1043-10

ITEM 14

ANALYSIS OF EXHAUST GAS DISCHARGES
FROM THE NORTH ANDOVER, MASSACHUSETTS FACILITY
OF WESTERN ELECTRIC COMPANY, INC.

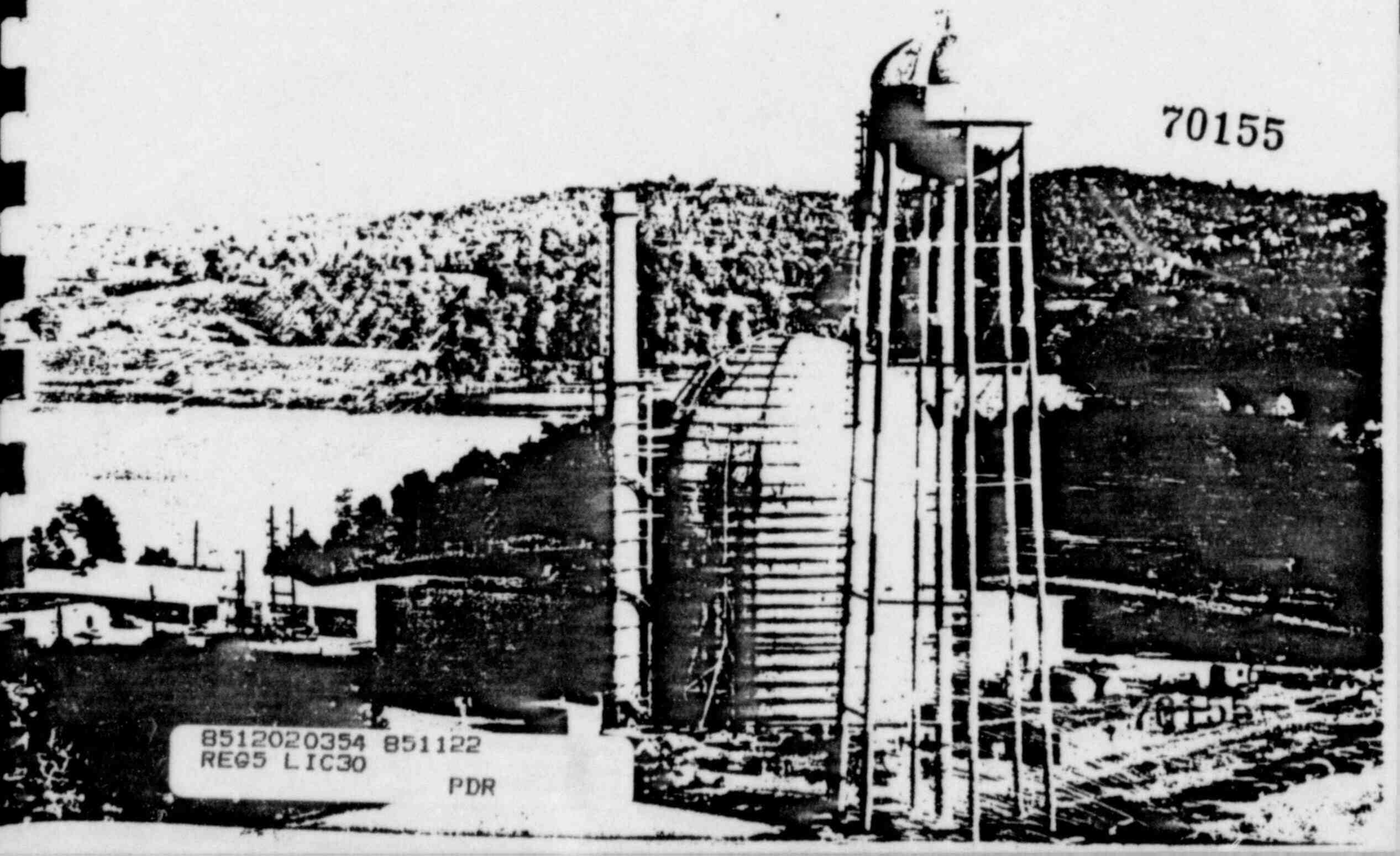
Prepared for

TRIO TECH INCORPORATED
Burbank, California

July 1974

APPLIED NUCLEONICS COMPANY, INC.
Los Angeles, California

70155



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By

The Technical Staff
APPLIED NUCLEONICS COMPANY, INC.
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I

INTRODUCTION

A Trio-Tech Leak Detection System has been installed at the North Andover, Massachusetts facility of Western Electric Company, Inc. The Leak Detection System uses krypton-85, an inert radioactive gas, to determine the hermeticity of sealed electronic components. Under normal operating conditions, a low level of krypton-85 is exhausted by the equipment. This gas is discharged to the atmosphere via an exhaust stack which is located on the roof of the building housing the equipment.

Because of the large number of components to be tested using the system and the resulting higher levels of krypton-85 discharge, questions have arisen as to whether, for licensing purposes, it will be necessary to consider the roof of the building a restricted area. Under the anticipated maximum operations, the krypton-85 concentration at the point of discharge, averaged over a one-year period, could be as high as 4.0×10^{-6} μCi/cm³. This concentration would be in excess of the level permitted in an unrestricted area, 3.0×10^{-7} μCi/cm³, but would be below the concentration permitted in a restricted area, 1.0×10^{-5} μCi/cm³.(1)

The purpose of this analysis is to determine the krypton-85 concentration profiles around the stack and facility under the postulated maximum operating conditions. This information will then be used as the basis for determining whether all or part of the facility roof would need be designated a restricted area. The

analysis is performed using the computer program "ANPLUM," an atmospheric dispersion code written by the technical staff of Applied Nucleonics Company, Inc.

(1) Title 10, Part 20 of the Code of Federal Regulations, "Standards for Protection Against Radiation."

II

METHOD

The analysis in this study was performed using the ANC atmospheric dispersion program, "ANPLUM," a program based on the Pasquill stability model.(2) The program solves and plots, as a function of distance downwind, the following general case equation:

$$\chi(x,y,z,H) = \sum_{i=1}^{6} \frac{Q\cdot f_i \cdot 10^{-6}}{2\pi\sigma_{yi}\,\sigma_{zi}\,u_i} \cdot \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_{yi}}\right)^2\right] \cdot \left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_{zi}}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_{zi}}\right)^2\right]\right\},$$

where χ = downwind concentration, (μCi/cm³).

x = downwind distance at which the concentration is being calculated, (meters).

y = distance from the centerline of the plume at which the concentration is being calculated, (meters).

z = distance above ground level at which the concentration is being calculated, (meters).

H = effective stack height, (meters).

Q = discharge rate (μCi/sec).

f_i = persistence fraction for each stability type

u_i = wind speed for each stability type, (m/sec).

σ_{yi} and σ_{zi} = standard deviations of the concentration distributions in the y- (horizontal) and z- (vertical) directions, respectively. These parameters are functions of the stability type and the downwind distance.

The program sums over the six stability types, A through F, specified in the Pasquill model. The parameters in the equation

are indicated in the plume geometry diagram shown in Figure 1. As seen in the figure, the effective stack height, H, is greater than the actual stack height, h. This plume rise is due to the exit gas velocity and thermal buoyancy effects, and is calculated in the program using the empirical equation derived by Holland:[2]

$$\Delta H = \frac{v_s d}{u} \left(1.5 + 2.68 \times 10^{-3} \cdot p \cdot \frac{Ts - Ta}{Ts} \cdot d\right),$$

where ΔH = plume rise above the stack, (meters).

v_s = stack gas exit velocity, (m/sec).

d = the inside stack diameter, (meters).

u = wind speed, (m/sec).

p = atmospheric pressure, (millibars).

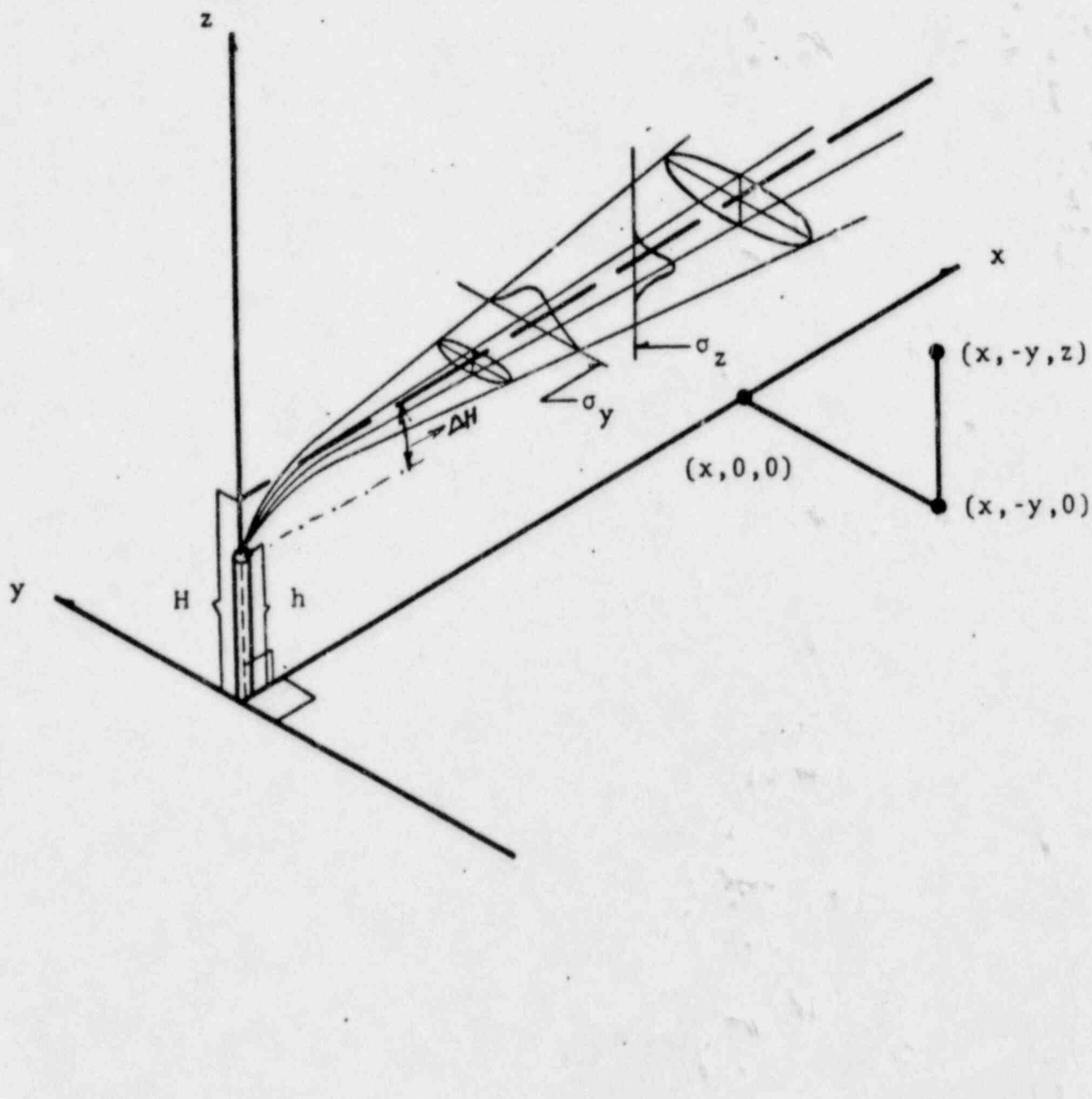
Ts = stack gas temperature, (^{o}Kelvin).

Ta = air temperature, (^{o}K).

The functions relating the σ_{yi} and σ_{zi} values to the downwind distance and the stability type are programmed in "ANPLUM". With appropriate input values for the other parameters, the program calculates and plots to a specified downwind distance at a specified calculational interval the downwind concentration. In each case, any or all of the six stability types may be considered. If only one stability type is specified, one concentration profile will be generated, the plotting symbol being the letter of the stability type used. If two or more stability types are considered, two plots will be generated; the first plot will show the concentration profile for each stability type using as plotting symbols the letter of each stability type, and

FIGURE 1

PLUME GEOMETRY SHOWING THE COORDINATE AXES
AND THE GAUSSIAN DISTRIBUTIONS
IN THE HORIZONTAL AND VERTICAL DIRECTIONS



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the second plot will show the weighted average concentration profile, weighting each of the individual profiles by the input persistence fractions and using the letter O as the plotting symbol.

An option available in ANPLUM is for the case of the discharge of a mixture of isotopes. Here the input includes, for each isotope being discharged, the discharge rate in microcuries per second and the appropriate radioactivity concentration guides (RCG) for total body exposure as well as each critical organ. For each distance downwind, the program will calculate the concentration of each isotope, determine what fraction of each appropriate RCG that concentration represents, and sum these fractional concentrations to determine the total concentration, expressed as a fraction of the weighted average RCG, for the total body and each critical organ. The total fraction for the total body exposure will be plotted as described previously. The program will also specify the distance downwind at which the greatest concentration occurs and will list, for that distance, the isotopes present, the concentrations, and the fractions of each of the RCG values.

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(2) D. Bruce Turner, Workbook of Atmospheric Dispersion Estimates, U.S. Department of Health, Education and Welfare, Washington, D.C.

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III

ANALYSIS

A plan view of the building roof, showing the location of the stack, is presented in Figure 2. The stack is five feet tall (1.53 m) and fourteen inches in diameter (0.35 m). The exhaust rate through the stack is 2600 cfm (1.23 m^3/sec). The height of the building, excluding the stack, is 45 feet (13.72 m).

In the analysis, the following operational conditions were assumed:

a. The equipment is used for 12 cycles/day and 260 days/yr.

b. The krypton-85 discharge rate is 50 mCi/cycle.

Under these conditions, over a period of one year, a total of 156 Curies of krypton-85 will be discharged. This corresponds to a discharge rate of 4.94 μCi/sec and a concentration at the point of discharge of 4.0 x 10^{-6} μCi/cm^3.

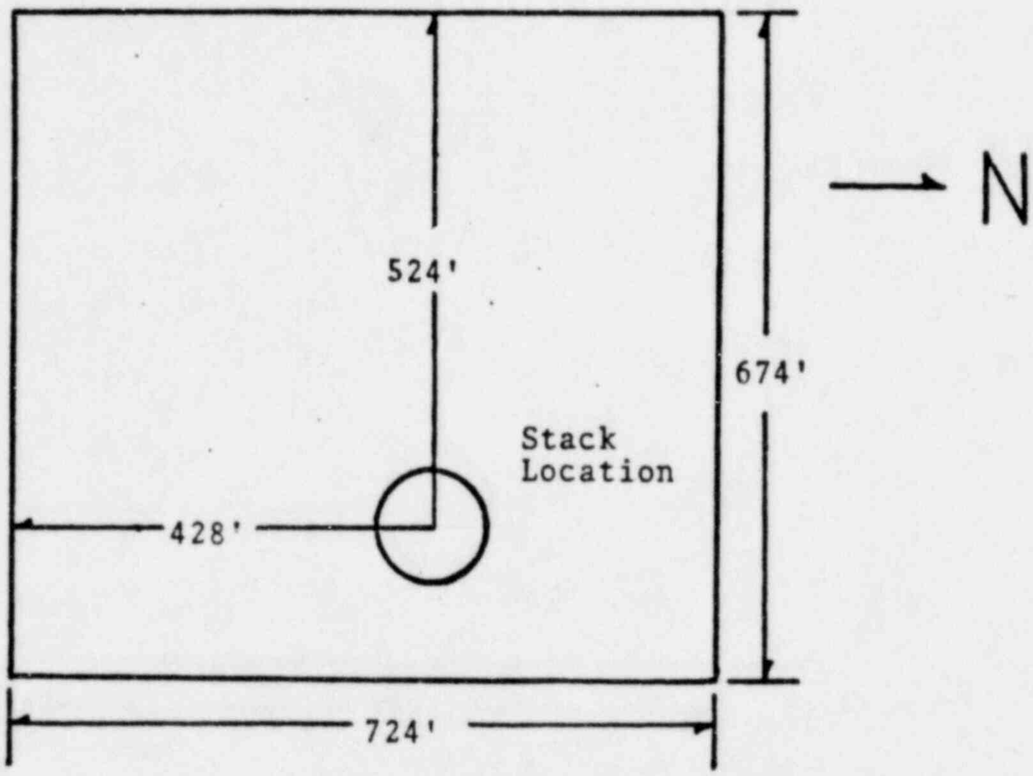
Three types of atmospheric conditions were considered in the analysis, as summarized below:

Atmospheric Condition	Pasquill Stability Type	Wind Speed (m/sec)
Stable	F	1.0
Neutral	D	6.0
Unstable	A	3.0

For each of these conditions, the krypton-85 concentration profile was calculated at three different heights: roof top, 13.72 m above ground level; 1.8 m above roof top, for the case of a six

FIGURE 2

PLAN VIEW OF THE FACILITY ROOF



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foot person walking on the roof, 15.52 m above ground level; and ground level at distances downwind.

