

**WHO SPECIFICATIONS AND EVALUATIONS
FOR PUBLIC HEALTH PESTICIDES**

ALPHA-CYPERMETHRIN

**LONG-LASTING (INCORPORATED INTO
FILAMENTS) INSECTICIDAL NET**

A racemic mixture of:

(*S*)- α -cyano-3-phenoxybenzyl-(1*R*,3*R*)-3-(2,2-dichlorovinyl)-
2,2-dimethylcyclopropane-carboxylate and
(*R*)- α -cyano-3-phenoxybenzyl-(1*S*,3*S*)-3-(2,2-dichlorovinyl)-
2,2-dimethylcyclopropane-carboxylate



**World Health
Organization**

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Disclaimer¹

WHO specifications are developed with the basic objective of promoting, as far as practicable, the manufacture, distribution and use of pesticides that meet basic quality requirements.

Compliance with the specifications does not constitute an endorsement or warranty of the fitness of a particular pesticide for a particular purpose, including its suitability for the control of any given pest, or its suitability for use in a particular area. Owing to the complexity of the problems involved, the suitability of pesticides for a particular purpose and the content of the labelling instructions must be decided at the national or provincial level.

Furthermore, pesticides which are manufactured to comply with these specifications are not exempted from any safety regulation or other legal or administrative provision applicable to their manufacture, sale, transportation, storage, handling, preparation and/or use.

WHO disclaims any and all liability for any injury, death, loss, damage or other prejudice of any kind that may be arise as a result of, or in connection with, the manufacture, sale, transportation, storage, handling, preparation and/or use of pesticides which are found, or are claimed, to have been manufactured to comply with these specifications.

Additionally, WHO wishes to alert users to the fact that improper storage, handling, preparation and/or use of pesticides can result in either a lowering or complete loss of safety and/or efficacy.

WHO is not responsible, and does not accept any liability, for the testing of pesticides for compliance with the specifications, nor for any methods recommended and/or used for testing compliance. As a result, WHO does not in any way warrant or represent that any pesticide claimed to comply with a WHO specification actually does so.

¹ This disclaimer applies to all specifications published by WHO.

INTRODUCTION

WHO establishes and publishes specifications* for technical material and related formulations of public health pesticides with the objective that these specifications may be used to provide an international point of reference against which products can be judged either for regulatory purposes or in commercial dealings.

From 2002, the development of WHO specifications follows the **New Procedure**, described in the Manual for Development and Use of FAO and WHO Specifications for Pesticides. This **New Procedure** follows a formal and transparent evaluation process. It describes the minimum data package, the procedure and evaluation applied by WHO and the experts of the “FAO/WHO Joint Meeting on Pesticide Specifications” (JMPS).

WHO specifications now only apply to products for which the technical materials have been evaluated. Consequently, from the year 2002 onwards the publication of WHO specifications under the **New Procedure** has changed. Every specification consists now of two parts, namely the specifications and the evaluation report(s):

Part One: The Specification of the technical material and the related formulations of the pesticide in accordance with chapters 4 to 9 of the above-mentioned manual.

Part Two: The Evaluation Report(s) of the pesticide, reflecting the evaluation of the data package carried out by WHO and the JMPS. The data are provided by the manufacturer(s) according to the requirements of chapter 3 of the above-mentioned manual and supported by other information sources. The Evaluation Report includes the name(s) of the manufacturer(s) whose technical material has been evaluated. Evaluation reports on specifications developed subsequently to the original set of specifications are added in a chronological order to this report.

WHO specifications under the **New Procedure** do not necessarily apply to nominally similar products of other manufacturer(s), nor to those where the active ingredient is produced by other routes of manufacture. WHO has the possibility to extend the scope of the specifications to similar products but only when the JMPS has been satisfied that the additional products are equivalent to that which formed the basis of the reference specification.

Specifications bear the date (month and year) of publication of the current version. Evaluations bear the date (year) of the meeting at which the recommendations were made by the JMPS.

* Footnote: The publications are available on the Internet under the WHO Prequalification Team - Vector Control Products (PQT-VC) website.

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WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN

INFORMATION

Common name

alpha-cypermethrin (E-ISO, BSI), alpha-cyperméthrine (F-ISO)

Synonyms

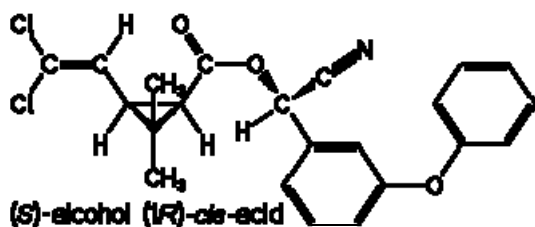
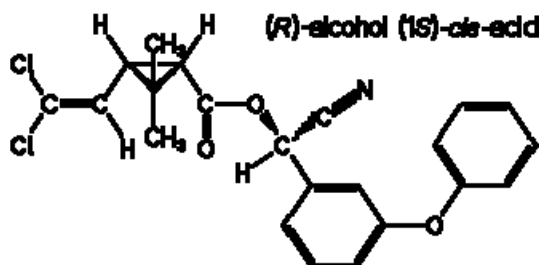
alphamethrin (rejected common name), alfoxylate

Chemical names

IUPAC a racemic mixture of: (S)- α -cyano-3-phenoxybenzyl-(1R,3R)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (R)- α -cyano-3-phenoxybenzyl-(1S,3S)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate

CA: [1 α (S*),3 α](\pm)-cyano(3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate

Structural formula



Empirical formula

C₂₂H₁₉Cl₂NO₃

Relative molecular mass

416.3

CAS Registry number

67375-30-8

CIPAC number

454

Identity tests

GC retention time, IR spectrum.

WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN LONG-LASTING (INCORPORATED INTO FILAMENTS) INSECTICIDAL NET

WHO specification 454/LN/2 (September 2019*)

This specification, which is PART ONE of this publication, is based on an evaluation of data submitted by the manufacturers whose name are listed in the evaluation reports (454/2009.2, 454/2011.1, 454/2011.2, 454/2013, 454/2014.1, 454/2019). It should be applicable to relevant products of these manufacturers but it is not an endorsement of those products, nor a guarantee that they comply with the specification. The specification may not be appropriate for the products of other manufacturers, irrespective of the source of TC. The evaluation reports (454/2009.2, 454/2011.1, 454/2011.2, 454/2013, 454/2014.1, 454/2019), given in PART TWO, form an integral part of this publication.

1 Description

The product shall be in the form of netting (Note 1), consisting of 150 denier (Note 2) monofilament, high density polyethylene fibres, incorporating technical alpha-cypermethrin complying with the requirements of WHO specification 454/TC (January 2013) together with any necessary other formulants. The product shall appear clean and shall be free from visible extraneous matter (Note 3), visible damage (such as splitting or tearing) and visible manufacturing defects (such as poorly made seams or a weave that is either not uniform or too loose to remain uniform in use), and shall be suitable for use as an insecticidal net with long-lasting activity (Notes 4 & 5).

