HETA 2003-0206
Evaluation of Radiation Exposures to U.S. Baggage Screeners

Peer Review Comments and Response to Peer Review Comments

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List of Abbreviations (not all are used in this document)

ACGIH®	American Conference of Governmental Industrial Hygienists
ALARA	As low as reasonably achievable
BOS	Logan International
BWI	Baltimore/Washington International
CAT	Computerized Axial Tomography
CBP	Customs and Border Patrol
CFR	Code of Federal Regulations
Cs	Cesium
CV	Coefficient of Variation
CVG	Cincinnati/Northern Kentucky International
DOE	Department of Energy
EDS	Explosive Detection System
FAA	Federal Aviation Authority
FAQ	Frequently asked questions
FDA	Food and Drug Administration
HHE	Health hazard evaluation
HNL	Honolulu International
IARC	International Agency for Research on Cancer
ICRP	International Council on Radiation Protection
LAS	McCarran International
LAX	Los Angeles International
LOD	Limit of detection
MDT	Harrisburg International
MIA	Miami International
NCRP	National Council for Radiation Protection
NIOSH	National Institute for Occupational Safety and Health
NRC	National Radiation Council
OEL	Occupational exposure limit
ORD	Chicago O'Hare
OSHA	Occupational Safety and Health Administration
OSL	Optically simulated luminescence
PBI	West Palm Beach International
PEL	Permissible exposure limit
PHL	Philadelphia International
PVC	Polyvinyl chloride
PVD	T.F. Green International
REL	Recommended exposure limit
Rem	Roentengen equivalent man
SI	Système International [International System]
TRX	Threat Image Protection Ready X-ray
TSA	Transportation Security Administration
TWA	Time-weighted average
μR/h	Micro Roentengen per hour

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Reviewer 1

1. I would recommend expansion of the introduction to include more details in areas relevant to the two objectives listed at the top of page 2. Specifically, more details on the carry-on baggage screening equipment would be useful. Are there several different types of machines used for carry-on screening? Compare and contrast the potential for radiation exposures between the carry-on and checked baggage machines in terms of both work practices and radiation energies used. A few pictures in this section would be helpful.

Response: We have very little additional information on TRX and EDS machines. We have added photographs to the Photograph Section of this report (pages 48–49) and added a section on "carry-on and checked baggage screener work activities"(pages 5–6)

2. Perhaps NIOSH should begin this section by describing the nature of an HHE and how it is used. For example, some readers may expect the type of design (randomization, power calculations, etc.) that is typical of a peer-reviewed research study. However, despite the limitations of a typical HHE, the results must be representative of situations that will be addressed in the recommendations. In this respect I am not entirely sure that the methods as described are adequate. A better description of how the 12 airports were selected should be added. Perhaps a table could be added that would show airport characteristics such as number of TSA screeners, types of machines used, machine locations, and existence of radiation protection training or programs. This might suggest useful comparisons that could be made between or within airports.

Response: We have added a better description of how the 12 airports were selected. (see page 8) We have also added a table describing many characteristics of the airports. We were not able to obtain all information systematically from the airports. (see Table 3, page 18) We do not believe that a description of the nature of an HHE is needed. However, we now discuss the limitations for this HHE, such as: (1) study participants were volunteers; (2) airports were not statistically selected; and (3) the results may not be generalized for all TSA baggage screeners. See page 43.

3. Since one of the most important aspects of this HHE was to characterize the potential for radiation exposure above background due to machine design or work practices, efforts should have been made to compare the outputs of each machine (4 EDS and how many TRX machines?) in a systematic way. Perhaps this was done but the description of "spot checks" and the personal dosimetry data collection is very sparse. It would be valuable to see a table of spot check data and dosimetry organized by each type of machine, as well as the protocol used for spot checks. For example, were measurements made at consistent locations for each machine and airport? Were they ever moved during the survey?

Response: We agree. We have added a table comparing doses from various TRX and EDS machines. See Table 6, page 23.