Wherever it was necessary to estimate an input parameter, a conservative value was assumed. In keeping with this philosophy, the analysis was performed based on the following assumptions and input parameters:

a. Only plume centerline concentrations were considered, y = 0.0 meters.

b. The wind direction, wind speed, and stability type remain constant throughout each case.

c. Thermal buoyancy of the exhaust gas is neglected; the only plume rise effect is due to the exit velocity of the gas.

d. The exhaust rate is constant at 1.23 m^3/sec (2600 cfm).

e. The krypton-85 is discharged at a continuous rate of 4.94 μCi/sec.

Using the information presented in this section as input to "AN-PLUM," the concentration profile for each of the nine cases was generated.

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IV

RESULTS

The concentration profiles for the nine cases considered are included in the Appendix to this report as Figures A-1 through A-9. The maximum concentration and the downwind distance at which that concentration occurs for each case are summarized in Table 1.

As indicated in Table 1, several of the points are considered inaccessible. For cases 1 and 4, the peak concentration levels occur at distances beyond the roof boundary. In case 9, the plume, in the absence of the building, would reach ground level within the building boundaries. Such a condition is, of course, impossible; but the results for this case and the other eight cases indicate that under no conditions will the krypton-85 concentration exceed the 3.0×10^{-7} μCi/cm³ level permitted in an uncontrolled area.

The greatest of the maximum concentration values occurs 8 meters downwind of the stack, 1.8 meters above the roof top, and under neutral atmospheric conditions (case 5). For this case, the peak concentration will be 8.51×10^{-8} μCi/cm³, about 1/3 of the permitted concentration in an uncontrolled area. The peak concentration values for the other conditions considered are below the level permitted in an uncontrolled area by factors ranging from 1 to 3 orders of magnitude.

TABLE 1

SUMMARY OF RESULTS

Case	Location	Atmospheric Conditions $\vec{U}$ (m/sec)	Maximum Concentration (μCi/cm^3)	Downwind Distance (m)
1	Roof top	Stable 1 m/s	4.11×10^{-9}	300*
2	Roof top	Neutral 6 "	7.69×10^{-9}	35
3	Roof top	Unstable 3 "	5.28×10^{-9}	25
4	1.8 m above roof top	Stable	7.04×10^{-9}	220*
5	1.8 m above roof top	Neutral	8.51×10^{-8}*	8 – 6 m/sec
6	1.8 m above roof top	Unstable	1.82×10^{-8}*	12 – 3 m/sec
7	Ground level	Stable 1 m/sec	1.02×10^{-9}	1000
8	Ground level	Neutral 6 m/sec	3.53×10^{-10}	300
9	Ground level	Unstable 3 m/sec	6.44×10^{-10}	90*

*Inaccessible points: for cases 1 and 4, these points lie in mid-air, beyond the boundaries of the building; for case 9, this point would lie at ground level within the building boundaries.

V

INFERENCES

There appears to be no necessity to designate the roof of the building as a restricted area. The plume rise due to the exit velocity of the exhaust gas, as calculated by "ANPLUM" and used in the dispersion calculations, will carry the exhaust gas from 1 meter to 7 meters above the five foot stack depending upon the prevailing atmospheric conditions, before the plume "bends over," as shown in the schematic diagram shown in Figure 1. This will carry the plume at the point of discharge above the height of even the tallest person. Thus, the only way a person could be exposed to a krypton-85 concentration in excess of the level permitted in an unrestricted area would be to stand next to the stack with his/her head in the path of the exhaust stream. Such a possibility would be easily precluded by such simple design modifications as either extending the stack or placing a fence around the stack. Either measure would prevent exposure in excess of the levels permitted for an uncontrolled area and would therefore eliminate the need to designate and control the roof of the building as a restricted area.

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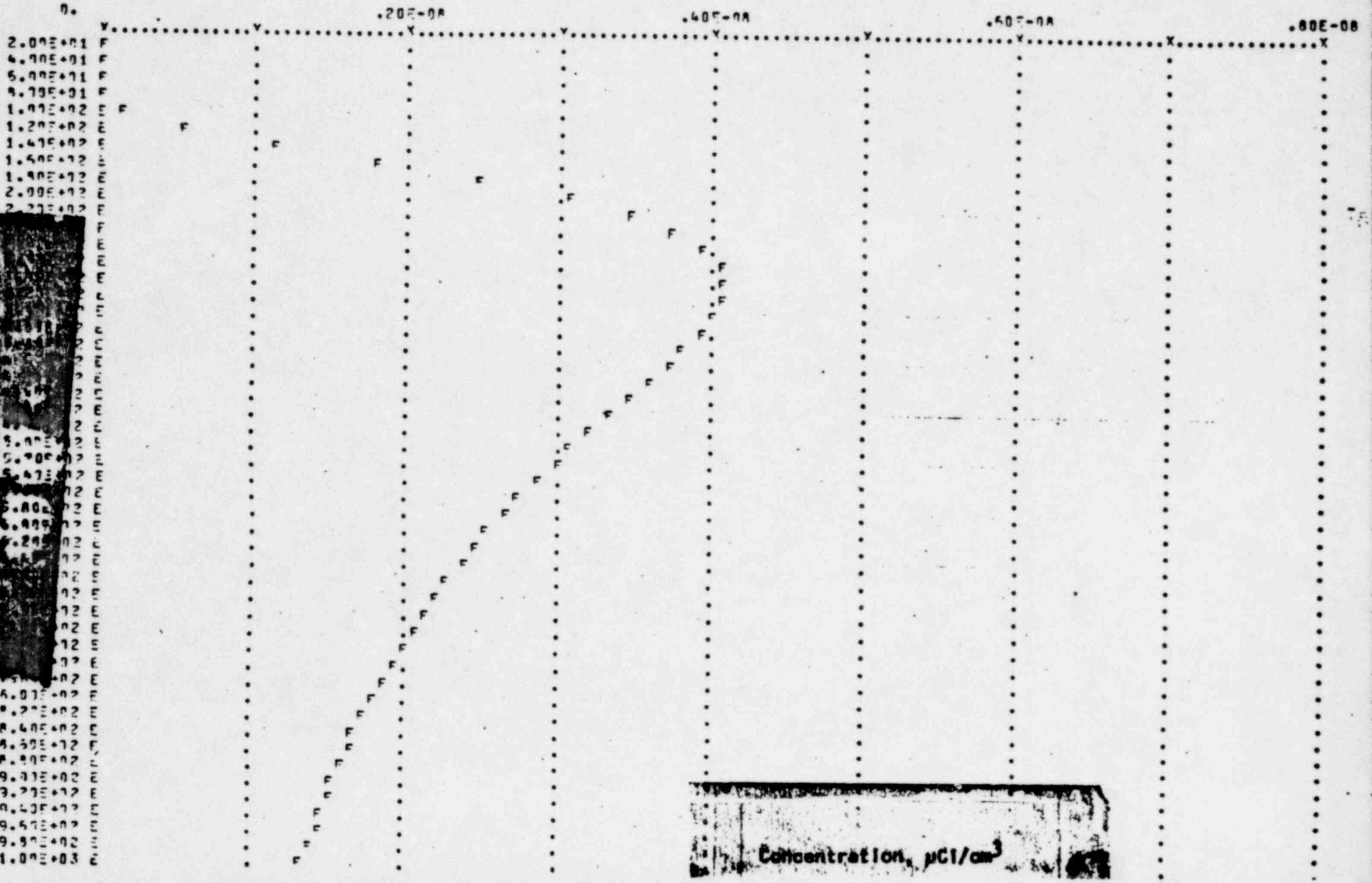
APPENDIX

DOWNWIND CONCENTRATION PROFILES FOR EACH STABILITY TYPE

MAXIMUM ABSOLUTE RESPONSE AND ABSISSA

0.	0.	0.	0.	0.	.411E-08
0.	0.	0.	0.	0.	.300E+03

Figure A-1
Concentration Profile
Roof Top - Stable Conditions

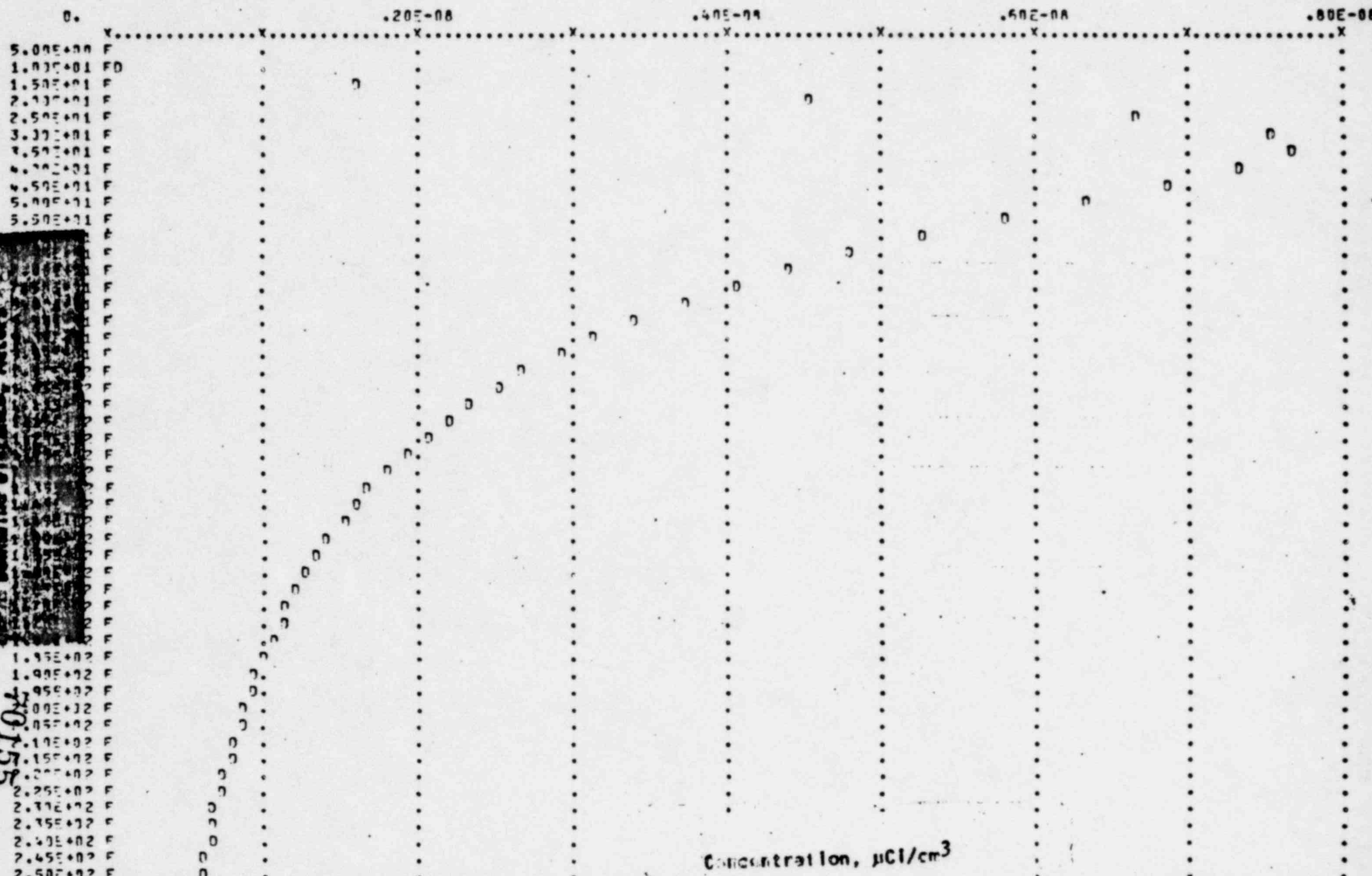


DOWNWIND CONCENTRATION PROFILES FOR EACH STABILITY TYPE

MAXIMUM ABSOLUTE RESPONSE AND ABSISSA

0.	0.	0.	.769E-08	0.	0.
0.	0.	0.	.350E+02	0.	0.

Figure A-2
Concentration Profile
Roof Top - Neutral Conditions

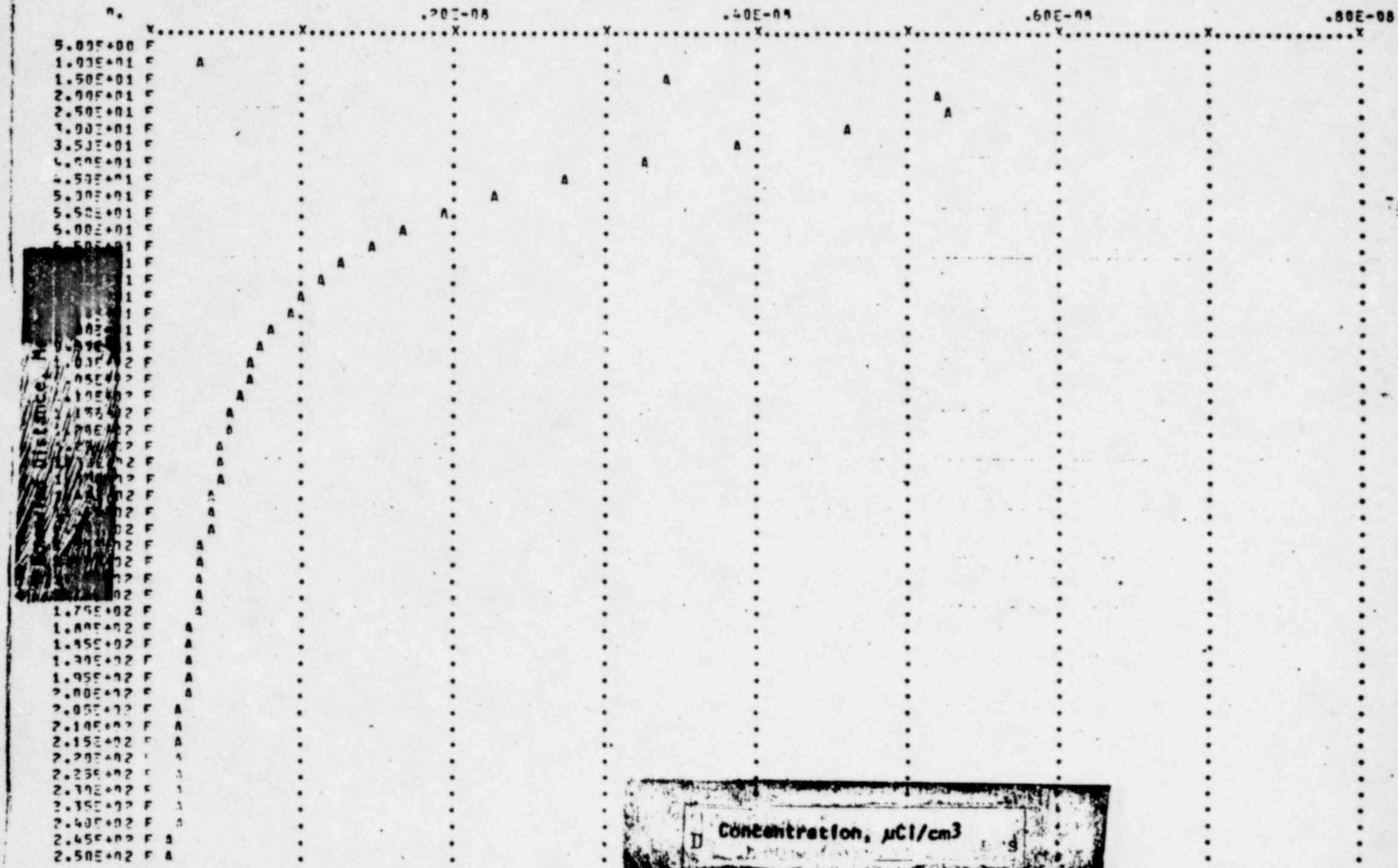


DOWNWIND CONCENTRATION PROFILES FOR EACH STABILITY TYPE

MAXIMUM ABSOLUTE RESPONSE AND ABSISSA

.524E-08	0.	0.	0.	0.	0.
.250E+02	0.	0.	0.	0.	0.

