



Instrumentation Services

Angular Dependence Testing of the Innovative Industrial Solutions (IIS) WAM 500 D Area Monitor

Revision 0

Performed By:	Tony Riggs, <i>EnergySolutions</i> , Instrument Technician	6/25/14
	Mike Pauli, <i>EnergySolutions</i> , Instrument Technician	6/26/14
Report By:	Jeff Dickinson, <i>EnergySolutions</i> I&C Leader, CHP, MS	6/27/14
Reviewed By:	Rich Palatine, Innovative Industrial Solutions	6/27/14

1. INTRODUCTION

This report presents results of angular dependence testing performed of the Innovative Industrial Solutions WAM 500 D Area Monitor. Measurement results presented in this report were performed during the week of 6/23/14 at EnergySolutions’ Bear Creek Rd facility using a Shepherd 28-6A Cs-137 open air calibrator. An open air calibrator was selected for testing to ensure a direction source of radiation (i.e., minimal scattering) was present to established angular response of the monitor. Measurements with the radiation source beam incident to the monitor front face (i.e., standard calibration position) and each of the other five sides of the monitor were performed at two separate exposure rates (i.e., 80 mR/hr and 800 mR/hr). The following sections of this report describe the test configurations and present measurement results.

2. ANGULAR DEPENDENCE TEST RESULTS

2.1. Calibration Verification Measurements

Three WAM 500 D Area Monitors were selected for angular dependence testing (i.e., serial numbers #400139, #400140, and #400141). All three monitors were previously calibrated on 5/29/14; however, to verify proper calibration of the three units selected for testing, calibration verification measurements were performed of each monitor prior to performance of angular response measurements. Table 2-1 below provides the result of the calibration verification measurements.

Table 2-1: Calibration Check of Test WAM 500 D Monitors¹

Calibration Point (mR/hr)	#400139		#400140		#400141	
	Reading (mR/hr)	Difference	Reading (mR/hr)	Difference	Reading (mR/hr)	Difference
0.5	0.48	-4.0%	0.52	+4.0%	0.48	-4.0%
5	4.70	-6.0%	4.84	-3.2%	4.84	-3.2%
50	48.4	-3.1%	50.0	-0.1%	50.5	+1.0%
500	470.2	-6.0%	466.2	-6.8%	502.2	+0.4%
5000	4780	-4.4%	4680	-6.4%	4640	-7.2%

¹ – Measurements performed using Shepherd 28-6A calibrator #118901 (certification date 6-13-14)

As shown in Table 2-1 above, all calibration verification measurements were within required calibration tolerance of ±10%. Calibration verification measurements were performed in the same position as the monitors are normally calibrated (i.e., with radiation source beam incident upon the front face of the monitor as shown in Figure 1 below). As per standard calibration protocols, the calibration distance was measured from the calibrator source center to the effective center of the monitor’s internal detector. The effective center of the monitor detector was also aligned/centered with beam during measurements.

2.2. Angular Dependence Measurement Positions

To determine the angular response of the WAM 500 D Area Monitor, the three calibrated monitors listed in Table 2-1 above were exposed to exposure rates of 80 mR/hr and 800 mR/hr with the directional source pointed toward each of the monitor’s six sides in turn. Figures 1 through 6 illustrate the position of the WAM 500 D relative to calibrator for each of the measurements performed.



Figure 1 – Standard Calibration Position
(beam directed to front face of monitor)



Figure 2 – Unit Rotated 180 Degrees
(beam directed to back side of monitor)

