Original Article

Comparative Evaluation of Spectral Transmittance of Some Welding Glasses with ANSI Z87.1

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Abstract

Background: Welding emits harmful rays to the eyes. We evaluate and compare the UV, blue light and IR transmittance characteristics of some currently available welding safety protectors with ANSI Z87.1 criteria.
Materials and Methods: Three type of welding safety protectors (three of each type) have been evaluated for spectral transmittance. One-sample T-test was performed to establish is there a statistically significant difference between the standard criteria and UV, blue and IR regions for the welding protectors (α=0.05).
Results: In ultraviolet (UV) (far and near) region, two types of the tested protectors (P1, P2) transmitted lower than the maximum allowable value specified in the standard ($P<0.001$). In infrared (IR) spectrum only one type (P3) transmitted lower than the maximum allowable value specified in the standard ($P<0.001$). In blue light region, all of the tested protectors transmitted lower than the maximum allowable value specified in the standard ($P<0.001$).
Conclusion: Although all of the tested glasses could meet some parts of the criteria, but none of them could meet the complete spectral transmittance requirements of ANSI Z87.1.
Keywords: Welding, ANSI Z87.1, Welding glasses

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Introduction

Welding is a hazardous process that is widely used in industries[1-3]. It is the most effective means of permanently joining metals[4]. There are approximately 60 different forms of welding, but some of them are commonly used. All produce ultraviolet (UV), visible and infrared (IR) radiation at damaging levels[5]. Previous studies indicated exposure to UV radiation (electromagnetic radiation with a wavelength shorter than 400 nm) has been linked to a spectrum of skin and eye diseases[6-9]. It should be noted, the eye does not develop a tolerance to UV exposure as does the skin but becomes more sensitive with repeating exposures[10].

IR radiation (electromagnetic radiation with a wavelength longer than 780 nm) is also responsible for several eye damages[11]. IR when combined with UV radiation and blue light can adversely affect the crystalline lens and lead to “glassblower’s” or “furnace men’s” cataract[9].

The effects of visible radiation (electromagnetic radiation with a wavelength between 400 nm and 780 nm) on the eyes are of most concern for persons who are welding[12]. It has been shown that eyes to be 800 times more susceptible to damage from the blue end of the visible spectrum than from the near IR[9]. It may cause a photochemical injury to the retina, called photoretinitis or blue-light hazard[13]. Photokeratocunjuctivitis (welder's flash), Pingueculum, Pterygium, corneal opacity, and pigmentary macular deposits are the common eyes disorders among welders[2,14,15].

Use of protective eyewear while welding helps to reduce harmful effects of ultraviolet, visible, and infrared radiation[4]. According to occupational safety and health administration (OSHA), for protection from radiant energy, workers must use personal protective equipment, such as safety glasses. The equipment must have filter lenses with a shade number that provides the appropriate level of protection. A shade number (ranged: 1.3-14) indicates the intensity of light radiation that is allowed to pass through a filter lens to one's eyes. Therefore, higher the shade number, darker the filter, and less light radiation that will pass through the lens[16]. There are several standards in the field of eye protection against welding harmful rays; one of the transmittance requirements for the filters used for welding eye protection is ANSI Z87.1 which is provided by American National Standards Institute[12]. The standard specifies allowable transmission values of the harmful rays through welding protectors.

Spectral transmittance requirements of ANSI Z87.1 state maximum far UV average transmittance for welding filters with shade number of 2.5, 5 and 10 are 0.1%, 0.02 % and 0.001%, respectively. In addition, the near UV average transmittance shall be less than one tenth of the minimum allowable luminous transmittance except for clear lenses. The blue light transmittance shall be less than the luminous transmittance except for clear lenses[17]. In IR region maximum far average transmittance for welding filters with shade number of 2.5, 5 and 10 are 12%, 2.5% and 0.6%, respectively.

With these facts in mind and because of lack of scientific research in this field, this study was designed to evaluate and compare the far and near UV, blue light and IR transmittance characteristics of some currently available welding safety protectors with ANSI Z87.1 criteria[17], this will help us to find which of them can protect eyes safely against the harmful rays during welding process.

