[DNFSB LETTERHEAD]

July 16,1993

Dr. Everett H. Beckner
Acting Assistant Secretary for Defense Programs
U.S. Department of Energy
Washington, D.C. 20585

Dear Dr. Beckner:

In December 1992 and February 1993 the DNFSB Staff visited the Pantex Plant near Amarillo, Texas to review closure of findings from the Qualification Evaluation for Dismantlement (QED) reviews. One of the QED findings stated "The Panasonic 802 TLD personnel dosimetry used at Pantex cannot distinguish between neutron and beta during the same exposure period." DOE and the Radiation Safety Department staff at the Pantex Plant have identified possible deficiencies in the personnel dosimetry program and are in the process of replacing the existing neutron dosimetry system (including accreditation of the new system), and characterizing the radiation spectra (neutron , beta, and gama) in areas of potential neutron doses. Adequate personnel monitoring for all radiation types expected to be encountered above prescribed dose levels is a requirement of DOE Orders and a goal of your newly issued Radiological Health and Safety Policy.

The DNFSB Staff conducted a detailed review of this subject which included a review of available documents, and discussions and interviews with Department of Energy (DOE) staff and contractor personnel at the Pantex Plant on March 17-18, 1993; and DOE EH-41 on March 31, 1993. The Board used Outside Experts, Auxier & Associates, Inc. to assist in this review.

Enclosed for your consideration and action as appropriate are the results of the review by Auxier & Associates, Inc. The most significant observations are the inability of existing dosimeters to accurately measure neutron dose; the lack of integration of the dosimeter program with the operational health physics program; and, the fact that accreditation of the personnel dosimetry system at a facility by the DOE Lab Accreditation Program (DOELAP) does not, in itself, ensure that the external dosimetry program at the facility can adequately measure external radiation doses in the radiation fields encountered at, the facility.

The Board notes that the evaluation and correction of deficiencies with the neutron dosimetry system at Pantex is ongoing. Please consider the enclosed observations during your continued review of this issue and keep us appraised of your progress.

If you need any further information, please let me know.

Sincerely,

John T. Conway
Chairman

Enclosure

c:
Mr. Mark Whitaker, Acting DR-1 (w/enclosure)

TECHNICAL REVIEW
OF THE
EXTERNAL DOSIMETRY PROGRAM
AT THE
PANTEX PLANT

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EXECUTIVE SUMMARY

A technical review of the external dosimetry program for neutrons at the Pantex Plant was performed for the Defense Nuclear Facilities Safety Board (DNFSB) by Drs. John A. Auxier and John R. Frazier of Auxier & Associates, Inc. The objective of the technical review was to determine the adequacy of the external dosimetry system currently used at the Pantex Plant, as well as the external dosimetry system proposed for use at the site. The focus of the review was on the ability of the neutron dosimeters to measure the radiation dose equivalent for the neutron fields present at potential exposure locations at the Pantex Plant.

A site visit to the Pantex Plant was made on March 17-18, 1993, by Drs. Auxier and Frazier. Each element of the external dosimetry program at the Pantex Plant was reviewed to determine whether the program is designed and implemented adequately to demonstrate compliance with the radiation protection standards for neutron radiation doses.

On March 31, 1993, a briefing on the subject of "External Dosimetry at Defense Nuclear Facilities" was presented by DOE staff at the offices of the DNFSB in Washington, D.C. Presentations during the meeting addressed DOE policy, guidance, and oversight for external dosimetry at DOE facilities. Discussions focussed on DOELAP, and the oversight and quality assurance for personnel dosimetry programs afforded by DOELAP.

After a careful review of the requirements and accepted good practices for external dosimetry, and after considering the information provided by DOE and the Radiation Safety staff at the Pantex Plant, the following summary statements are appropriate:

- The Panasonic TLD system, with the Model UD-802 AS dosimeter badge, has been used as the external dosimetry system at the facility since 1980. These dosimeters have neutron-sensitive elements and are assigned to all workers at the site. These dosimeters have a limited ability to measure neutron doses in the presence of other radiation fields (such as beta and gamma radiation) at the Pantex Plant.

