O ...AL LABORATORY

operated by

UNION CARBIDE CORPORATION

NUCLEAR DIVISION

for the

U.S. ATOMIC ENERGY COMMISSION

UNION CARBIDE

ORNL - TM - 2044

EXPERIENCE WITH MAY PACKS IN THE NUCLEAR SAFETY PILOT PLANT

L. F. Parsly, Jr.

NOTICE This document contains information of a preliminary nature and was prepared primarily for internal use at the Oak Ridge National Laboratory. It is subject to revision or correction and therefore does not represent a final report.

ORNL-TM-2044

Contract No. W-7405-eng-26

REACTOR DIVISION

EXPERIENCE WITH MAY PACKS IN THE NUCLEAR SAFETY PILOT PLANT

L. F. Parsly, Jr.

FEBRUARY 1968

OAK RIDGE NATIONAL LABORATORY
OAK RIDGE, TENNESSEE
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

CONTENTS

EXPERIENCE WITH MAY PACKS IN THE NUCLEAR SAFETY PILOT PLANT

L. F. Parsly, Jr.

ABSTRACT

May packs have been used extensively in the Nuclear Safety Pilot Plant to collect fission product samples. This report presents our experience and indicates areas where further development is recommended. We have not tried to present all available data, but rather to present and discuss typical results.

Particular problems include 1) possible loss of efficiency by silver-plated copper screens in the presence of 100 + % relative humidity, and 2) excessive deposition of particulate material in inlet check valves when sampling steam-air mixtures. We think the latter happens because the valve surfaces are wetted by condensate.

INTRODUCTION

The Nuclear Safety Pilot Plant (NSPP) is an experimental facility for study of the behavior of fission products in containment systems.[1-7] It includes a 1350 ft^3 (10 ft dia by 15 ft straight side) vertical cylindrical pressure vessel, a furnace in which UO_2 fuel specimens can be melted by means of a plasma jet, a filter test loop, other auxiliaries, and sampling systems.

May packs are air sampling devices used principally to characterize iodine. The device as originally devised by F. G. May of the Atomic Energy Research Establishment, Harwell, England, consisted of specially cleaned copper screens, a millipore filter, a charcoal-impregnated fiberglass filter and an activated charcoal bed. This since has been modified in several ways, and versions used in the Nuclear Safety Pilot Plant are described in the body of the report.

May packs have been applied in the NSPP to take samples of the model containment vessel atmosphere, the gases being transferred from the furnace into the model containment vessel, gases being purged from the vessel after an experiment, and gases being circulated through the test filter system. Some of the experiments have involved dry air atmospheres; others have involved air-steam mixtures. In the latter, the relative humidity is always 100% and some entrained liquid water may be present. We have used up to 110 May packs in a single experiment, and over the past three years have used several hundred May packs in our experiments.

Consequently, we have accumulated a wealth of data on the performance of May packs in various experimental situations. The purpose of this report is to summarize our experience, and to disseminate the information we have accumulated on May pack performance.

SUMMARY AND CONCLUSIONS

We have found modified May packs to be reasonably effective sampling devices both for runs in which iodine is present alone and runs in which a mixture of fission products is present. Our data show that May packs are effective in collecting essentially all of the activity in the gas samples.

We believe that there are several short-comings in the present May pack design and that some simplification of the devices is also possible. We do not consider it desirable to collect as much of the particulate activity as we do on the inlet check valves. We plan to try keeping the valves dry by using a steam jacket to maintain them at a high enough temperature to prevent condensation.

We suspect that I_2 behaves in a different way in the presence of steam than it does in dry atmospheres. We would like to see experiments conducted to obtain data on the behavior of known iodine compounds in May packs under various conditions. These conditions should include 100 + % relative humidity (i.e., air completely saturated and some liquid water present).

We feel that the best filter medium for particles has not been found. The ideal particle filter would have >99.95% efficiency, be readily soluble (but not in water) and adsorb a negligible quantity of iodine. Solubility is desirable from two points of view: it facilitates electron microscope slide preparation and it makes it practicable to dissolve samples and use some wet chemistry. Our analytical chemists found it almost impossible to get all of the activity off of the absolute filter medium.

We believe it is worthwhile to make a DOP (dioctyl phthalate) test on each May pack to assure proper installation of the high-efficiency filter. When we first did this, we found low efficiencies (ranging down to 85%) on approximately 25% of the May packs. These results led us to modify the filter installation in order to seal the filters better. However, we still find 10 to 20% of the filters initially fail the DOP test (we require >99.95% efficiency).

We believe the role of the charcoal paper should be evaluated critically. We are not sure what, if anything, it is telling us.

We recommend the use of only two charcoal beds, since our data show that additional beds collect neglibible amounts of material.

Our recommendation for a May pack would be as follows:

1. Inlet check valve (to isolate the May pack when no sample is being taken)
2. 5 silver-plated screens
3. Absolute filter
4. Charcoal bed
5. Charcoal bed

We suggest analyses be run as follows:

1. Composite of swabs of check valve inlet and outlet sections plus check valve internals.
2. Silver-plated screen No. 1
3. Silver-plated screen No. 2
4. Silver-plated screens Nos. 3-5
5. Absolute filter
6. Seals, etc., associated with filter
7. Charcoal bed No. 1 (assembled)
8. Charcoal bed No. 2 (assembled).

This is a significant reduction in the number of samples to be analyzed over the totals of 23 (complete loading) or 13 (silver screens plus charcoal paper omitted) which we had in many of the NSPP runs. We suggest that a soluble absolute filter should be used and that wet chemical analyses should be used whenever there is a complex fission product mixture and one isotope dominates. It should be possible to develop procedures in which some fractionation is done and gamma ray spectrometry is used to resolve resulting simpler mixtures.

We think it will be helpful to count the first two silver-plated screens separately from the remainder because the ratio of activity on these two in particular appears to give some significant data on how iodine is behaving.

Any sampler loading one recommends is necessarily a compromise. On the one hand, we want to get all of the useful data possible; on the other, we need to keep cost and time for sample preparation, unloading, and analysis within reason. We feel that the recommended loading and analytical procedure represent a reasonable compromise.

EQUIPMENT

In this section we describe how the May packs are constructed, procedures for assembly and testing, operational techniques and procedures for disassembly and analysis. Since the purpose of the NSPP is to study the behavior of released fission products under conditions simulating those in a water reactor containment building after a loss-of-coolant accident, most of our operation must be carried out remotely, and many of the experiments have been done in steam atmospheres. In the early stages of the program, we decided that it would be best to put the MCV atmosphere samplers inside the vessel. This minimized problems of losses in sampling lines and condensation of steam in the samplers, and we believe it was a good decision.

The purpose of a May pack is to differentiate among the several iodine forms which may exist. The chemistry of iodine is complex, and several iodine forms have been identified. These include elemental iodine (I_2), hydrogen iodide (HI), particulate forms (which probably include both solid iodine compounds and I_2 or HI adsorbed on other solids), methyl iodide and its homologs, and unidentified high-molecular-weight organic iodides. The intent in the original May pack was to collect I_2 on copper, particulates on a membrane filter, the high-molecular-weight organics on charcoal-impregnated filter paper, and the lower-molecular-weight organics on activated charcoal.

May Pack Proper

The May packs for the NSPP have gone through a good deal of evolution in the course of time. Because of the large number of May packs in use, we felt that ease of assembly and disassembly was an important design criterion. In retrospect, our original design (Fig. 1) was too simple. It was impossible to prevent by-passing of a significant part of the flow through the annulus between the inner tubes containing the filters or charcoal and the outer tube. In our present design (Fig. 2) we have overcome this problem by using O-ring seals.

We have used several different particle filter media. We started out using membrane filters. Standard cellulose membrane filters are advantageous in that it is fairly easy to prepare electron microscope slides. However, we found that they wouldn't take the temperatures required for steam runs. High temperature membrane filters are available, but generally these are not easy to dissolve so that the advantage of easy slide preparation is lost. Our second choice was Millipore type AP-20 fiberglass filter medium. Finally we used high-efficiency particulate air filter (HEPA) medium. We did the latter primarily to be consistent with other groups at ORNL. Using the HEPA filter medium has the disadvantage that we cannot buy filters cut to size; usually we get them by disassembling a commercial filter and punching out discs with a gasket punch. The AP-20 medium appeared to give satisfactory performance and can be bought cut to size. All of the filter media appear to collect elemental iodine. Our original thought was to place the silver-plated screens upstream of the particle filter. We felt that whenever both iodine and particulate fission products were present we could use data on the particulates to estimate how much of the particulate iodine might have been stopped on the screens. Recently, we have placed the absolute filters first to be consistent with other workers.