Methods

Nine available welding safety (three types) protectors evaluated in this study, which with shade number 2.5, 5 and 10, respectively. The first and third were made from glass while second one was made of plastic. They were collected randomly from Iranian central market for industrial safety clothes and glasses. Specifications of the tested welding protectors are given in table1.

The thicknesses of the filters were evaluated with a digital magnetic caliper (Minitest FH 4100 Electrophysik, Germany). After that, we used a special Cecil spectrophotometer (Cecil instruments, United Kingdom) for the measurement of transmittance spectra. A filter holder was used to ensure that the filter remained in a stable state throughout the measurement process. Each filter was removed from the protectors, and then inserted into the measurement holder. This holder was then placed within the spectrophotometer.

Before conducting each test, the baseline transmittance of the reference (without a filter) was measured and recorded. The scan was performed at 0.5 nm intervals at a scan speed of 10nm/s for the spectra and optical bandwidth of 4nm. Spectral transmittance (near UV, far UV, blue light and IR) was measured three times for each of the filter.

This study was conducted in a laboratory - Ophthalmic Lenses Verification Center (O.L.V.C.R) of Shahid Baheshti University of Medical Sciences; that is a collaborating laboratory of National Standard Organization of Iran (INSO).

Using SPSS software, one-sample T test was performed to establish whether a statistically significant difference existed between the standard criteria and UV (far and near), blue light and IR spectra means for the welding glasses (α=0.05).

Results

Spectral transmittances of three welding protectors were evaluated. The results of ultraviolet (far and near), blue light and IR rays transmission for each of the glasses are summarized in table 2. Each entry on the table is the average of eighteen values (two lenses of each glass and three experiments with each lens). For better comparison we have provided a single

Table 1: Specifications of the welding glasses evaluated in this study.

Type of Protector	Name	Shade number	Material	Thickness (mm)
Glasses	P1	2.5	Glasses	1.42
Glasses	P2	5	Plastic	2.33
Glasses	P3	10	Glasses	2.60

transmission graph for all of the samples evaluated in this study (Figure 1).

For a general comparison, as shown in the table 1, P2 welding glasses showed the least transmittance of far UV (0.002%) and P1 had the highest transmittance (0.004%). P3 had value of transmittance (0.003%). P1 and P2 transmitted lower than the maximum allowable value mentioned in the standard, while P3 transmitted higher than the standard criteria ($P<0.001$).

In the near UV region, P2 welding glasses showed the least transmittance of near UV (0.003%) and P1 had the highest transmission (0.115%). P3 had transmittance value of (0.005%). P1 and P2 protectors transmitted lower than the maximum allowable value of standard in contrast, P3 had higher transmittance value in this region ($P<0.001$).

P1 had the highest transmission value (8.960%) of blue light, after that P2 and P3 had transmissions values of (0.020%) and (0.005%), respectively. All of the tested protectors transmitted lower than the maximum allowable value of the standard ($P<0.001$).

In the IR waveband region, P1 had the highest value (70.253%), while P3 had the least value (0.002%) and P2 showed the values transmittance of (12.107%), P3 transmitted lower than the maximum allowable value of the standard ($P<0.001$). P1 and P2 transmitted higher than the maximum allowable value of the standard ($P<0.001$).

Discussion

Our results show that there are different amounts of UV, blue and IR spectra transmitted by all the eye protectors, although some of them are very similar. All of the welding protectors showed an overall reduction in transmittance of the all waveband evaluated in this study. It seems that difference between materials used for manufacturing the filters of the protectors, is the main reason for different transmission of the spectra, In addition, other factors such as thickness of the filters may have a role.

Our result are in contrast to a study about spectral transmission of welding glasses[18], however they only evaluated UV transmission of several branded welding glasses. Therefore they couldn't judge which of the tested glasses passed the transmittance requirements of ANSI Z87.1.

