RSP-0285

Contract 87055-10-1246-"R484.1"
Review of INFO-0286 (1988); Doses from Portable Gauges

Stantec Project No. 121698000

Stantec

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ABSTRACT

Stantec had been experimenting with calculated exposure since 2002. We had been using multipliers to calculate the exposure of our employees by counting three parameters and by assigning a multiplier value for each. Our results were balanced against the dosimetry used by some of the employees to adjust the multipliers. Our pool of data was minimal and we knew we needed a larger pool of data to enhance our performance. This limited tool allowed us to calculate a likely exposure for our employees especially those with little use of the portable gauges. It was most useful when trying to estimate the exposure to an employee following an incident or an overexposed dosimetry. The CNSC was looking for a data pool backed by a record of activities carried out by the employees. They were seeking data to answer a burning question. What was the contribution from neutron to a portable gauge operator? Previous research had only a limited data because of a small sample size and no modeling was possible to study the exposure because there was no activity log available to perform the task. During our attendance at a Radiation Conference someone had noted that we had common interests and introduced us to one another

A research project was initiated and the data was gathered from field personnel wearing Landauer® dosimetry combo with type TA1 Luxel® for gamma and CR39 for neutron. The one year assessment project with deployment of radiation monitors was initiated on June 1st, 2011 and was terminated on May 31st, 2012.

The employees submitted monthly exposure reports detailing key personal exposure information parameters as per the study terms which included:

- The hours transporting a gauge;
- The number of shots taken; and,
- The time taken to perform maintenance on the gauge as per manufacturer's instructions.

Once the assessment portion of the project was completed the exposure report was matched to the totals for the three parameters listed above to identify the most likely contributor of gamma/neutron exposure by density gauge operators.

DISCLAIMER

STANTEC CONSULTING

A sincere thank you to a colleague Ken Bisson for reviewing the material associated with this project.

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1. INTRODUCTION

This project was initiated to provide data to assist with the following:

The CNSC was looking for the following:

- Verify the exposure when an estimate of the exposure at 30 to 100 cm from device or transport case, neutron dose could account for 13.5% to 80% of total dose.
- Two main elements make up the dose a Gamma dose primarily from Cs-137 source and a Neutron dose from Am-241/Be source.
- Update the previous Info-0286 which became the source document for CNSC and for licensees for:
    - Risk assessment for portable gauge use
    - Dose tracking methodology
    - Training on risk and dose control
    - Dose limit compliance verification
- Info-0286 does not define a "shot", portable gauge users measure 2 to 6 times per recorded measurement and record average result.
    - Majority of licensees count the number of shots as the number of recorded results it could be (15% to 50%) of total shots counted
- Portable gauge licences "**moderate risk**"
    - There are transport concerns and theft/mobility.
    - It is assumed doses are less than 1mSv
- If neutron dose ~50% total dose; (x2), If recorded measurements ≠ exposures; (x2 to x6), If the transport dose was considered, (x1.2 to x3), than the actual doses may be between 1 and 30 times those currently reported based on 800 shot rule.
- There is a need for reliable data on total doses to portable gauge operators
- There is a need for accurate data on number of shots compared to total doses for operators
- There is a need to confirm whether the transport dose needs to be included/tracked separately from "shot" dose.

Our needs were much simpler we wanted to verify the neutron dose received by gauge operators, learn more about the neutron share of the radiation dose received by our employees and adjust our multipliers used when calculating our estimated doses.

- Better understanding of the amount and type of radiation received by the operators of portable gauges.

- Validation of the multipliers to calculate exposure for operators when dosimetry is below threshold.
- Cost savings on dosimetry when operators have moderate to low usage and the exposure reports come back with the indication of no data recorded.
- Allow licensee to better meet their obligations under the Nuclear Safety Control Act.

2. METHODOLOGY

2.1 Briefing

The Canadian Nuclear Safety Commission (CNSC) had identified a contractor (Stantec Consulting Limited) already calculating radiation exposure for their employees. A Microsoft PowerPoint Presentation was assembled for presentations in most of the large Stantec offices who would be taking part in the project. The presentation team consisting of one CNSC representative and one representative from Stantec who travelled across Canada during the period of June 1st 2011 to June 16th, 2011. A recording of the presentation was made and linked to the PowerPoint presentation for the benefit of employees unable to attend the scheduled presentations. A copy of the presentation has been provided in Appendix A.

