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Protective gloves for pesticide operators and re-entry workers — Performance requirements

Gant de protection pour les opérateurs manipulant des pesticides et les travailleurs de rentrée — Exigences de performances

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 13, *Protective clothing*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document addresses the performance requirements for gloves worn by operators handling liquid pesticide products as well as gloves worn by re-entry workers. It includes requirements for chemical resistant gloves that provide protection to the whole hand as well as gloves used for certain re-entry activities for which partial protection in the palm-side of the hand is sufficient.

This document classifies gloves into two categories: gloves that provide chemical protection to the whole hand and gloves that provide protection only to the fingertips and palm-side of the hand (suitable for certain re-entry tasks). Gloves that provide protection to the whole hand include two performance levels (G1 and G2) and a single performance level (GR) for gloves suitable for certain re-entry tasks. A brief description of the two categories is given below:

Chemical resistant gloves:

Material as well as whole glove testing is required for gloves classified as G1 and G2. In addition to tests conducted for chemical resistant glove, these gloves are also tested with a pesticide surrogate. Since the active ingredient of pesticides is typically a chemical with low vapour pressure and/or low solubility in collection media, EN 16523-1:2015 cannot be used to measure permeation of active ingredient in most pesticide products. Therefore, ISO 19918 is used to measure cumulative permeation with the pesticide surrogate. G1 gloves provide lower level of protection than G2 gloves.

— G1 gloves are suitable when the potential risk is relatively low. These gloves are not suitable for use with concentrated pesticide formulations and/or for scenarios where mechanical risks exist. G1 gloves are typically single use gloves.

— G2 gloves are suitable when the potential risk is higher. These gloves are suitable for use with diluted as well as concentrated pesticides. G2 gloves also meet the minimum mechanical resistance requirements and are therefore suitable for activities that require gloves with minimum mechanical strength.

Chemical resistant gloves with partial protection:

GR gloves provide protection only to the palm-side of the hand for a re-entry worker who is in contact with dry and partially dry pesticide residues that remain on the plant surface after pesticide application. This glove category is suitable only for re-entry activities where it has been determined that protection provided to the fingertips and palm-side of the hand is sufficient. They cannot be used in place of G1 and G2 gloves that protect the whole hand. GR gloves also have mechanical properties that are required for several re-entry tasks. Breathable material in the back of the hand provides comfort.

Registration of pesticide products, such as insecticides, herbicides, and fungicides, involves the assessment of operator and re-entry worker exposures and risks, which determines the need for PPE (including gloves) required for risk mitigation. See Annex A for information on risk assessment and use of PPE (including gloves) for risk mitigation. Protection should correspond to the identified risks in order to avoid a loss of comfort due to overprotection. Actual field trials are used to determine the operator risk while handling concentrates during mixing/loading, and applying diluted pesticides under different scenarios, as well as risks to re-entry workers exposed to dry, partially dry and wet residues. Since protective clothing can be contaminated in various ways, laboratory test methods used in the document rate materials and gloves rather than simulate the various field conditions. Laboratory tests are often accelerated tests and therefore laboratory data cannot be used for direct comparison with field data.

This document is intended for glove manufacturers, pesticide product manufacturers, trainers, regulators, and other individuals or organizations that make decisions regarding PPE for protection against pesticide products.

Protective gloves for pesticide operators and re-entry workers — Performance requirements

1 Scope

This document establishes minimum performance, classification, and labelling requirements for gloves worn by operators and re-entry workers handling pesticide products to protect the hands or hands and forearms against contact with those products. Gloves covered by this document include gloves made with elastomeric and polymeric materials in the areas that provide protection.

This document does not address protection against fumigants.

This document needs to be used in conjunction with ISO 21420.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 374-1, *Protective gloves against dangerous chemicals and micro-organisms — Part 1: Terminology and performance requirements for chemical risks*

ISO 19918, *Protective clothing — Protection against chemicals — Measurement of cumulative permeation of chemicals with low vapour pressure through materials*

ISO 21420:—[1], *Protective gloves — General requirements and test methods*

ISO 23388:2018, *Protective gloves against mechanical risks*

EN 374-2:2014[2], *Protective gloves against dangerous chemicals and micro-organisms — Part 2: Determination of resistance to penetration*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
active ingredient
component of a pesticide formulation, which is an active substance present in sufficient quantity that relates to an intended phytosanitarian purpose

1) To be published. Stage at the time of publication ISO/FDIS 21420:2019.