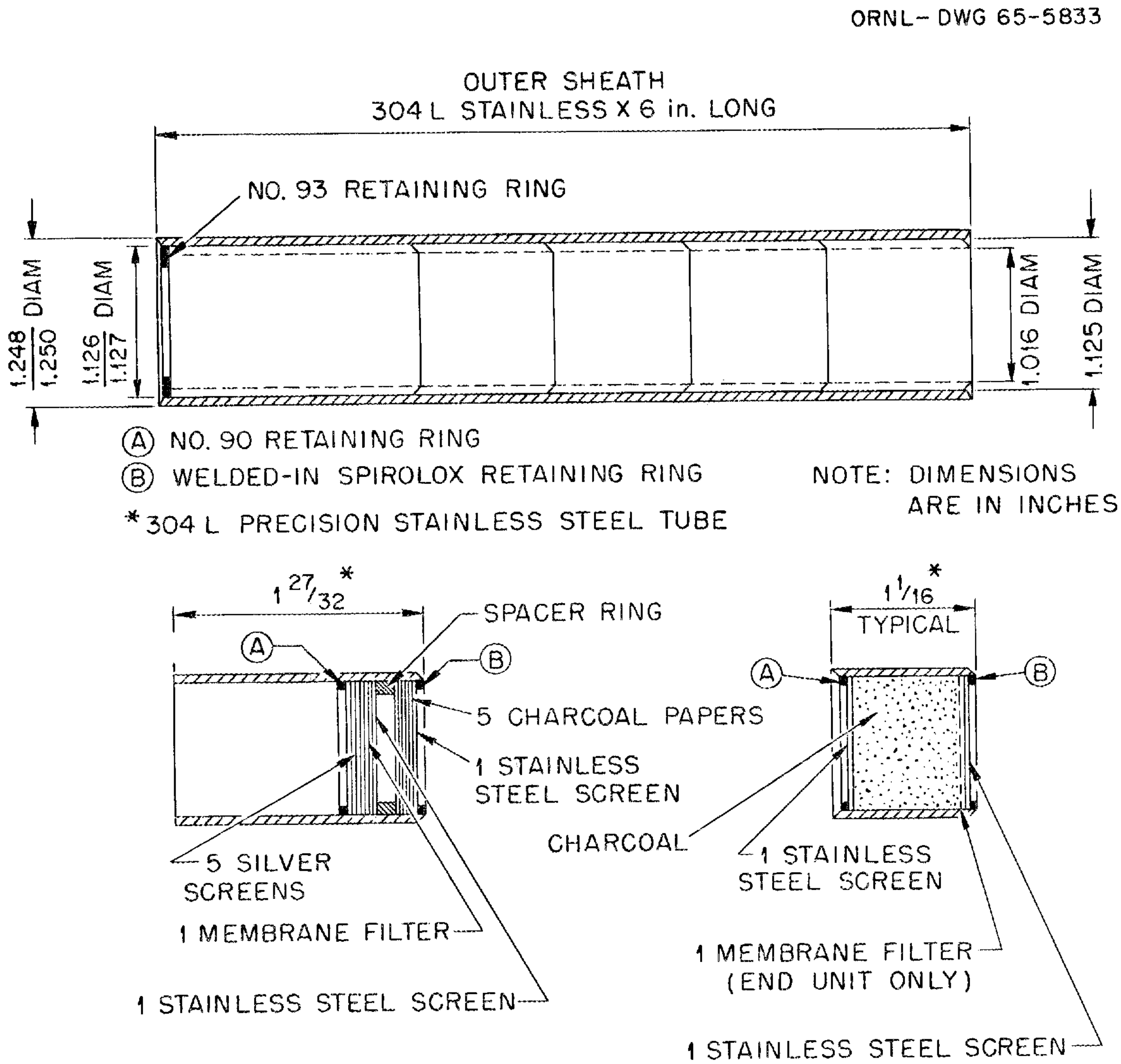

Fig. 1. NSPP May Pack Original Design

ORNL-DWG 67-11058

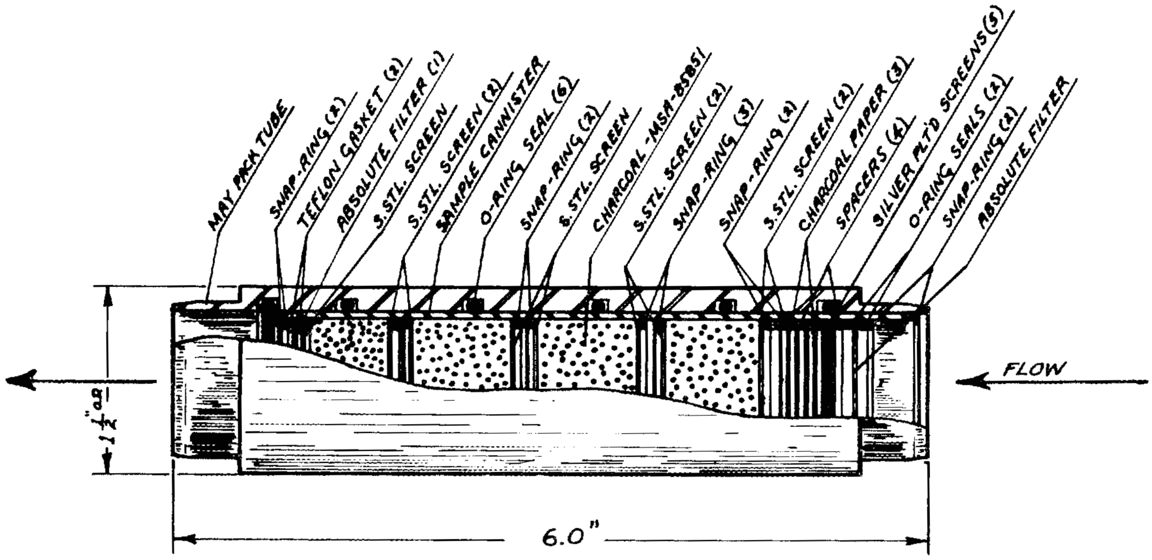

Fig. 2. Modified May Pack Assembly.

We have used five silver-plated 80-mesh copper screens in most of our experiments. We use silver plating because while freshly degreased and de-oxidized copper is more efficient than silver, its shelf-life is measured in hours, while silver retains its efficiency indefinitely. Our May packs frequently have to be assembled 2 to 4 weeks prior to use.

We use three Whatman type ACG/B charcoal-impregnated filters to collect the easily adsorbed organics. May established a precedent for using this material. It seems to be effective, and we have had no reason to change. We have run a few screening tests on other charcoal-impregnated media; none we have tested has been as effective as the ACG/B. Generally, we are not interested in doing sampling media development at the NSPP.

We then use four activated charcoal beds each one-inch deep. We originally used MSA-85851 charcoal (prior to its recognition as a specific for radioactive methyl iodide). This was replaced by Barneby-Cheney Type MI 10x20 mesh. After Parker et al.,[8,9] found that the MSA-85851 charcoal had a high efficiency for collecting methyl iodide under rather adverse conditions, we procured some more of it and started using two plain charcoal beds and two impregnated charcoal beds.

May Pack Clusters

In most cases we need to be able to collect a series of samples from a given sample point during an experiment. To accomplish this, we have designed May Pack Clusters. In these we install several May packs at a given location in a suitable housing, with some means of remotely connecting these in sequence to a vacuum and flow metering system. Up till now, we have designed three types of clusters:

(1) A twelve-May-pack cluster for installation inside the MCV (Fig. 3)

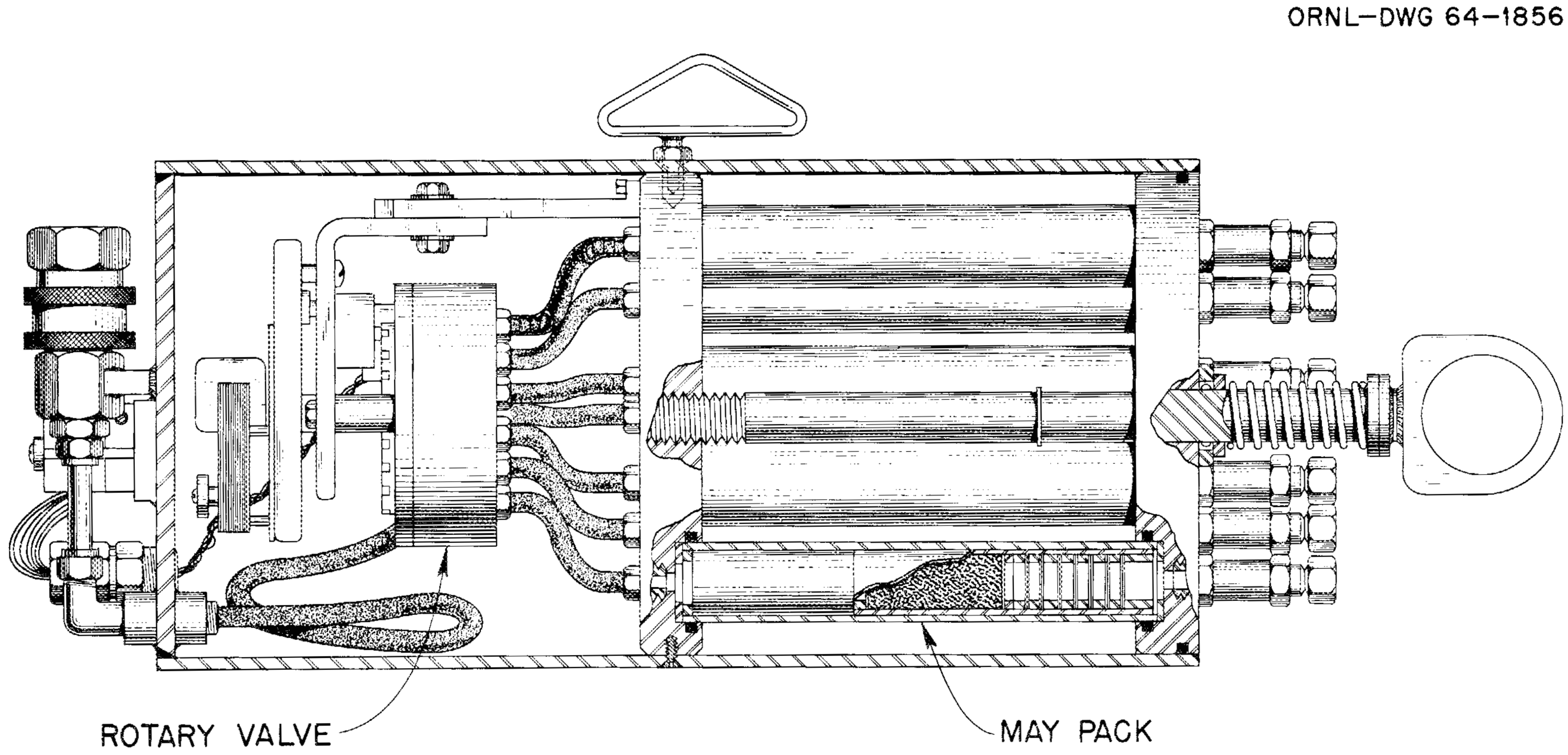

Fig. 3. 12 May Pack Cluster.

(2) A six-May-pack cluster used for applications external to the primary system (Fig. 4)

(3) A steam-jacketed three-May-pack cluster for sampling the line connecting the furnace to the MCV (Fig. 5).

For the first two of the above, we used Gelman sequential valves (Gelman Instrument Company, Ann Arbor, Michigan), for indexing. For application inside the MCV at elevated temperature we replaced the gearmotor furnished with the valve by an Enercon (Energy Conversion Systems Company, Grafton, Wisconsin), stepping motor and replaced the inner valves (bicycle tire valves) with ones containing Viton elastomer parts. For the three-element clusters, we used solenoid valves downstream of the May packs to control flow.

Sample Flow Metering

We originally set flows prior to a run and assumed these would remain constant. However, we ultimately concluded that direct measurement of the flow as each sample is taken is necessary and evolved the following system. The sample leaves the MCV through a vacuum line which is pitched in the direction of flow. A Research Controls pneumatically actuated miniature control valve is used to regulate flow. The air to the valve actuator is controlled by a manual loading station on the panel. The line continues to a condenser located in a chilled water (5^o to 10^oC) bath. Leaving the bath, the gas stream passes through a glass-wool plug to remove entrained moisture and then through a capillary flowmeter. The absolute pressure at the inlet to the capillary and the pressure differential across the capillary are sensed by pneumatic transmitters and displayed on indicators on the control panel. Calibrations of flow vs differential pressure were made at several inlet pressures,and flows are read from the calibration charts.