- The external dosimetry program at the Pantex Plant from 1980 through 1991 was adequate to determine external radiation doses from gamma radiation and, most likely, from beta radiation.

- For employees who worked in areas in which neutron doses could have been received from 1980 through 1991, the personnel dosimetry program appears to have been inadequate to determine the neutron dose.

- Inadequate performance of the personnel dosimetry program for neutron doses from 1980 through 1991 is indicated by the failure of the personnel dosimetry system to pass DOELAP Performance Tests in 1989. Although satisfactory performance was demonstrated for beta and gamma radiation fields, the system failed the Performance Tests in two mixed-field (gamma plus neutron) categories.

- The ability of the personnel dosimetry program to determine, with accuracy and precision, the total radiation dose (gamma plus neutron) in work areas where neutron doses could have been received for the period from 1980 through 1991 cannot be determined with existing information. This is due primarily to the absence of neutron spectrum measurements in areas where neutron doses could have been received at the Pantex Plant. A determination of the radiation spectra (neutron, beta, and gamma) that were (could have been) present from 1980 through 1991 in the areas of potential neutron doses could be incorporated into a retrospective review of the external doses assigned to workers in those areas during that time period, to determine the extent and magnitude of errors that could have occurred in the assigned dose equivalent for those workers.

- The personnel dosimetry program at the Pantex Plant during 1992 appears to have been an improvement over the program in place from 1980 through l991. The most significant improvement is the ability of the dosimeter system (with a new dose calculation algorithm) to pass DOELAP Performance Tests in all categories tested, including neutron and mixed field categories. Passing the DOELAP Performance Tests demonstrates that the dosimetry system can measure, with accuracy and precision, radiation doses under specific standard irradiation conditions.

- A new external dosimetry system has been developed for use at the Pantex Plant and is currently undergoing Performance Tests and has not yet replaced the existing system. The

new system uses the existing Panasonic dosimeter readers with a new badge that is designed to measure (with greater accuracy and precision) radiation doses for all neutron, photon, and beta fields expected to be encountered at the Pantex Plant. Performance testing of this dosimeter is expected to be completed by August 1993.

- Completion of DOELAP Accreditation for a personnel dosimetry system at a facility does not, in itself, ensure that the external dosimetry program at the facility can adequately measure external radiation doses in the radiation fields encountered at the facility. An active, operational health physics program performs several functions in support of the overall external dosimetry program at a nuclear facility. It did not appear that these functions of the operational health physics program at the Pantex Plant were being incorporated into the neutron personnel dosimetry program. DOE and the Radiation Safety Department staff at the Pantex Plant have identified possible deficiencies in the personnel dosimetry program in the area of neutron dosimetry (as indicated by previous failures to pass DOELAP Performance Tests for neutron dosimetry and a lack of characterization information for neutron fields) . Although relatively few workers are exposed to neutron fields at the Pantex Plant, adequate personnel monitoring for all radiation types expected to be encountered above prescribed dose levels is a requirement of DOE Orders. Therefore, replacement of the existing personnel dosimeter with one that is designed to measure neutron doses more accurately is planned for the Pantex Plant.

1.0 INTRODUCTION

A technical review of the external dosimetry program for neutrons at the Pantex Plant was performed for the Defense Nuclear Facilities Safety Board (DNFSB) by Drs. John A. Auxier and John R. Frazier of Auxier & Associates, Inc., under Contract No. DNFSB-93-041. The objective of the technical review was to determine the adequacy of the external dosimetry system currently used at the Pantex Plant, as well as the external dosimetry system proposed for use at the site. The technical review consisted of four phases: assembly of pertinent requirements for external dosimetry at U. S. Department of Energy (DOE) facilities; a site visit to the Pantex Plant; a briefing by DOE staff responsible for oversight of external dosimetry programs at DOE facilities; and preparation of a report to describe each phase of the project and present the overall summary of the review. This report completes the final phase of the review.

