

Appendix B

Appendix B Radiological Calculations and Calibrations

REACTOR PRESSURE VESSEL EXTERNAL DOSE RATE

A gamma dose rate measurement was taken at the Reactor Pressure Vessel (RPV) external wall near the core mid-height location. The reading was 7 mR/hour, as measured on inside wall of the Neutron Shield Tank. This dose is attributable to the residual Co-60, which was estimated from previous analytical analysis to be 1108 curies distributed throughout the internals and structural components of the RPV. Though other nuclides are known to reside in the RPV, only the gamma rays from Co-60 (1.17 and 1.32 MeV) are sufficiently energetic to penetrate the thermal shields and RPV wall, resulting in measurable doses above background external to the vessel.

Other isotopes within the RPV that contribute to the total curie content include Ni-59 and Ni-63 with trace amounts of Fe-55, C-14, and Nb-94. Ni-59 decays by electron capture and emits K-shell X-rays with a maximum energy of 8 keV. The large attenuation coefficients in stainless and carbon steel resulting from the photoelectric effect for these low energy photons would preclude their contribution to dose rates external to the vessel. Ni-63 decays by beta emission with an average beta energy of 17 keV. Even if it is conservatively assumed that all beta energies are converted to radiation by deceleration in the electric field of a nucleus (bremsstrahlung), as with Ni-59, the emitted photons would not penetrate the vessel wall.

In addition, the carbon steel RPV contains no natural nickel or cobalt that would have been activated during reactor operation. Previous calculations also showed that the thin stainless steel liner on the interior of the vessel contributes negligible activity to the current internal curie content.

The distribution of Co-60 activation in the RPV is heterogeneous, being dependent on stainless steel location, geometry, and neutron thermal flux profiles in the reactor during operation. The core basket and upper and lower transition nozzles comprise over 80% of the total Co-60 curie content in the vessel. The core barrel and inner and outer shield are intended to reduce the total neutron fluence on the RPV wall, thereby limiting degradation of the vessel's ability to endure abnormal transients.

An estimate of dose rate at the exterior of the RPV was made using a point source approximation located at the centerline of the vessel at the core mid-height. Though all internals and structural components provide some absorption and attenuation of Co-60 gamma photons, primarily through Compton scattering, shielding credit was taken only for the inner and outer shield, core barrel, RPV wall and steel annulus external to the RPV where the dose measurement was taken.

The following formula was used to estimate the exposure rate from a point that emits gamma rays:

$$D \text{ (R/hour)} = 0.5 C E/r^2 ,$$

where

- C = activity in curies = 1108 curies from previous analysis,
- E = gamma energy in MeV = 1.17 MeV + 1.32 MeV = 2.49 MeV,
(Note: Co-60 emits two gamma rays in over 99% of its disintegrations)
- r = distance from point source in meters = 1.12 m,
- D_o = 1108 R/hour.

Using this quantity for the gamma flux incident on the slab shield formed by the inner and outer shield, core barrel, RPV wall and steel annulus for insulation containment, the exposure dose external to the RPV was calculated using the formula for uncollided gamma flux multiplied by a suitable buildup factor:

$$D \text{ (measurement point)}/D_o = B(E, \mu t) e^{-\mu t} ,$$

where

- μ = energy-dependent linear attenuation coefficient for steel = 0.395 /cm,
- t = thickness of shield material between reference point and measurement point = 9.82 cm,
- B = buildup factor dependent on gamma energy (E) and relaxation lengths (μt) = 10.

Substituting these values in the above equation and solving for D:

$$D = 85 \text{ mR/hour} .$$

CRUD ANALYSIS

Smears of the interior piping of the primary system were taken at the entrance to the port and starboard side steam generators by removing access covers. A total of five smear samples was obtained from inlet of each steam generator hot leg, including three in the vicinity of the access cover, one on the interior of the access cover, and one at the tube sheet entrance. The principal isotope in the crud was confirmed to be Co-60 through use of gamma spectroscopy.

All 10 smears were counted on the Ludlum 2929 counter (#2). The smear taken at the port side tube sheet had a count rate 2.3 higher than any of the other nine smears and was used for crud analysis.

Net count rate = 78,764 counts per minute (cpm)

Counter efficiency = 20.8%

All smears were assumed to be 100 cm², so the activity level in disintegrations per second (dps) is:

$$78,764/0.208 = 378,673 \text{ dpm}/100\text{cm}^2 \times 60 \text{ sec}/\text{min} = 6311 \text{ dps}/100 \text{ cm}^2 .$$

$$1 \text{ curie} = 3.7\text{E}10 \text{ dps} .$$

$$\text{Activity} = 6311 \text{ dps}/100 \text{ cm}^2 \times 3.7\text{E}10 = 1.71\text{E}-9 \text{ C}/\text{cm}^2 .$$

Assuming this crud concentration to be uniformly distributed over the interior surface of the reactor pressure vessel:

$$\text{Reactor Pressure Vessel dimensions} = 27 \text{ ft. H} \times 8 \text{ ft. D} .$$

$$\text{Surface area} = 6.79\text{E}2 \text{ ft}^2 \times 9.29\text{E}2 \text{ cm}^2/\text{ft}^2 = 6.30\text{E}5 \text{ cm}^2 .$$

$$\text{Activity} = (1.71\text{E}-9 \text{ C}/\text{cm}^2) \times (6.30\text{E}5 \text{ cm}^2) = 1.08\text{E}-3 \text{ C} \sim 1 \text{ mC} .$$

This is a negligible quantity compared to the total estimated activity level in the pressure vessel of 4066 curies.

**Smear/Air Sample Counting
LLD, MDA, and Activity Determinations**

Each counter's average background count rate was determined and source efficiency tests performed. Background and source counts were based on a series of 20-minute counts. Results were as follows:

Counter #1

Alpha		Beta	
Background	Efficiency	Background	Efficiency
0.325 cpm	33.6%	39.2 cpm	25.2%

Counter #2

Alpha		Beta	
Background	Efficiency	Background	Efficiency
0.525 cpm	31.2%	42.15 cpm	20.8%

Lower limit of detection (LLD) (also referred to as net minimum detectable count rate [MDCR]) and minimum detectable activity (MDA) calculations were performed for several counting times based on NUREG/CR-4007.

$$LLD \text{ (net cpm)} = \frac{2.71 + (3.29) \sqrt{\frac{R_b (t_s) (t_s + t_B)}{t_B}}}{t_s} \qquad MDA \text{ (dpm)} = \frac{LLD}{Eff.}$$

where:

- R_b = background count rate (cpm),
- t_B = background count time (min),
- t_s = sample count time (min).

Gross minimum detectable counts were determined for each count time by the following formula.

$$MDC = t_s [\text{net MDCR (cpm)} + \text{background (cpm)}]$$

For air samples of 100 ft³ volume, MDA concentration in μCi/cc were calculated for appropriate counting times using the following formula:

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$$\text{MDA } (\mu\text{Ci/cc}) = \frac{\text{MDA(dpm)}}{(2.22\text{E}6 \text{ dpm})} \frac{1 \mu\text{Ci}}{(100 \text{ ft}^3)} \frac{1 \text{ ft}^3}{(28.32 \text{ L})} \frac{1 \text{ L}}{1000 \text{ cc}}$$

Results for all the above calculations for each counter are tabulated in the following charts.