2) Once published, EN 374-2:2014 will be replaced with ISO 374-2 which is under preparation. Stage at the time of publication ISO/DIS 374-2:2018.

3.2
decontamination
removal of a contaminant or contaminants from the surface or matrix, or both, of chemical protective materials to the extent necessary for its next intended use

Note 1 to entry: For this document, materials are limited to those used for chemical resistant gloves.

3.3
degradation
deleterious change in one or more mechanical properties of a material due to contact with a chemical or heat

Note 1 to entry: Indications of degradation may include flaking, swelling, disintegration, embrittlement, discoloration, dimensional change, appearance, hardening, softening, etc.

3.4
fumigant
pesticide in the form of gas

3.5
penetration
process by which a chemical moves through porous materials, seams, pinholes, or other imperfections in a material on a non-molecular level

3.6
permeation
process by which a chemical moves through a material on a molecular level, involving

— sorption of the molecules of the chemical into the contacted (outside) surface of a material,

— diffusion of the absorbed molecules in the material, and

— desorption of the molecules from the opposite (inner) surface of the material

3.7
pesticide
substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest or weeds

Note 1 to entry: Pesticides (plant protection products) approved for use in one country may not be approved in another country.

3.8
pesticide operator
person handling pesticides in agricultural settings, green spaces, roadsides, etc.

Note 1 to entry: Handling includes tasks such as mixing, loading, transferring, or applying pesticides; cleaning, adjusting, or repairing the parts of mixing, loading, or application equipment that may contain pesticide residues; assisting with the application of pesticides; and disposing of pesticides or pesticide containers.

Note 2 to entry: Farm, forest, nursery, and greenhouse are examples of agricultural settings.

3.10
re-entry worker
person who can be in contact with a partially or fully dried pesticide product, as part of their work/employment, in an area that has previously been treated

3.11
test chemical
liquid that is used to challenge the specimen of glove material

4 Classification and testing requirements

4.1 General

All gloves complying with this document shall fulfil the requirements of ISO 21420:—, Clauses 4, 5 and 7 with the exception of the minimum glove length. In addition, each type of glove shall be tested and classified by level of performance in accordance with the requirements as stated in Clause 4.

G1 gloves shall pass the penetration test and demonstrate a minimum level of liquid permeation resistance. G1 gloves are not suitable for use with concentrated pesticide formulations and/or for scenarios where mechanical risks exist.

G2 gloves shall pass the penetration test, and the glove material shall meet the liquid permeation requirements. G2 glove is suitable for use with concentrated as well as diluted pesticide formulations and for activities where mechanical risk exists.

GR gloves shall meet the permeation requirements in the palm area as well as mechanical requirements. GR gloves are not suitable for use by pesticide operators or for re-entry tasks for which partial protection to the fingertips and palm-side of the hand is not sufficient.

Table 1 provides a summary of the tests to be conducted for gloves for pesticide operators and re-entry workers. The stringency in the testing requirements to determine protection is higher for G2 gloves. Therefore, any G2 glove necessarily meets G1 requirements.

To be classified in either G1 or G2 or GR, all the applicable requirements shall be satisfied.

Table 1 — Testing requirements for G1, G2, and GR gloves

Subclause	Performance/Design Requirement	Standard; Clause	Requirements		
			G1	G2	GR
4.1	General requirements	ISO 21420	fulfilled	fulfilled	fulfilled
4.2.1	Penetration test	EN 374-2:2014, 7.2 and 7.3	pass	pass	
4.2.2.1	Resistance to permeation	ISO 374-1	≥Type C	≥Type B	≥Level 2 with chemical K
4.2.2.2	Resistance to permeation	ISO 19918	≤10 µg/cm²	≤1 µg/cm²	≤1 µg/cm²
4.2.3.1	Glove length		fulfilled	fulfilled	
4.2.3.2	Coated area				fulfilled
4.2.4	Mechanical requirements	ISO 23388:2018, 6.1		≥Level 2	≥Level 2
		ISO 23388:2018, 6.2		≥Level 1	≥Level 1
		ISO 23388:2018, 6.3		or ≥Level A	or ≥Level A
		ISO 23388:2018, 6.4			≥Level 1
		ISO 23388:2018, 6.5		≥Level 1	≥Level 1
NOTE Once the ISO/EN standards are published, the clauses equivalent to the EN standards stated in the table shall be required.					