2.0 REQUIREMENTS AND RECOMMENDED GOOD PRACTICES

Federal guidance for occupational radiation exposures was issued by the Executive Branch on January 20, 1987, and included external radiation dose limits (GPO 1987). This directive is the overall guidance applicable to Federally-control]ed operations, including DOE facilities. It is the stated policy of DOE to implement radiation protection standards that are consistent with Presidential-approved guidance to Federal agencies (DOE 1988b). To this end, DOE has implemented the Federal guidance of 1987, including radiation dose limits, in DOE Orders, primarily within DOE Order 5480.11 (DOE 1988b).

It is also the policy of DOE to operate its facilities so that radiation exposures are maintained within the limits specified in DOE Order 5480.11, and as far below the limits of this Order as reasonably achievable (DOE 1988b). A requirement of DOE Order 5480.11, paragraph 9a, is that "The exposure of an occupational worker to radiation resulting from routine DOE activities shall not cause the limiting values for assessed dose specified herein and summarized in Figure 1 to be exceeded." The radiation dose limit for stochastic effects specified in Figure 1 of DOE Order 5480.11 is 5 rem (annual effective dose equivalent), where the effective dose equivalent is from external and internal sources of radiation (DOE 1988b).

Another requirement of DOE Order 5480.l1, paragraph 9g, is that "Occupational workers shall be monitored, as appropriate, to demonstrate compliance with the radiation protection standards in paragraph 9b and to estimate the dose equivalents received from external and internal sources of radiation." For external radiation, DOE Order 5480.11 specifies that "Personnel dosimetry programs shall be adequate to demonstrate compliance with the radiation protection standards provided in paragraph 9b ." DOE Order 5480.l1 does not specify what constitutes "adequate dosimeters" within a radiation protection program.

External dosimetry is required for any radiation worker at a DOE facility who has the potential to exceed an external dose of 100 mrem/year (annual effective dose equivalent), 5000 mrem/year to the skin, 5000 mrem/year to any extremity, or 1500 mrem/year to the lens of the eye (DOE 1988b, DOE 1992). Since external radiation doses can be due to several types of radiation including gamma rays, x-rays, beta particles, and neutrons, exposure to more than one type of external radiation field may need to be monitored. Although there are no specific dose levels in DOE Order 5480.11 above which each type of external radiation must be monitored, the DOE Radiological Control Manual specifies, in Section 511, that "Neutron dosimetry shall be provided when a person is likely to exceed 100 mrem annually from neutrons "(DOE 1992).

DOE Order 5480.11 specifically references the American National Standard for Personnel Neutron Dosimeters (ANSI 1984) as the source of guidance for neutron dosimetry at DOE facilities. This Standard applies to dosimeters worn by individuals who may be exposed to neutrons with energies less than 20 MeV . The Standard notes the difficulties of neutron dosimetry, especially the inability of a single neutron dosimeter to respond properly over the entire range of neutron, energies that can be encountered in the workplace. Additionally, the Standard emphasizes that "the personnel dosimeter is only part of the neutron protection program" and that "it may be necessary to combine the data obtained from the personnel dosimetry system with information from other neutron monitoring techniques to make proper individual assessments of dose equivalent." (ANSI 1984).

