



DuPont Personal Protection
TECHNICAL BULLETIN
NUCLEAR RISKS



The miracles of science™

Specific questions have arisen related to the recent disaster which has occurred in Japan. A question frequently asked relates to protection from nuclear hazards. This question can be divided into two main areas: ionizing radiation hazards, and radioactive particle or liquid hazards.

The guidance below is based on garments made for use in Europe.

Ionizing Radiation Hazards

The fabrics used in single use protective garments will not provide a barrier to ionizing radiation (e.g., gamma rays, X-rays, or radioactive particles - alpha or beta). The standard protocol used to reduce radiation exposure would include time, distance, and shielding. For garments, limited shielding may be provided by specialty garments that contain lead based materials. DuPont Personal Protection does not offer any specialty garments that provide protection from ionizing radiation hazards.

Radioactive Contaminated Particle or Liquid Hazards

For hazards associated with radioactive contaminated particles or liquids, rather than blocking the radiation itself, appropriate garments are designed to minimize the penetration of radioactive materials to minimize contact with the skin and clothing worn underneath. These garments are designed to be worn in a potentially affected area and then be promptly removed and disposed of, such that long-term exposure to the radioactive contaminated material is minimized after leaving the potentially affected area and to avoid contaminating other areas. Chemical protective garments are intended for single use so that a cross-contamination with radioactive particles can be minimized. In general, more body coverage is better: hooded coveralls should aid in keeping clothing and hair free of radioactive materials. DuPont Personal Protection does offer specially designed garments that provide protection from radioactive particles and liquids. Specific fabric types, seam configurations, and garment designs should be specified to match the hazard. In addition, other appropriate PPE, such as but not limited to respirators, goggles, gloves, and footwear, etc., as identified by the hazard assessment should be used in conjunction with any garment selection.



Donning, doffing, and disposal of radioactive contaminated garments should only be conducted by properly trained personnel.

Tyvek® Classic, Tyvek® Classic Plus, Tychem® C (Standard and C2) as well as Tychem® F (Standard and F2) are tested according EN 1073-2 as protective clothing against radioactive contamination.

Protective Clothing Against Radioactive Contamination & The EN 1073-2 Standard

The suit inward leakage test

The EN 1073-2 standard was developed with the nuclear industry in mind, but does not apply for the protection against ionizing radiation. The 1073-2 standard itself is very similar to the Chemical Protective Clothing Type 5 standard (EN ISO 13982-1). With respect to whole suit particle protection levels, both standards reference the testing protocol "*Protective clothing for use against solid particulates - test method of determination of inward leakage of aerosols of fine particles into suits*" (EN ISO 13982-2). This test essentially determines the barrier efficiency of the suit when challenged with sodium chloride particulates of a defined size distribution.

In the above whole suit inward leakage test, a person wearing the protective suit enters a "testing chamber". Beneath the protective suit, the person has three measuring probes attached (one on the chest, one at the waist and one at the knee). Sodium chloride particulates (average size of 0.6 microns) are distributed throughout the cabin, the wearer performs a series of three physical activities (see figure 1):

- 3 minutes standing still
- 3 minutes "on the spot" walking (5km/h)
- 3 minutes squatting (at a rate of 5 squats per minute)

Sodium chloride particulates that penetrate the protective suit are counted by the probes beneath the suit¹. The amount of sodium chloride detected by each probe (per suit per exercise type) is expressed as a percentage ratio vs. the concentration of the "external" challenge of particulates. The results are then used to determine both a **performance classification** and a "**nominal protection factor**", analogous to respiratory standards.

For EN 1073-2, when tested according to EN 13982-2, six suits are tested. The total inward leakage results (TIL) are reported, as a ratio (in %) of the test particle concentration inside the suit & the test chamber.

$$\text{Total Inward Leakage (TIL)} = \frac{\text{Concentration of test particles (inside suit)}}{\text{Concentration of test particles in the chamber}}$$

¹ 3 minutes per activity per probe.

Nominal Protection Factor & Performance Class (EN 1073-2 / EN 13982-2)

There are three types of performance class to describe the suit particle protection level

Class 1 = Lowest particle barrier

Class 3 = Highest particle barrier

- The Nominal Protection Factor is a slightly different way of expressing the above inward leakage ratios.

First of all, the Total Average Inward Leakage² is calculated (TIL_A).

$$\text{Nominal Protection Factor} = \frac{100}{\text{Total Average Inward Leakage}}$$

In other words, a suit which offers the **highest protection** to the fine particulates will have **LOW inward leakage**, and thus a **HIGH nominal protection factor**.

