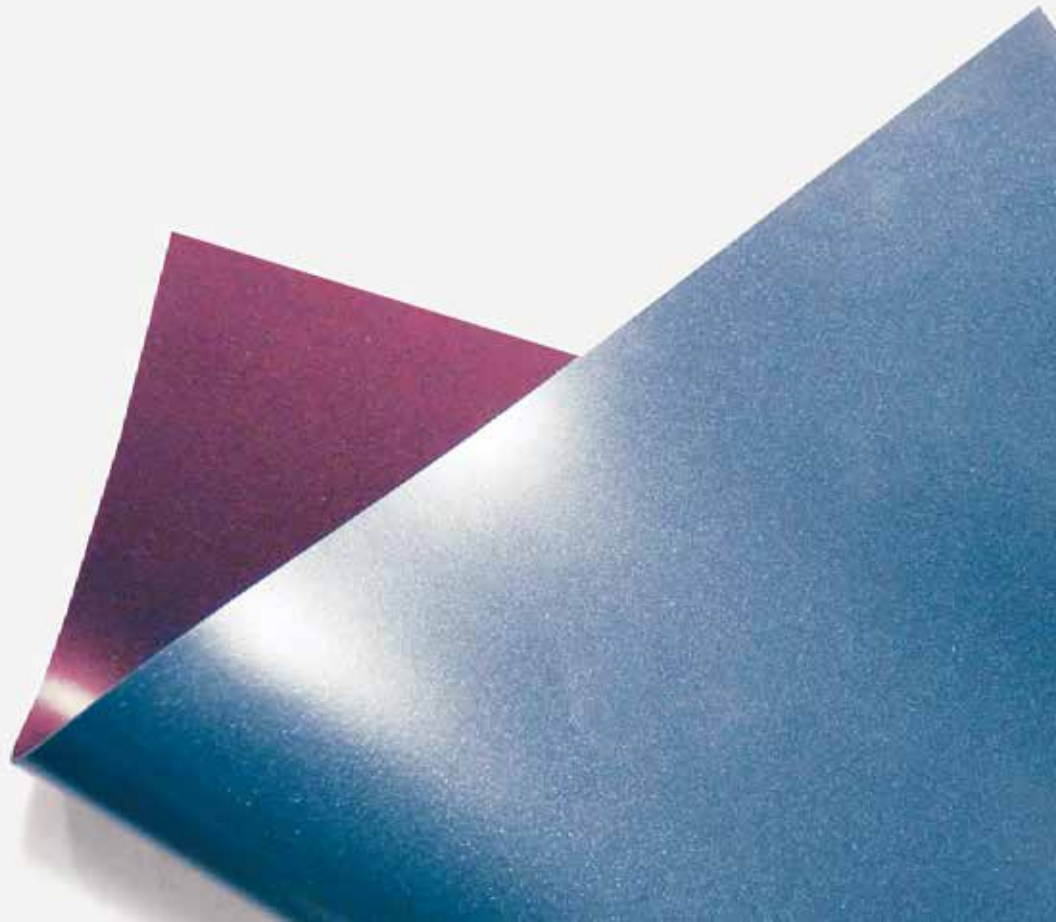




# **BI-LAYER PROTECTION AGAINST SCATTER RADIATION**





# AN ALL NEW INNOVATION IN RADIATION PROTECTION CORE MATERIAL

## THE STORY

Kiarmor is an all new innovation in radiation protection core material, the combination of two powerful radiation blocking materials into a single homogeneous sheet.

<b>Sb</b>	<b>Antimony</b>	<b>51</b> (Low atomic weight element)
<b>Bi</b>	<b>Bismuth</b>	<b>83</b> (High atomic weight element)

When viewed outside the apron, Kiarmor is Red on the bottom and consists of bismuth and Blue on the top and consists of antimony. Both elements are well known for their radiation protective qualities, but when combined in this precise process and configuration they form a powerful barrier and virtually eliminate absorbed dose to the apron wearer.

