EVALUATION OF LEAD EQUIVALENT IN LEAD-FREE MATERIALS

Ieva Masiulytė, dr. Marius Laurikaitis

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Personal protection

Most popular material used for protection from scattered radiation for personnel is lead.

Lead has high radiation absorption rate, but also it is toxic and heavy metal.

Because of that all werable protection is heavy and can cause back traumas and other disorders.

Lead-free materials

Instead of lead we can use others high atomic number metals like tungsten, bismuth, tin, antimony, copper, polymers.

Advantages: aprons are lighweighter and more comfortable for wearer, and reduces chance to get traumas.

Disadvantages: these materials absorbes incoming radiation more than lead and therefore attenuate less radiations.

Problem and aim of the work

Problem: lead-free protections not always fullfil requirements, and not meet lead equivalence which is stated by manufacturers.

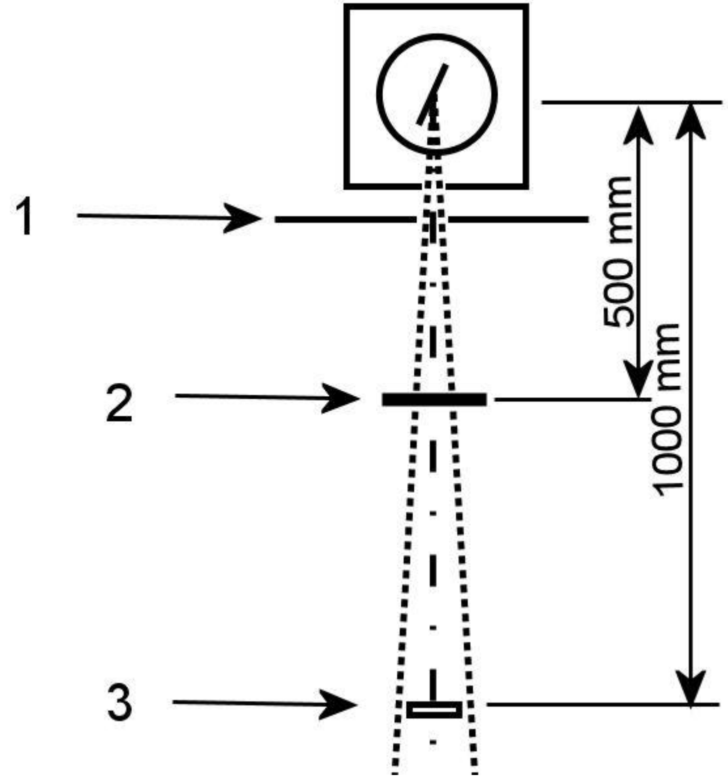
The aim of this work: to measure attenuation properties and determine lead equivalent for non-leaded materials, which are used for radiation protection.

Materials and Methods (1)

- X-ray machine Siemens MULTIX PRO.
- Fluoro Unfors Multi-O-Meter with external dose probe.

We used narrow beam geometry (MBG) as measurement method.

Experiments were performed using 81 kVp energy beam (HVL = 4,0 mm Al).



Experimental setup:
1 – beam limiting device;
2 – sample;
3 – detector.

Materials and Methods (2)

We calculated attenuation after measuring exposure with sample and without, using formula below.

$$Attenuation(percent) = \left(1 - \frac{expose\ with\ sample}{expose\ without\ sample}\right) x100$$

First we measured attenuation of pure lead foils (99,9%) and draw curve. Then from it we determined lead equivalent of lead-free materials and compared it with lead equivalent values stated by manufacturers.

Lead foils (thickness of each 0.1 mm)