2 Active ingredient

2.1 Identity tests (454/LN/M/2, CIPAC Handbook M, p.40, 2009)

The active ingredient shall comply with an identity test and, where the identity remains in doubt, shall comply with at least one additional test.

2.2 Alpha-cypermethrin content (454/LN/M/3.2, CIPAC Handbook M, p.41, 2009) (Notes 6 & 7)

The alpha-cypermethrin content shall be declared (5.8 g/kg) and, when determined, the average measured content shall not differ from that declared by more than $\pm 25\%$.

* This specification is applicable to long-lasting insecticidal nettings and nets produced by Shobikaa Impex Private Limited, V.K.A. Polymers Pvt. Ltd. and Disease Control Technologies LLC and commercialised under the trade names of Duranet, MAGNet and Royal Sentry, respectively. The subject of the extension of specifications for LN has been discussed by the JMPS in 2009. The Meeting agreed that - in contrast to other formulations - an extension of a specification to nominally similar LN of other manufacturers may not be possible with the data currently available and that the manufacturer and the product should be named in a footnote or in the specification.

Specifications may be revised and/or additional evaluations may be undertaken. Ensure the use of current versions by checking at the WHO Prequalification Team – Vector Control Products (PQT-VC) website.

2.3 Alpha-cypermethrin wash resistance index (MT 195, CIPAC Handbook O, p. 205, 2017)

The wash resistance index of alpha-cypermethrin from the netting, when determined, shall be within the range 95% to 101%.

3 Physical properties (Notes 6 & 12)

3.1 Netting mesh size

When counted by the method given in Note 8, the average number of complete holes/cm² shall be not less than 20 holes/cm² and the lowest value shall be not less than 20 holes/cm².

3.2 Dimensional stability of netting to washing (Note 9)

Not more than 10% shrinkage/expansion in both directions.

3.3 Bursting strength (Note 10)

The minimum bursting strength of the fabric shall be declared (not less than 400 kPa) and, when determined, the average shall be not less than that declared.

If seams are present, their average bursting strength shall be not less than the measured average for the fabric.

4 Storage stability

4.1 Stability at elevated temperature (MT 46.3.4, CIPAC Handbook O, p. 176, 2017)

After storage at 54 ± 2°C for 2 weeks, the determined average active ingredient content shall not be lower than 95%, relative to the determined average content found before storage (Note 11) and the product shall continue to comply with the clauses for:

- wash resistance index (2.3);
- dimensional stability to washing (3.2);
- bursting strength (3.3).

Note 1 The specification applies to manufactured nets and bulk netting.

Note 2 The linear density (denier) of the fibres cannot be measured in the manufactured net, but should be identified on the packaging.

Note 3 Occasional short lengths of loose thread present in the netting are not considered to be extraneous matter.

Note 4 Long-lasting insecticidal netting is expected to retain its insecticidal activity during its life span and through a number of washes.

Note 5 Flammability of the product is not part of the specification but it should be measured by the manufacturer, according to EN 1102, and the result presented on the package.

Note 6 Samples should be taken according to Figure 1 or on a convenient diagonal across the width of bulk material. Samples must be sufficiently large to conduct all tests required and representative of the net or netting. Except where seams are to be tested, do not test material within 10 cm of seams or selvages.

Use sharp scissors, or equivalent, to minimize damage to the fibres and fabric and thus avoid any consequential bias in the results of certain tests. Roll up the strips or squares and place them in labelled, new, clean aluminium foil prior to analysis. Samples should be kept cool, avoiding heat sources (including sun heat) or freezing, and analyzed/tested with minimum delay. Representative portions (sub-samples) for testing should be taken as described in each test method.

Test portion and replication requirements for physical test methods are defined in the methods or Notes referenced.

Note 7 The declared value for alpha-cypermethrin content in g/kg - 5.8 - is equivalent to 261 mg/m². The alpha-cypermethrin content may be declared as both g/kg and mg/m² but, in cases of dispute, g/kg values shall be used. If the active ingredient content is also specified as mg/m² of netting, the actual content on this basis is calculated from the measured values for active ingredient content in g/kg and mass of net/m². Mass of net/m² should be determined according to ISO 3801 (1977).

Note 8 In the absence of a simple or standard method to determine the size of holes, which may have complex shapes, in highly flexible fabrics, mesh size is determined by counting the number of holes in a square of the fabric. Counting may be done directly on the fabric or indirectly by taking a picture/photocopy of the fabric. Indirect methods may ease counting and provide a permanent record. The number of holes per measured area is converted in holes/cm². Before counting, the fabric should be conditioned according to ISO 139 (4 h, 20°C, 65% relative humidity).

Use a template to define the square of netting, taking care not to stretch or distort the fabric. The template should be a 1-2 mm thick rigid sheet, in/on which an accurately calibrated ($\pm 1\%$ in each dimension) square (e.g. 1 x 1 in or 5 x 5 cm) has been cut/marked. If a template is not available and a ruler must be used, great care is required to ensure that the area counted is square. Where practicable, one edge of the square to be counted should be aligned with a row of complete holes in the fabric. Incomplete holes $\geq \frac{1}{2}$ are counted as complete holes, whereas those $< \frac{1}{2}$ are not counted. Count 5 replicate squares selected according to Note 6, calculate the average and note the lowest value.

Another suitable method is the use of a stereomicroscope with an image analyser software, where the number of holes in a defined area is counted. In case of discrepancy between the netting mesh size using stereomicroscopic method and direct or indirect counting method, the stereomicroscopic method shall be the referee method.

Note 9 Method of preparation, marking and measuring: ISO 3759. Method of washing: ISO 6330. Method of calculation: ISO 5077. Size of test portions: 500 mm x 500 mm; mark off 350 mm x 350 mm within each test portion. Test a total of 4 replicate portions, 2 washed in each of 2 separate loads. Type of washing machine: ISO type A (front loading). Washing programme: 30°C Mild programme. Fill the washer with fabrics and ballast Type III (polyester ballast) up to 2 kg (according to the ISO 6330 standard). Drying: flat drying.

Note 10 Test method: ISO 13938 part 2 with conditioning of the fabric as specified in the ISO standard. The declared bursting strength, and testing for compliance with it, should be based on tests of 7.3 cm² areas of fabric. Five replicate tests should be conducted on samples taken at approximately equal distances on a diagonal across the netting, taking no sample within 10 cm of a border or seam. In made up rectangular nets, the "diagonal" may correspond to figure 1. The average of the 5 measurements is calculated.

The method to test seam bursting strength is identical to that used to test the fabric, except that 5 replicate tests should be made, with the seam centred on the test head. Up to 5 seams may be tested but, if there are < 5 seams, replicate measurements should be made on 1 or more seams, to provide a total of 5 measurements.

Note 11 Samples of the product taken before and after the storage stability test should be analyzed concurrently in order to reduce the analytical error.

Note 12 Normative references for physical tests:

Currently the following standards are the latest versions of the documents to be used for physical tests. The updated version of the standard should always be used when available.

ISO 139:2005/Amd.1:2011 Textiles - Standard atmospheres for conditioning and testing.-
Textiles - Standard atmospheres for conditioning and testing.

ISO 3801:1977 - Textiles - Woven fabrics - Determination of mass per unit length and mass per unit area.