Lead has long been the standard for radiation protection, simply put it does a great job and it's relatively inexpensive and plentiful. But, there's health problems associated with lead and it's rather heavy so in recent years many companies, (Infab included) have developed lighter weight reduced lead and lead free products. Generally speaking these materials perform fairly well in the narrow direct beam where they are routinely tested. BUT.....Infab has long been concerned about real world conditions, the ones that doctors, technicians and X-ray personnel are subjected to and that's not direct beam, it' s scatter radiation!!



## DANGERS OF SCATTER RADIATION

Scatter radiation is the dangerous stuff, it's the lower energy radiation and it doesn't pass through your body it's absorbed into it.

Why then is every single test for "lead equivalency" and radiation protection performed under the direct beam and not just the regular direct beam but the narrow direct beam that has NOTHING to do with real world conditions? The answer is because that test is easy and inexpensive to perform!!

## TESTING AND WHAT IT MEANS FOR KIARMOR

There are three test procedures for radiation protection material that are universally recognized. ASTM which is widely used in the USA and nowhere else, IEC 61331-1 which is widely used throughout the rest of the world and DIN which is the only standard allowed in Germany and the toughest of them all to meet or exceed.

Kiarmor protects every bit as well as pure lead in the direct beam AND passes every single one of the test standards mentioned above BUT it does something better than any other material available in the world today, it drastically reduces the absorbed dose from scatter radiation, the very type of harmful radiation you are exposed to on a daily basis while you work.

## WHY GO WITH KIARMOR

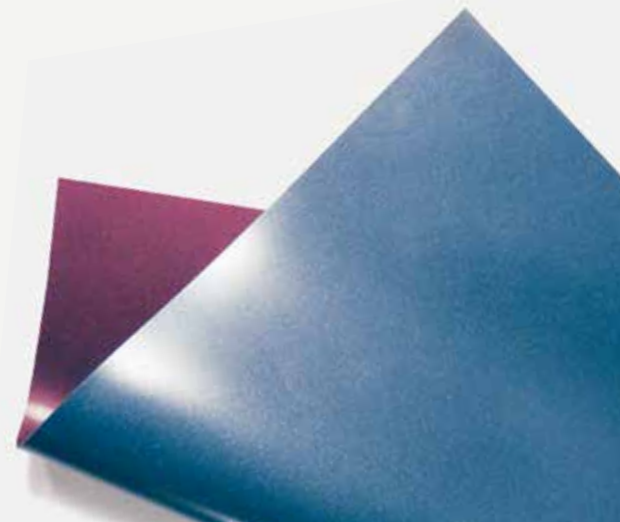
If you're concerned about the harmful effects of scatter radiation (and you should be) then you need to know there's something better and it's available right now. Kiarmor, a joint venture product between Kemmetech, Kent, England the world leader in radiation protection materials and Infab Corporation, the leading protective garment manufacturer and available now exclusively from Infab and our many distribution partners worldwide.



We aren't talking about a little bit better either. The Leeds University tests prove that Kiarmor is 40% more effective than other non lead or reduced lead materials and 20% better than lead materials at stopping the absorbed dose. These were tests performed in real world situations like the ones you face every day.

## THE KIARMOR CHALLENGE

There is no other product in the world that is like KIARMOR or does what it does. It is the technically certified lightest weight, highest protection level material you can buy, anywhere. Do not be fooled by imitators or competitors, ask them for their scientific testing and proof and scrutinize it closely before you make any decision to purchase.