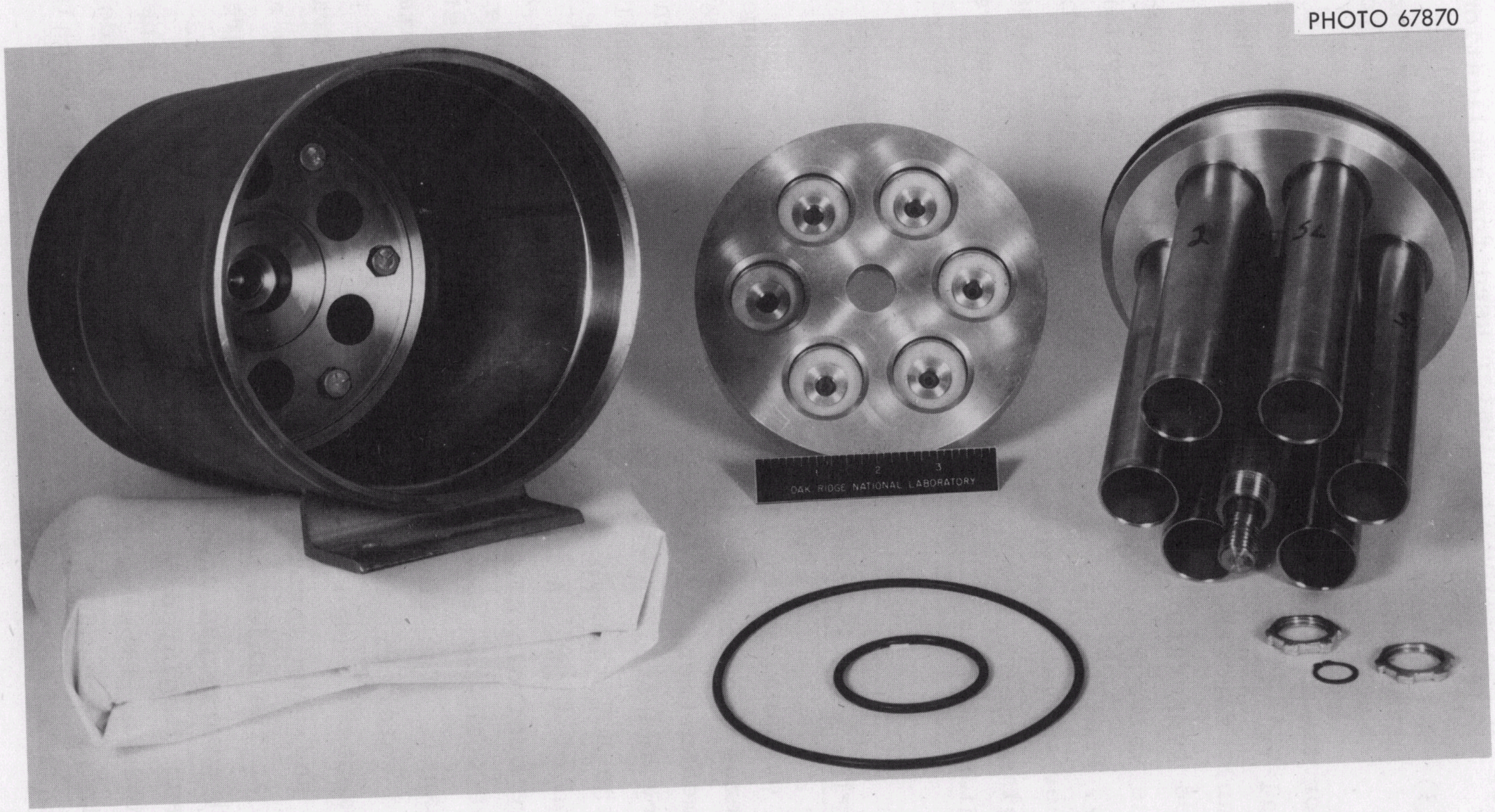

Fig. 4. Six May Pack Cluster.

PHOTO 84386

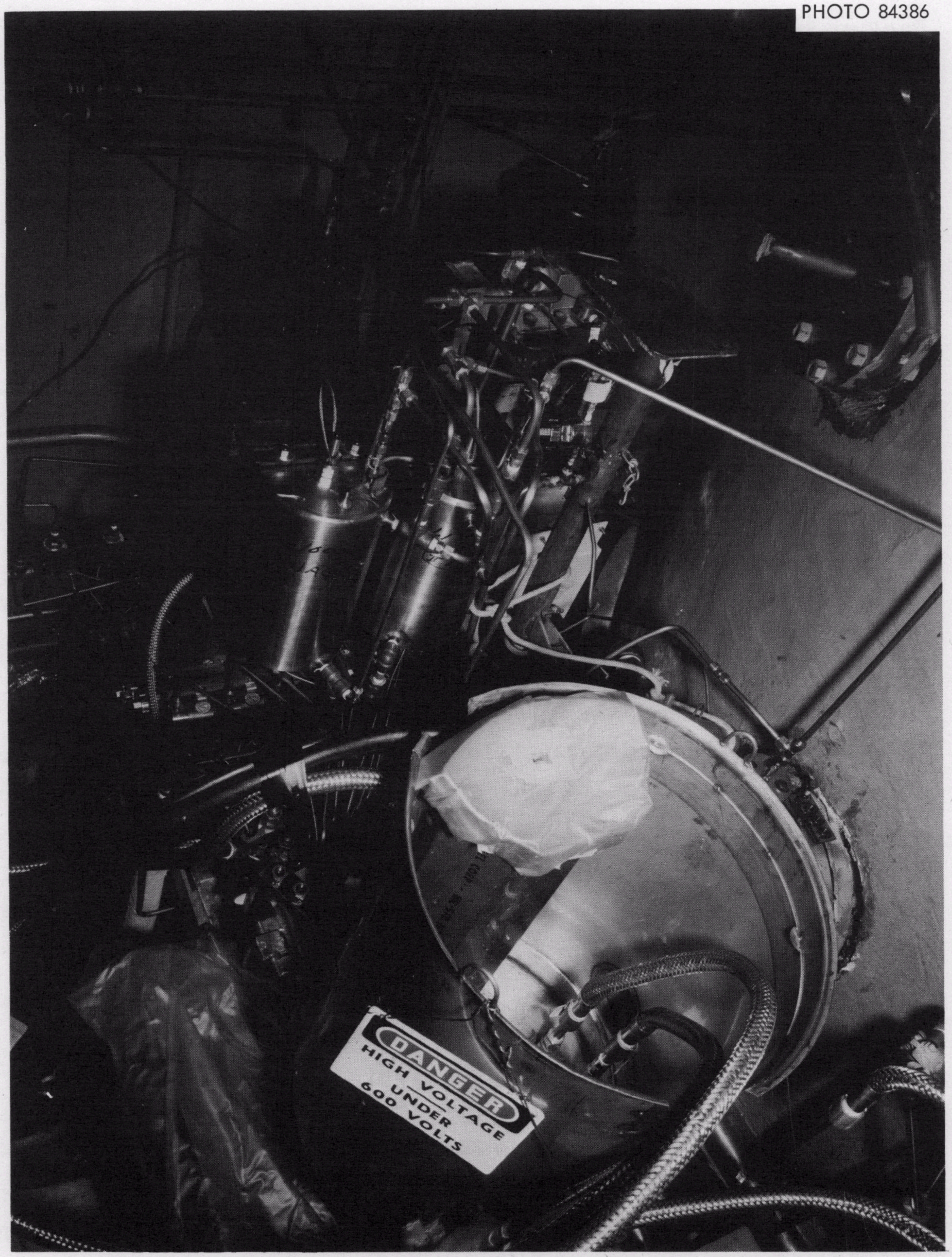

Fig. 5. View of NSPP Furnace Area Showing Two 3-May Pack Cluster Assemblies.

Backup Sampler

One question which is sometimes raised is: Do the May packs collect all of the sample? To try to answer this, we have provided a backup system on the exit gas from groups of May packs. This comprises the chilled water trap described above, a Drierite bed, and a charcoal bed maintained in a refrigerant bath at -50^{o} to $-55^{o}C$.

EXPERIMENTAL PROCEDURE

The May packs comprise five subassemblies. One subassembly tube contains the particle filter, silver-plated screens, and charcoal paper. Four tubes 1-in. dia by 1-in. long contain the charcoal. These subassemblies are assembled and pushed into the May pack tube (Fig. 2). At this point, each tube is given a DOP (di-octyl phthalate) test to verify proper installation of the particle filter. All assemblies found to be less than 99.95% efficient are reworked. The May packs are then assembled into clusters and the DOP test is repeated. In addition, flow checks are run to demonstrate that all inner valves of the sequential valve operate properly (no flow unless vacuum is applied to the particular May pack; normal flow when vacuum is applied). After completing the above bench checks, the May packs are installed and the flow checks are repeated in the field.

A sampling schedule is worked out in advance of each run. For the MCV May packs we use a standard flow of 1 liter/min (nominal) and sample for periods ranging from 5 min in the early part of a run to 2 hr very late in a run. The sampling period represents our best guess as to the amount of sample needed to give sufficient activity in the samples. We designate one of the first 6 samples to be a blank. We have found the blank helps in two ways. It defines "zero" for us. The gamma spectrum analysis usually finds some activity in all of the May packs; by comparing with the blank we can tell whether low activity measurements are real. Also, it gives us a reference point in the sample sequence. We have no other feedback on the sequential valve position when we use the Enercon drive and, in spite of a great deal of care on the part of the operating crew, sequencing errors occasionally do occur. Using the blank as a reference point, we can determine the correct sequence and salvage the data.

We record the upstream pressure and capillary differential pressure data at intervals during the sampling period. Unless an ice plug is forming in the low-temperature backup trap, the flow systems have proved to be quite stable.

After the run is over and the MCV has been purged, we start removing the May pack clusters from the vessel. Each MCV May pack has a vacuum line connected by means of a Snap-Tite coupling (Snap-Tite, Inc., Union City, Penna.) and three electrical conductors. The coupling is disconnected using a remote tool designed for the purpose and the electrical leads are cut. The clusters are then fished out, bagged and surveyed. Depending on the amount of activity found on the outside, disassembly is done in the open or in a glove box. The May packs are usually transferred to a hood where they are disassembled and the samples are bottled. An occasional sample will be too hot to handle in a hood; such samples are disassembled in a hot cell.

The inlet check valves used on the May packs are disassembled. The inlet and exit body sections are swabbed out and the ball, seat and spring are removed and bottled as a sample.

Practically all of our samples are analyzed by quantitative gamma ray spectrum analyses. Because very large numbers of samples are produced (one May pack cluster gives 276 samples), it would be impractical to do otherwise.

Similar procedures are used for the other types of cluster.. The three-May-pack clusters collect the most activity and must be removed remotely. The six-May-pack clusters are usually left in place until all remote unloading is complete and initial decontamination of the furnace and MCV is done. Then the cell is entered and they are disconnected and removed.

TYPICAL EXPERIMENTAL RESULTS

In this section we present examples of the results we have obtained under different experimental conditions in the NSPP. Our purpose is to present illustrations of the behavior we have observed rather than to include all of the data we have.

Results from NSPP Run 16[7]

The first data set is from NSPP Run 16. This run was made at room temperature and low pressure, using elemental iodine with ^{131}I tracer. It represents perhaps the most favorable condition for May pack operation, and we consider it a base-line case for May pack performance.