Other requirements pertaining to external dosimetry programs at DOE facilities are given in the following documents:

- DOE Order 5480.15, "Department of Energy Laboratory Accreditation Program for Personnel Dosimetry' (DOE 1987)

- DOE/EH-0026, "Handbook for the Department of Energy Laboratory Accreditation Program for Personnel Dosimetry Systems" (DOE 1986a)

- DOE/EH-0027 "Department of Energy Standard for the Performance Testing of Personnel Dosimetry Systems" (DOE 1986b)

- DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements" (DOE 1981)

- DOE Order 1324.2A, "Records Disposition" (DOE 1988a)

The external dosimetry program must also meet the accreditation requirements of DOE Order 5480.15, "DOE Laboratory Accreditation Program for Personnel Dosimetry" (DOE 1987). The DOE Laboratory Accreditation Program (DOELAP) is intended to provide a structured means for assuring the quality of personnel dosimetry performance at DOE and DOE contractor facilities through performance testing, dosimetry and calibration intercomparisons, and applied research.

Policy statements contained in DOE Order 5480.15 require that DOE shall:

- provide personnel safety protection, including adequate dosimeters in the working environment;

- establish and maintain an accreditation program consistent with the applicable requirements of DOE/EH-0026 and DOE/EH-0027;

- ensure that DOE and DOE contractor dosimetry programs are accredited at two-year intervals according to DOE/EH-0026 and DOE/EH-0027; and

- establish and maintain a DOE performance testing capability consistent with DOE/ID-12105.

Requirements that are scheduled to be implemented in the near future are specified in the DOE Radiological Control Manual (DOE 1992). A significant future requirement of this Manual is the "External Dosimetry Program Technical Basis Document". This Technical Basis Document is to be developed to describe all aspects of the external dosimetry program.

Other DOE requirements and guidance that are expected in the near future include:

- Proposed 10 CFR 835, "Radiation Protection for Occupational Workers"

- "External Dosimetry Program Implementation Guide"

- "External Dosimetry Program Technical Guide""

3.0 SITE VISIT TO THE PANTEX PLANT

Drs. Auxier and Frazier of Auxier & Associates, Inc. made a site visit to the Pantex Plant on March 17-18, 1993. Each element of the External Dosimetry Program at the Pantex Plant was reviewed to determine whether the Program is designed and implemented adequately to demonstrate compliance with the radiation protection standards for neutron exposures. Additionally, the Program was reviewed with respect to conformance with the DOELAP requirements. The focus of the review was on the ability of the neutron dosimeters to measure the radiation dose equivalent for the neutron energies at potential exposure locations at the Pantex Plant.

The following areas of the external dosimetry program for neutrons at the Pantex Plant were evaluated during the review:

- Neutron sources and neutron energy spectra throughout the Pantex Plant;
- Neutron personnel dosimeter design and energy response characteristics;
- Equipment, procedures, and methods for calibrating neutron dosimeters;
- Equipment, procedures, and methods for determining neutron dose from personnel dosimeter readings, especially algorithms for relating calibration results to individual field dosimeter readings;
- Methods used by the personnel dosimetry program to combine the data obtained from the personnel dosimetry system with information from other neutron monitoring data to assess individual neutron doses;
- Quality Assurance/Quality Control procedures and records;
- Previous audits, appraisals, reviews, etc. of the neutron personnel monitoring program; and
- Current status of DOELAP accreditation for the Pantex Plant.

3.1 PERSONNEL INTERVIEWED DURING SITE VISIT

The following personnel were interviewed during the on-site review at the Pantex Plant on March 17-18,1993:

Jerry Martin - Manager, Radiation Safety Department
Roby Enge - Department Scientist, Radiation Safety Department
Will Ivie - Dosimetry Manager
Mark Prather - External Dosimetry Supervisor
Neill Stanford - External Dosimetry Consultant

Gene Runkle - DOE Albuquerque/Health Physics Division

Other Pantex Plant staff and DOE personnel assigned to the site were present during briefings and tours, but discussions with these personnel were limited.

