X-847

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

November 18, 1957

To: J. A. Swartout

Re: PREVENTION OF RADIATION ACCIDENTS

In conformance with the request in your memorandum of November 12, I have reviewed the accidents we have had recently, listed some of the developments that led to their occurrence, and indicated where certain measures should be taken and responsibilities assumed both by management and by the Health Physics Division to reduce the probability of recurrence of such accidents in the future. As you requested, we are giving special study to especially hazardous operations currently in progress or planned for the near future. We will report our findings on these at a later date. The situation with respect to the recent series of accidents is as follows:

A. Management's Responsibility in the Prevention of Radiation Accidents

The ORNL has a record of giving the AEC cut rates on dangerous experimental operations. Who else but ORNL would have considered the first 1000 curie separation in Building 706C (now 3026C)--a building designed to handle 100 curies? Who else would carry on the RaLa Operation to a level of 10^5 curies in Building 706D (now 3026D) that is adequate for only 10^4 curies? Would any other laboratory attempt a 5×10^7 curie Thorex Operation in the cells of the old 205 (now 3019) building without insisting on major alterations in the building and the establishment of elaborate remote control equipment? Would anyone else agree to our metal recovery operations in Building 3505, a building that is poorly designed and furnished with improvised equipment?

Many of us began in this business at the University of Chicago when the atomic energy industry was in its infancy. As neophytes in the nuclear energy business, we were shocked to realize that the graphite ractor we were building at Oak Ridge would contain behind its shield not the equivalent of 4000 curies of radium (all the radium then available in the world was somewhat less than 4000 curies) but the equivalent of 2×10^8 curies of radium. We debated the feasibility of such an undertaking, but finally after months of debating and careful planning we took this cub (the concept of a large research reactor) from its West Stands Cradle, nestled it in the hills of Oak Ridge, and through the years we have fondled and nurtured it to its present stage of adolescence--first 1 curie, then 100 curies, and now 10^7 curies. We have lived so closely with this industry that we have not perceived its growth or realized we are trying to handle a powerful beast with equipment, techniques, operating procedures, and building facilities that are long since inadequate. We have improved our reactor facilities from time to time and have a Reactor Committee which studies each new reactor or major change in its operation, but I fear we have sorely neglected to give an equally careful study of the chemical, engineering, and accelerator operations. It has required a rash of accidents to bring us to our senses and shock us into the realization that we are engaged in a dangerous business. Perhaps some critics would say we are lucky that more accidents have not occurred all along or that this recent series of accidents is a quirk of statistics. However, I claim that years of training, constant vigilance, and our familiarity with radiation problems have developed skills and acuity to where we can (with some unnecessary risk) handle up to 10^5 curies in a chemical operation with reasonable safety using our old facilities. Going from 10^5 to 5×10^7 curies without retooling was a mistake and taxed our dependence on the human element to the breaking point.

In November, 1943, shortly after the Oak Ridge Graphite Reactor became critical we had our first serious accident. Dr. W. D. Whitaker, Director of the Laboratory, mistakenly overlooked the fact that radiation protection rules apply to everyone in the Laboratory. He led a party of dignitaries into a restricted area on the west wide of the reactor, and he and two others with him received doses of radiation variously estimated at 10 to 20 rem. In a way it is fortunate we had this accident early in our operations because it convinced management, perhaps in a way words could not have done, that strict adherence to health physics protection rules is of vital importance. For the past fourteen years we profited by this experience until October 4, 1957, we had our second accident--[redacted] unlocked and entered forbidden Cell 4 for about one minute and received an exposure of 63 rem. A few weeks later, November 6, 1957, we had our third serious accident. [redacted] stayed too long in Cell 7 or underestimated the dose rate in this cell and received 13.4 rem. Both of these accidents of recent date were in Building 3019 (the old 205 Building). In both cases persons entered cells without a survey meter, although the local regulations clearly require such a meter. However, I do not intend to stress the failure of the personal element in these cases--we always have this to deal with. I do wish to emphasize that a review of these two accidents has revealed that management of the ORNL (and I'm taking my share of the blame here) has developed almost a blind faith in its reliance on the human element to deal directly with almost unlimited radiation hazards. It is true that there was a breakdown in the enforcement of some of the local rules in the 3019 Building (and some of our radiation rules are as important as the "no match rule" in a powder factory), but it now seems even more shockingly true that the Thorex Operation should never have been undertaken by the Laboratory in the first place without providing adequate facilities. Not only were some men required to enter radiation fields of over 60 rem/hour to turn valves and clean filters during the course of the Thorex runs, but the Laboratory condoned operating procedures known to be extremely risky, e.g., depended on a scrubber to remove particulates from a 5×10^7 curie operation (scrubbers are notoriously poor for removing small air-borne particles). For years we have had a very effective Review Committee for Reactor Hazards. In retrospect we must ask why we have not had a similar committee for the "just as dangerous" chemical hazards. As of November 1, 1957, such a committee has been appointed, and this should go a long way toward a careful scrutiny of all new and modified chemical operations before they are approved by the Laboratory. Now that the Thorex Operation is being modified, this committee must, as soon as possible, turn its attention to other dangerous Laboratory operations. Let us hope that it will be at least another fourteen years before the next serious Laboratory accident!