4. With regard to dosimetry, a better description of how 6 airports were selected, as well as number and type of screening workers measured would be valuable. Was the variation in numbers reported in Figure 3 due to airport size, proportion of volunteers, those who adhered to protocols, presence of an existing dosimetry program, or other factors?

Response: We have summarized as best as we can information on number of employees at each airport, and the number of EDS and TRX machines as well as their orientation (stand-alone versus in-line) on page 18 (Table 3). As described in the methods section, we enrolled volunteers who expressed an interest in the study. The study subjects were not fully screened for eligibility (for example, we did not ask if they were on nuclear medication), nor were they chosen randomly from a pool of eligible participants. We believe this to be an important study limitation. Also, please note that Figure 3 is now Figure 6.

5. The list of organizations with recommended radiation exposure limits is helpful, but no indication is provided on which limits were used in this study. The section on page 13 indicates that the FAA adopted ACGIH limits, but then says that TSA is subject to OSHA regulations. I'm not sure what this means with regard to a worker who may periodically experience a leaking machine or high exposure scenario related to a baggage jam.

Response: We agree that the section is confusing and have therefore eliminated references to FAA and ACGIH. We would like focus on three facts: (1) the TSA workforce is subject to OSHA regulations; (2) there are other organizations that recommend standards applicable to TSA workers; and (3) we encourage TSA to protect workers according to the ALARA principle.

6. The section on health effects will not be very useful to TSA managers or workers. The workers have essentially zero chance of an acute radiation effect. The paragraph on chronic effects just says that these effects are still being studied. It would be more helpful to cite the recent BEIR VII report where the linear no-threshold model is endorsed. Although the LNT model assumes that there is some elevation in risk due to any exposure above background, the report could state that this excess risk of cancer is extremely small for the dose ranges measured in this study.

Response: We have streamlined this section; we no longer discuss health effects as a separate section and ALARA is discussed in greater detail. Please note that BEIR VII was referenced in the draft final report as National Academy of Sciences (reference 30). We are still referring to BEIR VII in this revised report (reference 11).

7. Although Table 2 provides conversions from mrem to mSv, the body of the report generally uses units in mrem. I have no problem with this, but many scientific organizations and journals require SI units whenever possible.

Response: We used mrem to remain consistent with current U.S. regulations which are organized in a format familiar to TSA screeners. However, Table 2 has been deleted, and the report no longer refers to SI units.

8. The primary handicap in statistical comparisons and reporting summary statistics was the fact that over 80% of measures were below the LOD of 1.0 mrem. Therefore, it appears that any statistical comparisons made between checked and carry-on screeners was based upon the proportion of measurements above the LOD. This should be stated in the tables.

Response: We now clarify that 1 mrem is not the LOD, but the smallest "non-zero" integer after the raw data is adjusted using control badges. We say that comparisons are based upon the proportion of measurements above 1 mrem as a footnote in Tables 14 and 15.

9. While the tables reporting percentiles from the 50th to 99th are helpful, the real issue in question seems to be the maximum values found. It is clear that "typical" exposures are very low, but what caused the high measurements sometimes recorded? A statement on page 11 that "It was not technically feasible to determine exposure profiles for badges with doses less than 100 mrem," is confusing.

Response: We cannot link poor work practices to the dosimetry data because we did not observe work practices during the dosimetry phase. We could suggest possible reasons for high doses based on our observations in Phase I of the study. We have included a reference that describes the methods of determining static/dynamic exposures, as well as photos of static and dynamic radiation profiles. According to the laboratory, the images on badges with doses below 100 mrem are too faint to accurately determine radiation profiles, and this is mentioned on page 14.

10. Other than attempts to exclude high measurements for deliberate tampering, were actual high measurements systematically linked to work practices or machine characteristics?

Response: No. Our study design did not allow us to link poor work practices, baggage throughput, and other factors that could affect dosimetry results to actual doses.

11. The description of walk-through surveys on page 16 hints at the potential causes of high dosimetry results, but I could not find any attempt to verify these observations using personal monitoring data. Page 18, mentions data on baggage throughput at 3 airports, but I could not find any statistical results linking throughput to high dosimetry measurements.