EN 12127:1997 - Textiles - Fabrics - Determination of mass per unit area using small samples.

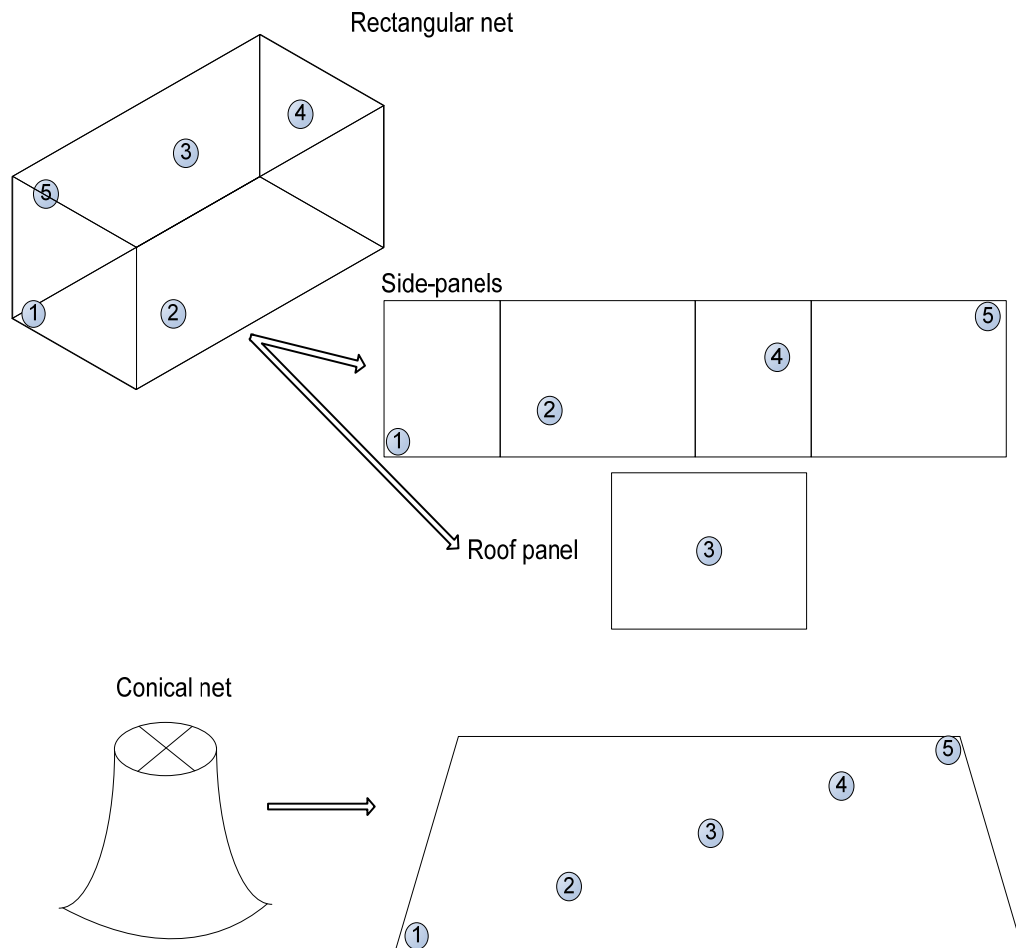
ISO 3759:2011 - Textiles - Preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change.

ISO 6330:2012 - Textiles - Domestic washing and drying procedures for textile testing.

ISO 5077:2007 - Textiles - Determination of dimensional change in washing and drying.

ISO 13938-2:1999 - Textiles - Bursting properties of fabrics - Part 2: Pneumatic method for determination of bursting strength and bursting distension

Figure 1 Recommended positions from which 5 pieces of netting should be taken from a made up bed net and combined to form a representative sample.



WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN LONG-LASTING (INCORPORATED INTO FILAMENTS) INSECTICIDAL NET

WHO specification 454/LN/3 (August 2015*)

This specification, which is PART ONE of this publication, is based on an evaluation of data submitted by the manufacturer whose name is listed in the evaluation report (454/2015.3). It should be applicable to relevant products of this manufacturer but it is not an endorsement of those products, nor a guarantee that they comply with the specification. The specification may not be appropriate for the products of other manufacturers, irrespective of the source of TC. The evaluation report (454/2015.3), given in PART TWO, form an integral part of this publication.

1 Description

The product shall be in the form of netting with a 4-locks knitting pattern (Note 1), consisting of 130 denier monofilament, high density polyethylene fibres, incorporating technical alpha-cypermethrin complying with the requirements of WHO specification 454/TC (January 2013) together with any necessary other formulants. The product shall appear clean and shall be free from visible extraneous matter (Note 2), visible damage (such as splitting or tearing) and visible manufacturing defects (such as poorly made seams or a weave that is either not uniform or too loose to remain uniform in use), and shall be suitable for use as an insecticidal net with long-lasting activity (Notes 3 & 4).

2 Active ingredient

2.1 Identity tests (454/LN/M/2, CIPAC Handbook M, p.40, 2009)

The active ingredient shall comply with an identity test and, where the identity remains in doubt, shall comply with at least one additional test.

2.2 Alpha-cypermethrin content (454/LN/M/3.2, CIPAC Handbook M, p.41, 2009) (Note 5)

The alpha-cypermethrin content shall be declared (4.5 g/kg) and, when determined, the average measured content shall not differ from that declared by more than $\pm 25\%$.

* This specification is applicable to long-lasting (incorporated into filaments) insecticidal nettings and nets produced by A to Z Textiles Mills Ltd. and commercialised under the trade name of MiraNet. The subject of the extension of specifications for LN has been discussed by the JMPS in 2009. The Meeting agreed that - in contrast to other formulations - an extension of a specification to nominally similar LN of other manufacturers was not possible with the data currently available and that the manufacturer and the product should be named in a footnote or in the specification.

Specifications may be revised and/or additional evaluations may be undertaken. Ensure the use of current versions by checking at the WHO Prequalification Team – Vector Control Products (PQT-VC) website.

2.3 Alpha-cypermethrin wash resistance index (MT 195) (Note 6)

The wash resistance index of alpha-cypermethrin from the netting, when determined, shall be within the range 95% to 101%.

3 Physical properties

3.1 Netting mesh size (Note 5)

When counted by the method given in Note 7, the average number of complete holes/cm² shall be not less than 20 holes/cm² and the lowest value shall be not less than 18 holes/cm².

3.2 Dimensional stability of netting to washing (Notes 5 & 8)

Not more than 5% shrinkage/expansion in both dimensions.

3.3 Bursting strength (Notes 5 & 9)

The minimum bursting strength of the fabric shall be declared (not less than 470 kPa) and, when determined, the average shall be not less than that declared.

If seams are present, their average bursting strength shall be not less than the measured average for the fabric.

4 Storage stability

4.1 Stability at elevated temperature (MT 46.3.4) (Note 10)

After storage at 54 ± 2°C for 2 weeks, the determined average active ingredient content shall not be lower than 95%, relative to the determined average content found before storage (Note 11) and the product shall continue to comply with the clauses for:

- wash resistance index (2.3);
- dimensional stability (3.2);
- bursting strength (3.3).

