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MOBILE PROTECTIVE SCREEN FOR NONSTATIONARY WORKPLACES FOR MANUAL ARC WELDING

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Results of analysis of workers protection from ultraviolet radiation generated by welding arc are given. It is shown that intensity of ultraviolet radiation in coated electrode manual arc welding and mechanized gas-shielded welding can many times exceed the admissible norms at the distance of several tens of meters from the welding site. Thus, hazardous radiation can affect the support personnel who are in the area, and, usually, have no individual protection means, other workers, as well as random people who happened to be (pass by) at an unsafe distance from nonstationary workplaces for arc welding. Proceeding from the obtained results, a pilot sample of a mobile protective screen for nonstationary workplaces of welders has been developed and produced. Results of development and testing of the proposed mobile protective screen are given. 6 Ref., 1 Table, 7 Figures.

Keywords: *arc welding, ultraviolet radiation, nonstationary workplaces, mobile protective screen*

In keeping with safety requirements, the welder uses the following individual protection means (IPM) at application of all kinds of electric arc welding: the eyes are protected by a filter, which is selected taking into account the brightness and spectral composition of optical radiation (OR); helmet, overalls and goggles do not leave any exposed skin. Thus, OR harmful effect can be neglected, if the welder observes the safety requirements. However, both foreign [1–4] and our own research results [5] show that the levels of intensity of ultraviolet radiation (UVR) exceed the maximum permissible level (MPL) at the distance of several tens of meters from the welding site. Thus, hazardous radiation can affect support personnel who are in the area and, usually, have no individual protection means, other workers, as well as random people who happened to be (pass by) at unsafe distance from nonstationary workplaces for arc welding.

The most common nonstationary workplaces for manual arc welding, where work is performed in open air and near which unprotected people can happen to be, are as follows: construction, emergency and repair operation sites, large-sized metal structure fabrication yards and home welding areas. The problem of protection from light radiation of the welding arc is also highly urgent during performance of welding operations in ship-repair and ship-building shops, car building and repair, as well as machine shops, where a large number of welders and workers of other professions and engineering-technical personnel are employed simultaneously, who often cannot avoid exposure to this hazardous factor that may result in them developing vision diseases.

Thus, the considered problem has always been urgent, and up to now it did not have any specific solution in the case of welding in nonstationary workplaces. Therefore, based on analysis of published and own data, as well as considering numerous comments of the workers and welding operation supervisors, the authors of this work came to the conclusion that it is necessary to create special means for protection from optical radiation of workers of different professions, being at a relatively short distance (up to 65 m) [5] from the welding site.

The main processes of welding in such places are coated electrode electric arc welding and mechanized gas-shielded metal-arc welding. Modern welding equipment, which is used in such processes, is characterized by relatively compact size and high mobility that allows welding operations to be performed in sites (territories) not prepared for it. Unpredictable conditions of welding in such cases do not allow developing versatile measures of UVR protection.

Time protection cannot be used, as in keeping with acting normative document [6], irradiation of exposed skin is not permitted at all.

Distance protection is complicated by exceeding normative UVR values within the radius of tens of meters that under the conditions of nonstationary welding sites makes it impossible to observe a safe distance for support personnel and environment, for instance, in dense urban developments.

Lowering of UVR intensity in its generation source also has a low efficiency, because even with the most optimum welding parameters (selection of welding

Figure 1. Welding cabins

consumable type, mode, current, etc.), at which minimum UVR level is observed, its effective values still are much higher than the requirements specified in normative documents.

Lowering UVR intensity in its propagation path, i.e. shielding, remains the only effective method of protection.

Welding cabins (Figure 1) are used in stationary workplaces, the walls of which should be painted in light colours with addition of zinc oxide or titanium white to paint for UVR absorption.

Cabin height is 1.8–2.0 m, the walls should not touch the floor by 25 to 30 cm to improve cabin ventilation. Use of such cabins in nonstationary workplaces nullifies the speed and mobility of performance of single welding operations. As transportation and mounting a cumbersome cabin or its assembly in structure welding site takes a lot of time, the cost of welding operations rises, particularly, in case of emergency welding operations. Moreover, welding conditions can be incompatible with welding cabin dimensions or position.