Counter # 1 (Serial #102001)								
Alpha					Beta			
Count time (minute)					Net MDCR			
Count time (minutes)	Net MDCR (cpm)	Gross MDC	MDA (dpm)	Air MDA** (μCi/cc)	Net MDCR (cpm)	Gross MDC	MDA (dpm)	Air MDA** (μCi/cc)
60	0.529	51	1.57	2.5E ⁻¹³	5.35	2673	21.2	3.4E ⁻¹²
30	0.632	28	1.88	2.99E ⁻¹³	6.03	1357	23.9	3.8E ⁻¹²
10	0.997	13	2.97	4.7E ⁻¹³	8.2	474	32.5	5.2E ⁻¹²
1	4.63	5	13.78	-	23.8	63	94.4	1.5E ⁻¹¹
0.5	8.1	4	24.1	-	34.9	37	139	-

** For 100-ft³ samples only.

Counter #2 (Serial #160019)								
Alpha					Beta			
Count time (minute)					Net MDCR (cpm)			
Count time in (minutes)	Net MDCR (cpm)	Gross MDC	MDA (dpm)	Air MDA** (μCi/cc)	Net MDCR (cpm)	Gross MDC	MDA (dpm)	Air MDA** μCi/cc
60	0.66	71	2.12	3.36E ⁻¹³	5.56	2862	26.7	4.25E ⁻¹²
30	0.779	39	2.50	3.97E ⁻¹³	6.26	1452	30.1	4.79E ⁻¹²
10	1.19	17	3.81	6.07E ⁻¹³	8.54	506	41.1	6.53E ⁻¹²
1	5.15	6	16.52	-	24.6	66	118	1.88E ⁻¹¹
0.5	8.8	4	28.3	-	36	39	173	-

** For 100-ft³ samples only.

Smear Activity Determination

When count rates exceed LLD values, smear activity is determined as follows.

$$\text{Activity (dpm)} = \frac{\text{net cpm}}{\text{Eff}}$$

Where net cpm = $\frac{\text{gross count}}{\text{count time}} - \text{background cpm}$

Values for LLD and smear scanning trigger levels are tabulated below.

Counter #1

<i>Beta counts</i>			
1-minute count		30-second count	
Gross count	Activity (dpm)	Gross count	Activity (dpm)
63	95 (MDA)	37	139 (MDA)
165	500	82	500
291	1000	145	1000
<i>Alpha counts</i>			
1-minute count		30-second count	
Gross count	Activity (dpm)	Gross count	Activity (dpm)
5	14 (MDA)	4	24 (MDA)
7	20	16	100
33	100	-	-

Counter #2

<i>Beta counts</i>			
1-minute count		30-second count	
Gross count	Activity (dpm)	Gross count	Activity (dpm)
66	118 (MDA)	39	173 (MDA)
146	500	73	500
250	1000	125	1000
<i>Alpha counts</i>			
1-minute count		30-second count	
Gross count	Activity (dpm)	Gross count	Activity (dpm)
5	16 (MDA)	4	28 (MDA)
6	20	15	100
31	100	-	-

Air Sample Activity Determinations

When count rates exceed LLD values, air sample activity is determined as follows:

$$\text{Activity } (\mu\text{Ci/cc}) = \frac{\text{net cpm}}{\text{Eff}} \times \frac{1 \mu\text{Ci}}{2.22\text{E}6 \text{ dpm}} \times \text{volume (cc)}$$

For 100-ft³ (2.832E⁶-cc) air samples, the net count rate can be inserted into the following instrument-specific equations as applicable.

Counter #1

Alpha airborne activity ($\mu\text{Ci/cc}$) = (net cpm) \times (4.73E⁻¹³).

Beta airborne activity ($\mu\text{Ci/cc}$) = (net cpm) \times (6.31E⁻¹³).

Counter #2

Alpha airborne activity ($\mu\text{Ci/cc}$) = (net cpm) \times (5.1E⁻¹³).

Beta airborne activity ($\mu\text{Ci/cc}$) = (net cpm) \times (7.65E⁻¹³).

Instrument Calibration and Use Logs are attached to this appendix.



RGP
3-24-05

**CALIBRATION
CERTIFICATE**

Duratek Instrument Services
628 Gallaher Road
Kingston, TN 37763
Phone: (865) 376-8337
Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

CUSTOMER INFORMATION		INSTRUMENT INFORMATION	
Customer Name: Duratek Instrument Services		Manufacturer: Ludlum	
Address: 628 Gallaher Rd Kingston, TN 37763		Model: 19	Serial Number: 95469 ✓
Contact Name: Thomas F. Scott		Probe: N/A	Serial Number: N/A
Customer Purchase Order Number: N/A	Work Order Number: 2005-02653	Calibration Method: Electronic And Source	

INSTRUMENT CALIBRATION INFORMATION					
Range (μ R/hr)	Calibration Standard Value	Tolerances (μ R/hr)	Instrument Response		Comments
			As Found (μ R/hr)	As Left (μ R/hr)	
5000 Black	4000 μ R/hr	3600 - 4400	*N/A	3800	Pulser: 101500 Cal Due: 09/24/05
	2500 μ R/hr	2250 - 2750	*N/A	2500	D-812: 2816 Cal Due: 04/15/05
	1000 μ R/hr	900 - 1100	*N/A	1000	DVM: TW12663 Cal Due: 03/22/05
500 Black	400 μ R/hr	360 - 440	*N/A	390	DTH-1A: 100799 Cal Due: 11/11/05
	250 μ R/hr	225 - 275	*N/A	250	
	100 μ R/hr	90 - 110	*N/A	100	Temp: 20.5°C Humidity: 31%
250 Red	Input cpm = 32,600	180 - 220	*N/A	195	Pressure: 742mmHg
	Input cpm = 19,500	108 - 132	*N/A	120	
	Input cpm = 8,150	45 - 55	*N/A	50	Geotropism: SAT Over Range: SAT
50 Black	Input cpm = 6,560	36 - 44	*N/A	39.5	Batteries: SAT Mech. Zero: SAT
	Input cpm = 4,090	22.5 - 27.5	*N/A	25	F/S Response: SAT Audio: SAT
	Input cpm = 1,440	9 - 11	*N/A	10	Light: SAT Precision Test: SAT
25 Red	Input cpm = 3,260	18 - 22	*N/A	19.5	Source: Cs-137 049711 Cert. Date: 04/09/04
	Input cpm = 1,956	10.8 - 13.2	*N/A	12	High Voltage As Found: 800V As Left: 725V
	Input cpm = 815	4.5 - 5.5	*N/A	5	cpm/ μ R/hr: As Found: 192 As Left: 163

COMMENTS

Special Remarks: High Voltage: 725Volts cpm/ μ R/hr: 163
* All As Finds off by more than 20% due to HV being set outside of correct plateau voltage setting.

STATEMENT OF CERTIFICATION

We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).

Instrument		
Calibrated By: <i>M. Pauli</i>	Reviewed By: <i>James G. Scott</i>	Date: 3-18-05
Calibration Date: 03/18/05	Calibration Due: 03/18/06 ✓	

LUDLUM 19 HIGH VOLTAGE PLATEAU DATA SHEET

Date: 03/18/05

Serial Number: 95469

High Voltage	Background	uR/hr
575	2	190
600	2	1600
625	3	2200
650	3	2900
675	4	3500
700	4	4100
725 (SET)	5	4600
750	6	4600
775	7	4900
800	9	offscale

* Source Geometry on contact with Detector-Cs137 #019455 @ 5uCi*

Performed By: Mike Paul

Date: 3-18-05

Reviewed By: John Paul

Date: 3-18-05



RUP
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CUSTOMER INFORMATION		INSTRUMENT INFORMATION	
Customer Name: Duratek Instrument Services		Manufacturer: Ludlum	
Address: 628 Gallaher Rd Kingston, TN 37763		Model: 19	Serial Number: 95499 ✓
Contact Name: Thomas F. Scott		Probe: N/A	Serial Number: N/A
Customer Purchase Order Number: N/A	Work Order Number: 2005-02653	Calibration Method: Electronic And Source	

INSTRUMENT CALIBRATION INFORMATION

Range (μ R/hr)	Calibration Standard Value	Tolerances (μ R/hr)	Instrument Response		Comments	
			As Found (μ R/hr)	As Left (μ R/hr)	Calibrated in accordance with CP-IN-WI-211 Rev 1	
5000 Black	4000 μ R/hr	3600 - 4400	3800	3800	Pulser: 101500	Cal Due: 09/24/05
	2500 μ R/hr	2250 - 2750	2450	2450	D-812: 2816	Cal Due: 04/15/05
	1000 μ R/hr	900 - 1100	950	950	DVM: TW12663	Cal Due: 03/22/05
500 Black	400 μ R/hr	360 - 440	400	400	DTH-1A: 100799	Cal Due: 11/11/05
	250 μ R/hr	225 - 275	250	250		
	100 μ R/hr	90 - 110	105	105	Temp: 20.5°C	Humidity: 31%
250 Red	Input cpm = 40,000	180 - 220	205	205	Pressure: 742mmHg	
	Input cpm = 24,000	108 - 132	120	120		
	Input cpm = 10,000	45 - 55	50	50	Geotropism: SAT	Over Range: SAT
50 Black	Input cpm = 7,880	36 - 44	40	40	Batteries: SAT	Mech. Zero: SAT
	Input cpm = 4,990	22.5 - 27.5	25	25	F/S Response: SAT	Audio: SAT
	Input cpm = 1,960	9 - 11	10	10	Light: SAT	Precision Test: SAT
25 Red	Input cpm = 4,000	18 - 22	20	20	Source: Cs-137 049711 Cert. Date: 04/09/04	
	Input cpm = 2,400	10.8 - 13.2	12	12	High Voltage As Found: 650V As Left: 650V	
	Input cpm = 1,000	4.5 - 5.5	5	5	cpm/ μ R/hr: As Found: 194 As Left: 200	

COMMENTS

Special Remarks: High Voltage: 650Volts cpm/ μ R/hr: 200

STATEMENT OF CERTIFICATION

We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).