3.2 TOPICS DISCUSSED

The following topics were discussed with Pantex Plant staff during interviews at the site:

* Purpose of the review
* Organization of the ES&H Division and the Radiation Safety Department
* External dosimetry program description
* Overview of radiation sources and types of radiation exposures at the site
* Sources and locations of neutron exposures
* Neutron energy spectra (calculations and measurements)
* Description and history of external dosimeters used at the site
* Dosimeter calibration methods, equipment, and facilities
* Procedures, records, and reports
* Quality Assurance/Quality Control for the external dosimetry program
* Status of DOELAP accreditation.

3.3 EVALUATION CRITERIA

Since the purpose of the review was to determine whether radiation workers at the Pantex Plant have been adequately monitored for neutron radiation doses, several questions were considered during the site visit. These questions included, but were not limited to, the following:

1. Have all locations been determined at the Pantex Plant where persons could potentially receive a neutron dose of 100 mrem or more per year?

2. Is neutron dosimetry provided to all persons who are likely to exceed 100 mrem per year from neutrons?

3. Since personnel dosimeters used at the site are albedo-based devices (thermoluminescent dosimeters) with an inherent sensitivity that is strongly dependent on neutron energy, have neutron energy spectra been determined (measured or calculated) at each potential exposure location?

4. Are dosimeter calibrations performed with neutron sources and energy spectra that are representative of energy spectra that are present at potential exposure locations at the Pantex Plant?

5. Are dose calculation algorithms adequate to assess neutron doses for the energy spectra at each potential exposure location at the site?

6. Are QA/QC procedures and records adequate, in place, and current?

7. Have all findings and recommendations from previous audits, appraisals, or reviews been given adequate attention and response?

8. Do the operational health physicists interact with the external dosimetry group to determine the appropriateness of dosimeter assignments for each work area?

3.4 OBSERVATIONS AT THE PANTEX PLANT

The questions listed in the preceding section, along with several other areas of inquiry, are addressed in the following list of preliminary observations made during the site visit:

* Locations at the Pantex Plant where potential neutron doses could be 100 mrem or more have been determined by Radiation Safety Department staff based on from knowledge of the locations of neutron sources at the site.

* The Panasonic TLD system with the Model UD-802 AS badge has been used as the external dosimetry system at the facility since 1980.

* These dosimeters have neutron-sensitive elements and are assigned to all workers at the site.

* The algorithm for converting raw readings for the TLD phosphors into dose estimates was changed once since 1980. This change became effective at the beginning of 1992.

* Minimum reportable doses for neutrons as measured with the Model UD-802 AS badge have changed from 50 mrem (prior to 1992), to 122 mrem (from January 1992 through October 1992), to 70 mrem (from November 1992 to date).

* Reportable neutron doses (i.e., doses exceeding the minimum reportable dose) are determined from dosimetry reports to occur for a small fraction of the radiation worker population at the Pantex Plant (e.g., 24 from a population of approximately 600 in 1989, 4 in 1991, and 50 in 1992.)

* The Pantex Plant staff reported that beta radiation doses and low-energy gamma radiation doses are not significant in locations of potentially significant neutron doses, but that the overall personnel neutron doses are much lower than doses from gamma-ray exposures.

* A review of the dosimetry records for 1989-1992 showed that the reported beta and gamma-ray doses were much less than the reported neutron doses for the individuals who had reportable neutron doses. [Reportable doses are the radiation doses that exceeded the detection limit.] In other words, the gamma-to-neutron dose ratio is very low for individuals for whom neutron doses were reported.

* To date, characterization of radiation spectra (especially neutron spectra) at the Pantex Plant has been limited . Neutron energy spectra have not been determined (measured or calculated) at each potential exposure location. It is expected that the neutron energy spectra in locations of potential neutron exposures have lower energies than the neutron spectrum from an unmoderated Cf-252 source.

* The algorithrn for routine processing of the Model UD-802 AS badge for personnel monitoring is the algorithm developed for an unmoderated Cf-252 spectrum. Since the dosimetry system is more sensitive to lower energy neutrons, it is likely that the neutron doses reported for personnel exposures will be overestimates of the neutron doses actually received by Pantex Plant personnel.

