DEVELOPING REQUIREMENTS AND TEST METHODS FOR WELDERS' PROTECTIVE CLOTHING FROM THE USER'S VIEWPOINT

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INTRODUCTION

During welding, primarily the hands, arms and neck area, and secondarily the chest, thighs and entire front of the body are exposed to sparks and molten drops. Uncovered areas, namely the neck and hands and between the arms and gloves are also exposed to UV-radiation (1). EN 470-1 (2), gives general design requirements, general requirements and specific safety requirements for welders' protective clothing. Specific safety requirements concern flammability and protection against small molten metal drops. The test method for determining the behavior of materials on the impact of small splashes of molten metal is presented in EN 348 (3), published also as ISO 9150. This method measures the insulation of the material when drops weighing 0.50 g fall on the same point at a velocity of 20 drops per minute. The method has many variables that are difficult to adjust and calibrate. A method with better reproducibility is needed. The specifications set in EN 470-1 are more applicable to gas welding than to arc welding. Specifications for the protective clothing used in arc welding are missing.

The aims of this study were to do the following: (1) Compare how the specifications of standards meet the requirements that welders set on their protective clothing and to study the applicability of a new method for testing the impact of small molten drops, (2) Compare the properties of fabrics used in a normal welding environment with laboratory test results of new and laundered (5x) Ultra Violet radiation (UV) pre-treated fabrics and (3) Compare W transmission of fabrics.

MATERIALS AND METHODS

Garments made of fabrics tested in different laboratories against welding drops were given for field trial in a shipyard. The welders evaluated the properties of the garments by filling out a questionnaire on insulation against flying drops, the sticking of drops in the folds of the fabric, adherence of molten drops to the fabric, ignition of the fabrics and strength properties. The garments were checked after every washing cycle and samples were cut for laboratory measurements at the end of the trial. In addition, fabrics were pre-treated in the laboratory by washing them 5 times and pre-treating by W radiation before the material measurements.

1. Materials. The materials used in the comparisons are specified in Table 1.

Table 1. Description of the materials

Sample	Material	Thickness (mm)*	Weight ($g \cdot m^{-1}$)*	Air permeability ($l \cdot m^{-1} \cdot s^{-1}$)*
1	Pyrovatex™ 100% CO, satin	1.17	470	22
2	COPES, 2/2 twill	0.70	380	52
3	Proban™ 100% CO, satin	0.71	330	38

* after five washing cycles, CO = cotton, PES = polyester

2. Methods. The properties defined in EN 470-1 (Table 2) were measured for new fabrics (limited flame spread after 5 washings), fabrics washed 5 times and pre-treated with UV radiation, and used fabrics. As an alternative test for EN 348, the hot ball test was performed for fabrics washed 5 times. UV transmission was measured for fabric samples cut from the sleeves of the garments.

Table 2. Properties measured and test methods

Requirement		Test method
Tensile strength	≥ 300 N	ISO 5081
Tear strength	≥ 15N	ISO 4674, meth. A1
Limited flame spread	after flame time ≤ 2 s afterglow time ≤ 2 s	EN532
Impact of molten metal drops	at least 15 drops before the temperature rises over 40 K	EN 348
Hot ball test	alternative test for above test	under preparation

2.1. UV treatment. The 5-times washed samples were exposed to UV radiation produced by a fused silica envelope, high-pressure xenon lamp (450 W). The lamp produced UV radiation with an appreciable amount of Ultra Violet C-type (UVC) radiation and therefore simulates the UVC radiation in normal welding processes. The distance from the lamp to the sample was 300 mm, and the exposure time was 50 h.

2.2. Hot ball test. A steel ball having a temperature of 750 ± 20°C and weighing 0.37 g with a diameter of 4.5 mm was dropped on the sample lying on a horizontal sensor support block and tightened with counterweights of 175 g at both ends. The distance of the free ball was 86 mm. The ball was heated inside a steel cone (to prevent cooling of the ball) in an oven. The steel ball was guided through a funnel onto the sample from the cone. The time for the temperature rise (T = 40K) was measured.

2.3 UV transmittance. The transmission measurements were made using a Deuterium lamp and a double monochromator equipped with a photomultiplier tube (PMT) detector. The samples were placed between the lamp and the double monochromator. The measurement range was 200 to 410 nm in steps of 5 nm, and the measurement area was a circle with a diameter of about 25 mm.

RESULTS

1. Flame spread. The requirement of EN 470-1 was fulfilled after laboratory tests for new, washed and W-treated, and used fabrics. In one sample of Fabric 1, loose threads around a hole were ignited in the flame spread test, but they extinguished spontaneously.

2. Protection against welding sparks and molten **drops.** The results of the hot ball test method correlated well with the results of the EN 348 method, and also with the welders' experiences of the fabrics in normal use.

3. Strength (Tensile and tear strength). Both strength properties greatly exceeded the limit values of EN 470-1 when new fabrics were tested. The mean value of tensile strength was 1080 N for Fabric 1,796 N for Fabric 2 and 1068 N for Fabric 3. The mean value of tear strength was 89 N for Fabric 1, 39 N for Fabric 2 and 69.5 N for Fabric 3. Washing and W treatment decreased the tensile strength by 3 to 18% and tear strength by 16 to 30%. After use, the lowest values in tensile strength were below the limit value for all materials, and the tear strength of Fabric 2 was below the limit value. After use and launderings, welders evaluated the strength of all fabrics to be between poor and moderate.

4. UV transmission. The highest W transmittance (0.0005 to 0.0015%) was measured for Fabric 2, which was the sparsest fabric with the highest air permeability. The holes in the fabric increased the transmission. The transmittance was almost zero for Fabrics 1 and 3, and they even had small holes.

DISCUSSION

The welders reported the insulation against hot welding drops to be moderate or better than moderate. In laboratory measurements the protection time against hot drops was 5.7 to 13 seconds. The limit value of 5.5 to 6 seconds may be sufficient for the hot ball test with given parameters. The welders also reported sticking of the drops in the folds. The test methods were not able to simulate this phenomenon.

In an earlier study, Schliiter et al. (4) in Germany found that the fabrics of the garments normally used by welders did not transmit W radiation and therefore no requirement is needed. Our tests indicate that fabrics transmit W radiation differently when clear holes are present. Inspection in bright light does not necessarily reveal UV transmission. The fraying of fabrics around holes may increase the W protection. More knowledge about W transmission is needed.

The limit values for strength properties are very low. W pre-treatment was more effective for tear strength than for tensile strength. In an earlier study, Schlüter et al. (4) found no differences in strength values, but they didn't wash the fabrics.

CONCLUSIONS

The results of the hot ball test were promising in describing the insulation against hot drops. Additional parallel measurements with different types of fabrics and in different laboratories are needed to define the details of the method. The limit values for strength properties should be raised.

REFERENCES

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