Instrument		
Calibrated By: <i>M. Paul</i>	Reviewed By: <i>Alonso G. Acosta</i>	Date: 3-18-05
Calibration Date: 03/18/05	Calibration Due: 03/18/06 ✓	



RUP
3-24-05

**CALIBRATION
CERTIFICATE**

Duratek Instrument Services
628 Gallaher Road
Kingston, TN 37763
Phone: (865) 376-8337
Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

CUSTOMER INFORMATION		INSTRUMENT INFORMATION	
Customer Name: Duratek Instrument Services		Manufacturer: Ludlum	
Address: 628 Gallaher Rd Kingston, TN 37763		Model: 19	Serial Number: 42972 ✓
Contact Name: Thomas F. Scott		Probe: N/A	Serial Number: N/A
Customer Purchase Order Number: N/A	Work Order Number: 2005-02653	Calibration Method: Electronic And Source	

INSTRUMENT CALIBRATION INFORMATION					
Range (μ R/hr)	Calibration Standard Value	Tolerances (μ R/hr)	Instrument Response		Comments
			As Found (μ R/hr)	As Left (μ R/hr)	
5000 Black	4000 μ R/hr	3600 - 4400	3950	3950	Pulser: 101500 Cal Due: 09/24/05
	2500 μ R/hr	2250 - 2750	2500	2500	D-812: 2816 Cal Due: 04/15/05
	1000 μ R/hr	900 - 1100	1000	1000	DVM: TW12663 Cal Due: 03/22/05
500 Black	400 μ R/hr	360 - 440	410	380	DTH-1A: 100799 Cal Due: 11/11/05
	250 μ R/hr	225 - 275	260	250	
	100 μ R/hr	90 - 110	110	105	Temp: 20.5°C Humidity: 31%
250 Red	Input cpm = 42,000	180 - 220	200	200	Pressure: 742mmHg
	Input cpm = 25,200	108 - 132	120	120	
	Input cpm = 10,500	45 - 55	50	50	Geotropism: SAT Over Range: SAT
50 Black	Input cpm = 8,450	36 - 44	40	40	Batteries: SAT Mech. Zero: SAT
	Input cpm = 5,240	22.5 - 27.5	25	25	F/S Response: SAT Audio: SAT
	Input cpm = 2,070	9 - 11	10	10	Light: SAT Precision Test: SAT
25 Red	Input cpm = 4,200	18 - 22	20	20	Source: Cs-137 049711 Cert. Date: 04/09/04
	Input cpm = 2,520	10.8 - 13.2	12	12	High Voltage As Found: 660V As Left: 660V
	Input cpm = 1,050	4.5 - 5.5	5	5	cpm/ μ R/hr: As Found: 213 As Left: 210

COMMENTS

Special Remarks: High Voltage: 660Volts cpm/ μ R/hr: 210

STATEMENT OF CERTIFICATION

We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).

Instrument		
Calibrated By: <i>M. Paul</i>	Reviewed By: <i>Thomas F. Scott</i>	Date: 3-18-05
Calibration Date: 03/18/05	Calibration Due: 03/18/06 ✓	



RF
3-24-05

**CALIBRATION
CERTIFICATE**

Duratek Instrument Services
628 Gallaher Road
Kingston, TN 37763
Phone: (865) 376-8337
Fax: (865) 376-8331

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CUSTOMER INFORMATION			INSTRUMENT INFORMATION		
Customer Name: Duratek Instrument Services			Manufacturer: Ludlum		
Address: 628 Gallaher Road, Kingston, TN 37763			Model: 12	Serial Number: 91037 ✓	
Contact Name: Thomas Scott			Probe: 44-9 ✓	Serial Number: N/A	
Contract/Task Number: N/A		Work Order Number: 2005-02626	Calibration Method: Electronic and Source		
INSTRUMENT CALIBRATION INFORMATION					
Instrument Range	Calibration Standard Value	Instrument Response		Comments	
		Before Calibration	After Calibration	Calibrated in accordance with OEM Technical Manual	
X 1	100	100	100	Pulser: 101500	Cal Due: 09/24/05
X 1	250	250	250	D-812: 2816	Cal Due: 04/15/05
X 1	400	400	400	DTH-1A: 100799	Cal Due: 11/11/05
X 10	1,000	1,000	1,000		
X 10	2,500	2,500	2,500	Temperature: 23.0 °C	
X 10	4,000	4,000	4,000	Pressure: 738mmHg	
X 100	10,000	10,000	10,000	Humidity: 23%	
X 100	25,000	25,000	25,000		
X 100	40,000	40,000	40,000		
X 1000	100,000	100,000	100,000	Audio: SAT	Batt. Check: SAT
X 1000	250,000	250,000	250,000	Fast/Slow: SAT	Reset: SAT
X 1000	400,000	400,000	400,000	HV Pushbutton: SAT	Overrange: SAT
EFFICIENCY DETERMINATION				Geotropism: SAT	
Instrument Range	Source ID and Value	Net cpm	Efficiency	Background: 50cpm Threshold: 35mV	
EFF X1	Tc-99#119720 at 2,562dpm	290	11.3%		
EFF X10	Tc-99#119718 at 20,520dpm	2,600	12.7%		
EFF X100	Tc-99#109408 at 259,518dpm	29,950	11.5%		
Average	N/A	N/A	11.8	Limited Use: X1000 Scale for information only. Use with 44-9.	
High Voltage	900V	897V	897V		
STATEMENT OF CERTIFICATION					
We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).					
Instrument					
Calibrated By: <i>Mike Pauli</i>		Reviewed By: <i>Thomas G. Scott</i>		Date: 3-10-05 ✓	
Calibration Date: 03/10/05			Calibration Due: 03/10/06 ✓		



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3-24-05

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CUSTOMER INFORMATION		INSTRUMENT INFORMATION	
Customer Name: Duratek Instrument Services		Manufacturer: Ludlum	
Address: 628 Gallaher Road, Kingston, TN 37763		Model: 12	Serial Number: 75809 ✓
Contact Name: Thomas Scott		Probe: 44-9 ✓	Serial Number: N/A
Contract/Task Number: N/A	Work Order Number: 2005-02626	Calibration Method: Electronic and Source	

INSTRUMENT CALIBRATION INFORMATION

Instrument Range	Calibration Standard Value	Instrument Response		Comments	
		Before Calibration	After Calibration	Calibrated in accordance with OEM Technical Manual	
X 1	100	100	100	Pulser: 101500	Cal Due: 09/24/05
X 1	250	250	250	D-812: 2816	Cal Due: 04/15/05
X 1	400	400	400	DTH-1A: 100799	Cal Due: 11/11/05
X 10	1,000	1,000	1,000		
X 10	2,500	2,500	2,500	Temperature: 23.0 °C	
X 10	4,000	4,000	4,000	Pressure: 738mmHg	
X 100	10,000	10,000	10,000	Humidity: 23%	
X 100	25,000	25,000	25,000		
X 100	40,000	40,000	40,000		
X 1000	100,000	100,000	100,000	Audio: SAT	Batt. Check: SAT
X 1000	250,000	250,000	250,000	Fast/Slow: SAT	Reset: SAT
X 1000	400,000	400,000	400,000	HV Pushbutton: SAT	Overrange: SAT