4.2 Performance requirements

4.2.1 Penetration

Tests shall be performed on three gloves to measure glove integrity in accordance with EN 374-2. All three gloves shall pass both tests. Gloves tested with air can then be used to conduct tests with water.

4.2.2 Permeation

4.2.2.1 Glove materials for G1, G2, and GR shall be conditioned and breakthrough time measured in accordance with ISO 374-1.

Glove materials for G1 shall comply with at least the requirement for Type C.

Glove materials for G2 shall comply with at least the requirement for Type B.

NOTE 1 The test is needed to ensure that G1 and G2 gloves have a minimum resistance to chemicals before assessing it for protection against pesticides.

GR glove materials shall be tested with test chemical K. GR gloves shall comply with at least the minimum requirement of Performance Level 2 (breakthrough time of 30 min) when tested with chemical K.

NOTE 2 Test chemical K (40 % sodium hydroxide) was selected for testing as it is a commonly used water-based test chemical that can differentiate between the different types of glove coating.

4.2.2.2 Glove materials for G1, G2 and GR shall be conditioned and cumulative permeation measured in accordance with ISO 19918. Pesticide surrogate EC-DY (concentrate with 10 % disperse yellow dye) shall be used as the test chemical. Composition and other information for the test chemical is included in Annex B.

When requested, other pesticides representing the workplace can be added. For additional testing the procedure, test methods, and pass criteria shall be the same as that for pesticide surrogate EC-DY. The test chemical shall be the specific pesticide formulation, either concentrated or diluted with water in accordance with the manufacturer's instructions.

NOTE 1 Pesticide formulations are mixtures that, when diluted in water, are often emulsions or suspensions. During the test, agitation in the challenge test cell can be necessary. Selective detection systems can be required to detect the active ingredient.

For G1, G2 and GR glove materials, tests shall be conducted with a diluted formulation for one hour. Water grade 3 (according to ISO 3696) or deionized water shall be used to prepare the diluted solution with 2,5 % EC-DY. In addition, for G2 glove materials, the test shall be conducted with the concentrate for 15 minutes.

NOTE 2 To prepare 100 ml of diluted test chemical, 2,5 ml of EC-DY is made up to 100 ml (0,25 % disperse yellow 26 dye).

NOTE 3 The duration of the test is not based on actual use time since the permeation test is an accelerated test in which the surface of the specimen is in constant contact with the test chemical. Although the duration of the exposure can be for a longer period during field application with the dilute formulation, the entire surface is not in constant contact with the test chemical. In case of accidental spills, the operator needs to remove the glove immediately, and therefore the contact time with the concentrate is much shorter.

Three specimens taken from three gloves shall be tested for each testing condition. For a glove longer or equal to 400 mm, three additional specimens shall be tested from the front or back of the cuff area when testing with the concentrate.

For gloves classified as G1 the maximum cumulative permeation shall be 10 µg/cm^2 disperse yellow 26 dye for all specimens when tested against the diluted surrogate EC-DY.

For gloves classified as G2 the maximum cumulative permeation shall be 1 µg/cm^2 disperse yellow 26 for all specimens when tested against the diluted and concentrate surrogate EC-DY.

For gloves classified as GR the maximum cumulative permeation shall be 1 µg/cm^2 disperse yellow 26 for all specimens when tested against the diluted surrogate EC-DY.

NOTE 4 An accelerated laboratory test is used to classify materials. The maximum limits are not appropriate for use in calculating default protection factors used for exposure mitigation in operator exposure and risk assessment.