The data collected by one of three May pack clusters installed in the MCV for Run 16 are presented in Table 1. The table presents the time the sample is taken (midpoint of sampling period), the volume of MCV atmosphere taken as sample, counts on each component, and subtotals for each class of component. The data were taken on a 200 channel analyzer using a NaI (Tℓ) crystal and reduced to disintegrations per minute ^{131}I by a computer program which makes a least-squares fit of the experimental data to a standard spectrum and corrects for decay time and counting geometry. The spectrum resolution program reports a dpm value and an estimated error for each sample. Our data reduction program

Table 1. Computer Output NSPP Run 16

May Pack Cluster No. 6

NSPP RUN NO 16 IODINE RELEASED INTO DRY MCV IODINE-131 TRACER

MAY PACK CLUSTER NO 5, ELEVATION 5 FT ABOVE CENTER, RADIUS 15 INCHES,SOUTH

TIME SAMPLE TAKEN,HR	0.25	1.00	2.00	3.00	4.50	BLANK	6.50	10.50	15.00	20.00	24.00	45.00
SAMPLE VOLUME,LITERS	10.13	10.60	10.64	22.38	35.57	0.0	38.19	69.60	64.80	58.80	61.80	121.20
						DISINTEGRATIONS PER MINUTE						
	1.39E 06	1.83E 05	7.32E 05	1.19E 06	5.52E 05	1.20E 06	4.03E 05	3.81E 06	6.49E 05	3.72E 05	3.09E 05	2.59E 05
	2.16E 07	1.63E 07	1.23E 07	2.45E 06	1.56E 07	1.43E 06	1.24E 06	1.96E 07	3.18E 06	1.06E 06	2.25E 06	2.04E 06
	3.58E 05	1.12E 06	2.04E 05	2.22E 05	8.00E 05	1.66E 05	2.97E 04	3.92E 05	2.41E 05	5.84E 04	9.68E 04	9.49E 04
CHECK VALVES	2.06E 07	1.48E 07	1.04E 07	1.07E 06	1.41E 07	2.80E 06	0.0	2.10E 07	1.27E 06	0.0	0.0	0.0
	2.76E 07	2.20E 07	2.02E 07	1.47E 07	3.39E 07	5.29E 03	2.08E 07	9.42E 06	1.40E 06	6.84E 05	4.20E 05	3.33E 05
	2.57E 05	7.60E 06	8.30E 06	2.64E 06	1.38E 07	2.27E 03	7.19E 06	5.86E 06	2.69E 06	2.71E 05	4.94E 05	3.95E 05
ABSOLUTE FILTER	2.79E 07	2.96E 07	2.85E 07	1.73E 07	4.77E 07	7.57E 03	2.80E 07	1.53E 07	4.09E 06	9.55E 05	9.14E 05	7.28E 05
	4.09E 07	0.0	0.0	0.0	5.72E 07	0.0	0.0	0.0	4.35E 05	0.0	0.0	0.0
	4.76E 06	0.0	0.0	0.0	1.60E 06	0.0	0.0	0.0	1.90E 04	0.0	0.0	0.0
	3.13E 05	0.0	0.0	0.0	3.51E 05	0.0	0.0	0.0	9.64E 03	0.0	0.0	0.0
	6.84E 04	0.0	0.0	0.0	3.28E 04	0.0	0.0	0.0	9.74E 03	0.0	0.0	0.0
	2.33E 04	0.0	0.0	0.0	4.32E 04	0.0	0.0	0.0	1.59E 04	0.0	0.0	0.0
SILVER PLATED SCREENS	4.60E 07	0.0	0.0	0.0	5.92E 07	0.0	0.0	0.0	4.90E 05	0.0	0.0	0.0
	8.40E 04	0.0	0.0	0.0	2.56E 05	0.0	0.0	0.0	1.88E 05	0.0	0.0	0.0
	3.91E 04	0.0	0.0	0.0	4.26E 04	0.0	0.0	0.0	6.49E 04	0.0	0.0	0.0
	3.45E 04	0.0	0.0	0.0	4.76E 05	0.0	0.0	0.0	5.74E 04	0.0	0.0	0.0
	4.06E 02	0.0	0.0	0.0	9.96E 03	0.0	0.0	0.0	4.45E 03	0.0	0.0	0.0
CHARCOAL PAPER	1.58E 05	0.0	0.0	0.0	7.85E 05	0.0	0.0	0.0	3.14E 05	0.0	0.0	0.0
FILTER TUBE	2.10E 06	0.0	0.0	0.0	3.39E 06	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.72E 05	2.85E 07	1.59E 07	5.13E 07	1.53E 06	9.48E 03	2.87E 07	1.35E 07	9.30E 05	5.21E 06	5.03E 06	8.94E 06
	4.68E 03	1.63E 06	1.59E 06	6.46E 06	7.45E 02	8.10E 03	5.99E 05	9.90E 05	1.04E 04	2.57E 05	1.45E 06	9.31E 04
	0.0	0.0	0.0	7.16E 03	5.68E 02	0.0	4.65E 03	2.12E 02	3.68E 02	6.72E 02	6.50E 02	1.52E 03
	0.0	0.0	0.0	0.0	6.77E 02	7.24E 02	5.14E 02	2.70E 03	9.22E 02	2.29E 03	5.46E 02	1.57E 03
PLAIN CHARCOAL BEDS	4.77E 05	3.01E 07	1.75E 07	5.78E 07	1.53E 06	1.83E 04	2.93E 07	1.45E 07	9.42E 05	5.47E 06	6.49E 06	9.04E 06
	0.0	0.0	0.0	2.33E 03	0.0	0.0	3.99E 02	0.0	2.70E 02	3.26E 02	2.96E 02	0.0
	3.89E 02	0.0	0.0	6.44E 02	4.45E 02	8.33E 02	5.76E 02	1.83E 03	7.37E 02	1.51E 03	5.32E 02	4.49E 02
	0.0	0.0	0.0	0.0	3.67E 02	0.0	1.05E 03	2.44E 02	3.70E 02	1.91E 02	2.96E 02	3.57E 02
	1.57E 03	0.0	4.18E 02	6.70E 02	2.60E 03	1.66E 03	8.72E 02	2.23E 03	7.90E 03	1.35E 03	4.11E 03	2.09E 03
IMPREG CHARCOAL BEDS	1.95E 03	0.0	4.18E 02	3.65E 03	3.41E 03	2.49E 03	2.89E 03	4.30E 03	9.27E 03	3.37E 03	5.23E 03	2.89E 03
TOTAL ACTIVITY,DIS/MIN	9.72E 07	7.45E 07	5.65E 07	7.62E 07	1.27E 08	2.83E 06	5.73E 07	5.08E 07	7.12E 06	6.43E 06	7.41E 06	9.77E 06
CONC. (DIS/(MIN)(L))	9.60E 06	7.03E 06	5.31E 06	3.40E 06	3.57E 06	2.83E 06	1.50E 06	7.30E 05	1.10E 05	1.09E 05	1.20E 05	8.06E 04

accepts the dpm value only if it is at least twice the estimated error; lower values are handled as 0.

Under "check valves," the subtotal printed is that on the check valve for the sample in question less than on the check valve for the blank sample. Negative values were corrected to 0. We did this because we believe part of the activity is deposited during the entire run and part while the sample is being drawn through the valve. The activity on the check valve associated with the blank is the best estimate we can get of the amount collected by each valve during the whole run. The three parts listed are: inlet section swabs; internals; outlet section swabs.

Under "absolute filter" the first number represents the filter proper while the second is a composite sample of the supporting screen and the O-rings used to seal the filter.

In this run the complete May pack loading was installed in tubes 1, 5, and 9 only. The silver-plated screens, charcoal paper and filter tube were omitted from the other nine samples. Omitted samples are handled as zero activity.

The charcoal beds are unloaded and the charcoal and hardware for each bed are submitted as separate samples. Under "charcoal beds," the first and third numbers are the charcoal; the second and fourth are the metal parts.

The results show that the concentration of iodine collected by the plain charcoal beds decreased by a factor of 3 between samples 1 and 9 while the concentration of the fraction collected by the silver-plated screens decreased by a factor of 600.

Effectively all of the I collected by the charcoal beds was on the first bed. Except for the blank, the most found on the second bed was 0.12% of the first. The impregnated charcoal beds generally showed activity of the same order as found on the blank sample. When higher activity was found it was almost always on the hardware section of the second impregnated charcoal bed. This included a back-up absolute filter and the activity probably is due to dust entrained from the first charcoal bed.

Results from NSPP Run 15[6]

The second data set is from NSPP Run 15. In this run we melted a Zircaloy-2 clad UO_2 fuel specimen which had been irradiated to approximately 20,000 Mwd/T in the NRX, stored for approximately 5 years and reirradiated to give approximately 300 millicuries of ^{131}I. The melt-zone atmosphere was intended to be oxidizing but the results obtained indicate it was reducing. We assume the Zircaloy used up all the available oxygen. We looked for 9 isotopes in the gamma spectrum analysis: ^{95}Zr-Nb, ^{106}Ru, ^{131}I, ^{137}Cs, ^{140}Ba-La, ^{144}Ce, ^{85}Kr, ^{99}Mo, and ^{132}TeI. We found significant amounts of the ^{131}I, ^{137}Cs, ^{140}Ba, and ^{144}Ce and these results are presented in Tables 2-5. As in Run 16, only May packs 1, 5, and 9 were completely loaded.

The Run 15 results show that 70 to 95% of the particulate matter was collected in the inlet check valves (based primarily on the Cs and Ce data). The iodine analyses indicate no iodine on the check valves for most of the samples. We suspect a good deal of iodine may have been on them but could not be distinguished in the spectrum analysis because of the large amount of ^{137}Cs, in particular. Our analytical people inform us that it is difficult to get good values on constituents comprising less than about 10% of the total.

We believe that the principal reason for the high pick-up of particulate material by the inlet check valves was the presence of a film of condensate on the valve surfaces (later in this report we will present data from another run which support this hypothesis). We now believe that the inlet

Table 2. Computer Output

NSPP Run 15, May Pack Cluster No. 6

Iodine-131

Table 2

NSPP RUN NO 15 MAY PACK CLUSTER NO 6 ELEVATION = 5 FT BELOW CENTER LINE RADIUS = 31 INCHES PLAN ORIENTATION SOUTH

ISOTOPE =IODINE-131

TUBE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
SAMPLE TIME,HR	0.50	1.00	2.00	0.0	3.00	6.00	9.50	11.80	15.70	18.80	20.00	23.00
SAMPLE VOLUME,LITERS	10.50	10.50	9.20	0.0	9.80	9.70	18.90	10.50	18.80	19.00	19.00	54.70
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.28E 04	0.0	3.40E 04
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHECK VALVE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.28E 04	0.0	3.40E 04
	6.23E 05	2.50E 05	1.49E 05	4.94E 04	1.18E 05	8.62E 04	0.0	2.30E 04	0.0	2.94E 03	4.45E 03	1.16E 04
	2.45E 06	4.61E 05	1.25E 06	0.0	1.05E 06	0.0	0.0	1.16E 06	0.0	0.0	0.0	0.0
ABSOLUTE FILTER	3.08E 06	7.10E 05	1.40E 06	4.94E 04	1.17E 06	8.62E 04	0.0	1.19E 06	0.0	2.94E 03	4.45E 03	1.16E 04
	3.15E 04	0.0	0.0	0.0	6.07E 04	0.0	0.0	0.0	6.12E 03	0.0	0.0	0.0
	1.52E 04	0.0	0.0	0.0	5.66E 04	0.0	0.0	0.0	1.40E 04	0.0	0.0	0.0
	1.99E 04	0.0	0.0	0.0	1.82E 04	0.0	0.0	0.0	1.86E 04	0.0	0.0	0.0
	1.83E 04	0.0	0.0	0.0	1.58E 04	0.0	0.0	0.0	1.46E 04	0.0	0.0	0.0
	5.02E 03	0.0	0.0	0.0	3.68E 04	0.0	0.0	0.0	6.13E 03	0.0	0.0	0.0
SILVER PLATED SCREENS	9.01E 04	0.0	0.0	0.0	1.88E 05	0.0	0.0	0.0	5.95E 04	0.0	0.0	0.0
	1.06E 04	0.0	0.0	0.0	1.32E 05	0.0	0.0	0.0	1.36E 04	0.0	0.0	0.0
	5.49E 03	0.0	0.0	0.0	3.77E 04	0.0	0.0	0.0	5.27E 03	0.0	0.0	0.0
	3.66E 03	0.0	0.0	0.0	2.42E 04	0.0	0.0	0.0	3.90E 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	3.36E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHARCOAL PAPER	1.97E 04	0.0	0.0	0.0	1.94E 05	0.0	0.0	0.0	2.27E 04	0.0	0.0	0.0
FILTER TUBE	3.53E 04	0.0	0.0	0.0	3.59E 03	0.0	0.0	0.0	3.51E 03	0.0	0.0	0.0
	1.92E 05	1.35E 06	1.79E 06	1.06E 05	9.18E 05	1.14E 06	1.32E 06	5.33E 05	3.45E 05	7.83E 04	9.92E 04	2.72E 05
	1.01E 03	1.06E 05	3.18E 04	2.66E 03	6.07E 03	9.61E 03	6.25E 03	2.77E 03	6.12E 02	0.0	8.03E 02	7.55E 02
	1.75E 03	1.84E 04	5.49E 03	0.0	0.0	1.31E 03	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.31E 02	0.0	0.0	0.0	9.01E 02
PLAIN CHARCOAL BEDS	1.95E 05	1.47E 06	1.83E 06	1.09E 05	9.24E 05	1.16E 06	1.33E 06	5.36E 05	3.46E 05	7.83E 04	1.00E 05	2.74E 05
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.53E 02	7.89E 02
	2.17E 03	0.0	1.88E 03	2.17E 03	0.0	0.0	0.0	5.28E 02	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.01E 03	0.0	0.0	0.0	0.0
IMPREG. CHARCOAL BEDS	2.17E 03	0.0	1.88E 03	2.17E 03	0.0	0.0	0.0	1.53E 03	0.0	0.0	9.53E 02	7.89E 02