* DOELAP accreditation was first attempted in 1989 with the old algorithm for the Model UD-802 AS badge. Accreditation was not received at that time due to failure of the Performance Test. Although satisfactory performance was demonstrated for one neutron irradiation category (unmoderated Cf-252 neutron spectrum), the system failed the Performance Test in two mixed-field (photon + unmoderated Cf-252) categories. Performance of the dosimetry system was very poor for these mixed field categories. In some cases, neutron doses were reported as several times the actual delivered dose. But for 12 of 30 test dosimeters (in the two mixed field categories) receiving neutron doses ranging from 0.118 rem to 2.601 rem, the neutron doses were reported by the Pantex Plant as 0.000 rem.

* DOELAP accreditation was attempted in 1992 with new algorithms for the Model UD-802 AS badge. The dosimetry system successfully passed the Performance Test in all categories, including moderated and unmoderated Cf-252 neutron categories andfour mixed field (photon + neutron) categories. Doses from photons and doses from neutrons were measured accurately and precisely with the new algorithms for these categories of the Performance Test.

* A new external dosimetry system has been developed for use at the Pantex Plant. The system uses the existing Panasonic dosimeter readers with a new badge containing both the Model UD-809 and Model UD-812 dosimeters. Performance Testing of this dosimeter is underway and is expected to be completed by August 1993. The new dosimeter is designed to measure radiation doses for all neutron, photon, and beta fields expected to be encountered at the Pantex Plant. A unique feature of the new dosimeter system is the proposed ability of the system to perform a simple characterization of the neutron energy spectrum in which the badge has been irradiated and to correct the dosimetry response accordingly.

* It appears that the limitations of the Model UD-802 AS badge for measuring neutron doses (especially in mixed-field conditions) will be overcome with the Model UD-809/812 badge.

* It appears that the neutron sensitivity has not been determined for each badge (Model

UD-802) used since 1980, and there is no plan to determine the badge-specific neutron sensitivity for each new badge (Model UD-809/812).

* A documented (proceduralized) method for evaluating the appropriateness of the external dosimetry system (including dose calculation algorithm) for neutron dosimetry at each location of potential neutron exposure does not exist at the Pantex Plant.

* Plant management stated that work will not commence on components that have the most significant neutron fields until the new dosimetry system has successfully completed Performance Testing and is in place as the personnel dosimeter for Radiation Workers at the Pantex Plant.

4.0 BRIEFING BY DOE STAFF

A briefing on the subject of "External Dosimetry at Defense Nuclear Facilities" was presented by DOE staff on March 31, 1993, at the offices of the DNFSB in Washington, DC. A copy of the meeting agenda is shown in Attachment I.

Presentations were given by: C. Rick Jones, R. Thomas Bell, and Robert M. Loesch of DOE Headquarters (EH-41); and R. Douglas Carlson and Rick Cummings of DOE Idaho Operations Office. Dr. C. S. Sims of Oak Ridge National Laboratory also participated in the briefing by describing some technical aspects of neutron dosimetry programs, including neutron personnel dosimeters. Copies of briefing notes were distributed by DOE staff.

DOE noted that additional guidance from DOE for external personnel dosimetry is forth-coming. For example, the "Implementation Guide for External Dosimetry" has been prepared but has not been released, pending issuance of 10 CFR 835 as a Final Rule.

Presentations during the meeting focussed on DOELAP and the oversight and quality assurance for personnel dosimetry programs afforded by DOELAP. There appeared to be a reliance, by the DOE staff, on DOELAP as the mechanism that ensures that personnel dosimetry is adequately performed at a DOE facility. As noted previously, DOELAP provides a mechanism for standardizing external dosimetry performance under standard exposure conditions. There is a tendency to equate "adequacy" of a personnel dosimetry program with DOELAP accreditation, but the achievement of DOELAP accreditation alone does not ensure that the external dosimetry program accurately and precisely determines the radiation doses actually received at a facility . As noted by a DOE contractor during the briefing, DOELAP accreditation in conjunction with an active, operational health physics program can ensure that external radiation dosimetry is performed accurately and precisely.