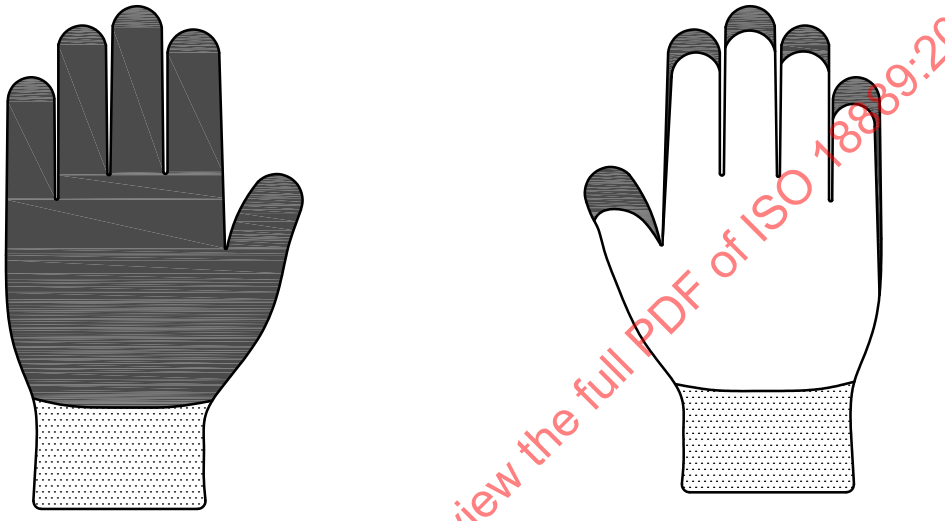
4.2.3 Glove design requirement

For safety reasons, the gloves shall have minimum design requirements.

4.2.3.1 Minimum length shall be 240 mm for G1 and 290 mm for G2 gloves. For G1 gloves with length between 240 mm and 290 mm, a statement in accordance with Clause 7 i) shall be required.

NOTE An overlap of approximately 50 mm between the glove and the garment is included to prevent the possibility of pesticides penetrating between the garment sleeve and the glove [see Clause 7 i)].

4.2.3.2 GR gloves shall have at least the fingertips and palm-side of the hand coated (see Figure 1).



a) Palm-side of the hand **b) Back of the hand**

Figure 1 — Minimum area (coloured grey) to be coated for GR gloves

4.2.4 Mechanical requirements

G2 and GR protective gloves shall fulfil the following minimum mechanical requirements in accordance with ISO 23388:

— Abrasion resistance – Minimum performance level 2 in accordance with 6.1 of ISO 23388:2018.

— Cut resistance – Minimum performance level 1 in accordance with 6.2 or minimum of performance level A in accordance with 6.3 of ISO 23388:2018.

— Tear resistance – Minimum performance level 1 for GR gloves in accordance with 6.4 of ISO 23388:2018.

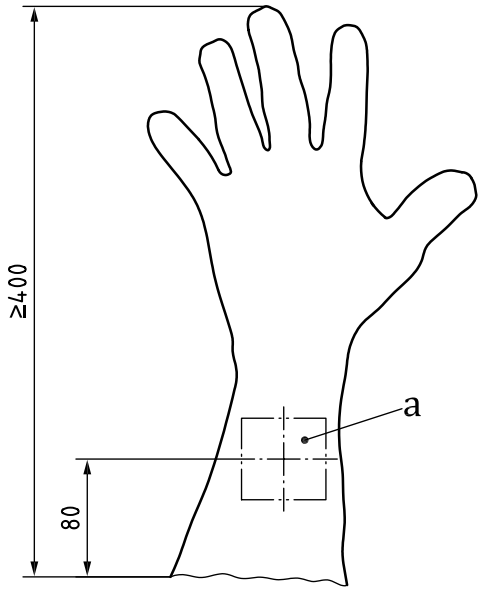
— Puncture resistance – Minimum performance level 1 in accordance with 6.5 of ISO 23388:2018.

5 Sampling

5.1 Sampling for permeation

Three test specimens shall be taken from the palm area. If the glove is longer or equal to 400 mm and if the cuff is claimed to protect against pesticide risks, three additional test specimens shall be taken with the centre being at 80 mm from the end of the cuff (see Figure 2).

Dimensions in millimetres



a Additional test specimens taken with the centre being at 80 mm from the end of the cuff.

Figure 2 — Sample location for gloves ≥400 mm

All the different materials constituting the glove shall be tested if different from the palm. In the case of seams in the hand area this area shall be tested.

5.2 Sampling for penetration

Sampling procedure for determining the resistance to water penetration as specified in 5.2, shall be in accordance with EN 374-2.