Note 1 The specification applies to manufactured nets and bulk netting.

The knitting pattern of this netting material is characterised by having a lock in each of the 4 corners of a hole – see figure 1 hereafter

Note 2 Occasional short lengths of loose thread present in made up nets are not considered to be extraneous matter.

Note 3 Long-lasting insecticidal netting is expected to retain its insecticidal activity during its life span and through a number of washes (public health products).

Note 4 Flammability of the product is not part of the specification but it should be measured by the manufacturer, according to 16CFR Part 1610, and the result presented on the package. The linear density (denier) of the fibres cannot be measured in the netting or the manufactured bed net but it should be identified on the packaging.

Note 5 Samples should be taken according to Figure 2 or on a convenient diagonal across the width of bulk material. Samples must be sufficiently large to conduct all tests required and representative of the net or netting. Except where seams are to be tested, do not test material within 10 cm of seams or selvages.

Use sharp scissors, or equivalent, to minimize damage to the fibres and fabric and thus avoid any consequential bias in the results of certain tests. Roll up the strips or squares and place them in labelled, new, clean aluminium foil prior to analysis. Samples should be kept cool, avoiding heat sources (including sun heat) or freezing, and analyzed/tested with minimum delay. Representative portions (sub-samples) for testing should be taken as described in each test method.

Note 6 The method MT 195 for determination of wash resistance index of LN was adopted as full CIPAC MT method in 2013. Prior to its publication in the next Handbook, copies of the method can be obtained through the CIPAC website, <http://www.cipac.org/prepubme.htm>

The net samples have to be stored at 40°C for 2 days between washings. The content of alpha-cypermethrin in the net pieces before and after washing should be determined by the method 454/LN/M/3.2, CIPAC Handbook M, p.41, 2009. Wash resistance index values higher than 100% up to 101% are acceptable due to the uncertainty of measurement of the CIPAC method MT 195.

Note 7 In the absence of a simple or standard method to determine the size of holes, which may have complex shapes, in highly flexible fabrics, mesh size is determined by counting the number of holes in a square of the fabric. Counting may be done directly on the fabric or indirectly by taking a picture/photocopy of the fabric. Indirect methods may ease counting and provide a permanent record. Before counting, the fabric should be conditioned according to ISO 139 (1973) (4 h, 20°C, 65% relative humidity).

Use a template to define the square of netting, taking care not to stretch or distort the fabric. The template should be a 1-2 mm thick rigid sheet, in/on which an accurately calibrated ($\pm 1\%$ in each dimension) square (e.g. 1 x 1 in or 5 x 5 cm) has been cut/marked. If a template is not available and a ruler must be used, great care is required to ensure that the area counted is square. Where practicable, one edge of the square to be counted should be aligned with a row of complete holes in the fabric. Incomplete holes $\geq \frac{1}{2}$ are counted as complete holes, whereas those $< \frac{1}{2}$ are not counted. Count 5 replicate squares selected according to Note 5, calculate the average and note the lowest value.

Note 8 Method of preparation, marking and measuring: ISO 3759 (2007). Method of washing: ISO 6330 (2001). Method of calculation: ISO 5077 (1984). Size of test portions: 500 mm x 500 mm; mark off 350 mm x 350 mm within each test portion. Test a total of 4 replicate portions, 2 washed in each of 2 separate loads. Type of washing machine: ISO type A (front loading). Washing programme: ISO type 8A (gentle cycle 30°C). Fill the washer with dummy load (with fabric as per ISO standard) up to the standard of 2 to 4 kg. Drying: flat drying.

Note 9 Test method: ISO 13938 part 2 (1999), with conditioning of the fabric as specified in the ISO standard. The declared minimum bursting strength, and testing for compliance with it, should be based on tests of 7.3 cm² areas of fabric. Five replicate tests should be conducted on samples taken at approximately equal distances on a diagonal across the netting, taking no sample within 10 cm of a border or seam. In made up rectangular nets, the "diagonal" may correspond to one produced by conceptually arranging the panels end to end). The average of the 5 measurements is calculated.

The method to test seam bursting strength is identical to that used to test the fabric, except that 5 replicate tests should be made, with the seam centred on the test head. Up to 5 seams may be tested but, if there are <5 seams, replicate measurements should be made on 1 or more seams, to provide a total of 5 measurements.

Note 10 The extension of the scope (CIPAC/4956) of CIPAC method MT 46.3 for the accelerated storage procedure of the LN formulations regarding determination of active ingredient content and wash resistance index was adopted as a provisional CIPAC MT method in 2014. Prior to its publication in the next Handbook, copies of the method can be obtained through the CIPAC website, <http://www.cipac.org/prepubme.htm>

Note 11 Samples of the product taken before and after the storage stability test should be analyzed concurrently in order to reduce the analytical error.

Figure 1 Knitting pattern of MiraNet LN.

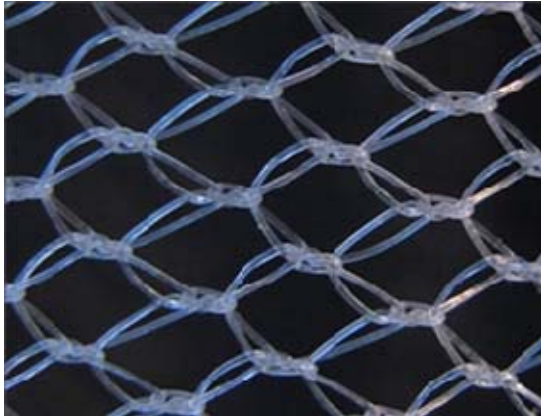
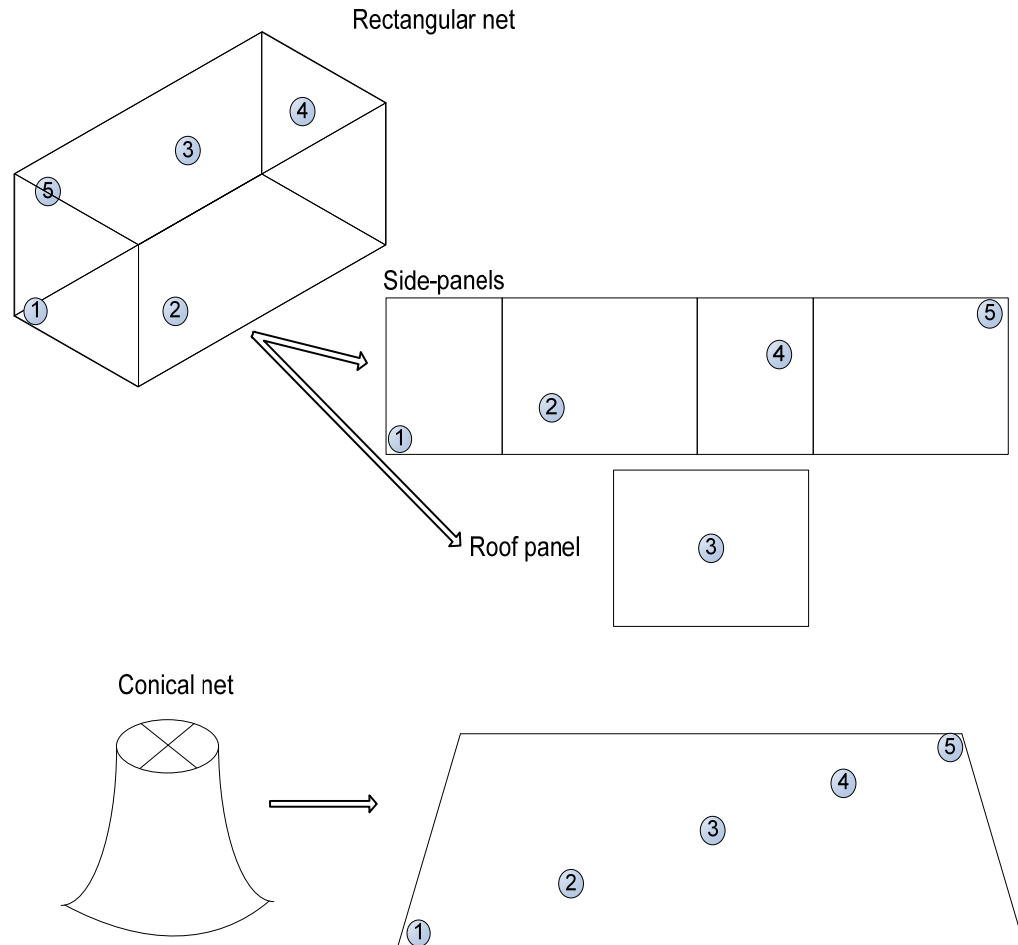