The presentation covered the rationale for the project and most important, it defined three main parameters and their reporting requirements.

Those main parameters were the following:

- Travelling Hours: which was defined as the time spent inside a vehicle when traveling to site or sitting inside the vehicle on standby or completing paper work and the gauge was in proximity.
- Number of Shots: which was defined as each time an operator would depress the start button to initiate a count. This would include any counts not used or recalculated.
- Maintenance Hours: which was defined as the number of hours spent performing a maintenance activity such as cleaning the gauge, cleaning the shutter as per the manufacturer's instructions and performing an inspection activity within the storage area of the density gauges.

The presentation contained information on where the dosimetry pouch would be worn, where the gauge would be placed and stored in the vehicle and along with its' orientation, and finally how the employee position themselves one metre distance from the gauge when counting. A dosimeter pouch was supplied that was worn around the neck to ensure a homogenous wearing pattern by all users, this pouch contained identification and return instruction should it be lost. This pouch also allowed the current dosimetry to be carried in the same location as the research dosimetry.

2.2 Monthly Reporting

The operators were to forward their individual and monthly exposure reports (reference Appendix B) to the Radiation Safety Officer (RSO). The RSO would keep tabs on the calculated exposure of each participant. There are an infinite numbers of conditions that could be reported, for ease of operation three key parameters were retained.

The exposure was calculated as follows:

- Travelling Hours: the multiplier was picked as the default distance between the driver and the gauge set at 1 m, a distance deemed ***worst case scenario***, to assess representative Gamma and Neutron radiation levels from the gauge. For this parameter dose was estimated at 1 m for uniformity and to allow for worst case scenario, set exposure rate is 0.002 µSv/h.

- Gauge Shots: Previously the radiation level used was a representative Gamma Neutron Radiation level from the front of the scaler at 30 cm, this multiplier was increased following review and discussion with the CNSC. The exposure was set at 0.0005µSv per shot.

- Maintenance: a representative Gamma Neutron Radiation level from the front of the scaler at 10 cm was used for uniformity, the set rate is 0.004µSv/h

The reported activities carried out by the employees were entered in a Microsoft Excel sheet for quick use (reference Appendix C), the monthly exposure reports were modified to remove the name of the employees and link the report to a dosimetry report from Landauer® (dosimeter supplier) for comparison.

2.3 Sample Size

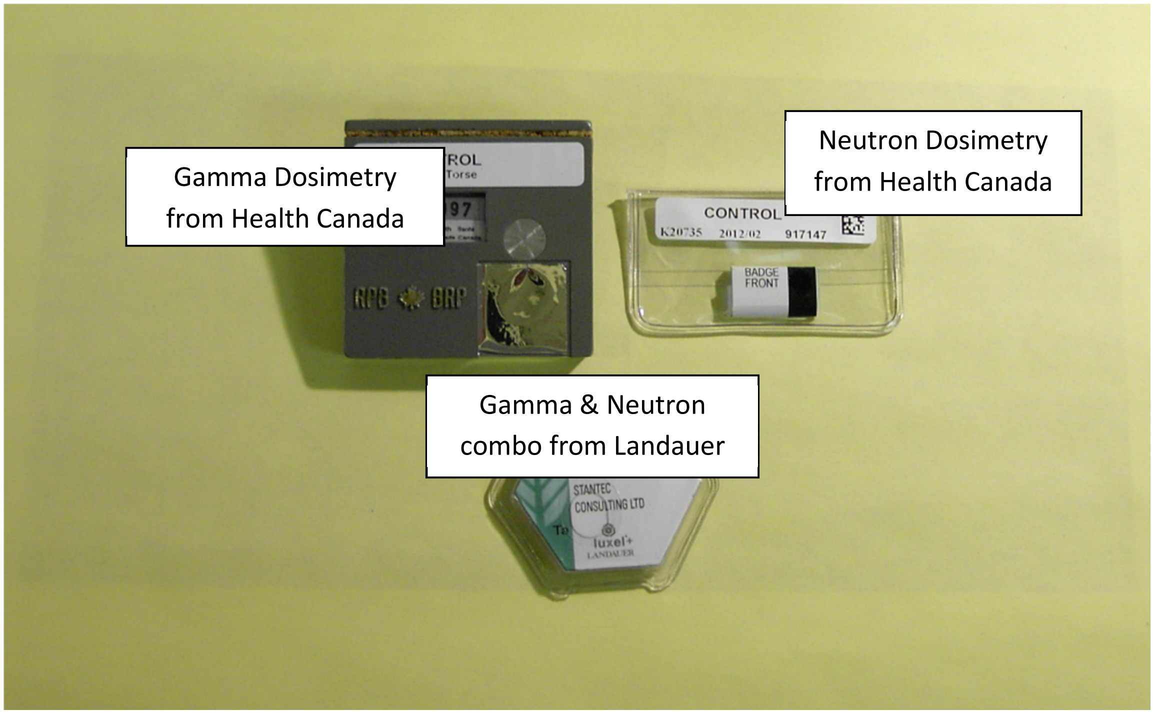
Originally 235 trained Stantec employees were eligible to participate in the assessment study. Stantec RSO anticipated that the participation numbers would not exceed 200 and as such 200 dosimeters were ordered. As the project evolved the numbers of active participants would change in accordance with the contracted site work activities and as such activity levels within any area and the seasonal requirements for work resulted in varied participant activity and dose levels.

