NATIONAL PHYSICAL LABORATORY
Teddington Middlesex UK TW11 0LW Telephone +44 20 8977 3222

Test Report

Determination of Attenuation Properties of Materials using Diagnostic X-Radiation

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FOR:	Kemmetech Ltd Unit 4, Arnold Business Park Branbridges Road East Peckham Tonbridge TN12 5LG United Kingdom
DESCRIPTION:	Determination of Attenuation properties of Bi-Layer Low Lead Vinyl Material according to BS EN 61331-1:2014 using the modified Broad Beam Geometry (Eder and Schlattl, 2018[1])
DATE OF MEASUREMENTS:	19 July and 19 September 2018

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

X-ray Tube Voltage kV	**Added filtration** 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

RESULTS:

Table II
Bi-Layer Low Lead Vinyl, sample #60, 0.25mm nominal Lead equivalent
Measured Area density: 2.90 kg/m^2

kV	F_{mBBG}	δ_{mBBG}	PASS/FAIL†
60	46.16	0.2483	PASS
70	24.00	0.2512	PASS
90	11.13	0.2550	PASS
110	7.28	0.2470	PASS

Table III
Bi-Layer Low Lead Vinyl, sample #61, 0.35mm nominal Lead equivalent
Measured Area density: 3.99 kg/m^2

kV	F_{mBBG}	δ_{mBBG}	PASS/FAIL†
60	111.6	0.3344	PASS
70	50.17	0.3473	PASS
90	18.01	0.3477	PASS
110	10.92	0.3313	PASS

Table IV
Bi-Layer Low Lead Vinyl, sample #51, 0.5mm nominal Lead equivalent
Measured Area density: 5.80 kg/m^2

kV	F_{mBBG}	δ_{mBBG}	PASS/FAIL†
60	394.6	0.4982	PASS
70	116.1	0.5095	PASS
90	31.46	0.5093	PASS
110	17.63	0.4752	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:

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

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 by 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 ±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*