HEALTH PHYSICS AND SAFETY DIVISION

HEALTH PHYSICS AND SAFETY DIVISION

1972 ANNUAL PROGRESS REPORT

August 1, 1973

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

IN
F
O
R
M
A
L

R
E
P
O
R
T

BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York 11973

HEALTH PHYSICS AND SAFETY DIVISION
Informal Report

ANNUAL PROGRESS REPORT
January 1 - December 31, 1972

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

August 1, 1973

N O T I C E

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, or any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

MASTER

Table of Contents

	<u>Page</u>
Forward	i
Organization Chart	ii
A Radiation Monitoring and Alarm System (Amcos II) for Habitable Areas of an Accelerator Complex - Louis M. Picinich and Carl H. Distenfeld	1
A Digital Environmental Monitor - John D. Chester and Robert L. Chase	2
Direct Measurements of Dose Equivalent in Aircraft - F.P. Cowan, J.D. Chester, A.V. Kuehner and L.F. Phillips	3
Sampling and Analysis of Radioactive Substances in the Atmosphere - Andrew P. Hull	4
Sternglass: A Case History - Andrew P. Hull and Ferdinand J. Shore	4
Reactor Effluents: As Low as Practicable or as Low as Reasonable? - Andrew P. Hull	6
Portable Mixed Radiation Dose Equivalent Meter - A.V. Kuehner, J.D. Chester and J.W. Baum	7
Minimizing Surface Dose with Medium Z Electron Shields - John W. Baum and Leigh F. Phillips	8
Environmental Monitoring TLD Studies - James T. Gilmartin and John W. Baum	9
Evaluation of Alternate Methods of Charcoal Filter Efficiency Determination - Nathaniel A. Greenhouse, Jr.	16
Training - Nathaniel A. Greenhouse	17
Semi-automatic Film Ready - Alan V. Kuehner	20
Calibration Facility - John D. Chester and Budd S. Pollock	21
TLD Extremity Dosimeter - Leigh F. Phillips	22
Radiological Assistance Plan - Leigh F. Phillips	23
Secondary Calibrator Using Sr-Y Betas - Michael Verderosa, John D. Chester and John W. Baum	24

Table of Contents con't.

	<u>Page</u>
Automation of Gamma Spectroscopy - Joseph A. Ash	25
Nanometer Energy Deposition Studies - J.W. Baum, M.N. Varma, A.V. Kuehner, C.L. Wingate and R. Brommage	25
Nanometer Dosimetry Using Liquid Scintillators - Eugene Levin and John W. Baum	27
Developmental Study of Personnel Neutron Dosimetry at the AGS - Carl H. Distenfeld and Joseph R. Klemish, Jr.	30
Expected Energetic Secondary Neutrons Missing in 200 MeV Proton Water Shield - Carl H. Distenfeld	31
Preliminary Report - Halon 1301 Fire Tests - John B. Deitz	32

Forward

During the past year, we have instituted a new series of technical reports. These are designed to disseminate information about the work underway in the BNL Health Physics & Safety Division prior to, or in lieu of, final publication.

This document, which summarizes our technical activities during 1972, has been selected for extended distribution. This is being done to acquaint our colleagues with this series.

If you would like to receive Health Physics & Safety Informal Reports as they are issued, or if you would like copies of specific reports listed at the end of this report, please let us know.

Charles B. Meinhold
Division Head
Health Physics & Safety Division

HEALTH PHYSICS & SAFETY DIVISION
C. B. WEISBOLD, Division Head (4209)

J. W. BALM, Associate Head (Technical)
R. W. YOUNG, Associate Head
(Safety & Plant Protection)

Secretaries: A. D'Esposito (4208)
V. Suara (4267)
D. Thompson (4207)
Administrative Officer: L. Snydan (4228)

J. W. BALM (4207)

Instrument Maintenance & Development

J. Chester* (4212)	G. Hughes (4212)
B. Pollock (3120)	A. Neo (3120)
E. Hagelberg (4212)	R. Zantopp (4212)

Research & Special Projects

J. Ash (4211)	
A. Kuchner (4226)	
M. Varma (4226)	

AGS Special Measurement & Shielding Studies

C. Distenfeld (4640)	
J. Klemish (4640)	

L. C. ENDA (4267)

Waste Disposal & Reclamation

S. Pearsall (3277)	F. Kulesa (3277)
E. Walsh (4038)	M. Lewis (3277)
	M. Sanders (3277)

A. P. HILL (4210)

Environmental Monitoring & Internal Dosimetry

R. Williams (4211)	E. Hartmann (4216)
J. Steimers (4216)	D. Henze (4216)
	J. Noble (4210)

Collaborators: F. Haughey
M. Heller
J. Hunter
E. Levin
C. Wingate

Legend:
* Affirmative Action Representative
** Deputy Affirmative Action Representative
*** S. S. Coordinator
**** Training Supervisor

W. R. CASEY (4660)

Alternating Gradient Synchrotron (AGS)

F. Costello (4660)	G. Jayne (4660)
T. Malinowski (4660)	R. Long (4660)
	L. Polywoda (4660)
	W. Turbill (4660)
	(vacancy)

C. W. FLOOD* (4207)

Medical-Biology

N. Carter (3572)	H. Verry (3572)
------------------	-----------------

Chemistry-Physics

R. Gardner (4027)	E. Edwards (4027)
	R. Vargas (4309)

S. A. GREENHOUSE** (4207)

High Flux Beam Reactor (HFBR)

A. Humm (4424)	J. Batdorf (4424)
	D. Morris (4424)
	J. Roessler (4424)

Applied Science

A. Lukas (4482)	W. Wilschusen (4482)
-----------------	----------------------

L. F. PHILLIPS (4207)

Personnel Monitoring

C. Sweeney (4215)	M. Dohrman (4215)
	D. German (4215)
	M. Krupski (4215)

Dosimetry

J. Gilbratn (4215)	
--------------------	--

R. W. YOUNG (4265)

Safety Engineering

P. Edwards (4267)	
H. Schulman (4267)	
G. Hall (4267)	

Fire Protection Engineering

J. Dettl (4265)	
-----------------	--

Fire Group (4215)

L. Seidman (Chief) (4215)	W. Nirkowski (Capt.)
M. Kinney (Asst. Ch.)	P. Peters (Capt.)
	F. Strier (Capt.)

Firefighters:

N. Carroll	F. Leon
L. DiPietro	D. McKenna
B. Duran	D. Medeck Jr.
V. Drenowski	R. Mosley
R. Dunn	F. Painter
G. Eleazer**	R. Phillips
R. Farmer	J. Rhodes
J. Farrell	R. Safrank
D. Gilliam	S. Takata
J. Kenny	A. Teixeira
M. Lalush	R. Werner
	T. Wilson Jr.