B. Health Physics' Responsibility in the Prevention of Radiation Accidents

The recent rash of radiation incidents leading to accidents and near accidents points up very clearly that certain steps must be taken immediately in order that the Health Physics Division can adequately carry out its obligations to the Laboratory. A few of the incidents which indicate weaknesses in our system of operation as well as a laxness in the general attitude of Laboratory employees toward the dangers of radiation are as follows:

1. On October 4, 1957, an employee disregarded regulations and warning signs, entered hot Cell 4 in Building 3019 through error under an alleged fool-proof lock and key system, and received 63 rem of penetrating dose which is more ~~than twice the "once-in-a-lifetime"~~ emergency dose.*

2. During the month of October, 1957, general contamination from dispersion of Pa^{233} was allowed to continue over a period of several days. There was a 5000% increase (with reference to the average for the first six months of 1957) in fallout particles of high activity (10^6 to 10^7 d/24 hours) in the plant site during the week ending October 7.

3. Between October 14 and October 29, 1957, an employee at Y-12 (not an ORNL employee) received an accumulated dose of enriched uranium as a result of a grinding operation. On November 2 the body burden was estimated from measurements made with a low background body counter to be 1.2 mg of enriched uranium oxide. Estimates from blood samples place the body burden at between 1 and 10 mg. From the above measurements it is estimated that the $\int^{\infty} Rdt$ dose will be about 30 rem to the lungs. (The low background body counter indicated no significant enriched uranium in the kidneys.)

---

*The National Committee on Radiation Protection Handbook 59 allows a "once-in-a-lifetime" dose up to 25 rem. The following quotation is taken from NCRP Handbook 59, pages 71 and 72:

"Reasonably, if a body dose of 25 r received all at once is considered to have no effect on the radiation tolerance status, two doses of 12.5 r each separated by a short or a long interval, or other fractionated exposures of the same total dose, should be negligible, also. Whether this is so or not is immaterial, because it is impractical (although desirable) to keep account of such exposures over a long period of time--especially when the worker changes places of employment. Therefore, 'once in a lifetime' should be interpreted to mean one episode in a lifetime."

* * *

"The individual concerned should know the nature of the accidental or emergency exposure and the doses involved. It shall be his responsibility to inform his present and his future employers of such occurrence."

* * *

". . . it (the 'once in a lifetime exposure') does influence the radiation tolerance status, otherwise there would be no reason for not permitting a repetition of a similar exposure. Accordingly, it is generally desirable to institute compensatory measures in such cases. This is particularly true when the conditions of occupational exposure are such that the possibility of recurrence of technical overexposure cannot be excluded."

4. On October 25, 1957, a release of activity from the pipe tunnel at the Thorex Operation in Building 3019 resulted in the inhalation of significant doses of Pa^{233} by four workmen performing duties in the facility and two health physicists who expedited the evacuation during the emergency. Fecal samples were submitted, and it was found that one of the workmen had a Pa^{233} contamination of 1.2×10^6 d/m in the total feces for October 26, 1957. The other three workmen had less Pa^{233} in the feces. Subsequent low background body counter examination of this workman and one of the health physicists revealed that they had estimated body burdens of 1.6 and 1.4 μc of Pa^{233}, respectively. The estimated $\int_0^\infty$ Rdt dose in each case will be about 0.7 rem to the lungs and 0.4 rem to the lower large intestine.

