentration is specified, then the Aerosol Concentration is computed from the upstream photometer voltage (read from the AFT) based on the Photometer Correlation coefficients entered in the Run Parameters screen.

The box on the right side of the screen is a window for displaying the raw data received from the AFT. The format of the data that appears in the window is similar to the paper tape printout from the AFT. Data will appear in the window at intervals of approximately one minute.

The program keeps track of the run time during the test. For each set of data received from the AFT, the program computes the mass in the challenge aerosol based on the formula:

$$\textit{Cumulative Challenge} = \sum_{i} C_{grav}\, Q\, \Delta t$$

where C_{grav} is the gravimetric concentration (from the Run Parameters screen), Q is the flow reading from the AFT, and Δt is the time elapsed since the last penetration reading (based on the computer's internal clock). The Cumulative Challenge is the amount of

aerosol that the sample has been exposed to. (Perhaps a better name would be Cumulative Exposure.) The cumulative load on the filter is computed as:

$$Cumulative\ Load = \sum_i C_{pm}\, Q\, \Delta t\, (1 - Pn)$$

where *Pn* is the penetration reading from the AFT. The cumulative volume of air that passes through the filter is calculated in similar fashion. The values on the screen are updated throughout the test and the results are stored in the data file. The accuracy of the Cumulative Load and Cumulative Challenge values depends on two factors: the accuracy of the gravimetric concentration that was specified in the Run Parameters screen; and the constancy of the gravimetric concentration throughout the test.

When the Cumulative Challenge exceeds the specified Maximum Load value (from the Run Parameters screen), the program beeps three times to alert the operator that the test is over. As mentioned before, the program cannot control the test, so it cannot command the AFT to open the chucks. The program will continue collecting data from the AFT and will continue to beep three times after each penetration reading. The data collection routine stops automatically when the operator opens the chucks on the AFT.

Data collection can be stopped at any time during the test by pressing the ESCape key. This mechanism is provided in case the operator needs to abort data collection before the end of a test. Note, however, that the program "loses track" of the test filter once the ESCape key is pressed, so the values reported for Cumulative Challenge and Cumulative Load will not be correct unless the chucks are opened at the same time.

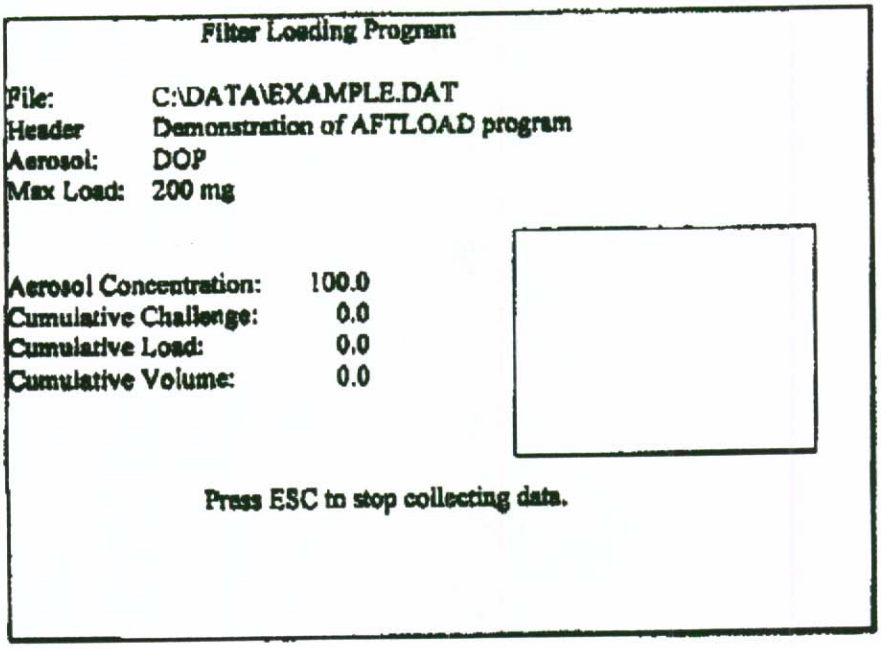


Figure 4. The data collection screen.

View data file

The last option on the Main Menu is "View data file," accessed by the F4 key. This subroutine invokes the BROWSE.COM program (supplied on the AFTLOAD.EXE program disk) to display the data file. The HOME, END, PAGE UP, PAGE DOWN, and arrow keys can be used to scroll through the file. Press ESCape to return to the AFTLOAD program.

An example of a data file is attached (EXAMPLE.DAT). The header information from the "Run Parameters" screen is stored first followed by the date and time of the test (as read from the AFT). The body of the file consists of nine columns of test data. The first three columns ("Flow", "dP", and "Pn") are read from the AFT. The fourth column ("dt") is the time elapsed since the last reading. In the file EXAMPLE.DAT, the first reading is completed approximately 36 seconds after the chucks are closed. Subsequent readings occur at intervals of approximately 70 seconds.

Columns 5-7 ("BG", "DN", and "UP") are the background, downstream, and upstream photometer voltages reported by the AFT. The downstream and upstream voltages correspond to the respective aerosol concentrations. During a load test, the downstream aerosol concentration is checked approximately once every 70 seconds. The upstream aerosol concentration is checked one time for every five readings of the downstream concentration. The program inserts the most recent value of the upstream photometer voltage in column 7 (since that is the value used by the AFT to compute penetration). The last two columns are the Cumulative Mass Challenge that the sample has been exposed to and the Cumulative Mass Load on the sample.

As soon as the Cumulative Mass Challenge exceeds the target exposure (100 or 200 mg), the program generates a Test Summary table which lists the duration of the test (i.e., time to reach the target exposure), the air volume that passed through the sample during the test, the initial pressure drop across the sample, and the maximum penetration that was observed during the test. Once the target exposure is exceeded, the program will continue to record data, however it will not update the maximum penetration value. When the chucks are opened, the CHUCK OPENED message appears and one final row of data is printed (see page 2 of the EXAMPLE.DAT file). Another Test Summary table is generated listing the total time that the filter was in the chucks and the total volume of air that passed through the filter.

The data files generated by the AFTLOAD program can be printed directly (e.g., "COPY EXAMPLE.DAT LPT1:") or they can be loaded into a word processing or spreadsheet program for plotting or further analysis. Check your program's documentation on "Importing Files."