From the total of 176 employees who participated in the project, a total of seven (7) dosimeters were lost and 35 employees did not receive a dosimeter (participate in the assessment study) or did not alert their supervisor that they needed a dosimeter when their assignment changed. Those results were included in the data even if there is no dosimetry correlation and can still be useful when trying to perform dose modeling with actual activities by gauge operators.

Five (5) of the missing dosimeters were later recovered. The useable sample size was based on 139 employees. Where possible the dosimetry as reported by Health Canada (dosimeter analytical laboratory) was entered for comparison, it is to be recognized that the sampling period cannot be reconciled.

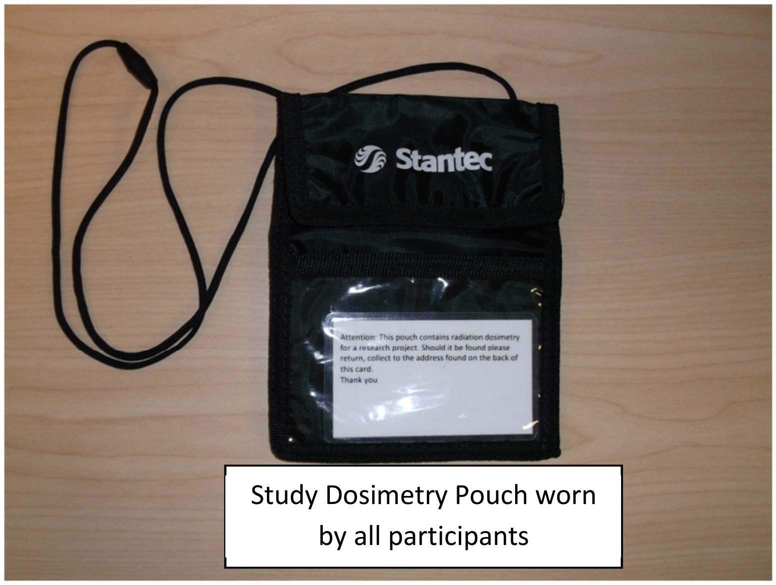
2.4 Dosimetry

The most significant element of the dosimetry systems provided by Landauer® was the fact that the system could and was worn for a period of 12 months (1-year). This would allow many short time users the ability to wear the dosimetry for longer than the normal three months wearing period. Stantec and the CNSC expected that this would eliminate many instances where no measurement was reported because the exposure level was lower than the threshold level for reporting the dose.



The industry standard three month dosimeter wearing period often reports no measurement either in gamma or neutron dosimetry. Landauer® dosimetry combo with type TA1 Luxel ® for gamma and CR39 for neutron was secured from the supplier and provided to all study participants. All participants wore both their regular dosimetry on a three month cycle and the project dosimetry set it included thermoluminescent dosimeters (gamma) for some offices and from one (1) office and the CR39 (neutron) on a three month wearing cycle .