PERCENTAGE DISTRIBUTION

CHECK VALVE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	43.6113	0.0	10.6238
ABSOLUTE FILTER	89.9942	32.5491	43.3395	30.7417	47.0825	6.9390	0.0	68.8000	0.0	2.0393	4.2206	3.6100
SILVER PLATED SCREENS	2.6332	0.0	0.0	0.0	7.5995	0.0	0.0	0.0	13.7760	0.0	0.0	0.0
CHARCOAL PAPER	0.5764	0.0	0.0	0.0	7.8410	0.0	0.0	0.0	5.2651	0.0	0.0	0.0
FILTER TUBE	1.0326	0.0	0.0	0.0	0.1452	0.0	0.0	0.0	0.8132	0.0	0.0	0.0
PLAIN CHARCOAL BEDS	5.7000	67.4509	56.6021	67.9089	37.3318	93.0610	100.0000	31.1110	80.1456	54.3493	94.8752	85.5198
IMPREG CHARCOAL BEDS	0.0633	0.0	0.0583	1.3493	0.0	0.0	0.0	0.0890	0.0	0.0	0.9042	0.2465

Table 3. Computer Output

NSPP Run 15, May Pack Cluster No. 6

Cesium-137

Table 3

NSPP RUN NO 15 MAY PACK CLUSTER NO 6 ELEVATION = 5 FT BELOW CENTER LINE RADIUS = 31 INCHES PLAN ORIENTATION SOUTH

ISOTOPE =CESIUM-137

TUBE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
SAMPLE TIME,HR	0.50	1.00	2.00	0.0	3.00	6.00	9.50	11.80	15.70	18.80	20.00	23.00
SAMPLE VOLUME,LITERS	10.50	10.50	9.20	0.0	9.80	9.70	18.90	10.50	18.80	19.00	19.00	54.70
	1.64E 07	3.11E 05	2.24E 07	1.78E 05	5.12E 05	4.71E 05	1.93E 05	5.25E 06	2.11E 05	1.52E 05	1.57E 05	2.67E 05
	1.69E 08	1.63E 08	3.21E 07	1.11E 07	3.08E 07	4.94E 07	6.42E 07	2.00E 07	7.35E 06	1.20E 06	2.92E 05	4.42E 05
	2.83E 07	4.06E 06	3.97E 06	1.86E 05	1.13E 07	8.00E 06	6.15E 06	2.47E 05	5.67E 06	2.04E 05	2.16E 05	3.66E 05
CHECK VALVE	2.14E 08	1.67E 08	5.85E 07	1.15E 07	4.26E 07	5.79E 07	7.06E 07	2.55E 07	1.32E 07	1.56E 06	5.74E 05	1.08E 06
	3.17E 06	8.60E 04	1.19E 05	3.33E 04	1.36E 05	2.64E 05	3.12E 05	6.96E 04	4.11E 05	3.10E 03	1.05E 04	2.06E 03
	1.81E 07	7.77E 06	1.66E 07	1.74E 06	2.59E 07	1.76E 07	1.48E 07	1.18E 07	7.69E 06	9.12E 04	2.46E 05	1.47E 05
ABSOLUTE FILTER	2.13E 07	7.86E 06	1.67E 07	1.77E 06	2.61E 07	1.78E 07	1.51E 07	1.19E 07	8.10E 06	9.43E 04	2.57E 05	1.49E 05
	3.32E 02	0.0	0.0	0.0	3.73E 02	0.0	0.0	0.0	5.81E 02	0.0	0.0	0.0
	1.29E 02	0.0	0.0	0.0	2.46E 02	0.0	0.0	0.0	9.59E 01	0.0	0.0	0.0
	2.36E 02	0.0	0.0	0.0	3.67E 02	0.0	0.0	0.0	5.89E 01	0.0	0.0	0.0
	3.32E 03	0.0	0.0	0.0	1.65E 02	0.0	0.0	0.0	2.48E 02	0.0	0.0	0.0
	2.49E 03	0.0	0.0	0.0	2.22E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SILVER PLATED SCREENS	6.50E 03	0.0	0.0	0.0	1.37E 03	0.0	0.0	0.0	9.83E 02	0.0	0.0	0.0
	2.13E 03	0.0	0.0	0.0	1.63E 02	0.0	0.0	0.0	1.80E 02	0.0	0.0	0.0
	2.44E 02	0.0	0.0	0.0	2.85E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.45E 02	0.0	0.0	0.0	6.76E 02	0.0	0.0	0.0	7.57E 02	0.0	0.0	0.0
	1.12E 05	0.0	0.0	0.0	1.27E 02	0.0	0.0	0.0	8.71E 01	0.0	0.0	0.0
CHARCOAL PAPER	1.15E 05	0.0	0.0	0.0	1.25E 03	0.0	0.0	0.0	1.02E 03	0.0	0.0	0.0
FILTER TUBE	2.75E 05	0.0	0.0	0.0	4.80E 04	0.0	0.0	0.0	5.02E 04	0.0	0.0	0.0
	2.25E 03	0.0	3.24E 03	0.0	0.0	0.0	0.0	1.12E 03	0.0	2.07E 02	2.18E 02	0.0
	8.31E 02	4.78E 03	3.68E 04	8.40E 03	0.0	1.55E 04	2.77E 04	8.85E 03	1.36E 02	4.75E 02	2.02E 03	5.13E 02
	1.14E 03	0.0	3.20E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.36E 02
	5.53E 02	2.87E 02	1.35E 02	0.0	2.89E 02	8.82E 01	6.42E 02	2.92E 02	0.0	1.56E 02	0.0	0.0
PLAIN CHARCOAL BEDS	4.78E 03	5.07E 03	4.05E 04	8.40E 03	2.89E 02	1.56E 04	2.83E 04	1.03E 04	1.36E 02	8.39E 02	2.23E 03	7.50E 02
	7.87E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	6.01E 02	4.40E 02	2.71E 02	0.0	4.85E 02	3.59E 02	8.89E 02	2.25E 02	2.69E 02	1.27E 02	0.0	1.48E 02
	6.70E 03	9.72E 02	5.18E 02	0.0	1.91E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.37E 02	7.08E 02	1.79E 02	7.48E 02	1.02E 03	2.44E 02	5.02E 02	4.07E 02	3.11E 02	3.29E 02	1.82E 02	7.91E 02
IMPREG. CHARCOAL BEDS	8.62E 03	2.12E 03	9.68E 02	7.48E 02	1.70E 03	6.03E 02	1.39E 03	6.32E 02	5.80E 02	4.55E 02	1.82E 02	9.39E 02

PERCENTAGE DISTRIBUTION

CHECK VALVE	90.7717	95.5127	77.7527	86.5942	62.0153	76.4290	82.3734	68.1971	61.8930	94.2178	68.9049	87.6830
ABSOLUTE FILTER	9.0542	4.4832	22.1923	13.3369	37.9084	23.5496	17.5919	31.7739	37.8630	5.7040	30.8050	12.1795
SILVER PLATED SCREENS	0.0028	0.0	0.0	0.0	0.0020	0.0	0.0	0.0	0.0046	0.0	0.0	0.0
CHARCOAL PAPER	0.0487	0.0	0.0	0.0	0.0018	0.0	0.0	0.0	0.0048	0.0	0.0	0.0
FILTER TUBE	0.1170	0.0	0.0	0.0	0.0698	0.0	0.0	0.0	0.2348	0.0	0.0	0.0
PLAIN CHARCOAL BEDS	0.0020	0.0029	0.0538	0.0633	0.0004	0.0206	0.0330	0.0275	0.0006	0.0507	0.2682	0.0611
IMPREG CHARCOAL BEDS	0.0037	0.0012	0.0013	0.0056	0.0025	0.0008	0.0016	0.0017	0.0027	0.0275	0.0218	0.0765

Table 4. Computer Output

NSPP Run 15, May Pack Cluster No. 6

Barium-Lanthanium-140

Table

NSPP RUN NO 15 MAY PACK CLUSTER NO 6 ELEVATION = 5 FT BELOW CENTER LINE RADIUS = 31 INCHES PLAN ORIENTATION SOUTH

ISOTOPE =BARIUM-LANTHANUM-140

TUBE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
SAMPLE TIME.HR	0.50	1.00	2.00	0.0	3.00	6.00	9.50	11.80	15.70	18.80	20.00	23.00
SAMPLE VOLUME.LITERS	10.50	10.50	9.20	0.0	9.80	9.70	18.90	10.50	18.80	19.00	19.00	54.70
	0.0	0.0	0.0	5.01E 03	1.04E 04	8.47E 03	2.06E 03	1.48E 05	3.92E 03	3.92E 03	1.72E 03	0.0
	4.15E 06	3.98E 06	7.64E 05	2.32E 05	8.18E 05	7.19E 05	1.00E 06	5.20E 05	1.73E 05	1.54E 04	3.35E 03	1.20E 04
	0.0	0.0	5.22E 04	2.40E 03	2.12E 05	1.44E 05	1.11E 05	6.24E 03	7.94E 04	0.0	0.0	0.0
CHECK VALVE	4.15E 06	3.98E 06	8.16E 05	2.39E 05	1.04E 06	8.71E 05	1.11E 06	6.74E 05	2.57E 05	1.94E 04	5.08E 03	1.20E 04
	1.36E 05	1.46E 03	2.84E 03	8.36E 02	3.79E 03	7.18E 03	0.0	1.82E 03	1.95E 04	0.0	5.30E 02	0.0
	3.11E 05	1.05E 05	3.72E 05	4.47E 04	6.71E 05	3.69E 05	4.17E 05	2.56E 05	1.46E 05	1.32E 03	0.0	3.71E 03
ABSOLUTE FILTER	4.46E 05	1.06E 05	3.75E 05	4.56E 04	6.75E 05	3.76E 05	4.17E 05	2.57E 05	1.65E 05	1.32E 03	5.30E 02	3.71E 03
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.18E 02	0.0	0.0	0.0
	9.95E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.23E 02	0.0	0.0	0.0	1.48E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.83E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.65E 02	0.0	0.0	0.0
SILVER PLATED SCREENS	4.06E 02	0.0	0.0	0.0	1.48E 02	0.0	0.0	0.0	3.83E 02	0.0	0.0	0.0
	1.49E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.74E 02	0.0	0.0	0.0
	7.59E 03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHARCOAL PAPER	7.74E 03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.74E 02	0.0	0.0	0.0
FILTER TUBE	9.58E 03	0.0	0.0	0.0	9.10E 02	0.0	0.0	0.0	1.24E 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	8.69E 02	4.36E 02	0.0	0.0	1.26E 03	0.0	0.0	0.0	0.0	0.0
	4.81E 02	0.0	0.0	0.0	0.0	0.0	0.0	2.72E 02	0.0	3.60E 02	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.76E 02	0.0	0.0	0.0
PLAIN CHARCOAL BEDS	4.81E 02	0.0	8.69E 02	4.36E 02	0.0	0.0	1.26E 03	2.72E 02	2.76E 02	3.60E 02	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.28E 02	0.0	0.0
	0.0	0.0	2.26E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	2.26E 02	0.0	1.94E 02	0.0	0.0	2.50E 02	0.0	3.58E 02	0.0	0.0	0.0
IMPREG. CHARCOAL BEDS	0.0	2.26E 02	2.26E 02	1.94E 02	0.0	0.0	2.50E 02	0.0	3.58E 02	2.28E 02	0.0	0.0