Police Group (4238)

A. Paskiewicz (Chief) (4238)

F. Bugala (Capt.)	W. Austin Jr. (Sgt.)
E. Eichler (Capt.)	G. Baer Jr. (Sgt.)
D. Hettlerick (Capt.)	J. Gonde (Sgt.)
W. Stafford (Capt.)	J. Meyer (Sgt.)
K. Wocel (Capt.)	M. Mooney (Sgt.)

Patrolmen:

R. Baulch	D. Jackson
A. Berretta	R. Lee**
L. Doreckel	L. Lento
J. Conley	S. Lonski
W. Dawson	M. McAllister
D. Grant	R. McKenzie
A. Greener	M. Montcalve Jr.
B. Gauthrey	W. Pollack
C. Hulac	F. Remiszewski
T. Laroed	H. Richardson Jr.
	H. Weinmann

Contract Services: (4264)
B. Gardner, Shorthand
T. Schmitt, Optician

A Radiation Monitoring and Alarm System (Amos II)
for Habitable Areas of an Accelerator Complex, *

Louis M. Picinich** and Carl H. Distenfeld

AMOS II was developed as a radiation monitor for use in experimental areas of the Alternating Gradient Synchrotron (AGS). AGS pulse width variations, several microseconds to one second within standard repetition rates, dictate the use of an integrating type detector. The detector assembly consists of a polyethylene lined, ethylene filled integrating pulse discharge ionization chamber (IPDIC) and associated electronics. This assembly may be operated remotely from the AMOS II chassis. The alarm feature is field adjustable and consists of local audio and visual indicators plus a remote area coded alarm sent via radio telemetry to Health Physics Operations. Manual reset of this alarm initiates reminder alarms of 10 seconds duration and repetition periods inversely proportional to dose rates, as long as the alarm condition exists. Interconnected AMOS II units will allow simultaneous operation of alarm indicators without affecting the independent operation of the individual units. Local indication of prevailing dose rates is accomplished using five dose rate bands to display possible area worktime limitations directly in days or weeks. A detector failure alarm is incorporated in the ratemeter function. Unique modular design was employed to facilitate interchangeability and ease of maintenance.

*Abstract of BNL 17025

**Presently with Grumman Corp., Bethpage, N.Y.

A Digital Environmental Monitor*

John D. Chester and Robert L. Chase

An instrument has been designed to replace the Dynamic Condensor Electrometer to measure the background radiation levels at the boundaries of Brookhaven National Laboratory. The detector is a 2" x 2" tin loaded plastic scintillator, whose energy response is air equivalent, coupled to a bi-alkali cathode 2" photomultiplier tube operated in the direct current mode. The output of the photomultiplier is digitized by a current to frequency converter, and the resultant pulses fed to a scaler. The system is programmed to calibrate itself once an hour to compensate for changes in photomultiplier tube gain due to changes in temperature. During the calibration cycle a number, which is a function of the system's gain, is generated and held in a register, and is then used to weight the data accumulated between calibration cycles. The output data is stored on a six digit non-resetting printing register. The register, which can be programmed to print at any time interval desired, also prints the day of the year, time of day and station number. The instrument, which is calibrated to 10 counts per μR , has a minimum sensitivity of 1 $\mu\text{R/hr}$ and was designed so that it will not saturate at 10 mR/hr , making it useful in the event of an accidental high level activity release. The digital logic is accomplished by the use of integrated circuits mounted on printed circuit boards housed in NIM modules. The detector is housed in an aluminum weather tight container. Two of the units have been in operation for over a year with no significant maintenance problems.

*Abstract of BNL 16922

Direct Measurements of Dose Equivalent in Aircraft*

F. P. Cowan, J. D. Chester, A. V. Kuehner and L. F. Phillips

Measurements of dose equivalent rate have been made in RB-57F aircraft at altitudes up to 60,000 feet using an instrument developed by Baum, Chase and Kuehner. The dose-equivalent meter utilizes an 8" diameter chamber of the type used in the Rossi LET spectrometer, three suitably biased amplifiers for data reduction, a digitizer circuit and a two minute print-out interval. The circuits are arranged to provide values of both absorbed dose rate and dose equivalent rate.

The instrument was flown at elevations of 30K, 38K, 50K and 60 K feet from Eielson Air Force Base, Fairbanks, Alaska during May and June of 1971. Results obtained are summarized in the following table.

<u>Altitude</u>	<u>Duration</u>	<u>Geomag. Lat.</u>	<u>mrad/h</u>	<u>mrem/h</u>	<u>Quality Factor</u>
30,000	42 min.	69.4°	0.159	0.234	1.47
38,000	42 min.	69.6°	0.288	0.489	1.70
50,000	36 min.	68.4°	0.489	0.793	1.62
60,000	46 min.	67.3°	0.603	1.039	1.72

These results agree well with those obtained by Foelsche and by Trout. Similar measurements are currently being made at selected lower latitudes for altitudes of 10, 20, 30 and 40 thousand feet. Results have thus far been obtained at geomagnetic latitudes of 50 and 58 degrees.

*Abstract of BNL 17060. See also Final Report on an interagency agreement between U.S. Atomic Energy Commission and the Environmental Protection Agency, BNL 17291.

Sampling and Analysis of
Radioactive Substances in the Atmosphere

Andrew P. Hull

The Radioactive Substances Subcommittee of the Intersociety Committee on Methods for Air Sampling and Analysis (ISC) has formulated and published nine tentative methods for the sampling and analysis of radioactive substances, and has several more under consideration. Together these include most of the nuclides or classes of nuclides commonly encountered in the environment. A description of these methods, with some of the considerations underlying them, was prepared and is available as a Health Physics & Safety informal report (BNL-17303).