For the study there were sometimes two or three dosimeters situated in the study dosimetry pouch so all dosimeters would be measuring from the same uniform vantage point. The study participants were identified by dosimetry serial number, office number (O1 to O19) and employee number (E1 to E40).



Study Dosimetry Pouch worn by all participants

2.5 Equipment

For the study direct read dose meters were employed and included the following units:

- RDS-30 Survey Meter was used for Gamma readings. Last calibrated August 15, 2011.
- Ludlum Model 2363 Gamma-Neutron Survey Meter & model 42-41 Prescila neutron probe was later used to take additional readings. Last calibrated November 17, 2011.

3. DOSIMETRY DATA

3.1 Compiling Data

The process to return the dosimeters took longer than first anticipated. An additional factor in the report delay was that the dosimetry provider undertook a change in the dosimetry report during the study which complicated the data entry and review.

3.2 Preliminary Results

- A preliminary review of the results considered the following information:

  One of the benefits of calculating the exposure as the project progressed was to identify four (4) employees who were designated as Nuclear Energy Workers (NEW) when their office relied solely on regular dosimetry processed quarterly, but usually came back indicating an exposure level lower than detection.

  - A change in the wearing period for our dosimetry, the study is now evaluating utilizing a four (4) month cycle and possibly a six (6) month cycle.

- It appears that neutron activity was only recorded when the participant took over 800 shots in combination with the associated transportation time.
  - It should be noted that one participant had 98 hours of transportation and 289 shots and had their dosimetry reporting neutron exposure.
- Some employees who have reported a high usage and took numerous shoots had dosimetry reporting very small numbers.
  - Based on this data it can be presumed that the dosimetry system was not worn when the study activities were carried out.
  - The Stantec RSO during the study witnessed numerous worn out and dusty state of many pouches.
  - One e-mail has been sent to Landauer asking them to verify for anomalies in the data for some of the dosimetry identified by the Stantec RSO
  - A few dosimeters were not worn because the Stantec RSO verified this with the dosimetry data from Health Canada which also had also recorded a low exposure.
  - The anomaly here may be from the failure by the participant to wear the dosimetry system every day when conducting activities with the portable gauge.
- Three dosimetry results reported a high exposure that did not match the documented activities.
  - The Stantec RSO suspects that this dosimetry system was left in proximity of a gauge for a period of time when no activities were carried out.
- When the dosimetry systems arrived from the service provider the Stantec RSO had amalgamated the control badges into one reading for all dosimetry (reference Appendix D).
- The service provider was contacted to obtain the values of the control dosimetry (Appendix E).
  - The control values identified by the service provider were assigned to a zone, additional dosimetry was used as control for additional zones and when no control dosimetry existed the default value was assigned for that zone.
  - The corrected values were then calculated have been provided in Appendix F.
  - Control dosimetry serial number 0917381 went missing so serial number 0917421 was assigned for zone five which includes office numbers four (O4) and seven (O7).
  - Control dosimetry serial number 0917382 was assigned for zone two which includes offices number two, nine, twelve and nineteen.
  - Control dosimetry serial number 0917383 was assigned for zone one which includes office number one, eight, ten and fourteen.
    - Control dosimetry serial number 0917384 was assigned for zone three which includes offices number thirteen, sixteen and seventeen. Control dosimetry serial

number 0917385 was assigned for zone four which includes office number three. Control dosimetry serial number 0917585 was assigned for zone six which includes office number eighteen. Control dosimetry serial number 0917470 was assigned for zone eight which includes office number eleven. The remaining offices were assigned to zone seven and used the default values which included offices number five, six and fifteen.