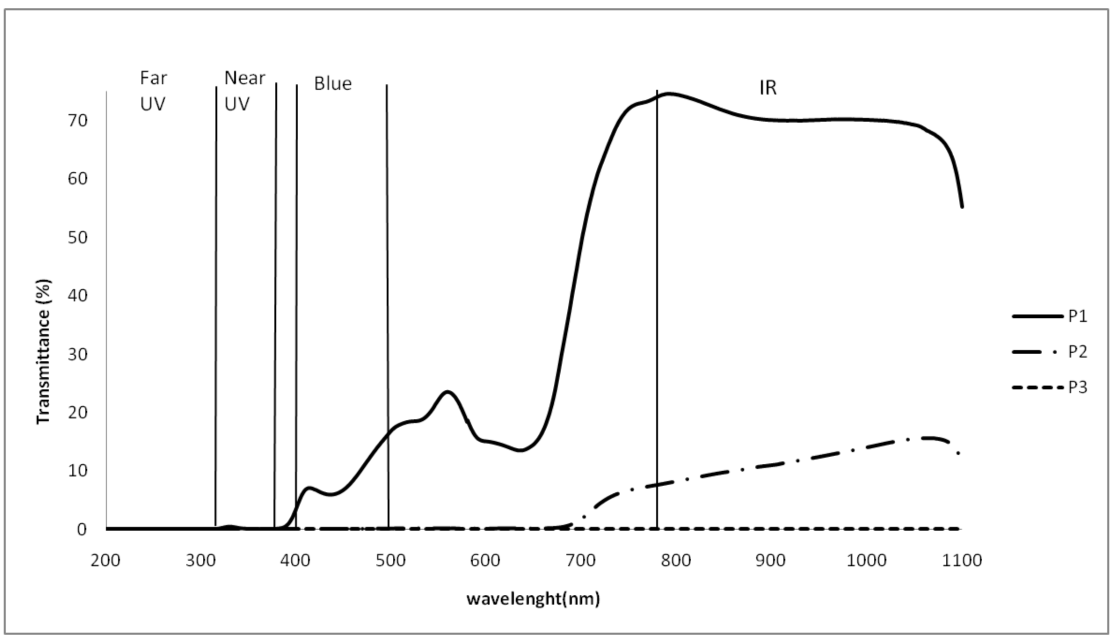

Figure 1. Spectral transmittance of the welding glasses tested in this study

Table 2: Spectral transmittance of the welding protectors evaluated in this study

Welding protectors	Far UV %	Near UV %	Blue light %	IR %
P1	0.004±0.00	0.115±0.13	8.960±3.58	70.253±2.79
P2	0.002±0.00	0.003±0.00	0.020±0.02	12.107±2.47
P3	0.003±0.00	0.005±0.00	0.005±0.00	0.002±0.00

1) Average±SD values of the measured wavebands are shown.
2) P= Protector

The results of this study is comparable with a similar study[19] in that 12 welding protectors were evaluated and one of them could pass the criteria while in this study none of the tested protectors could pass the spectral transmittance criteria, in addition they evaluated 4 kind of protectors from different countries but in this study samples were from Iranian productions. They used ANSI Z87.1 2003, but we used 2010 edition of the standard, although the editions are very similar, but in the latter some modifications are seen e.g. blue light transmission criteria.

The spectra of the evaluated protectors had a curved shape graph and it had several peaks at different points on the spectral transmittance of the samples.

Considering the requirements all the protectors tested in this study have good blocking properties for blue light spectra and they could pass the criteria, but in far and near UV, P1 and P2 and in IR region only P3 met the specified values. However, because of the instrument range, we were unable to test wavelengths longer than 1100nm of the protectors.

Conclusion

Finally, we concluded although all of the tested glasses could meet some parts of the criteria throughout the spectrum, but none of them could meet the complete spectral transmittance requirements of ANSI Z87.1.

Further studies on other kinds of eye protectors used in industrial activities are recommended; it can be helpful for users to find which product can provide better protection against the hazards.

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Conflict of interest

The authors have no financial interest in the products discussed in this article.

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