EXAMPLE.dat

Header: Example of DOP load test
AFT Serial No.: nnn
Operator: PK
Neutralizer: On
Aerosol Type: DOP
Maximum Load: 200 mg
Run Mode: Constant Challenge Concentration

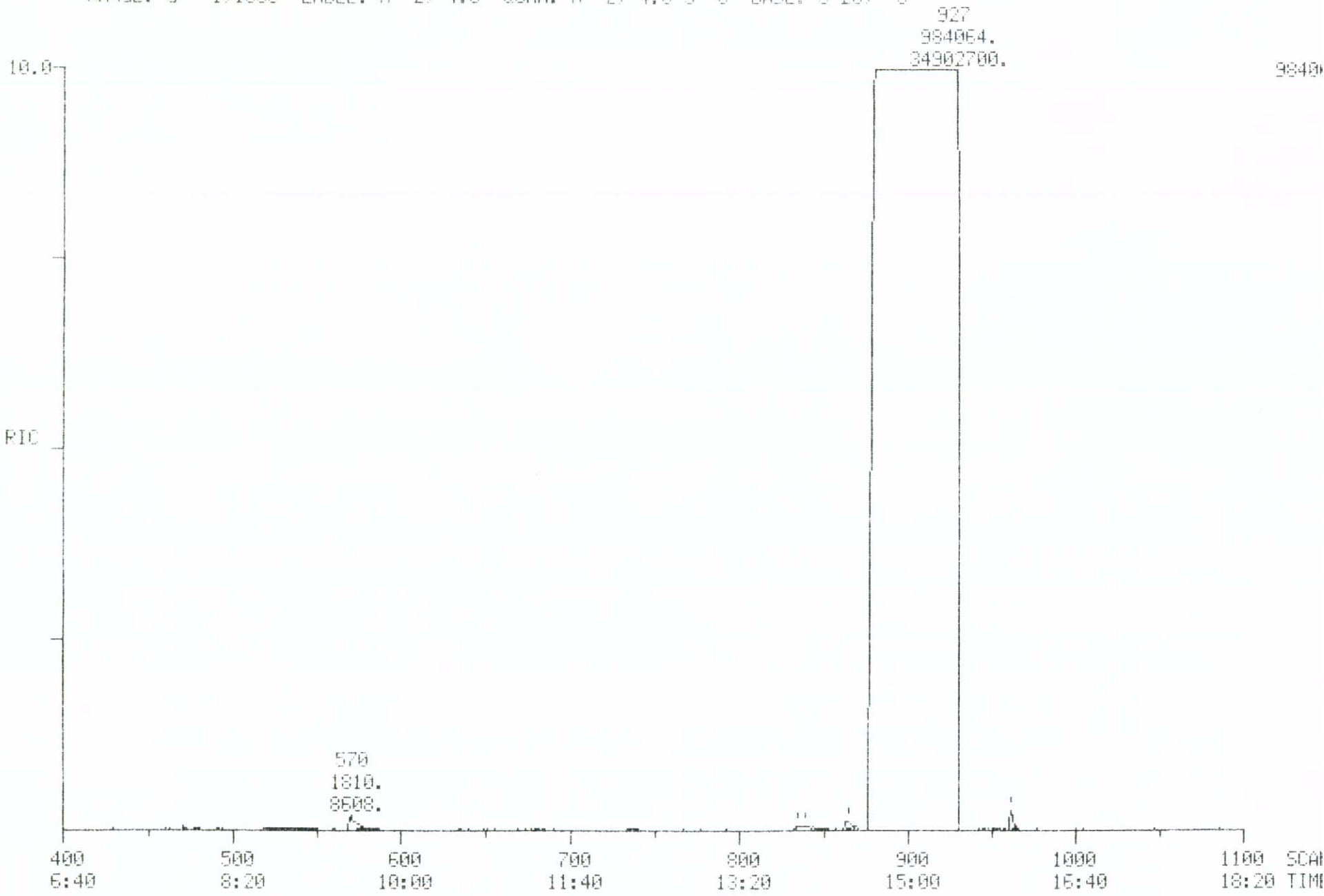
Gravimetric Concentration: 112.3 mg/m3

Start Time (AFT Clock): 12:24 14 JAN 94

				Photometer			Cumulative	
Flow	dP	Pn	dt	BG	DN	UP	Chlnge	Load
LPM	mmH2O	%	s	mV	mV	mV	mg	mg
84.4	4.9	20.6	35.82	-0.335	-129	-624	5.7	4.5
84.4	5.0	26.3	70.41	-0.336	-164	-624	16.8	12.7
84.9	5.0	27.6	70.74	-0.335	-172	-624	28.0	20.8
85.0	5.0	30.3	70.69	-0.335	-189	-624	39.3	28.7
85.1	5.1	33.2	70.69	-0.336	-207	-624	50.5	36.2
85.0	5.1	36.2	82.39	-0.335	-219	-607	63.7	44.6
85.0	5.1	38.7	70.74	-0.335	-235	-607	74.9	51.5
85.1	5.1	41.3	70.86	-0.336	-251	-607	86.2	58.1
86.4	5.3	43.0	70.69	-0.337	-261	-607	97.6	64.6
85.2	5.2	44.7	70.63	-0.336	-271	-607	108.9	70.8
84.9	5.2	46.8	82.56	-0.336	-284	-606	122.0	77.8
84.9	5.1	48.2	70.52	-0.335	-292	-606	133.2	83.6
85.0	5.2	50.3	70.80	-0.333	-305	-606	144.5	89.2
84.9	5.2	51.1	70.47	-0.333	-310	-606	155.7	94.7
84.8	5.2	52.5	70.63	-0.333	-318	-606	166.9	100.0
84.8	5.2	53.5	82.39	-0.334	-321	-600	180.0	106.1
85.0	5.3	55.9	70.80	-0.334	-335	-600	191.3	111.1
85.0	5.2	55.7	70.63	-0.334	-334	-600	202.5	116.1

TEST SUMMARY
Test Duration: 00:21:12.46
Total Flow Volume: 1802.7 L
Initial Pressure Drop: 4.9 mm H2O
Maximum Penetration: 55.9 %

RIC
04/20/94 13:08:00
DATA: NIOSH1 #1
CALI: CAL42094 #3
SCANS 400 TO 1100
SAMPLE: DOP NEW NO LIGHT NO HEAT
CONDS.: 50-325 AT 15DEG/MIN. POST 10MIN. DB-5 CAP. COL. 25ML
RANGE: G 1,1800 LABEL: N 2, 4.0 QUAN: A 2, 4.0 J 0 BASE: U 20, 8

