PROTECTIVE CLOTHING IN TRANSPORT OF LIQUID CHEMICALS

H. Meinander and H. Laamanen
VTT Chemical Technology, P.O. Box 1402, FIN-33101 Tampere, Finland

INTRODUCTION

Drivers of tank lorries for transport of liquid chemicals participate in the filling and draining operations, and they are transiently exposed to splashes of the chemicals. For that part of their work they need protective clothing with some degree of barrier properties, whereas most of the time when they are only exposed to the cabin or outdoor environment, normal clothing is sufficient. The variety of chemicals that are handled is large, and their health risk and penetration properties vary. **As** the exposure is temporary and in most cases local and relatively small, true chemical protective clothing is not considered to be necessary, except in very special cases, e.g. phenol. Generally reusable clothing is preferred over disposable clothing, and coated fabrics are avoided due to comfort problems.

The objective of this project is to develop protective clothing for drivers to match the requirements defined by the work and environmental conditions. Both the material properties and the garment design are considered, with a special emphasis on the chemical protective clothing worn in the filling and draining operations. The electrostatic properties are regarded as a safety factor when handling explosive liquids and are, in any case, a comfort factor. The constancy of the properties as a function of wear and care treatments is important.

MATERIALS AND METHODS

Test fabrics and chemicals

The fabrics for the material tests were received from the textile and clothing industry partners of the project. The fabrics are listed in table 1.

Tests were done on original fabrics as well as after different washing treatments. Both laboratory and commercial laundry treatments were performed, and the influence of rinsing agents, fluorocarbon aftertreabnent and different thermal after-treatments were studied.

For the penetration tests, 7 frequently transported chemicals were chosen to represent the total variety of about 200 items. The test chemicals were: sulphuric acid (approx. 95 %), lye (51 %), hydrochloric acid (31 %), methanol (100 %), white spirit (100 %), formic acid (100 %) and diesel petrol.

Table 1. Test materials, penetration indices P and repellency indices R for diesel; original and washed fabrics, warp direction

Sample no.	Fibre content, note	Original P	Original R	5 x washed, lab. P	5 x washed, lab. R
1	100 % PES	0	97,1	0	97,9
2	100 % PES	0,3	97,3	1,03	97,0
3	100 % PES	-0,4	97,7	0,04	97,6
4	100 % PES, microfibre	0,12	97,9	0,16	97,7
5	100 % PES	-0,16	97,6	0	97,5
6	100 % PA	0,04	97,4	-0,04	97,5
7	100 % PES	1,31	96,4	1,25	95
8	35 PA / 65 PVC, coated	0	95,9	0,04	95,7
9	55 PA / 45 PU, coated	0	96,9	0,20	97,6
10	75 PES / 25 PU, coated	-0,8	98,2	0	97,4
11	95 PES / 5 CF	22,1	49,5	-	-
12	100 % PES	0,75	96,7	-	-
13	65 CO / 35 PES	20,4	43,8	24,3*)	27,1*)
14	67 PES / 33 CO	26,5	37,4	34,8*)	2,3*)
15	60 CO / 40 PA	27,1	30,2	23,9*)	24,6*)
16	70 PES / 30 CO	18,6	50,4	25,8*)	34,4*)

*) 10 X washed, commericial laundry

Test of resistance to penetration of chemicals, EN 368 /1/

The test apparatus is shown in figure 1 and the principle is: A measured volume of the test liquid is applied in the form of a fine stream or jet onto the surface of the clothing material resting in an inclined gutter. Measurement of the respective proportions of the applied liquid which penetrate the specimen and are repelled by its surface indicate the potential of the material for use in the field of application.

The indices of penetration (P) and repellency (R) are calculated as

$$P = \frac{M_p \cdot 100}{M_t}$$

$$R = \frac{M_r \cdot 100}{M_t}$$

where M_p is the mass of test liquid deposited on the absorbent paper/film combination, M_t is the mass of test liquid discharged on the specimen, and M_r is the mass of test liquid collected in the beaker.

Test of electrostatic properties. surface resistivitv. EN 1149-1/2/

The specimen is placed on an insulating base plate and electrode assembly is rested on the specimen. A DC potential (normally 100 V) is applied to the electrode assembly and the resistance Rs of the fabric is measured in Ω. The specimens are conditioned for at least *24* hours and the test is performed in an atmosphere of (23 ± 1) °C and (25 ± 5) % RH.

Wear trials

Two materials with good chemical repellency were chosen for the wear trials and protective coveralls were produced in a design that considered both the subjective desires of the drivers and the protection requirements. 6 drivers used the coveralls during a winter-spring-summer period to get subjective feedback of the garments under different environmental and work conditions.

