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Test Report

Determination of Attenuation Properties of Materials using Diagnostic X-Radiation

FOR:	Lite Tech Inc 975 Madison Ave Norristown 19403 United States
DESCRIPTION:	Determination of Attenuation properties of various Material according to BS EN 61331-1:2014 using the modified Broad Beam Geometry (Eder and Schlattl, 2018[1])
DATE OF MEASUREMENTS:	16 -19 June 2020

Reference: 2020060011_1

Date of Issue: 08 July 2020

Checked by: DJM

Signed: (Authorised signatory)

Name: G A Bass on behalf of NPLML

CONDITIONS:

Distance from x-ray tube to target sample: 0.8m
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*
50 - 150	2.5

*The inherent filtration of the x-ray tube was determined to be 0.5mmAl equivalent (according to ISO 4037-1:1996), giving a total filtration of 3.0mmAl

F_{mBBG} is the attenuation ratio in the modified Broad Beam Geometry[1], given by:

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

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 $\boldsymbol{\delta_{mBBG}}$ 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*

RESULTS:

Table II
Xenolite Strata 300 leadfree Lot# 5092/5085, sample #190, 0.25mm nominal Lead equivalent
Measured Area density: 2.81 kg/m^2

kV	**F_{mBBG}**	**δ_{mBBG}** mm	**PASS/FAIL**†
60	34.45	0.2355	PASS
70	20.14	0.2470	PASS
90	9.47	0.2564	PASS
110	6.36	0.2476	PASS

Table III
Xenolite Strata 300 Bi-layer Lot# 5058/5086, sample #191, 0.35mm nominal Lead equivalent
Measured Area density: 3.95 kg/m^2

kV	**F_{mBBG}**	**δ_{mBBG}** mm	**PASS/FAIL**†
60	97.90	0.3469	PASS
70	43.34	0.3493	PASS
90	15.99	0.3604	PASS
110	9.81	0.3396	PASS

Table IV
Xenolite Strata 300 Bi-layer Lot# 5092/5085, sample #192, 0.5mm nominal Lead equivalent
Measured Area density: 5.54 kg/m^2

kV	**F_{mBBG}**	**δ_{mBBG}** mm	**PASS/FAIL**†
60	344.74	0.5077	PASS
70	107.89	0.4909	PASS
90	28.64	0.4950	PASS
110	16.58	0.4661	PASS

Table V

Xenolite Strata 200 Part-lead Lot# 5084/5074, sample #193, 0.25mm nominal Lead equivalent
Measured Area density: 2.99 kg/m^2

kV	**F_{mBBG}**	**δ_{mBBG}** mm	**PASS/FAIL**†
70	18.27	0.2351	PASS
90	8.93	0.2458	PASS
110	6.10	0.2394	PASS

Table VI

Xenolite Strata 200 Bi-layer Lot# 5083/55/60, sample #194, 0.35mm nominal Lead equivalent
Measured Area density: 4.56 kg/m^2

kV	**F_{mBBG}**	**δ_{mBBG}** mm	**PASS/FAIL**†
60	114.96	0.3658	PASS
70	50.29	0.3709	PASS
90	17.50	0.3799	PASS
110	10.90	0.3638	PASS

Table VII

Xenolite Strata 200 Bi-layer Lot# 5084/5074, sample #195, 0.5mm nominal Lead equivalent
Measured Area density: 5.92 kg/m^2

kV	**F_{mBBG}**	**δ_{mBBG}** mm	**PASS/FAIL**†
60	311.19	0.4936	PASS
70	104.47	0.4855	PASS
90	28.79	0.4962	PASS
110	16.60	0.4665	PASS

Table VIII

EVAL 900 100% Pb Lot# 5001, sample #196, 0.25mm nominal Lead equivalent
Measured Area density: 3.62 kg/m^2

kV	**F_{mBBG}**	**δ_{mBBG}** mm	**PASS/FAIL**†
60	45.14	0.2624	PASS
70	23.46	0.2661	PASS
90	10.41	0.2740	PASS
110	7.28	0.2750	PASS
120	6.40	0.2736	PASS
150	4.83	0.2751	PASS

Table IX
EVAL 900 100% Pb Lot# 4952, sample #197, 0.35mm nominal Lead equivalent
Measured Area density: 4.90 kg/m^2

kV	**F_{mBBG}**	**δ_{mBBG}** mm	**PASS/FAIL†**
60	102.01	0.3517	PASS
70	47.98	0.3640	PASS
90	16.64	0.3689	PASS
110	11.28	0.3718	PASS
120	9.75	0.3681	PASS
150	7.06	0.3677	PASS

Table X
EVAL 900 100% Pb Lot# 5001, sample #198, 0.5mm nominal Lead equivalent
Measured Area density: 7.11 kg/m^2

kV	**F_{mBBG}**	**δ_{mBBG}** mm	**PASS/FAIL†**
60	421.95	0.5362	PASS
70	127.83	0.5196	PASS
90	32.79	0.5290	PASS
110	21.02	0.5288	PASS
120	17.99	0.5239	PASS
150	12.51	0.5220	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_{IB} is the Lead equivalence of the material under test, the condition can be written as:

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

The Lead equivalence in the Inverse Broad Beam geometry, δ_{IB} has been replace with δ_{mBBG} for this determination.

Checked by: DJM