- - - - -

Sternglass: A Case History*

Andrew P. Hull and Ferdinand J. Shore**

Recently Dr. Ernest Sternglass has questioned the adequacy of the AEC's limits for the radiation exposure of the public from the effluents of nuclear facilities. In what appears to be an extension of arguments previously advanced in the context of fallout from nuclear weapons testing, he has indicated the occurrence of excess infant mortality adjacent to

*Abstract of BNL 16613

**Queens College, City University of New York
Flushing, New York 11367

nuclear power reactors, nuclear research and development laboratories, educational and testing reactors, and a fuel reprocessing facility. On this basis he has called for the lowering of standards, a moratorium on the construction and operation of power reactors, and for extensive epidemiological studies to search for low-level radiation effects.

A review of much of Sternglass' fallout-related presentations and of the accompanying commentary discloses much scientific disagreement with his hypotheses. In addition, a comparison of extended time series data for infant mortality with that for effluent releases from five principal facilities implicated by Sternglass, indicates that his correlations are instances of year-to-year statistical fluctuations about long term trends that do not support his arguments.

On the basis of established dose-effect relationships, the average population doses produced by nuclear facility effluents are found to be orders of magnitude too small to produce the claimed mortality. The explanatory mechanisms adduced by Sternglass are not confirmed by experimental research, and depend on intakes of radioactivity into the body which cannot be demonstrated. Infant mortality appears to be so strongly correlated with other variables such as socio-economic circumstances, as to obscure the possibility of making meaningful studies of low-level radiation effects of nuclear facility produced exposures.

Reactor Effluents: As Low as Practicable or as Low as Reasonable?*

Andrew P. Hull

Recent amendments proposed by the U.S. Atomic Energy Commission to 10CFR50, set forth numerical guides to keep radioactivity in light-water-cooled nuclear power reactors as low as practicable. These are intended to restrict the exposures of nearby persons to 1% or less of the current limits to individuals in the general public.

For the most part the amendments contain "across the board" concentration limits, primarily based on their technical practicability. These are radiologically questionable, insofar as they are not related to a projected dose to an individual with reference to specific nuclides, and they are not detectable by straightforward environmental sampling and analysis techniques.

The proposed 1% limits in radiation exposures from power reactor effluents are lacking in scientific warrant insofar as the calculated risk related to current reactor effluents is insignificant, relative to other sources of exposure and other kinds of environmental hazards. If adopted, they would occasion a projected expenditure of from $\$3 \times 10^4$ to $\$1 \times 10^6$ per man-rem saved, which is shown to be excessive on several cost-benefit comparisons.

Design guides for reactor effluent releases based on 10% of current standards would appear adequate to achieve the AEC's intent. To remove public misunderstanding of the possible total population exposure from the operation of nuclear reactors, a population dose limit of 0.017 rem/year to be specifically apportioned to such operation and related activities is also proposed.

*Abstract of paper published in Nuclear News, Vol. 15, No. 11, pp. 53-59, Nov. 1972

Portable Mixed Radiation Dose Equivalent Meter*

A.V. Kuehner, J.D. Chester and J.W. Baum

A portable instrument has been developed which measured both absorbed dose and total dose equivalent rates over 6 orders of magnitude. It is based on a 20 cm diameter modified Rossi-type tissue equivalent linear energy transfer (L) spectrometer. The detector is sealed for up to six months with gas purity maintained by means of a desiccant. Detector microphonics are avoided by using a Benjamin-type electrode structure. Dose equivalent values are obtained by means of a simple electrometer plus biased amplifier system. This system uses the detector as an ion chamber with gas gain, and at the same time as a proportional counter. The total current from the detector is proportional to absorbed dose. Two biased amplifiers give additional gain to pulses from particles with L's greater than 3.5 keV/ μ . These weighted pulses, when added to the current measurement, yield an output proportional to dose equivalent. An internal alpha source permits several calibration checks to be made without external sources or equipment. When tested with monoenergetic neutrons and neutrons plus gammas, the instrument's errors have been less than $\pm 12\%$.

A recent application of the instrument has been to measure the natural background radiation profile at elevations up to 60,000 feet. For this measurement it was adapted for automatic data recording using two voltage to frequency converters and a register which prints the integral doses every 2 minutes. In this form it is capable of monitoring dose rates over 3 decades without range switching.

*Abstract of BNL 17298

Minimizing Surface Dose with Medium Z Electron Shields

J.W. Baum and L.F. Phillips

Surface and 0.1" depth dose studies as a function of distance from a collimated gamma source have shown that a large but easily avoidable surface dose can result from electrons ejected from the source and collimator. This dose is not detected by the usually employed ionization chambers which have walls of 450 mg/cm^2 thickness. The extra undesirable surface dose is very important in x- and gamma-ray therapy routines in radiobiology experiments and in dosimeter calibrations.

Figure 1 shows results obtained using a stainless steel clad ^{60}Co source positioned at the rear end of a 4" diameter by 8" deep hole in a lead collimator. A 1" diameter by 3/4" deep, screen window ionization chamber was used to measure dose in the first 25μ of tissue. To determine the ratio of surface to penetrating dose, measurements were made with and without a 100 mil lucite absorber placed directly in front of the ionization chamber. The ratio of (dose without lucite)/(dose with 100 mil lucite) gives the surface-to-penetrating dose ratio. With no electron shield on the source, the surface-to-penetrating dose increases from about 0.97 to 2.4 as the detector-to-source distance is varied from 300 cm to 26 cm. Placing a 1/8" thick electron shield over the beam port at the source eliminates most of the excess dose and results in a surface-to-penetrating dose which falls from about 0.98 at 300 cm to about 0.90 at 60 cm and then rises slowly to 1.03 at 26 cm.

The improvement achieved by use of copper compared with lucite results from fewer forward scattered electrons produced in shields of intermediate Z.

Data of Hine⁽¹⁾ indicate that material with a Z of ~40 should be somewhat better than copper and near optimum in this respect.

These data illustrate the importance of using a medium Z electron shield near the source for ⁶⁰Co therapy. Similar effects may be expected with other sources such as x-ray machines and Betatrons, the effects would be more pronounced at higher energies and shorter distances. The results also demonstrate the need for careful experimental design and dosimetry in radiobiology experiments involving sensitive tissues or organisms which may be exposed to the source and collimator electrons. Similar considerations are important in the calibration of thin walled dosimeters, although in this case one usually prefers a minimum variation of dose with depth. Thus, use of the 1/8" lucite shield and distances greater than 100 cm are best for calibration purposes.