Figure 2 Recommended positions from which 5 pieces of netting should be taken from a made up bed net and combined to form a representative sample.



WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN LONG-LASTING (INCORPORATED INTO FILAMENTS) INSECTICIDAL NET

WHO specification 454/LN/4 (September 2020*)

This specification, which is PART ONE of this publication, is based on an evaluation of data submitted by the manufacturer whose name is listed in the evaluation report (454/2020). It should be applicable to relevant products of this manufacturer but it is not an endorsement of those products, nor a guarantee that they comply with the specification. The specification may not be appropriate for the products of other manufacturers, irrespective of the source of TC. The evaluation report (454/2020), given in PART TWO, forms an integral part of this publication.

1 Description

The product shall be in the form of netting (Note 1), consisting of 120 ± 5 denier (Note 2) monofilament, high density polyethylene fibres, incorporating technical alpha-cypermethrin complying with the requirements of WHO specification 454/TC (January 2013) together with any necessary other formulants. The product shall appear clean and shall be free from visible extraneous matter (Note 3), visible damage (such as splitting or tearing) and visible manufacturing defects (such as poorly made seams or a weave that is either not uniform or too loose to remain uniform in use), and shall be suitable for use as an insecticidal net with long-lasting activity (Note 4).

2 Active ingredients

2.1 Identity tests (454/LN/M/2, CIPAC Handbook M, p. 40, 2009)

The active ingredient shall comply with an identity test and, where the identity remains in doubt, shall comply with at least one additional test.

2.2 Alpha-cypermethrin content (454/LN/M/3.2, CIPAC Handbook M, p. 41, 2009) (Note 5)

The alpha-cypermethrin content shall be declared (5.8 g/kg) and, when determined, the average measured content shall not differ from that declared by more than $\pm 25\%$.

* This specification is applicable to long-lasting insecticidal nettings and nets produced by Disease Control Technologies LLC and commercialised under the trade name of Royal Sentry® 2.0. The subject of the extension of specifications for LN has been discussed by the JMPS in 2009. The Meeting agreed that - in contrast to other formulations - an extension of a specification to nominally similar LN of other manufacturers may not be possible with the data currently available and that the manufacturer and the product should be named in a footnote or in the specification.

Specifications may be revised and/or additional evaluations may be undertaken. Ensure the use of current versions by checking at the WHO Prequalification Team - Vector control products (PQT-VC) website.

2.3 Alpha-cypermethrin wash resistance index (MT 195, CIPAC Handbook O, p. 205, 2017) (Note 6)

The wash resistance index of alpha-cypermethrin from the netting, when determined, shall be within the range 90% to 100%.

3 Physical properties (Notes 5 & 13)

3.1 Fabric weight (mass per m²) (ISO 3801 / EN 12127)

The mass per unit area shall be declared (35 g/m²), and when determined, shall not differ from that declared by more than $\pm 10\%$.

3.2 Netting mesh size

When counted by the method given in Note 7, the average number of complete holes/cm² shall be not less than 17 holes/cm² and the lowest value shall be not less than 16 holes/cm².

3.3 Dimensional stability of netting to washing (Note 8)

Not more than 5% expansion and 10% shrinkage in both dimensions.

3.4 Bursting strength (ISO 13938:2) (Note 9)

The bursting strength of the fabric shall be declared (not less than 350 kPa) and, when determined, the average shall be not less than that declared.

If seams are present, their average bursting strength shall be not less than the measured average for the fabric.

3.5 Flammability (EN 1102) (Note 10)

Tested according to EN 1102 the following requirements should be achieved*:

After removing the ignition source the following fire phenomena should not occur: ignition, propagation of the flame or glow, flaming debris or ignition of the filter paper.

* Fulfilling the requirements above means that the flame speed rate is 0 mm/s, i.e., no flame or glow achieves first and third marker threads.

Formation of holes is allowed provided that the burnt or melted width and length of the holes does not exceed 50 mm and 150 mm, respectively.

4 Storage stability

4.1 Stability at elevated temperature (MT 46.4) (Note 11)

After storage at $54 \pm 2^\circ\text{C}$ for 2 weeks, the determined average active ingredients content shall not be lower than 95%, relative to the determined average content found before storage (Note 12) and the product shall continue to comply with the clauses for:

- wash resistance index (2.3),
- dimensional stability to washing (3.3),
- bursting strength (3.4).

Note 1 The specification applies to netting, in bulk, and to finished bed nets, which may be rectangular, conical, or other design.

Note 2 The linear density (denier) of the yarn cannot be measured in the netting or the manufactured bed net, but it should be identified on the packaging.

Note 3 Occasional short lengths of loose thread present in the netting are not considered to be extraneous matter.

Note 4 Long-lasting insecticidal netting is expected to retain its insecticidal activity during its life span and through a number of washes (public health products).

Note 5 Samples should be taken according to Figure 1 or on a convenient diagonal across the width of bulk material. Samples must be sufficiently large to conduct all tests required and representative of the net or netting. Except where seams are to be tested, do not test material within 10 cm of seams or selvages.

Use sharp scissors, or equivalent, to minimize damage to the fibres and fabric and thus avoid any consequential bias in the results of certain tests. Roll up the strips or squares and place them in labelled, new, clean aluminium foil prior to analysis. Samples should be kept cool, avoiding heat sources (including direct sunlight) or freezing, and analyzed/tested with minimum delay. Representative portions (sub-samples) for testing should be taken as described in each test method.