RESULTS

Penetration of chemicals

The penetration and repellency indices for diesel petrol of all tested fabrics **as** originally received and after repeated washings are presented in table 1. Generally the polyester fabrics (samples no. 1, 2, **3,** 4, 5, 7 and 12) have reasonably good repellency values. Polyamide (no. 6) is destroyed by some of the chemicals and therefore out of question for this purpose. The coated fabrics (no. 8, 9 and 10) all have good repellency, but are not accepted due to comfort reasons. The polyester fabric with a grid of carbon fibre yams (no. 11) has a relatively poor repellency, **as** have also the fabrics with a cellulose fibre content (no. 13, 14, 15 and 16). The influence of washing on the chemical penetration properties was very small.

Methanol showed the highest penetration index and the lowest repellency index of all test chemicals, as can be seen in table 2 which shows the R indices of sample 5 for all test chemicals. Generally the polyester fabrics have a reasonably good repellency to all chemicals both as originally received and after repeated washing. The flourocarbon finish is however essential to provide the chemical resistance.

Table 2. Sample no. 5, repellency indices R for the different chemicals

Chemical	Original	5 x lab. washed	No fluorocarbon finish	1 x washed, fluorocarbon	1 x washed rinsing agent
Sulphuric acid	98,6	98,6	92,9	97,4	97,8
Lye	99,7	99,8	97,1	98,7	98,9
Hydrochl.acid	94,7	98,3	43,6	98,4	98,6
Methanol	90,0	88,9	0,13	57,1	78,9
White spirit	98,0	98,1	15,4	95,6	94,9
Formic acid	93,7	94,1	21,0	93,0	91,5
Diesel petrol	97,6	97,5	42,9	98,1	98,2

Electrostatic properties

In order to be classified as an electrostatic dissipative fabric according to EN 1149-1/2/, the surface resistance shall be less than $5x10^{10}$ Ω. None of the tested fabrics reached this value either in the original or in the washed state. The **100 %** synthetic fabrics showed very high, in some cases extremely high, values whereas the coated and the cellulose fibre blend fabrics were on a lower level.

Table **3.** Surface resistance Rs of the fabrics, fabric front side

Sample no.	Original	5 x lab. washed
1	$3{,}0x10^{13}$	$5{,}8x10^{14}$ *)
2	$2{,}8x10^{11}$	$3{,}1x10^{13}$
3	$1{,}4x10^{14}$	$2{,}1x10^{14}$
4	$1{,}0x10^{15}$ *)	$5{,}5x10^{14}$ *)
5	$1{,}0x10^{16}$ *)	$1{,}1x10^{15}$ *)
6	$4{,}9x10^{14}$ *)	$6{,}1x10^{13}$ *)
7	$7{,}7x10^{13}$ *)	$7{,}1x10^{14}$ *)
8	$8{,}1x10^{10}$	$5{,}4x10^{10}$
9	$5{,}2x10^{12}$	$1{,}5x10^{12}$
10	$3{,}9x10^{12}$	$3{,}2x10^{12}$
11	$8{,}7x10^{10}$	-
12	-	-
13	$5{,}3x10^{11}$	$1{,}1x10^{11}$ 1)
14	$5{,}3x10^{10}$	$3{,}0x10^{11}$ 1)
15	$2{,}1x10^{11}$	$4{,}2x10^{10}$ 1)
16	$5{,}5x10^{11}$	$3{,}3x10^{11}$ 1)

*) **voltage 500 V**
1) **10 X washed, commercial** laundry

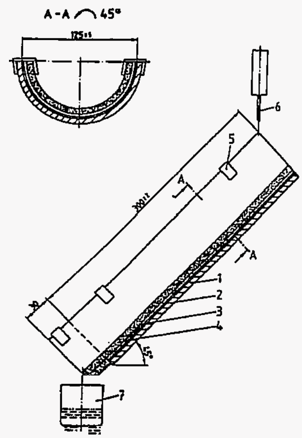

Figure **1.** Apparatus for testing chemical resistance of fabrics. 1=gutter, 2=protective film, 3=filter paper, 4=test specimen, 5=clips, 6=hypodermic needle, 7=weighing bottle

CONCLUSIONS

The fluorocarbon finish is essential to provide chemical resistance to the fabrics. If totally removed due to repeated washings (corresponding to the unfinished fabric in table 2), a resistance can be achieved by a fluorocarbon aftertreatment. Normal washing with or without rinsing agent does not have a notable influence on the resistance properties.

None of the tested fabrics combined a good chemical resistance with a low electrostatic resistance.

REFERENCES

1. **EN 368: 1992.** Protective clothing - Protection against liquid chemicals - Test method: Resistance of materials to penetration by liquids. Brussels: European Committee for Standardisation, **1992.** 8 p.
2. **EN 1149-1.** Protective clothing - Electrostatic properties - Part **1:** Surface receptivity (Test methods and requirements). Brussels: European Committee for Standardisation, **1995.** 10 p.