EFFICIENCY DETERMINATION

Instrument Range	Source ID and Value	Net cpm	Efficiency	Geotropism: SAT	
EFF X1	Tc-99#119720 at 2,562dpm	305	11.9%	Background: 40cpm	Threshold: 36mV
EFF X10	Tc-99#119718 at 20,520dpm	2,460	12.0%		
EFF X100	Tc-99#109408 at 259,518dpm	29,460	11.4%		
Average	N/A	N/A	11.8%	Limited Use: X1000 Scale for information only. Use with 44-9.	
High Voltage	900V	901V	901V		

STATEMENT OF CERTIFICATION

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Instrument	Calibrated By: <i>Mike Paul</i>	Reviewed By: <i>Thomas G. Scott</i>	Date: 3-10-05
Calibration Date: 03/10/05		Calibration Due: 03/10/06 ✓	



RJA
3-24-05

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Kingston, TN 37763
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Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

CUSTOMER INFORMATION		INSTRUMENT INFORMATION	
Customer Name: Duratek Instrument Services		Manufacturer: Ludlum	
Address: 628 Gallaher Road, Kingston, TN 37763		Model: 3	Serial Number: 97416 ✓
Contact Name: Thomas F. Scott		Probe: 44-9 ✓	Serial Number: N/A
Contract/Task Number: N/A	Work Order Number: 2005-02626	Calibration Method: Electronic and Source	

INSTRUMENT CALIBRATION INFORMATION				
Instrument Range	Calibration Standard Value	Instrument Response		Comments
		Before Calibration	After Calibration	
X0.1	100	100	100	Pulser: 101500 Cal Due: 09/24/05
X0.1	250	250	250	DVM: TW12663 Cal Due: 03/22/05
X0.1	400	400	400	D-812: 2816 Cal Due: 04/15/05
X1	1,000	1,000	1,000	DTH-1A: 100799 Cal Due: 11/11/05
X1	2,500	2,500	2,500	
X1	4,000	4,000	4,000	Temperature: 23.0 °C
X10	10,000	10,000	10,000	Pressure: 738 mmHg
X10	25,000	25,000	25,000	Humidity: 23 %
X10	40,000	40,000	40,000	
X100	100,000	100,000	100,000	Audio: SAT Batt. Check: SAT
X100	250,000	250,000	250,000	Fast/Slow: SAT Reset: SAT
X100	400,000	400,000	400,000	Background: 40 cpm Threshold: 35mV

EFFICIENCY DETERMINATION*				Overrange: SAT
Instrument Range	Source ID and Value	Net cpm	Efficiency	* Efficiency determined ~1/4" from 45 mm disc.
EFF X1	Tc-99#119720 at 2,562dpm	260	10.1%	
EFF X10	Tc-99#119718 at 20,520dpm	2,260	11.0%	
EFF X100	Tc-99#109408 at 259,518dpm	29,460	11.4%	
Average Efficiency	N/A	N/A	%	Limited Use: X100 Scale for information only. Use with 44-9.
High Voltage	900V (±5%)	902V	902V	

STATEMENT OF CERTIFICATION

We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).

Instrument	Calibrated By: <i>Nike Paul</i>	Reviewed By: <i>Thomas F. Scott</i>	Date: 3-10-05
Calibration Date: 03/10/05	Calibration Due: 03/10/06 ✓		



**CALIBRATION
CERTIFICATE**

Duratek Instrument Services
528 Gallaher Road
Kingston, TN 37763
Phone: (865) 376-8337
Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

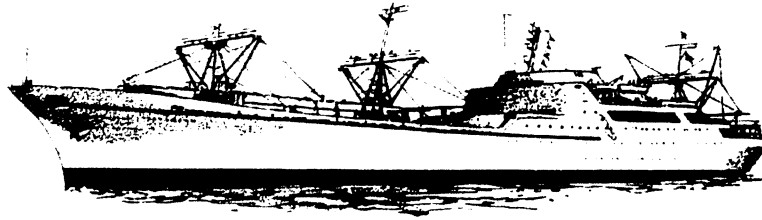
CUSTOMER INFORMATION			INSTRUMENT INFORMATION		
Customer Name: Duratek Instrument Services			Manufacturer: Autmess		
Address: 628 Gallaher Road Kingston, TN. 37763			Model: 6112D	Serial Number: 28991	
Contact Name: Tom Scott			Probe: N/A	Serial Number: N/A	
Contract/Task Number: N/A		Work Order Number: N/A*	Calibration Method: Electronic and Source		

INSTRUMENT CALIBRATION INFORMATION						
Instrument Range	Desired	**Tolerance	Instrument Response		Comments	
			Before Calibration	After Calibration		
mR/hr					Timer: 02010806	Cal Due: 03/04/05
mR/h					DVM: TW12662	Cal Due: 03/08/05
mR/h	1	.80-1.20	1	1	D-812: 2816	Cal Due: 04/15/05
mR/h	40	32 - 48	42	40	DTH-1A: 100799	Cal Due: 11/11/05
mR/h	200	160-240	161	170	Sources Used:	
mR/h	616	493-739	530	631	Cs137 019701	Cert. Date: 07/16/04
					Cs137 019702	Cert. Date: 04/08/04
R/hr					Cs137 049711	Cert. Date: 04/09/04
R/h	1.88	1.50 - 2.26	2.1	1.9	Temp: 24.1 °C	Humidity: 36 %
R/h	21.1	16.9 - 25.3	23.3	21.7	Pressure: 738 mmHg	
R/h	98	78.4 - 118	111	116	**Per manufacturer manual, instrument precision is ± 20%.	
R/h	360	288-432	390	344	Geotropism: N/A	
R/h	720	576 - 864	806	700	Sensitivity Check: SAT	
mR (Exposure Rate)					Batteries: SAT	
mR	10.2	8.2 - 12.3	11	11	Over Range: SAT	
Exposed to 616 mR/hr field for 60 seconds					Precision Test: SAT	
High Voltage					Digital Zero: SAT	
HV	#-600 vdc	#-600	-546	-546	* Returned repaired from Eberline.	

STATEMENT OF CERTIFICATION

We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).

Instrument	Reviewed By:		Date: 2-15-05
Calibrated By:			
Calibration Date: 02/14/05	Calibration Due: 02/14/06		



DBR-1 Reader Calibration Certificate

DBR-1 Reader Serial Number: 230011
 ROM Version: 1.02
 RAM Version: 1.16.53
 Calibration Plug Serial Number: 204024
 Calibration Plug Calibration Date: 25Feb2005 / Battery Voltage: 8.9V/8.8V

The Calibration of the DBR-1 Reader was performed in accordance with DBR-1 User's Guide version 1.16, Section 3.4 entitled "Calibrating the DBR-1".

As-Found readings for the DBR-1 Reader were:

Parameter	Reading	Tolerance	Parameter	Reading	Tolerance
G	-2	+/- 26	M	42	+/- 26
R	30	+/- 26	L	2	+/- 26
H	325	+/- 101	I	110	+/- 5001

As-Left readings for the DBR-1 Reader were:

Parameter	Reading	Tolerance	Parameter	Reading	Tolerance
G	0	+/- 26	M	0	+/- 26
R	0	+/- 26	L	0	+/- 26
H	12	+/- 101	I	110	+/- 5001

MARAD Contract # DTMA2P05133

Work Performed In Accordance with WPI's Nuclear QA Manual

Calibrated by: _____

John Bowen
 John Bowen

Date: _____

021 APR 2005

Reviewed by: _____

Robert Pennock
 Robert Pennock

Date: _____

4-01-05



**CALIBRATION
CERTIFICATE**

Duratek Instrument Services
628 Gallaher Road
Kingston, TN 37763
Phone: (865) 376-8337
Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

CUSTOMER INFORMATION		INSTRUMENT INFORMATION	
Customer Name: WPI		Manufacturer: Radeco	
Contact Name: John Bowen		Model: H-810DC	
Address: 2000 Kraft Drive, Suite 2100, Blacksburg, VA 24060		Serial Number: 0865	
Contract/Task Number: WP105-0079	Work Order : 2005-02636	Calibration Method: Air Flow	

INSTRUMENT CALIBRATION INFORMATION					
Instrument Range (LPM)	Standard Value (LPM)	Tolerance ($\pm 10\%$)	As Found	As Left	Comments
14 - 99	43	39-47	42	42	Barometer: 8029 Cal Due: 12/13/05
	70	63 - 77	68	68	Thermometer: 8029 Cal Due: 12/13/05
	93	82 - 102	93	93	Venturi: 8029 Cal Due: 12/13/05
					DTH-1A: 100799 Cal Due: 11/11/05
					Temperature: 20.4 °C
					Pressure: 739mmHg
					Humidity: 32%
					Previous Media: N/A
					Current Media: Customer Provided Glass Fiber
					Final Range: 14 - 99 LPM
					Calibrated IAW OEM

STATEMENT OF CERTIFICATION

We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).