5. On November 6, 1957, an employee was sent into hot Cell 7 of Building 3019 and into an area with a last recorded survey of ~ 60 r/hr. He received a penetrating dose of 13.4 rem, which must be considered as a "once-in-a-lifetime" emergency dose**. In entering the operating area of Cell 7 this employee was required to pass through an opening so small that on previous occasions personnel are known to have become stuck and required assistance in freeing themselves. Fortunately, in this instance, the employee was not steatopygous and did not become stuck in the opening.

One can place his finger on several circumstances which led to the above incidents, and the Health Physics Division must assume its full share of responsibility in these matters. I think that to dwell at length on these items would be unduly tiresome, but a brief discussion of the more obvious weaknesses would be profitable in order that one can get a clearer idea of the course of action which the Health Physics Division is now undertaking. The situation is as follows:

(1) We have been unable, on some occasions, to pin-point air-borne sources of contamination. There have been occasions when we could have acted promptly and avoided considerable apprehension during fallout conditions, had there been available the proper kind of remote monitoring equipment. Of more concern, however, is the potential full-scale evacuation which always hangs over us. In fact, should an excessive release of activity occur today, we would have no reliable means of coping intelligently with the potentialities of the problem. Over a year ago the local AEC turned down several proposals we made for the extension of our area monitoring system. Health Physics is responsible for monitoring the fallout but has not been permitted sufficient equipment or enough stations to discriminate readily between the fallout from weapons tests and that from the ORNL.

(2) In the case of the employee who entered the cell through the narrow opening, our first estimate of exposure was exaggerated almost by a factor of 2. The cadmium filter in the back of the red badge had been lost. Fortunately, because of the magnitude of the operation in Thorex and in accordance with standard practice, we had placed an additional film badge (white badge) on the employee. After determining

** Same as footnote (*) at bottom of page 3.

the dose from the white badge, we realized something was wrong and subsequently discovered the lost filter after physically examining the red badge. Although our error was corrected fairly soon (on the day following the incident), we certainly contributed to the confusion of the moment. Months ago Health Physics attempted to begin use of a new badge (green badge) which would eliminate the above fault. The green badges have been stocked in a bin for six months because of AEC opposition to their use.

(3) The determination of internal dose by the examination of body fluids, although fairly reliable and in many respects the most valuable of all internal dose data, leaves considerable to be desired. Because of the unavailability of a low background body counter in the Oak Ridge area, we have, on several occasions, been forced to send persons to Chicago for body counting and, as a consequence, we were several days in the process of determining whether there had been a serious inhalation accident. Even more serious is the fact that when there is a large amount of an insoluble radioactive material (e.g., Pa^{233} or $U^{238}O_2$ + F.P.) contained on large air-borne particles (1 to 10μ), the primary hazard is to the lower large intestine, and, unless the body counting is carried out in a few hours following the accident, the results may be practically meaningless. Health Physics has had proposals pending for low background body counters for several years, but they have been blocked because of the cost.

(4) Perhaps our greatest failure is in our inability to make clear to everyone involved that techniques must be precise and procedures must be followed carefully when an operation such as Thorex is involved. Upon studying the Thorex operation, I have been somewhat surprised to learn that key personnel in the Thorex organization have failed to use pocket meters regularly. How can a supervisor expect his men to make no exception in obeying the rules if he disregards them at his own convenience? The use of the quarterly film badge cycle requires that pocket meters be used in operations such as Thorex in order that we pick up potential overexposures prior to the ending of the quarter. We have long understood and tried to emphasize that the "companion" method of determining dose is too dangerous for use where highly hazardous radioactive materials are being handled. For example, in the Y-12 incident, it was reported that several employees performing the same kind of work as the exposed employee received only trace exposure. In an operation as dangerous as Thorex, it is unthinkable that a man would be sent into an area thought to be at a radiation level of 60 r/hour and not make certain that he has an operating warning device, such as a cutie pie or a pocket screamer, in hand. What is wrong with our training that a man will wager his life on the applicability of a 60 r/hour survey measurement made on a previous shift? Certainly we cannot send a Health Physics surveyor along to read the survey meters on such an operation without unnecessarily using up his exposure time.