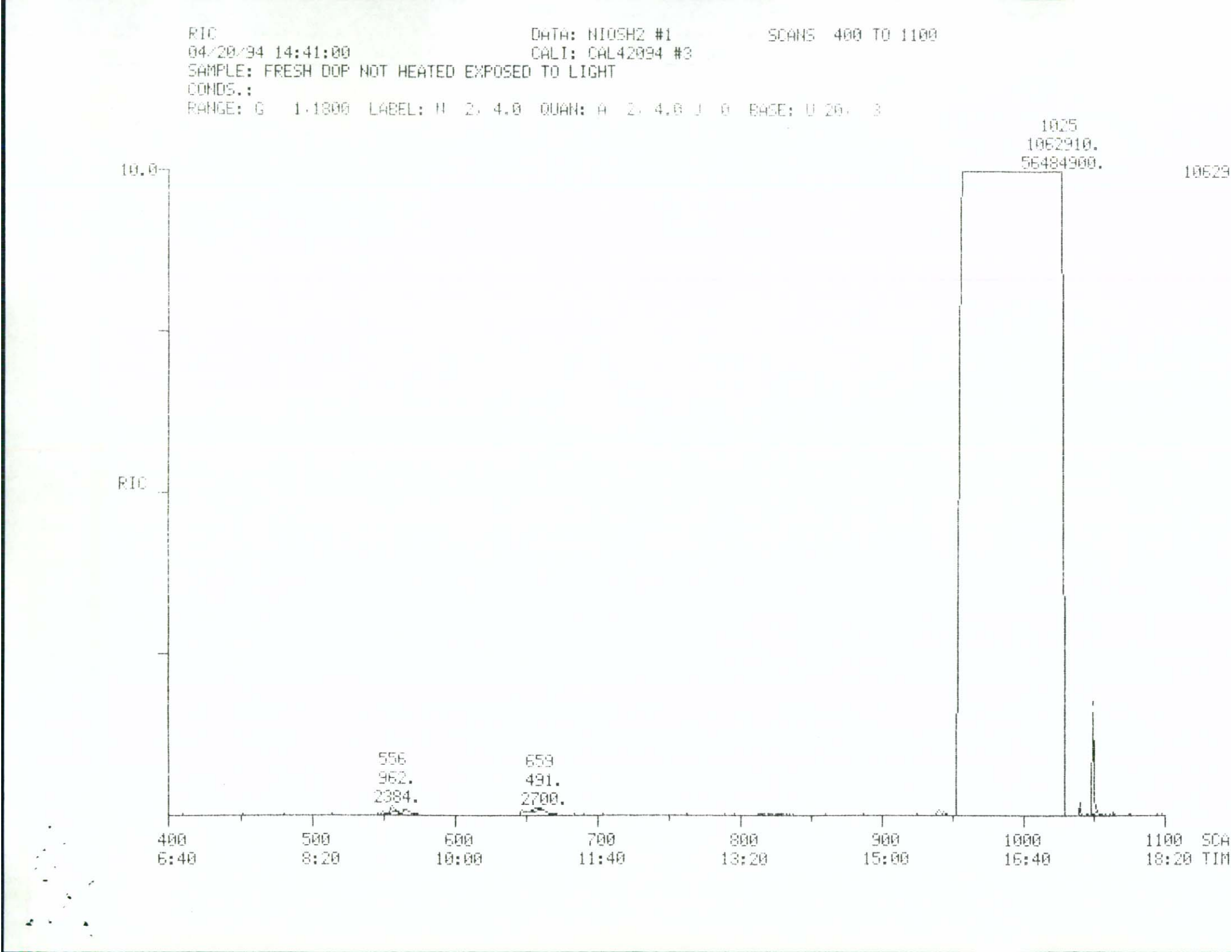


Quantitation Report File: B1QUANLIST

Data: NIOSH1.TI
04/20/94 13:08:00
Sample: DOP NEW NO LIGHT NO HEAT
Conds.: 50-325 AT 15DEG/MIN. POST 10MIN. DB-5 CAP. COL. 25ML
Formula: Instrument: 4500 Weight: 0.000
Submitted by: GF Analyst: BS Acct. No.:

AMOUNT=AREA * REF AMNT/(REF AREA * RESP FACT)
Resp. fac. from Library Entry

No	m/z	Scan	Time	Ref	RRT	Meth	Area(Hght)	Amount	%Tot
1	RIC	570	9:30	5	0.615	A BB	8608.	0.025	0.02
2	RIC	835	13:55	5	0.901	A BB	484.	0.001	0.00
3	RIC	839	13:59	5	0.905	A BB	92.	0.000	0.00
4	RIC	865	14:25	5	0.933	A BB	3606.	0.010	0.01
5	RIC	927	15:27	5	1.000	A BB	34902700.	100.000	99.95
6	RIC	962	16:02	5	1.038	A BB	4880.	0.014	0.01


RIC
04/20/94 14:41:00
DATA: NIOSH2 #1
CALI: CAL42094 #3
SCANS 400 TO 1100
SAMPLE: FRESH DOP NOT HEATED EXPOSED TO LIGHT
CONDS.:
RANGE: G 1.1800 LABEL: N 2. 4.0 QUAN: A 2. 4.0 J 0 BASE: U 20. 3
1025
1052910.
56484900.
10629
10.0
RIC
556
962.
2384.
659
491.
2700.
400
6:40
500
8:20
600
10:00
700
11:40
800
13:20
900
15:00
1000
16:40
1100
18:20
SCA
TIM

Quantitation Report File: B1QUANLIST

Data: NIOSH2.TI
04/20/94 14:41:00
Sample: FRESH DOP NOT HEATED EXPOSED TO LIGHT
Conds.:
Formula: Instrument: 4500 Weight: 0.000
Submitted by: Analyst: Acct. No.:

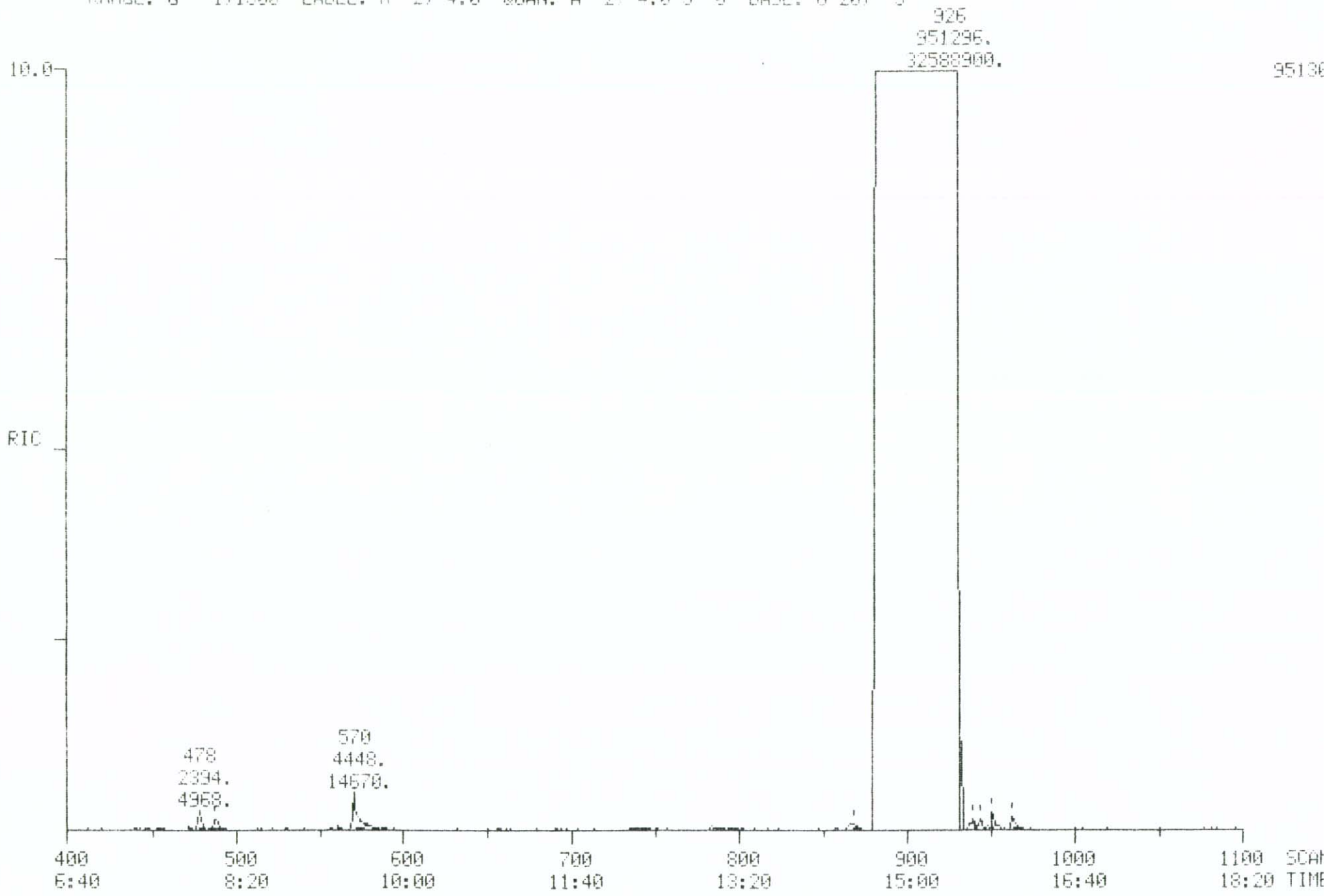
AMOUNT=AREA * REF AMNT/(REF AREA * RESP FACT)
Resp. fac. from Library Entry