Figure A-3
Concentration Profile
Roof Top - Unstable Conditions

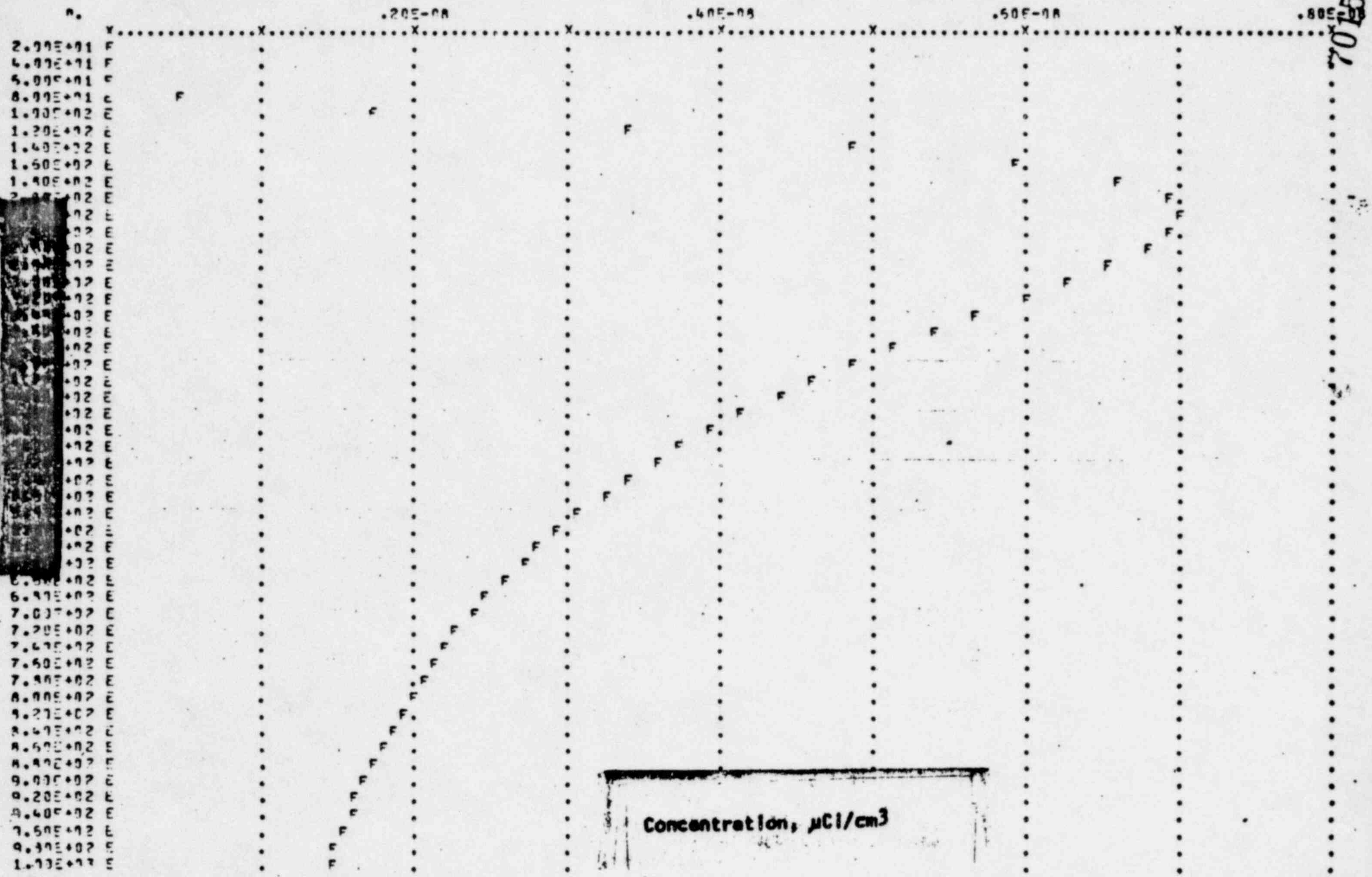


DOWNWIND CONCENTRATION PROFILES FOR EACH STABILITY TYPE

Figure A-4
Concentration Profile
1.8 m Above Roof Top - Stable Conditions

MAXIMUM ABSOLUTE RESPONSE AND ABSISSA

0.	0.	0.	0.	0.	.704E-08
0.	0.	0.	0.	0.	.220E+03



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DOWNWIND CONCENTRATION PROFILES FOR EACH STABILITY TYPE

MAXIMUM ABSOLUTE RESPONSE AND ABSISSA

0.	0.	0.	.851E-07	0.	0.
0.	0.	0.	.800E+01	0.	0.

Figure A-5
Concentration Profile
1.8 m Above Roof Top - Neutral Conditions

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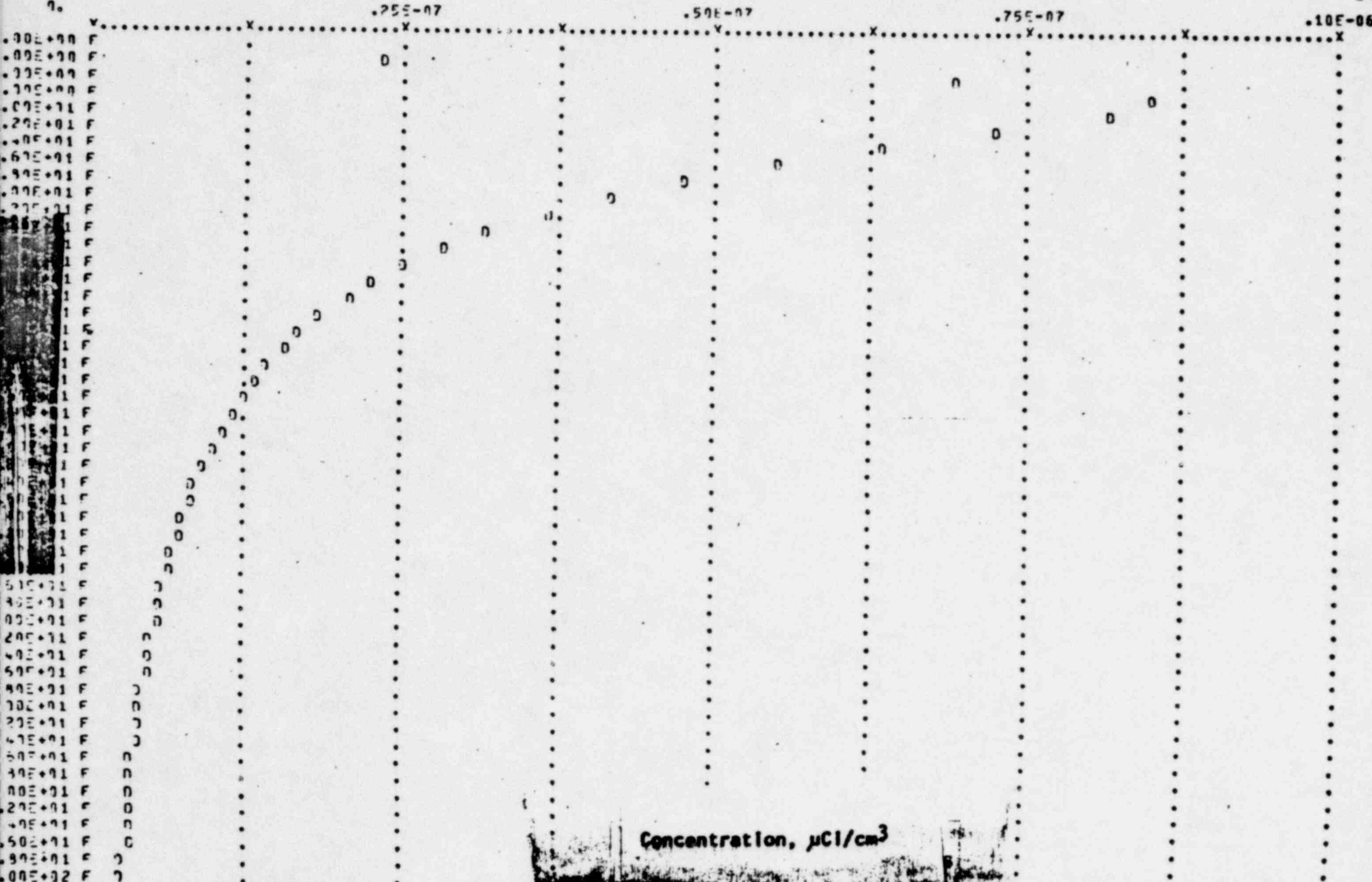
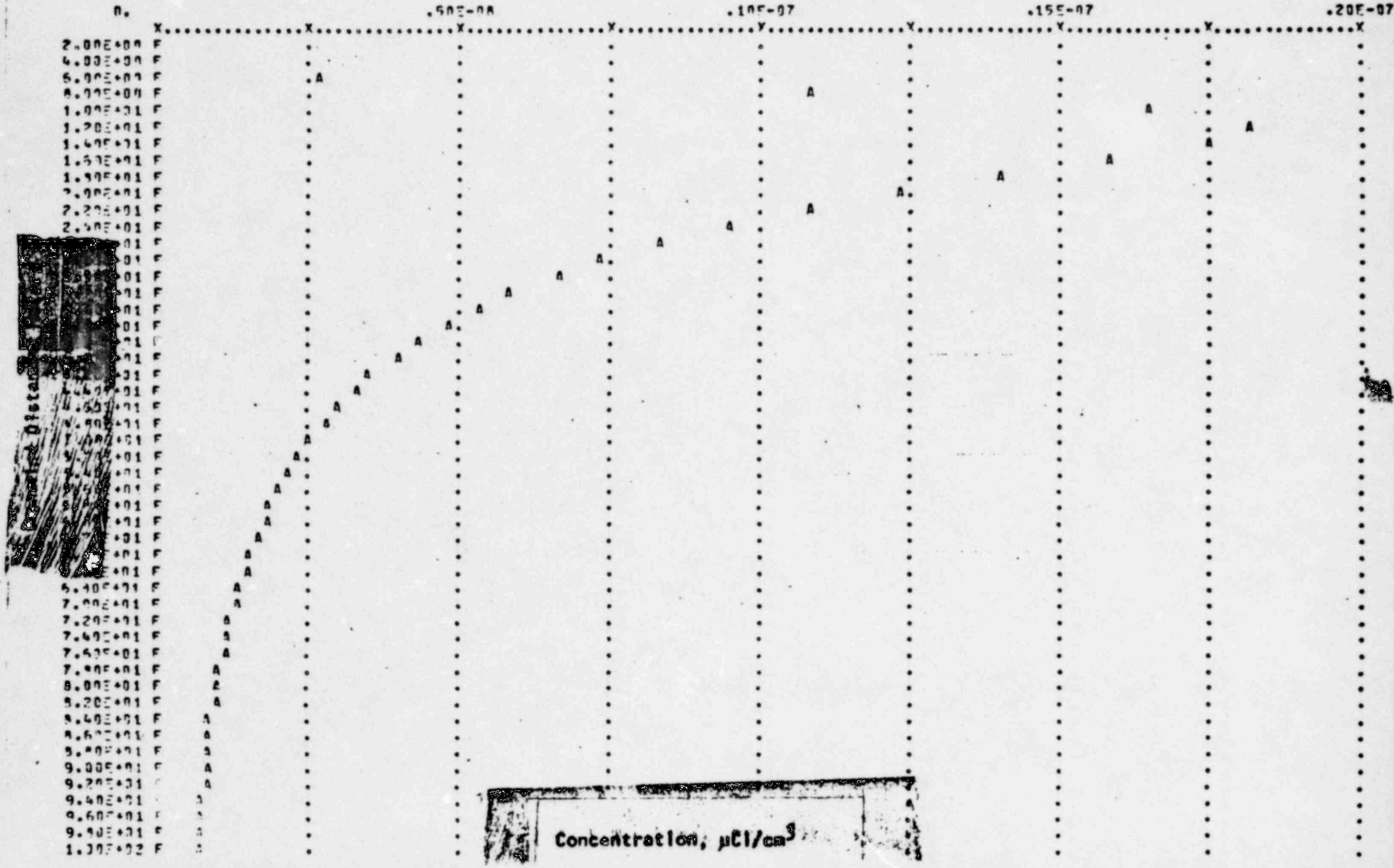


COMBINED CONCENTRATION PROFILES FOR EACH STABILITY TYPE

Figure A-6
Concentration Profile
1.8 m Above Roof Top - Unstable Conditions

MAXIMUM ABSOLUTE RESPONSE AND ABSCISSA

.192E-07	0.	0.	0.	0.	0.
.120E+02	0.	0.	0.	0.	0.