6 Marking

6.1 General

Marking of the protective gloves for pesticide operators and re-entry workers shall be in accordance with the marking requirement for protective gloves of ISO 21420 and with the following.

6.2 Specific marking for protective gloves for pesticide operators and re-entry workers

The pictogram to be used shall be based on the symbol ISO 7000-3126 The pictogram shall be the ISO 7000-3126 with ISO 18889 written at the bottom and the level of protection (stated G1, G2, or GR based on the level) on the right of the pictogram (see Figure 3).

Figure 3 — Specific marking (Application of ISO 7000-3126 pictogram) for G1, G2 and GR gloves

7 Information supplied by the manufacturer

The information supplied by the manufacturer shall be in accordance with the requirements for information as defined in ISO 21420.

The following warnings or equivalent wording shall be added:

a) "This information does not reflect the actual duration of protection in the workplace and the differentiation between mixtures and pure chemicals;"

"It is recommended to check that the gloves are suitable for the intended use because the conditions of use at the workplace may differ from the test conditions, in particular in terms of temperature, abrasion and degradation."

"When used, protective gloves may provide less resistance to dangerous chemicals due to changes in physical properties. Movements, snagging/rubbing, degradation caused by chemical contact, etc. may reduce the actual use time significantly. For corrosive chemicals, degradation can be the most important factor to consider in the selection of chemical resistant gloves."

b) "The duration of the test is not based on actual use time since the permeation test is an accelerated test in which the surface of the specimen is in constant contact with the test chemical. Although the duration of the exposure may be for a longer period during field application with a dilute formulation, the entire surface is not in constant contact with the test chemical";

c) "Before usage inspect the gloves for any defect or imperfections";

d) "Remove the glove immediately if contaminated by a concentrate spill";

e) If there is no information about decontamination, then the glove is intended for single use only, and the following warning shall be added: "For single use only";

f) For gloves with fabric lining, a warning shall be included informing the users that the absorbent lining material has the potential of absorbing the pesticide. Instructions should at least include doffing procedures to prevent contamination of the glove lining.

g) If applicable, conditions or factors that significantly reduce the protective qualities of the item shall be included;

In addition, if applicable, the following information shall be included:

h) For reusable gloves, the manufacturer shall provide the relevant instructions for decontamination;

i) For G1 and G2 gloves, the pesticide shall not have the possibility to penetrate between the garment sleeve and the glove. For G1 glove with a glove length between 240 mm and 290 mm, a caution sentence shall be included in the user instruction to check the minimum overlap. If the overlap is less than approximately 50 mm between the glove and the sleeve, a glove with longer length should be used.

j) For G1 and G2 gloves, if the cuff is not claimed to offer the same level of chemical protection as the palm area, it shall be mentioned in the user notice.

k) The relevant following definition shall be included in the user instruction of gloves complying with ISO 18889:

— G1 gloves are suitable when the potential risk is relatively low. These gloves are not suitable for use with concentrated pesticide formulations and/or for scenarios where mechanical risks exist.

— G2 gloves are suitable when the potential risk is higher. These gloves are suitable for use with diluted as well as concentrated pesticides. G2 gloves also meet the minimum mechanical resistance requirements and are therefore suitable for activities that require gloves with minimum mechanical strength.

— GR gloves provide protection only to the palm-side of the hand for re-entry worker who is in contact with dry and partially dry pesticide residues that remain on the plant surface after pesticide application. This glove category is suitable only for re-entry activities where it has been determined that protection provided to the fingertips and palm-side of the hand is sufficient.

Annex A
(informative)

Risk assessment — PPE to mitigate risk

Globally, pesticide products are known as plant protection products (PPP). Pesticides or PPP are strictly regulated by regulatory bodies responsible for the authorization of the product to be placed on the market. In order to register their products for sale, companies are required to submit dossiers to the authorizing agency. Based on the documents provided by the registrant, the authorizing body determines the potential risk to human health and the environment, including risks to the pesticide operator and re-entry worker. The toxicity of the product and the exposure are typically used to determine potential risk. Exposure models based on field studies that are representative of different exposure scenarios are often used to determine potential exposure. The potential risk is typically calculated for the different exposure scenarios in which the pesticide product can be used. For example, for a pesticide product, exposure assessment to pesticide operators could be calculated for spraying using an enclosed tractor cab, knapsack spraying and indoor application using a spray gun, and other means of application that are prevalent in the country where the product is being registered. In addition, calculations are done for mixing and loading and other operations. Similarly, re-entry studies are conducted to determine the potential exposure to re-entry workers. For many re-entry activities hand protection is important as the activities often include tasks in which the hands are in contact with plants with pesticide residues after application. The risk assessment often serves as the basis for determining the PPE to be used to mitigate risk, taking into account the part of the body that needs the most protection[4].