(1) Hine, G.J., "Secondary Electron Emission and Effective Atomic Numbers", Nucleonics, Vol. 10, pp. 9-15, January, 1952.

- - - - -

Environmental Monitoring TLD Studies

James T. Gilmartin and John W. Baum

General

The Environmental Monitoring TLD field study was begun on May 31, 1972. TLD response to background radiation is currently being measured at six radiation monitoring stations. At four of these stations background measure-

FIGURE 1

ments are also made with the dynamic condenser electrometer (DCE) and digital environmental monitor (DEM) type monitors.

Two types of phosphors are being evaluated: $\text{CaF}_2(\text{Dy})$ and LiF 700. The $\text{CaF}_2(\text{Dy})$ dosimeters are read on a monthly cycle; the LiF 700's are on a 3 month, 6 month and a 1 year cycle. Beginning with the third month a larger size ($1/4" \times 1/4" \times 0.035"$) $\text{CaF}_2(\text{Dy})$ was placed in the field to increase the sensitivity of the monthly dosimeters. Intercomparison measurements are being made between the various systems.

Calibration Procedure and Annealing

Both the CaF and the LiF TLD's are heat annealed in the same manner, i.e., one hour at 400°C and twenty-four hours at 80°C . In addition, both types of TLD's are given a post-exposure annealing at 80°C for twenty minutes just prior to readout.

Calibrations are done using the collimated ^{60}Co source. The CaF TLD's are exposed to the ^{60}Co gammas using the 0.1575" thick Cu sleeve identical to the one used in the field to correct for the energy dependence of the CaF TLD's. The LiF TLD's are exposed to the ^{60}Co gammas inside a teflon sleeve identical to the holder employer for them in the field.

After exposure to a known amount of ^{60}Co gammas, the exposed TLD's are read out in the identical manner as the unknown TLD's from the field. The amount of current per exposure dose gives the calibration factor to calculate the total integrated dose received by the TLD's exposed in the environment.

Both types of TLD are read out over a 30 second period to a maximum temperature of 220°C . The post-exposure anneal eliminates any low temperature traps that could give rise to spurious readings.

Results

To measure the fading effect of the $\text{CaF}_2(\text{dy})$ TLD's, several irradiated dosimeters from a batch are read out on the day of exposure; the others in the batch are placed in the field and are read out at the end of the monthly cycle when the background monitor TLD's are returned for readout. Preliminary data from two months experience shows the larger $\text{CaF}_2(\text{Dy})$ TLD's fade in the order of 12% per month, and the smaller size $\text{CaF}_2(\text{Dy})$ TLD's fade about 11.6% per month.

In order to measure the contribution of self-dosing from the materials under evaluation, part of each batch is inserted into a low background gun barrel shield located inside a shielded counting room. In addition to the heavy concrete and steel shielding, the inner liner of the gun barrel is further shielded by 3/4" of mercury. Table I lists the apparent exposure to each type of phosphor within the gun barrel low background shield.

Table II is a tabulation of the measured station exposures, with corrections for fading, averaged in mR/wk. Stations P-2, P-4 and P-7 are essentially measuring natural background radiation and fallout, while stations P-9 and S-13 are measuring natural background radiation, fallout and the additional increase in background from the ^{137}Cs ecology field source. Station S-6 is located just opposite the Waste Management compound and is also close enough to the ^{60}Co source in the Biology Field to detect the added background from these sources. The ^{60}Co source was removed from operational service on November 1, 1972, which will allow several months data to be compiled on the background increase due to the Waste Management Group's operations without the interference of the ^{60}Co source.

Conclusions

Table III lists the measured background levels in mR/wk determined with the DCE and DEM instruments. A comparison of these results with those of Table II for the TLD systems leads to the conclusion that the CaF detectors are reading low by about 16%. This is most likely due to the added shielding effect for radiations which are not normal to the cylindrical copper shield. (Calibrations are made at normal incidence). Spherical shields will be designed to avoid this in the future.

A large discrepancy in the results of the small $\text{CaF}_2(\text{Dy})$ TLD's vs. the larger $\text{CaF}_2(\text{Dy})$ TLD's in the period of 11/7 through 12/5/72 is as yet unexplained, and would indicate a longer period of evaluation is necessary before a field TLb system can be considered fully operational.

TABLE I - Average mR/week in Gun Barrel Shield

Small CaF_2 (Dy)

(1/8" x 1/8" x 0.035")

Period of Measurement

<u>5/31 - 7/6</u>	<u>7/14 - 8/15</u>	<u>9/20 - 10/11</u>	<u>11/7 - 12/5</u>
0.39	0.59	N.A.	2.28

Large CaF_2 (Dy)

(1/4" x 1/4" x 0.035")

<u>8/18 - 9/19</u>	<u>9/20 - 10/31</u>	<u>11/7 - 12/5</u>
0.24	0.76	0.67

LiF (700)

(1/8" x 1/8" x 0.035")

<u>5/31 - 9/19</u>
1.41

TABLE II - Apparent Radiation Exposures, mR/wk

Small CAF_2 (Dy)
(1/8" x 1/8" x 0.035")

<u>Station</u>	<u>Period of Measurement</u>				
	5/31-7/6	7/14-8/15	8/18-9/19	9/20-10/31	11/7-12/5
P-2	1.25	1.73	-	1.88	3.65
P-4	1.16	1.61	-	1.60	3.69
P-7	1.26	1.62	-	1.52	3.35
P-9	2.38	2.80	-	2.93	4.14
S-6	14.88	15.53	-	31.15	21.25
S-13	1.84	2.66	-	3.51*	3.72

Large CAF_2 (Dy)
(1/4" x 1/4" x 0.035")

P-2	-	-	1.00	1.25	1.59
P-4	-	-	1.02	1.30	1.76
P-7	-	-	1.02	1.36	1.65
P-9	-	-	2.27	2.50	2.74
S-6	-	-	18.84	24.85	17.90
S-13	-	-	1.84	2.18	2.33

LiF (700)
Period 5/31 - 9/19/72

P-2	1.05
P-4	1.11
P-7	0.96
P-9	1.84
S-6	15.42
S-13	1.54

*Reading dubious; neutron source up in adjacent room during readout.

