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Applied to Life.™

Personal Safety

# 3M™ Protective Apparel Chemical Testing Guide

## Penetration, Repellency and Permeation

Differential permeation. Applied to returning you home safely.

# 3M™ Protective Apparel Chemical Testing Guide

The primary purpose of a protective coverall is to protect the wearer's body. In terms of Personal Protective Equipment (PPE), Body Protection normally refers to protecting the skin from the harmful effects of chemicals – either liquids or solids. This guide focuses on protection from liquid chemicals and how those tests are performed.

There are six Types of Chemical Protective Clothing, ranging from gas tight Type 1 to liquid splash Type 6. Three are specific to liquid chemicals and are referred to as Type 6, Type 4 and Type 3. The suits are also subjected to different tests either on the full suit or on the

material, depending on the Type of protection they are intended to offer. In each case the fabric is tested for various physical properties and also chemical properties with more specific mandatory chemical tests.

These tests are known as Permeation, Penetration and Repellency and it is these tests this guide will focus on.

The fabric of all coveralls is tested for Penetration and Repellency, but in addition the fabrics and seams of Type 3 and Type 4 coveralls are also tested for Permeation.



## Penetration and Repellency Test

### How Are The Tests Done?

Penetration and Repellency are two separate tests, but normally carried out in tandem.

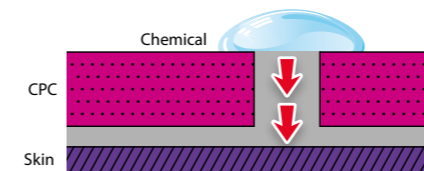
Together, the Penetration and Repellency tests are often known as a “gutter test” due to the way the testing rig looks and is set up. 3M tested to EN 368:1993 until it was superseded by EN ISO 6530.

Both tests are set up in the same manner. The fabric being tested is weighed and placed in a semi-circular gutter at an angle of 45° on top of an absorbent piece of fabric, which is itself placed on top of a piece of film.

### Penetration Test

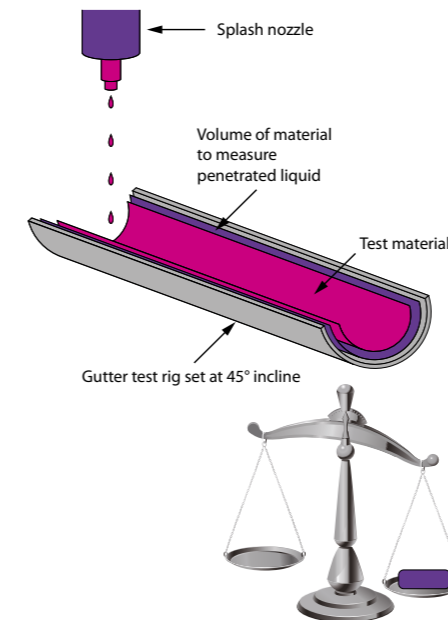
10ml of the challenge chemical is delivered onto the fabric from a height of 100mm within 10 seconds using a syringe. After 60 seconds the levels of any Penetration and Repellency are measured.

Penetration is measured by deducting the weight of the absorbent fabric and film after the test from their original weight. The result will be zero if there has been no penetration.



**Penetration** is a test to see whether a particular chemical will go through the fabric.

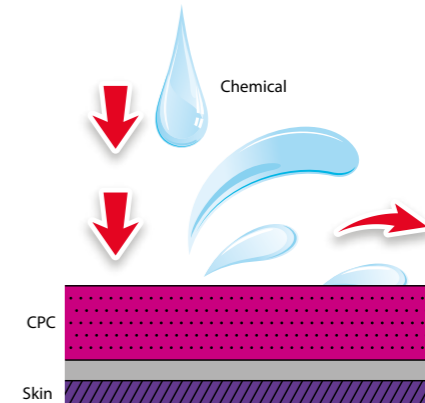
### Gutter Test - Penetration



Results are normally given in terms of classes based on the percentages of Penetration and Repellency, the higher the class number the better the performance. For example, the classification system in EN 14325 (the Standard which sets out the test methods and performance classification of chemical protective clothing in Europe) has the following classes:

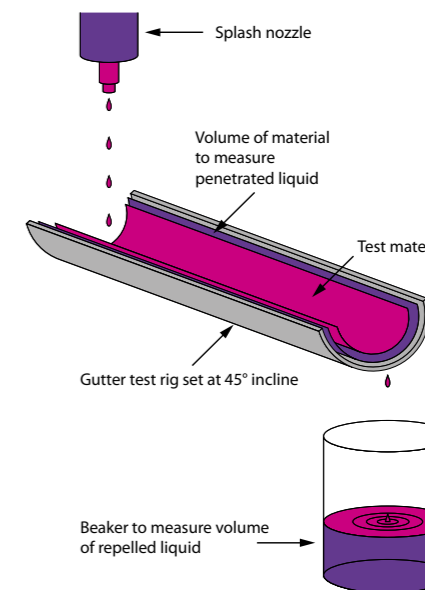
### Repellency Test

A beaker for collecting any chemical repelled off the fabric is weighed and placed at the end of the gutter. Repellency is measured by deducting the weight of the empty beaker at the start of the test from the weight of the beaker at the end of the test – ideally this will be the weight of the challenge chemical i.e. it has all been repelled off the fabric into the beaker.



