TRANSPORT WORKER RADIATION EXPOSURES HANDLING AIR SHIPMENTS OF RADIOACTIVE MATERIALS

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1. INTRODUCTION

The transport of radioactive materials is a complex operation involving many entities and requires for many radionuclides speedy transit. There is the consignor or shipper giving the package to a freight forwarder who in turn gives it to an airline carrier who transports the package in a timely fashion. At the receiving end the airline carrier gives the package to a freight forwarder who delivers the package to the ultimate consignee. There are variations of this flow with some consignors, consignees and airline carriers acting as their own freight forwarders.

This study (1) was undertaken to determine exposures to transport workers handling packages containing radioactive material (ram) at the Buffalo and Rochester area airports. Such workers are normally without any personnel monitoring devices. Their exposure would be incidental to loading, unloading and sorting packages in cargo areas and processing the necessary paper work.

2. METHODOLOGY

For the purposes of this study all air carriers and freight forwarders located at the Buffalo and Rochester area airports were studied. A freight forwarder in the New York City was included in study because he did a great deal of containerization of ram packages for air transport. Each site was checked by radiation survey meter for external radiation, smears were taken on ram packages and in cargo areas where ram packages were handled and stored to detect presence of removable radioactive material contamination and finally all individuals who might be exposed to ionizing radiation were issued thermoluminescent dosimeter (TLD) badges: two types were available - one type to be worn on the body to determine the whole body dose issued to all individuals potentially exposed and the other a ring badge to be worn on the finger to determine hand exposure for those persons handling packages.

survey
For the package a seven consecutive day surveillance period was used at each airport. At each location whole body TLD (WB) badges were assigned to all personnel involved in handling and recording of packages including supervisors, dispatchers and handlers. TLD ring badges were assigned to handlers and other employees depending on duties. The normal badge wearing period was 6 - 8 weeks.

3. RESULTS

During the 7 day study period at Buffalo Airport 143 ram packages moved through the airline cargo areas. Of these 12 (9%) ram packages were exempt from labeling because they contained small quantities of radioactive material. The remaining labeled ram package were distributed as follows:

57 (40%) packages Radioactive White I, 12 (9%) Radioactive Yellow II and 58 (41%) Radioactive Yellow III; the total observed TI handled during the 7 day period was 78.7 TI units while the labeled value was 111.9 TI units; assuming the 7 day study period was representative of most weeks in the year, the values extrapolate on an annual basis to 5819 (label) and 4092 (observed) TI units.

At the Rochester Airport 25 ram packages were moved through airport during the study period. These were distributed as follows:

15 (62%) Radioactive White I, 8 (33%) Radioactive Yellow II and 1 (4%) Radioactive Yellow III; during study period only 3.3 (label) 2.4 (obs) TI units were handled which extrapolates on an annual basis to 172 (label) 125 (obs) TI units, or only 3% of the value handled at Buffalo Airport.

At Buffalo Airport the predominant radionuclide based on TI was MoTc-99 with 37 (label), 25.1 (obs) TI units. The total activity handled was 190.0 Ci,contributed mainly by Ir-192, 164.0 Ci involving 2 separate shipments of 1 sealed source each - 112 Ci and 52 Ci, and MoTc-99 - 19.0 Ci. The corresponding TI units were Ir-192; 4 (label) 2.6 (obs) TI units; the other radionuclides contributing large TI units were Na-24: 13.4 (label) 14.3 (obs) TI units; I-131: 17.7 (label) 9.58 (obs) TI units; K-42: 12.8 (label) and 10.4 (obs). Na-24 and K-42 have half lives of 15 and 12 hours respectively and are produced at the University Reactor in the Buffalo Area and consequently these radionuclides are handled at Buffalo Airport with little decay. For Na-24 the TI (obs) was slightly higher than the TI (label) and for K-42 the TI (obs) was slightly lower. On the other hand for MoTc-99 the TI (obs) was only 68% of the TI (label) indicating considerable decay. The total activity handled on an annual basis at the Buffalo Airport and extrapolated from study period would be almost 10,000 Ci contributing 5800 (label) 4100 (obs) TI units.

The New York City freight forwarder who was included in the survey received ram packages from several radiopharmaceutical firms and forwarded them to all parts of the United States. To expedite this transfer the firm assembled groups of ram packages going to a given region into containers or overpacks. Based on the one day observation during which TLD area and personnel badges were distributed this firm handled 222 ram packages per week and 11,544 packages annually. The total TI handled per week would be 592 TI units (label) and 30,800 TI units (label) annually.

