Comparison of Lead-free and Conventional x-ray aprons for Diagnostic Radiology

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Introduction

- Lead is considered to be the most suitable material for protection against x-ray exposure due to its high mass attenuation coefficient for a wide energy range.
- It is the only element that has been used for the production of x-ray aprons worn by Radiation Personnel.

Introduction -2

There is need for alternatives to lead x-ray aprons as:

1. The weight of lead aprons often causes discomfort and fatigue during prolonged examinations.

2. They are associated with cervical/lumbar spine and other neurological health problems.

3. Lead is considered a hazardous material.

Introduction -3

- Lightweight environmentally friendly composite materials have been in the production of the so called “lead-free” aprons.
- Tin (Sn50), antimony (Sb51), or tungsten (W74) are some of the materials used.
- The evaluation of the protective effects of lead-free materials are stated at a single value of the tube voltage and not for the complete diagnostic energy range.

Introduction -4

The Medical Physics Department of Nicosia General Hospital carried out a study to evaluate whether lead-free aprons are as effective as conventional lead aprons.

Materials and Methods

- Lead aprons of 0.5/0.25 mm thickness and lead-free aprons with the same lead equivalence were compared.
- A series of transmission measurements over the diagnostic energy range (60-120 kVp) were performed on each apron.

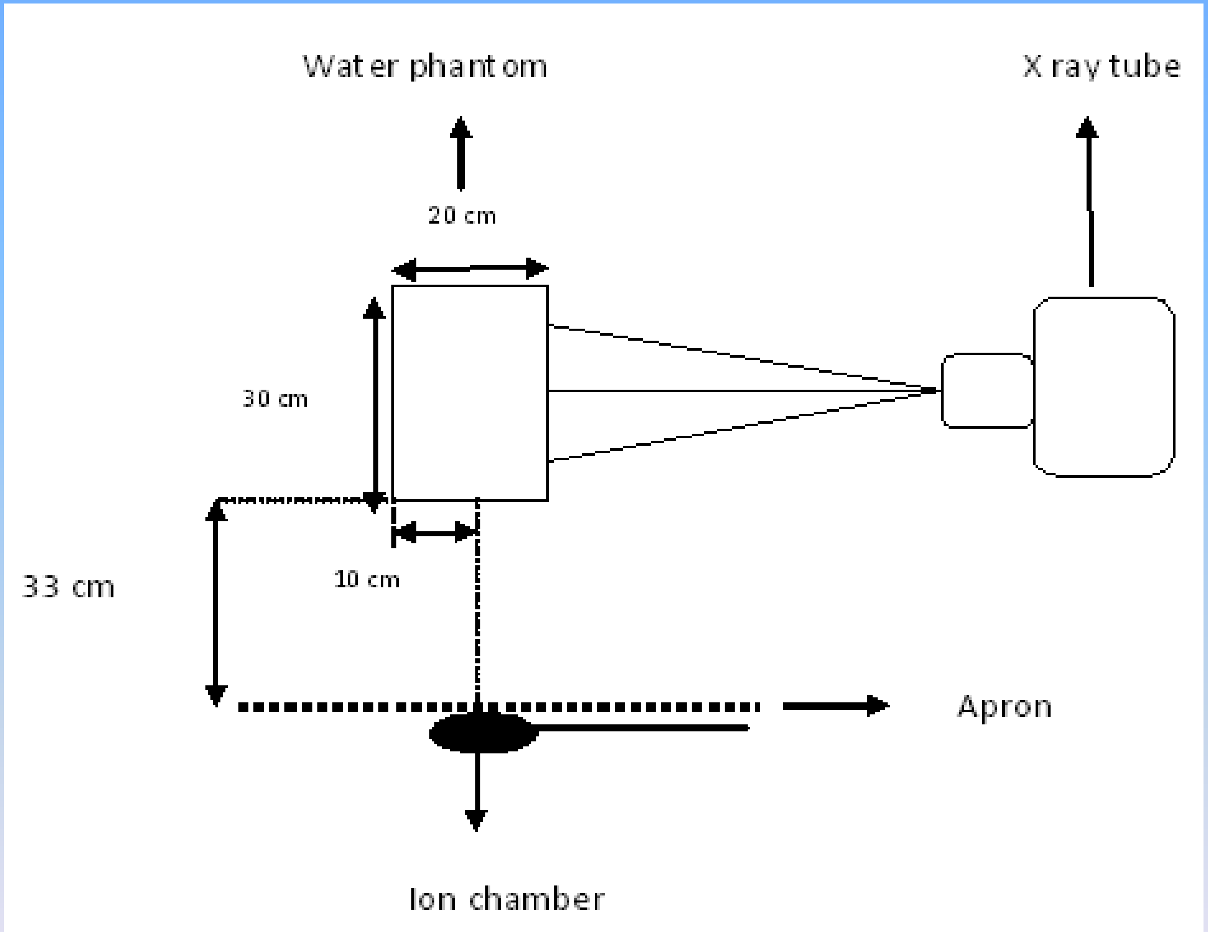
Materials and Methods -2

- Broad beam geometry instead of narrow beam was used to include the contribution of secondary radiation (scattered and fluorescent).
- Lead-free materials with atomic numbers below 60 generate significant amount of fluorescent radiation.

Materials and Methods -3

- A fluoroscopic x-ray system (Model Mecall Superix 180N).
- A 30x30x20 cm water phantom was used to simulate an overweight patient and a field size of 30x30 cm.
- Exposure measurements were recorded with a calibrated Radcal 2026C electrometer plus 180cc ionization chamber.
- The effective attenuation of both conventional lead and lead-free aprons was calculated across the diagnostic energy range.

Materials and Methods -4
Experiment Set-Up:



Results

Attenuation at different beam qualities for scattered x-rays

Apron Brand	Attenuation (%)				Average Attenuation (%)
kVp	60	80	100	120	
HVL (mmAl)	2.5	3	4	5	
Lead-free 1	99.3	98.0	96.3	94.7	97.1
Lead-free 2	99.3	98.1	96.5	94.8	97.2
Lead-free 3	99.5	98.7	97.3	95.7	97.8
Lead-free 4	99.4	98.4	97.0	95.4	97.6
Lead-free 5	95.3	89.6	84.2	79.6	87.2
Conventional	100	99.2	97.8	96.4	98.4

Results -2

Average attenuation over weight for lead-free aprons

Apron Brand	Average Attenuation (%)/weight (kg)
Lead-free 1	22.1
Lead-free 2	22.1
Lead-free 3	25.1
Lead-free 4	24.4
Lead-free 5	21.8

Conclusions

1. None of the lead-free aprons provide lead equivalency (LE) of 0.5mm as stated by their manufacturers.
2. Lead -free aprons with the same weight, exhibit different levels of attenuation at the same beam quality.

   - The attenuation effect of each constituent material varies significantly with energy.

   - It is impossible for the manufacturers to state lead equivalency across the entire diagnostic energy range.
3. Materials with high atomic numbers and low densities provide the best attenuation.

Conclusions -2

Concluding the study showed that the **Acceptance testing of lead-free aprons** is essential to ensure that they meet their manufacturer's specifications as well as the necessity for the establishment of **acceptable tolerance levels at different diagnostic energies.**