TABLE III - DCE and DEM Results, mR/wk

DCE Measurements

<u>Station</u>	<u>Period of Measurement</u>				
	6/2-7/7	7/14-8/18	8/18-9/22	9/39-11/3	11/10-12/1
P-2	1/55	1.60	1.66	1.63	1.84
P-4	1.68	1.77	1.85	1.79	1.81
P-7	1.71	1.76	1.88	1.84	1.95
P-9	3.11	3.44	3.48	3.26	3.18

DEM Measurements

P-4				(9/16-10/28)
				1.77
P-7		(7/12-8/15)		(9/16-10/28)
		1.59		1.55
P-9	(5/31-6/20)	(7/27-8/2)	(8/31-9/20)	(9/10-11/1)
	3.51	3.58	3.56	3.20

Evaluation of Alternate Methods
for Charcoal Filter Efficiency Determination

Nathaniel A. Greenhouse, Jr.

Annual tests are made of the iodine removal efficiency of the High Flux Beam Reactor (HFBR) exhaust air filtration system. The current method involves intercomparison of air samples taken upstream and downstream of the filters after introducing ^{128}I (25 min half-life) into the exhaust air duct. Though adequate, this method has several disadvantages including personnel exposure problems and "logistics" problems associated with handling a short half-life isotope.

Analytical and experimental studies have been conducted in search of alternative testing techniques which do not require the introduction and collection of radioactive iodine. Adequate sensitivity appeared to be the limiting consideration from the sample analysis standpoint, since the downstream samples are expected to contain 10 to 100 picograms of I_2 assuming a practical initial I_2 input of about 5 grams and a filter efficiency of 99.9+%. The alternatives considered all involved the use of stable elemental iodine and the same basic sampling procedure, with subsequent sample analysis by the following methods:

- (a) activation analysis--Theoretically this technique appeared to be more than adequate with respect to sensitivity and precision. However, the sample collection medium (activated charcoal) was found after activation to have too high a background contribution for an acceptable signal-squared to background ratio. Other collection media and methods were

considered, but all were either too troublesome or too costly.

- (b) mass spectrometry--This technique also appeared to have sufficient sensitivity, but was rejected because of difficult sample handling and preparation problems and high cost.
- (c) x-ray fluorescence--X-ray emission spectrography, particularly with proton excitation, seems the most attractive of the techniques considered for three reasons: (1) the technique is adequately sensitive, (2) the samples can be collected easily on thin activated charcoal-loaded filter paper, and (3) the analytical apparatus is available through the Dept. of Applied Science (DAS), and is planned to be fully automated in the near future for use in DAS air sampling research programs.

An experimental test using this technique is planned for 1973.

- - - - -

Training

Nathaniel A. Greenhouse, Jr.

Health Physics Summer Training Program

The twenty-third annual summer training program for health physics graduate students was conducted from June 10 to August 18, 1972. Sixteen graduate students from Rutgers University, University of Illinois,

University of Kansas, University of Michigan, University of Tennessee, and Rensselaer Polytechnic Institute participated in the standard three-phase program. In addition, four undergraduates from the Radiological Health Physics Program at Lowell Technological Institute participated in a special on-the-job training session which included the orientation portion (Phase I) of the graduate students' program.

Innovations in this year's session included lecture/discussions in safety disciplines other than health physics, health physics and safety training methods, and emergency planning; and student participation in a realistic emergency exercise.

At the end of the summer program most of the graduate students had completed their academic degree requirements and were seeking employment in the health physics field. All but one of them had found suitable jobs by the end of 1972.

Radiation Measurements Short Course

The Health Physics and Safety Division was awarded a grant by the National Institute of Occupational Safety and Health (NIOSH) to develop a short course in basic ionizing radiation protection and measurements. The course was developed in response to the training requirements implicit in the Occupational Safety and Health Act of 1970 in which the Secretary of the Department of Health, Education and Welfare is charged with the responsibilities for education and training to provide an adequate supply of qualified personnel to carry out the mission of the Act.

The document which was developed contained the necessary lesson plans, lecture outlines, and laboratory exercises for a series of five lectures

and two laboratory sessions suitable for presentation at the two-year level. Instructors guides, reference lists, visual aids, and laboratory data sheets were included. The completed document was sent to NIOSH in August 1972.

Noontime Seminar Series

A weekly program of noontime seminars was developed in response to a need for technical cross training of Health Physics & Safety Division professionals and senior technicians in the various safety disciplines. The subjects covered to date have included basic presentations in Health Physics, Industrial Hygiene, Electrical Safety, Fire Safety, and Cryogenics Safety, as well as a series of presentations on the implications and implementation of the Occupational Safety and Health Act. A seminar series on computer programming was completed in May 1972.

Other Health Physics & Safety Training Efforts

Division personnel participated in the following training programs or lecture sessions during 1972.

- (a) Basic training for two new HP&S technicians.
- (b) Four lectures on "The Handling of Radiation Accident Victims" for ambulance drivers and emergency room personnel.
- (c) Two "basic radiation safety and reactor safety" lectures for apprentice electricians.
- (d) HP&S Technicians Refresher Course (under development).
- (e) HP&S Refresher Training for Reactor Crews (under development).
- (f) Emergency Training for Fireman (in progress).

Semi-Automatic Film Reader

Alan V. Kuehner

A digital densitometer has been designed and built which rapidly semi-automatically measures the optical density under the three filter areas Cd, Al and OW (Open window), for each film. The film badge number is entered on a numeric keyboard while these areas are scanned. The information is stored, displayed, and on manual command is printed on a teletype and punched on paper tape. The data from the paper tape is transferred to the CDC 6600 computer via FOCUS (a remote terminal file manipulation system). The computer extracts the dose information and returns it to the teletype and to the 6600 printer. This data is then manually posted in the same manner as the data from the manual densitometer was previously.

A more complex program is being written which will post and maintain nearly all Personnel Monitoring records. This program will store detailed records for each person of his exposures over the past 60 weeks. These records will include the doses recorded by the film badge for neutrons, gamma plus x-radiation, and betas. It will also store records of extremity, forearm, and internal exposures. The program will make available through FOCUS a summary of each person's exposure history.

