CALCULATIONS FOR NON-EMPLOYEE IN ADJECNT OFFICE
ASSUMPTIONS: ✓ SOURCE ROD IN SHIELD FOR 5 MINUTES (CONSERVATIVE)
• CALCULATIONS FOR SOURCE ROD IN SHIELD
• DISTANCE OF SOURCE SHIELD TO NON-EMPLOYEE = 15' (CONSERVATIVE)

APPENDIX G
PUBLIC DOSE CALCULATION WORKSHEET

To demonstrate compliance, you must show that the maximum dose to any ***member of the public*** will be less 100 millirem in a year and that the maximum dose in any ***unrestricted area*** will be less than 2 millirem in any one hour. The typical limiting case involves the storage of gauges. Several simplifying and conservative assumptions are made in this calculation method:

- No shielding other than the shielding in the gauge is assumed to be present.
- All gauges are assumed to be at the same distance as the closest gauge.
- Sources are assumed to remain in the shielded position within the gauge.
- Each gauge is assumed to be a point source and dose rates are assumed to decrease with the inverse square of distance from the gauge.
- Gauges are assumed to be in storage all of the time.

More realistic assumptions can be made or actual measured dose rates can be used if necessary to demonstrate compliance.

Step	Instruction	Result
	DOSE TO MEMBER OF PUBLIC IN ONE YEAR	
1	Identify the individual member of the public likely to receive the highest dose from gauges in storage. This will be the person who spends the most time in the vicinity of the stored gauges or who is closest to the gauges. This individual will be the focus of the calculation.	NON TA EMPLOYEE, 1st FLOOR ADJECENT OFFICE AREA
2	Determine the maximum dose rate in mrem/hr at a distance of three feet (1 meter) for each gauge kept in the storage location. This value may be obtained from the radiation profile in the gauge operation manual, from the manufacturer, or from Transport Index on the Yellow II label on the transport case. Calculate the sum of the dose rate values for all of the gauges that may be stored at this location and enter the result. Remember to include both gamma and neutron dose.	0.35 mRem/hr (MEASURED WIMETER)
3	Enter the distance in feet from the position occupied by the person identified in step 1 to ~~the nearest gauge in the storage area.~~ SOURCE SHIELD.	15'
4	Calculate the square of the distance from step 3 and enter the result.	225
5	Divide the value from step 4 by 9 and enter the result. This is a factor that accounts for the difference between the dose rate at 3 feet and the dose rate at the distance at which the person is located.	25
6	Divide the dose rate (mrem/hr) from step 2 by the result from step 5 and enter the result.	0.0140
7	Enter the number of hours in a year that the individual will be present in the vicinity of the gauges. For example, an individual working full-time near the near the gauges, would be present approximately 2000 hrs in a year (8 hrs per day x 5 days per week x 50 weeks per year).	0.0833 (5 MINUTES)
8	Multiply the result from step 6 by the result from step 7 and enter the result. This is the maximum dose in mrem the individual could receive in one calendar year. If this value is less than 100 mrem, the annual dose limit is met; continue with step 9 to determine if the unrestricted area dose rate limit is met.	0.0012 mREM/YR. <100 O.K.

FROM SOURCE SHIELD

	DOSE IN UNRESTRICTED AREAS IN ONE HOUR	
9	Determine the minimum distance in feet to any unrestricted area ~~outside the gauge storage area and record the~~ value. This could be an area above, below, or adjacent to the storage area that is unrestricted **for the purpose of radiation control.** The area need not be occupied, just accessible to members of the public, which may include company employees.	15'
10	Calculate the square of the distance from step 9 and enter the result.	225
11	Divide the value from step 10 by 9 and enter the result. This is a factor that accounts for the difference between the dose rate at 3 feet and the dose rate at the distance in step 9.	25
12	Divide the dose rate (mrem/hr) from step 2 by the result from step 11 and enter the result. This is the maximum dose in mrem that could be received in one hour in the closest unrestricted area. If this value is less than 2 mrem, the dose limit for unrestricted areas is met.	0.014 mRem/HR <2 O.K.
Calculations performed by Ralph Boedeker		**Date** 1-13-14

If either dose limit is exceeded, you should either recalculate that dose using more realistic assumptions and data or take steps to reduce the dose received by members of the public using the principles of time, distance, and shielding.