No	m/z	Scan	Time	Ref	RRT	Meth	Area(Hght)	Amount	%Tot
1	RIC	556	9:16	3	0.542	A BB	2384.	0.004	0.00
2	RIC	659	10:59	3	0.643	A BB	2700.	0.005	0.00
3	RIC	1025	17:05	3	1.000	A BB	56484900.	100.000	99.94
4	RIC	1049	17:29	3	1.023	A BB	27216.	0.048	0.05

RIC
04/20/94 15:54:00
SAMPLE: NEW DOP HEATED 170DEG. CENT.
CONDS.:
RANGE: G 1.1000 LABEL: N 2. 4.0 QUAN: A 2. 4.0 J 0 BASE: U 20. 3

DATA: NIOH3 #1
CALI: CAL42094 #3

SCANS 400 TO 1100



Quantitation Report File: B1QUANLIST

Data: NIOH3.TI
04/20/94 15:54:00
Sample: NEW DOP HEATED 170DEG. CENT.
Conds.:
Formula: Instrument: 4500 Weight: 0.000
Submitted by: Analyst: Acct. No.:

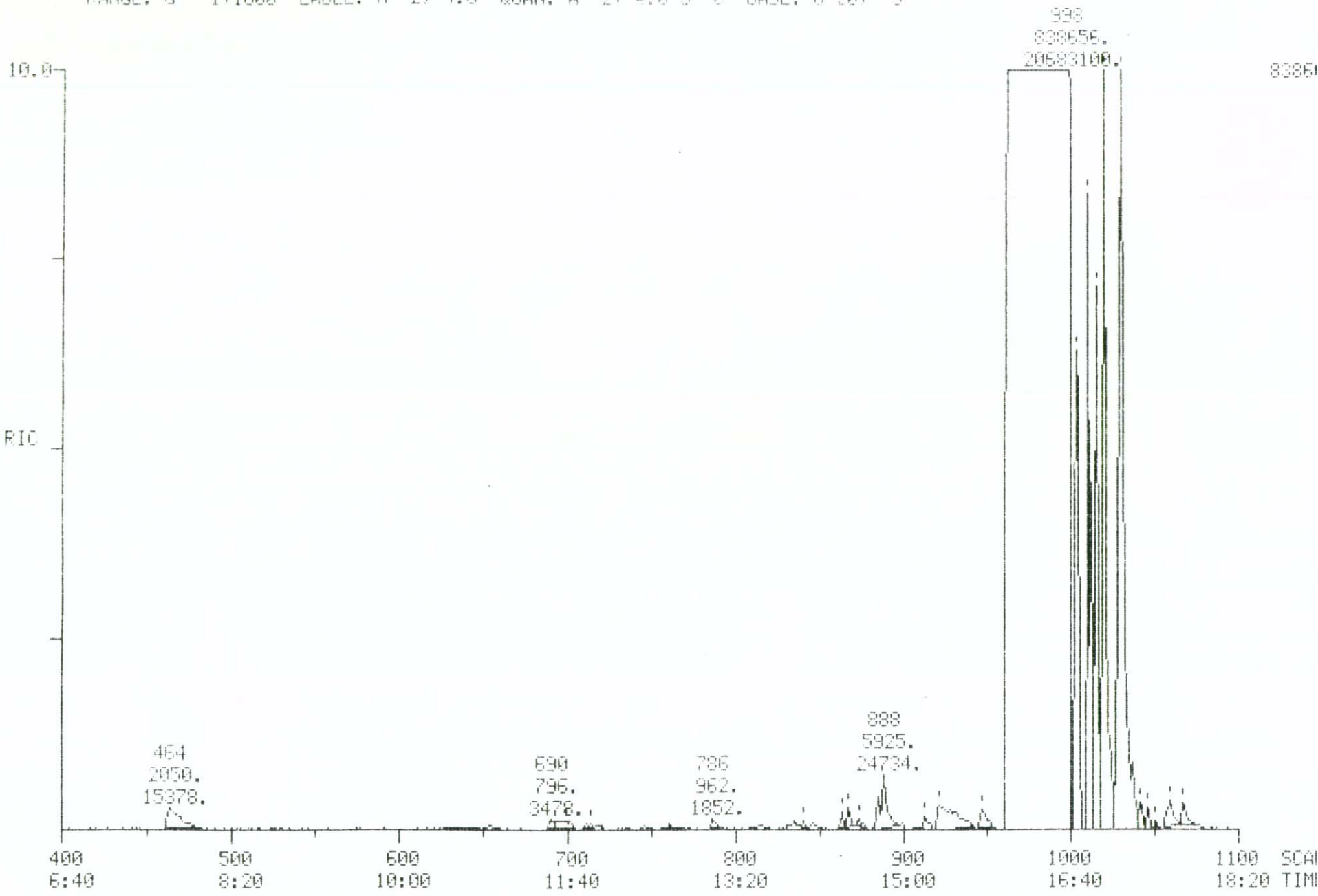
AMOUNT=AREA * REF AMNT/(REF AREA * RESP FACT)
Resp. fac. from Library Entry

No	m/z	Scan	Time	Ref	RRT	Meth	Area(Hght)	Amount	%Tot
1	RIC	478	7:58	5	0.516	A BB	4968.	0.015	0.02
2	RIC	487	8:07	5	0.526	A BB	2607.	0.008	0.01
3	RIC	570	9:30	5	0.616	A BB	14670.	0.045	0.04
4	RIC	868	14:28	5	0.937	A BB	3394.	0.010	0.01
5	RIC	926	15:26	5	1.000	A BB	32588900.	100.000	99.88
6	RIC	939	15:39	5	1.014	A BB	3184.	0.010	0.01
7	RIC	944	15:44	5	1.019	A BB	2752.	0.008	0.01
8	RIC	951	15:51	5	1.027	A BB	3666.	0.011	0.01
9	RIC	963	16:03	5	1.040	A BB	2848.	0.009	0.01

RIC
04/20/94 17:04:00
SAMPLE: OLD DOP
CONDS.:
RANGE: G 1.1800 LABEL: N 2. 4.0 QUAN: A 2. 4.0 J 0 BASE: U 20. 3

DATA: NIOSH4 #1
CALI: CAL42094 #3

SCANS 400 TO 1100



Quantitation Report File: B1QUANLIST

Data: NIOSH4.TI
04/20/94 17:04:00
Sample: OLD DOP
Conds.:
Formula: Instrument: 4500 Weight: 0.000
Submitted by: Analyst: Acct. No.:

AMOUNT=AREA * REF AMNT/(REF AREA * RESP FACT)
Resp. fac. from Library Entry

No	m/z	Scan	Time	Ref	RRT	Meth	Area(Hght)	Amount	%Tot
1	RIC	464	7:44	14	0.465	A BB	15378.	0.074	0.07
2	RIC	690	11:30	14	0.691	A BV	3478.	0.017	0.02
3	RIC	699	11:39	14	0.700	A VB	6184.	0.030	0.03
4	RIC	714	11:54	14	0.715	A BB	904.	0.004	0.00
5	RIC	786	13:06	14	0.788	A BB	1852.	0.009	0.01
6	RIC	840	14:00	14	0.842	A BB	896.	0.004	0.00
7	RIC	864	14:24	14	0.866	A BB	2744.	0.013	0.01
8	RIC	867	14:27	14	0.869	A BB	3628.	0.018	0.02
9	RIC	874	14:34	14	0.876	A BB	2104.	0.010	0.01
10	RIC	888	14:48	14	0.890	A BB	24734.	0.120	0.11
11	RIC	913	15:13	14	0.915	A BB	3600.	0.017	0.02
12	RIC	922	15:22	14	0.924	A BB	34592.	0.167	0.16
13	RIC	947	15:47	14	0.949	A BB	8284.	0.040	0.04
14	RIC	998	16:38	14	1.000	A BB	20683100.	100.000	94.36
15	RIC	1004	16:44	14	1.006	A BB	137120.	0.663	0.63
16	RIC	1011	16:51	14	1.013	A BV	173680.	0.840	0.79
17	RIC	1016	16:56	14	1.018	A VV	104688.	0.506	0.48
18	RIC	1021	17:01	14	1.023	A VV	278400	1.346	1.27
19	RIC	1031	17:11	14	1.033	A VV	399792.	1.933	1.82
20	RIC	1042	17:22	14	1.044	A VB	6288.	0.030	0.03
21	RIC	1046	17:26	14	1.048	A BB	4504.	0.022	0.02
22	RIC	1051	17:31	14	1.053	A BB	1512.	0.007	0.01
23	RIC	1059	17:39	14	1.061	A BB	13064.	0.063	0.06
24	RIC	1067	17:47	14	1.069	A BB	7978.	0.039	0.04

Department of Biochemistry
West Virginia University
School of Medicine

Mr. Gary Fletcher
NIOSH
944 Chestnut Ridge Road
Morgantown, WV 26505

March 29, 1994

RE: GC/Mass Spectrometer Analysis of D.O.P. Samples.

Four samples of D.O.P. were analyzed, they were as follows:
1. New D.O.P. (no light, no heat)
2. New D.O.P. (exposed to light only)
3. New D.O.P. (heated to 170 deg. C., no light) (Light tan liquid)
4. Old D.O.P. (Brown liquid)

All samples were analyzed under the same instrument conditions.
(GC) 50-325deg. at 15deg/min. Post 10min.
(Mass Spec) EI 70EV.

Figure 1. shows the ion curve of sample #1, the New D.O.P.

Figure 2. shows the ion curve of Sample #2, exposed to light.

Figure 3. shows the ion curve of sample #3, exposed to heat.

Figure 4. shows the ion curve of sample #4, old D.O.P.

Figure 5. shows a comparison of sample 1 to sample 2.

Figure 6. shows a comparison of the mass spectra of D.O.P. in sample 1 to sample 4.

Tables 2 through 4 show a difference in the amount of D.O.P when compared to that of Table 1. (New D.O.P.)

The NIST/EPA Library search of the peaks observed indicated the formation of other phthalic compounds and their esters among them the possibility of isomers from the D.O.P.

Breakdown transitional compounds were unidentifiable, although they gave the characteristic of a base peak(149amu) and a peak at 167amu that are good indicators of plasticizers.

From the results of the analyses it should be noted that the D.O.P. does breakdown when exposed to light and heat. The samples analyzed showed sample 1 was 99.95% pure and each sample decreased in purity to only 94.36% for sample 4.

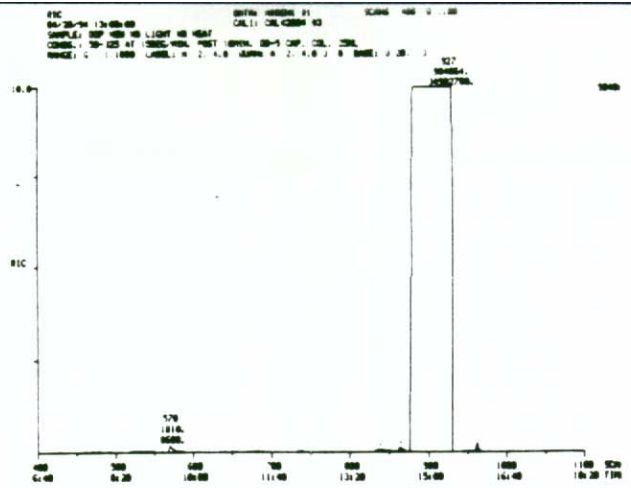


FIGURE 1.

New D.O.P.

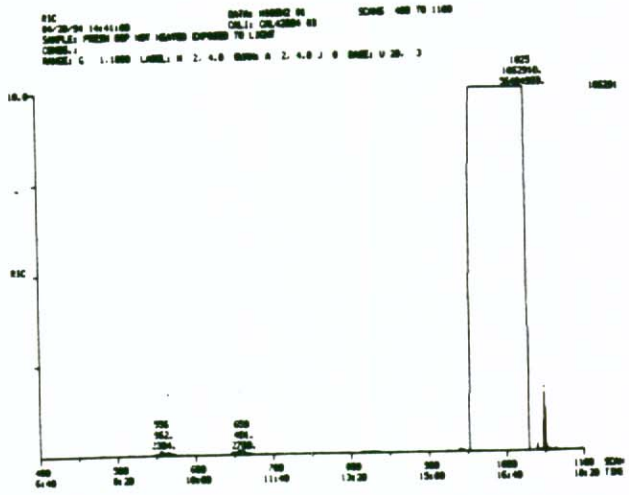


FIGURE 2.

Exposed to Light

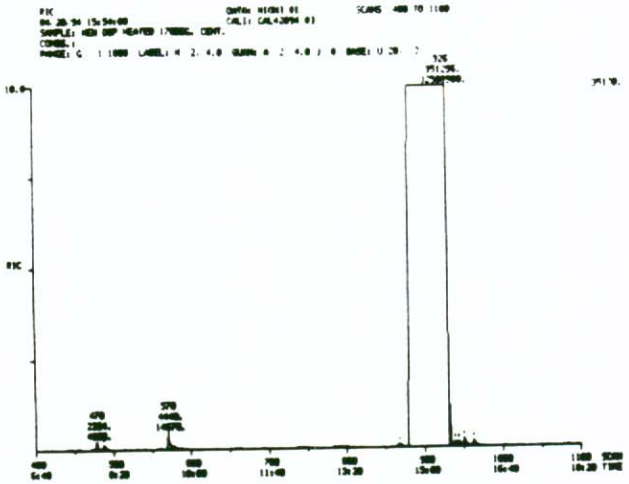


FIGURE 3.