A suit which offers a low nominal protection factor, e.g. "5", means it had an average of 20% inward leakage.

- To determine the performance classification, the total average inward leakage value per activity (standing, walking and squatting) is calculated (TIL_E). This value and also the Nominal protection factor are both considered in order to determine which performance class is attributed to the suit. See **Table 1**.

Table 1

Class	Mean value of inward leakage at the three sampling positions inside the suit during exercise		Nominal protection factor*
	One activity (TIL_E) %	All activities (TIL_A) %	
3	0.3	0.2	500
2	3	2	50
1	30	20	5

* Nominal protection factor = $100 / TIL_A$.

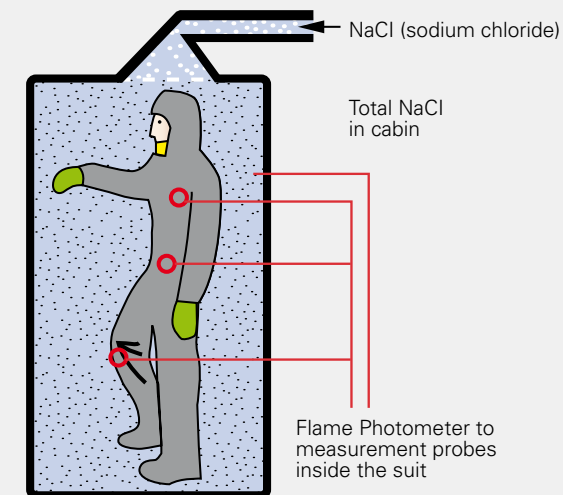
A performance class of 3, i.e. the "highest" performance class can be understood as: The highest value for the inward leakage³ measured for each of the three activities (TIL_E) is less than 0.3% and also the overall total average inward leakage (TIL_A) is less than 0.2 %.

² For all six suits, all the exercises and all 3 probes.

³ Average of the 3 probes and all suits per activity.

EN 1073-2 references the EN 13982-2 "Protective clothing for use against solid particulates - test method of determination of inward leakage of aerosols of fine particles into suits".

Fig. 1 - The suit inward leakage test



- Test particles: Sodium chloride (0.6 μm)
- Six suits tested
- Test conditions:
 - 3 min standing*
 - 3 min walking*
 - 3 min squatting*
 - 3 measurement probes: chest, waist and knee
- * Per measurement probe.
- Results in: % inward leakage
 - Highest % average leakage of the 3 activities (TIL_E)
 - Overall % average inward leakage (TIL_A)

$$\text{Nominal protection factor} = \frac{100}{(TIL_A)}$$

Dry Environment - Contamination of Radioactive Particles

For dry radioactive particle hazards, **hooded DuPont™ Tyvek® coveralls** are suggested for your consideration. In addition, whether or not over-taped seams are required would be dictated by the expected intensity of the exposure. Garments with over-taped seams offer a higher overall protection to particles than garments with stitched seams and should ideally be preferred.

Table 2 below shows the performance of different DuPont garments in terms of particle hold-out as measured by the whole suit inward leakage test (EN 13982-2 with results expressed according to 1073-2).

DuPont garment name	Fabric & Seam Type	Results expressed according to EN 1073-2 Protective clothing against radioactive contamination (6 garments)			
		Highest mean value of total inward leakage for one "activity" (TIL _E) %	Mean value of total inward leakage for all "activities" (TIL _A) %	Nominal protection factor	Performance Class
ProShield® 10	SMS / Stitched	17 %	9 %	10	1
ProShield® 30	Microporous Film / Stitched	8 %	4 %	25	1
Tyvek® Dual	Tyvek® (front) & SMS (rear) / Stitched	9 %	4 %	25	1
Tyvek® Industry	Tyvek® / Stitched	5 %	2 %	38	1
Tyvek® Classic	Tyvek® / Stitched	5 %	2 %	48	1
Tyvek® Labo	Tyvek® / Stitched	2 %	1 %	81	2
Tyvek® Classic Plus	Tyvek® / Stitched & over-taped	1 %	0 %	255	2

Typical values: based on mean of 22 test reports. Additional taping at cuffs, ankles & mask applied.