PERCENTAGE DISTRIBUTION

CHECK VALVE	89.9210	97.3954	68.4673	83.8051	60.6226	69.8499	72.6989	72.3338	60.4865	91.0441	90.5491	76.3641
ABSOLUTE FILTER	9.6840	2.5990	31.4408	15.9739	39.3158	30.1501	27.2027	27.6371	38.8467	6.1868	9.4509	23.6359
SILVER PLATED SCREENS	0.0088	0.0	0.0	0.0	0.0086	0.0	0.0	0.0	0.0903	0.0	0.0	0.0
CHARCOAL PAPER	0.1680	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1351	0.0	0.0	0.0
FILTER TUBE	0.2078	0.0	0.0	0.0	0.0530	0.0	0.0	0.0	0.2922	0.0	0.0	0.0
PLAIN CHARCOAL BEDS	0.0104	0.0	0.0730	0.1530	0.0	0.0	0.0821	0.0292	0.0649	1.6948	0.0	0.0
IMPREG CHARCOAL BEDS	0.0	0.0055	0.0190	0.0680	0.0	0.0	0.0163	0.0	0.0842	1.0742	0.0	0.0

Table 5. Computer Output

NSPP Run 15, May Pack Cluster No. 6

Cerium-144

NSPP RUN NO 15 MAY PACK CLUSTER NO 6 ELEVATION = 5 FT BELOW CENTER LINE RADIUS = 31 INCHES PLAN ORIENTATION SOUTH

ISOTOPE =CERIUM-144

TUBE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
SAMPLE TIME,HR	0.50	1.00	2.00	0.0	3.00	6.00	9.50	11.80	15.70	18.80	20.00	23.00
SAMPLE VOLUME,LITERS	10.50	10.50	9.20	0.0	9.80	9.70	18.90	10.50	18.80	19.00	19.00	54.70
	2.75E 06	1.50E 04	1.10E 06	6.62E 03	1.37E 04	1.28E 04	2.44E 03	0.0	3.62E 03	4.71E 03	3.86E 03	0.0
	9.72E 06	1.05E 07	2.42E 06	3.74E 05	5.62E 05	3.61E 06	4.84E 06	1.28E 06	2.40E 05	2.27E 04	5.38E 03	2.04E 04
	1.35E 06	1.60E 05	1.21E 05	2.49E 03	2.32E 05	0.0	0.0	6.19E 03	0.0	3.04E 03	3.00E 03	1.02E 04
CHECK VALVE	1.38E 07	1.07E 07	3.65E 06	3.83E 05	8.08E 05	3.63E 06	4.85E 06	1.29E 06	2.44E 05	3.05E 04	1.22E 04	3.06E 04
	3.98E 05	3.89E 03	5.38E 03	1.45E 03	5.43E 03	1.09E 04	1.33E 04	2.51E 03	4.17E 04	0.0	5.27E 02	0.0
	1.15E 06	2.92E 05	5.34E 05	6.96E 04	1.82E 06	1.39E 06	1.14E 06	3.83E 05	4.06E 05	2.83E 03	1.40E 04	5.11E 03
ABSOLUTE FILTER	1.55E 06	2.96E 05	5.39E 05	7.11E 04	1.82E 06	1.40E 06	1.15E 06	3.85E 05	4.48E 05	2.83E 03	1.45E 04	5.11E 03
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.60E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	1.57E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SILVER PLATED SCREENS	2.60E 02	0.0	0.0	0.0	1.57E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHARCOAL PAPER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FILTER TUBE	4.40E 04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	1.85E 03	3.40E 02	3.13E 02	8.53E 02	1.44E 03	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	4.32E 02	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PLAIN CHARCOAL BEDS	0.0	0.0	1.85E 03	3.40E 02	3.13E 02	1.28E 03	1.44E 03	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	8.50E 02	5.95E 02	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.91E 02	0.0
	0.0	0.0	0.0	0.0	0.0	7.55E 02	0.0	2.51E 02	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.78E 02	2.41E 02	0.0
IMPREG. CHARCOAL BEDS	0.0	0.0	0.0	0.0	8.50E 02	1.35E 03	0.0	2.51E 02	0.0	1.78E 02	4.32E 02	0.0

PERCENTAGE DISTRIBUTION

	1	2	3	4	5	6	7	8	9	10	11	12
CHECK VALVE	89.6483	97.3084	87.0807	84.2747	30.7193	72.0611	80.7417	77.0008	35.2735	91.0004	45.0765	85.6686
ABSOLUTE FILTER	10.0647	2.6916	12.8751	15.6504	69.2306	27.8866	19.2343	22.9843	64.7264	8.4681	53.3342	14.3314
SILVER PLATED SCREENS	0.0017	0.0	0.0	0.0	0.0060	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHARCOAL PAPER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FILTER TUBE	0.2853	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PLAIN CHARCOAL BEDS	0.0	0.0	0.0441	0.0749	0.0119	0.0255	0.0240	0.0	0.0	0.0	0.0	0.0
IMPREG CHARCOAL BEDS	0.0	0.0	0.0	0.0	0.0323	0.0268	0.0	0.0149	0.0	0.5316	1.5893	0.0

section of the May pack cluster should be heated to keep the valves dry, and plan to test a modified May pack cluster with a heated inlet section the next time we use a May pack cluster in an air-steam atmosphere.

The behavior of the iodine on the silver-plated screens was quite different in Runs 15 and 16. This is shown in Fig. 6 which presents iodine activity vs screen number for these two runs. The radically different slopes indicate either that the efficiency of the screens is much less in the saturated atmosphere of Run 15 than in the dry atmosphere of Run 16 or that the screens were not collecting the same iodine compound in the two runs.

As before, effectively all of the iodine which reached the charcoal beds was retained on the first plain charcoal bed.

The isotopes which we are certain are transported as particles (Cs, Ba and Ce) were collected primarily by the absolute filters.

Results from NSPP Run 14[5]

A third data set we wish to present is from May Pack Cluster No. 4 in Run 14 (Tables 6 and 7). This is the data set which leads us to believe that condensate in the check valves is responsible for the high collection of particles on the check valves. We think the difference in behavior between sample No. 6 and the other samples is indicative of the effect of condensate. We have designed and built a steam-jacketed inlet section for one of our May Pack Clusters and plan to test it the next time we use May packs in an air-steam atmosphere.

Results from NSPP Run 11[4]

Table 8 contains data collected by May pack Cluster No. 1 in Run 11. We have included only the three May packs

ORNL-DWG 67-11057

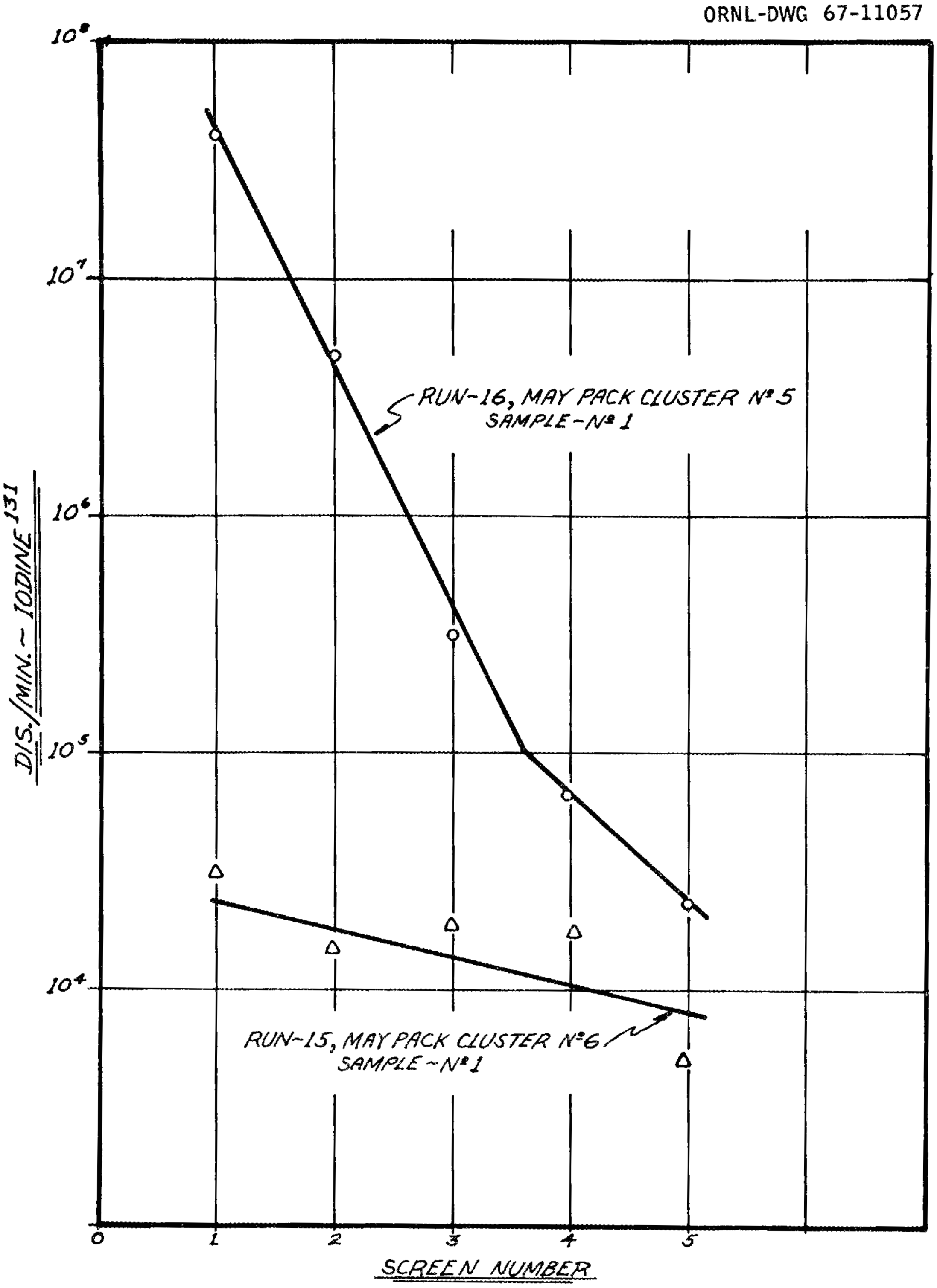

Fig. 6. Comparison of Typical Data for Silver-Plated Screens for Runs 15 and 16.

