



# Test Report

## Determination of Attenuation Properties of Materials using Diagnostic X-Radiation

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**FOR:**

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**DESCRIPTION:**

Determination of Attenuation properties of Lightweight Lead Vinyl Material according to BS EN 61331-1:2014 using the modified Broad Beam Geometry (Eder and Schlattl, 2018<sup>1</sup>)

**DATE OF MEASUREMENTS:** 19 July 2018

**Reference:** 2018070339\_1

**Date of Issue:** 16 November 2018

**Checked by:** 

**Signed:** 

**Name:** G A Bass

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(Authorised signatory)

on behalf of NPLML

# NATIONAL PHYSICAL LABORATORY

Continuation Sheet

## CONDITIONS:

Distance from x-ray tube to target sample: 1.5m  
Ionisation chamber used: PTW TW34069-2.5 s/n 000231

All equipment associated with the measurements performed in this report has direct traceability to UK national standards or UKAS accredited calibration facilities.

**Table I**  
61331-1:2014 X-ray beam qualities

<u>X-ray Tube Voltage</u> kV	<u>Added filtration</u> mmAl*
50	2.5
60	2.5
70	2.5
90	2.5
110	2.5
150	2.5

\*The inherent filtration of the x-ray tube was determined to be 0.3mmAl equivalent (according to ISO 4037-1:1996), giving a total filtration of 2.8mmAl

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## RESULTS:

**Table II**

Lightweight Lead Vinyl, sample #52, 0.25mm nominal Lead equivalent  
Measured Area density: 3.35 kg/m<sup>2</sup>

<u>kV</u>	<u>F<sub>mBBG</sub></u>	<u>δ<sub>mBBG</sub></u>	<u>PASS/FAIL†</u>
50	92.86	0.2334	PASS
60	39.37	0.2371	PASS
70	20.42	0.2415	PASS
90	9.64	0.2458	PASS
110	6.71	0.2448	PASS
150	4.50	0.2472	PASS

**Table III**

Lightweight Lead Vinyl, sample #53, 0.35mm nominal Lead equivalent  
Measured Area density: 4.65 kg/m<sup>2</sup>

<u>kV</u>	<u>F<sub>mBBG</sub></u>	<u>δ<sub>mBBG</sub></u>	<u>PASS/FAIL†</u>
50	352.5	0.3319	PASS
60	100.3	0.3323	PASS
70	42.63	0.3429	PASS
90	15.86	0.3446	PASS
110	10.50	0.3424	PASS
150	6.71	0.3435	PASS

**Table IV**

Lightweight Lead Vinyl, sample #54, 0.5mm nominal Lead equivalent  
Measured Area density: 6.62 kg/m<sup>2</sup>

<u>kV</u>	<u>F<sub>mBBG</sub></u>	<u>δ<sub>mBBG</sub></u>	<u>PASS/FAIL†</u>
50	1735	0.4669	PASS
60	313.1	0.4680	PASS
70	99.89	0.4824	PASS
90	28.33	0.4820	PASS
110	18.21	0.4842	PASS
150	11.18	0.4848	PASS

†Determination of the lead equivalent class for a specified range of radiation qualities according to IEC 61331-1 clause 5.5.

Clause 5.5.3 of IEC 61331-1:2014 states that a relative standard uncertainty of 7% be taken into account in the decision of conformity in assigning the class of the Lead equivalent thickness to the material under test. If  $t_{pb}$  is the standard Lead equivalent thickness class (0.25mm, 0.35mm, 0.5mm or 1mm) and  $\delta_{mBBG}$  is the Lead equivalence of the material under test, the condition can be written as:

$$\delta_{mBBG} \geq 0.93t_{pb}$$

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$F_{mBBG}$  is the attenuation ratio in the modified Broad Beam geometry, given by:

$$F_{mBBG} = \frac{K_0 - K_B}{K_1 - K_B}$$

where  $K_0$  = Air Kerma Rate without the test object in the beam

$K_1$  = Air Kerma Rate with the test object in the beam

$K_B$  = Background Air Kerma Rate with the test object replaced by a sheet of material with an attenuation ratio greater than  $10^5$ .

The Lead equivalent value  $\delta_{mBBG}$  in mm using the Modified Broad Beam Geometry is obtained from fits to the attenuation curves  $F_{mBBG}$  of Lead foils of known thicknesses and of at least 99.995% purity.

## UNCERTAINTIES

The uncertainty in the Lead equivalence value  $\delta_{mBBG}$  is  $\pm 5\%$ . The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor  $k = 2$ , providing a level of confidence of approximately 95%.

## REFERENCES

1. IEC 61331-1: A new setup for testing lead free X-ray protective clothing, Heinrich Eder and Helmut Schlattl, *Physica Medica* 45 (2018) 6–11

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