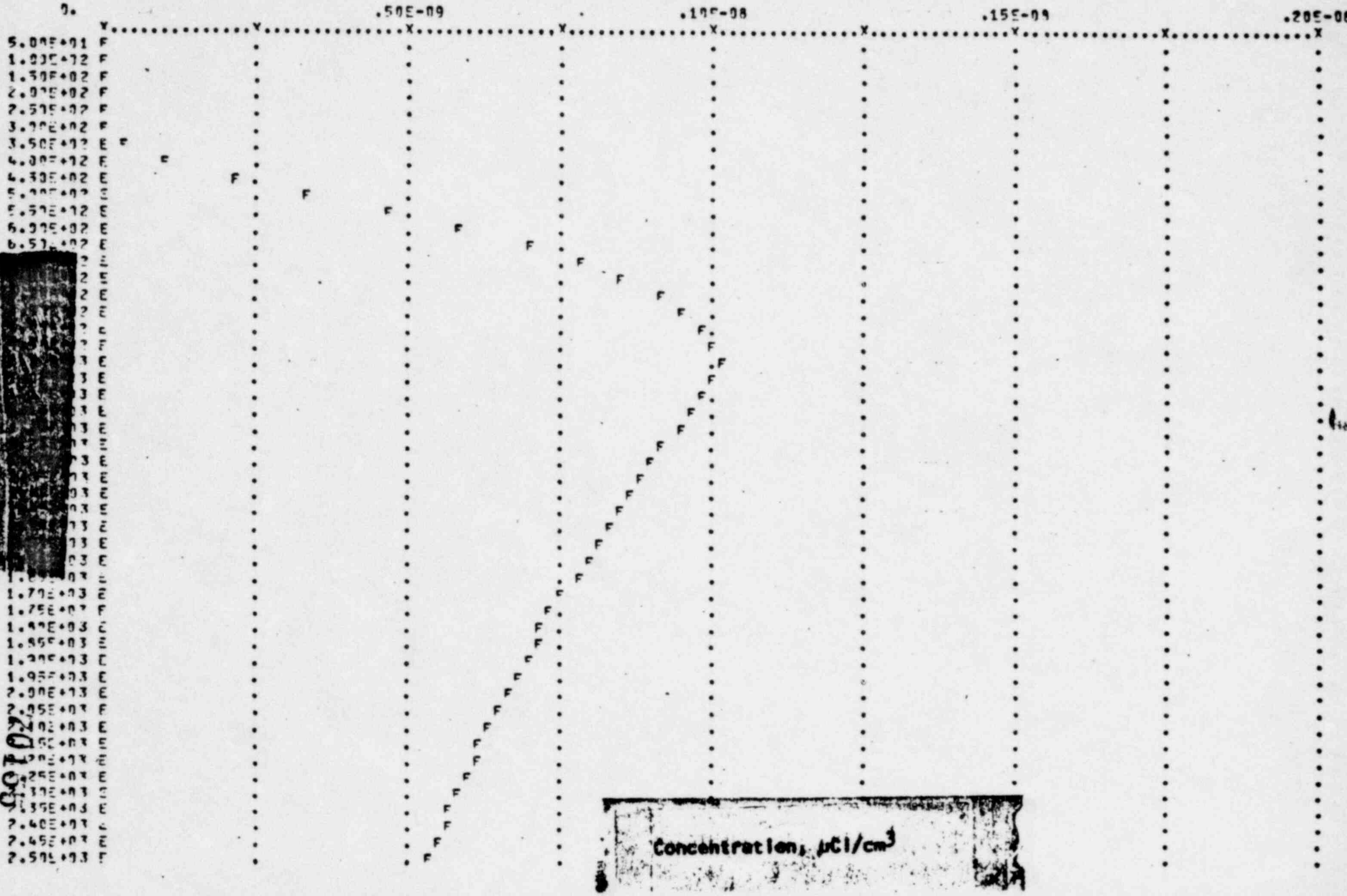


DOWNWIND CONCENTRATION PROFILES FOR EACH STABILITY TYPE

Figure A-7
Concentration Profile
Ground Level - Stable Conditions

MAXIMUM ABSOLUTE RESPONSE AND ABSCISSA

0.	0.	0.	0.	0.	.192E-08
0.	0.	0.	0.	0.	.100E+04

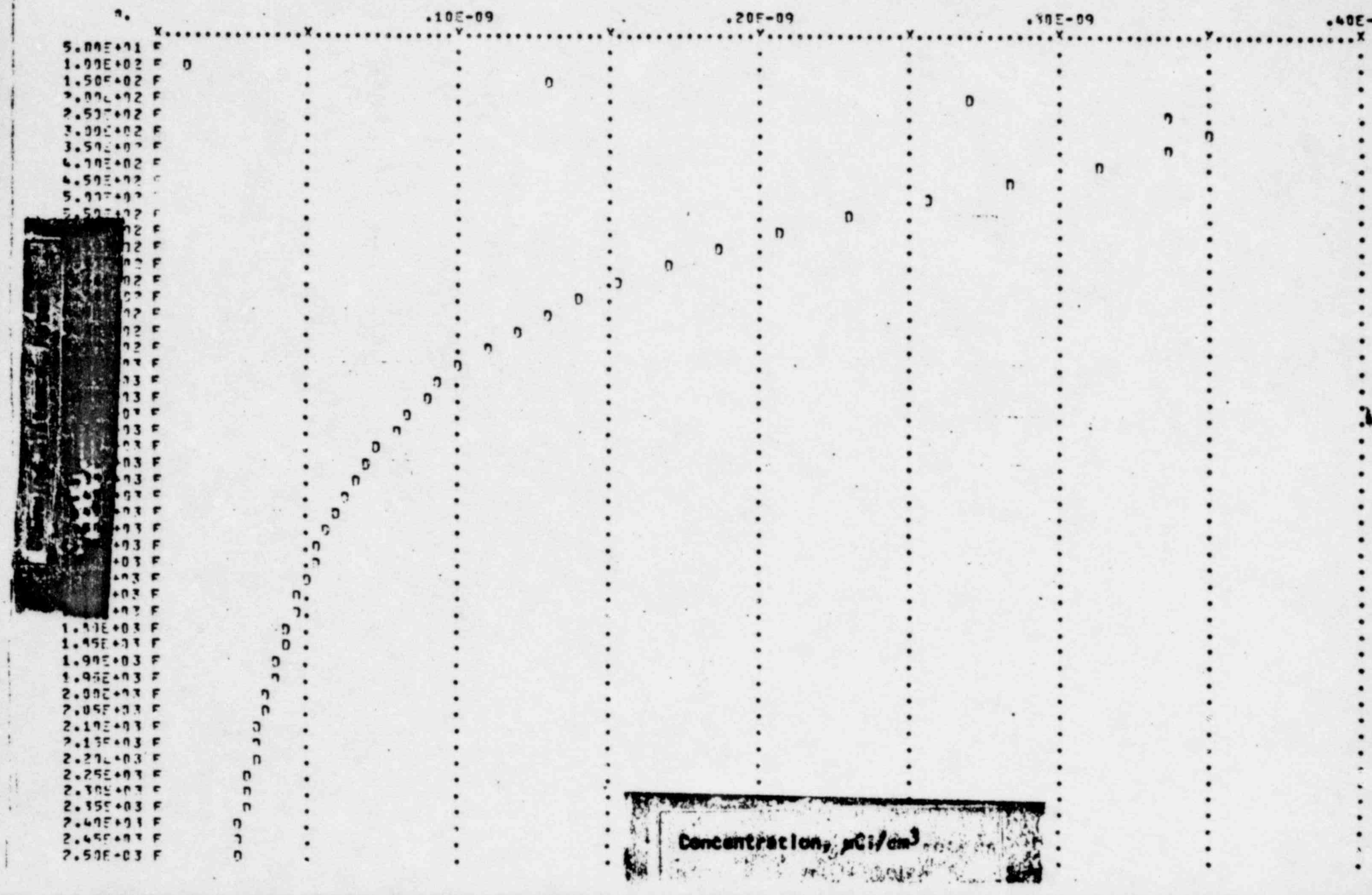


DOWNWIND CONCENTRATION PROFILES FOR EACH STABILITY TYPE

MAXIMUM ABSOLUTE RESPONSE AND ABSISSA

0.	0.	0.	.357E-09	0.	0.
0.	0.	0.	.300E+03	0.	0.

Figure A-8
Concentration Profile
Ground Level - Neutral Conditions

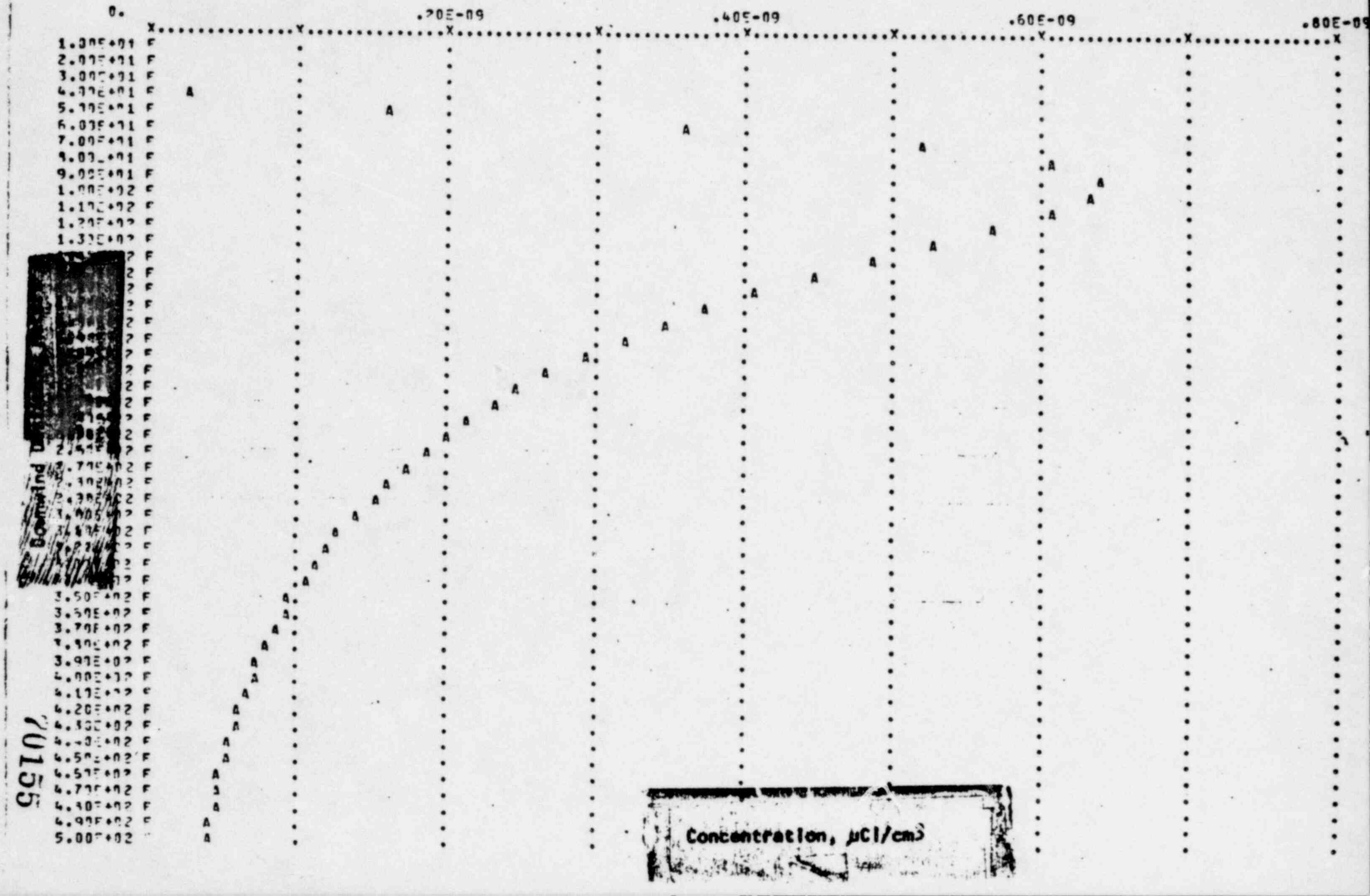


DOWNWIND CONCENTRATION PROFILES FOR EACH STABILITY TYPE

MAXIMUM ABSOLUTE RESPONSE AND ABSCISSA

.644E-09	0.	0.	0.	0.	0.
.900E+02	0.	0.	0.	0.	0.

Figure A-9
Concentration Profile
Ground Level - Unstable Conditions



SUBJECT: KRYPTON 85 GROSS AND FINE LEAK TEST, HMA

1. SCOPE

1.1 This specification describes the procedure for determining hermeticity of HMAs, as required by MIL-STD-883 Method 1014, Test Condition B and MIL-STD-750 Method 1071, Test Condition B.

2. PREPARATION AND SETUP

2.1 Activation Console

NOTES:

a. The specific activity of Krypton-85 gas shall be determined the first week of each month by the Radiation Safety Officer.

b. The bombing pressure or time will be recorded on the Kr-85 Monthly Specific Activity Log (Figure 1) and the Activation Run Log (Figure 2).

c. Process pressure remains constant at 5 psia for Stinger POST E Sections, with time the variable factor. All other HMAs vary pressure with time held constant.

2.1.1 Verify that vacuum gauge indicator is set at .5 mm.

2.1.2 Verify that storage overpressure indicator is set for 10 psi over the actual pressure.

2.1.3 Verify that the activation pressure is set at the pressure indicated in the Kr-85 Monthly Activity Log (Figure 1).

2.1.4 Verify time is set per Kr-85 Monthly Activity Log (Figure 1).

2.1.5 Verify radiation indicator is set at 7 milliroentgen per hour (mr/hr).

2.1.6 Verify that storage pressure is within 2 psi of storage pressure recorded at the completion of the last run in the Activation Run Log (Figure 2).

2.1.7 Verify activation pressure gage indicates "ATM" when in "VENT COMPLETE" mode.

2.1.8 Verify vacuum gage indicates "ATM" when in "VENT COMPLETE" mode.

2.1.9 Verify that the radiation gage indicates approximately 2 to 3 mr/hr.

2.2 Ratemeter (Figure 3)

2. PREPARATION AND SETUP (Continued)

2.2.1 Turn power switch on.

2.2.2 Verify time constant knob is set at "1.0".

2.2.3 Verify meter range knob is set as "5K".

2.2.4 Verify meter switch is set at "CPM".

2.2.5 Verify "GO/NO-GO" needle is adjusted to the set point specified in the Rate Meter Daily Calibration Log (Figure 4).

2.3 Geiger-Mueller Survey Meter

2.3.1 The survey meter shall be located outside the activation room. It must be carried into the room whenever the room is occupied. It serves as a portable radiation detector and is used during maintenance/service and for scanning HMAs after parts have been pressurized prior to removing the parts from the activation room.

2.3.2 Check Geiger-Mueller meter prior to entering the activation room.

2.3.2.1 Turn rotary switch to "BATTERY CHECK". Depress "BATTERY CHECK" button. Observe meter reading. Needle must fall with the black band labeled "BATTERY CHECK". If below this reading, batteries must be replaced.

2.3.2.2 Rotate selector switch to "0-10 mr/hr" range. Remove probe from handle and place it against the source mounted on the side of the meter housing. Rotate "CALIBRATE KNOB" until the meter reading agrees with the source strength stamped on the meter nameplate.

2.3.3 Carry the unit into the activation room. When running the activation console, place unit on the top of the console adjacent to the chamber hatch. Observe reading. At no time during the run should the meter reading exceed 2 mr/hr. If it does, press the activation console "STOP" button, leave the room, removing the meter, and notify the Radiation Safety Officer.

2.3.3.1 When meter is not in use, rotate the rotary switch to the off position.

3. PROCEDURE - TESTING

3.1 Activation Console

3.1.1 Place HMAs into loading trays. Place loading trays onto the spindle holder.

3.1.2 Lift hatch cover by its handle until it is fully open.

3.1.3 Depress white switch to lock the activation chamber hatch. Pull locking lever toward the operator while keeping the white switch depressed.

3. PROCEDURE - TESTING (Continued)

3.1.4 Depress both "OPEN" switches until the hatch raises to a fully opened position.

3.1.5 Remove or place the necessary number of aluminum filler blocks in the activation chamber to fill chamber except for the space occupied by the HMAs to be tested. Place HMAs in the chamber.

3.1.6 Depress both "CLOSE" switches until hatch is fully closed.

3.1.7 Push locking lever toward the activation chamber.

3.1.8 Close hatch cover.

3.1.9 Log all information in the Activation Run Log (Figure 2).

3.1.10 Push EVACUATE button to begin the cycle (Figure 5).

NOTE: The activation console will run automatically through the entire cycle, stopping when "VENT COMPLETE" light is lit. If at any time during the cycle, an alarm condition exists, immediately notify the Radiation Safety Officer. Do not push any buttons on the activation console.

3.1.11 Complete information on the Activation Run Log.

3.1.12 Perform steps 3.1.2 through 3.1.4.

3.1.13 Remove HMAs from the activation chamber.

3.1.14 Perform steps 3.1.6 through 3.1.8 to secure chamber.

3.1.15 Check devices with the Geiger-Mueller survey meter (reference Paragraph 2.3). Reading shall not exceed 2 mr/hr. Segregate any parts with a reading in excess of 2 mr/hr and notify Radiation Safety Officer for disposition. Place any units with a high reading under the hatch cover.

NOTE: HMAs must be tested within one hour after completion of the activation cycle.

NOTE: If storage pressure varies by more than 2 psi from the previous run, discontinue test and notify Radiation Safety Officer.

3.2 Ratemeter

3.2.1 Remove the plug from the scintillation crystal cavity.

3.2.2 Place HMAs into the scintillation cavity well and press the reset button (Figure 3).

3. PROCEDURE - TESTING (Continued)

3.2.2 (Continued)

Note 1: If one or more HMAs fail, the "NO-GO" light will come on and a buzzer will sound. In case of a group failure, insert each individual HMA into the crystal well and segregate failed parts.

Note 2: Return failed units to the activation room and follow decontamination procedure (reference Paragraph 5.0).

3.2.3 Replace the plug over the scintillation crystal cavity at the completion of testing.

4. POCKET DOSIMETER

4.1 Any personnel who must enter the activation room who are not on the authorized employee list (Figure 6) must be escorted by an authorized person, and wear a pocket dosimeter clipped on the outside of their smock.

4.2 Remove the protective cap from the charging end of the pocket dosimeter (Victoreen Model 451/A or equivalent).

4.2.1 Remove charging contact cap from dosimeter charger (Victoreen Model 2000A or equivalent).

4.2.2 Insert pocket dosimeter into charging contact plug and press down firmly. While holding down, adjust hairline to the "0" point on the scale. Release pressure and then press down lightly to verify dosimeter is calibrated. Readjust if necessary. Replace protective cap.

4.3 Complete information specified on the Visitor Dosimeter Log (Figure 7).

4.4 After completion of work inside the activation room, place the pocket dosimeter into the charging contact and press down lightly (DO NOT REMOVE PROTECTIVE CAP). Observe the dosimeter reading and record in Visitor Dosimeter Log (Figure 7).

4.5 Replace charging contact cap.

5. DECONTAMINATION PROCEDURE

This procedure is to be used to remove entrapped Krypton gas from failed HMAs. Units which exceed 2 mr/hr as measured by the survey meter after removal from the activation chamber, or which fail testing at the rate meter station, shall be decontaminated.

5.1 Lift activation console hatch cover and place units in the back area of the cover, then close hatch.

5. DECONTAMINATION PROCEDURE (Continued)

5.2 After 24 hours minimum, recheck radiation level with the Geiger-Mueller survey meter. Any units measuring less than 2 mr/hr may be transferred to the rate meter station and retested per 3.2 through 3.2.3.

5.3 Any parts which now pass the rate meter test are safely decontaminated. Parts may now be written up as failures and vacuum baked again and resealed.

5.4 Any parts which measure more than 2 mr/hr or fail 5.3 shall be placed in the vacuum bake oven and subjected to a 24-hour minimum vacuum back at .5 torr. Retest per 5.2 and 5.3. Units which still have residual amounts of Kr-85 gas may be subjected to a total of five 24-hour vacuum bake cycles.

5.5 HMAs which do not return to a background radiation level reading must have the lid pierced. Using a spring-loaded center punch, pierce the lid, approximately .1 inches in from any side. Place the HMAs inside activation console hatch cover for 24 hours (Paragraph 5.1).

5.6 Repeat 5.2. Reject these parts and route to delid operation.

6. PREPARATION AND CONTROLS

6.1 The equipment shall be maintained and calibrated per MPS 122.68-01.

7. SAFETY REQUIREMENTS

7.1 The Tracer-flo Activation Console contains radioactive Krypton-85 gas. All personnel coming in close contact with the machine or testing devices are subjected to small doses of Gamma radiation. Only personnel whose duties require access to the activation room will be issued film badges. It is mandatory for these persons to wear film badges while inside the activation room (film badges must not be taken outside of the HMA assembly area). Film badges will be collected monthly and test to determine the REM (Roentgen Equivalent Man) received by each employee. This information is available upon request from the Radiation Safety Officer. It is the responsiblity of the Radiation Safety Officer to maintain a current list of authorized employees who require access to the activation room (Figure 6).