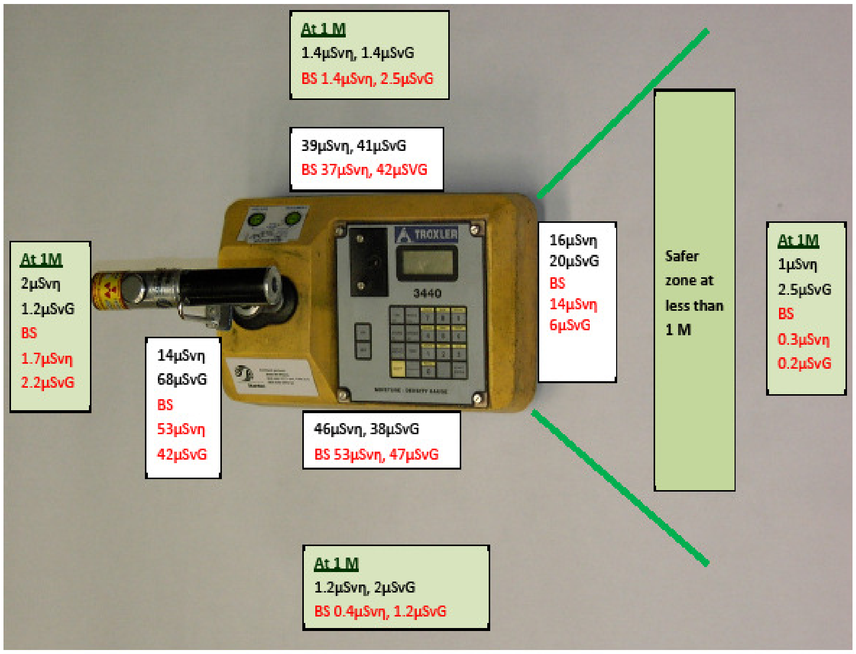
When dosimeter monitoring is required it is recommended that it be based on this study and that it be upgraded to include gamma/neutron combined dosimetry. The contribution of neutron becomes important when a gauge operator has a significant use of over 800 shots and/or when they are required to travel long distances. The contribution of neutron to the dose of operators who reported few shots and little travel time could not be measured through dosimetry, this group comprised most of the operators involved in this project.

A review the multipliers for the Stantec calculated exposure will be undertaken. The calculated exposure was theoretically higher than the measured actual exposure for 49% of the assessments. The calculated exposure was lower than the measured exposure 29% of the time. The change to the multipliers is expected to be small given the results obtained in this research project. When Stantec assigned our values for multipliers we acted conservatively in favour of being higher (worst case) over having readings that were too low (best case scenario), this approach supports the data collected in this study.

3.3 Posters

Two posters were created to relay information to the participants. The first poster shows the safest/optimum position of where to stand with relationship to back scatter when the gauge is in use. The second poster shows how to orient the type A unit when transporting the gauge.