In petrochemical industry welding tents (Figure 2) are widely used during performance of welding operations on pipelines.

Welding tents offer a number of advantages: they provide protection from unfavourable meteorological conditions (rain, snow, low temperatures), are resistant to wind gusts, unlike curtains or enclosures, and make effective UVR shield. However, welding tents also have a number of significant disadvantages:

● need for compulsory application of ventilation — in an almost closed space natural removal of welding fumes at their significant evolution becomes impossible. It is necessary to use supply-and-exhaust ventilation, which increases the time to prepare the workplace, makes additional requirements to power supply and increases the work cost;

● possible lack of natural light — the tent material cannot be totally transparent, as a green house effect is created, so that during daylight hours the tent should be lighted by an artificial light source;

● absence of versatility — during pipeline laying the tent encloses the pipe and can move along it to the next welding site. Thus, there is no need to spend time and resources on assembly-disassembly of the tent. Under other conditions such an advantage turns into a disadvantage that in combination with mounting of ventilation and lighting systems makes application of welding tents in nonstationary workplaces not cost effective.

Curtains or mobile welding screens are devoid of all the above disadvantages: they have relatively small weight, are convenient in transportation, and are easy to mount in any sites. Curtain posts can be additionally fitted with rollers for ease of movement over flat hard surface, and can be of sliding or hinged design that allows changing curtain height or profile. Used as the screen can be polished aluminium, which effectively absorbs UVR, or less expensive fireproof canvas. Polyvinylchloride (PVC) films have been developed recently, which have multiple advantages over traditional screen materials.

The objective of this work is a comprehensive study of requirements to mobile devices for UVR shielding and development of a mobile protective screen (MPS) on their base.

Conditions of welding in nonstationary workplaces are characterized by their unpredictability. Therefore, a number of factors should be taken into account in MPS development:

Figure 2. Welding tents

Figure 3. Hazard warming signs «Caution. Non-ionizing radiation» (*a*) and «Caution. Welding» (*b*)

Structure stability. Unevenness of the surface, on which MPS is placed, should be taken into account, as well as this surface hardness. During welding operations, which are performed outside, it is necessary to envisage resistance against wind gusts;

Height adjustment. In stationary welding stations the parts being welded are placed on work tables, and the welder is working while sitting that enables calculation of the height of enclosure and height of the space between the floor and screen lower edge. Under the conditions of nonstationary workplaces the parts can be on floor (ground) level or, contrarily, at a certain height. It is necessary to envisage such MPS position as to ensure free access of air at the bottom of the screen for ventilation, and, at the same time, effective UVR shielding;

Easy access to the workplace. In welding cabins the workplace can be accessible from one side through a door or canvas curtain. When mounting MPS it is necessary to envisage the possibility of free sliding of the screens both for outside access to surfaces to be welded from the required side, and for leaving the welding zone to the safe side after work completion;

Durability and wear resistance of the structure. MPS design should take into account a large number of assembly-disassembly cycles for transportation and displacement and it should be easy to clean from contamination. The screen should be fireproof and resistant to the impact of spatter and drops of molten metal;

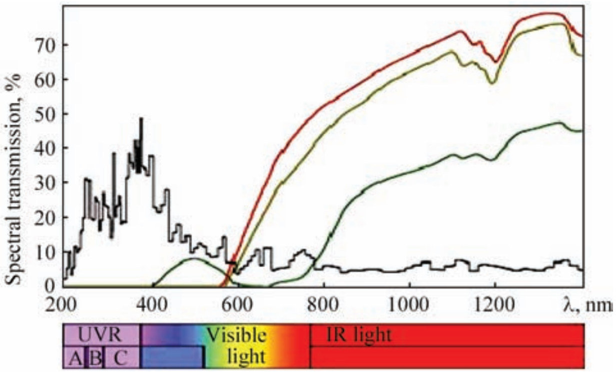

Figure 4. Dependence of screen material spectral transmission on wave length

Placing safety signs. MPS not only has a protective function, but also gives a warning about unsafe work performance and presence of hazardous factors. Therefore, it is recommended to place hazard warning signs according to DSTU ISO 17846:2013 (Figure 3).