7.2 Visitors must be escorted by authorized personnel when entering the activation room and must be issued a pocket dosimeter (Paragraph 4.0). Record dosimeter reading in Visitor Dosimeter Log (Figure 7).

7.3 The Geiger-Mueller survey meter must be carried into the activation room each time the room is entered. Do not leave the survey meter in the unoccupied activation room.

7.3.1 Additional film badges will be used as area monitors on all air input ducts located within 50 feet of the exhaust stack on the roof of the building. These badges will be collected monthly and processed.

7. SAFETY REQUIREMENTS (Continued)

7.4 The activation console is equipped with both visual and audible alarm indictors which are activated by equipment malfunction. The visual alarm indicators are located on the right side of the activation console control panel (Figure 5). The audible alarm produces a loud buzzing sound.

7.4.1 Hatch Alarm - Visual. Hatch or hatch cover not properly secured. Recheck that all locking mechanisms are completely closed.

7.4.2 Radiation Alarm - Visual and Audible. Indicates excessive radiation is escaping through the exhaust vent. Immediately leave the room and notify Radiation Safety Officer.

7.4.3 Battery Low Alarm - Visual. Backup battery is low and requires replacement. Notify Radiation Safety Officer.

7.4.4 Power Fail Alarm - Visual and Audible. Indicates a power failure has occurred. Notify Radiation Safety Officer.

7.4.5 Storage High Alarm - Visual. Indicates storage tank pressure has increased beyond set-point. Immediately leave the room and notify the Radiation Safety Officer.

7.4.6 Exhaust Blower Alarm - Visual and Audible. Indicates exhaust blower is inoperative. Immediately leave the room and notify the Radiation Safety Officer.

7.5 All maintenance/calibration of activation console must be accomplished with the Radiation Safety Officer present.

8. MATERIALS AND EQUIPMENT

NOTES: a. When trade names are shown in parentheses, they are for information only. Other products procured to the listed specification are also acceptable.

b. The procurement specification listed last for each item is the number under which the material is normally stocked.

8.1 Tracer-Flo Activation Console, Model 30010-1A-28

8.2 Ratemeter, Model 2011-15

8.3 Geiger-Mueller Survey Meter, Model 480-195-B or equivalent

8.4 Aluminum Filler Blocks, Model 4801202

8.5 Krypton-85 Standard Vial, Model 480278

8.6 Krypton-85 Radioactive Gas

8. MATERIALS AND EQUIPMENT (Continued)

8.7 Pocket Dosimeter, Model 541/A or equivalent

8.8 Pocket Dosimeter Charger, Model 2000A or equivalent

8.9 Parts Basket, Model 4801172

8.10 Vacuum Bake Oven

8.11 Center Punch (DU ____________) or equivalent

8.12 Holding Fixture - E Section DU ____________

9. REFERENCES

9.1 MIL-STD-750, Method 1071, Test Condition B

9.2 MIL-STD-883, Method 1041, Test Condition B

10. SUPPLEMENT

10.1 Refer to MPS 122.68 SUPPLEMENT, dated , for figures.

MPS 122.68 SUPPLEMENT

SUBJECT: KRYPTON 85 GROSS AND FINE LEAK TEST, HMA

This supplement is a part of MPS 122.68, dated ______ and of future revisions unless so noted in the basic MPS

KR-85 MONTHLY SPECIFIC ACTIVITY LOG

Month ______________ **Year** ______ **Package** ________________

1. Kr-85 Standard Current Activity

   Ao = Original Activity = ____________ µCi

   $T_{1/2}$ = Half Life of Kr-85 (from Trio Tech Tables) = ____________

   A = Ao x $T_{1/2}$ = Current Activity = ____________ µCi

		MPS Para #
2. Scintillation Plateau Curve Setting = ____________ volts		3.28
3. Gas Samples		
a) Background Reading #1	____________ CPM	3.32
Background Reading #2	____________ CPM	3.32
Background Reading #3	____________ CPM	3.32
Average Background Reading	____________ CPM	3.32
b) Kr-85 Standard Reading #1 (minus background)	____________ CPM	3.38
Kr-85 Standard Reading #2 (minus background)	____________ CPM	3.38
Kr-85 Standard Reading #3 (minus background)	____________ CPM	3.38
Average.Kr-85 Standard Reading	____________ CPM	3.38
c) Average of Gas Sample #1 (minus background)	____________ CPM	3.35
Average of Gas Sample #2 (minus background)	____________ CPM	3.39
Average of Gas Sample #3 (minus background)	____________ CPM	3.39
Average of Gas Samples 1, 2, 3.	____________ CPM	

Figure 1. Kr-85 Monthly Specific Activity Log

4. Specific Activity Calculations

$$S = \frac{R1}{R2} \times \frac{A}{C}$$

Where

S = Specific Activity

R1 = Average Gas Sample Reading (minus background)

R2 = Average Kr-85 Standard Reading (minus background)

A = Current Activity

C = Predetermined Gas Sample Size (2 Torr in 3cc vial)

$$S = \frac{\_\_\_\_\_\_ CPM}{CPM} \times \frac{\_\_\_\_\_\_ \mu Ci}{.00789 \text{ Atm-cc}}$$

S = ______ μCi/ATM-cc

5. Curie Content

$$\text{Curies} = \frac{S \times P \times V}{1 \times 10^{6} \ \mu Ci/Ci}$$

Where

S = Specific Activity = ______ μCi/ATM-cc

P = Storage Pressure in Atmospheres = ______ PSIA

V = Free Volume of Storage Chamber = 1.15×10^{4} cc OK

$$\text{Curies} = \frac{\_\_\_\_\_\_ \mu Ci/ATM\text{-}cc \times \_\_\_ ATM \times 1.15 \times 10^{4}\ cc}{1 \times 10^{6}\ \mu Ci/Ci}$$

Curies = ______

Figure 1 (Continued)

6. Activation Pressure

$$Pe^2 - Pi^2 = \frac{R}{S \times K \times T \times Q \times t}$$

Where

R = Reject Set Point = ________

S = Specific Activity = ________ µCi/ATM-cc

K = Package Constant = ________

T = Activation Time = ________ Hours

Q = Leak Rate = ________

t = Time Conversion = 3.6×10^3 Sec/Hr

Pi= Internal Pressure = 1 ATM

Pe^2 = ________

$Pe = \sqrt{Pe^2}$ = ________ ATM

Activation Pressure = Pe x 14.7 PSI/ATM = ________ PSIA

6. A. Alternate Calibration

Use when Activation Pressure must be held at a specific value of 5 PSIG

$$T = \frac{R}{S \times Q \times K \times t\ (Pe^2 - Pi^2)}$$

Where

R = Reject Set Point = ________

S = Specific Activity = ________ µCi/Atm-cc

K = Package Constant = ________

Q - Leak Rate = ________

t = Time Conversion = 3.6×10^3 Sec/Hr

$(Pe^2 - Pi^2)$ = Activation Pressure = .79586

T = ________

Test Performed by ________ Date ________

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Figure 1 (Continued)

Figure 1

KRYPTON 85 DECAY CHART

Yrs	0	1	2	3	4	5	6	7	8	9	10	11
	Months											
	1.00000	.99501	.99004	.98412	.97921	.97433	.96850	.96367	.95886	.95313	.94838	.94270
1	.93800	.93332	.92774	.92311	.91851	.91393	.90846	.90393	.89852	.89404	.88869	.88426
2	.87985	.87459	.87022	.86588	.86070	.85641	.85129	.84704	.84282	.83777	.83360	.82944
3	.82448	.82036	.81627	.81139	.80734	.80251	.79851	.79453	.78978	..78584	.78192	.77724
4	.77236	.76951	.76490	.76109	.75653	.75276	.74901	.74453	.74081	.73712	.73271	.72905
5	.72469	.72108	.71748	.71319	.70963	.70609	.70187	.69837	.69489	.69073	.68728	.68317
6	.67977	.67638	.67233	.66898	.66564	.66166	.65836	.65442	.65115	.64791	.64403	.64082
7	.63762	.63381	.63065	.62750	.62375	.62064	.61692	.61385	.61079	.60713	.60410	.60109
8	.59750	.59452	.59155	.58801	.58508	.58158	.57868	.57579	.57235	.56949	.56665	.56326
9	.56045	.55710	.55432	.55156	.54826	.54552	.54280	.53956	.53686	.53419	.53099	.52834
10	.52518	.52256	.51996	.51685	.51427	.51170	.50864	.50611	.50358	.50057	.49807	.49509
11	.49262	.49017	.48723	.48480	.48239	.47950	.47711	.47425	.47189	.46954	.46673	.46440
12	.46208	.45932	.45703	.45475	.45203	.44977	.44708	.44485	.44263	.43999	.43779	.43561
13	.43300	.43084	.42827	.42613	.42400	.42147	.41937	.41727	.41478	.41271	.41065	.40819
14	.40616	.40373	.40171	.39971	.39732	.39534	.39337	.39101	.38906	.38712	.38481	.38289
15	.38060											

HALF-LIFE 10.76 YEARS

CALCULATION INTERVAL 1.0 MONTHS

Figure 1 (Continued

~~FIGURE~~ 2

ACTIVATION RUN LOG

DATE	RUN #	QTY	PARTS #	RUN START TIME	CYCLE START CONDITIONS			CYCLE END CONDITION			INIT	COMMENTS
					ACT. PRESS	TIMER	STORAGE PRESS	STORAGE PRESS	GEIGER MUELLER	RUN END TIME		

Figure 2. Activation Run Log

~~Fig. 3~~ ~~RATEMASTER CONTROL PANEL~~

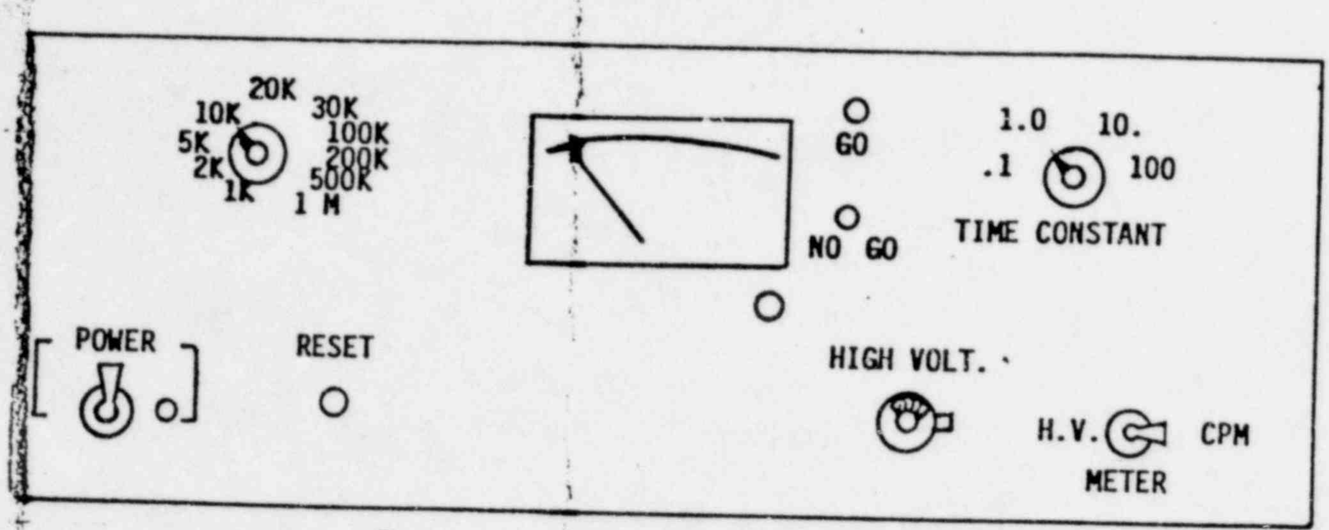

Figure 3 Rate Master Control Panel

~~Fig 5. Activation Console Control Panel~~

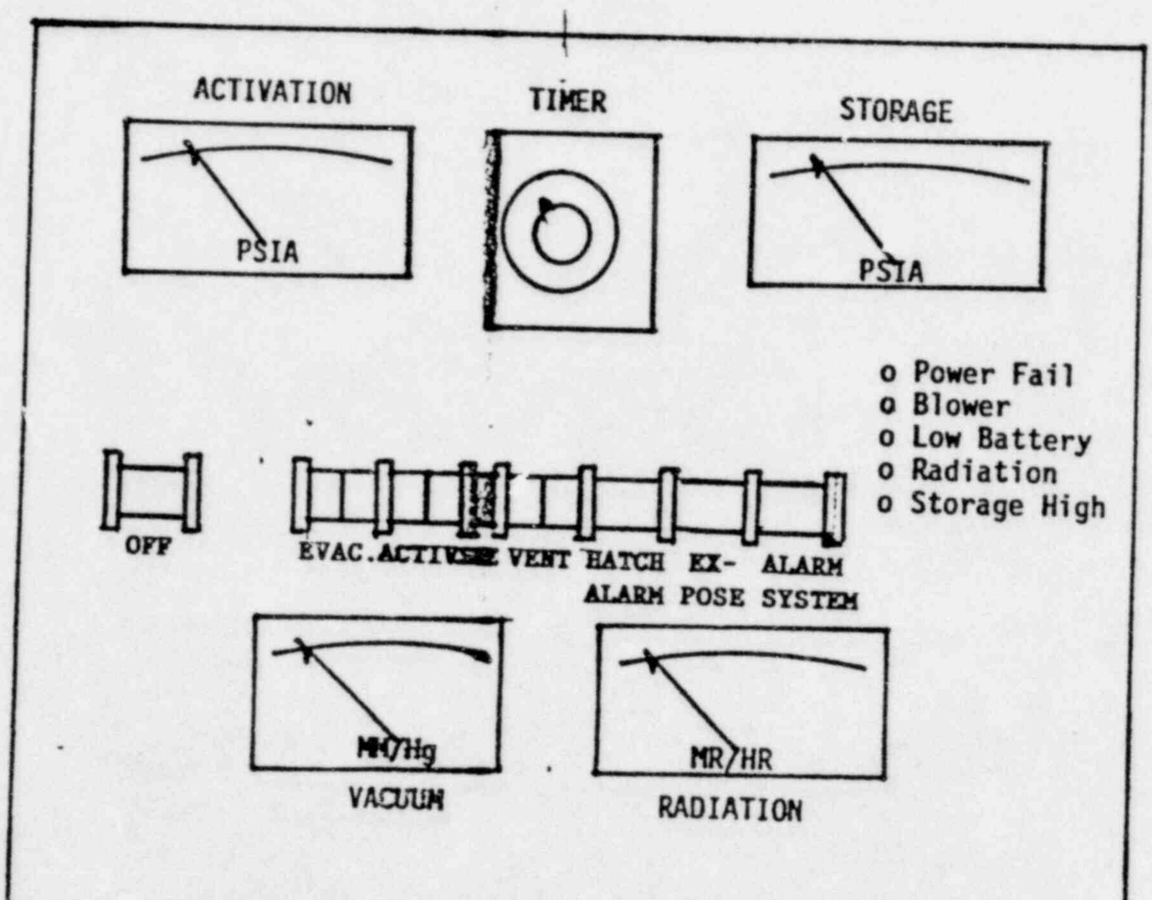

Fig 5. Activation Console Control Panel

~~FIGURE 3~~ 4

RATEMETER DAILY CALIBRATION LOG

HI VOLTAGE (KV)	BACKGROUND (CPM)	KR 85 STD. (CPM)	SET POINT (CPM)	KR 85 CURRENT ACTIVITY (μCi)	CALIBRATION BY	DATE

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Figure 4. Ratemeter Daily Calibration Log

FIGURE 6

FILM BADGE LOG
PERSONNEL AUTHORIZED TO ENTER TRACER-FLO ROOM

NAME	FILM BADGE NUMBER	SOCIAL SECURITY NUMBER	DATE OF BIRTH	RAD. SAFETY OFFICER APPROVAL	DATE APPROVED

Figure 6 Film Badge Log

~~FIGURE 7~~

VISITOR DOSIMETER LOG

NOTE: All visitors who enter activation room must be entered in this log.