Instrument		
Calibrated By:	Reviewed By:	Date: 3-22-05
Calibration Date: 03/17/05	Calibration Due: 03/17/06	



**CALIBRATION
CERTIFICATE**

Duratek Instrument Services
628 Gallaher Road
Kingston, TN 37763
Phone: (865) 376-8337
Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

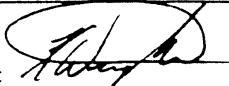
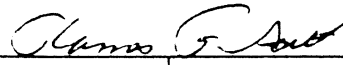
CUSTOMER INFORMATION		INSTRUMENT INFORMATION	
Customer Name: WPI		Manufacturer: Radeco	
Contact Name: John Bowen		Model: H-810DC	
Address: 2000 Kraft Drive, Suite 2100, Blacksburg, VA 24060		Serial Number: 0864	
Contract/Task Number: WP105-0079	Work Order: 2005-02636	Calibration Method: Air Flow	

INSTRUMENT CALIBRATION INFORMATION


Instrument Range (LPM)	Standard Value (LPM)	Tolerance (±10%)	As Found	As Left	Comments	
14 - 99	42	38-46	31	42	Barometer: 8029	Cal Due: 12/13/05
	68	61 - 75	57	68	Thermometer: 8029	Cal Due: 12/13/05
	89	80 - 98	82	89	Venturi: 8029	Cal Due: 12/13/05
					DTH-1A: 100799	Cal Due: 11/11/05
					Temperature: 20.4 °C	
					Pressure: 739mmHg	
					Humidity: 32%	
					Previous Media: N/A	
					Current Media: Customer Provided Glass Fiber	
					Final Range: 42 - 89 LPM	
					Calibrated IAW OEM	

STATEMENT OF CERTIFICATION

We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).

Instrument		
Calibrated By: 	Reviewed By: 	Date: 3-22-05
Calibration Date: 03/17/05	Calibration Due: 03/17/06	




 3-30-05
**CALIBRATION
 CERTIFICATE**
 Page 1 of 2

Duratek Instrument Services
 628 Gallaher Road
 Kingston, TN 37763
 Phone: (865) 376-8337
 Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

CUSTOMER INFORMATION		INSTRUMENT INFORMATION	
Customer Name: Duratek Instrument Services		Manufacturer: Ludlum	
Address: 628 Gallaher Road, Kingston, TN 37763		Model: 2221	Serial Number: 197766 ✓
Contact Name: Tom Scott		Probe: N/A	Serial Number: N/A
Customer Purchase Order Number: N/A	Work Order Number: 2004-02391	Calibration Method: Electronic	

INSTRUMENT CALIBRATION INFORMATION								
Instrument Range	Calibration Standard Value CPM	Rateometer Response		Calibration Standard Value CPM	Time Base (min)	Tolerances (cpm) ± 10%	Scaler Response	
		As Found	As Left				As Found	As Left
X 1	100	100	100	1,000 CPM	.1	90 – 110	99	99
X 1	250	250	250	1,000 CPM	.2	180 – 220	200	200
X 1	400	400	400	1,000 CPM	.5	450 – 550	499	499
X 10	1,000	1,000	1,000	1,000 CPM	1	900 – 1,100	994	994
X 10	2,500	2,500	2,500	1,000 CPM	2	1.8K – 2.2K	1,987	1,987
X 10	4,000	4,000	4,000	1,000 CPM	5	4.5K – 5.5K	4,987	4,987
X 100	10,000	10,000	10,000					
X 100	25,000	25,000	25,000					
X 100	40,000	40,000	40,000					
X 1000	100,000	100,000	100,000					
X 1000	250,000	250,000	250,000					
X 1000	400,000	400,000	400,000					

STATEMENT OF CERTIFICATION

We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).

Instrument		
Calibrated By: <i>M. Paul</i>	Reviewed By: <i>James F. Acet</i>	Date: <i>12-7-04</i>
Calibration Date: <i>12/07/04</i> ✓	Calibration Due: <i>12/07/05</i> ✓	

Model: 2221

Serial Number: 197766

M&TE					Environmental Conditions					
Volt Meter	Due Date:	03/08/05	ID	TW12662	D-812	Due Date:	04/15/05	ID:	2816	
Pulser	Due Date:	09/24/05	ID	101500	DTH-1A	Due Date:	11/1/05	ID:	100799	
Timer	Due Date:	03/04/05	ID	02010806	Temp: 22.1 °C	Pressure: 736 mmHg	Humidity: 54%			
INSTRUMENT CALIBRATION INFORMATION										
Special Test										
Geotropism	Sat (✓) Unsat ()			Hold			Sat (✓) Unsat ()			
BAT > 4.5	Sat (✓) Unsat ()			Volume Test			Sat (✓) Unsat ()			
Mechanical Zero	Sat (✓) Unsat ()			Audio Divide			Sat (✓) Unsat ()			
Digital Zero	Sat (✓) Unsat ()			Window Switch			Sat (✓) Unsat ()			
Count	Sat (✓) Unsat ()			Lamp			Sat (✓) Unsat ()			
High Voltage Calibration										
Voltage	Tolerance ± 2%			As Found			As Left			
400	392-408			404			404			
1,000	980-1,020			1,001			1,001			
1,500	1,470-1,530			1,501			1,501			
1,900	1,862-1,932			1,900			1,900			
Threshold/Gain Calibration (Desired Ratio <u>10</u> mV/100)										
<u>Input</u>	<u>As Found Value</u>	<u>As Found Ratio (mV/100)</u>		<u>As Left Value</u>	<u>As Left Ratio (mV/100)</u>					
10	96	10.4		96	10.4					
20	203	9.9		203	9.9					
30	309	9.7		309	9.7					
40	411	9.7		411	9.7					
Logmeter Scale Linearity Check										
<u>Input</u>	<u>±20% Tolerance</u>	<u>As Found</u>	<u>As Left</u>							
LOG	400	320-480	400	400						
LOG	4,000	3,200-4,800	4,000	4,000						
LOG	40,000	32,000-48,000	40,000	40,000						
LOG	400,000	320,000-480,000	400,000	400,000						
COMMENTS										
Calibrated in accordance with the OEM Technical Manual										
Instrument										
Calibrated By: <i>M. Paul</i>					Reviewed By: <i>Ronald G. Scott</i> Date: <i>12-7-04</i>					
Calibration Date: 12/07/04					Calibration Due: 12/07/05					



06P
3-30-05

**CALIBRATION
CERTIFICATE**
Page 1 of 2

Duratek Instrument Services
628 Gallaher Road
Kingston, TN 37763
Phone: (865) 376-8337
Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

CUSTOMER INFORMATION		INSTRUMENT INFORMATION	
Customer Name: Duratek Instrument Services		Manufacturer: Ludlum	
Address: 628 Gallaher Road, Kingston, TN 37763		Model: 2221	Serial Number: 94954 ✓
Contact Name: Tom Scott		Probe: N/A	Serial Number: N/A
Customer Purchase Order Number: N/A	Work Order Number: 2004-01977	Calibration Method: Electronic	

INSTRUMENT CALIBRATION INFORMATION								
Instrument Range	Calibration Standard Value CPM	Ratemeter Response		Calibration Standard Value CPM	Time Base (min)	Tolerances (cpm) ± 10%	Scaler Response	
		As Found	As Left				As Found	As Left
X 1	100	100	100	1,000 CPM	.1	90 - 110	98	98
X 1	250	250	250	1,000 CPM	.2	180 - 220	198	198
X 1	400	400	400	1,000 CPM	.5	450 - 550	494	494
X 10	1,000	1,000	1,000	1,000 CPM	1	900 - 1,100	988	988
X 10	2,500	2,500	2,500	1,000 CPM	2	1.8K-2.2K	1,975	1,975
X 10	4,000	4,100	4,100	1,000 CPM	5	4.5K-5.5K	4,940	4,940
X 100	10,000	10,000	10,000					
X 100	25,000	25,000	25,000					
X 100	40,000	40,500	40,500					
X 1000	100,000	100,000	100,000					
X 1000	250,000	250,000	250,000					
X 1000	400,000	400,000	400,000					

STATEMENT OF CERTIFICATION

We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).