**Repellency** is a test to see whether the chemical being tested stays on the fabric or rolls off.

### Gutter Test - Repellency



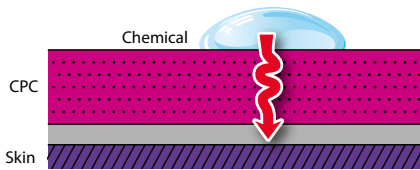
Penetration and Repellency Classes (EN 14325)		
Class Level	Penetration	Repellency
Class 3	<1%	>95%
Class 2	>1% and <5%	>90% and <95%
Class 1	>5% and <10%	>80% and <90%

# Permeation

Permeation is the way in which molecules of a substance travel through the fabric. As this occurs on a chemical level it isn't always easy to detect with the naked eye.

## When a liquid permeates there are three stages:

1. Absorption of molecules onto the contacted surface
2. Diffusion of the absorbed molecules within the material
3. Desorption from the opposite surface of the material



## Permeation Test

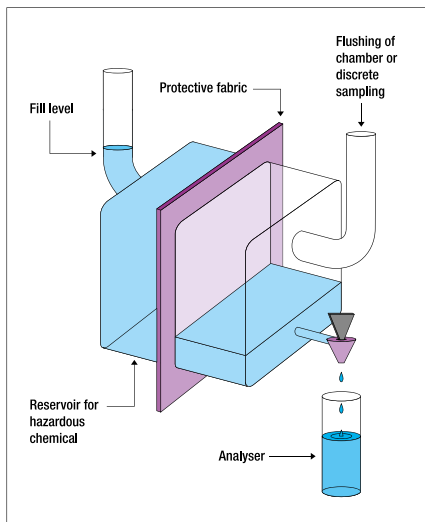


Image courtesy of Quick Selection Guide to Chemical Protective Clothing, Forsberg & Mansdorf, Copyright 2007 John Wiley & Sons, Inc. Reprinted with permission from John Wiley & Sons, Inc.

## How Are The Tests Done?

3M tests to the following permeation standards EN 374, EN ISO 6529 and ASTM F-739.

EN 374 reports the breakthrough detection time at a permeation rate of 1.0 µg/cm<sup>2</sup>/min and refers to the EN 14325 classification in the table shown. ASTM F-739 reports the normalised breakthrough detection time at a permeation rate of 0.1 µg/cm<sup>2</sup>/min.

You can also find both of the normalised permeation rates of 0.1 µg/cm<sup>2</sup>/min and 1.0 µg/cm<sup>2</sup>/min reported in EN ISO 6529.

In all methods the resistance to permeation of a challenge chemical is determined by measuring the time it takes the chemical to breakthrough to the other side.

The apparatus is set up so that the protective material separates the test chemical from the collecting medium with the outer surface of the specimen in contact with the test chemical.

The concentration of the test chemical found in the collecting medium is analysed to determine the amount that has permeated as a function of time. When a certain permeation rate is detected, the time in minutes is recorded – this is the breakthrough time.

Generally there are two permeation rates depending on the Standard that is being used – either 1.0µg/cm<sup>2</sup>/min or 0.1µg/cm<sup>2</sup>/min. For example if the permeation rate is 1.0µg/cm<sup>2</sup>/min we are saying that the breakthrough time is reached when 1.0 micrograms of

the chemical being tested are detected in the analyser part of the test rig per square centimetre of fabric per minute.

If this rate is not reached within the 8 hours specified in the standard, then the breakthrough time is recorded as 480 minutes greater. Note that this does not mean that there was no permeation – just that the threshold rate was not reached.

The Permeation Classes table shows the class categorisation of breakthrough times for ISO 6529:2001 reporting to 1.0 µg/cm<sup>2</sup>/min, EN 14325 and EN 374. The lowest breakthrough time is used to determine the performance level.

ISO 6529:2001 reporting to 0.1 µg/cm<sup>2</sup>/min and ASTM F739-2007 states results as breakthrough times in minutes only. For example, ISO 6529:2001 - Permeation @ 0.1 µg/cm<sup>2</sup>/min, BTT > 480 mins, Result > 480 mins.

Permeation Classes (EN 14325)	
Class Level	Minutes
Class 6	<480 mins
Class 5	<240 and <240 mins
Class 4	<120 and <240 mins
Class 3	<60 and <120 mins
Class 2	<30 and <60 mins
Class 1	<10 and <30 mins

\*The lowest breakthrough time is used to determine performance level.



To find out more about testing or to discuss which solution may best meet your needs contact a 3M representative. You can also visit the 3M Chemical Test library on <http://go.3M.com/CHTL> to review the chemical protective properties of the fabrics used in our range and see which 3M™ Protective Apparel solution could best meet your needs.



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**Data given here is: for information only. Breakthrough times are not safe wear times. Permeation rates increase with temperature. Permeation testing does not assess: degradation; mechanical defects; product design/fit.**

**Important Notice**  
 This guide is only an outline. It should not be used as the only means for selecting protective clothing. Before using any protective clothing, the wearer must read and understand the user instructions for each product. Specific country legislation must be observed. If in doubt, contact a safety professional. Selection of the most appropriate PPE will depend on the particular situation and should only be made by a competent person knowledgeable of the actual working conditions and the limitations of PPE.

Final determination as to the suitability of these products for a particular situation is the employer's responsibility. This information is subject to revision at any time. Always read and follow all *User Instructions* supplied with your 3M™ Protective Coveralls in order to ensure correct operation. If you have questions contact 3M Technical Service.

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