As part of the development of this program a more accurate film analysis technique has been developed. This technique uses the density information from all three filter areas rather than the two (OW and Cd) used with the previous system. This allows more accurate determination of x-ray, mixed gamma and x-ray, thermal neutron, and mixed gamma plus

thermal neutron exposures. When any of these conditions are detected, corrections are made to the reported dose. For thermal neutron exposures the density under the aluminum filter is used to obtain the gamma dose. This avoids the increase in density under the cadmium filter due to capture gammas. X-ray exposures are determined from a function of the ratio of doses indicated by the aluminum and cadmium filter areas. This ratio is also used to obtain a more accurate measure of any beta exposure which was recorded on the same film as the x-ray exposure. This technique should result in a significant improvement in the accuracy of our film badge dose measurements for persons exposed to thermal neutrons or x-rays.

- - - - -

Calibration Facility

John D. Chester and Budd S. Pollock

As a part of the reorganization of the Instrumentation and Health Physics and Safety Divisions, the Nuclear Instrument Calibration and Maintenance Group was made a part of the Health Physics and Safety Division. Two large 2.25 and 10.4 curie sources were moved to the calibration facility and the building modified to provide a high level calibration range. An exclusion fence has been erected outside the building at 5 mR/hr line and an interlock and safety system installed to control the operation of all sources in the building. The facility is now designed to provide a collimated ^{60}Co gamma field up to 80 R/h; a free air ^{60}Co gamma field up to 2 R/h, and a free air ^{137}Cs gamma field up to 12 R/h. In addition to the gamma sources, a 10 curie PuBe source has been installed to provide a free air neutron calibration facility.

FIGURE 2

TLD Extremity Dosimeter

Leigh F. Phillips

A TLD dosimeter was assembled for a specific personnel extremity problem and is used now as an interim dosimeter for general use at BNL. Two TLD 700, 1/8 inch chips are used for an open window and shield region of a finger ring dosimeter. The old ORNL plastic film ring was modified by cutting a large open window in the plastic cover, allowing several layers of mylar to protect the open window TLD. Beneath this is placed a plastic shield (267 mg/cm^2) covering the "shield" TLD which, in turn, is placed in a machined notch at the base of the ring.

The mixed beta and gamma dose estimates may be made by several methods, depending upon the sophistication in data treatment desired.

Our usual method:

$$G = 0.43 S - 0.026 W$$

$$B = 0.52 W - 0.60 S$$

where: G = gamma exposure in Roentgens
 B = beta dose in rads
 S = net shield charge in nC
 W = net open window charge in nC

A typical calibration curve is shown below.

RAP TEAM EMERGENCY EQUIPMENT

I. PORTABLE KITS

A. Instrument Kit - Color Code = Red (3 each)

- 1) Radector III
- 2) GM Counter (end window + thin wall) one instrument box and head set
- 3) Alpha Scintillator (2 probes)
- 4) Air Sampler and Filter paper
- 5) Integrating Alarm Dosimeter
- 6) Self Reading Pocket Dosimeters (6 each 1 R) + Charger
- 7) Check Sources (on instruments)
- 8) Flashlight (2 cell)
- 9) Dated Batteries (6 each)
- 10) Stop Watch
- 11) 7Li TLD Badges (6 each)
- 12) Plastic Bags (6 each instrument)

B. Data or Reference Kit - Color Code = Blue (2 each)

- 1) Road Maps
- 2) Radiation Handbooks and RAP Manual
- 3) Data Pads, Graph Paper, Pencils, Ruler
- 4) Masking Tape and Rope Tape
- 5) Signs and Tags
- 6) Small Sample Containers
- 7) Tape Measure
- 8) Pocket Knife
- 9) Polaroid Camera and Film
- 10) Smear Books and Filter Paper
- 11) Slide Rule
- 12) Small Plastic Bags

C. Protective Clothing Kit - Color Code = Brown (4 kits for 2 people each)

- 1) Head Covers
- 2) 1/2 Face Respirator and Filters
- 3) Gloves (Heavy Plastic and Autopsy) 2 sizes
- 4) Coveralls (Medium and Large)
- 5) Shoe Covers (Medium and Large)
- 6) Splash Suit + 1 Poncho
- 7) Tape (wide, masking)
- 8) Wash and Dry Packets
- 9) Plastic Bags (Medium and Large)

D. Sample Collection Kit - Color Code = Green (4 each)

- 1) Plastic Bags (3 sizes)
- 2) Sample Containers - Bottles (3-5 sizes)
- 3) Sample Containers - Cans (3-5 sizes)
- 4) Masking Tape
- 5) Grease Pencils
- 6) Trowel
- 7) Tags
- 8) Scissors
- 9) Tongs

II. SHELF ITEMS

A. Radiation Air Sampling Communications Equipment

- 1) Fidler (1)
- 2) Tritium Monitor (2) - one stored at HFBR
- 3) GM Counters (4)
- 4) Neutron Monitors (2)
- 5) Teletector (1)
- 6) Alpha (Scintillator) (7)
- 7) Rad Guns, Jordan (2)
- 8) Geiger, Pocket Type (3)
- 9) CDV-720 Ion Chamber (10)
- 10) Ludlum 11A with 2n + α probes
- 11) CS-40 (3)
- 12) Staplex Air Sampler
- 13) Loud Hailers (4)
- 14) Radios
- 15) Rope
- 16) Hard Hats
- 17) Flashlights
- 18) Binoculars (2)
- 19) Scope (1)
- 20) Gas Masks

III. EMERGENCY TRUCK

A. The following equipment is carried on the Emergency Truck:

- 1) Road Maps
- 2) RAP Manual
- 3) First Aid Kit
- 4) Radio
- 5) Tool Kit ("Fundamental")
- 6) Jumper Cable
- 7) Fire Extinguisher
- 8) Flares
- 9) Blankets (2)
- 10) Shovel
- 11) Flashlight and/or Lamps
- 12) Plastic Tarpaulin

Radiological Assistance Plan

Leigh F. Phillips

Assistance was given to the AEC in developing the Radiological Assistance Plan (RAP) at BNL. This included the reorganization of emergency instrument kits, emergency truck, and updating sections of the RAP manual. The emergency inventory is keyed to the needs of the state as defined in our planning discussions with them. A list of emergency equipment for portable kits, shelf items and the emergency truck is shown below. A detail of capability and organization is published in the AEC Region I Radiological Assistance Plan, Parts I and II, dated November 1972.

Secondary Calibrator Using Sr-Y Betas

Michael Verderosa, J.D. Chester, and J.W. Baum

The precise calibration of gamma sensitive instruments usually requires a well defined free-air calibration source. However, secondary calibrations, which insure that the instrument has not deviated from the initial sensitivity, may be made using a variety of source - detector configurations and relationships. For example, many instruments utilize a small built-in check source to list at least one point on the instrument just prior to use.