# STEP BY STEP GUIDE TO UNDERSTANDING KV, KEV AND EFFICIENCY OF KIARMOR BI-LAYER IN COMPARISON TO LEAD-FREE OR COMPOSITE MATERIALS

1. kV is the voltage (Kilovolts = 1000s of volts) across the X-ray lamp that generates the keV (Kilo Electron Volts) spectrum (wavelength bandwidth) of X-ray energy for the main beam. **(Not to be confused with keV).**
2. The keV X-ray spectrum ranges from approximately 15keV to the maximum level of kV used in the X-ray lamp excitation. In other words, if you use 100kV (typical standard X-ray) across the X-ray lamp, the keV spectrum will range from approximately 15keV to 100keV. If you use 60kV (typical fluoroscope) the keV spectrum will range from approximately 15keV to 60keV.

Fig 1 - Typical keV Spectrum  
Generated from 100kV

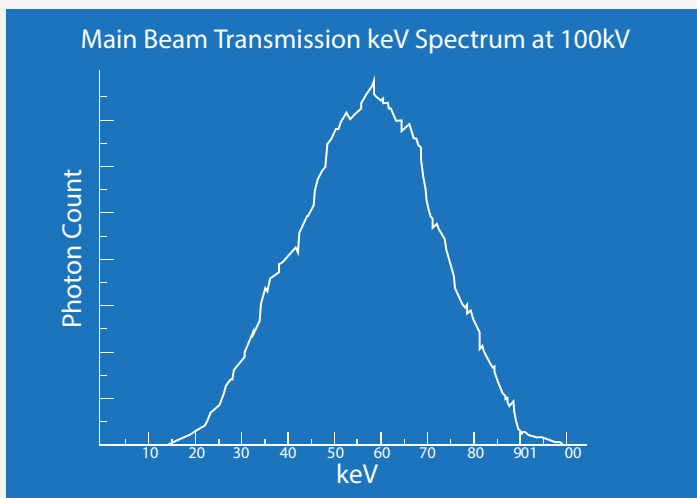
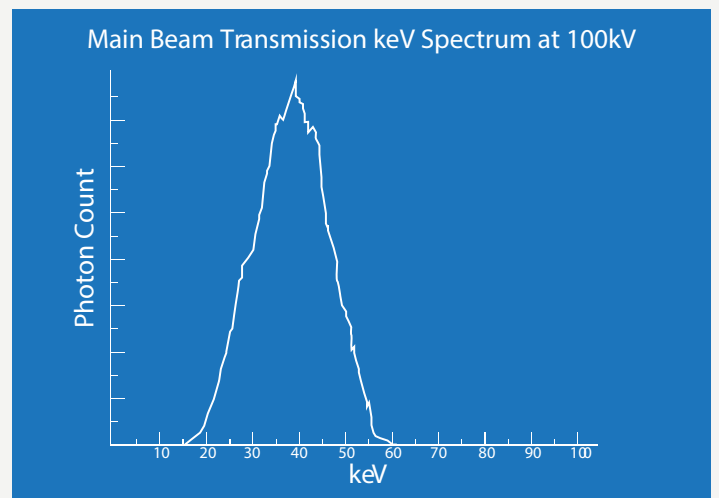


Fig 2 - Typical keV Spectrum  
Generated from 60kV



*Note: The photon count on the Y axis is dependent on current/time selected, so no real scale applied.*

## KIARMOR BI-LAYER COMPARISON

- Scatter radiation is typically 1% of the main beam. Furthermore, the higher keV energies in the main beam do not scatter as much as they pass through the patient, or object, being X-rayed, whilst the lower energies scatter more easily because they do not have the penetrating power. Therefore, if you look at the resulting keV spectrum for the scatter radiation, the top end of the keV spectrum is reduced.

Typically, if you generated the main beam using 100kV on the lamp, the main beam energy, in terms of keV, will range from approximately 15keV to 100keV (Fig 1) and the scatter radiation will range from approximately 15keV to just over 60keV (Fig 3). If you generated the main beam using 60kV across the lamp, the main beam energy, in terms of keV, will range from approximately 15keV to 60keV (Fig 2) and the scatter radiation will range from approximately 15keV to just over 45keV (Fig 4).