Instrument	Calibrated By: <i>M. Paul</i>	Reviewed By: <i>Alma G. Scott</i>	Date: <i>8-5-04</i>
Calibration Date: 08/05/04 ✓		Calibration Due: 08/05/05 ✓	

Model: 2221Serial Number: 94954

M&TE					Environmental Conditions				
Volt Meter	Due Date:	03/08/05	ID	TW12662	D-814	Due Date:	10/22/04	ID:	2525
Pulser	Due Date:	09/18/04	ID	101500	Psychron	Due Date:	02/10/05	ID:	7480
Timer	Due Date:	10/23/04	ID	22226011	Temp: 20.4°C	Pressure: 738mmHg	Humidity: 48%		
INSTRUMENT CALIBRATION INFORMATION									
Special Test									
Geotropism	Sat (✓) Unsat ()			Hold			Sat (✓) Unsat ()		
BAT > 4.5	Sat (✓) Unsat ()			Volume Test			Sat (✓) Unsat ()		
Mechanical Zero	Sat (✓) Unsat ()			Audio Divide			Sat (✓) Unsat ()		
Digital Zero	Sat (✓) Unsat ()			Window Switch			Sat (✓) Unsat ()		
Count	Sat (✓) Unsat ()			Lamp			Sat (✓) Unsat ()		
High Voltage Calibration									
Voltage	Tolerance ± 2%			As Found			As Left		
400	392-408			388			400		
1,000	980-1,020			981			1,003		
1,500	1,470-1,530			1,468			1,500		
1,900	1,862-1,932			1,855			1,898		
Threshold/Gain Calibration (Desired Ratio <u>10</u> mV/100)									
<u>Input</u>	<u>As Found Value</u>		<u>As Found Ratio (mV/100)</u>		<u>As Left Value</u>		<u>As Left Ratio (mV/100)</u>		
10	91		10.9		91		10.9		
20	183		10.9		183		10.9		
30	289		10.4		289		10.4		
40	391		10.2		391		10.2		
Logmeter Scale Linearity Check									
<u>Input</u>	<u>±20% Tolerance</u>		<u>As Found</u>		<u>As Left</u>				
LOG	400		320-480		400		400		
LOG	4,000		3,200-4,800		4,000		4,000		
LOG	40,000		32,000-48,000		45,000		45,000		
LOG	400,000		320,000-480,000		450,000		450,000		
COMMENTS									
Calibrated in accordance with the CP-IN-WI-237 rev 1									
Instrument									
Calibrated By: <i>Mike Paul</i>					Reviewed By: <i>Alma F. Acat</i> Date: <i>8-5-04</i>				
Calibration Date: 08/05/04					Calibration Due: 08/05/05				



RJP
3-30-05

**DETECTOR
CERTIFICATE**

Duratek Instrument Services
628 Gallaher Road
Kingston, TN 37763
Phone: (865) 376-8337
Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

CUSTOMER INFORMATION				DETECTOR INFORMATION			
Customer Name: Duratek Instrument Services				Manufacturer: Ludlum			
Address: 628 Gallaher Rd Kingston, TN 37763				Detector Model: 43-5			
Contact Name: Thomas Scott				Serial Number: 127385 ✓			
Customer Purchase Order Number: N/A		Work Order Number: 2004-01610		Evaluation Method: Source			
DETECTOR EFFICIENCY/RESPONSE/PRECISION INFORMATION							
1) Source Nuclide: Th ²³⁰		Serial Number: 119739		Activity (dpm) : 18,600		Certification Date: 10/20/97	
Parameter	As Found	As Left	Linearity Test		CPM (Source #1)		
Count 1	2,270	2,270	Count 1 (Heel)		2,355		
Count 2	2,171	2,171	Count 2 (Center)		2,173		
Count 3	2,230	2,230	Count 3 (Toe)		2,329		
Average	2,224	2,224	Average		2,286		
Background (cpm)	4.6	4.6	Pass/Fail		PASS		
Net Counts	2,219	2,219			Tolerance ±10%		
Efficiency %	11.9%	11.9%			Min: 2,057	Max: 2,515	
SCALER INFORMATION				DETECTOR INFORMATION			
Model	Serial Number		Due Date	Background (cpm)	Operating Voltage	Threshold	
2221	197766		12/07/05	4.6	550V	100 = 10mV	
Detector Setup Report	YES	NO ✓	Barcode Report	YES	NO ✓	Voltage Plateau YES ✓ NO	
COMMENTS							
5 minute background							
STATEMENT OF CERTIFICATION							
We Certify that the detector listed above was evaluated for proper operation prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this detector).							
Detector		Certified By: <i>M. Paul</i>		Reviewed By: <i>Alonso F. Acosta</i>		Date: 3-28-05	
Certification Date: 04/30/04 ✓				Certification Due: 04/30/05 ✓			



PH
330-05

**CALIBRATION
CERTIFICATE**

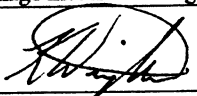
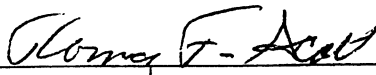
Duratek Instrument Services
628 Gallaher Road
Kingston, TN 37763
Phone: (865) 376-8337
Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

Customer Information			Instrument Information		
Customer Name: Duratek Instrument Services			Manufacturer: Ludlum		
Address: 628 Gallaher Road, Kingston, TN 37763			Model: 2929	Serial Number: 160019 ✓	
Contact Name: Thomas F. Scott			Probe: 43-10-1	Serial Number: 167229 ✓	
Customer Purchase Order Number: N/A		Work Order Number: N/A	Calibration Method: Electronic And Source		
Instrument Calibration Information					
M&TE	ID Number	Calibration Due Date	Environmental Conditions		
Thermometer	2525	10/22/04	Temperature (°C)	21.8	
Barometer	2525	10/22/04	Pressure (mmHg)	748	
Hygrometer	7480	02/10/05	Humidity (%)	48	
Pulse Generator	762	04/13/05	Calibrated in accordance with OEM.		
DVM	TW12662	03/08/05			
Isotope	Source ID Number	Original Activity (dpm)	Source Cert. Date	Decayed Activity (dpm)	
Th ²³⁰	119701	19,080	10/14/97	19,080	
Pu ²³⁹	019442	13,613	06/01/92	13,608	
Tc ⁹⁹	109407	24,288	10/01/94	24,287	
Sr/Y ⁹⁰	090213	45,200	08/04/98	39,063	
Frequency Calibration					
Desired (cpm)	Tolerances (cpm)	Alpha As Found (cpm)	Alpha As Left (cpm)	Beta As Found (cpm)	Beta As Left (cpm)
40	40	40	40	40	40
400	(392-408)	400	400	400	400
4,000	(3,920-4,080)	4,000	4,000	4,000	4,000
40,000	(39.2K-40.8K)	40,004	40,004	40,004	40,004
400,000	(392K-408K)	400,040	400,040	400,041	400,041
Background Determination		Alpha As Found	Alpha As Left	Beta As Found	Beta As Left
Counts, C _b		20	6	1,374	1,189
Time, T _b	(min)	20	20	20	20
Rate, R _b	(cpm)	1	0.3	68.7	59.5
Statement of Certification					
We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).					
Instrument		Reviewed By: <i>Thomas F. Scott</i>		Date: 8-4-04	
Calibrated By: <i>[Signature]</i>		Calibration Date: 08/04/04 ✓		Calibration Due: 08/04/05 ✓	