To carry this principal a step further, an instrument calibration box has been designed. This box contains a Sr-Y beta source, located in a shielded well. Above the well is a 12" diameter, 3/8" thick lucite wheel containing 12 holes located on a 5.3" radius. These holes contain filters which may be rotated successively into position between source and the instrument being calibrated.

The entire assembly is housed in a clear lucite box having 3/8" thick walls and three windows which allow CS-40, CDV-700, and thin-end-window GM detectors to be conveniently positioned in the radiation field.

Preliminary testing was performed with a 200 μ Ci source. This provided a range of instrument readings from 0.1 mrad/hr to about 200 mrad/hr. A large (50 mc) source will be installed in 1973 to make it possible to check the 50 rad/hr range of the CS-40.

Automation of Gamma Spectroscopy

Joseph A. Ash

The automation of the gamma spectrometry scanning and analysis is presently being pursued. All efforts thus far have been devoted to the computer programming. The program here will be patterned after the HASL system utilizing our newly acquired Northern Scientific Econ II Series Multi-channel Analyzer. The program was initiated to reduce the man hours consumed by the present manual analysis system.

- - - - -

Nanometer Energy Deposition Studies

John W. Baum, Matash N. Varma, Alan V. Kuehner,
Catherine L. Wingate* and Robert Brommage

A large fraction of the radio-biology literature and our earlier modeling work indicated that DNA is probably the primary target of interest in many of the effects induced by radiation in cellular systems. Since the DNA helix is only about 2 nanometers ($20\text{\AA}$) thick, it is assumed that meaningful dosimetry must consider the probability distributions of energy deposition in regions of about this size.

We are examining nanometer energy deposition (NED) patterns in three ways. One method involves the use of a unique variable-pressure ionization chamber (LET_r chamber) with internal screen-walled probe (described in BNL 14767).

* State Univ. of N.Y., Stony Brook, N.Y. 11790

The ionization density, in regions of a few $\text{\AA}$ to a few $1000 \text{\AA}$ from the track of a heavy ion, is explored by means of the movable internal probe. Heavy ion tracks are enlarged relative to condensed media by factors up to 10^8 by using the chamber at pressures down to 10^{-3} Torr. Preliminary measurements have been made for oxygen, chlorine, bromine and iodine ions of energy from about 30 MeV to 120 MeV. Analysis of these results is in progress for comparison of experiment with theory. The track models and computer programs being developed will make it possible to predict results for a wide range of ions and energies including many which cannot be studied experimentally.

A second method being examined employs liquid scintillators. Quenching and track product interactions are being explored since these reflect spatial and temporal aspects of the energy deposition and migration. Through appropriate choice of solvent and quenching agents we can alter the ratio of high NED to low NED response. Early results show that nanometer energy deposition effects are most pronounced in solvents with poor energy transfer properties e.g. p-dioxane (see next report below).

The third type of system investigated was solid thermoluminescent dosimeters (TLD's). NED effects are possible in TLD's due to recombination effects at very high NED values and enhanced sensitivity at lower NED values. BeO was found to be most interesting in this regard. At gamma doses of about 10^4 rads, BeO sensitivity increased to about 20 times its value at 1 rad. At low doses, this results in greater sensitivity to heavy ions than photons, since in the track of a heavy ion a larger fraction of the energy is deposited in concentrations of 10^4 rads and above.

Nanometer Dosimetry Using Liquid Scintillators

Eugene M. Levin* and John W. Baum

We are investigating the possible applicability of quenched organic liquid scintillator systems to nanometer dosimetry. It is known that following irradiation of liquid scintillators by charged particles, quenching of excitation is related to the local density of energy deposition; the ratio of α to β efficiency is less than one due to considerable quenching within the α track. In the preliminary results reported below, the introduction of an additional quencher (chloroform) is shown to affect the fluorescence yields of various scintillators, and in particular, their α/β ratio.

Background

The study of energy transfer from an excited solvent to a fluor shows⁽¹⁾ two distinct effects attributable to quenching of solvent excitation within the high density track of an α particle, as distinct from β excitation characteristics. These are referred to as static and dynamic quenching. The fraction of energy deposited in the solvent under β excitation which can transfer to the fluor (L_β) is greater than the corresponding fraction (L_α) under α particle excitation. Static quenching is attributed to interactions within the α track, over and above the deexcitation processes which compete with energy transfer to the fluor. The first excited solvent state is also susceptible to quenching within the track; this dynamic quenching competes with energy transfer to the solute (fluor). The competition between transfer of energy to the

* York College, CUNY, Jamaica, N.Y. 11432

fluor, and the various de-excitation processes, is investigated by measuring the fluorescence of appropriately excited solutions differing in fluor concentration. The curves which one obtains, of fluorescence vs. fluor concentration, are called transfer curves.

Apparatus

At present, our solutions are contained in quartz vials, cylindrical in shape and open to the air. The bottoms are flat quartz discs, and ID is about 22 mm. Fluorescence is measured from below by an EMI 9635QB photomultiplier (low noise), with integrated readout (no energy discrimination) on a Keithley 419 Picoammeter. The light-tight system permits excitation from above the solution, using α and β sources.

Results

To date, we have studied energy transfer from several solvents to fluors such as phenyl bi-phenyl oxadiazole (PBD) and di-phenyl oxazole (PPO), the latter being favored because of its high solubility. Our initial results with air-equilibrated solutions show the general behavior characteristics of Berlman's ⁽¹⁾ model. Whereas his cited work is restricted to a solvent (xylene) for which the superior transfer efficiency is due to efficient excitation migration through the solvent, we are also interested in solvents (such as p-dioxane) which exhibit lower transfer efficiencies.

The initial processes following passage of a charged particle include a substantial amount of molecular ionization in which the electron remains within the coulomb capture radius of the parent molecular ion. Depending on the di-electric constant of the solvent, this distance can be as much

as 150 Å. Chloroform, as an electron scavenger, can interfere with excitation of solvent molecular state(s) which have the ability to transfer energy to the fluor. Here the fluor never gets a chance to compete for the energy, and the quenching effect should be independent of the fluor concentration.