Fig 3 - Typical Resultant keV Spectrum for Scatter Radiation for Main Beam Generated at 100kV

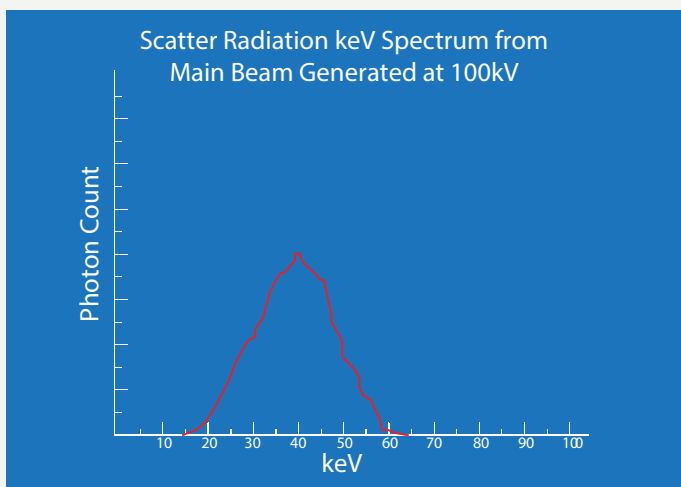
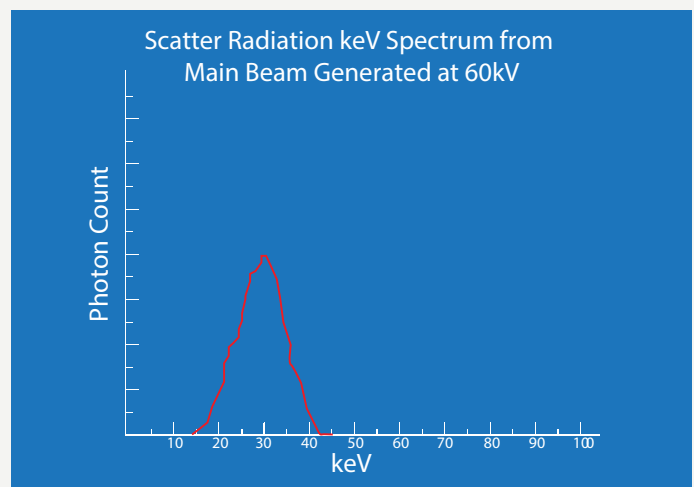


Fig 4 - Typical Resultant keV Spectrum for Scatter Radiation for Main Beam Generated at 60kV



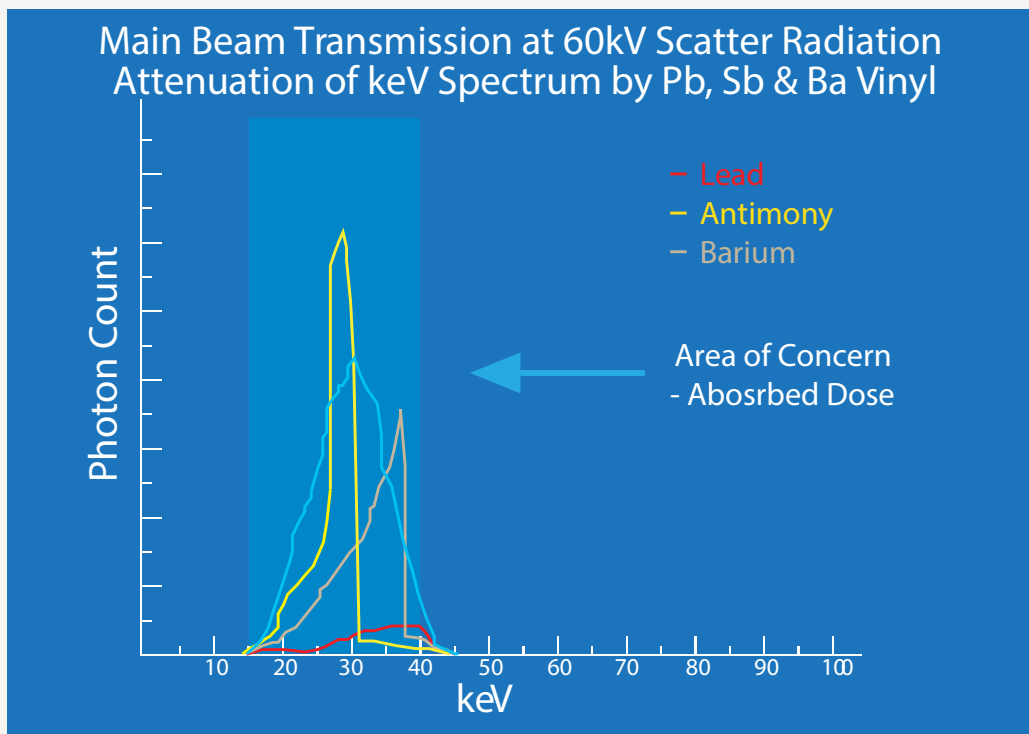
Note: The keV scale of the Y axis (Photon Count) would be approximately a 50th of the graphs for the main beam.

