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A Study of Shielding and Comfort Performance for Selected Fabrics Used as Casing Material for X-Ray Protective Aprons ⋆

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Abstract

Lead aprons are typically worn by radiographers to protect them from harmful radiation. As such, a good radiation shield must have a high Lead Equivalence to minimize the transmitted radiation dose during exposure. While most radiation shields fulfil this requirement by using matrices of lead and other substances, most aprons are uncomfortable to wear. Further, if the examination takes longer than expected, the radiographer will feel discomfort because of the heavy weight of the apron, or the smooth surface of the coated casing material. Another issue is the poor fit and design of the aprons due to the stiffness of the lead sheet. In general, the comfort characteristics of any textile material are related to air permeability, moisture management, abrasion resistance, fabric structure, thickness and weight, as well as yarn types. The objective of this study is to use standard testing methods to characterize some selected fabrics in terms of their X-ray shielding ability, physical, mechanical, and morphologic properties. The implication of this research will help for further study of this type of fabrics to improve thermal comfort of X-ray protective clothing.

Keywords: Lead Apron; X-Ray Shielding; Moisture Management; Fabric Comfort; Air Permeability; Abrasion Resistance

1 Introduction

Ionizing radiation has two main uses in human: to kill cancerous cells and to diagnose disease or injury [1]. X-ray is the most common form of radiation used in medical diagnosis. The radiation is passed from a source, through a specific part of the patient's body to generate images (radiography). During such procedures, the resulting ions affect normal biological processes and ecological balance [2]. To prevent unnecessary exposure to the radiologist and the patient, various protection measures have been standardized and are continually being improved [1].

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Radiation shielding is categorized into biological and thermal shielding. Biological shielding is designed to reduce radiation to a safe and acceptable level for living organisms. The danger of exposure is further classified into external and internal categories [3]. External radiation emanates from an outside source and can only be reduced by providing a safe distance, a protective shield, and a time limit to the exposure. Internal radiation is a medical and hygiene problem and does not involve any external shielding.

Lead aprons are the most common type of personal shielding in radiology departments and the medical imaging industry, in general. Lead is an ideal material for radiation protection, but it compromises the comfort of the wearer [4]. The issue of comfort becomes even more important if the lead apron is worn for a long time. According to Van et al. [5], the most common comfort issue when selecting a lead apron is the weight of the apparel. Lead is a heavy metal, making a lead apron very heavy. Long-hour use of heavy aprons and apparel, especially in a catheterization laboratory or surgeries, can lead to discomfort, back pain, and the risk of permanent back problems. Modern technology has produced ultra-lite and light-weight aprons, but most are still heavy, and weigh about 3.8 kg [6].

Radiation shields are meant to be worn during radiological diagnostic/interventional procedures and/or oncological treatments. The shields are worn by clinicians, patients and physicians to selectively shield, isolate and protect parts of their body from radiation. The shields are reusable, meaning same shields may be used many times by different care providers and patients. For this reason, earlier shields were not finished to facilitate easy cleaning after use. These unsanitary shields may pose health risks to a person when they are used to cover parts of the body, especially the gonadal region. Adopting the hygienic use of the shields is one of the methods of tackling the problem [7, 8]. Hence, an apron casing is used for ease of cleaning.

Clothing insulation has a significant impact on thermal comfort, because it influences the heat loss and consequently the thermal balance. More layers of insulating clothing can avoid heat loss and help either keep an individual warm or lead to overheating. Medical protective clothing made of different materials should not induce any thermal discomfort. Such an uncomfortable sensation experienced by surgeons can decrease their psychomotor skills, and at the same time adversely influence the way an operation is carried out [9]. In this context, if a radiologist attempts to do examinations for more than 60 minutes, thermal discomfort becomes an issue and could negatively affect their performance, even though they usually perform procedures in an air-conditioned room. The heavy weight of the aprons and layers of clothing underneath, as well as the type of activities undertaken, all have an impact on the thermal comfort sensation.

It is generally agreed that thermal resistance, water-vapour resistance, moisture transfer, air permeability and surface friction are the most important parameters when choosing an apron [10, 11]. There are also other factors like size, fit and mobility of the wearer [12]. It is essential to consider these parameters when designing protective clothing. The attributes of an individual, the clothing and the environment influence comfort. Good personal apparel protection should be highly breathable. Breathability is the ability of a material to allow for the transmission of moisture vapour, or air, through it. The driving force of the moisture vapour is the level of humidity and heat on either side of the fabric, an attribute referred to as differential pressure. In the context of lead aprons, comfort without reducing the protectiveness of the material is critical [13].

This research investigates the comfort performance of a specific range of textile fabrics that could be used as alternative casing aprons. In ascertaining comfort elements in the current