DATE	NAME	COMPANY/DEPARTMENT	ESCORTED BY	TIME IN	TIME OUT	DOSIMETER READING

Figure 7. Visitor Dosimeter Log

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~~FIGURE 8~~ 9

SCINTILLATION PLATEAU MONTHLY CURVE LOG

Calib by______________________

Date______________________

High Volt Set Point______________________

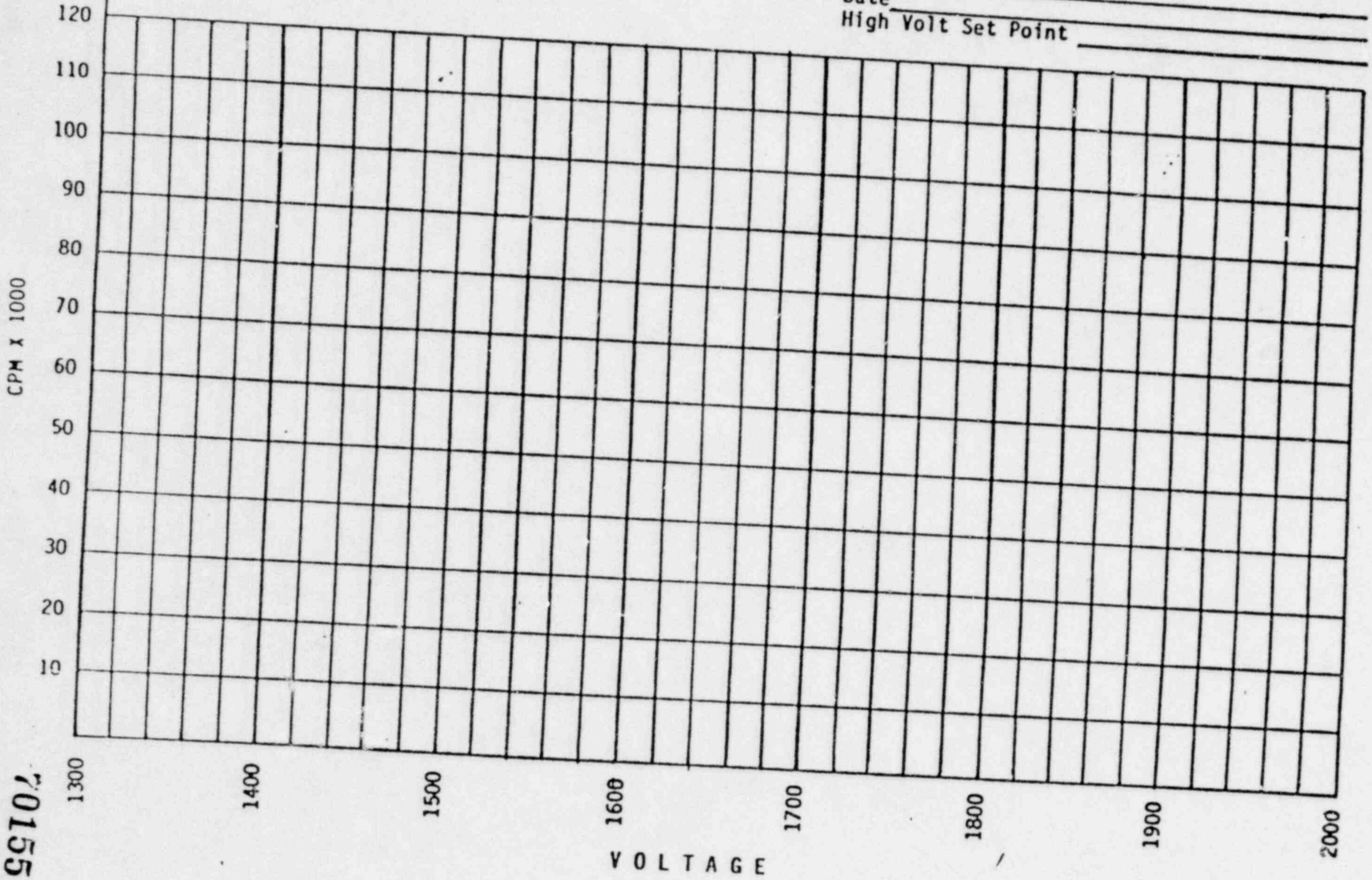

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Figure 8. Scintillation Plateau Monthly Curve Log

~~FIGURE 8~~

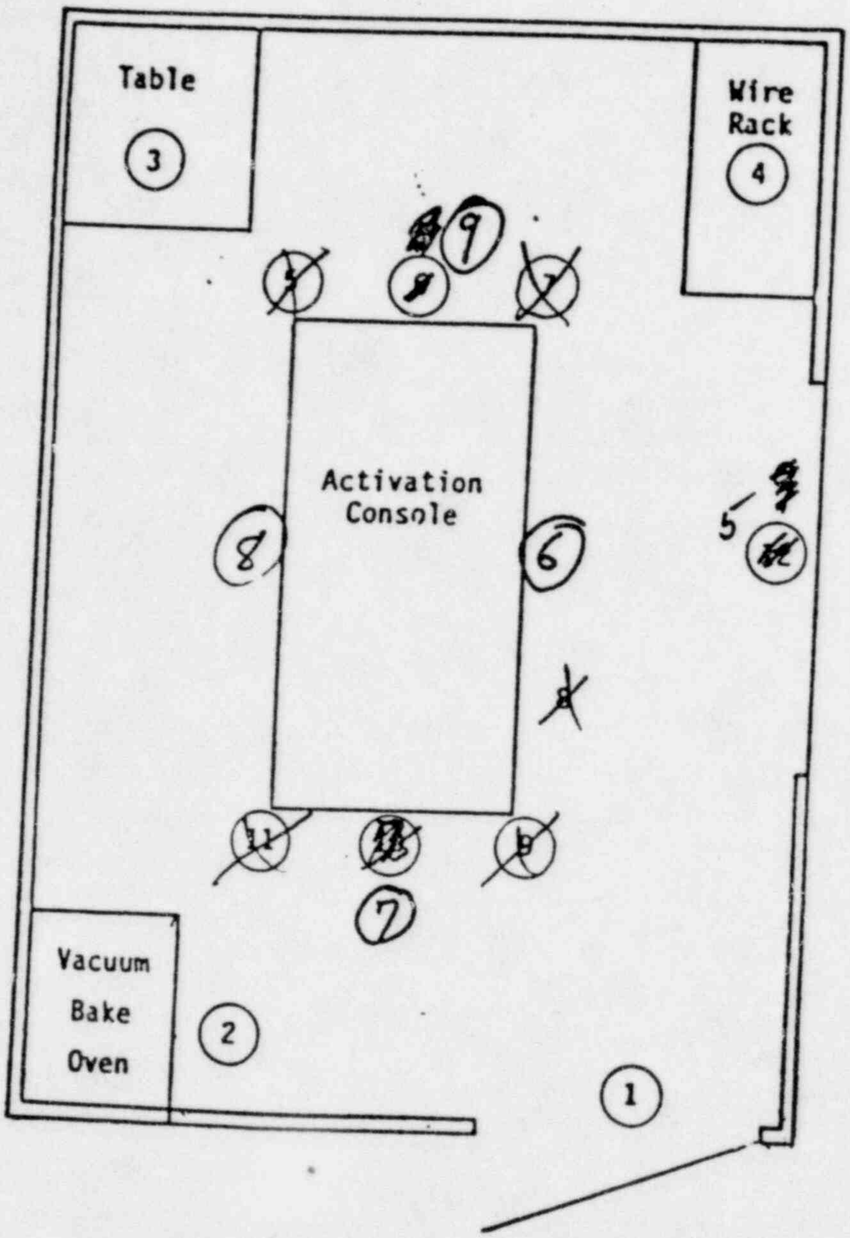
CURIE RECEIPT LOG

DATE	CURIES RECEIVED	CURIES IN CONSOLE	CURIE LOSS THIS MONTH	CURIE LOSS THIS YEAR	TOTAL KR ON HAND	CURIES REPORTED BY	COMMENTS

Figure 7 Curie Receipt Log

ACTIVATION ROOM SURVEY LOG

To be Performed Weekly



1. ________ MR/HR
2. ________ MR/HR
3. ________
4. ________
5. ________
6. ________
7. ________
8. ________
9. ________ MR/HR.
~~10.~~ ________
~~11.~~ ________ ~~MR/HR~~
~~12.~~ ________ ~~MR/HR~~

All readings taken
3 feet from floor

~~Figure 10. Activatio~~

Surveyed by ____________________

Date ____________________

Figure 10. Activation Room Survey Log

~~FIGURE 11~~ 12

QUARTERLY CALIBRATION/MAINTENANCE CHECKLIST

DATE	INITIALS	
		1. Activation Run Log. Complete log for each run cycle. 2. Kr-85 Specific Activity Log. Complete record of loss and usage. 3. Curie Receipt Log. Receipt on-hand quantities of Kr-85. 4. Activation Console. All cycles operating normally in both manual and automatic modes. 5. Functional test of all alarm and warning systems. 7. All lights and indicators functioning. 8. Calibrate Ratemeter counting station 9. Clean activation chamber, filler blocks and O ring. 10. Change vacuum pump oil if necessary. 11. Review film badge records. 12. Review radioactive material licenses and conditions. 13. Change compressor oil if necessary. 14. Calibrate pressure, vacuum gauges and vacuum switch. 15. Perform Leak Test and determine new monthly specific activity after maintenance. 16. Measure exhaust blower efficiency. Must be 750 CFM minimum Actual_______CFM.

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Figure 11. Quarterly Calibration/Maintenance Checklist

FIGURE 12

GEIGER MUELLER SURVEY METER LOG

To Be Performed Weekly

DATE	NAME	BATTERY	CHECK SOURCE	
			HI.	LOW

Figure 12 Geiger Mueller Survey Meter Log

~~FIGURE 13~~

MONTHLY TRACER FLO SAFETY CHECK LOG

RADIATION SAFETY ALARM	HATCH ALARM	BLOWER ALARM	TESTED BY	DATE	COMMENTS

Figure 13 Monthly Tracer-Flo Safety Check Log

~~FIGURE 14~~

MAINTENANCE LOG

DATE	NAME	DETAILED DESCRIPTION OF MAINTENANCE PERFORMED

Figure 19. Maintenance Log.

SUBJECT: KRYPTON 85 LEAK TEST EQUIPMENT, MAINTENANCE AND CALIBRATION REQUIREMENTS

Reference MPS 122.68 and 122.68 SUPPLEMENT.

1. SCOPE

1.1 This specification describes the procedures and documentation necessary to adequately and safely maintain and calibrate the Krypton 85 Leak Test System.

NOTES: a. This specification shall be used in conjunction with MPS 122.68. All requirements of MPS 122.68 must be met.

b. No changes to this MPS shall be instituted without prior approval of the cognizant Radiation Safety Officer.

c. Unless otherwise specified in this document, all mainte nance and calibration must be performed with personnel certified to service Trio Tech Kr 85 equipment present.

d. All maintenance/calibration performed, with the exception of the daily ratemeter calibration, shall be recorded in maintenance log (Figure 14).

2. RATEMETER CALIBRATION/SETUP

NOTES: a. Calibration is to be performed daily.

b. This calibration may be performed without the presence of the Radiation Safety Officer.

2.1 Set "POWER" switch "ON". Allow 10-minute warm-up.

2.2 Remove the plug from the scintillation crystal cavity.

2.3 Set "METER" switch to "HV".

NOTE: Note the high voltage reading. It should correspond to the voltage recorded on the Scintillation Plateau Curve Log (Figure 8). Record the required information in the Ratemeter Daily Calibration Log (Figure 4). Adjust high voltage if necessary.

2.4. Set "METER" switch to "CPM".

2.5 Set "TIME CONSTANT" knob to "10.0".

2.6 Set "METER RANGE" knob to "5K".

2. RATEMETER CALIBRATION/SETUP (Continued)

2.7 Push reset button and record counts per minute (CPM). Take two additional readings and record the average background of the three readings. Adjust "GO/NO-GO" needle to _ CPM above the average background reading. Record the required information in the Ratemeter Daily Calibration Log (Figure 4).

2.8 Place Kr-85 standard vial into the scintillation cavity and push the reset button. Record the reading and take two additional readings. Calculate the average of the three readings. Record the information in the Ratemeter Daily Calibration Log.

2.9 Remove the Kr-85 standard and return it to its storage location.

2.10 Replace plug over the scintillation cavity.

2.11 Set "TIME CONSTANT" knob to "1.0".

3. KRYPTON-85 SPECIFIC ACTIVITY CALCULATION

NOTE: The Kr-85 gas concentration shall be determined by Department 24-9 in conjunction with Department 27 the first working week of each month or whenever greater than 2 psi change is observed in storage pressure from the previous run cycle. Use Geiger-Mueller survey meter placed next to sample vial during this test.

3.1 Remove bottom panels as necessary to expose the control panel and hand valve "C".

3.2 Place aluminum filler blocks in the activation chamber and close chamber.

3.3 Attach sample vial to fitting at hand valve "C". Place stopcock on sample vial in the open position.

3.4 Turn the main key control switch to the "MANUAL" position.

3.5 Turn the sample key to the "ON" position.

3.6 Open hand valve "C".

3.7 Set "FILL" toggle switch to "ON" (this opens Valves 13 and 14).

3.8 Adjust vacuum gage indicator to .1 mm on the activation console control panel.

3.9 Record run information in the Activation Run Log (Figure 2).

3.10 Depress "EVACUATE" button on the activation console control panel. Allow system to pump down for 10 minutes.

3. KRYPTON-85 SPECIFIC ACTIVITY CALCULATION (Continued)

3.11 Depress "OFF" button on the activation console control panel.

3.12 Observe both vacuum gages for stable readings. If an upward deflection is observed on the gage on the control panel, this indicates a leak in the fittings attaching the sample vial. Retighten if necessary. The entire system must be leak-free prior to continuing.

3.13 Set "FILL" toggle switch "OFF" and close hand valve "C".

3.14 Readjust vacuum gage indicator to .5 mm on the activation console control panel.

3.15 Depress "EVACUATE" button.

3.16 When "EVACUATE COMPLETE" light comes on, depress "ACTIVATE" button.

3.17 Depress "OFF" button when 2.5 psi is indicated on the activation pressure gage.

3.18 Set "FILL" toggle switch to "ON" and slowly open hand valve "C".

3.19 Wait 3 minutes, then depress the "STORE" button.

IMPORTANT: As the system is pumping down towards 2 mm (as indicated on the vacuum gage) slowly close hand valve "C". When vacuum gage on the supervisor's control reads exactly 2 mm, close hand valve "C" completely while simultaneously closing the stopcock on the sample vial. The sample vial must have exactly 2 mm of gas inside in order to accurately measure the system specific activity.

3.20 Set "FILL" toggle switch to "OFF".

3.21 Turn the sample key to the "OFF" position. Allow system to pump down until the "STORE COMPLETE" light is lit.

3.22 Depress "VENT" button.

3.23 Remove sample vial.

3.24 Log run information in the Activation Run Log (Figure 2).

3.25 Take sample vial and Kr-85 standard to the Ratemeter station.

3.26 Remove plug and plug retainer from the scintillation crystal cavity.

3.27 Set Ratemeter power switch "ON". Allow 10-minute warm-up before proceeding.

3. KRYPTON-85 SPECIFIC ACTIVITY CALCULATION (Continued)

3.28 Set meter switch to "HV READ" and record the high voltage reading on Kr-85 Monthly Specific Activity Log (Figure 1). All further readings will be recorded on this form.

3.29 Set "METER" switch to "CPM".

3.30 Adjust time constant knob to 10.0.

3.31 Adjust meter range knob to 5K.

3.32 Press reset. Record background reading. Read and record background a total of three times. Average the three background readings and record the average.

3.33 Adjust meter "RANGE" knob to 50K.

3.34 Place the sample vial into the scintillation crystal cavity.

3.35 Press reset button. Subtract the average background reading from the observed reading and record. Repeat this procedure to obtain a total of three readings. Average the three readings and record.

3.36 Remove the sample vial from the scintillation crystal cavity and return it to the activation room. Open the stopcock by the exhaust fan to allow the Kr-85 gas to dissipate.

3.37 Adjust meter "RANGE" knob to 100K.

3.38 Place the Kr-85 standard vial in the scintillation crystal cavity.

3.39 Press reset button. Read meter and subtract the average background reading to determine the actual count. Repeat this procedure to obtain a total of three readings and record. Average the three readings and record.

3.40 Repeat 3.3 through 3.38 to obtain two additional gas samples. When all gas samples are completed proceed to the next step.