Exposed to Heat

170 Deg. Cent.

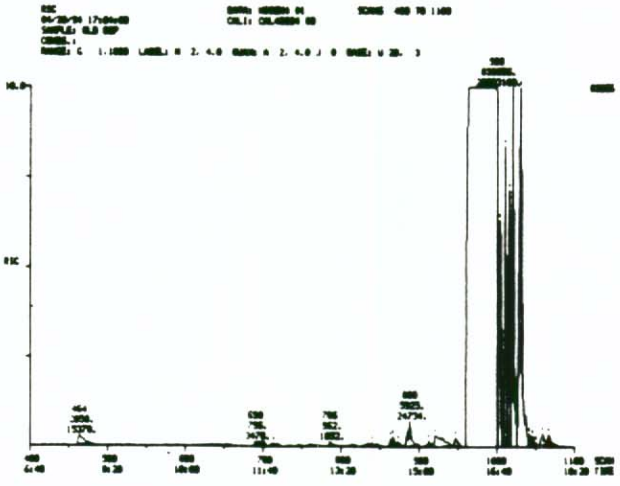


FIGURE 4.

Old D.O.P.

Quantitation Report File: B1QUANLIST

Data: NIOSH1.TI
04/20/94 13:08:00
Sample: DOP NEW NO LIGHT NO HEAT
Conds.: 50-325 AT 15DEG/MIN. POST 10MIN. DB-5 CAP COL. 25ML
Formula: Instrument: 4500 Weight: 0.000
Submitted by: GF Analyst: BS Acct. No.

AMOUNT=AREA * REF AMNT/(REF AREA * RESP FACT)
Resp. fac. from Library Entry

TABLE 1.

New D.O.P.

No	m/z	Scan	Time	Ref	RRT	Meth	Area(Hght)	Amount	%Tot
1	RIC	570	9:30	5	0.615	A BB	8608.	0.025	0.02
2	RIC	835	13:55	5	0.901	A BB	484.	0.001	0.00
3	RIC	839	13:59	5	0.905	A BB	92.	0.000	0.00
4	RIC	865	14:25	5	0.933	A BB	3606.	0.010	0.01
5	RIC	927	15:27	5	1.000	A BB	34902700.	100.000	99.95
6	RIC	962	16:02	5	1.038	A BB	4880.	0.014	0.01

Data: NIOSH2.TI
04/20/94 14:41:00
Sample: FRESH DOP NOT HEATED EXPOSED TO LIGHT
Conds.:
Formula: Instrument: 4500 Weight: 0.000
Submitted by: Analyst: Acct. No.

AMOUNT=AREA * REF AMNT/(REF AREA * RESP FACT)
Resp. fac. from Library Entry

TABLE 2.

Exposed to Light

No	m/z	Scan	Time	Ref	RRT	Meth	Area(Hght)	Amount	%Tot
1	RIC	556	9:16	3	0.542	A BB	2384.	0.004	0.00
2	RIC	659	10:59	3	0.643	A BB	2700.	0.005	0.00
3	RIC	1025	17:05	3	1.000	A BB	56484900.	100.000	99.94
4	RIC	1049	17:29	3	1.023	A BB	27216.	0.048	0.05

Data: NIOH3.TI
04/20/94 15:54:00
Sample: NEW DOP HEATED 170DEG. CENT.
Conds.:
Formula: Instrument: 4500 Weight: 0.000
Submitted by: Analyst: Acct. No.

AMOUNT=AREA * REF AMNT/(REF AREA * RESP FACT)
Resp. fac. from Library Entry

TABLE 3.

Exposed to Heat 170 Deg.

No	m/z	Scan	Time	Ref	RRT	Meth	Area(Hght)	Amount	%Tot
1	RIC	478	7:58	5	0.516	A BB	4968.	0.015	0.02
2	RIC	487	8:07	5	0.526	A BB	2607.	0.008	0.01
3	RIC	570	9:30	5	0.616	A BB	14670.	0.045	0.04
4	RIC	868	14:28	5	0.937	A BB	3394.	0.010	0.01
5	RIC	926	15:26	5	1.000	A BB	32588900.	100.000	99.88
6	RIC	939	15:39	5	1.014	A BB	3184.	0.010	0.01
7	RIC	944	15:44	5	1.019	A BB	2752.	0.008	0.01
8	RIC	951	15:51	5	1.027	A BB	3666.	0.011	0.01
9	RIC	963	16:03	5	1.040	A BB	2848.	0.009	0.01

Data: NIOSH4.TI
04/20/94 17:04:00
Sample: OLD DOP
Conds.:
Formula: Instrument: 4500 Weight: 0.000
Submitted by: Analyst: Acct. No.:

AMOUNT=AREA * REF AMNT/(REF AREA * RESP FACT)
Resp. fac. from Library Entry

TABLE 4.

Old D.O.P.

No	m/z	Scan	Time	Ref	RRT	Meth	Area(Hght)	Amount	%Tot
1	RIC	464	7:44	14	0.465	A BB	15378.	0.074	0.07
2	RIC	690	11:30	14	0.691	A BV	3478.	0.017	0.02
3	RIC	699	11:39	14	0.700	A VB	6184.	0.030	0.03
4	RIC	714	11:54	14	0.715	A BB	904.	0.004	0.00
5	RIC	786	13:06	14	0.788	A BB	1852.	0.009	0.01
6	RIC	840	14:00	14	0.842	A BB	896.	0.004	0.00
7	RIC	864	14:24	14	0.866	A BB	2744.	0.013	0.01
8	RIC	867	14:27	14	0.869	A BB	3628.	0.018	0.02
9	RIC	874	14:34	14	0.876	A BB	2104.	0.010	0.01
10	RIC	888	14:48	14	0.890	A BB	24734.	0.120	0.11
11	RIC	913	15:13	14	0.915	A BB	3600.	0.017	0.02
12	RIC	922	15:22	14	0.924	A BB	34592.	0.167	0.16
13	RIC	947	15:47	14	0.949	A BB	8284.	0.040	0.04
14	RIC	998	16:38	14	1.000	A BB	20683100.	100.000	94.36
15	RIC	1004	16:44	14	1.006	A BB	137120.	0.663	0.63
16	RIC	1011	16:51	14	1.013	A BV	173680.	0.840	0.79
17	RIC	1016	16:56	14	1.018	A VV	104688.	0.506	0.48
18	RIC	1021	17:01	14	1.023	A VV	278400.	1.346	1.27
19	RIC	1031	17:11	14	1.033	A VV	399792.	1.933	1.82
20	RIC	1042	17:22	14	1.044	A VB	6288.	0.030	0.03
21	RIC	1046	17:26	14	1.048	A BB	4504.	0.022	0.02
22	RIC	1051	17:31	14	1.053	A BB	1512.	0.007	0.01
23	RIC	1059	17:39	14	1.061	A BB	13064.	0.063	0.06
24	RIC	1067	17:47	14	1.069	A BB	7978.	0.039	0.04

FIGURE 5.

Comparison of New D.O.P. and Old D.O.P.

Note The retention time difference is because the data collected started late.