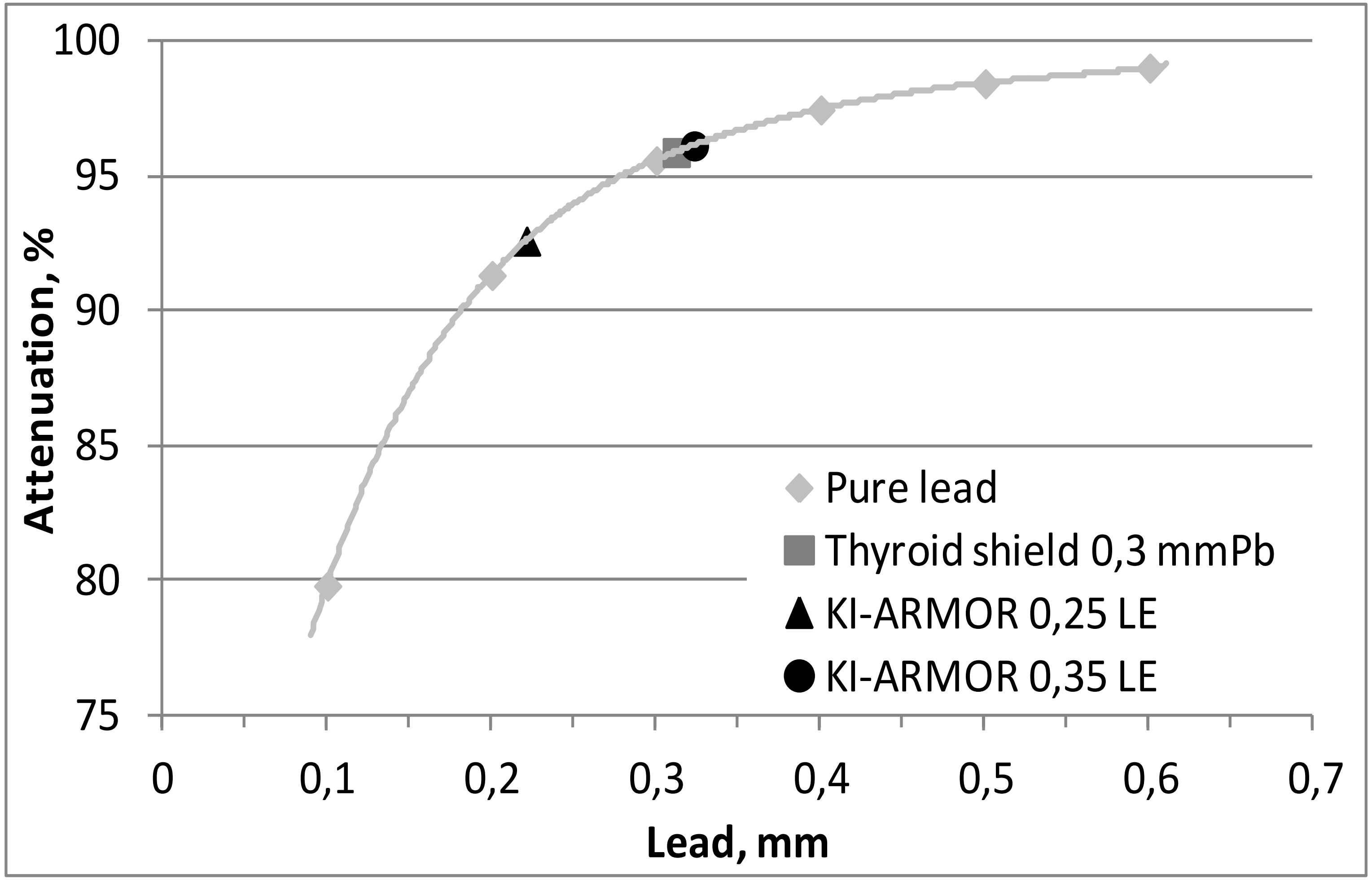
Materials and Methods (3)

As lead-free materials we used two KI-ARMOR Bi-Layer materials (0.25 mm LE and 0.35 mmLE). They are made from antimony and bismuth. While regular lead apron can weight up to 7 kg, aprons made from this material weights 1.8 kg (0.25 mmLE), and 2.3 kg (0.35 mmLE).

For comparison we used Leaded Thyroid Shield (0.3 mmPb). Weight of this is 0.3 kg. The apron of this material weights 2.5 kg.

Results (1)

Using curve of lead attenuation (when beam energy was 81 kVp) we can find lead equivalent of our samples.



Results (2)

The leaded material (thyroid shield) – determined lead thickness is 4 % higher than declared value.

KI-ARMOR 1 determined lead equivalence is 11.6 % lower than stated.

KI-ARMOR 2 determined lead equivalence is 7.7 % lower than stated.

Sample	Manufacturer stated lead equivalence, mm	Determined lead equivalence, mm
Thyroid shield	0.30	0.31
KI-ARMOR 1	0.25	0.22
KI-ARMOR 2	0.35	0.32

Conclusions

KI-ARMOR lead-free materials shows lower lead equivalence comparing with manufacture stated values due to the fact that it is measured in primary beam experimental setup. For this reason another methodology should be used.

Lead-free materials are designed to be used in scattered radiation. Because of that these materials should not be used to protect from primary X-ray beams and should not be used for patient‘s protection.

Thank you for your attention

References

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