- Absorbed dose is created from radiation that does not pass through the body. That is the lower ranges of keV, typically 15keV to approximately 45keV. Scatter radiation is primarily made up of this range of keV and the core material needs to be at its most efficient and effective in this range to be truly effective in protecting the user.
- Given the principles above, and taking the example of fluoroscopy, which typically uses between 60kV to 70kV across the lamp to generate the X-rays, the main beam will have keV energies from 15keV to approximately 65keV. However, the scatter radiation will have energies from 15keV to approximately 45keV. This means that the vast majority of the radiation is in the absorbed dose range as it lacks the penetrating power and will stay in the body of the recipient.

## KIARMOR BI-LAYER COMPARISON

6. Current Lead-free materials use lower weight atomic elements, for example, Antimony, Tin, Barium etc., to provide lighter materials that are just able to pass current test standards such as ASTM and IEC 61331-1. However, these elements have K-edges in the critical area of keV in terms of absorbed dose, which is not picked up by the test standards. Higher atomic weight elements, such as Lead or Bismuth, have K-edges beyond the keV spectrum for typical scatter radiation and do not have the same issue. K-edges create fluorescence and a break-down of the efficiency of these elements in terms of absorbing photon energy from an X-ray source, or the derived scatter radiation. In fact, these K-edges can actually increase the dose to the wearer of an X-ray protection apron as the fluorescence causes an increase in photon energy to the wearer of an X-ray protection apron made from these lower atomic weight elements (Fig 5). The same applies to materials using a composite (mixture) of a higher and lower atomic weight element, for example, Bismuth/Antimony, or a Lead composite material. That this occurs right next to the wearer is the worst case scenario in terms of protection against absorbed dose.

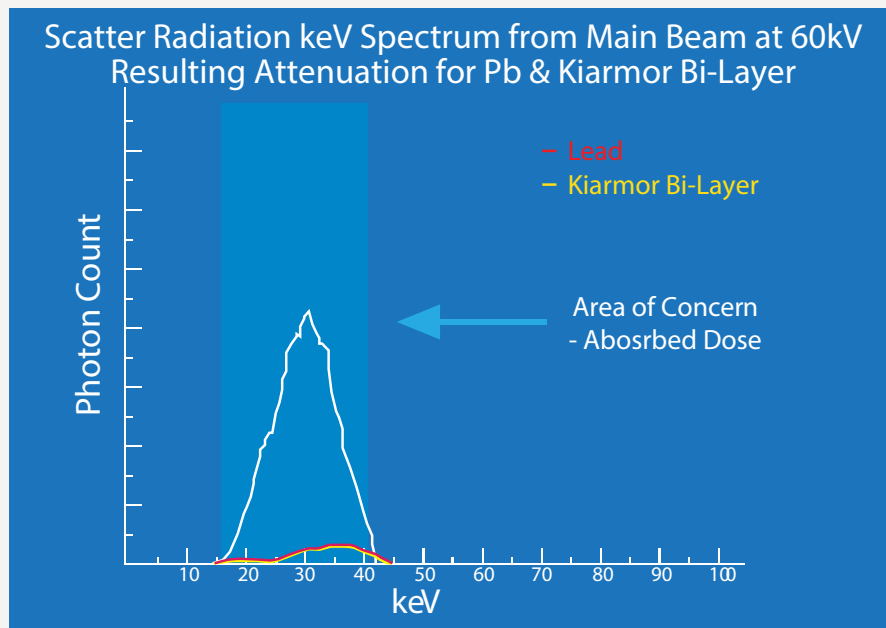
Fig 5 - Attenuation Properties of Typical Lead-free Materials and Composites in Scatter Radiation