Note 6 The content of alpha-cypermethrin in the net pieces before and after washing should be determined by the CIPAC method 454/LN/M/3.2, CIPAC Handbook M, p. 41, 2009. Wash resistance index values as low as 90% and up to 100% are acceptable due to the inherent active ingredient content variation known to exist between samples taken from the same net.

Note 7 In the absence of a simple or standard method to determine the size of holes, which may have complex shapes, in highly flexible fabrics, mesh size is determined by counting the number of holes in a square of the fabric. Counting may be done directly on the fabric or indirectly by taking a picture/photocopy of the fabric. Indirect methods may ease counting and provide a permanent record. The number of holes per measured area is converted in holes/cm². Before counting, the fabric should be conditioned according to ISO 139 (4 h, 20°C, 65% relative humidity).

Use a template to define the square of netting, taking care not to stretch or distort the fabric. The template should be a 1-2 mm thick rigid sheet, in/on which an accurately calibrated ($\pm 1\%$ in each dimension) square (e.g. 1 x 1 in or 5 x 5 cm) has been cut/marked. If a template is not available and a ruler must be used, great care is required to ensure that the area counted is square. Where practicable, one edge of the square to be counted should be aligned with a row of complete holes in the fabric. Incomplete holes $\geq \frac{1}{2}$ are counted as complete holes, whereas those $< \frac{1}{2}$ are not counted. Count 5 replicate squares selected according to Note 6, calculate the average and note the lowest value.

Another suitable method is the use of a stereomicroscope with an image analyser software, where the number of holes in a defined area is counted. In case of discrepancy between the netting mesh size using stereomicroscopic method and direct or indirect counting method, the stereomicroscopic method shall be the referee method.

Note 8 Method of preparation, marking and measuring: ISO 3759. Method of washing: ISO 6330. Method of calculation: ISO 5077. Size of test portions: 500 mm x 500 mm; mark off 350 mm x 350 mm within each test portion. Test a total of 4 replicate portions, 2 washed in each of 2 separate loads. Type of washing machine: ISO type A (front loading). Washing programme: 30°C Mild programme. Fill the washer with fabrics and ballast Type III (polyester ballast) up to 2 kg (according to the ISO 6330 standard). Drying: flat drying.

Note 9 Test method: ISO 13938 part 2 with conditioning of the fabric as specified in the ISO standard. The declared bursting strength, and testing for compliance with it, should be based on tests of 7.3 cm² areas of fabric. Proposed specifications based on tests of 50 cm² area must be supported by data showing the suitability of the proposed value and its relationship to minimum of 250 kPa (which is based on 7.3 cm² area). Five replicate tests should be conducted on samples taken at approximately equal distances on a diagonal

across the netting, taking no sample within 10 cm of a border or seam. In made up rectangular nets, the “diagonal” may correspond to figure 1. The average of the 5 measurements is calculated.

The method to test seam bursting strength is identical to that used to test the fabric, except that 5 replicate tests should be made, with the seam centred on the test head. Up to 5 seams may be tested but, if there are < 5 seams, replicate measurements should be made on 1 or more seams, to provide a total of 5 measurements.

Note 10 Flammability test according to EN 1102, using the surface ignition method (position the burner perpendicular to the surface of the specimen).

The following observations shall be reported: the afterflame time, the afterglow time, the maximum burnt or damage width and length, whether or not flame reaches vertical edge of the specimen, whether or not a hole is burnt or melted in the sample, whether or not any flaming debris falls below the bottom edge of the sample and ignition of the filter paper.

Definitions according to ISO 4880:1997 (not included in EN 1102:2016 and EN ISO 6941:1995):

- Ignition: initiation of combustion.
- Combustion: exothermic reaction of a combustible substance with an oxidizer, accompanied by flames and/or glowing and/or emission of smoke.

Procedure for measuring burnt or damage width and length dimensions of each sample:

Remove the sample from the sample holder and place it on a flat horizontal surface. Place a rule on top of the test sample along the line of maximum damage and parallel with the length side of the test specimen. Measure the maximum length in millimetres from the lowest point of burnt or damage to the end of the hole. To measure the burnt or damage width, proceed in the same way but with the ruler parallel to the width side of the test sample. Proceed in the same way for the other 5 samples.

Note 11 MT 46.4 is the harmonized and revised version of MT 46.3 and was accepted as full CIPAC method in 2020. Prior to its publication in a next Handbook, copies of the method can be obtained through the CIPAC website, <http://www.cipac.org/index.php/methods-publications/pre-published-methods>

Note 12 Samples of the formulation taken before and after the storage stability test may be analyzed concurrently after the test in order to reduce the analytical error.

Note 13 Normative references for physical tests:

Currently the following standards are the latest versions of the documents to be used for physical tests. The updated version of the standard should always be used when available.

ISO 139:2005/Amd.1:2011 Textiles - Standard atmospheres for conditioning and testing.- Textiles - Standard atmospheres for conditioning and testing.

ISO 3801:1977 - Textiles - Woven fabrics - Determination of mass per unit length and mass per unit area.

EN 12127:1997 - Textiles - Fabrics - Determination of mass per unit area using small samples.

ISO 3759:2011 - Textiles - Preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change.

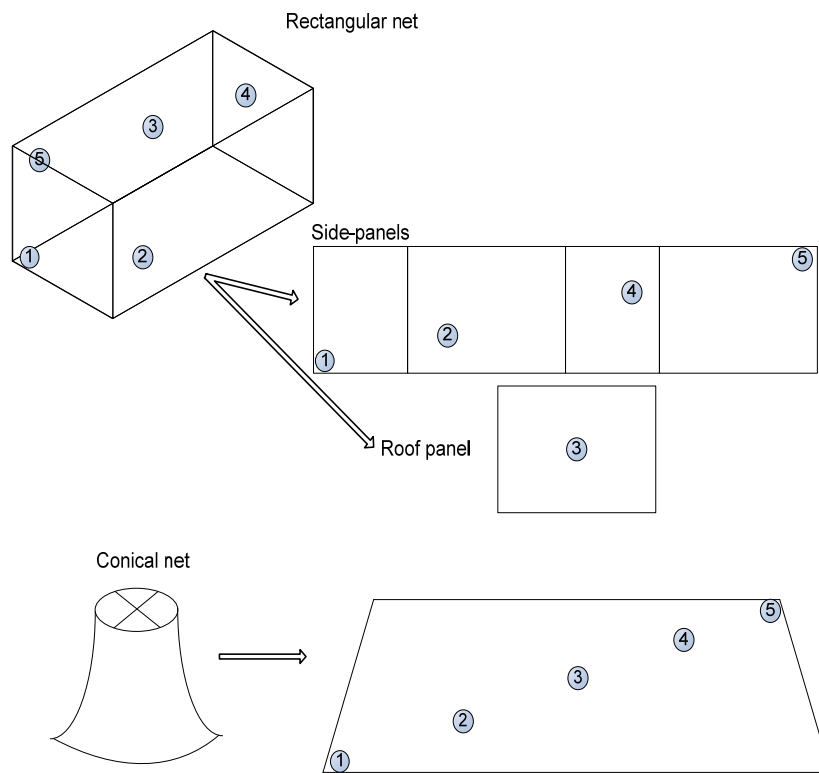
ISO 6330:2012 - Textiles - Domestic washing and drying procedures for textile testing.