Considering the features of working conditions during welding operations performance, and, primarily, the need for effective UVR shielding, it is proposed to use Screenflex PVC film as a protective screen. Screenflex protective film has the properties of ultraviolet/infrared radiation filter, which effectively filters welding arc radiation. This allows application of the material as a protective screen, in keeping with EN 1598. Characteristics of EN Screenflex film are given in the Table.

The above-mentioned characteristics lead to the conclusion that the film meets all the main requirements for protective screen material, namely:

- provides effective UVR shielding in keeping with EN 1598;
- transmits light in the visible range;
- has acoustic insulation properties;
- has dense, tear-resistant design that promotes long-term application;
- is fireproof and resistant to molten metal drops and sparks;
- does not conduct electric current;

Characteristics of ScreenFlex protective film

Parameter (properties)	Parameter value	Norm (Standard)	Description
Fire resistance	–	EN 1958	Standard classification of refractory properties and fire resistance of material
Light transmission,%	0.01–13	–	Quantity of visible light passing through the material
Sound insulation, dB	>35	DIN 52210	Averaged level of sound pressure (frequency of 0.1–3.2 kHz) that is reduced by a curtain of 1.76 m^2 area and 5 mm thickness
Thermal conductivity, W/(m·K)	0.16	ASTM C177	The smaller this value, the more insulating the material
Application temperature, °C	–15–50	EN 1876	Temperature range, in which material preserves its mechanical properties (flexibility)
Surface resistance, Ohm·cm	$4 \cdot 10^{13}$	IEC 60093	Electrical resistance of material surface, measured at 500 V voltage
Water absorption, %	–0.2	EN ISO 62	Change of material mass after staying under special conditions (evolution)
Density, g/cm^3	1.2–1.3	ASTMD 792	Mass per unit of volume

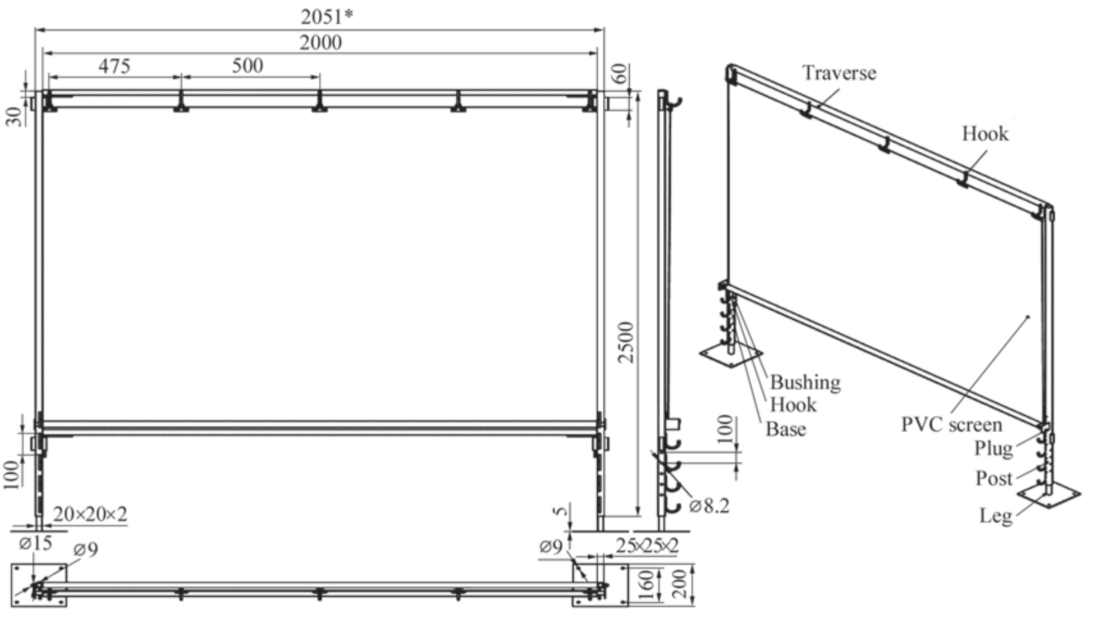

Figure 5. MPS assembly drawing

● does not absorb moisture and is easy to clean.