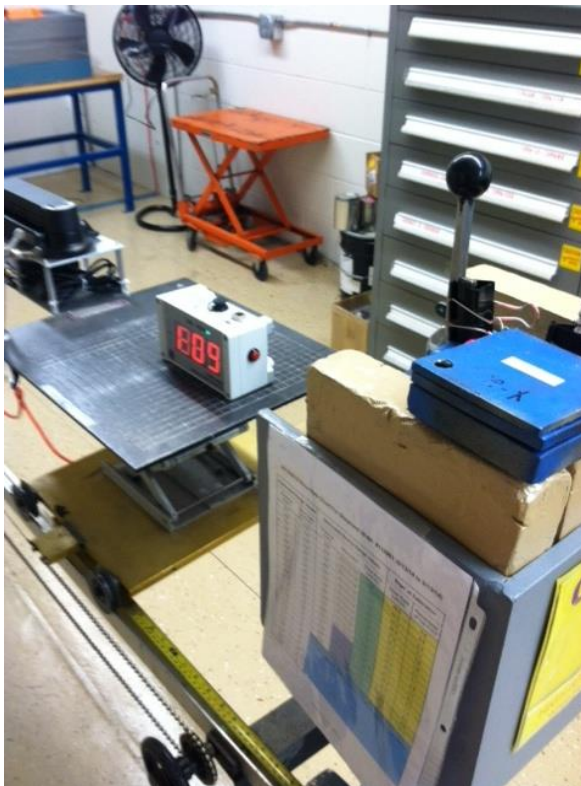


Figure 3 – Unit Rotated 90 Degrees
(beam directed to left side of monitor)



Figure 4 – Unit Rotated 270 Degrees
(beam directed to right side of monitor)

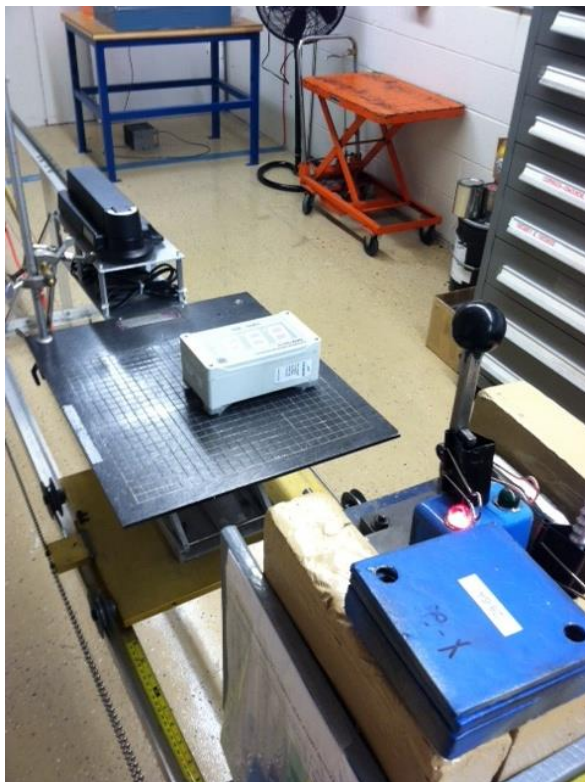


Figure 5 – Unit Rotated Down
(beam directed to top of monitor)

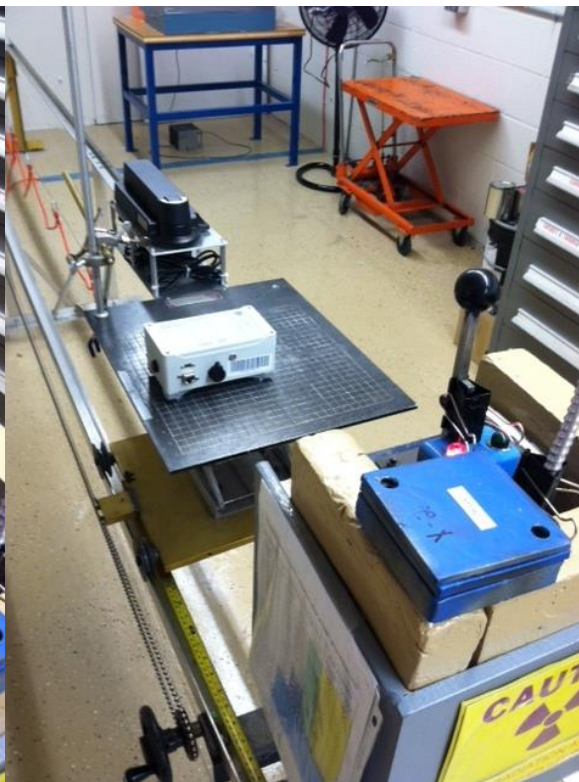


Figure 6 – Unit Rotated Up
(beam directed to bottom of monitor)

2.3. Angular Dependence Measurement Results

Five measurements were taken at each of the monitor positions shown in Figures 1 – 6. The average result for each angular position is shown in Tables 2-2 and 2-3 for exposure rates of 80 mR/hr and 800 mR/hr, respectively. The monitor was repositioned for each angular measurement to ensure the beam was aligned to the effective center of the monitor's internal detector and the calibration distance was adjusted to ensure the proper distance between source and effective center of detector for targeted exposure rate.