- Limit the time personnel spend in the vicinity of the gauges
- Increase the distance between the gauges and personnel
- Add shielding to reduce the dose rate

OCCUPANCY FACTORS

The following occupancy data may be used when data for specific personnel are not available:

Area	Occupancy Factor (T)
Work areas such as offices, laboratories, shops, wards, nurses' stations; living quarters; children's play areas; and occupied space in nearby buildings.	Full Occupancy (T=1)
Corridors, rest rooms, elevators using operators, unattended parking lots.	Partial Occupancy (T=1/4)
Waiting rooms, toilets, stairways, unattended elevators, janitor's closets, outside areas used only for pedestrians or vehicular traffic.	Occasional Occupancy (T=1/16)

Reference: NCRP Report No. 49, *Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma Rays of Energies Up to 10 MeV, 1976*

SHIELDING HALF-VALUES*

Material	Cs-137 Gamma Radiation	Am:Be Neutron Radiation
Lead	¼ in.	N/A
Concrete	2 in.	4 in.

* The half-value is the thickness of material that will reduce the dose rate by one-half.

CALCULATIONS FOR NON-MONITORED EMPLOYEE ON 2nd FLOOR
- SOURCE ROD IN SHIELD FOR 5 MINS (CONSERVATIVE)
- CALCULATIONS FOR SOURCE ROD IN SHIELD
- DISTANCE OF SOURCE SHIELD TO NON-MONITORED EMPLOYEE = 10' (VERY CONSERVATIVE).
- THERE IS A MIN. 4' CONCRETE SLAB FOR 2nd FLOOR WHICH REDUCES DOSE; CONSERVATIVELY IGNORE REDUCED DOSE DUE TO SLAB.

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- No shielding other than the shielding in the gauge is assumed to be present.
- All gauges are assumed to be at the same distance as the closest gauge.
- Sources are assumed to remain in the shielded position within the gauge.
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More realistic assumptions can be made or actual measured dose rates can be used if necessary to demonstrate compliance.

Step	Instruction	Result
	DOSE TO MEMBER OF PUBLIC IN ONE YEAR	
1	Identify the individual member of the public likely to receive the highest dose from gauges in storage. This will be the person who spends the most time in the vicinity of the stored gauges or who is closest to the gauges. This individual will be the focus of the calculation.	NON-MONITORED EMPLOYEE, 2nd FLOOR.
2	Determine the maximum dose rate in mrem/hr at a distance of three feet (1 meter) for each gauge kept in the storage location. This value may be obtained from the radiation profile in the gauge operation manual, from the manufacturer, or from Transport Index on the Yellow II label on the transport case. Calculate the sum of the dose rate values for all of the gauges that may be stored at this location and enter the result. Remember to include both gamma and neutron dose.	0.35 mRem/Yr (MEASURED w/METER)
3	Enter the distance in feet from the position occupied by the person identified in step 1 to the ~~nearest gauge in the storage area.~~ SOURCE SHIELD.	10'
4	Calculate the square of the distance from step 3 and enter the result.	100 SF
5	Divide the value from step 4 by 9 and enter the result. This is a factor that accounts for the difference between the dose rate at 3 feet and the dose rate at the distance at which the person is located.	11.1
6	Divide the dose rate (mrem/hr) from step 2 by the result from step 5 and enter the result.	0.0315
7	Enter the number of hours in a year that the individual will be present in the vicinity of the gauges. For example, an individual working full-time near the near the gauges, would be present approximately 2000 hrs in a year (8 hrs per day x 5 days per week x 50 weeks per year).	0.0833 (5 minutes)
8	Multiply the result from step 6 by the result from step 7 and enter the result. This is the maximum dose in mrem the individual could receive in one calendar year. If this value is less than 100 mrem, the annual dose limit is met; continue with step 9 to determine if the unrestricted area dose rate limit is met.	0.0026 mRem/Yr. < 100 O.K.

FROM SOURCE SHIELD

	DOSE IN UNRESTRICTED AREAS IN ONE HOUR	
9	Determine the minimum distance in feet to any unrestricted area ~~outside the gauge storage area~~ and record the value. This could be an area above, below, or adjacent to the storage area that is unrestricted **for the purpose of radiation control.** The area need not be occupied, just accessible to members of the public, which may include company employees.	10'
10	Calculate the square of the distance from step 9 and enter the result.	100
11	Divide the value from step 10 by 9 and enter the result. This is a factor that accounts for the difference between the dose rate at 3 feet and the dose rate at the distance in step 9.	11.1
12	Divide the dose rate (mrem/hr) from step 2 by the result from step 11 and enter the result. This is the maximum dose in mrem that could be received in one hour in the closest unrestricted area. If this value is less than 2 mrem, the dose limit for unrestricted areas is met.	0.0315 mRem/hr <2 O.K.
Calculations performed by Ralph Boedeker		**Date** 1-13-14

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