



DuPont Personal Protection
CLOTHING TO PROTECT
AGAINST INFECTION



The miracles of science™



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1. Introduction



In recent years there has been an increasing number of incidents involving biological agents and the spread of highly infectious diseases, as often reported in the media. Epizootic diseases, such as bird flu or BSE, can lead to substantial economic losses and even food supply shortfalls. With tourism and business trips, there is a risk that tropical, highly infectious diseases, such as lassa fever or ebola, will also be brought into Europe. Severe acute respiratory syndrome (SARS) remained in the headlines for weeks because the outbreak was difficult to control, despite the many efforts implemented. Governments have classified the risk of a biological terrorist attack as “serious”. Viruses and bacteria are mutating and becoming increasingly resistant to many medicines and disinfectants. The use of personal protective equipment is an essential measure for people responsible for care, treatment, transport, preventive measures and decontamination, not only for their own safety, but also for that of their environment. With regard to this, there are several priority aims:

- Effectively containing the infection outbreak,
- Preventing the infection spreading to infection-free areas,
- Avoiding contamination and infection amongst first aid and rescue workers,
- Observing health and safety requirements when using detergents and disinfectants,
- Choosing the right personal protective equipment for the application.

In this booklet, you will find useful information on the performance of our protective suits when handling biological agents.

2. Protection when handling biological agents

Whether in agriculture, the food industry, waste separation and recycling facilities, sewer systems or in the emergency services sectors, if workers come into contact with biological agents, safe and reliable protective clothing is essential to prevent infections and the spread of germs, for example.

What are biological agents?

A comprehensive definition can be found in EU directive 2000/54EC on biological substances. "Biological agents" refers primarily to micro-organisms such as bacteria, viruses and fungi. According to this directive, it also refers to biological materials, including those which have been genetically modified, as well as agents. What is important is that these substances can be pathogenic, sensitising or toxic.

What are the biological agent risk groups?

A distinction is made between four risk groups according to the risk of infection for humans. For each risk group there are containment measures, which in turn are divided into protection levels. More detailed information on this can be found in the aforementioned directive.

How do we come into contact with biological agents?

A wide variety of activities can bring you into contact with bacteria, viruses or fungi, for example:

1. The manufacture and use of biological agents (this includes, for example, isolation, production, propagation, use, processing, filling, transferring, mixing, supply and disposal).
2. Occupational contact with people, animals, plants, biological products, objects and materials (if this involves the release of biological agents and contact with them).

The EU directive 2000/54EC on Biological Substances distinguishes between "specific" and "non-specific" activities. Further details can be found in the Ordinance.

Where do biological agents occur and what diseases can they trigger?

Occupation	Biological agent	Disease
Sewage treatment	Clostridium tetani, hepatitis, leptospira interr., protozoa, nematodes	Tetanus, leptospirosis, hepatitis, worms
Documentation (archives, libraries, museums)	Mildew	Aspergillosis
Mining	Leptospira interrogans	Leptospirosis
Fishing	Leptospira interrogans	Leptospirosis
Meat processing	Prions, e. coli, salmonella, anthrax	CJD, UTI, enteritis, anthrax
Forestry	TBEV, borrelia burgd., rabies virus	TBEV, borreliosis, rabies
Gardening	Clostridium tetani	Tetanus
Health care	HBV virus, mycob. tuberculosis, bordet. pertussis, HIV	Hepatitis, tuberculosis, whooping cough, AIDS
Farming (crop, dairy, animal)	Leptospira interr., brucella spec., coxiella burnetti, mites	Leptospirosis, brucellosis, Q-fever, allergies
Leather industry	Bacillus anthracis	Anthrax
Waste disposal industry	Mildew, enterovirus, bacteria	Aspergillosis, Gastroenteritis
Cleaning industry	E. coli, salmonella	Urinary tract infections, enteritis
Bird rearing	Chlamydia psittaci, Cryptoc. neoformans	Ornithosis, cryptococcosis
Water management	Legionella	Legionnaires' disease

Source: Occupational Exposure Limit Values 2003 (BGIA Report 2/2003). Ed.: German Federation of Institutions for Statutory Accident Insurance and Prevention (HVBG), Sankt Augustin 2003