An individual's risk when handling pesticides/PPP is a function of the hazard (ability to cause harmful effects due to the toxicity of the product) and the exposure of the individual. Once the product is placed on the market, the only way to reduce risk is by reducing exposure. According to the ALARP principle (ALARP – As Low As Reasonably Practicable), exposure should firstly be reduced by engineering controls and administrative measures and lastly by the use of PPE in combination with good work practices and hygiene. It is the responsibility of the risk assessors to determine the PPE required for risk mitigation. The G1 gloves allow the use of single-use gloves that provide a balance between protection when applying diluted formulation and the ability to perform tasks for which dexterity is important (e.g., changing nozzles) and no mechanical risk is present. In addition, the low cost and easy disposal of disposable gloves prevent issues with donning and doffing when the operator may require hand protection for short duration in the middle of an application or cleaning. Based on risk assessment, G2 gloves may be required when handling concentrates or diluted products with higher toxicity and/or exposure. G2 gloves may also be required for tasks that require minimum mechanical resistance in addition to chemical resistance. Based on re-entry studies conducted in France[5][6], GR gloves are suitable for re-entry tasks where the re-entry worker is exposed to dry or partially dry pesticide residues primarily in the fingertip and palm side of the hand. In early morning, when foliage is fully wet with dew, gloves that provided protection to the whole hand were worn. Cooler temperature in the morning and the use of these gloves for short duration made the practice acceptable for the workers. It is the responsibility of the risk assessors to determine the glove category and performance level. Risk assessment is beyond the scope of this standard.

Some regional/national legislations require pesticide/PPP producers to inform users about the most appropriate personal protective equipment to be worn when using a particular PPP. This document can be used by countries to specify glove requirements on pesticide/PPP labels and Safety Data Sheets.

Annex B
(normative)

Surrogate test chemical

Surrogate test chemical EC-DY shall be used for permeation tests specified in 4.2.2.2. The composition of the surrogate test chemical is given in Table B.1. The surrogate test chemical is based on studies conducted for the selection of test chemicals and development of a surrogate test chemical. No studies have been conducted to determine the shelf life of the mixture. However, based on the chemicals in the mixture, shelf life of two years or more is expected.

Table B.1 — Composition of Surrogate test chemical EC-DY

Chemical	CAS #	Function	Nominal composition (mass fraction in %)	Calculated nominal composition (g/l)	Company (if applicable)
Disperse Yellow 26	16611-15-7	Dye (replaces active ingredient)	10	100	
Soprophor BSU	99734-09-5	Emulsifier	2	20	Cytec Solvay Group
Aerosol® OT-A ND	NA - Blend	Emulsifier	18	180	Cytec Solvay Group
Benzylalkohol	100-51-6	Co-solvent	25	250	
Solvesso 200 ND	64742-94-5	Solvent	45	up to 1 L	Exxon Mobil

To ensure consistency in the formulation used for testing, several batches of surrogate produced by HPC Standards were tested. The information required for ordering the EC-DY surrogate and the technical grade of disperse yellow 26 dye required for the preparation of standards is given below:

HPC Standards GmbH
Am Wieseneck 7
04451 Cunnersdorf
Germany

Phone: +49 34291 33 72 36
Fax: +49 34291 33 72 39

contact@hpc-standards.com
www.hpc-standards.com

The data in Table B.2, Figures B.1 and B.2 have been obtained in a collaborative correlation trial organised by ISO/TC 94/SC 13/WG 3.

Table B.2 — Results of correlation trial

Tested material	0,24 mm latex sheet	0,10 mm nitrile glove*
Tested chemical	Surrogate EC-DY diluted to 2,5 %	
Number of participating laboratories	4	4
Number of operators	5	5
Mean value (in µg/cm^2)	5,1	0,5
Standard deviation (in µg/cm^2)	1,8	0,26