NOTE: Products that utilize 'SMS' or microporous film substrates (e.g., DuPont™ ProShield® 10 [SMS] and DuPont™ ProShield® 30 [microporous film]) are appropriate for particle protection, however careful consideration should be given to using products that utilize SMS or microporous film substrates for disaster response activities because:

- 1) Microporous film fabrics may be easily abraded and the barrier layer can be readily worn away.
- 2) "SMS" fabrics tend to have quite open structures, offering low dry particle holdout performance to fine particulates.

Mixed Dry & Wet Environments, Contamination of Radioactive Particles and Liquids

For liquids that have been contaminated by radiation, hooded Tychem® C & F coveralls may provide protection of the wearer from the chemical hazard, but not from ionizing radiation. Based on the chemical permeation data, you are able to select the fabric that offers an adequate chemical barrier. Permeation data for the DuPont fabrics can be accessed via www.dpp-europe.com or contact our techline service via: www.dpp-europe.com/technicalsupport

Table 3 below indicates the preferred and adequate solutions in case of mixed particulate and liquid contamination:

Table 3

				Nuclear Hazards - Descriptions & examples			
				Dry contamination	Mixed dry & wet contamination		
DuPont™ garment name	Fabric description	Seam type	Certification types	Radioactive particles	Radioactive particles, liquid mist & aerosols	Radioactive particles & heavy liquid spray with concentrated inorganic chemicals (max 2 bar pressure)	Radioactive particles & heavy liquid spray with a range of organic chemicals. (max 3 bar pressure)*
Proshield® 10	SMS	Stitched	5 & 6	●	●	●	●
Proshield® 30	Microporous film	Stitched	5 & 6	●	●	●	●
Tyvek® Dual	Tyvek® Front SMS rear	Stitched	5 & 6	●	●	●	●
Tyvek® Classic	Tyvek®	Stitched	5 & 6	○	○	●	●
Tyvek® Classic Plus	Tyvek®	Stitched & over-taped	4b, 5 & 6	●	●	●	●
Tyvek® Classic Plus (with attached socks)	Tyvek®	Stitched & over-taped	4b, 5 & 6	●	●	●	●
Tychem® C & C2	Tychem® C & C2	Stitched & over-taped	3b, 4, 5 & 6	○	●	●	●
Tychem® C (with attached socks)	Tychem® C	Stitched & over-taped	3b, 4, 5 & 6	○	●	●	●
Tychem® F & F2	Tychem® F & F2	Stitched & over-taped	3b, 4, 5 & 6	○	○	○	●
Tychem® F (with attached socks)	Tychem® F	Stitched & over-taped	3b, 4, 5 & 6	○	○	○	●

Warning: The garments do not provide a barrier to ionizing radiation

* Verify chemical permeation data.

- Not recommended
- Adequate
- Preferred
- Potentially over-specified

Warnings:

It is the user's responsibility to determine the nature and level of hazard and the proper personal protective equipment needed. The information set forth herein reflects laboratory performance of fabrics, not complete garments, under controlled conditions. It 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. In many cases, seams and closures have shorter breakthrough times and higher penetration rates than the fabric. Please contact DuPont for specific data. These garments are intended for limited use and should be disposed of after single use. If fabric becomes torn, abraded or punctured, end user should discontinue use of garment to avoid potential exposure.

- 1) Tyvek®, Tychem® and Proshield® garments do not provide protection from Ionizing radiation.*
- 2) Tyvek®, Tychem® and Proshield® garments are not flame resistant and should not be used around heat, flame, sparks or in potentially flammable or explosive environments.*
- 3) Tyvek®, and Tychem® garments with attached socks made of the garment material. For these models, these attached socks must be worn inside protective outer footwear and are not suitable as outer footwear. These attached socks do not have adequate durability or slip resistance to be worn as the outer foot covering.*
- 4) DuPont™ Tyvek® coveralls can be considered for use with the appropriate respirators and other suitable PPE.*
- 5) Tychem® aprons and smocks are available for situations where prolonged liquid exposure may be limited to the front of the torso and/or arms of the wearer. These aprons and smocks can be worn with Tyvek® to provide localized protection while limiting the level of thermal discomfort.*

For more information on our support services, please contact:

DuPont Personal Protection

DuPont de Nemours Luxembourg S.à.r.l.

L-2984 Luxembourg

Tel.: +800 3666 6666 (international toll-free)

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

Or visit our website at: www.dpp-europe.com

For technical support consult our techline via:

www.dpp-europe.com/technicalsupport



The miracles of science™