ISO 5077:2007 - Textiles - Determination of dimensional change in washing and drying.

ISO 13938-2:1999 - Textiles - Bursting properties of fabrics - Part 2: Pneumatic method for determination of bursting strength and bursting distension

EN 1102:2016 - Textiles and textile products. Burning behaviour. Curtains and drapes. Detailed procedure to determine the flame spread of vertically oriented specimens.

Figure 1 Recommended positions from which 5 pieces of netting should be taken from a made up bed net and combined to form a representative sample.



PART TWO
EVALUATION REPORTS

ALPHA-CYPERMETHRIN

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WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN

FAO/WHO EVALUATION REPORT 454/2020

Recommendations

The Meeting recommended the following.

The specification for Royal Sentry® 2.0 [alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net], proposed by Disease Control Technologies LLC, and as amended, should be adopted by WHO.

Appraisal

A draft specification and supporting data for Royal Sentry® 2.0 [alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net], provided by Disease Control Technologies LLC, were considered by the Meeting for development of a new WHO specification. The proposed specification was in agreement with the LN specification guideline of the FAO/WHO Manual on pesticides specifications (FAO/WHO 2016). The data and test reports provided by the manufacturer to support this new specification were generated by different laboratories.

The LN under consideration (Royal Sentry® 2.0) is an alpha-cypermethrin incorporated long-lasting insecticidal net of 120 ± 5 denier made from a proprietary blend of High Density Polyethylene (HDPE). The insecticide is incorporated into the monofilament yarn during the extrusion process from a proprietary Linear Low Density Polyethylene (LLDPE) masterbatch containing alpha-cypermethrin and other formulants. The finished product contains 5.8 g/kg alpha-cypermethrin. The fabric construction relies on a warp knit using a 4-lock stitch.

A WHO specification (454/LN/2) is currently published for LN incorporating alpha-cypermethrin at 5.8 g/kg from Shobikaa Impex Private Limited (Duranet), V.K.A. Polymers Pvt. Ltd. (MAGNet) and Disease Control Technologies LLC (Royal Sentry), but these LN are of 150 denier yarn. Moreover, they have different physical-chemical specification clauses than Royal Sentry® 2.0. The Meeting concluded that a new specification had to be developed for this new product.

The alpha-cypermethrin technical material incorporated into the LN is from a source compliant with the existing WHO specification for alpha-cypermethrin TC (Tagros Chemical India Pvt. Ltd.).

Description

The Meeting concluded that the description of Royal Sentry® 2.0 made of 120 ± 5 denier monofilament high density polyethylene yarn incorporating alpha-cypermethrin complies with the requirements of the Manual.

Active ingredient

The nominal content of alpha-cypermethrin in Royal Sentry® 2.0 is 5.8 g/kg, with a tolerance of $\pm 25\%$, corresponding to 203 mg/m^2 (fabric weight = 35 g/m^2).

Data provided by the manufacturer for alpha-cypermethrin content on 5 nets from 3 different batches showed that the product complies with the target dose of 5.8 g/kg \pm 25% (mean = 5.89 g/kg, range = 5.35 - 6.75 g/kg, RSD = 3.21%, n = 15). The CIPAC method 454/LN/M/3.2 published in Handbook M was used for the determination of the active ingredient content.

Spatial variation data provided by the manufacturer by measuring the active ingredient content on 3 individual net pieces of nets from 3 different batches showed an acceptable homogeneity of the active ingredient content within the net (mean = 5.64 g/kg, 5.84 g/kg and 6.10 g/kg; RSD = 3.52%, 9.45% and 9.29%).

Data verifying the content of alpha-cypermethrin in nets used in efficacy studies were also provided. All tested samples complied with the declared content (5.8 g/kg \pm 25%).

Active ingredient wash resistance index

An adequate amount of active ingredient must be present at the surface of the LN, for efficacy reasons, whereas the majority must reside within the LN, to avoid excessive losses during washing and to provide a reservoir from which the surface is replenished with active ingredient. The incorporation process can influence the retention of alpha-cypermethrin when the LN is subjected to repeated washing. The monitoring of the depletion of the active ingredient content by washing is accomplished by analysing separate washed and unwashed pieces of the same fabric using the CIPAC method MT 195 for determination of wash resistance index of LN, published in the Handbook O.

The manufacturer provided data on 3 nets (3 different batches) using the CIPAC method MT 195 that showed that the alpha-cypermethrin wash resistance index was 96.0%, 98.0% and 99.2%. The manufacturer proposed to specify a range of 90% to 100%, and this was agreed by the Meeting.

When washed up to 25 times, Royal Sentry 2.0 showed an exponential decay of alpha-cypermethrin content in function of the number of washes (free-migration stage behaviour). The overall alpha-cypermethrin retention after 4 washes and 20 washes was 91.6% and 71.9%, corresponding to an average retention index per wash of 97.8% and 98.4%, as calculated by the exponential regression curve after 4 washes and 20 washes, respectively. This is in agreement with the specification tolerance.

Relevant impurities

There are no relevant impurities identified in the published WHO specification 454/TC for alpha-cypermethrin, therefore no impurity was specified for Royal Sentry® 2.0.

Physical properties

The manufacturer provided fabric weight data for 3 nets (3 different batches), determined by ISO 3801. The fabric weight was in the range 35.1 - 35.4 g/m² which complies with the specified limit of 35 g/m² ± 10%.

The manufacturer provided netting mesh size data for 3 nets (3 different batches) showing that the average number of complete holes/cm² ranged from 20.3 to 20.4 holes/cm² and that the minimum number of complete holes/cm² was 20.2 holes/cm². The manufacturer proposed specification clauses for netting mesh size of not less than 17 holes/cm² with the lowest value of not less than 16 holes/cm². The Meeting considered that this was acceptable.

Test data provided by the manufacturer for 3 nets (3 different batches) showed that the dimensional stability to washing complies with the specified limit of not more than 5% expansion and 10% shrinkage.

The bursting strength measured by the recommended ISO standard 13938-2:1999 (pneumatic method) for 3 nets (3 different batches) was determined to be in the range 380 - 413 kPa. On this basis the specification clause of 350 kPa was proposed and was considered acceptable by the Meeting.

Flammability was tested using the EN 1102 method for 3 nets (3 different batches). No ignition, propagation of flame or glow was observed. There was no flaming debris and no ignition of the filter paper. The meeting concluded that Royal Sentry® 2.0 complies with the specification clause.

Storage stability

The manufacturer provided data for 3 nets (3 different batches) after storage at 54°C for 2 weeks showing that the average alpha-cypermethrin content is higher than 95% relative to the average content found before storage (95.9%, 97.9% and 96.2%) and that the wash resistance index remains within the limits of the proposed specification clause (wash resistance index of 99.3%, 95.7% and 97.2% after storage).

The manufacturer also provided data for 3 nets (3 different batches) showing that the dimensional stability of the net to washing and the bursting strength remains essentially unchanged after storage at 54°C for 2 weeks.

