



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 Bi-Layer Lead Free Vinyl Material according to BS EN 61331-1:2014 using the modified Broad Beam Geometry (Eder and Schlattl, 2018¹)

DATE OF MEASUREMENTS: 19 September 2018

Reference: 2018110282_2

Date of Issue: 16 November 2018

Checked by: 

Signed: 

Name: G A Bass

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(Authorised signatory)

on behalf of NPLML

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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*
60	2.5
70	2.5
90	2.5
110	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

Bi-Layer Lead Free Vinyl, sample #62, 0.25mm nominal Lead equivalent
Measured Area density: 2.80 kg/m²

kV	E_{mBBG}	δ_{mBBG}	PASS/FAIL†
60	42.54	0.2408	PASS
70	23.10	0.2465	PASS
90	11.03	0.2534	PASS
110	7.041	0.2406	PASS

Table III

Bi-Layer Lead Free Vinyl, sample #63, 0.35mm nominal Lead equivalent
Measured Area density: 3.90 kg/m²

kV	E_{mBBG}	δ_{mBBG}	PASS/FAIL†
60	116.95	0.3392	PASS
70	50.96	0.3495	PASS
90	18.30	0.3510	PASS
110	11.05	0.3340	PASS

Table IV

Bi-Layer Lead Free Vinyl, sample #64, 0.5mm nominal Lead equivalent
Measured Area density: 5.68 kg/m²

kV	E_{mBBG}	δ_{mBBG}	PASS/FAIL†
60	513.67	0.5037	PASS
70	135.91	0.4970	PASS
90	35.68	0.5026	PASS
110	19.24	0.4659	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 δ_{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:

$$F_{mBBG} = \frac{\dot{K}_0 - \dot{K}_B}{\dot{K}_1 - \dot{K}_B}$$

where \dot{K}_0 = Air Kerma Rate without the test object in the beam

\dot{K}_1 = Air Kerma Rate with the test object in the beam

\dot{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 δ_{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 δ_{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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