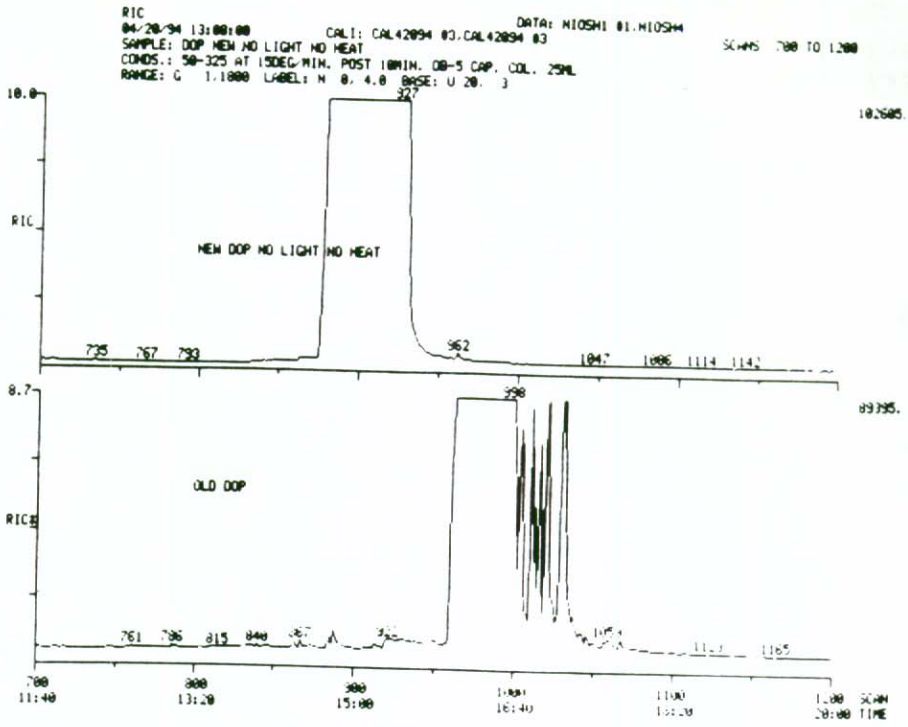
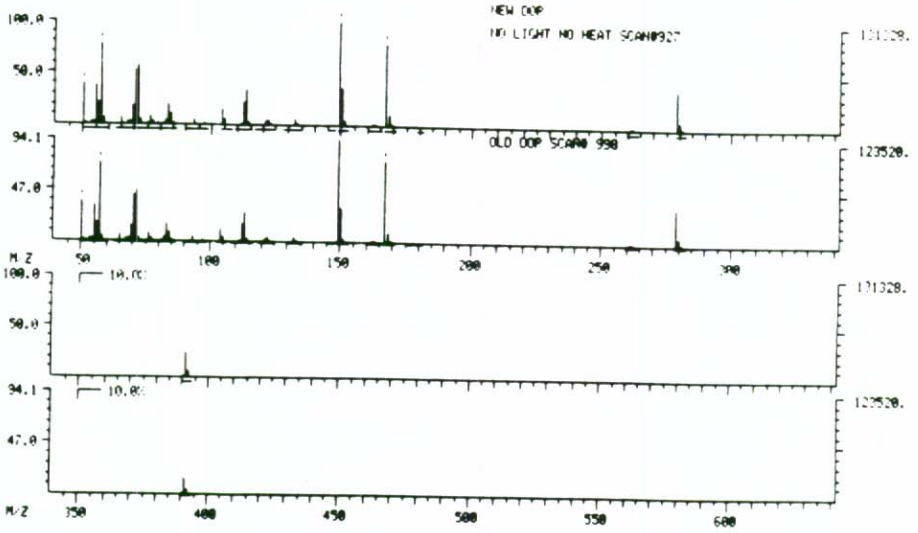


FIGURE 6.

Comparison of Mass Spectra between New D.O.P. and Old D.O.P.



I have enclosed the hard data collected from the analyses.

If there are questions concerning the analyses, please give me a call at 293-5970.

Robert R. Smith

Robert R. Smith

Mgr/Mass Spectrometry Center

DRAFT JUNE 15, 1994

PARTICULATE FILTER INSTANTANEOUS-PENETRATION PROCEDURE TO TEST NEGATIVE PRESSURE RESPIRATORS AGAINST LIQUID PARTICULATES

1. PURPOSE

1.1. This is a procedure to test negative pressure respirators designed for protection against dusts, fumes, mists, and combinations. The respirator filter units shall be capable of providing protection against both solid and liquid contaminates. This procedure may be used for testing all particulate filters including those used individually or in conjunction with cartridges and canisters for chin-style, front-mounted, and back-mounted gas masks.

2. GENERAL

2.1. This procedure describes the Particulate Filter Instantaneous-Penetration Procedure to Test Negative Pressure Respirators Against Liquid Particulates in sufficient detail that a person in the appropriate technical field can conduct the test and determine whether or not the product passes the test.

3. EQUIPMENT/MATERIALS

3.1. The list of necessary test equipment and materials follows:

TSI Model 8110 Automated Respirator Tester or equivalent instrument with a forward light scattering detector

Particle sizing instrument (such as a Differential Mobility Particle Sizer) capable of determining submicron particles according to count median diameter (CMD)

Balance accurate to 0.0001 grams (g)

Gelman 102 mm, type A/E glass filters or equivalent high efficiency filters

Temperature and humidity chamber capable of maintaining 38 ± 2°C and 85 ± 5% relative humidity

Timer (accurate to 0.01 second)

Tweezers

Dioctyl phthalate (DOP)

Photometer

Respirator filter holder for specific manufacturer type which is compatible with TSI respirator tester

Optional data acquisition system

4. TESTING REQUIREMENTS AND CONDITIONS

4.1. Test equipment and instruments must have been calibrated at least as frequently as, and according to, the instrument manufacturer's specifications, using calibration standards traceable to those set by the National Institute of Standards Technology or other nationally recognized standards.

4.2. Normal laboratory safety practices must be observed. This includes safety precautions described in the current ALOSH Facility Laboratory Safety and Hazardous Waste Manuals.

5. PROCEDURE

5.1. Respirator filters and cartridges will be tested as follows:

5.1.1. The air-purifying elements of the respirator, including the filter holders and gaskets will be tested for particle penetration.

5.1.2. When filters are not separable from the respirator body, the exhalation valves will be sealed to ensure that any leakage due to the exhalation valve is not included in the filter penetration measurement.

5.1.3. Filters used in conjunction with gas mask canisters and odd or unusually shaped filters may be tested on a headform assembly or assembly provided by manufacturer.

5.2. Respirator filters will be challenged by a neutralized liquid (DOP) aerosol at 25 ± 5°C. Respirators intended for protection against both liquid and solid aerosols will be tested against a liquid aerosol only. The particle size distribution will be a count median diameter between 0.17 and 0.22 micrometers and a geometric standard deviation not exceeding 1.6. Each respirator filter unit will be challenged with an aerosol concentration not exceeding 200 mg/m^3.

5.2.1 The following procedure will be routinely employed to insure that the DOP particle size distribution will remain in the range of .17 and .22 micrometers with a geometric standard deviation of less than 1.6. A standard filter instantaneous penetration will be determined using DOP aerosol. The standard filter test will be employed during testing to verify that the aerosol distribution is optimized and has not changed.

5.3. Respirator filters will be pre-conditioned at 85 ± 5 percent relative humidity and 38 ± 2.5°C for 25 ±1 hour. After conditioning, the filters could be sealed in a gas tight container until tested.

5.3.1. Filters will be mounted and sealed on holders to prevent leakage around the filter holder. Single air purifying respirator filters will be tested at a challenge flow rate of 85 Lpm ± 5%. Filters used as a pair in a respirator will be tested using a single filter of the pair at 42.5 Lpm ± 5% challenge flow rate.

5.3.2 Challenge flow rate must be checked for stbility for at least 30 seconds prior to testing.

5.4. A sample of 30 filters will be tested against the DOP liquid aerosol. Three filters will be tested and evaluated to determine the method for the remaining 27 filters.

5.4.1. Type 1. If filter testing results in a straight line (Figure 1), for the remaining 27 filters, record the initial penetration reading.