3. Protective clothing according to EN 14126:2003



According to the EU directive 2000/54EC on Biological Substances, employers are obliged to make suitable protective clothing available to their employees. What clothing provides protection against biological agents? **According to EN 14126**, in order to protect against bacteria, viruses and other micro-organisms, special requirements are defined for the clothing materials used to protect against infectious agents. These materials must protect the skin, and therefore the wearer, against possible contact with biological substances and prevent the spread of germs. Suits with overtaped seams are recommended, since viruses, bacteria and spores are

small enough to penetrate through the openings of sewn seams. Protective suits made of EN 14126 compliant materials can be identified by the biohazard pictogram. On the basis of the standard, the protective garment should be certified as category III chemical protective clothing. The clothing types to protect against biological agents are broken down as follows:

Protective clothing Types according to EN 14126:2003

Type	Description	Relevant standard
1aB, 1bB, 1cB, 2B	Gas-tight, non-gas-tight	EN 943-1, EN 943-2
3B	Protection against pressurised liquid chemicals	EN 14605
4B	Protection against liquid aerosols	EN 14605
5B	Protection against airborne solid particulate chemicals	pr EN ISO 13982-1
6B	Limited protection against liquid mist	pr EN 13034

EN 14126 comprises the following material tests:

- Penetration test using synthetic blood (ISO/FDIS 11603),
- Resistance to penetration by viruses (ISO/FDIS 16604),
- Resistance to penetration by bacteria (ISO/DIS 22610),
- Resistance to penetration by biologically contaminated aerosols (ISO/DIS 22611),
- Resistance to penetration by contaminated dust (ISO/DIS 22612).

Preliminary test according to ISO/FDIS 16603:

The synthetic blood used for this test is a mixture of cellulose, colouring, buffer solution and stabilising agents. Its red colour helps to identify the pressurisation at which the liquid penetrates through the material.

Table 1: Classification according to ISO/FDIS 16603 – Penetration by infected liquids, using synthetic blood. Pressurisation duration: 5 min

Class	Exposure pressure [kPa]
6	20
5	14
4	7
3	3,5
2	1,75
1	0

Virus test according to ISO/FDIS 16604:

The virus test and classification run along the same lines as ISO/FDIS 16603, the only difference being that liquid contaminated with a bacteriophage or virus (Phi-X-174) is used instead of synthetic blood.

Bacteria test according to ISO/DIS 22610:

This draft standard sets out the procedure for testing a material's resistance to wet bacterial penetration. The test method involves superimposing the bacterial-contaminated donor material onto the test material and subjecting it to mechanical rubbing. Table 2 shows six classes, as defined in the draft standard, with their corresponding breakthrough times, indicating the point at which the bacteria demonstrably penetrate the barrier material.

Table 2: Classification according to ISO/CD 22610 – Resistance to penetration by bacteria

Class	Bacterial penetration [min]
6	> 75
5	> 60
4	> 45
3	> 30
2	> 15
1	< 15

Aerosol test according to ISO/DIS 22611:

When testing the barrier effect against biologically contaminated aerosols, a bacterium solution (Staphylococcus Aureus) suspended in an aerosol is sprayed onto both an unprotected cellulose-nitrate membrane and one covered with the test material (the pore size of the membrane is approx. 0.45 µm). Both membranes are subsequently analysed to establish their bacterial load. In order to classify the results, the penetration ratio (ratio of the load of the unprotected cellulose-nitrate membrane to the load of the membrane protected with the test material) is calculated and given in log units (Table 3).

Table 3: Classification according to ISO/DIS 22611 – Resistance to penetration by biologically contaminated aerosols

Class	Penetration ratio without/with test material [log]
3	> 5
2	> 2
1	> 1

Note on the reading of these results: By means of an example, according to this classification, a Class 1 barrier material allows the penetration of up to 100 of the 1,000 bacteria on the surface sprayed with the aerosol (i.e. 10% of the bacteria). Class 2 materials of the same surface size allow 10 of the 1,000 through (1%) and material in the highest class (3) allow the penetration of just 1 of 100,000 bacteria (0.001%).

NB: This test has since been withdrawn (2007). We are continuing to cite these values as EN 14126:2003 has not been modified.