Following several discussions between yourself, the Laboratory Director, others in management, and members of the Health Physics Division, we have concluded that immediate corrective action is indicated on the following items:

1. We must increase the number of monitoring stations and, in some cases, modify certain parts of the equipment. The information provided by these stations must be made available readily at a central point by telemetering techniques.

2. A stack monitor must be designed, tested, and installed at each of the Laboratory stacks.

3. The film badge must be maintained mechanically perfect to be an accurate dose meter. The new film badges must be placed into service at the earliest possible moment.

4. Personnel must be required to use pocket meters and other dose measuring devices where indicated.

5. A study must be undertaken immediately to develop a lightweight warning meter which will be used by Laboratory personnel.

6. Fixed monitors should be installed during the construction stage in areas that may need to be entered if the exposure rate may be in excess of 5 rem/hour.

7. We must obtain a low background body counter.

8. Management should never again permit an improvised and/or questionable operation to be undertaken in the Laboratory as was done in the case of Thorex.

9. All responsible supervisors must be thoroughly indoctrinated as to the hazards of radiation and directed by management to comply with the best practices in radiation protection.

10. No planned Laboratory operation may be carried out where the dose rate in the working area is greater than 5 rem/hour except under the direct supervision of a health physicist. In an emergency when a health physicist is not available, a Laboratory supervisor may assume this Health Physics responsibility, but following such action a complete report must be submitted to the Director of the Health Physics Division. All cases of suspected exposure in excess of 0.3 rem/day shall be reported immediately to the local Health Physics representative.

We are currently putting together firm recommendations for the design, procurement, and installation of the electronic and other mechanical devices necessary to fulfill some of the above recommendations. The education of personnel relative to the importance of maintaining safe working conditions and in preserving a proper respect for radiation hazards is a continuing endeavor which must start with management. We are accelerating our health physics educational activities, and we will be available to other groups throughout the Laboratory to assist in similar educational programs.

Original Signed
K. Z. MORGAN

K. Z. Morgan

bc: J. C. Hart
E. E. Anderson
E. G. Struxness cc-Santain 12/18/57
G. S. Hurst
H. P. Yockey

CC: A. M. Weinberg

KZM/...

Swartout

in ref Prevention of Radiation Accidents

In conformance with the request in your ~~letter~~ memo of November 12, 1957 I have reviewed the accidents we have had recently, listed ~~gave~~ some of the developments that ~~led to their~~ occurrence and indicated where certain measures should be taken and responsibility assumed by both management and by Health Physics to reduce the probability of recurrence of such accidents in the future. As you requested we are giving special study to especially hazardous operations currently in progress or planned for ~~operation in~~ the near future. We will report our findings on these at a later date. The situation with respect to the recent series of accidents is as follows:

A - -

[illegible] copies to Hart, Bodg, Strauss, Hurst & Yockey

cc Chapin

(2)

Draft

A - Managments Responsibility in the PREVENTION of RADIATION ACCIDENTS

I. Adequate Consideration of Radiation Hazards Before Commiting the Laboratory to Embark on a New Program and Before Making Major Changes in Existing Programs.

a. Our Past Operations. ORNL has a record of giving the AEC cut rates on dangerous experimental operations. Who else but ORNL would have considered the first 1000 curie separation in building 706C (now 3026C), a building designed to handle 100 curies? Who else would carry on the RaLa operation to a level of 10^5 curies in the 706D building (now 3026D) that is adequate for only 10^4 curies? Would any other laboratory attempt a 5×10^7 curie Thorex operation in the cells of the old 205 (now 3019) building without insisting on major alterations in the building and the establishment of elaborate remote control equipment? Would anyone else agree to our metal recovery operations in building 3505 a building that is poorly designed and furnished with improvised equipment?