## KIARMOR BI-LAYER COMPARISON

- By arranging Lead-free materials as a Bi-layer, with a lower atomic weight element at the top (for example, Antimony) and a higher atomic weight element at the bottom (for example, Bismuth), the K-edge effect is nullified and the additional photons created by the fluorescence of the lower atomic weight element is absorbed by the higher atomic weight element (Fig 6).

Fig 6 - Attenuation Properties of a Bi-layer Lead-free Material (Bismuth/Antimony) in scatter radiation



Independent testing has shown that this Bi-layer configuration is 20% more effective than Lead and 40% more effective than Lead-free materials and composites in terms of absorbed dose. Kiarmor Bi-layer passes all current and future standards, IEC 61331-1, ASTM and DIN 6857-1 (specifically designed for Lead-free materials with geometry and beam conditions designed to capture the K-edge and fluorescence).

# LEEDS UNIVERSITY SUPPLEMENTAL REPORT

Full 10 Page Preliminary Report available online at [Infabcorp.com/leeds](http://Infabcorp.com/leeds)

## Kemmetech Bi-layer Project

### Supplementary Report : Bismuth and Antimony Samples

*Dr. Amanda Fender and Dr. David Brettle, Leeds Teaching Hospitals NHS Trust 5th October 2012*

This report contains material that is intended for Kemmetech only and is subject to the terms of the non-disclosure agreement that is in place between Leeds Teaching Hospitals NHS Trust and Kemmetech. These are preliminary results and may be altered after further scrutiny of the experimental data.

## Introduction

This work was performed as part of a collaborative project between Leeds Teaching Hospitals NHS Trust (LTHT) and Kemmetech. The aim of the project is to compare the level of protection from radiation provided by a range of composite materials and bi-layers formed of the two constituent materials of the composite materials.

The same samples will be tested by LTHT and the National Physical Laboratory (NPL). At the NPL, the materials will be tested in the primary radiation beam, as described by IEC 6331-1. At LTHT, the samples will be tested in real world conditions, in a typical fluoroscopy scatter beam that would be encountered by an interventionalist or radiographer during fluoroscopy guided procedures. Spectral and air kerma rate measurements will be made at LTHT, which will enable the relative risk of wearing an apron made of each sample tested to be determined.

This brief report presents some supplementary information to compliment the preliminary report for the first set of samples in this project.

## Results

### *Effective dose and skin dose estimations*

Figure 1 and Figure 2 show the  $H^*(10)$  (effective dose estimate) and  $H'(0.07)$  (skin dose estimation) for each of the bismuth and antimony samples relative to the value that would be achieved with a 0.25 mm Pb foil.