Note the combination of absolute opacity of screen material for UVR and light transmission in the visible range. Graphs of dependence of spectral transmission on wave length are shown in Figure 4.

It is recommended to use red-coloured PVC film as MPS material. Firstly, the red colour is a signal of possible hazard. Secondly, this is exactly the material that better transmits light in the visible range in its warm portion that allows safely observing performance of welding operations and monitoring compliance with safety requirements and progress of the process.

It is also important to note that the screen almost does not delay infrared radiation and, thus, greenhouse effect is eliminated that provides comfortable working conditions.

A pilot sample of the respective MPS was designed and manufactured, taking into account all the above requirements and recommendations (Figure 5).

The screen consists of two sliding posts, adjustable by height using bushings and traverse with hooks, to which the PVC screen, which is rolled around a metal rod, is fastened.

The post lower part has four hooks, that enables moving the coil with PVC screen by height from 0.1 to 0.4 m for ventilation, depending on the features of the welding site. Bushings enable reliable fixing of the coil rod to the hooks that gives additional rigidity to the entire structure.

Moreover, different legs can be fastened to the posts, if required. Leg fastening by «arrow» type enables placing several MPS at 90 degr. angle (Figure 6) that provides a tight enclosure of welding operations site.

Pilot sample of MPS (Figure 7) was manufactured and tested in June, 2016 in the plant of OJSC «Pivnichni-Ukrainiskij budivelnij alians». Welding of metal structures was performed by FroniusTransPocket 2500 welding unit in unprepared workplaces, using Monolith RTs 46 electrodes of 4 mm diameter during daylight hours in an open area at moderate wind. MPS

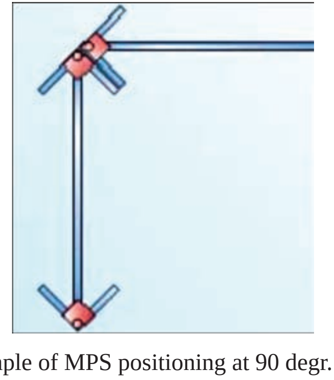

Figure 6. Example of MPS positioning at 90 degr. angle

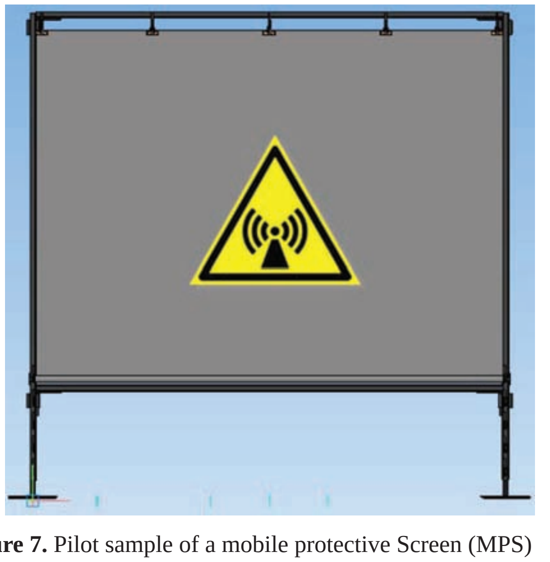

Figure 7. Pilot sample of a mobile protective Screen (MPS)

structure was placed on an uneven surface directly on the ground. MPS stability was ensured by driving four metal rods into the ground through holes in post bases. Handling operations were performed at 15 to 20 m from the welding site, and builders cabin, path for passage of people and site of concreting works were in the line-of-sight zone. MPS was located at 1.5 m distance from the welding site, so as to block direct visibility of the welding arc from all the places of possible stay of workers. Under these conditions of operation performance, application of one MPS was enough. It was noted that such MPS positioning does not interfere with welder's work, protects nearby workers from UVR adverse impact, warns about possible hazard of staying near the work performance site, and still enables monitoring the welding operations.

Testing in production premises allowed determination of the following advantages of MPS: compactness, easy mounting, convenience of movement, availability of adjustments for surface unevenness and ability of safe outside observation. Placing hazard signs on the surface of screen protective film can be also regarded as a positive new feature.

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