CROSS TALK SHEET & EFFICIENCY SHEET

Instrument ID: 160019

As Found Alpha Threshold (mv)			As Left Alpha Threshold (mv)		
200			175		
Alpha Source: Performed using Pu²³⁹ 019442					
Paramter and Tolerance	Alpha As Found	Alpha As Left	Beta As Found	Beta As Left	
Source Count, C _s	26,040	25,562	1,510	259	
Time, T _s (min)	5	5	5	5	
Rate, R _s (cpm)	R _{s[α]} = 5,207	R _{s[α]} = 5112.4	R _{s[β]} = 302	R _{s[β]} = 51.8	
EFF (% c/d) (>25%)	38.3%	37.6%	N/A	N/A	
%Crosstalk [α to β] (< 10%)	$\frac{R_{s[\beta]} - R_{b[\beta]}}{R_{s[\alpha]} - R_{b[\alpha]}} = \frac{51.8 - 59.5}{5,112.4 - 0.3} = 0\%$				
As Found Beta Low Threshold	As Left Beta Low Threshold	As Found Beta High Threshold	As Left Beta High Threshold		
6.0 mv	4.0 mv	65 mv	50 mv		
Beta Source: Performed using Tc⁹⁹ 109407					
Paramter and Tolerance	Alpha As Found	Alpha As Left	Beta As Found	Beta As Left	
Source Count, C _s	2	2	29,607	25,562	
Time, T _s (min)	5	5	5	5	
Rate, R _s (cpm)	R _{s[α]} = 0.4	R _{s[α]} = 0.4	R _{s[β]} = 5852.7	R _{s[β]} = 5,112.6	
EFF (% c/d) (>10%)	N/A	N/A	24.1%	20.8%	
%Crosstalk [β to α] (< 1%)	$\frac{R_{s[\alpha]} - R_{b[\alpha]}}{R_{s[\beta]} - R_{b[\beta]}} = \frac{0.4 - 0.3}{5,882.6 - 59.5} = 0.002\%$				
High Voltage Power					
Desired Voltage	Tolerance	DVM As Found	DVM As Left	2929 Meter As Found	2929 Meter As Left
600	540 - 660	603	603	600	600
800	720 - 880	807	807	800	800
1,000	900 - 1,100	1,014	1,014	1,000	1,000
1,200	1,080 - 1,320	1,214	1,214	1,200	1,200
1,300	1,170 - 1,430	1,318	1,318	1,300	1,300
High Voltage		As Found	Vern Dial Reading	As Left	Vern Dial Reading
		883V	3.42	800V	3.20
Statement of Certification					
We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).					
Instrument					
Calibrated By: 		Reviewed By: 		Date: 8-4-04	
Calibration Date: 08/04/04			Calibration Due: 08/04/05		

EFFICIENCY SHEET

Instrument ID: 160019

As Found Alpha Threshold (mv)		As Left Alpha Threshold (mv)		
175		175		
Alpha Source: Th²³⁰ #119738				
Paramter and Tolerance	Alpha As Found	Alpha As Left	Beta As Found	Beta As Left
Source Count, C _s	N/A	29,721	N/A	4,300
Time, T _s (min)	5	5	5	5
Rate, R _s (cpm)	R _{s[α]} = N/A	R _{s[α]} = 6,759	R _{s[β]} = N/A	R _{s[β]} = 800.5
EFF (% c/d) (>25%)	N/A	31.2%	N/A	N/A
%Crosstalk [α to β] (< 10%)	$\frac{R_{s[\beta]} - R_{b[\beta]}}{R_{s[\alpha]} - R_{b[\alpha]}} = \frac{N/A}{N/A} = N/A$			
As Found Beta Low Threshold	As Left Beta Low Threshold	As Found Beta High Threshold	As Left Beta High Threshold	
4.0mv	4.0mv	50mv	50mv	
Beta Source: Sr/Y⁹⁰ 090213				
Paramter and Tolerance	Alpha As Found	Alpha As Left	Beta As Found	Beta As Left
Source Count, C _s	N/A	112	N/A	84,221
Time, T _s (min)	5	5	5	5
Rate, R _s (cpm)	R _{s[α]} = N/A	R _{s[α]} = 22.1	R _{s[β]} = N/A	R _{s[β]} = 16784.7
EFF (% c/d) (>10%)	N/A	N/A	N/A	43.0%
%Crosstalk [β to α] (< 1%)	$\frac{R_{s[\alpha]} - R_{b[\alpha]}}{R_{s[\beta]} - R_{b[\beta]}} = \frac{N/A}{N/A} = N/A$			
Statement of Certification				
We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).				
Instrument		Reviewed By: <i>Thomas G. Scott</i>		
Calibrated By: <i>[Signature]</i>		Date: 8-4-04		
Calibration Date: 08/04/04			Calibration Due: 08/04/05	

Detector 43-10-1 #167229 Raw Data (Counts)

Voltage	Background		Pu-239		Tc-99		N/A		N/A	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
600	0	11	4199	0	1835					
650	0	34	4770	203	3106					
700	0	41	5028	197	4063					
750	0	46	5145	217	5106					
800	2	48	5151	272	5868					
850	1	84	5200	497	5818					
900	0	505	5277	1683	5892					
950										
1000										

Source Info

Nuclide Pu-239
 ID 19442
 Initial DPM 13613
 Certification Date 6/1/92
 Today's Date 8/4/04
 Source Age (Years) 12.18
 Half-Life (Years) 2.41E+04
 Corrected Activity 13608
 Voltage Increments: 50 VDC

Tc-99

109407
 24288
 10/1/94
 8/4/04
 9.84
 2.13E+05
 24287

Pu-239

8/4/04
 104.59
 #DIV/0!
 #DIV/0!

Tc-99

8/4/04
 104.59
 #DIV/0!
 #DIV/0!

N/A

8/4/04
 104.59
 #DIV/0!
 #DIV/0!

N/A

8/4/04
 104.59
 #DIV/0!
 #DIV/0!

Net CPM

Voltage	MDA/Cross-Talk		Alpha Eff. (%)		Beta Eff. (%)		Pu-239		Tc-99		N/A	
	Beta MDA	Alpha MDA	Beta-Alpha	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Beta
600	241.6	8.8	0.0%	0.0%	7.51%	30.9%	4199	-11	0	1824	0	-11
650	235.9	7.7	0.0%	0.0%	12.65%	35.1%	4770	169	0	3072	0	-34
700	196.3	7.3	0.0%	0.0%	16.56%	36.9%	5028	156	0	4022	0	-41
750	164.5	7.2	0.0%	0.0%	20.83%	37.8%	5145	171	0	5060	0	-46
800	145.8	24.6	0.0%	0.0%	23.96%	37.8%	5149	224	0	5820	-2	-48
850	192.1	19.3	0.0%	0.0%	23.61%	38.2%	5199	413	-1	5734	-1	-84
900	483.6	7.0	0.0%	0.0%	22.18%	38.8%	5277	1178	0	5387	0	-505
950	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00%	0.0%	0	0	0	0	0	0
1000	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.00%	0.0%	0	0	0	0	0	0

Signature 5-4-04

Thomas F. Boyd 8-4-04



RFH
3-30-05

**CALIBRATION
CERTIFICATE**

Duratek Instrument Services
628 Gallaher Road
Kingston, TN 37763
Phone: (865) 376-8337
Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