# LEEDS UNIVERSITY SUPPLEMENTAL REPORT

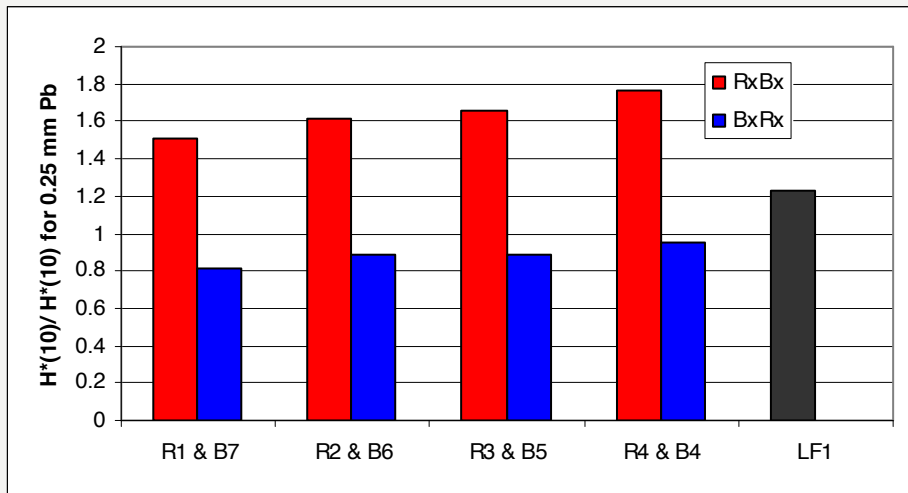


Figure 1:  $H^*(10)$  for each bi-layer sample and the lead free composite material normalised to the  $H^*(10)$  for 0.25 mm lead foil. Red bars RxBx (lead closest to tube), blue bars BxRx (antimony closest to tube), grey bar LF1 (lead free composite).

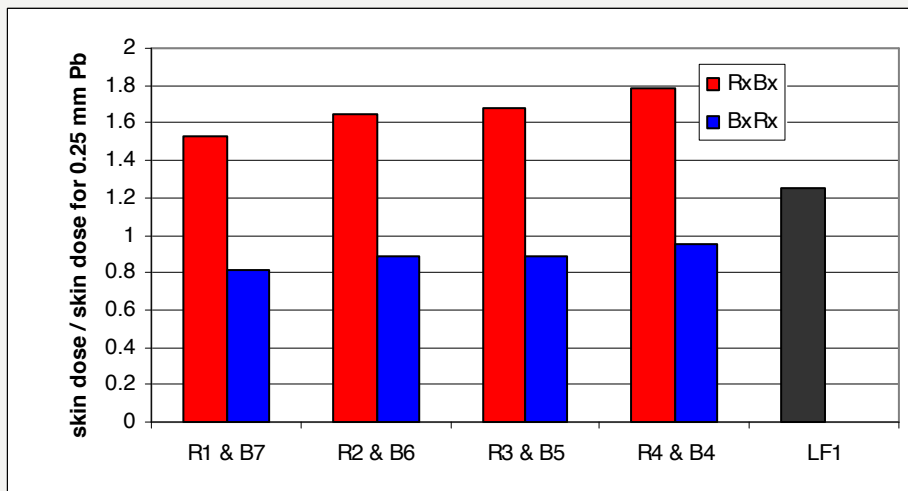


Figure 2:  $H^*(0.07)$  for each bi-layer sample and the lead free composite material normalised to the  $H^*(0.07)$  for 0.25 mm lead foil. Red bars RxBx (lead closest to tube), blue bars BxRx (antimony closest to tube), grey bar LF1 (lead composite).

## Discussion and conclusions

These results suggest that using the bi-layer samples with antimony at the tube side can result in a reduction in effective dose of up to 20% compared with 0.25 mm lead foil. By contrast, the lead-free composite material was found to increase effective dose by approximately 20% compared with a lead foil 0.25 mm thick.