Response: See comment 10

12. The potential for high exposure seems to be related to baggage jams. If possible, it would be very useful to report means and ranges for radiation levels from either real-time measurements or personal dosimeters when baggage jams were known to occur.

Response: We agree. We have included data taken specifically during baggage jams. However, because the data was collected by different personnel or data was presented to NIOSH staff in different formats; it is not possible to present overall data with the measures suggested by the reviewers. In response to this comment we describe in Table 5 the machines where workers reported a frequency for bag jams, and where we took measurements. See Table 5, page 22.

13. For personal dosimeters, it may be possible to make comparisons for airports or workers where baggage jams were common relative to workers or airports where they were rare.

Response: This is not possible for the following reasons: (1) apart from a couple of airports that reported that bag jams are rare, many airport workers said bag jams occurred "often", and provided frequencies with varying denominators (shift, day, month, etc) – therefore, we cannot say which airport(s) that participated in the dosimetry phase had high or low bag jams; and (2) unless we had some sort of physical presence at the airports during the dosimetry phase, and documented the bag jams, we cannot link the two.

14. With regard to deleting some "non-occupational" exposures, were they only deleted if the worker was undergoing nuclear medicine treatment, if tampering was found, or if exposure was "static?"

Response: Yes. See page 14.

If values were deleted for other reasons, this should be mentioned.

Response: Not applicable because the values were not deleted for other reasons.

15. I would recommend that doses less than the LOD should be reported as such, not as "zero" doses.

Response: A lot of the confusion on LOD may have been because of our statement "doses below the LOD were assigned a value of zero." We now explain that because most of the badges, which had non detectable raw doses, were adjusted by controls that had non-detectable doses, the net dose is at the most zero. See page 13 - "adjusting for background radiation." Assigning a value of "< LOD" will be biasing the values towards high doses.

16. The discussion seems to focus on the median or "typical" dose for baggage screeners. In my opinion, the atypical workers are of much more interest. As mentioned earlier, more effort and discussion should be focused on the reasons for periodic high measurements. Could the machines be designed better to reduce or eliminate the chance of bad work practices? Can baggage jams be cleared effectively and in a timely fashion without producing potential high dose scenarios?

Response: We now point out possible reasons for the high doses from our walk-through observations starting on page 17. Because we did not observe workers during the dosimetry phase, we cannot link poor work practices or malfunctioning equipment as a definite cause for the high doses. The fact that we are not able to link the doses to work activities is a study limitation.

17. I think the NIOSH recommendation that routine dosimetry is unwarranted is not supported by the data. It is clear that a combination of poor machine design and maintenance, together with bad work practices can result in unnecessary radiation exposures. As the report mentions, most radiation departments in large medical centers with similar exposure potentials maintain dosimetry programs. Until machine designs improve and effective ways to quickly deal with baggage jams are incorporated, a dosimetry program could be a valuable tool to identify both workers and scenarios that have higher exposure potential. Requiring baggage screeners to wear dosimeters may also help to reinforce in their minds that the potential for over-exposure exists.

Response: Our recommendation that routine dosimetry is not warranted was based on our data which showed that 90% of the values were at or below 1 mrem. However, the report has been revised to acknowledge limitations of the study and we now call for additional targeted monitoring of employees in selected airports for at least a year on a quarterly basis. We also recommend that TSA make participation in the additional dosimetry program mandatory, and that the program is run by a health or medical physicist. See page 38.

Reviewer 2

1. I am somewhat bothered by the reporting of the median doses, since in almost all cases they were zero (really, less than detectable). After reading the Summary on page v, I was a bit taken aback by the maximum doses reported in Table 6, Page 25.

Response: We agree. We now emphasize the percent of estimated cumulative whole body and wrist doses that exceed 100 mrem (this is the public limit and the monitoring threshold for DOE). See tables 16 and 17, pages 36–37.