Customer Information			Instrument Information		
Customer Name: Duratek Instrument Services			Manufacturer: Ludlum		
Address: 628 Gallaher Road, Kingston, TN 37763			Model: 2929	Serial Number: 102001 ✓	
Contact Name: Thomas F. Scott			Probe: 43-10-1	Serial Number: 103276 ✓	
Customer Purchase Order Number: N/A		Work Order Number: 2004-02092	Calibration Method: Electronic And Source		
Instrument Calibration Information					
M&TE	ID Number	Calibration Due Date	Environmental Conditions		
Thermometer	2525	10/22/04	Temperature (°C)	21.1	
Barometer	2525	10/22/04	Pressure (mmHg)	746	
Hygrometer	7480	02/10/05	Humidity (%)	76%	
Pulse Generator	120935	04/13/05	Calibrated in accordance with CP-IN-WI-235.		
DVM	6565015	10/14/04			
Isotope	Source ID Number	Original Activity (dpm)	Source Cert. Date	Decayed Activity (dpm)	
Th ²³⁰	119739	18,600	10/20/97	18,600	
Tc ⁹⁹	119718	20,520	10/14/97	20,520	
Pu ²³⁹	019442	13,613	06/01/92	13,613	
Frequency Calibration					
Desired (cpm)	Tolerances (cpm)	Alpha As Found (cpm)	Alpha As Left (cpm)	Beta As Found (cpm)	Beta As Left (cpm)
4	4	4	4	4	4
40	(39-41)	40	40	40	40
400	(392-408)	398	398	398	398
4,000	(3,920-4,080)	3,984	3,984	3,982	3,982
40,000	(39.2K-40.8K)	39,836	39,836	39,824	39,824
400,000	(392K-408K)	398,318	398,318	398,345	398,345
Background Determination		Alpha As Found	Alpha As Left	Beta As Found	
Counts, C _b		6	4	1,193	1,088
Time, T _b	(min)	20	20	20	20
Rate, R _b	(cpm)	.30	.20	59.65	54.4
Statement of Certification					
We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).					
Instrument		Reviewed By: <i>Thomas F. Scott</i>		Date: 9-13-04	
Calibrated By: <i>[Signature]</i>		Calibration Date: 09/13/04 ✓		Calibration Due: 09/13/05 ✓	

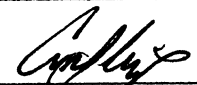
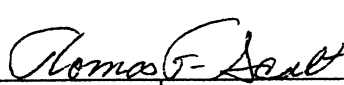
CROSS TALK SHEET

Instrument ID: 102001

As Found Alpha Threshold (mv)			As Left Alpha Threshold (mv)		
180			180		
Alpha Source: Cross Talk – Performed using Pu²³⁹ 019442					
Parameter and Tolerance	Alpha As Found	Alpha As Left	Beta As Found	Beta As Left	
Source Count, C _s	26,546	26,546	982	982	
Time, T _s (min)	5	5	5	5	
Rate, R _s (cpm)	R _{s[α]} = 5,309.2	R _{s[α]} = 5,309.2	R _{s[β]} = 196.4	R _{s[β]} = 196.4	
EFF (% c/d) (>25%)	28.5%	28.5%	N/A	N/A	
%Crosstalk [α to β] (< 10%)	$\frac{R_{s[\beta]} - R_{b[\beta]}}{R_{s[\alpha]} - R_{b[\alpha]}} = \frac{196.4 - 54.4}{5309.2 - 0.2} = 2.68\%$				
As Found Beta Low Threshold	As Left Beta Low Threshold	As Found Beta High Threshold	As Left Beta High Threshold		
4mv	4mv	50mv	50mv		
Beta Source: Cross Talk-Performed using Tc⁹⁹ 119718					
Parameter and Tolerance	Alpha As Found	Alpha As Left	Beta As Found	Beta As Left	
Source Count, C _s	5	5	26,119	26,119	
Time, T _s (min)	5	5	5	5	
Rate, R _s (cpm)	R _{s[α]} = 1	R _{s[α]} = 1	R _{s[β]} = 5,223.8	R _{s[β]} = 5,223.8	
EFF (% c/d) (>25%)	N/A	N/A	25.2%	25.2%	
%Crosstalk [β to α] (< 1%)	$\frac{R_{s[\alpha]} - R_{b[\alpha]}}{R_{s[\beta]} - R_{b[\beta]}} = \frac{1.0 - 0.20}{5233.8 - 54.4} = 0.00015\%$				
High Voltage Power					
Desired Voltage	Tolerance	DVM As Found	DVM As Left	2929 Meter As Found	2929 Meter As Left
600	540 – 660	600	600	600	600
800	720 – 880	800	800	800	800
1,000	900 – 1,100	1,000	1,000	1,000	1,000
1,200	1,080 – 1,320	1,200	1,200	1,200	1,200
1,300	1,170 – 1,430	1,300	1,300	1,300	1,300
High Voltage		As Found	Vern Dial Reading	As Left	Vern Dial Reading
		750V	3.26	750V	3.26
Statement of Certification					
We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).					
Instrument					
Calibrated By: <i>[Signature]</i>		Reviewed By: <i>[Signature]</i>		Date: <i>9-13-05</i>	
Calibration Date: 09/13/04			Calibration Due: 09/13/05		

EFFICIENCY SHEET

Instrument ID: 102001

As Found Alpha Threshold (mv)		As Left Alpha Threshold (mv)		
180		180		
Alpha Source: Efficiency determined using Th²³⁰ #119739				
Paramter and Tolerance	Alpha As Found	Alpha As Left	Beta As Found	Beta As Left
Source Count, C _s	31,208	31,208	N/A	N/A
Time, T _s (min)	5	5	N/A	N/A
Rate, R _s (cpm)	R _{s[α]} = 6,241.6	R _{s[α]} = 6,241.6	R _{s[β]} = N/A	R _{s[β]} = N/A
EFF (% c/d) (>25%)	33.6%	33.6%	N/A	N/A
%Crosstalk [α to β] (< 10%)	$\frac{R_{s[\beta]} - R_{b[\beta]}}{R_{s[\alpha]} - R_{b[\alpha]}} = \frac{N/A}{N/A} = N/A$			
As Found Beta Low Threshold	As Left Beta Low Threshold	As Found Beta High Threshold	As Left Beta High Threshold	
4.3mv	4.3mv	50mv	50mv	
Beta Source: Efficiency determined using Tc⁹⁹ #119715				
Paramter and Tolerance	Alpha As Found	Alpha As Left	Beta As Found	Beta As Left
Source Count, C _s	N/A	N/A	26,119	26,119
Time, T _s (min)	N/A	N/A	5	5
Rate, R _s (cpm)	R _{s[α]} = N/A	R _{s[α]} = N/A	R _{s[β]} = 5,223.8	R _{s[β]} = 5,223.8
EFF (% c/d) (>25%)	N/A	N/A	25.2%	25.2%
%Crosstalk [β to α] (< 1%)	$\frac{R_{s[\alpha]} - R_{b[\alpha]}}{R_{s[\beta]} - R_{b[\beta]}} = \frac{N/A}{N/A} = N/A$			
Statement of Certification				
We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).				
Instrument				
Calibrated By: 	Reviewed By: 	Date:	9-13-04	
Calibration Date: 09/13/04		Calibration Due: 09/13/05		

**N.S. SAVANNAH
DAILY DOSIMETRY READER
CALIBRATION CHECK**

**RADOS DBR-1
Dosimeter reader**

Limits: G = ±26, R = ±26, H = ±101, M = ±26, L = ±26, I = ±5001

Date	4-2-05	4-4-05	4-5-05	4-6-05	4-7-05	4-8-05	
Code	Value	Code	Value	Code	Value	Code	Value
G	1	G	1	G	2	G	2
R	0	R	4	R	3	R	2
H	41	H	97	H	65	H	15
M	6	M	19	M	17	M	6
L	4	L	9	L	16	L	4
I	110	I	110	I	110	I	110
Pass	R&P						

Date	4-11-05	4-12-05	4-13-05	4-14-05	4-15-05	4-18-05	
Code	Value	Code	Value	Code	Value	Code	Value
G	1	G	2	G	2	G	2
R	4	R	3	R	5	R	4
H	28	H	27	H	8	H	26
M	9	M	1	M	7	M	1
L	3	L	1	L	2	L	0
I	110	I	110	I	110	I	110
Pass	R&P						

Date	4-19-05	4-20-05	4-21-05	4-22-05	4-25-05	4-26-05	
Code	Value	Code	Value	Code	Value	Code	Value
G	2	G	1	G	2	G	1
R	7	R	3	R	4	R	4
H	5	H	37	H	71	H	85
M	8	M	3	M	11	M	22
L	3	L	2	L	6	L	9
I	110	I	110	I	110	I	102
Pass	R&P						

Date	4-19-05	4-20-05	4-21-05	4-22-05	4-25-05	4-26-05	
Code	Value	Code	Value	Code	Value	Code	Value
G	?	G	?	G	?	G	?
R	?	R	?	R	?	R	?
H	?	H	?	H	?	H	?
M	?	M	?	M	?	M	?
L	?	L	?	L	?	L	?
I	?	I	?	I	?	I	?
Pass	R&P						

Initial under Value column for Pass