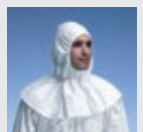
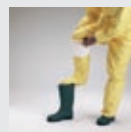
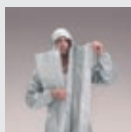
Dust test according to ISO/DIS 22612:

For the barrier test against contaminated dust, a pre-sterilised material specimen is fixed in the test apparatus and administered with contaminated (*Bacillus Subtilis*) talcum powder. An agar plate is placed underneath. During the test, this test assembly is shaken. The particles which penetrate the material are analysed after incubation of the agar plate, whereby a non-contaminated test specimen is run as a control. The results (mean values from 10 single results at a given time) are measured in penetration log units (Table 4).

Table 4: Classification according to ISO/DIS 22612 – Resistance to contaminated dust (CFU: colony forming units)

Class	Penetration ratio with/without test material [log]
3	≤ 1
2	≤ 2
1	≤ 3

NB: When looking at this classification it becomes apparent that, based on the comparatively small gauging surface used for the test, i.e. 20 x 20 cm², a suit material can allow an average of 9.99 CFU to penetrate and still achieve the highest class of protection, i.e. Class 3. Regarding the fineness of dust, this standard only stipulates that 95% of the contaminated talcum powder used must have particle sizes smaller than 15 µm. It does not lay down any specifications regarding the distribution of particle sizes.



4. Selecting protective apparel against biological agents, making sure particular risks are factored in

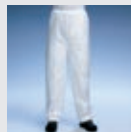
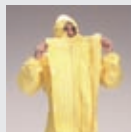
How should users select their protective apparel against infectious agents?

The current standards on chemical protection and bio barriers should of course be taken into consideration. The first thing to do when making a selection, however, is to carry out a risk assessment. By starting from the type of biohazard and assessing the transmission paths, it is possible to gain insight into the geometric dimensions of a particular biological substance. These extend from subviral particles to viruses with nanometre dimensions and parasites with micrometre dimensions and beyond. If the transmission path by which the majority of these particles are transported is the ambient air, their “aerodynamic diameter” must be given particular consideration (Table 5). The requirements regarding the particle tightness of protective suits etc. can then be deduced from this.

Table 5: Particle sizes in biologically contaminated aerosols according to [3]*

Particle	Aerodynamic diameter [μm]
Viruses	0,02 – 0,3
Bacteria	0,2 – 10
Bacterial spores	0,5 – 1,5
Fungal cells and filaments	10
Fungal spores	2 – 8
Moss spores	5 – 30
Fern spores	20 – 60
Pollen	5 – 250

Spunbonded nonwovens, microporous films and coated spunbonded nonwovens are often used to make protective suits. Coated spunbonded nonwovens are particle-tight and also provide excellent resistance to liquid contact under pressure. In most cases, spunbonded nonwovens and microporous films, on the other hand, only resist liquid contact when virtually no pressure is exerted, and as a general rule they are not 100% particle-tight either: spunbonded nonwovens and microporous films no longer act as a barrier to particles if the latter are smaller than approx. 1 μm in diameter. Therefore, for protection against particles which are smaller than a micrometre, a coated nonwoven or laminate film is recommended.



* [3] Linsel, Gunter: “Bioaerosole – Entstehung und biologische Wirkungen” (Biologically contaminated aerosols – Origin and biological effects), The German Federal Institute for Occupational Safety and Health – BAuA, Berlin, March 2001

5. Protective coveralls by DuPont Personal Protection

TYVEK® and TYCHEM® bio barriers: For safe protection against biological agents

In addition to the tests for chemical protective clothing, TYVEK® and TYCHEM® protective clothing materials by DuPont are tested using special procedures for determining the effectiveness of the barrier against infectious agents. Direct contact with bacteria, biologically contaminated liquid aerosols and solid particles is determined in this way and the bio barrier tested. Simply wearing protective clothing will not guarantee protection. The protective effect of the suits can only be ensured if the clothing is put on and taken off in the correct way and if correct working procedures are followed. For example, a suit being taken off incorrectly may result in the wearer becoming contaminated. DuPont Personal Protection can provide a training video on this subject entitled "Correct use of protective clothing". When selecting and using personal protective equipment, it is essential to make sure that the equipment, such as protective suits, gloves or breathing apparatus, is compatible. DuPont Personal Protection offers protective suits which cover all four risk groups as well as types 3 to 6.