Table 6. Computer Data for I on May Pack Cluster No. 4, Run 14

Table 6

NSPP RUN 14 MAY PACK CLUSTER NO 4, ELEVATION 5 FT ABOVE CENTER LINE, RADIUS 31 INCHES

ISOTOPE =IODINE-131

TUBE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
SAMPLE TIME,HR	0.25	0.67	0.93	0.0	1.50	3.00	5.00	8.03	11.50	13.38	15.50	23.50
SAMPLE VOLUME, LITERS	11.70	10.80	11.00	0.0	21.40	23.16	21.12	33.74	25.16	13.50	30.30	66.60
DISINTEGRATIONS PER MINUTE												
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.11E 05	0.0	1.09E 05	0.0	5.94E 04	0.0	0.0	7.92E 04	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHECK VALVE	2.11E 05	0.0	1.09E 05	0.0	5.94E 04	0.0	0.0	7.92E 04	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	3.33E 04	2.08E 04	0.0	1.06E 04	3.31E 04	0.0	0.0	0.0	0.0	0.0	0.0
ABSOLUTE FILTER	0.0	3.33E 04	2.08E 04	0.0	1.06E 04	3.31E 04	0.0	0.0	0.0	0.0	0.0	0.0
	1.87E 02	0.0	0.0	0.0	7.14E 03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	1.79E 03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	1.45E 03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	8.27E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	1.12E 03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SILVER PLATED SCREENS	1.87E 02	0.0	0.0	0.0	1.23E 04	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.41E 02	0.0	0.0	0.0	1.41E 03	0.0	0.0	0.0	1.41E 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	7.95E 02	0.0	0.0	0.0	1.52E 03	0.0	0.0	0.0
	2.36E 02	0.0	0.0	0.0	5.40E 02	0.0	0.0	0.0	1.17E 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHARCOAL PAPER	6.77E 02	0.0	0.0	0.0	2.74E 03	0.0	0.0	0.0	4.10E 03	0.0	0.0	0.0
FILTER TUBE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.65E 03	3.73E 04	6.99E 04	0.0	6.65E 04	5.46E 04	3.10E 04	4.71E 04	3.91E 04	4.13E 03	2.11E 03	8.22E 03
	0.0	2.24E 04	2.63E 04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.32E 02	2.33E 03	3.45E 03	0.0	3.07E 03	6.56E 03	2.32E 03	3.19E 03	2.12E 02	0.0	0.0	2.86E 03
	0.0	0.0	0.0	3.97E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PLAIN CHARCOAL BEDS	4.18E 03	6.20E 04	9.96E 04	3.97E 02	6.96E 04	6.12E 04	3.33E 04	5.03E 04	3.93E 04	4.13E 03	2.11E 03	1.11E 04
	0.0	0.0	0.0	0.0	3.50E 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.75E 02	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IMPREG. CHARCOAL BEDS	0.0	0.0	0.0	0.0	3.50E 02	0.0	0.0	0.0	1.75E 02	0.0	0.0	0.0
ACTIVITY, DIS/(MIN)(L)	2.16E 05	9.53E 04	2.29E 05	3.97E 02	1.55E 05	9.43E 04	3.33E 04	1.29E 05	4.36E 04	4.13E 03	2.11E 03	1.11E 04
PERCENTAGE DISTRIBUTION												
CHECK VALVE	97.6644	0.0	47.5049	0.0	38.3246	0.0	0.0	61.1630	0.0	0.0	0.0	0.0
ABSOLUTE FILTER	0.0	34.9313	9.0652	0.0	6.8391	35.1156	0.0	0.0	0.0	0.0	0.0	0.0
SILVER PLATED SCREENS	0.0866	0.0	0.0	0.0	7.9533	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHARCOAL PAPER	0.3134	0.0	0.0	0.0	1.7711	0.0	0.0	0.0	9.4065	0.0	0.0	0.0
FILTER TUBE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PLAIN CHARCOAL BEDS	1.9357	65.0687	43.4299	100.0000	44.8862	64.8844	100.0000	38.8370	90.1920	100.0000	100.0000	100.0000
IMPREG CHARCOAL BEDS	0.0	0.0	0.0	0.0	0.2258	0.0	0.0	0.0	0.4015	0.0	0.0	0.0

Table 7. Computer Data for Cesium on May Pack Cluster No. 4, Run 14

NSPP RUN 14 MAY PACK CLUSTER NO 4, ELEVATION 5 FT ABOVE CENTER LINE, RADIUS 31 INCHES

ISOTOPE =CESIUM-137

TUBE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
SAMPLE TIME,HR	0.25	0.67	0.93	0.0	1.50	3.00	5.00	8.03	11.50	13.38	15.50	23.50
SAMPLE VOLUME, LITERS	11.70	10.80	11.00	0.0	21.40	23.16	21.12	33.74	25.16	13.53	30.30	66.60
DISINTEGRATIONS PER MINUTE												
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.09E 07	1.16E 08	1.11E 08	1.78E 04	2.05E 08	1.61E 05	3.39E 07	5.06E 07	4.13E 07	1.31E 06	7.94E 05	7.44E 05
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHECK VALVE	4.09E 07	1.16E 08	1.11E 08	1.78E 04	2.05E 08	1.61E 05	3.39E 07	5.06E 07	4.13E 07	1.31F 06	7.94E 05	7.44E 05
	9.28E 04	0.0	0.0	0.0	1.98E 06	0.0	0.0	0.0	6.43E 04	0.0	0.0	0.0
	2.37E 07	4.37E 07	4.63E 07	1.71E 03	5.38E 07	1.93E 08	1.32E 07	1.54E 07	1.06E 07	3.74E 05	2.06E 05	5.20E 05
ABSOLUTE FILTER	2.38E 07	4.37E 07	4.63E 07	1.71E 03	5.58E 07	1.93F 08	1.32E 07	1.54E 07	1.07E 07	3.74E 05	2.06E 05	5.20E 05
	1.88E 03	0.0	0.0	0.0	2.99E 03	0.0	0.0	0.0	1.28E 03	0.0	0.0	0.0
	1.48E 03	0.0	0.0	0.0	7.05E 02	0.0	0.0	0.0	6.28E 02	0.0	0.0	0.0
	1.41E 03	0.0	0.0	0.0	3.43E 02	0.0	0.0	0.0	6.91E 02	0.0	0.0	0.0
	1.64E 03	0.0	0.0	0.0	2.00E 02	0.0	0.0	0.0	1.81E 03	0.0	0.0	0.0
	8.19E 02	0.0	0.0	0.0	4.45E 02	0.0	0.0	0.0	8.02E 02	0.0	0.0	0.0
SILVER PLATED SCREENS	7.23E 03	0.0	0.0	0.0	4.68E 03	0.0	0.0	0.0	5.21E 03	0.0	0.0	0.0
	6.69E 03	0.0	0.0	0.0	5.32E 02	0.0	0.0	0.0	5.41E 02	0.0	0.0	0.0
	8.71E 02	0.0	0.0	0.0	2.08E 02	0.0	0.0	0.0	5.29E 02	0.0	0.0	0.0
	1.12E 03	0.0	0.0	0.0	2.01E 02	0.0	0.0	0.0	1.19E 03	0.0	0.0	0.0
	9.58E 02	0.0	0.0	0.0	2.30E 02	0.0	0.0	0.0	2.34E 03	0.0	0.0	0.0
CHARCOAL PAPER	9.64E 03	0.0	0.0	0.0	1.17E 03	0.0	0.0	0.0	4.60E 03	0.0	0.0	0.0
FILTER TUBE	6.78E 03	0.0	0.0	0.0	2.81E 04	0.0	0.0	0.0	1.26E 04	0.0	0.0	0.0
	4.64E 04	8.26E 04	4.56E 03	1.47E 02	2.34E 03	3.48E 03	5.16E 02	1.84E 03	2.47E 04	1.25E 02	0.0	0.0
	5.68E 03	6.59E 05	4.55E 05	4.17E 03	4.19E 02	0.0	2.12E 05	4.46E 05	1.17E 03	6.55E 03	1.79E 03	3.72E 03
	1.36E 03	1.38E 03	9.88E 03	0.0	5.36E 02	4.65E 02	4.97E 02	2.88E 02	0.0	1.93E 02	8.23E 02	0.0
	7.38E 02	6.90E 02	4.84E 03	0.0	3.10E 02	1.54E 03	3.63E 02	0.0	1.95E 02	0.0	0.0	0.0
PLAIN CHARCOAL BEDS	5.42E 04	7.44E 05	4.74E 05	4.32E 03	3.60E 03	5.49E 03	2.13E 05	4.48E 05	2.61E 04	6.87E 03	2.61E 03	3.72E 03
	8.40E 02	1.00E 03	1.23E 03	2.37E 02	5.13E 02	3.75E 03	1.73E 02	1.63E 02	1.85E 02	0.0	0.0	0.0
	8.21E 02	2.30E 03	7.20E 02	1.71E 02	2.66E 02	4.92E 02	7.08E 02	0.0	1.34E 02	1.76E 02	0.0	1.75E 02
	5.31E 03	4.69E 03	5.45E 03	2.52E 02	2.86E 03	2.86E 03	1.03E 04	1.66E 02	6.65E 02	1.74E 02	1.66E 02	3.22E 02
	4.72E 02	1.77E 03	1.77E 03	8.01E 02	3.12E 02	1.55E 03	5.48E 03	4.27E 02	1.73E 02	6.52E 02	2.11E 02	4.53E 02
IMPREG. CHARCOAL BEDS	7.44E 03	9.76E 03	9.17E 03	1.46E 03	3.95E 03	8.65E 03	1.67E 04	7.56E 02	1.16E 03	1.00E 03	3.77E 02	9.50E 02
ACTIVITY, DIS/(MIN)(L)	6.48E 07	1.60E 08	1.58E 08	2.53E 04	2.61E 08	1.93E 08	4.73E 07	6.64E 07	5.20E 07	1.69E 06	1.00E 06	1.27E 06
PERCENTAGE DISTRIBUTION												
CHECK VALVE	63.1387	72.2951	70.3496	70.3891	78.5978	0.0833	71.6248	76.1487	79.4020	77.4291	79.1633	58.6441
ABSOLUTE FILTER	36.7298	27.2353	29.3440	6.7621	21.3863	99.9094	27.8893	23.1757	20.5028	22.1057	20.5386	40.9378
SILVER PLATED SCREENS	0.0112	0.0	0.0	0.0	0.0018	0.0	0.0	0.0	0.0100	0.0	0.0	0.0
CHARCOAL PAPER	0.0149	0.0	0.0	0.0	0.0004	0.0	0.0	0.0	0.0088	0.0	0.0	0.0
FILTER TUBE	0.0105	0.0	0.0	0.0	0.0108	0.0	0.0	0.0	0.0242	0.0	0.0	0.0
PLAIN CHARCOAL BEDS	0.0836	0.4635	0.3006	17.0713	0.0014	0.0028	0.4508	0.6744	0.0501	0.4059	0.2605	0.2932
IMPREG CHARCOAL BEDS	0.0115	0.0061	0.0058	5.7774	0.0015	0.0045	0.0352	0.0011	0.0022	0.0592	0.0376	0.0749