Many of us began in this business at the University of Chicago when the atomic energy industry was in its infancy. As neophytes in the nuclear energy business, we took this cub (the concept of a large research reactor) from its West Stands cradle, nested it in the hills of Oak Ridge and through the years we have fondled and nurtured it to its present stage of adolescence -- first 1 curie, then 100 curies and now 10^7 curies. We were shocked to realize that the graphite reactor we were building at Oak Ridge would contain behind its shield not the equivalent of 4000 curies of radium, (all the radium then available in the world was somewhat less than 4000 curies) but the equivalent of 2×10^8 curies of radium. We debated the feasibility of such an undertaking, but finally after months of debating and careful planning We have lived so closely with it that we have not perceived its growth or realized we are trying to handle a powerful beast with equipment, techniques, operating procedures, and building facilities that are long since inadequate. It has required a rash of accidents to bring us to our senses and shock us into the realization that we are engaged in a dangerous business. Perhaps some critics would say we are lucky that more accidents have not occurred all along or that this recent series of accidents is a quirk of statistics. However, I claim that years of training, constant vigilance and our familiarity with radiation problems have developed skills and acuity to where we can (with some unnecessary risk) handle up to 10^5 curies in a chemical operation with reasonable safety using our old facilities. Going from 10^5 to 5×10^7 curies without retooling was a mistake and taxed our dependence on the human element to the breaking point.

this industry

We have improved our reactor facilities from time to time and have a Reactor Committee which studies each new reactor or major change in its operation but I fear we have sorely neglected to give an equally careful study ... and accelerator operation.

B. Our Present and Future Operations. In November, 1943, shortly after the OR Graphite Reactor became critical we had our first serious accident. Dr. W. D. Whitaker, Director of the Laboratory, mistakenly overlooked the fact that radiation protection rules apply to everyone in the laboratory. He lead a party of dignitaries into a restricted area on the west side of the reactor and he and two others with him received doses of radiation variously estimated at 10 to 20 rem. In a way it is fortunate we had this accident early in our operations because it convinced management perhaps in a way words could not have done that Health Physics protection is of vital importance. For the past fourteen years we profited by this experience until October 4, 1957, we had our second accident; [redacted] unlocked and entered forbidden cell 4 for about one minute and received an exposure of 63 rem. A few weeks later November 6, 1957, we had our third serious accident. [redacted] stayed too long in cell 7 or underestimated the dose rate in this cell and received 13.4 rem. Both of these accidents were in Building 3019 (the old 205 building). In both cases persons entered cells without a survey meter (cutie pie) although the local regulations clearly require such a meter. However, I do not intend to stress the failure of the personal element in these cases — we always have this to deal with. I do wish to emphasize that a review of these two accidents has revealed that management of ORNL (and I'm taking my share of the blame here) has developed almost a blind faith in its reliance on the human element to deal directly with almost unlimited radiation hazards. It is true that there was a breakdown in the enforcement of some of the local rules in the 3019 Building (and some of our radiation rules are as important as the "no match rule" in a powder factory), but it now seems even more emphatically true that the Thorex operation should never have been undertaken in the first place by the laboratory without providing adequate facilities. Not only were men required almost routinely to enter radiation fields of over 60 rem/hr to turn valves and clean filters during the course of the Thorex runs but there were condoned operating procedures known to be extremely risky, e.g. depending on a scrubber to remove particles from a 5 x 10^7 curie operation. For years we have had a very effective Review Committee for Reactor Hazards. In retrospect we must ask why we have not had a similar committee for the "just as dangerous" chemical hazards. As of November 1, 1957, such a committee was appointed by management and this should go a long way toward a careful scrutiny of all chemical operations before they are approved by the Laboratory. Now that the Thorex operation is being closed out this committee must as soon as possible turn its attention to other dangerous Laboratory operations. Let us hope that it will be at least another 14 years before the next serious laboratory accident!

~~To: J. A. Swartout~~

~~Subject:~~ B - Health Physics' Responsibility in the Prevention of Radiation Accidents

The recent rash of radiation incidents leading to accidents and near accidents, points up very clearly that certain steps must be taken immediately in order that the Health Physics Division can adequately carry out its obligations to the Laboratory. A few of the incidents which ~~clearly~~ indicate weaknesses in our system of operation as well as a laxness in the general attitude of Laboratory employees toward the dangers of radiation are as follows:

1. On October 4, 1957, an employee disregarded regulations and warning signs, entered hot Cell 4 in Building 3019 through error under an alleged fool-proof lock and key system, and received 63 rem ~~xxxxxxxxxx~~ of penetrating dose which is more than twice ~~his lifetime~~ the "once in a lifetime" emergency dose.* (The NCRP Handbook 59 allows a "once in a lifetime" dose up to 25 rem.)
2. During the month of October 1957 general contamination from dispersion of Pa-233 was allowed to continue over a period of several ~~weeks.~~ days. There was a 50% increase in fallout particles of high activity (10^6 to 10^7 d/24 hr) in the plant site during the week ending October 7 (with reference to the average for the first six months of 1957).
3. Between Oct 14 and Oct. 29, 1957, ~~On October , 1957~~ an employee at Y-12 (not an ORNL employee) received an accumulated ~~excessive~~ dose of enriched uranium ~~U-235~~ as a result of a grinding operation. On Nov. 2nd ~~days after the accident~~ the body burden was estimated from measurements with a more low background ~~test~~ body counter, to be 1.2 mg of enriched uranium oxide.

* The following quotation is taken from NCRP-Handbook 59

more down

From these measurements, it is estimated that the $\int_0^\infty$ Rdt dose will be about 30 rem to the lungs and rem to the kidneys.

4. On October 25, 1957 a release of activity from the pipe tunnel at the Thorex operation in Building 3019 resulted in the inhalation of massive doses of Pa-233 by four workmen performing duties in the facility. Fecal samples submitted by one of the workmen indicated a Pa-233 contamination of 1.2×10^6 d/m in the total feces for October 26, 1957. Subsequent total body counter examination of this workman and one of his associates who had less Pa-233 in his feces revealed that each had an estimated total body burden of μc of Pa-233. The estimated $\int_0^\infty$ Rdt dose in each case will be about 0.7 rem to the lungs and 0.4 to the lower large intestine.

5. On November 6, 1957, an employee was sent into hot Cell 7 of Building 3019 with a last recorded survey of ~60 r/hr, where he received a penetrating dose of 13.4 rem. This must be considered as a "once in a lifetime dose.* In

*"Reasonably, if a body dose of 25 r received all at once is considered to have no effect on the radiation tolerance status, two doses of 12.5 r each separated by a short or a long interval, or other fractionated exposures of the same total dose, should be negligible, also. Whether this is so or not is immaterial, because it is impractical (although desirable) to keep account of such exposures over a long period of time -- especially when the worker changes places of employment. Therefore, "once in a lifetime" should be interpreted to mean one episode in a lifetime...... The individual concerned should know the nature of the accidental or emergency exposure and the doses involved. It shall be his responsibility to inform his present and his future employers of such occurrence.... It (the "once in a lifetime exposure") does influence the radiation tolerance status, otherwise there would be no reason for not permitting a repetition of a similar exposure. Accordingly, it is generally desirable to institute compensatory measures in such cases. This is

entering the operating area of Cell 7 this employee was required to pass through an opening so small that on previous occasions personnel are known to have become stuck and required assistance in freeing themselves. Fortunately, in this instance, the employee did not become stuck in the opening.

---

particularly true when the conditions of occupational exposure are such that the possibility of recurrence of technical overexposure cannot be excluded."

One can place his finger on several circumstances which led to the above incidents, and the Health Physics Division must assume its full share of responsibility in these matters. I think that to dwell at length on these items would be unduly tiresome, but ~~I do believe, however, that~~ a brief discussion of the more obvious weaknesses would be profitable in order that one can get a clearer idea of the course of action which the Health Physics Division is now undertaking. The situation is as follows:

1. We have been unable, on some occasions, to pin-point airborne sources of contamination. There have been occasions when we could have acted promptly and avoided considerable apprehension during fallout conditions, had there been available the proper kind of remote monitoring equipment. Of more concern, however, is the potential full-scale evacuation which always hangs over us. In fact, should an excessive release of activity occur today, we would have no reliable means of coping intelligently with the potentialities of the problem. Only a year ago ~~Earlier this same year,~~ the local AEC turned down several proposals we made for the extension of our area monitoring system. Health Physics is responsible for monitoring the fallout but has not been permitted sufficient equipment or enough stations to readily discriminate between the fallout from weapons tests ~~Nevada~~ and that from ORNL.