DuPont recommended garments for protection against biological substances			
Garment model	Protection against biologically contaminated dust	Protection against biologically contaminated liquids	Risk groups
TYVEK®			<ul style="list-style-type: none"> <input checked="" type="checkbox"/> Risk groups 1, 2 <input checked="" type="checkbox"/> risk groups 1, 2, 3, 4
TYVEK® Classic Plus Model CHA5 (4B, 5B, 6B)	✓		1. Biological agents unlikely to cause sickness in humans.
TYVEK® Classic Plus with socks Model CHA6 (4B, 5B, 6B)	✓		2. Biological agent that could cause sickness in humans and represent a danger to employees; substance dispersal among the population is unlikely; effective preventive measures or treatment is normally possible.
TYCHEM®			3. Biological agent, that can cause severe illness in humans and represent a serious risk for employees; a risk of dispersal among the population may occur, but effective preventive measures or treatment are normally possible.
TYCHEM® C Standard Model CHA5 (3B, 4B, 5B, 6B)	✓	✓	4. Biological agent that causes severe illness in humans and represents a serious risk for employees; the risk of dispersal among the population is high under some circumstances; effective preventive measures or treatment are not normally possible.
TYCHEM® C Standard with socks Model CHA6 (3B, 4B, 5B, 6B)	✓	✓	
TYCHEM® C2 Model CHZ5 (3B, 4B, 5B, 6B)	✓	✓	
TYCHEM® F Standard Model CHA5 (3B, 4B, 5B, 6B)	✓	✓	
TYCHEM® F Standard with socks Model CHA6 (3B, 4B, 5B, 6B)	✓	✓	
TYCHEM® F2 Model CHZ5 (3B, 4B, 5B, 6B)	✓	✓	



Also available with integrated socks!
Thumb-loops are now a standard garment feature.

Chemical Protective Coveralls, Category III



					
Type 4	Type 5	Type 6	EN 14126 Type 4B	EN 1149-1	EN 1073-2

- ✓ Barrier against many inorganic chemicals in low concentrations and particles larger than 1µm
- ✓ Protection against particulate radioactive contamination
- ✓ Barrier against solid biological contaminated particles of risk groups 1 and 2
- ✓ Combines the reliable performance of a Type 4B with the comfort of a nonwoven suit
- ✓ Suitable for usage in Ex-Zones
- ✓ Contains no halogen compounds so can be disposed of without any further residues that harm the environment or health
- ✓ Garment design offers ease of movement to the wearer
- ✓ Suitable for usage in clean-room applications. Garment can be sterilized.



* DuPont pictograms.

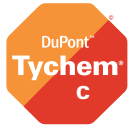
** The antistatic treatment is only effective when relative humidity is > 25%.

*** Gives no protection against radioactive radiation.

Classification according to EN 14126

Test	Test result	Classification according to EN 14126: 2003
Resistance to viruses		No classification
Resistance to bacteria	Breakthrough time t <15min	Class 1
Resistance to contaminated dust	Penetration log cfu 2.1	Class 1
Resistance to biologically contaminated aerosols	Penetration log ratio 2.6	Class 1

Coveralls made of TYCHEM® C



Also available with integrated socks!
Thumb-loops are now a standard garment feature.

Chemical Protective Coveralls, Category III



Type 3	Type 4	Type 5	Type 6	EN 14126 Type 3B	EN 1149-1: 1995	EN 1073-2

- ✓ Protection against numerous inorganic chemicals
- ✓ Resists liquid splashes up to 2 bar
- ✓ Particle-tight fabric
- ✓ Biological protection – meets the EN 14126 requirements in the highest performance class
- ✓ Protection against particulate radioactive contamination
- ✓ Particularly lightweight protection
- ✓ Suitable for usage in Ex-Zones
- ✓ For applications where decontamination is needed: the fabric is resistant to certain commonly used decontamination substances
- ✓ Contains no halogen compounds so can be disposed of without any further residues that harm the environment or health.



* DuPont pictograms.