# KIARMOR: A NEW STANDARD OF RADIATION PROTECTION

- The lightest and most flexible radiation protection material available
- Provides 20% greater protection against absorbed dose when compared to Standard Lead products
- Provides 40% greater protection against absorbed dose when compared to Lead-free, or low-Lead composites
- Tested and certified to IEC 61331-1:1994; IEC 61331-1:2013/2014 (Draft); ASTM F2547-06 and DIN 6857-1, designed specifically to test Lead-free and low-Lead composites

## NATIONAL PHYSICAL LABORATORY TEST RESULTS & CERTIFICATION

KIARMOR Bi-layer materials have been tested and certified by the National Physical Laboratory against the following standards:



- IEC 61331-1:1994
- DIN 6857-1
- IEC61331-1:2013/2014 (Draft)



Also tested and certified against ASTM F2547-06



# CERTIFICATIONS

## NPL



**NATIONAL PHYSICAL LABORATORY**  
Teddington, Middlesex, UK TW11 0LW Telephone +44 20 8977 3722

### Certificate of Calibration

Determination of the shielding properties  
of low-Lead and Lead-free vinyl samples

This certificate provides traceability of measurement to recognised national standards, and to the units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This certificate may not be reproduced other than in full, unless permission for the publication of an approved extract has been obtained in writing from the Managing Director. It does not of itself impose on the subject of calibration any attributes beyond those shown by the data contained herein.

**FOR:** Kenatech Ltd  
Unit 4 Arnold Business Park  
Branbridges Road  
East Peckham  
Kent  
TN12 5HE

**DESCRIPTION:** Determination of Lead equivalence of low-Lead and Lead-free vinyl samples in accordance with BS EN 61331-1:2002

**DATE OF MEASUREMENTS:** 14 to 31 May 2013

**CONDITIONS:**

Distance from x-ray tube to target sample: 0.5m  
Distance from x-ray tube to detector: 1.1m  
Ionisation chamber used: TS100M

All equipment associated with the measurements performed in this report has direct traceability to UK national standards or UKAS accredited calibration facilities. The bi-layer samples were circular in cross section with a diameter of approximately 110mm.

**Table I**  
61331-1:2002 X-ray beam qualities

X-ray Tube Voltage kV	Additional filtration mmCu
80	0.15
100	0.25

Reference: 2013060054-2  
Date of Issue: 03 June 2013  
Checked by: *[Signature]*

Signed: *[Signature]*  
Name: G A Bass  
(Authorised signatory)  
on behalf of NPLML

Page 1

### NATIONAL PHYSICAL LABORATORY

Continuation Sheet

**RESULTS:**

**Table II**  
Bi-layer, low-Lead vinyl sheet, 0.500mm\* nominal Lead equivalent

kV	Equivalent Lead thickness mm	Attenuation %
80	0.5446	97.8
100	0.5254	93.4

**Table III**  
Bi-layer, Lead-free vinyl sheet, 0.500mm\* nominal Lead equivalent

kV	Equivalent Lead thickness mm	Attenuation %
80	0.5496	97.7
100	0.5230	92.9

\*two 0.25mm layers together

Attenuation = 1 - attenuated/un-attenuated x 100

**UNCERTAINTIES**

The uncertainty in the Lead equivalence 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%.

Reference: 2013060054-2  
Checked by: *[Signature]*

Page 2



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## TERMS

### Absorbed Dose:

All X-Ray procedures expose people to a quantity of radiation. Absorbed dose describes the measure of ionizing radiation that remains in the body or organs.

A 0.25mm LE Apron allows approximately 10% penetration of source radiation (90% attenuation).

At 0.5mm LE this becomes 2% (98% attenuation). The difference is five times - or 500%.

KIARMOR's ultra-lightweight, Lead-free composition lets medical personnel work longer, with the highest level of protection at a fraction of the weight.

### Bi-Layer Technology:

KIARMOR's unique design and production methodology creates a Bi-Layer material tested by KI GLOBAL in partnership with world-leading health, science and technology partners.

Kiarmor is made from one homogeneous layer of two distinct, Lead-free materials and is certified by the National Physical Laboratory (NPL) for use by interventional radiologists, cardiologists and healthcare professionals working with radiation in hospitals worldwide.