The overall dosimetry program at a DOE facility is reviewed during the DOELAP accreditation process. There are no specific criteria listed by which the on-site DOELAP assessors determine whether the personnel dosimetry program incorporates information from the operational health physics program at the site to determine the dose equivalent. For example, information such as neutron energy spectra and neutron dose rates determined by the operational health physics

program is ordinarily used by a personnel dosimetry program to determine the neutron dose equivalent.

5.0 SUMMARY

After a careful review of the requirements and good practices for external dosimetry, and after considering the information obtained from DOE and the Radiation Safety staff at the Pantex Plant, the following summary statements are appropriate:

1. The external dosimetry program at the Pantex Plant from 1980 through 1991 appears to have been adequate to determine the external radiation dose from gamma radiation and, most likely, from beta radiation. For employees who worked in areas in which neutron doses could have been received during this period, the personnel dosimetry program appears to have been inadequate to determine the neutron dose. Adequacy of the personnel dosimetry program for determining the total radiation dose cannot be determined with existing information, due primarily to the absence of neutron spectrum measurements in areas where neutron doses could have been received.

2. The personnel dosimetry program at the Pantex Plant during 1992 appears to have been an improvement over the program in place from 1980 through 1991. The most significant improvement is the ability of the dosimeter to pass DOELAP performance testing in all categories tested, including neutron and mixed field irradiations.

3. Neutron personnel monitoring with albedo-based dosimeters (such as the Panasonic Model UD-802 and UD-809/812) is strongly dependent on the energies of the neutrons producing the dose. Therefore, it is essential that these neutron personnel dosimetry systems incorporate adjustments (corrections) for any differences between the neutron energy spectrum producing the dose and the neutron energy spectrum in which the dosimeter is calibrated. In the absence of such adjustments (corrections), the measured neutron dose can be in error. The extent of the error is determined by the energy dependence of the dosimeter and the magnitude of the difference between the field spectrum and the calibration spectrum.

4. It would be prudent to incorporate the adjustments (corrections) noted above for neutron dosimetry into a retrospective review of the external doses assigned to workers in areas of potential neutron doses at the Pantex Plant from 1980 to date, to determine the extent and magnitude of errors that could have occurred in the assigned dose equivalent of those workers.

5. Site-specific, area-specific, and task-specific neutron dosimeter correction factors have not been determined for the existing personnel dosimetry system (Panasonic Model UD-802) . Use of these correction factors is necessary for neutron dosimetry at a facility , such as the Pantex Plant, where the neutron spectra differ from the neutron calibration spectra. Specific correction factors can be determined in a number of ways , such as by performing side-by-side irradiations of the personnel dosimeter and "energy-independent" neutron

instruments. Alternately, neutron spectra can be measured at each work area, for each task, and subsequently incorporated with the known energy dependence of the personnel dosimeter to calculate an appropriate correction factor. The design of the new personnel dosimeter (Panasonic Model UD-809/812) allows for a dosimeter-specific, irradiation-specific correction factor without the need for additional instrumentation.

6. It is considered good practice to verify that the appropriate neutron-sensitive dosimeter elements are present in each new personnel dosimeter (such as the Panasonic Model UD-809/812) prior to deployment as the replacement for the existing dosimeters (such as the Panasonic Model UD-802). Current plans for deployment of the new dosimeter by Pantex Plant staff do not include such a determination.