2. A colleague and I investigated the results (as best we could from the summary data presented), and it appears that the individual airport and composite results are all lognormally distributed. (This can be done using censored (less-than) values.) We found that the median monthly dose is really about 0.1 mrem from Table 5s and 6 (which is below the limit of detection) and the mean monthly dose is about 0.6 mrem. (And, we also found that LAX and BOS are higher than the other airports.) The geometric standard deviation of these distributions is quite large (7 to 8). I might suggest that a brief analysis using the assumption of lognormality be added in the cumulative data analysis section around page 29 – 30. I think that this would show that the likelihood of annual doses exceeding 100 mrem is much less than 0.1%, which would strongly support the later conclusion that monitoring is not required.

Response: A lot of the confusion on LOD may have been because of our statement "doses below the LOD were assigned a value of zero." We now clarify that the doses were not "<LOD", but an actual number which is the resultant of control measures subtracted from raw measures. We also recognize that there are many scientifically valid ways to describe the data. In this draft we now emphasize percent of doses above 100 mrem and list the three highest doses as a means of drawing attention to the few high measures (and conversely to the majority of low measures). These results show that only a small number of individuals (13 of 854) had an estimated cumulative dose of 100 mrem or more.

3. If I understand the first bullet on page 36, line 801, you are suggesting some follow-up measurements using personal dosimeters. This is rather subtly worded, and could be interpreted as recommending that dosimeters be used – which seems to contradict the conclusion on line 772, page 35. This could also be interpreted as a call for "more science" to fund the researchers, since they've already said it isn't needed. This proposal for more research could be coupled with the discussion I've suggested above regarding determination of the lognormality of the dose distribution, which might make it both more palatable for funding agencies and less intimidating for the workers.

Response: We have strengthened our recommendation on additional monitoring. We now call for additional targeted monitoring of employees in selected airports for at least a year on a monthly or quarterly basis. We also recommend that TSA make participation in the additional dosimetry program mandatory. See page 38.

4. This is actually well written and understandable, except perhaps for the use of the median doses as a basis for discussions. Some might interpret the emphasis on the "zero" results to be a diversion from the maxima. The "big" doses certainly draw the reader's attention. A way of emphasizing the unlikely (and probably spurious nature) of these "big" numbers would help.

Response: We agree. We now emphasize the percent of estimated cumulative doses that exceed 100 mrem (this is the public limit and the monitoring threshold for DOE). See Tables 16 and 17, pages 36–37.

Reviewer 3

1. Table 2, page 13 – background is 0-20 μR – state over what time period.

Response: We have deleted Table 2.

2. The report is thoughtful and thorough. However, I am concerned about the several high doses reported to several workers (some near or over 500 mrem, including one near 1000 mrem). Based on the levels expected, and those recorded for the vast majority of handlers, I would think that routine badging of these employees would not be warranted from a radiation protection standpoint (although it might be instituted in some cases simply to communicate a culture of safety and reassure the workers, especially if requested). The report suggests further investigation of these high values, to see if they may have been due to tampering, nuclear medicine or other medical exposures, etc. and I agree. However until this is resolved, I don't think that routine badging can be categorically ruled out. If it is poor work practice, leaky devices, or other situations leading to real exposures of this level, badging may be necessary in some cases. These are not doses that are particularly worrisome, but certainly ones that should be recorded. If they are due to tampering or other non-work-related causes, this should be determined and a way to avoid this should be sought.

Response: We agree. Text has been changed to acknowledge study limitations. We now recommend additional targeted monitoring of employees in selected airports for at least a year on a quarterly basis. We also recommend that TSA make participation in the additional dosimetry program mandatory and that the dosimetry program be managed by a health or medical physicist. See page 38.

3. Page 13-14 – the more up to date terms 'stochastic' and 'nonstochastic' should probably be used.

Response: We agree. However, we have streamlined the entire "Evaluation Criteria" section for clarity, and no longer mention chronic or acute health effects.

4. Some of the manufacturing defects found in certain machines (page 16) could be cited in the executive summary.

Response: We agree. See page v of the current draft.

5. Page 23 – the number of significant figures in the average background number is excessive.

Response: This equation (derived by the laboratory based on a year-long study of background radiation throughout the U.S) was used to estimate background levels by NIOSH investigators and the contract laboratory. Therefore it is appropriate to report the exact equation that was used for computation.