2. In the case of the employee who entered the cell through the narrow opening, our first estimate of exposure was exaggerated almost by a factor of 2. The cadmium filter in the back of the red badge had been lost. Fortunately, because of the magnitude of the operation in Thorex, and in accordance with standard practice, we had placed an additional film badge (white badge)

on the employee. After determining the dose from the white badge, we realized something was wrong and subsequently discovered the lost filter after physically examining the red badge. Although our error was corrected fairly soon, (on the day following the incident) we certainly contributed to the confusion of the moment. Months ago Health Physics attempted to begin use of a new badge (green badge) which would eliminate the above fault. The green badges have been stocked in a bin for six months because of AEC opposition to their use.

(3) ~~4.~~ The determination of internal dose by the examination of body fluids, although fairly reliable and in many respects the most valuable of all internal dose data, leaves considerable to be desired. Because of the unavailability of a low background body counter in the Oak Ridge area, we have, on several occasions, been forced to send persons to Chicago for body counting and, as a consequence, we were several days in the process of determining whether ~~or not~~ there had been a serious inhalation accident. Even more serious is the fact that when there is a large amount of an insoluble radioactive material (e.g. Pa-233 or $U^{238}O_2$ + F.P.) contained on large airborne particles (1 ≥ 10 μ), the primary hazard is to the lower large intestine, and, unless the body counting is carried out in a few hours following the accident, the results may be practically meaningless. Health Physics has had proposals pending ~~projects~~ for low background body counters for ~~for~~ several years ~~xxx~~ but they have been blocked because of the cost.

(4) D. Perhaps our greatest failure is in our inability to make clear that techniques must be precise and procedures must be followed carefully where an operation such as Thorex is involved. Upon studying the Thorex operation, I have been somewhat surprised to learn that key personnel in the Thorex organization have failed to use pocket meters regularly. How can a supervisor expect his men to make no exception in obeying the rules if he disregards them at his own convenience? The use of the quarterly film badge cycle requires that pocket meters be used in order that we pick up potential overexposures prior to the ending of the quarter. We have long understood and tried to emphasize that the "companion" method of determining dose is too dangerous for use where highly hazardous radioactive materials are being handled. For example, in the Y-12 incident, it was reported that several employees performing the same kind of work as the exposed employee received only trace exposure. In an operation as dangerous as Thorex, it is unthinkable that a man would be sent into an area thought to be at a radiation level of 60 r/hr and not make certain that he has an operating warning device such as cutie pie or a pocket screamer in hand. What is wrong with our training that a man will wager his life on the applicability of a 60 r/hr survey measurment made on a previous shift? Certainly we cannot send a Health Physics surveyor along to read the survey meters on such an operation without unnecessarily using up his exposure time.

Following several discussions between yourself, the Laboratory Director, others in management, and members of the Health Physics Division, we have concluded that immediate corrective action is indicated on the following items:

1 ~~A-1.~~ We must increase the number of monitoring stations and, in some cases, modify certain parts of the equipment. The information provided by these stations must be made ~~readily~~ available readily at a central point by telemetering techniques.

2 ~~A-2.~~ A stack monitor must be designed, tested, and installed at each of the Laboratory stacks.

3 ~~B-1.~~ The film badge must be maintained mechanically perfect to be an accurate dose meter. The new film badges must be placed into service at the earliest possible moment.

4 ~~B-2.~~ Personnel must be required to use pocket meters and other dose measuring devices where indicated.

~~B-3.~~ A study must be undertaken immediately to develop a lightweight warning meter which will be used by Laboratory personnel.

6 ~~B-4.~~ Fixed monitors should be installed during the construction stage in areas that may need to be entered if ~~where~~ the exposure rate may be in excess of 5 rem/hr.

7 ~~C-1.~~ We must obtain a ~~whole~~-body counter.

D-1. Management should never again permit an improvised and/or questionable operation to be undertaken in the laboratory ~~function~~ as was done in the case of Thorex.

~~*A, B, C, and D refer to corrective measures to A, B, C, and D as discussed above.~~

9 ~~D.2.~~ All responsible supervisors must be thoroughly indoctrinated as to the hazards of radiation and directed by management to comply only with the best practices in radiation protection.