7. Individuals for whom neutron doses were reported received neutron doses during one to approximately seven months of each year for 1989-1992. Generally, neutron doses were received by these employees in only one to three months of each year. Doses less than the detection limit were not reported. The detection limit for neutron doses was 50 mrem from 1980 through 1991, 122 mrem from January through October of 1992, and 70 mrem for November and December of 1992. [There has been no prescribed standard method for determining the minimum reportable dose for an external dosimetry system at DOE facilities. Therefore, changes in dosimetry algorithms and changes in interpretation of what constitutes the "minimum reportable dose" have led to the different values used for this quantity at the Pantex Plant.] It is the stated practice at the Pantex Plant to limit the number of months that each employee can be assigned to work areas in which neutron doses can be received. If it were not for this practice of limiting neutron exposures, it is plausible that an employee could have received a total neutron dose of approximately 1300 mrem in 1992 with zero neutron dose being assigned to the employee's external dosimetry records. This radiation dose would not be totally overlooked since, with the dosimeter system used at the Pantex Plant, most of this dose would be interpreted as being due to gamma rays (but at a lower reported dose). In other words, if work assignments were not restricted for areas in which neutron doses could be received, unreported doses, if they occurred at all, would not be as great as postulated above.

8. Neither of the facets of DOELAP specifically addresses whether the personnel dosimetry program is accurately and precisely measuring the radiation doses actually encountered in a work area. Although this limitation is not generally a problem for external dosimetry for gamma radiation or x rays, differences between neutron calibration spectra and neutron spectra encountered in work areas can lead to inaccurate neutron dose measurements with energy-dependent neutron dosimeters (such as the Panasonic TLDs).

9. Completion of DOELAP Accreditation for a personnel dosimetry system at a facility does not, in itself, ensure that the external dosimetry program at the facility can adequately measure external radiation doses in the radiation fields encountered at the facility. Good practice dictates that there must be an active, operational health physics program in place to complement the personnel dosimetry system at a facility. The overall operational health physics program at a facility performs several functions in support of the overall external

dosimetry program. These functions include, but are not limited to, the following

* evaluate exposure conditions to determine the type of external dosimeter that should be assigned to individuals entering an area of potential exposure

* ensure that the type of dosimeter(s) assigned to each worker for a specific job and work area are appropriate

* ensure that dosimeters are proporly worn by all individuals to whom a dosimeter is assigned

* evaluate exposure conditions that would necessitate additional corrections of dosimeter response (e.g., radiation energy spectra in work areas that differ significantly from calibration spectra)

* assist the dosimeter processing staff in determining what, if any, additional corrections are needed to assess dose equivalents.

It did not appear that these functions of the operational health physics program at the Pantex Plant were being incorporated into the neutron personnel dosimetry program.

10. As noted by DOE in the DOELAP Handbook (DOE 1986), "personnel dosimetry performance is direclly related to the assurance of worker safety." Obviously, this statement applies only to work areas where radiation doses are sufficiently high as to impact worker safety. Such work areas of potentially high radiation doses effect a very small fraction of the monitored employees at the Pantex Plant. If deficiencies in performance of a personnel dosimetry program are observed, then this would suggest a reduced ability of the program) to assure worker safety in the areas of potentially high radiation doses. DOE and the Radiation Safety Department staff at the Pantex Plant have identified deficiencies in the neutron personnel dosimetry program (as indicated by previous failures to pass DOELAP Performance Tests for neutron dosimetry and a lack of characterization information for neutron fields). As a consequence of these deficiencies, it follows that the neutron dosimetry program at the Pantex Plant from 1980 through 1991 was inadequate to determine neutron doses.

11. Although relatively few workers are exposed to neutron fields at the Pantex Plant, adequate personnel monitoring for all radiation types expected to be encountered above prescribed dose levels is a requirement of DOE Orders. Therefore, replacement of the existing personnel dosimeter with one that is designed to measure neutron doses more accurately is planned for the Pantex Plant. Careful monitoring of the performance of new personnel dosimeters immediately following emplacement and throughout their use in the future is clearly indicated for the Pantex Plant.

LIST OF REFERENCES

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