** The antistatic treatment is only effective when relative humidity is > 25%.

*** Gives no protection against radioactive radiation.

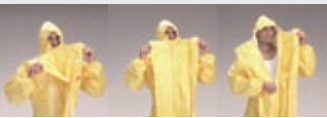
Classification according to EN 14126

Test
Resistance to viruses
Resistance to bacteria
Resistance to contaminated dust
Resistance to biologically contaminated aerosols

Coveralls made of TYCHEM® C2



Greater mechanical resistance combined with an innovative double-zip design



Chemical Protective Coveralls, Category III



Type 3	Type 4	Type 5	Type 6	EN14126 Type 3B	EN 1149-1: 1995	EN 1073-2

Equal barrier to TYCHEM® C with higher mechanical strength

- ✓ Protection against numerous inorganic chemicals
- ✓ Resists liquid splashes up to 2 bar
- ✓ Particle-tight fabric
- ✓ Biological protection – meets the EN 14126 requirements in the highest performance class
- ✓ Protection against particulate radioactive contamination
- ✓ Comfortable, textile-like touch of inside fabric thanks to the new multi-layer systems
- ✓ Lightweight – helps wearers to perform at their best
- ✓ Easy dressing and undressing helping to reduce the risk of cross contamination
- ✓ For applications where decontamination is needed: the fabric is resistant to certain commonly used decontamination substances
- ✓ Contains no halogen compounds so can be disposed of without any further residues that harm the environment or health.



* DuPont pictograms.

** The antistatic treatment is only effective when relative humidity is > 25%.

*** Gives no protection against radioactive radiation.

Test result	Classification according to EN 14126:
20 kPa	Class 6
Breakthrough time t >75min	Class 6
Penetration log cfu <1	Class 3
Penetration ratio log >5	Class 3

Coveralls and accessories made of TYCHEM® F



Also available with integrated socks!
Thumb-loops are now a standard garment feature.

Chemical Protective Coveralls, Category III



Type 3	Type 4	Type 5	Type 6	EN 14126 Type 3B	EN 1149-1: 1995	EN 1073-2

- ✓ Protection against numerous organic and highly concentrated inorganic chemicals
- ✓ Resists liquid splashes up to 5 bar
- ✓ Particle-tight clothing material
- ✓ Biological protection – meets the EN 14126 requirements in the highest performance class
- ✓ Protection against particulate radioactive contamination
- ✓ Suitable for use in Ex-Zones
- ✓ For applications where decontamination is needed: the fabric is resistant to commonly used decontamination substances
- ✓ Contains no halogen compounds so can be disposed of without any further residues that harm the environment or health.



* DuPont pictograms.

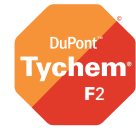
** The antistatic treatment is only effective when relative humidity is > 25%.

*** Gives no protection against radioactive radiation.

Classification according to EN 14126

Test
Resistance to viruses
Resistance to bacteria
Resistance to contaminated dust
Resistance to biologically contaminated aerosols

Coverall made of TYCHEM® F2



Greater mechanical resistance combined with an innovative double-zip design

Chemical Protective Coverall, Category III



Type 3	Type 4	Type 5	Type 6	EN 14126 Type 3B	EN 1149-1: 1995	EN 1073-2

Equal barrier to TYCHEM® F with higher mechanical strength

- ✓ Protection against numerous organic and highly concentrated inorganic chemicals
- ✓ Resists liquid splashes up to 5 bar
- ✓ Particle-tight clothing material
- ✓ Biological protection – meets the EN 14126 requirements in the highest performance class
- ✓ Protection against particulate radioactive contamination
- ✓ Higher level of protection through outstanding design features for demanding tasks
- ✓ Lightweight – helping wearers to perform at their best
- ✓ Easy dressing and undressing helping to reduce the risk of cross contamination
- ✓ For applications where decontamination is needed: the fabric is resistant to the commonly used decontamination substances
- ✓ Contains no halogen compounds so can be disposed of without any further residues that harm the environment or health.



* DuPont pictograms.

** The antistatic treatment is only effective when relative humidity is > 25%.

*** Gives no protection against radioactive radiation.

Test result	Classification according to EN 14126:
20 kPa	Class 6
Breakthrough time t >75min	Class 6
Penetration log cfu <1	Class 3
Penetration ratio log >5	Class 3

Disclaimer

This information is based upon technical data that DuPont believes to be reliable. It is subject to revision as additional knowledge and experience are gained. DuPont makes no guarantee of results and assumes no obligation or liability in connection with this information.

It is the user's responsibility to determine the level of toxicity and the proper personal protective equipment needed. This information is intended for information use by persons having technical skill for evaluation under their specific end-use conditions, at their own discretion and risk.