Table 8. MCV May Pack Cluster No. 1

Run No. 11

Sampling Time, hr	1.13	8.88	20.88
Sample Volume, liters	13.4	12.6	15.0
	Disintegrations per Minute		
Retaining ring	1.21×10^7	4.20×10^3	3.81×10^2
Silver-plated screens	2.18×10^5	3.32×10^4	8.29×10^3
	9.93×10^4	2.18×10^4	1.07×10^4
	5.85×10^4	3.08×10^4	1.25×10^4
	2.98×10^4	2.10×10^4	8.03×10^3
	2.00×10^4	1.37×10^4	4.45×10^3
Spacer	1.13×10^3	5.26×10^2	6.33×10^2
Subtotal "Silver-Plated Screens"	4.39×10^5	1.25×10^5	4.49×10^4
Fiberglass filter	1.98×10^3	1.46×10^3	5.62×10^2
Support screen	1.12×10^3	5.95×10^2	2.44×10^2
Spacer	2.38×10^3	1.42×10^3	6.46×10^2
Subtotal "Filter"	5.48×10^3	3.46×10^3	1.45×10^3
Charcoal-impregnated fiberglass	1.12×10^5	9.52×10^4	1.79×10^4
	4.85×10^4	6.45×10^4	8.94×10^3
	1.61×10^5	1.10×10^5	3.57×10^4
Support screen	4.66×10^3	4.73×10^2	3.27×10^2
Subtotal "Charcoal Paper"	3.27×10^5	2.10×10^5	6.29×10^4
Charcoal beds	9.02×10^5	2.49×10^5	7.10×10^4
	1.25×10^4	2.74×10^2	5.9×10^1
	8.90×10^2	4.29×10^2	1.98×10^2
	1.33×10^3	3.95×10^2	1.07×10^2
Retaining ring	-0-	1.36×10^2	-0-
Subtotal "Charcoal Beds"	9.17×10^5	2.50×10^5	7.14×10^4
Total	1.69×10^6	6.49×10^5	1.81×10^5

which were completely loaded. This run was made with oxidizing conditions in the furnace and air-steam in the MCV, and we believe that I_2 was the predominant form. We feel these data illustrate three points: (1) The activity distribution on the silver-plated screens is much flatter than we find for I_2 in dry atmospheres. (2) The distribution in the charcoal papers is erratic. (3) The activity in the charcoal beds is high and concentrated in the first bed. We suspect abnormal behavior of the silver plate with respect to I_2 accounts for (1) and (3).

Water Pickup by Charcoal Beds

Sometime ago, the suggestion was made that saturation of the charcoal beds by water might adversely affect their performance. In order to obtain data in this regard, we collected data on the charcoal weight gain during some of the runs. Table 9 presents some of the data we collected during Run 10. These data indicated to us that the beds did not pick up an excessive amount of water. We got similar data in every case and shortly came to the conclusion that the many weighings involved in taking these data were not justified.

Data from Backup Systems

As described under "Equipment," we provided a rather elaborate backup system for our May pack clusters. The purpose of this system was to provide proof that no significant fraction of the activity in the sample had gotten through the May pack. Our results show this to be the case unless there is some way for the sample to by-pass the May pack.

Table 10 presents some of the results which we obtained. Except for MCV May pack Cluster No. 2 in Run 18, the results indicate that no more than 0.1% of the I and Cs got through

Table 9. Charcoal Bed Weight Gains
(Data from May Pack Cluster No. 1 in Run 10)
Increase in Charcoal Bed Weight, grams

Sample Number	Bed Number			
	1	2	3	4
1	.19	.42	.44	.41
2	.41	.21	.25	.29
3	.10	.04	.06	.10
4	.11	.07	.20	-0-
5	.12	.07	.09	.01
6	.28	.05	.11	.09
7	.24	.19	.17	.05
8	.13	.08	-.01	.13
9	.09	.16	.09	.03
10	.31	-.04	.09	.05
11	.25	.09	.01	.08
12	.11	.02	.02	.35

Based on 48 charcoal beds, the weight of charcoal per bed is 6.1 ± 0.5 g at the 95% confidence level.

Table 10. Illustrative Data on Backup Results

Run No.	May Pack Cluster Identification	Isotope	Total Activity in May Pack	Total Activity in Backup
			Disintegrations per Minute	
18	MCV No. 2	Iodine-131	6.3×10^{6}	2.6×10^{7}
18	MCV No. 5	Iodine-131	3.4×10^{8}	3.9×10^{4}
18	MCV No. 6	Iodine-131	3.5×10^{8}	3.8×10^{4}
15	MCV No. 6	Iodine-131	1.7×10^{7}	1.8×10^{4}
15	MCV No. 6	Cesium-137	7.9×10^{8}	4.6×10^{4}
15	Transfer line, furnace end	Iodine-131	1.5×10^{9}	-0-
15	Transfer line, furnace end	Cesium-137	6.8×10^{9}	1.3×10^{3}
15	MCV No. 1	Iodine-131	5.1×10^{7}	3.7×10^{4}
15	MCV No. 1	Cesium-137	1.6×10^{9}	1.2×10^{6}

the May packs. In Run 18, the quick-disconnect in the sample line to May pack Cluster No. 2 apparently slipped loose. We were unable to produce normal flow and the data show that most of what little we got must have entered downstream of the May pack.

REFERENCES

1. L. F. Parsly, Jr., "Nuclear Safety Pilot Plant Hazards Summary Report," USAEC Report ORNL-TM-683, Oak Ridge National Laboratory, October 4, 1963.

2. J. L. Wantland and T. H. Row, "Behavior of Iodine in Air — A Resumé of the First Seven Runs Conducted at the Nuclear Safety Pilot Plant," USAEC Report ORNL-4050, Oak Ridge National Laboratory, April 1967.

3. L. F. Parsly, Jr. and T. H. Row, "Study of Fission Products Released from Trace-Irradiated UO_2 into Steam-Air Atmospheres," USAEC Report ORNL-TM-1588, Oak Ridge National Laboratory, May 20, 1966.

4. L. F. Parsly, Jr. and T. H. Row, "Behavior of Fission Products Released from Synthetic High-burnup UO_2 in Steam Atmospheres," USAEC Report ORNL-TM-1698, Oak Ridge National Laboratory, February 1967.

5. L. F. Parsly, Jr. and T. H. Row, "Behavior of Fission Products Released into a Steam-Air Atmosphere from Overheated UO_2 Previously Irradiated to 20,000 Mwd/T," USAEC Report ORNL-TM-1908, Oak Ridge National Laboratory,(in press).

6. L. F. Parsly, Jr. J. K. Franzreb, P. P. Holz, I. Iyori, T. H. Row, and J. L. Wantland, "Nuclear Safety Program Annual Progress Report for Period Ending December 31, 1966," USAEC Report ORNL-4071, Oak Ridge National Laboratory, pages 84-87.

7. Wm. B. Cottrell, "ORNL Nuclear Safety Research and Development Program Bimonthly Report for November-December 1966," USAEC Report ORNL-TM-1742, Oak Ridge National Laboratory, January 13, 1967.

8. G. W. Parker and A. Ferreli, Nuclear Safety Program Semiannual Progress Report, June 30, 1965, USAEC Report ORNL-3843, Oak Ridge National Laboratory, pages 194-210.

9. R. D. Ackley, et al., Nuclear Safety Program Semiannual Progress Report, December 31, 1965, USAEC Report ORNL-3915, Oak Ridge National Laboratory, pages 66-70.

INTERNAL DISTRIBUTION

ORNL-TM-2044

1. R. D. Ackley
2. R. E. Adams
3. T. D. Anderson
4. C. J. Barton
5. S. E. Beall
6. M. Bender
7. R. L. Bryan
8. J. P. Blakely
9. G. E. Boyd
10. R. B. Briggs
11. W. E. Browning, Jr.
12. J. R. Buchanan
13-15. W. B. Cottrell
16. E. N. Cramer
17. G. E. Creek
18. F. L. Culler, Jr.
19. W. K. Ergen
20. D. E. Ferguson
21. M. H. Fontana
22. A. P. Fraas
23. J. K. Franzreb
24. S. H. Freid
25. J. S. Gill
26. W. R. Grimes
27. P. N. Haubenreich
28. P. P. Holz
29. W. H. Jordan
30. S. I. Kaplan
31. P. R. Kasten
32. G. W. Keilholtz
33. M. J. Kelly
34. O. H. Klepper
35. J. O. Kolb
36. T. S. Kress
37. J. A. Lane
38. C. E. Larson
39. C. G. Lawson
40. T. F. Lomenick
41. R. A. Lorenz
42. M. I. Lundin
43. R. N. Lyon
44. H. G. MacPherson
45. R. E. MacPherson
46. A. P. Malinauskas
47. W. J. Martin
48. H. C. McCurdy
49. J. W. Michel
50. R. P. Milford
51. A. J. Miller
52. C. E. Miller, Jr.
53. F. H. Neill
54. G. W. Parker
55-64. L. F. Parsly, Jr.
65. P. Patriarca
66. A. M. Perry
67. R. H. Rainey
68. B. F. Roberts
69. G. C. Robinson
70. M. W. Rosenthal
71. T. H. Row
72. A. W. Savolainen
73. C. L. Segaser
74. L. B. Shappert
75. L. J. Shersky
76. R. P. Shields
77. M. D. Silverman
78. O. Sisman
79. M. J. Skinner
80. B. A. Soldano
81. I. Spiewak
82. D. B. Trauger
83. J. Truitt
84. C. S. Walker
85. J. L. Wantland
86. W. T. Ward
87. C. D. Watson
88. G. M. Watson
89. G. A. West
90. G. D. Whitman
91. F. J. Witt
92. W. D. Yuille
93. F. C. Zapp
94. Nuclear Safety Information Center
95-96. Central Research Library
97-98. ORNL – Y-12 Techn. Library Document Reference Section
99-101. Laboratory Records Dept.
102. Laboratory Records, ORNL R.C.

EXTERNAL DISTRIBUTION

ORNL-TM-2044

103. H. W. Behrman, ORO
104. W. G. Belter, RDT
105. M. Booth, RDT
106. W. H. Burgus, Phillips Petroleum Company
107. D. F. Cope, ORO
108. H. L. Hamester, RDT
109. H. G. Hembree, RDT
110. R. K. Hilliard, Pacific Northwest Laboratory
111. Dave King, IDO
112. J. A. Lieberman, RDT
113. J. D. McCormick, Pacific Northwest Laboratory
114. G. B. Matheney, Phillips Petroleum Company
115. D. L. Morrison, Pacific Northwest Laboratory
116. R. R. Newton, RDT
117. G. J. Rogers, Pacific Northwest Laboratory

118-120. C. M. Slansky, Idaho Nuclear Corporation

121-124. S. J. Szawlewicz, RDT

125. T. R. Wilson, Phillips Petroleum Company

126-140. DTIE

141. Laboratory and University Division, ORO

142-143. G. Burley, DRL