Ram packages were found in this study with few exceptions to be shipped in conformity with regulations. The major exception was a package with a surface dose rate greater than 300 mrem/hr and where upon opening by the shipper, it was found that the internal shield was left out. Packages and cargo areas were all essentially free of surface contamination.

Of the 41 transport workers who worked for the airlines at Buffalo Airport and who wore TLD badges for periods ranging from 6 to 8 weeks, two workers would receive 0.60 and 1.55 rem per year based on doses received during monitoring period. Nine would have received exposures between 0.25 to 0.5 rem/y based on monitoring period results. Out of 42 ring TLD badges issued only 28 were returned. Of these, two showed positive results which would indicate hand exposures of 0.24 and 6.01 rem/y. One individual who worked for A5 which is both an air cargo carrier and freight forwarder had the

highest whole body and hand exposure 1.55 and 6.01 rem/y respectively. The cargo personnel working for the freight forwarders returned 52 TLD whole body badges, one worker would have received 0.67 rem/y based on the results of the monitoring period. Two whole body badges indicated that the wearers would have received 0.30 and 0.36 rem/y. Out of 67 ring badges issued 41 were returned and two indicated 0.31 and 0.42 rem/y hand exposure.

At the Rochester Airport, out of the 19 whole body and ring badges issued 11 whole body and 9 ring badges were analyzed and none gave any exposure above the minimum detectable.

At the New York City freight forwarder out of 17 whole badges issued 15 were returned from this firm and were worn for periods ranging from 31 to 63 working days. Of the 15 badges, 7 gave readings above minimum detectable and ranged from 0.24 to 1.69 rem/y. All but one badge was above the 0.5 rem/y. Of the transport workers who had positive whole body doses, the 3 who returned ring badges, had exposures of 0.71, 1.03 and 1.11 rem/y. The other 4 ring badges issued to workers with positive whole body dose were lost. Out of a total of 16 ring badges distributed only 8 were returned.

An estimate of the average population dose for the sample of workers who were monitored at each location is given by the following equation:

$$(PD)\ \text{avg.} = \frac{\sum_i D_i}{\sum_i n_i} \times 250, \quad \frac{\text{man-rem}}{\text{y}}, \quad \text{where } \sum_i D_i \text{ is sum of doses}$$

received and $\sum_i n_i$ is sum of the days the badges were worn.

Table I summarizes this calculation for each location.

4. CONCLUSION

With the advent of sensitive TLD badges it is now possible to objectively determine whether additional radiation precautions are needed in a given operation.

Handling 5800 TI units (label)/y, Buffalo Airport transport workers had a population average dose value of 0.14 man-rem/y, within the 0.17 man-rem/y recommended. At 31,000 TI units (label)/y the sample definitely exceeded the population value. At 170 TI units (label)/y the population dose value was zero. One might draw the following conclusion: handling between 100-1000 TI units (label)/y probably will result in average and individual dose values within the recommended limits; between 1,000 to 10,000 TI units (label)/y, transport workers occasionally will exceed the recommended individual value but sample average dose value will be at or less than the recommended population dose limits; greater than 10,000 TI units (label)/y transport workers become radiation workers and should be monitored and inspected accordingly.

Location	Company	TI Handled	Average Population Dose	Average Annual Population Dose/TI
		TI units (label) y	Man-rem y	Man-rem TI
Buffalo Airport Airlines	A1	2225.6	0.061	0.000027
	A2	504.4	0.032	0.000063
	A3	0	0.18	-
	A4	2906.8	0.16	0.000055
	A5	182	0.49	0.0027
	Totals	5818.8	0.14	0.000024
Buffalo Airport Freight Forwarder	D1	2116.4	0	0
	D4	1643.2	0.21	0.000128
	D5	0	0.046	-
	D7	0	0	-
	Totals	3759.6	0.021	0.0000055
Rochester Airport Airlines	A1	20.8	0	0
	A2	0	0	-
	A4	93.6	No badges returned	-
	A5	57.2	0	-
	Totals	171.6	-	-
Rochester Airport Freight Forwarder	D5	0	-	-
	D7	26	-	-
	D10 & 11	140.4	0	0
	Totals	166.4	-	-
New York City Freight Forwarder	E6	30,800	0.36	0.000012

Table 1 Average Annual Population Dose Estimates

REFERENCE

1. This study was supported in part by a grant from the U.S. Nuclear Regulatory Commission and the U.S. Department of Transportation. This paper is based on material taken from the complete report submitted in December 1975 to these agencies.