Figure 3 shows the effect of incremental addition of CHCl_3 to a 5 g/l solution of PBD in o-xylene, scintillator with high transfer efficiency. It is of interest that in this case both α - and β -excited solutions exhibit nearly the same rate of dropoff with the addition of chloroform. Figure 4, in marked contrast, shows the quite different behavior of a dioxane system, a system with poor transfer efficiency. Here the relative effect of added CHCl_3 for the β excited solution is much larger than for the α case.

These latter results are of particular interest in that they confirm our hope that differences between densely and sparsely ionizing radiations could be enhanced by suitable choice of scintillator and quenching agent. This enhanced difference is important since it reflects basic underlying differences in energy deposition and migration patterns occurring in regions of space of the order of a few nanometers in size. Thus, our scintillator system has spatial resolution properties comparable to that of the key biological target molecule (DNA) which has a diameter of about 20 Å.

Since quenching efficiency is a function of both radiation quality (e.g. LET) and concentration of quenching agent, we can develop systems which utilize variations in the latter to measure or deduce "radiation quality" or Quality Factor.

- (1) Berlman, Isadore B., "Luminescence in a Scintillation Solution Excited by α and β Particles and Related Studies in Quenching", J. Chem. Phys. 34, 598-603, 1961.

FIGURE 3

FIGURE 4

Developmental Study of Personnel Neutron Dosimetry at the AGS

Carl H. Distenfeld and Joseph R. Klemish, Jr.*

Neutron exposure at Brookhaven National Laboratory is primarily received by the occupants of the experimental facilities associated with the Alternating Gradient Synchrotron. The exposure field is composed mainly of neutrons and gamma rays of differing composition and energy spectra.

Natural thorium fission track detectors and ^6LiF TLD materials are capable of responding to different parts of the neutron spectra. This provides a discrete response for each exposure spectrum. The personnel monitoring value of a fission track-TLD system depends on consistent dose equivalent response with field location. A multisphere Bonner neutron spectrometer was used to determine the maximum neutron dose equivalent. Concurrently, ^{232}Th fission track detectors and TLD (^6Li and ^7Li) were exposed. This procedure was repeated to establish the variation of calibration constants with field location. The constants weighted over field spectral variations are 3.5 mrem/spark for the Th fission track detector and 0.2 to 0.04 mrem/mR for the TLD difference detectors, depending on spectrum softness defined as TL to track ratio.

The most significant difficulties in employing thorium fission track detection involves the radioactivity of the detector and the prejudice against monitoring exposure with a radioactive dosimeter. In this regard the fission track efficiency was studied with different foil thicknesses

*Abstract of BNL 17452

down to about one micron. It was observed that the production of fission fragments is optimum for foils of about 5 microns thickness. The personnel exposure from a minimally shielded foil of about 5 microns thickness (5 cm^2) is about 1.3 to 2.1 mR/40 hour week at 0.5 cm for foils about 2 to 15 years old.

Expected Energetic Secondary Neutrons Missing
in 200 MeV Proton Water Shield

Carl H. Distenfeld

The start-up survey of the Brookhaven 200 MeV proton linac isotope production facility, BLIP, revealed that the shield offered more attenuation than expected.

Shielding consists of a water-filled stainless steel tank buried in sand and filled to about 32 feet above the proton target point. The proton beam, nominally 10^{15} sec^{-1} , projects horizontally across a part of the 8-foot diameter tank, thus establishing a transverse orientation between beam direction and water shield.

Experimental results indicated about 1/4 less water shielding was needed to reach design leakage levels of 2.5 mrem/hr. This was due to a proton induced secondary neutron spectrum devoid of significant components above about 80 MeV. The design spectrum was harder and therefore more penetrating than the real spectrum, which had a measured attenuation length of 58.2 cm.

Additional study is needed to explain the presence of this significantly softer transverse secondary neutron spectrum. The study should have practical implications for future shielding design.

- - - - -

Preliminary Report - Halon 1301 Fire Tests*

John B. Deitz

Preliminary results were obtained on the first two of a series of five tests in instrument trailers. The test fires were formed in 4 sq. foot pans containing methyl alcohol and paper. The trailer volume was 3200 cu. ft. Measured HF concentration from Halon 1301 decomposition in air after fire extinguishment was on the order of several hundred parts per million. Sufficient Halon 1301 decomposition was found to prevent continued occupancy by personnel in the trailer.

Since approximately 40 trailers were to be equipped with Halon 1301 fire extinguishing systems, additional studies were planned and are in progress.

*Abstract of BNL 13942

down to about one micron. It was observed that the production of fission fragments is optimum for foils of about 5 microns thickness. The personnel exposure from a minimally shielded foil of about 5 microns thickness (5 cm^2) is about 1.3 to 2.1 mR/40 hour week at 0.5 cm for foils about 2 to 15 years old.

Expected Energetic Secondary Neutrons Missing
in 200 MeV Proton Water Shield

Carl H. Distenfeld

The start-up survey of the Brookhaven 200 MeV proton linac isotope production facility, BLIP, revealed that the shield offered more attenuation than expected.

Shielding consists of a water-filled stainless steel tank buried in sand and filled to about 32 feet above the proton target point. The proton beam, nominally 10^{15} sec^{-1} , projects horizontally across a part of the 8-foot diameter tank, thus establishing a transverse orientation between beam direction and water shield.

Experimental results indicated about 1/4 less water shielding was needed to reach design leakage levels of 2.5 mrem/hr. This was due to a proton induced secondary neutron spectrum devoid of significant components above about 80 MeV. The design spectrum was harder and therefore more penetrating than the real spectrum, which had a measured attenuation length of 58.2 cm.

Additional study is needed to explain the presence of this significantly softer transverse secondary neutron spectrum. The study should have practical implications for future shielding design.

Preliminary Report - Halon 1301 Fire Tests*

John B. Deits

Preliminary results were obtained on the first two of a series of fire tests on bookroom fire tables. The test fires were formed in 4 sq. foot pans containing metal shavings and paper. The trailer volume was 1400 cu. ft. Removal of heat from Halon 1301 decomposition in air shows a decomposition rate on the order of several hundred parts per million. Reducing Halon 1301 concentration was found to prevent continued decomposition of material in the reaction.

Tests approximately at scale were to be completed with Halon 1301 fire extinguishing systems. Additional results were planned and are in progress.

*Abstract of NRC 1964