3.41 Replace plug retainer and plug over the scintillation crystal cavity.

3.42 Reset ratemeter controls:

a. "TIME CONSTANT" knob to 1.0
b. Meter Range Knob to 5.0K
c. Meter Switch to "CPM"

3.43 Perform the following steps on the activation console.

3.44 Turn main key control switch to "AUTOMATIC".

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3. KRYPTON-85 SPECIFIC ACTIVITY CALCULATION (Continued)

3.45 Replace bottom panels.

3.46 Return all materials to their proper storage location.

3.47 Complete all data entry as follows:

3.47.1 Using the readings obtained at the ratemeter, calculate the Kr-85 Monthly Specific Activity Log (Figure 1).

3.47.2 Record all required information in the Curie Receipt Log (Figure 9).

3.47.3 Record the new calculated activation pressure or activation time in the Activation Run Log (Figure 2).

3.48 Adjust the activation pressure indicator to correspond to the pressure in 3.47.3 if necessary.

3.49 As an alternate procedure, activation pressure may be held at a specified value and activation time varied in order to achieve proper system sensitivity.

4. PREVENTIVE MAINTENANCE SCHEDULE - ACTIVATION CONSOLE

4.1 Weekly (may be performed without Department 24-9 present).

4.1.1 Verify hatch alarm is functioning properly.

4.1.2 Check that hatch cover moves smoothly and locks properly in the upright position.

4.1.3 Clean hatch cover, inside and out with glass cleaner.

4.1.4 Inspect the latch solenoid and switch for proper operation.

4.1.5 Open hatch and check for smoothness of travel.

4.1.6 Open activation chamber.

4.1.6.1 Remove O-ring and clean. Check for damage.

4.1.6.2 Clean O-ring groove and bottom of cover with disposable wipes (Kimwipe) and isopropyl alcohol (IPA).

4.1.6.3 Apply a thin film of Apiezon high vacuum grease to the O-ring surface and replace into the seal groove.

4.1.6.4 Close hatch and check for smoothness of travel.

4.1.7 Verify exhaust blower alarms are functioning properly.

4. PREVENTIVE MAINTENANCE SCHEDULE - ACTIVATION CONSOLE (Continued)

4.1.8 Verify radiation alarms are functioning properly.

4.1.9 Verify power failure alarms are functioning properly.

4.1.10 Verify storage high alarm is functioning properly.

4.1.11 Check that all lights are working properly.

4.1.12 Perform activation room survey and record radiation levels at designated points in the Activation Room Survey Log (Figure 10).

4.2 Monthly (requires Department 24-9 presence)

4.2.1 Check that Vacuum Pumps 1 and 2 have the proper oil level. Add oil if necessary.

4.2.2 Inspect V-belts on Vacuum Pumps 1 and 2. Replace if necessary.

4.2.3 Inspect cabinet interior for oil leaks and foreign material.

4.2.4 Verify that the vacuum pump block gage reads 20 inches.

4.2.5 Inspect the external physical condition of all solenoid valves.

NOTE: Use Geiger-Muller Survey meter when entering the cabinet through the lead doors.

4.2.6 Remove all filler blocks from the activation chamber. Clean with IPA and disposable wipes. Inspect chamber interior for foreign material. Clean with IPA.

4.2.7 Verify activation console is functioning properly in both manual and automatic modes during all phases of the cycle run.

4.2.8 Check all safety alarms and record in monthly Tracer-Flo Safety Check Log (Figure 13).

4.3 Quarterly (requires Department 24-9 presence)

4.3.1 Inspect exhaust fan for proper operation. Verify that exhaust blower is exhausting 800 cfm minimum. Record actual reading obtained on the Quarterly Maintenance checklist (Figure 11).

4.3.2 Calibrate vacuum and pressure gages and vacuum switch (reference Pages 37 to 39 of Tracer-Flo maintenance manual).

4.3.3 In conjunction with Department 24-9, verify and perform all items on Quarterly Calibration/Maintenance checklist (Figure 11).

4. PREVENTIVE MAINTENANCE SCHEDULE - ACTIVATION CONSOLE (Continued)

4.4 Semi-annally (requires Department 24-9 presence).

4.4.1 Change oil in Vacuum Pump 1. Check radioactivity level of the used oil using the Geiger-Mueller Survey Meter. If the reading is above 2 mr/hr, store the oil in an open container inside the rear of the activation console until the activity level drops below 2 mr/hr. The oil can then be disposed of through normal salvage methods.

4.4.2 Certify radiation meter (reference page 40 of Triotech maintenance manual).

4.5 Annually (requires Department 24-9 presence).

4.5.1 Rebuild all solenoid valves.

4.5.2 Change oil in Vacuum Pump 2.

4.5.3 Change oil in compressor.

NOTE: Used vacuum pump and compressor oil must be stored in an open container inside the rear of the activation console until the radiation level drops below 2 mr/hr. The oil can then be disposed of through normal salvage methods.

4.5.4 Change V-belts on both vacuum pumps.

4.5.5 Certify Geiger-Mueller Survey Meter, pocket dosimeters and charger/reader.

4.5.6 MANDATORY: Leak test all fittings and valves.

4.5.7 Perform Kr-85 specific activity.

4.5.8 Certify radiation meter (reference Page 40 of TrioTech maintenance manual).

5. PREVENTIVE MAINTENANCE SCHEDULE - RATEMETER (Department 24-9 presence is not required for any Ratemeter calibration)

5.1 Daily

5.1.1 Calibrate ratemeter (Paragraph 2.0).

5.2 Monthly

5.2.1 Verify the photomultiplier tube height is 1/2-inch below the casting surface.

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5. PREVENTIVE MAINTENANCE SCHEDULE - RATEMETER (Continued)

5.2.2 Check for proper lid balance and tension.

5.2.3 Clean the scintillation crystal cavity with disposable wipes and IPA.

5.2.4 Run scintillation plateau curve (TrioTech ratemeter manual, Page 5, Paragraphs 4 through 4f).

5.3 Quarterly

5.3.1 Calibrate ratemeter (reference TrioTech Ratemeter manual, Page 8, Paragraph 8).

5.3.2 Remove cover and clean interior.

6. SUPPLEMENT

6.1 Refer to MPS 122.68-01 SUPPLEMENT, dated , for figures.

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ITEM 16

KRYPTON 85 RADIATION SAFETY MANUAL

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TABLE OF CONTENTS

1

INTRODUCTION

1.1 Objectives

The purpose of a radiation protection program is to establish safe working conditions where Kr-85 is used. Besides safeguarding company and client personnel, we want to provide maximum protection for the public at all times. Additional purposes are to establish safety procedures and a system of recording which will meet the requirements of Federal, State and local agencies and keep exposures to radiation as low as reasonably achievable.

This Radiation Safety Manual contains standards and procedures for the control of exposure of personnel to radiation. It is not the intent to give detailed procedures for each situation, but to provide a guide to accomplish work involving radiation in a safe and efficient manner.

1.2 Personal Responsibility

The primary responsibility for radiation protection lies with the individual and his supervisor. Each individual is also responsible for the safety and welfare of others in his work area, and for observing and obeying all applicable rules and procedures. Each supervisor is responsible for seeing that all radiological safety rules and procedures are followed, all personnel are properly instructed in radiation protection, and work involving radiation is performed safely. It is also each worker's responsibility to notify the Radiation Safety Officer immediately of any unusual incident involving radiation or any changes in procedure or working conditions which have not been previously evaluated.

Figure 1 shows the Radiation Safety Organization.

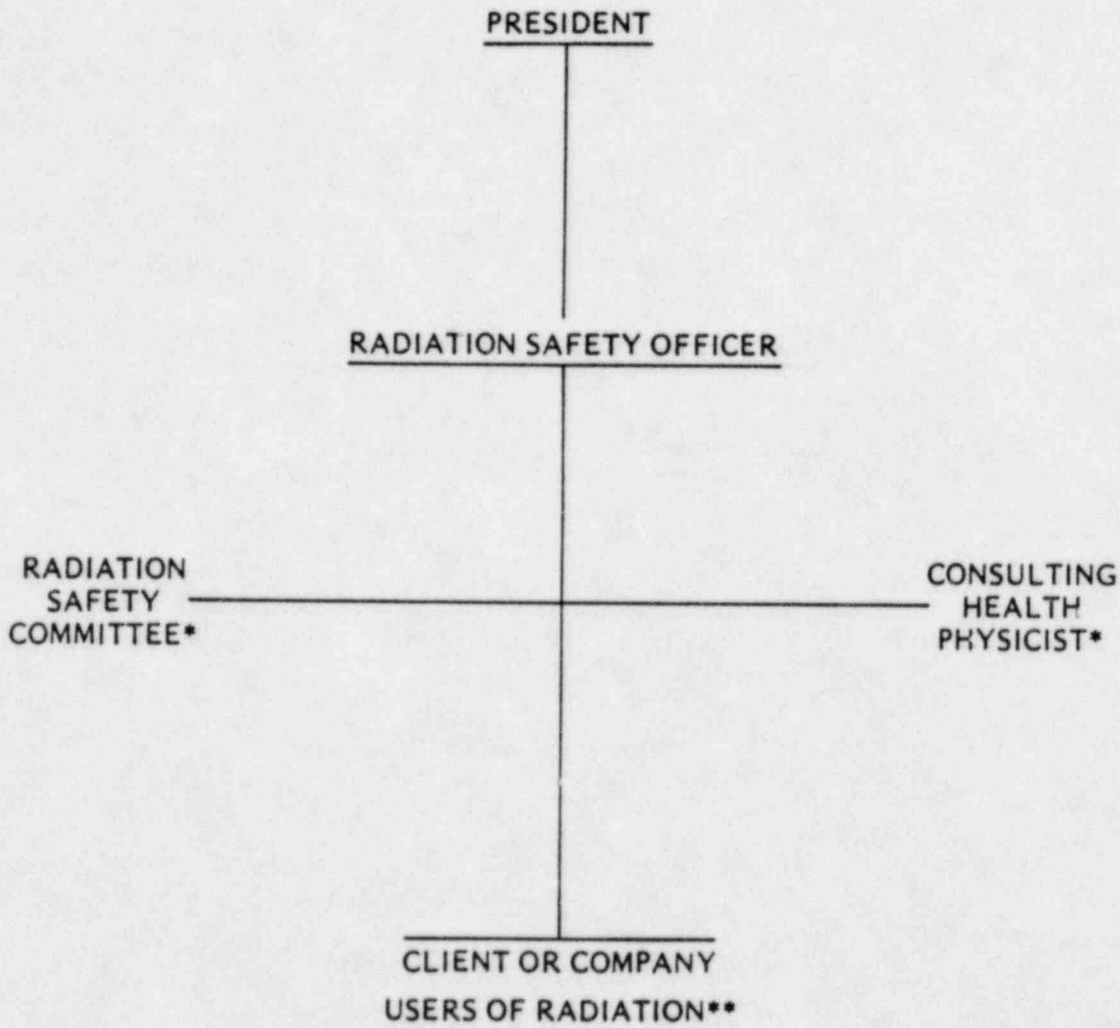
1.3 Responsibility of the Radiation Safety Committee, Radiation Safety Officer, and Health Physicist

A Radiation Safety Committee is not a legal requirement for the TRACER-flo® system, but may be used at the option of the individual company using the equipment. In the absence of the Radiation Safety Committee, the Radiation Safety Officer assumes the responsibilities of the committee.

It is the responsibility of the Radiation Safety Committee to review procedures, license applications, and new experiments when significant radiological hazards exist. The Committee may, at its discretion, establish policies and procedures for using radioactive materials.

FIGURE 1

RADIATION SAFETY ORGANIZATION



* Not a legal requirement.

** The responsible users of the TRACER-flo® equipment will be named on the license and thereby approved by the state licensing agency.

It is the responsibility of the Radiation Safety Officer to verify that the radiological safety procedures are followed by all personnel and to insure compliance with all applicable Federal and State regulations pertaining to radiation protection. It is also his responsibility to maintain required radiation records.

The Health Physicist or Radiation Safety Officer will make an initial survey during the first application of any new procedure involving radioactive materials.

1.4 Radiation Control Regulations

The basic reference document for this radiation safety manual is: Title 10, Part 20 of the Code of Federal Regulations (10CFR20) "Standards for Protection Against Radiation".

* NOTE *

For licensing in other countries, the appropriate regulations would be cited here . . . .

1.5 The Nature of Krypton-85

Kr-85 is a radioactive gas which decays with a 10.7 year half-life. Most decays are accompanied by the release of a beta ray (electron) with about 0.7 MeV of energy. In about ½ of 1% of the decays, a weak beta and a gamma ray of about 0.5 MeV are released. The stronger beta ray can travel up to 6 feet in air, and can penetrate up to 2½ mm into tissue. The major biological effect is to produce injury to exposed skin. The beta rays are too weak to penetrate to the sensitive layers of the eye. As a noble gas, Krypton is practically insoluble in body tissues. In the event Kr-85 gas is inhaled into the lung, the lung tissue receives only 1.7% the dose to the skin from the same concentration.

RADIATION EXPOSURE STANDARDS

2.1 General

It is a mandated policy to keep radiation exposure as low as reasonably achievable. Therefore, it is the responsibility of each individual to keep his exposure as low as possible, consistent with discharging his duties. The present exposure limits have been established in accordance with the Code of Federal Regulations (10CFR20) for persons working in the nuclear industry such that job performance can be accomplished with no detectable bodily injury. These limits have also been established at levels low enough such that exposure to radiation due to normal medical and dental X rays need not be included in the accumulated dose of the individual. However, it is the responsibility of the individual to see that any unusual medical or dental radiation exposure is recorded in his exposure history.

2.2 External Radiation Exposure

Table 1 gives the permissible radiation exposure values based on the quarterly values given in 10CFR20.101.

TABLE 1

OCCUPATIONAL DOSE EQUIVALENT LIMITS

Location		mrem/week	rem/qtr	cSv/week	Sv/qtr
1.	Whole body; head and trunk; active blood forming organs; lens of eyes; or gonads	100	1.25	0.1	0.0125
2.	Skin of whole body	600	7.5	0.6	0.075
3.	Hands and forearms; feet and ankles	1500	18.75	1.5	0.1875

The weekly values are guides only and may be exceeded provided the total exposure for the quarter does not exceed the value specified above. The dose to the whole body may be increased with approval of the Radiation Safety Officer to 3.0 cSv per quarter provided the radiation history of the individual has been established and his total accumulated occupational exposure in rems will not exceed 5(N-18) where "N" equals his age at his last birthday.

For Kr-85, exposure is due chiefly to beta rays absorbed by exposed skin. For occupational workers, doses from radioactive gases are limited by not allowing the gas concentration in air to exceed a maximum permissible concentration (MPC). The MPC value for Kr-85 is 3.7×10^5 Bq/m^3 per cubic meter of air averaged over a 40 hour work week.

2.3 Internal Radiation Exposure

Since Krypton gas is essentially inert and insoluble, internal radiation exposure will be negligible under conditions in which external exposures are within the permissible levels.

2.4 Emergency Exposure

In case of an emergency situation, personnel may receive doses in excess of the permissible levels. Certain incidents require notification of the licensing authority. Notification may be required immediately, within 24 hours, or within 30 days. Consult the Radiation Safety Officer or 10CFR20.403 to determine notification requirements in the event of an emergency.

2.5 Over-Exposure

In case an individual receives exposure in excess of the prescribed limits for any calendar quarter, he shall be removed from any exposure until further notice. An investigation of each over-exposure shall be conducted. Appropriate reports shall be made to State and local authorities as prescribed by law.

3

CONTROL OF RADIATION EXPOSURE

The official area designations as given in 10CFR20 are presented in subsections 3.1 and 3.2.

3.1 Controlled (Restricted) Areas

Controlled area means any area to which access is controlled by the user for purposes of radiation safety pursuant to the provisions of this regulation. Airborne radioactivity areas, high radiation areas, and radiation areas shall be considered controlled areas. Controlled areas shall not be any areas used as residential quarters.

A controlled area is one in which access is controlled by doors, barriers, signs, guards or ropes. Any area where radiation is present in sufficient quantity to create the conditions described below must be designated a controlled area:

> Radiation intensities are such that whole body exposure in excess of 5.7×10^{-5} cSv/hr may occur, averaged over 1 year.
>
> Airborne radioactivity in excess of the concentrations for unrestricted areas may occur. For Kr-85, the limit is 1.11×10^{4} Bq per cubic meter.

There shall be no eating or smoking in restricted or controlled areas. Means shall be provided for monitoring personnel exposure in controlled areas. If needed, protective clothing and respiratory equipment shall be used.

3.2 Uncontrolled (Unrestricted) Areas

An uncontrolled area is any area which is not a controlled area for radiation safety purposes.

3.3 Radiation Badges

A major technique for controlling personnel doses is the use of radiation badges. Persons operating or maintaining the TRACER-flo® unit are radiation workers, and must wear their radiation badge when entering the restricted area in the vicinity of the machine. The badges are not to be taken away from the plant at the end of the work day. They must be worn with the front of the badge exposed to room air. Take care that clothing or other material doesn't cover the badge. Beta rays are readily stopped by clothing, so the badge will not record your true dose unless it is completely uncovered. Badges should be collected and replaced monthly by the Radiation Safety Officer.