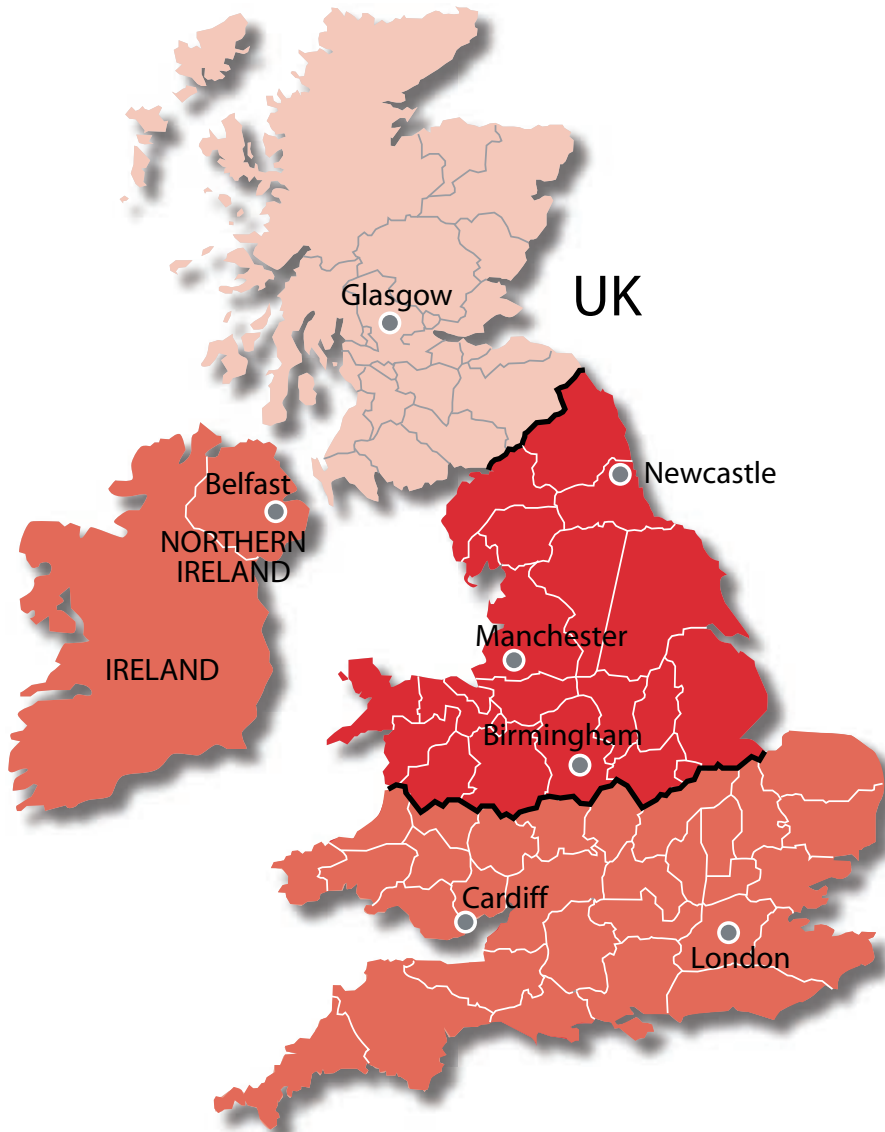
Anyone intending to use this information should first verify that the garment selected is suitable for the intended use. If the fabric becomes torn, abraded or punctured, end users should discontinue using the garment to avoid potential exposure to chemicals. Since conditions of use are outside our control, we can give no express or tacit guarantee, concerning, for example common commercial practice or suitability for a particular purpose, and accept no liability in connection with the use of this information.

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DuPont is there to help you



Neil Sutherland
Sales representative
Mobile: +44 7881 482 250
E-mail: Neil.Sutherland@gbr.dupont.com

Christine Gentle
Sales representative
Mobile: +44 7768 330 218
E-mail: Christine.Gentle@gbr.dupont.com

Ian Samson
Sales representative
Mobile: +44 7879 437 055
E-mail: Ian.D.Samson@gbr.dupont.com



DuPont Solutions for Personal Protection

DuPont Personal Protection

www.dpp-europe.com

Tel: +800 3666 6666

Fax: +352 3666 5071

E-mail: personal.protection@lux.dupont.com



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