10 ~~D.3.~~ No planned Laboratory operation may be carried out where the dose rate in the working area is greater than 5 rem/hr except under the direct supervision of a health physicist. In an emergency when a health physicist is not available, a Laboratory supervisor may assume this Health Physics responsibility but following such action a complete report must be submitted to the Director of the Health Physics Division. All cases of suspected exposure in excess of 0.3 rem/day shall be reported immediately to the local Health Physics representative.

We are currently putting together firm recommendations for the design, procurement, and installation of the electronic and other mechanical devices necessary to fulfill some of the above ~~xxxxxxxx~~ recommendations. The education of personnel relative to the importance of maintaining safe working conditions and in preserving a proper respect for radiation hazards is a continuing endeavor which must start with Management. We are accelerating our Health Physics educational activities and we will be available to other groups throughout the Laboratory to assitst in similar educational programs.

K. Z. Morgan

(2)
Exposure at 3019

Date of Incident — Oct 4, 1957

Date of measurements —

Pocket meter read — Oct 4.

Film for dose estimate read — Oct 9.

Name — [redacted] age 23 (Birth date — [redacted])

CSD [redacted]

Percent of MPD (5/11-18) — 266.0%

Total dose to date D_p — 66.5 rem D_m — 72.2 rem.

Out for

(3)

Exposure at Y-12

Date of Incident — Oct 14 — Oct 29, 1957.

Date of measurements —

Urine samples — Oct 21, Oct 23, Oct 28,
Oct 29 through Nov. 4.

Blood sample — Nov. 1

Whole Body Counter — Nov 2

Name — [redacted]* age [redacted]

Est. Total dose from incident — ~30 rem. (This is est. from body counter)

Body Burden — Est. from blood sample — Lung 1 to 10 milligram

Est from whole body counter — Lung 1.2 milligram ± 25%

The compound was Uranium oxide.

* This name has not been officially released.

(2) Fall out

Date of accident — week ending Oct 7, to present.

Fall out of Pa^{233} –

activity size d/24 hrs	particles/ft² (Plant Site Stations)		
	av. 1st half/1957	av. week Ending 10/7	av. week Ending 1[illegible]
$< 10^5$	122.4	5036	724.4
$10^5 - 10^6$	1.65	21.4	24.7
$10^6 - 10^7$	0.67	31.4	31.4
$> 10^7$	0.10	3.9	19.8.

Largest particles, as indicated above were during week ending 10/28.

(4)

Exposure at 3019

Date of Accident - Oct 25, 1957

Date of Measurements -

Fecal sample - 1st sample Oct 26, 1957.

Whole Body Measurement - Nov. 8, 1957

Name - [redacted]* Age. [redacted]

C S Da [redacted]

Total dose to date D_p 13.1 rem D_m 19.8 rem

Body burden 1.4 μc Pa^{233} Total dose for accident - Lungs 0.7 rem
Lower intestine 0.4 "

Percent of MPD (5N-18) - 14.6%.

* [redacted], [redacted] and [redacted] were on same job but N received highest dose.

(5)

Exposure at 3019

Date of Incident – Nov. 6, 1957

Date of Measurement –

Pocket meter read – Nov 6, 1957

Film for dose estimate read – Nov 7, 1957.

Name – [redacted] age [redacted] (Birth date [redacted])

CSDa [redacted] (at ORNL since [redacted])

Percent of MPD (5N-18) – 13.7%

Total Dose to Date D_p – 15.1 D_m 27.5

$$D = Q\left(\frac{\mu c}{g}\right) 3.7\times10^{4}\left(\frac{dis}{sec\ \mu c}\right) 3600\times24\left(\frac{sec}{d}\right)$$

$$E\left(\frac{MeV}{dis}\right) 1.6\times10^{-6}\left(\frac{ergs}{MeV}\right)\frac{1}{100}\left(\frac{g\ rad}{erg}\right)$$

$$D = 51.2\,QE = 51.2\times.0018\times.4 = .037\ \text{rem/day}$$

.08

$$\frac{1.2\times10^{6}\,\frac{\ell}{m}}{,300} \times \frac{1}{3.7\times10^{4}}\,\frac{\mu c\,s}{\ell}\;\frac{1}{,60}\left(\frac{m}{s}\right)$$

.001,8 μc