3.4 Purchasing of Radioactive Materials

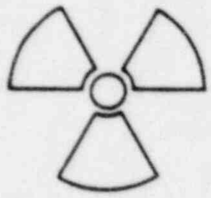
It is the responsibility of any person authorizing the purchase of radioactive materials to obtain the approval of the Radiation Safety Officer before the purchase order is issued. The Radiation Safety Officer is responsible for verifying that the purchased radiation material does not exceed the limits set forth in the radioactive materials license.

4

WARNING SIGNS, SYMBOLS, BARRIERS

4.1 Signs

The radiation warning sign colors are yellow and magenta. This color combination shall be used only in conjunction with radiation sources or areas and for establishing the boundary of the controlled areas.



The radiation symbol is shown above. The symbol is magenta and the background is yellow. Barrier rope is yellow and magenta plastic braided rope.

4.2 Radiation Area

"Radiation area" means any area, accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive in any one hour a dose in excess of 0.005 cSv, or in any 5 consecutive days a dose in excess of 0.1 cSv.

Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION
RADIATION AREA

4.3 High Radiation Area

"High radiation area" means any area, accessible to personnel, in which there exists radiation originating in whole or in part within licensed material at such levels that a major portion of the body could receive in any one hour a dose in excess of 0.1 cSv.

Each high radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION
HIGH RADIATION AREA

4.4 Airborne Radioactivity Area

As used in the regulations in this manual, "airborne radioactivity area" means (i) any room, enclosure, or operating area in which Kr-85 gas exists in concentrations in excess of 3.7×10^5 Bq per cubic meter or (ii) any room enclosure, or operating area in which Kr-85 gas exists in concentrations which, averaged over the number of hours in any week during which individuals are in the area, exceed 9.25×10^4 Bq per cubic meter.

Each airborne radioactivity area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION
AIRBORNE RADIOACTIVITY AREA

5

TRANSPORTATION OF RADIOACTIVE MATERIAL

The interstate transportation of radioactive materials is under the jurisdiction of the Federal Department of Transportation under the authority of the Code of Federal Regulations, title 49.

The intrastate transportation of radioactive materials is governed by State regulations. Before radioactive materials are transported, the Radiation Safety Officer will be advised. He will review and approve transportation procedures and labels.

6

Kr-85 RADIATION EMERGENCIES

A. Notify all persons to vacate area immediately.

B. Stop source of Kr-85 gas leak if this can be done in a few seconds time.

C. Vacate area and permit no one to enter.

D. Notify the Radiation Safety Officer or Health Physicist.

E. Monitor and record the radiation levels outside the room involved.

F. Do not re-enter the area or resume work without the express permission of the Radiation Safety Officer.

RECEIPT AND OPENING OF Kr-85 GAS CYLINDERS

BEFORE PROCEEDING, EXAMINE THE WIRE/LEAD SEAL ON THE VALVE HANDLE AND EXAMINE THE WAX SEAL ON THE VALVE TENSION NUT AND THE WAX SEAL ON THE BLIND GLAND. IF ANY SEAL IS BROKEN, RETURN THE LOADED CYLINDER TO TTI. IF ALL THREE SEALS ARE INTACT, PROCEED AS FOLLOWS:

1. Break the seal at the blind gland and connect the cylinder to your gas-handling vacuum system. Without breaking the wire/lead seal on the valve handle or the wax seal on the tension nut, pump against the closed valve to determine whether or not a leak is present. If a leak is detected, disconnect the cylinder, replace the blind gland, replace the protective cap on the cylinder, and return the cylinder to TTI.

2. If no leaks are detected, the wire/lead seal on the valve handle may be broken and the cylinder pressure verified and the contents removed.

   CAUTION: Do not break the wax seal on the tension nut for any reason. This seal must be intact when cylinder is returned to TTI.

IMPORTANT NOTE

Be sure to complete the logbook entry for each new cylinder accepted.

ITEMS 16,17

RADTRACE CO.

3821 SOUTH TEAKWOOD STREET (714) 731-7055
SANTA ANA, CALIFORNIA 92707

NRC License No. 04-13104-01

January 7, 1985

Mr. R. Lareau
C/O General Dynamics Corp.
P.O. Box 2507
Pomona, Ca. 91766

Dear Mr. Lareau,

This letter is to confirm that you and John Baker successfully completed the Tracer-Flo training course conducted at Micro-Rel Inc. January 20, 1982.

The course covered radiation safety, unit operation and maintenance.

You demonstrated your ability in operation of the equipment and safety aspects, both by written examination and practical application to assume responsibility for control of the By Product Material on your license.

Sincerely,

C. Gene Bell

C. Gene Bell
General Manager

70155

RICHARD L. LAREAU

RESUME OF QUALIFICATIONS

319 Garfield Avenue
Placentia, California 92670

Telephone (714) 528-5214

SUMMARY OF QUALIFICATIONS:

Scope of Experience

Background encompasses over 20 years in the field of Electronics, with an emphasis on hands-on Hybrid Technology. Also extensive Quality Assurance experience.

Areas of Expertise

-- Complete Facilitization Including Layout, Equipment & Staffing
-- Personnel Training & Management
-- All Areas of Hybrid Technology: Substrate Design ... Layout ... Art Work Preparation ... Printing ... Firing ... Trimming ... All Assembly Techniques ... Encapsulation/Sealing ... Final Testing
-- Cost Analysis
-- Research & Development

EXPERIENCE:

Mar 1980-Aug 1982

Micro Rel (Division of Medtronics) Tempe, AZ
PROCESS ENGINEER
Responsible for processing, quality and yield of chip carrier assemblies used in high reliability pacemakers. Includes die bond, automatic wire bond, seam seal, Hi Rel environmental testing. Through tooling design leading to automation, substantially improved thruput and yield.

Duties included process engineering responsibilities for Trio-Tech Kr-85 radioactive gas fine leak test equipment. Directly responsible for implementation and control of all procedures, log books, maintenance, calibration and operation of this system. Successfully completed radiation safety course which covered nuclear physics, chemistry, biology, as well as all measurement instruments utilized in a radiation environment. Course also included detailed theory, operation and maintenance of the Trio-Tech equipment.

1978-1980

Custom Devices Tempe, AZ
PROCESS ENGINEER
Responsible for quality, yield and process parameters for multilayer hybrid thick film substrates utilized in pacemakers and commercial product line. Includes all phases of thick film manufacture, die attach, wire bond, reflow solder techniques, and encapsulation on commercial line.

1974-1978

Talley Corporation
Westclox Division-Wristwatch-High Volume Commercial LaSalle, IL
Electrodynamics Division-Military Products Rolling Meadows, IL
HYBRID FACILITY MANAGER
Responsible for initial setup of successful prototype production thick film facilities at both divisions. Included equipment selection, facility layout, staffing, training and supervision of all subordinate personnel. Handled design and complete cost analysis of all new hybrid designs. Involved material, labor and yield factors, and resulted in significant cost reduction and increased yields. Implementation of processes for prototype and production manufacture.

Applied working and technical knowledge of all phases of thick film techniques and active device attachment techniques including thermal-compression ball-bonding, beam lead and ultra-sonic wedge bonding.

continued....

1970-1974 Sparton Electronics Jackson, MI

HYBRID MICROCIRCUIT LAB MANAGER

Responsible for initial setup of thick film facility for the manufacture of MIL-SPEC thick film modules. Designed and manufactured prototype and production modules for both commercial and military application.

1969-1970 Solitron Devices Old Tappan, NY

THICK FILM PROCESSING ENGINEER/PRODUCTION SUPERVISOR

Responsible for all quality control and production personnel involved in the manufacture of high volume commercial thick film substrates utilized in automotive application.

1967-1969 Columbia Components Hempstead, NY

QUALITY CONTROL/PROCESS MANAGER

Responsible for all quality control and inspection personnel. Generated and maintained all specifications from initial design and manufacture, through final environmental testing to insure process integrity. Total responsibility for all phases of High-Rel Minutemen Missile hybrid processing, quality control and test.

Prior Experience Garrett Corporation
AiResearch Division Los Angeles, CA

Began career with this organization as Electrical Inspector. Rapid promotions to Lead Man, Foreman, General Foreman, Laboratory QA Manager and to

SUPERVISOR, MICROCIRCUIT LABORATORY

Directed all phases of research and development of hybrid thin and thick film microcircuits for this company's initial entry into this field. Promoted from

LABORATORY QUALITY ASSURANCE MANAGER

Responsible for supervising all QA functions in various electronic nucleonic and electromechanical laboratories. Supervised outside source inspection on classified projects. Responsible for monitoring all production, environmental and reliability testing as well as review of test procedures and reports. Included interface with numerous NASA and company QA representatives for witness and inspection of various items and functional tests.

On special assignment reported directly to top AiResearch management as a division troubleshooter to resolve particular production quality problems.

MILITARY: United States Navy -- Honorable Discharge

REFERENCES: Excellent personal and professional references are available and will be furnished upon request.

GENERAL DYNAMICS
Pomona Division
P.O. Box 2507, Pomona, California 91769 • 714-620-7511
Material Center • 714-620-6411; East Valley Plant • 714-987-0075

Stamement of Radiological Training and Experience

User: James G. Kulleck

Title: Design Specialist

Organization: General Dynamics, Pomona Division

Address: 1675 W. Mission Blvd.

City: Pomona Zip: 91769

State: California

State Radiological License No.: 1096-70

Federal Radiological License No.: Sub-1086

Generally Licensed Radiological Materials:

sealed sources of ^{147}Pm, ^{204}Tl and ^{90}Sr used for measuring the thickness of plated coatings. ^{14}C labeled Test solutions for surface characterization studies. ^{3}H used in static monitoring instrumentation.

Federally Licensed Source Material:

less than 1000 kilograms of solid depleted uranium, molydenum alloy (98% / 2% respectively) encased in 0.15 inch thick nylon sabots.

User's Educational Background:

Highest earned degree: Ph.D.

University: University of Texas- Austin, Texas

Major Course of Study: Nuclear Physics

Minor Course of Study: Mathematics

Radiologically Related Studies:

Nuclear Physics - 54 hrs.

Selected Topics in Nuclear Physics - 54 hrs.

Nuclear Theory - 54 hrs.

Dissertation Studies involved activities related to the detection of high energy particles and the calibration of related equipment.

Extended Education Studies: X-ray diffraction Techniques - 41 hrs.
Radiographic Radiation Safety - 16 hrs.

Statement of Radiological Training and Experience

User's Work Experience:

1. Dates: From Feb. 1979 to present
   Title and Duties: Design Specialist - determine material properties using x-ray and electon diffraction methods and x-ray fluorescence techniques. Plant radiation safety officer - monitor sealed sources and instrumentation for radiation hazard.
   Employer: General Dynamics
   Address: Pomona, California
2. Dates: From Jan. 1973 to Dec. 1979
   Title and Duties: General Manager - determined elemental composition of materials using energy dispensive x-ray fluorescence techniques.
   Employer: Analex, Inc.
   Address: Anaheim, Calif.
3. Dates: From Sept. 1970 to Nov. 1972
   Title and duties: Adjunct Assistant Professor of Physics--taught nuclear physics laboratory course and participated in various cyclotron experiments in a "controlled area" (Type B) laboratory. Also used microcurie ^{55}Fe sources for calibrating equipment.
   Employer: University of California
   Address: Los Angeles, California
4. Dates: From Jan.1967 to Aug.1970
   Title and Duties: Research Assistant - participated in various nuclear and atomic physics experiments using a Van de Graaff accelerator in a "controlled area" (Type B) laboratory. Also, used microcurie ^{55}Fe and millicurie ^{60}Co and ^{249}Cf sources for calibrating equipment and experimental studies.
5. Dates: From Jan. 1965 to Sept. 1965
   Title and Duties: Student - participated in laboratory exercises using nuclear physics instrumentation and curie strength Pu-Be source.
   Employer: St. Edward's University
   Address: Austin, Texas

RESUME OF QUALIFICATIONS

JOHN J. BAKER
P.O. Box 771
Phoenix, Arizona 85001

Telephone: (602) 966-3464 Home
(602) 968-6411 Work
(602) 242-4460 Message

OCCUPATIONAL OBJECTIVE: I am seeking to affiliate with a reputable organization which recognizes accomplishment and drive and rewards accordingly. I hope to gain additional skills and expertise to complement my previous educational and employment background.

EXPERIENCE:

11/80 to Present

MEDTRONIC/Micro-Rel
2343 West 10th Place
Tempe, Arizona 85281

<u>IC Assembly Operations Product Planner</u> (Internal Promotion)

My primary responsiblity as Product Planner is to coordinate the generation and implementation of the IC Assembly Operations Factory Plan and to supervise IC Assembly Operations scheduling, expediting, and administrative reporting.

Various aspects of the job are:
•To coordinate, review and publish the KCR Response and IC Assembly Operations Factory Plan.
•To supervise and coordinate product scheduling, expediting, and implementation of the weekly schedules.
•To distribute appropriate weekly reports to applicable groups that provide visibility of product status, yield and schedules.
•To assist in determining manufacturing capacity and limitations.
•To coordinate the changing of manufacturing variables such as yield, labor, utilization and cycle time which are interactive with the product planning process.
•To monitor the start-up and completion of product lines to ensure the necessary raw materials are available and potential obsolescence is minimized.
•To interface with Materials Requirements Planning to ensure the availability of all critical piece parts.
•To act as a focal point to ensure that the IC Assembly Operations Factory Plan is consistent with the Hybrid, Thick Film and Wafer Fab KCR responses.

<u>I.C. Assembly Production Supervisor</u> (Internal Promotion)

The basic job responsibilities I was assigned as Production Supervisor of I.C. Assembly were as follows:

- To meet production schedules.
- To ensure that the proper procedures were being followed.
- To plan efficient methods of production so as to optimize utilization of equipment and personnel in order to maximize productivity of the department.
- To interpret administrative policies for employees, review employee performance, and recommend salary increases.
- To interface with both direct and indirect support groups to ensure a common understanding of plans, schedules, problems, processes, etc.
- To select personnel to meet staffing requirements, maintain appropriate personnel records, evaluate employee performance, develop performance plans, and to administer discipline as required to run a safe and efficient manufacturing environment.
- To conduct communication meetings to keep employees abreast of current status of projects pending and future goals relative to the department and company.
- To identify problem situations and improvement methods; then, work with the appropriate personnel for resolution and implementation.
- To monitor product yields, HPC's, product flow, etc., to ensure maximum efficiency and effectiveness of all I.C. Assembly Operations.
- To assist in developing the fiscal year budget and then monitor expenditures and performance.

Sustaining Process Engineer (Internal Promotion)

The primary function of my work was to provide engineering support to Production in the manufacture of integrated circuit assemblies.

Various job responsibilities were:

- To develop, evaluate and implement potential new processes, new process controls and new materials to be used for the packaging and assembly of integrated circuits.
- To disposition product with process and material related defects.
- To implement new package designs and modify existing designs to achieve optimum assembly yields.
- To participate in vendor presentations of new equipment, materials, etc., to determine possible application to present assembly and support activities.
- To implement cost awareness and yield enhancement ideas beneficial to the reliability and expediency of processing in IC Assembly Operations.
- To review, revise and initiate all process and support specifications/documentation critical to IC Assembly processes.
- To institute mechanical and visual inspection criteria to ensure hi-rel integrity meeting or exceeding MIL-STD-883 specifications.

Sustaining Process Technician

Basic responsibilities included:
•To provide engineering support to Production for the setup and troubleshooting of assembly and hi-rel environmental test equipment.
- I successfully completed the "Basic Setup and Adjustments Course for the K & S Model No. 1419 Automatic Wire Bonder" which I attended in Horsham, Pennsylvania.
- I also successfully completed the "Tracer-Flo Training Class" conducted by Gene Bell.
- Other equipment I utilized and maintained are as follows:
    - Laurier Die Bonders
    - Unitek, Westbond and Hughes Wire Bonders
    - Nikon and Olympus Microscopes
    - SSEC Seam Sealers
    - Trio-Tech Gross Leak Pressurization System and Bubble Tester
    - Centrifuge by Centrisafe
    - SSE Temperature Cycle
    - Adco-Tech Automatic Marker

•To provide training to operators on new equipment, processes and process controls.

EDUCATION:

EDUCATION:	St. Mary's High School Phoenix, Arizona	Graduated 1973
	Arizona State University Tempe, Arizona	Bachelor of Science Degree in Management earned in 1978

REFERENCES: Excellent personal and professional references are available on request.