5.4.2. Type 2. If filter testing results in a curve which indicates degradation over time (Figure 1), preload the remaining 27 filters with DOP and record maximum penetration reading. When testing a single filter, preload the filter with 200 ± 5 mg DOP. Preload single filters of a pair configuration with 100 ± 5 mg DOP.

5.4.3. Type 3. If filter testing shows increased efficiency during the complete run (Figure 1), for the remaining 27 filters, record the initial penetration reading.

5.4.4. For any other filter type, determine loading at which maximum loading occurs and test at that loading.

5.4.5. If any one of the 30 test filters has a penetration greater than 1.2 times the designated limit, further testing of that filter will be terminated. Any filter that exceeds the specified limit shall be remounted and retested to ensure that leakage was not caused by a mounting leak. If retesting eliminates the excessive leakage, that sample will be considered an invalid sample.

5.5. The DOP aerosol concentration will be determined daily by the following gravimetric method and calculated as milligrams per cubic meter (mg/m^3).

5.5.1. Weigh a Gelman 102 mm filter to the nearest 0.0001 g, mount in the gravimetric filter holder, subject it to the generated aerosol, and reweigh the filter. Use a timer to monitor the duration of the test. Record the pre- and post-weights, time, and average flow rate on the Instantaneous-Penetration Filter Test Data Sheet (Figure 2). The weight change should be a significant value over the pre-weight.

5.5.2. The DOP aerosol concentration can be monitored by a calibrated photometer placed in line on the mixing chamber exhaust.

5.6. The DOP particle size will be monitored routinely to ensure the particle size distribution count median diameter remains between 0.17 and 0.22 micrometers with a geometric standard deviation of not more than 1.6.

5.7. The penetration of the first 3 filters will be measured, recorded, and printed at approximately 1 minute intervals during the test period. The highest instantaneous penetration observed throughout the test of each filter will be recorded as the maximum penetration of that filter. An optional data acquisition system can be used for data collection and evaluation.

5.8. Determine and record the maximum filter penetration for each of the 30 filters. Calculate the mean maximum penetration (m) and the standard deviation (s).

6. PASS/FAIL CRITERIA

6.1. For the sample of 30 to demonstrate acceptable performance, the test statistic U must meet the following

conditions:

6.1.1. For type A filters, $U = m + 2.22\ s \leq 0.0003$

6.1.2. For type B filters, $U = m + 2.22\ s \leq 0.01$

6.1.3. For type C filters, $U = m + 2.2..\ s \leq 0.05$

7. RECORDS/TEST SHEETS

7.1. Test data collected will be recorded on the Particulate Instantaneous-Penetration Filter Test Data Sheet.

7.2. Attach the strip printout of the penetration data for each test to the back of each data sheet.

7.3. Notify the manufacturer of test results.

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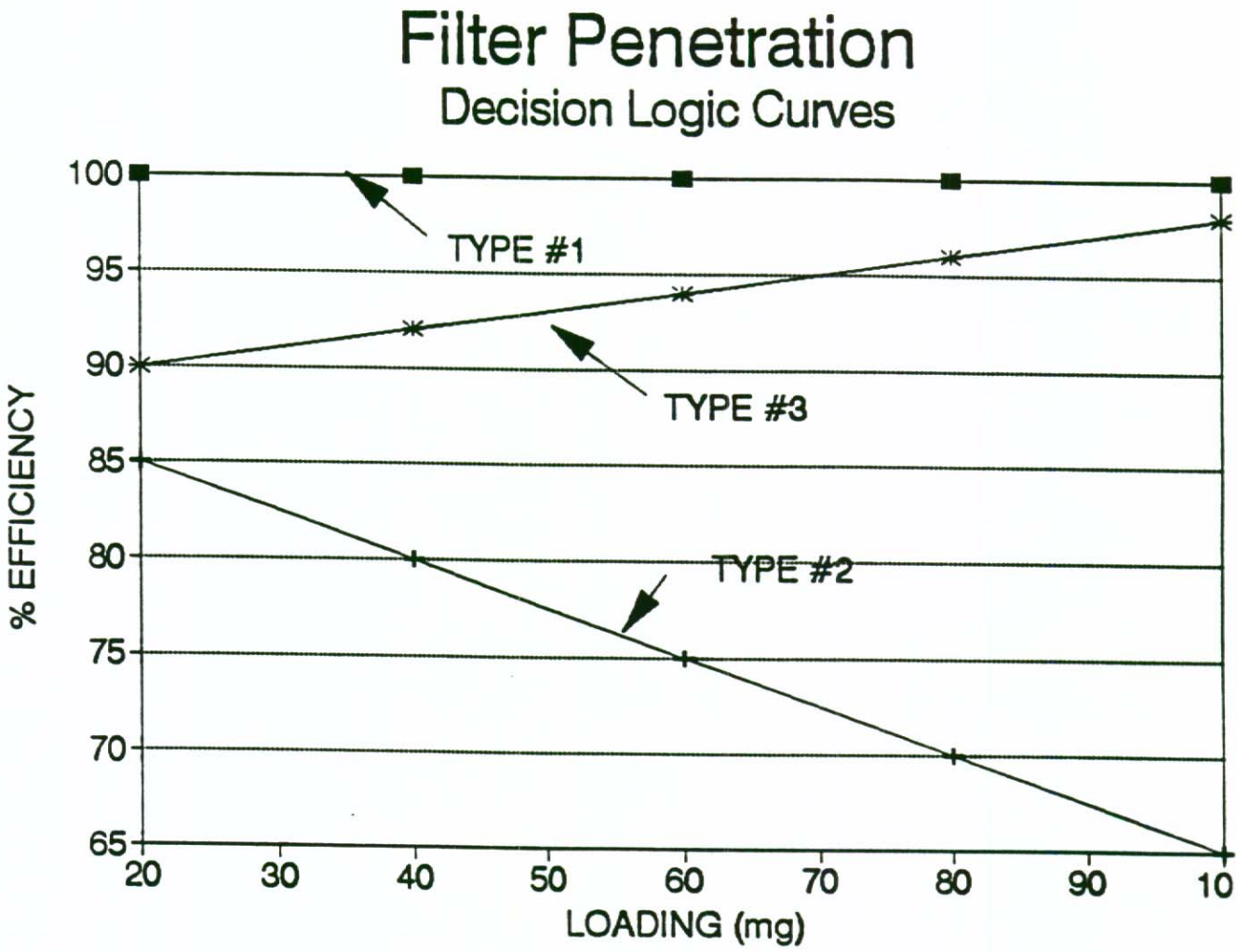

Figure 1

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PARTICULATE FILTER INSTANTEOUS-PENETRATION TEST DATA SHEET

MANUFACTURER:_____ STEP #:_____

APPROVAL NUMBER:_____ TYPE:_____

TEST SYTEM MODULE:
_____CARTRIDGE
_____CHAMBER

AEROSOL:
_____DOP
_____NACL

FILTER TESTS

Test No.	Maximum Penetration	Initial Δ Pressure	Photometer Reading Start	Photometer Reading Finish	Date/Operator
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Aerosoal concentration

Date Time	Pre Weight (mg)	Post Weight (mg)	Wt. Diff. (mg)	Air Flow (Lpm)	Time (min)	Conc. (mg/m^3)

Instantaneous-Penetration Filter Test Data Sheet
Figure 2