Poster No. 1 – Best Standing Position Against Back Scatter Operation

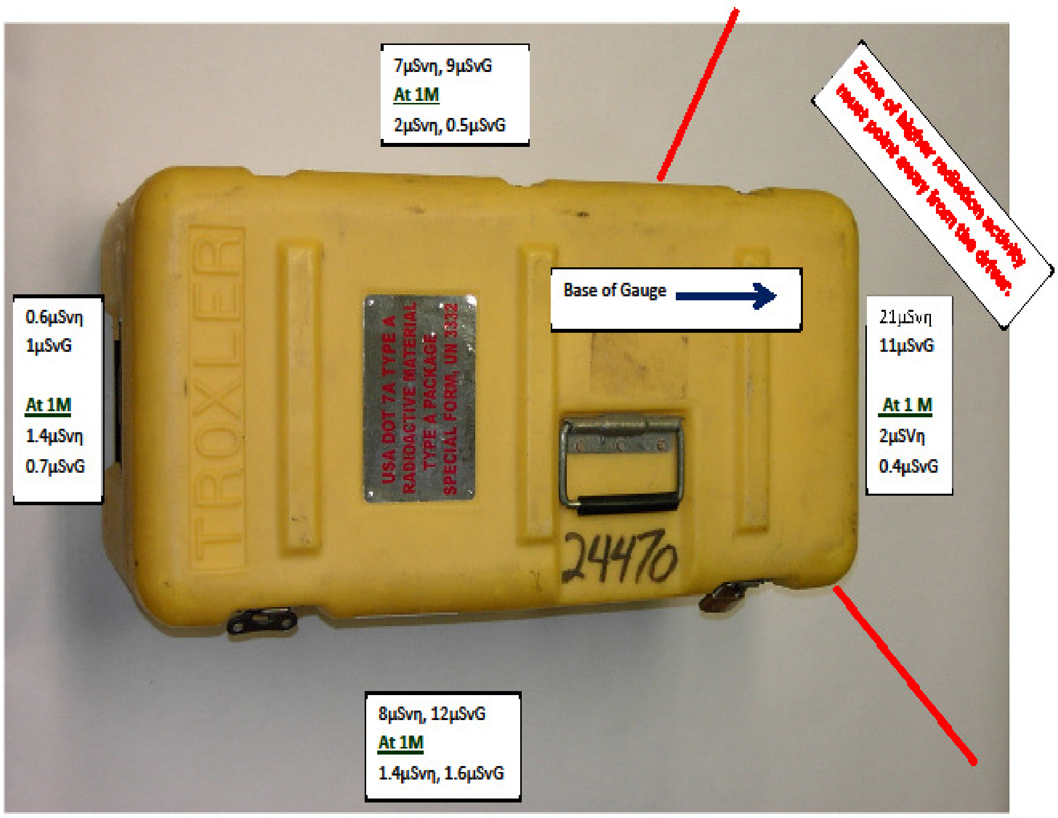


All radiation levels in µ=micro, Sv=Sievert, η=neutron , G=Gamma, BS= Back Scatter position

Radiation Activity levels and safe zone for a Portable Gauge

Poster No. 2 - Identifies the Area to be Positioned away from the driver.

Poster No. 2 – Orientation of gauge for Transport



All radiation levels in µ=micro, Sv=Sievert, η=neutron , G=Gamma

Radiation Activity levels and safe zone for the transport of a Portable Gauge

3.4 Feedback

Once the collection of the project information was complete a short feedback form was sent to the participating employees to gather feedback on two points and give them the opportunity to add comments of their own. (reference Appendix G)

3.5 Additional Research

Additional data should be collected on possible exposure to lower leg extremities:

- It would be informative to evaluate the amount of radiation received by a field employee to their leg extremity.
- A brief calculation indicates a potentially high exposure/dose value. This is limited by the fact that we do not know how long a density gauge is carried between test sites.
- It would be useful to have some data relating to lower leg/foot exposure levels under real work conditions.

4. SUMMARY

During the research project the highest calculated exposure was 4.8 mSv , the highest gamma dosimetry reading was 2.35 mSv and the highest neutron dosimetry was 0.6 mSv. It should be noted that only 0.09 % of the neutron dosimetry had reported a dose higher than the threshold.

When considering the spread, the exposure was distributed between 76% less than 1 mSv and 32 % more than 1 mSv but less than 5 mSv. Of the dosimetry not properly worn and allowed to accumulate an exposure not attributed to the operator 0.02 % of the dosimetry fell in this group.

Since this research data was running parallel to our own operations 25 operators were classified as Nuclear Energy Worker (NEW) during the length of this project.

5. CLOSING

We hope the CNSC following Departments will find enough information to possibly take action on some of the following points:

- Transport Licensing and Special Services Division
  - Transport index determination and compliance with IAEA TS-R-1 transport requirements requires confirmation of neutron dose contributions
- Radiation Protection Division
  - Reviewing dose estimates and authorizing NDR modifications
- Environmental Compliance and Laboratory Services Division
  - Purchasing sufficient and appropriate equipment for neutron measurement
- Operations and Inspections Division
  - Compliance inspections for dose monitoring and instrumentation requirements for portable gauges
- Nuclear Substances and Radiation Devices Division

- Licence application review requires determination whether 800 shot rule appropriate for dose monitoring
- Annual Compliance Reporting forms and Licence Application forms include 800 shot rule
- Instrumentation requirements to be determined for licensees.

At Stantec we used the information to make changes to our Radiation Safety Program by providing better information to our operators. We have already taken action on the amount of shielding required in many of our storage locations because of the contribution from the neutrons which we can now measure.

We are presently evaluating a follow-up project. We would use 100 dosimeters to record the activities of the heaviest users from each office. We hope this will clean up the data for heavy users of the portable gauges, incidentally this group also recorded neutron radiation the main focus of this research project.

APPENDIX A

Power Point Presentation to Introduce the Project

APPENDIX B

Monthly Activities Reports from the Employees

APPENDIX C

Excel Calculated Exposure Report

APPENDIX D

Dosimetry Results from Landauer

APPENDIX E

Excel Raw Data for Control Dosimeters

APPENDIX F

Hand Corrected Dosimetry Results from Landauer

APPENDIX G

Feedback from Operators