As shown in Tables 2-2 and 2-3, there is very little angular dependence for radiation incident to the face (calibration position), back, or right side of monitor where detector is internally located. The measurement results for these locations at both 80 mR/hr and 800 mR/hr were below 4%.

Radiation incident to the top, bottom, and left side of the monitor did show a decreased response (likely due to shielding of detector from other internal components). At 80 mR/hr, the average decrease in response of the three monitors tested was in the range of 15% to 20% as shown in Table 2-2. At 800 mR/hr, the decreased response for the top, bottom and left side of monitor was similar, but slightly lower (i.e., in the range of 10% to 15%).

Table 2-2: Angular Dependence Measurement Results at 80 mR/hr¹

Exposure Position (Monitor side facing source beam)	#400139		#400140		#400141		Average
	Exposure Rate (mR/hr)	Angular Response (vs Cal Position)	Exposure Rate (mR/hr)	Angular Response (vs Cal Position)	Exposure Rate (mR/hr)	Angular Response (vs Cal Position)	Angular Response (vs Cal Position)
Front Face	81.3	N/A	81.5	N/A	85.5	N/A	N/A
Back Side	80.5	-0.9%	80.4	-1.4%	85.8	+0.4%	-0.6%
Left Side	60.9	-25.0%	65.9	-19.2%	72.0	-15.8%	-20.0%
Right Side	81.4	+0.2%	82.1	+0.8%	85.1	-0.4%	+0.2%
Top	66.6	-18.0%	65.0	-20.2%	69.8	-18.3%	-18.8%
Bottom	66.8	-17.8%	70.2	-13.9%	73.9	-13.6%	-15.1%

¹ – Measurements performed using Shepherd 28-6A calibrator #118901 (certification date 6-13-14)

Table 2-3: Angular Dependence Measurement Results at 800 mR/hr¹

Exposure Position (Monitor side facing source beam)	#400139		#400140		#400141		Average
	Exposure Rate (mR/hr)	Angular Response (vs Cal Position)	Exposure Rate (mR/hr)	Angular Response (vs Cal Position)	Exposure Rate (mR/hr)	Angular Response (vs Cal Position)	Angular Response (vs Cal Position)
Front Face	761.4	N/A	770.0	N/A	789.4	N/A	N/A
Back Side	799.6	+5.0%	795.0	+3.2%	815.6	+3.3%	+3.8%
Left Side	616.4	-19.0%	628.4	-18.4%	718.8	-8.9%	-15.4%
Right Side	774.4	+1.7%	787.0	+2.2%	803.4	+1.8%	+1.9%
Top	660.0	-13.3%	655.8	-14.8%	687.6	-12.9%	-13.7%
Bottom	673.4	-11.6%	704.4	-8.5%	693.0	-12.2%	-10.8%

¹ – Measurements performed using Shepherd 28-6A calibrator #118901 (certification date 6-13-14)

3. SUMMARY

Three (3) IIS WAM 500 D Area Monitors were tested to determine the angular dependence of the monitor. All three monitors tested were verified to be within the standard calibration tolerance of $\pm 10\%$ prior to angular dependence testing. Angular testing showed very little (i.e., less than 4%) difference between calibration orientation (i.e., calibration beam incident upon monitor face) and the back or right side of monitor where the internal detector is located. There is a decreased response relative to calibration for radiation incident to the top, bottom, or left side of monitor. The angular dependence of these positions was determined to be approximately 15% (i.e., range of 10% to 20% for the monitors and exposure rates tested).