The Meeting concluded that the data demonstrate that Royal Sentry® 2.0 can comply with the relevant clauses following storage stability testing at 54°C for 2 weeks.

ANNEX 1: REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
	Disease Control Technologies	2018	Royal Sentry® 2.0 LLIN Submission Dossier for WHO PQT Evaluation Under a New Specification. Dossier submitted by Diseases Control Technologies LLC to WHO Prequalification Team. July 20, 2018.
7191164623-CHM17/03 to 08-CSY	Xiao Zhou	2017	Chemical Analysis of Mosquito Net Sample. Reports N° 7191164623-CHM17/03 to 08-CSY of TÜV SÜD PSB Singapore for Diseases Control Technologies LLC, August 15 and 17, 2017.
7191164623-EEC17/01-02-09-10-11-12-13-CSL	Shareen Chan	2017	Testing of mosquito netting submitted by Disease Control Technologies, LLC on 08 Jun 2017. Reports N° 7191164623-EEC17/01-02-09-10-11-12-13-CSL of TÜV SÜD PSB Singapore for Diseases Control Technologies LLC, July 05, 2017.
1702 CREC/LSHTM	Corine Ngufor	2018	Phase II experimental hut evaluation of the efficacy and wash resistance of Royal Sentry® 2.0 LN against pyrethroid resistant <i>Anopheles gambiae</i> s/ in Cove, Benin. Report N° 1702 CREC/LSHTM of London School of Hygiene & Tropical Medicine for Disease Control Technologies LLC, May 04, 2018.
18074	A. Vijayakumar	2018	Chemical Evaluation of DuraNet, Royal Sentry® 2.0, Royal Guard® and PPF Only LN Samples Following the Phase II Hut Trials Conducted in Cove, Benin by London School of Hygiene and Tropical Medicine. Report N° 18074 of International Institute of Biotechnology and Toxicology (IIBAT), Tamil Nadu, India for Disease Control Technologies LLC, July 07, 2018. GLP.
17/01	Sarah Moore	2018	Phase I evaluation of alpha-cypermethrin (Royal Sentry® 2.0) long-lasting insecticidal nets compared to DuraNet® against susceptible <i>Anopheles gambiae</i> s.s. and pyrethroid-resistant <i>Anopheles arabiensis</i> strains. Report N° 17/01 of Ifakara Health Institute (IHI) for Disease Control Technologies LLC, July 19, 2018.
18075	A. Vijayakumar	2018	Chemical Evaluation of DuraNet, Royal Sentry® 2.0, Royal Guard® and PPF Only LN Samples Following the Phase I Laboratory and Phase II Hut Trials Conducted in Tanzania by Ifakara Health Institute (IHI). Report N° 18075 of International Institute of Biotechnology and Toxicology (IIBAT), Tamil Nadu, India for Disease Control Technologies LLC, July 17, 2018. GLP.
	FAO/WHO	2016	Manual on development and use of FAO and WHO specifications for pesticides. Second revision of the 1 st edition. FAO, Rome and WHO, Geneva, March 2016 (internet publications).
	WHO	2019	WHO Prequalification Team Vector Control Decision Document Royal Sentry 2.0 (Long Lasting Mosquito Net Treated with Alpha-cypermethrin). Available on the WHO PQT-VC website.

WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN

FAO/WHO EVALUATION REPORT 454/2019

Recommendations

The Meeting recommended the following:

The minimum bursting strength limit of the existing WHO specification 454/LN/2 for alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net (LN) should be revised from 450 kPa to 400 kPa.

Appraisal

Shobikaa Impex Private Limited (India), manufacturer of alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net (LN) of the trademark Duranet, requested the Meeting to revise the minimum bursting strength limit of the existing WHO specification 454/LN/2 from 450 kPa to 400 kPa. The main reason is to cover small variations encountered during the manufacturing of the LN and to specify a more realistic limit.

The manufacturer provided quality control data from their own laboratory on 5 different batches but also a test report from another laboratory on the 5 same batches to support the change of the bursting strength specification limit. The test method used was the recommended ISO 13938-2:1999 (pneumatic method). The manufacturer also provided the Meeting with a statement declaring that the manufacturing process of Duranet did not change, and that the other parameters are not affected by this change.

The Meeting agreed with this request, considering that the new proposed limit is less stringent than the existing one, so there is no adverse impact for the other manufacturers producing MAGNet and Royal Sentry whose the equivalence with Duranet was granted.

The Meeting also proposed:

- to update the references to the CIPAC methods MT 195 for wash resistance index and MT 46.3.4 for stability at elevated temperature which are now published in the Handbook O.
- to update in the specification the footnotes for physical tests (netting mesh size, dimensional stability to washing and bursting strength) according to the last updated version (July 2019) of the LN specification template.

The Meeting noted that, according to the LN specification template of the 2016 first edition - third revision of the FAO/WHO Manual on specifications for pesticides and the last updated version (July 2019) of the LN specification template, the additional clauses of fabric weight (mass per m²) and flammability should be included in the specification. The Meeting finally concluded that data requirements for fabric weight and flammability will be part of a WHO PQT-VC data call in to all manufacturers whose the LN specifications do not yet include these parameters and clauses.

ANNEX 1: REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
	M. Arunkumar	2017	Bursting strength of Duranet. Test reports submitted to JMPS. Shobikaa Impex Private Limited, 12 September 2017, 14 September 2017, 23 October 2017 and 25 October 2017.
042018095	A. Ramesh	2018	Analytical test report on bursting strength of alpha-cypermethrin – Duranet LN. Study No. 042018095 of 24 February 2018.

WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN

FAO/WHO EVALUATION REPORT 454/2014.3

Recommendations

The Meeting recommended the following.

The specification for alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net, with a 4-locks knitting pattern, proposed by A to Z Textile Mills Ltd., and as amended, should be adopted by WHO.

Appraisal

A draft specification and supporting data for alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net (LN), provided by A to Z Textile Mills Ltd. were considered by the Meeting for development of a new WHO specification. The data and test reports provided by the manufacturer to support this specification were generated by the manufacturer.

The LN under consideration (MiraNet) is a warp-knitted fabric in which alpha-cypermethrin is incorporated into mono-filament polyethylene fibres of 130 denier at the target dose of 4.5 g alpha-cypermethrin per kg of netting material.

The manufacturer provided a written confirmation that the active ingredient (alpha-cypermethrin) incorporated into the LN is from a source compliant with the existing WHO specification for alpha-cypermethrin TC (Tagros Chemicals India Ltd.).

The alpha-cypermethrin (incorporated into filaments) LN produced by this manufacturer was tested and evaluated by WHOPES and a time-limited interim recommendation for its use in malaria prevention and control was issued in 2015 (WHO 2015).

Description

The Meeting agreed that the specification should be applied to netting, in bulk, and to finished bed nets, made from 130 denier mono-filament polyethylene fibres. The manufacturer informed the Meeting that the knitting pattern of this netting material is characterized by a lock in each of the 4 corners of a hole for the purpose of strength and ravelling resistance. The Meeting agreed to reflect this property in the description clause and to include a figure of this knitting pattern. Nevertheless this property was not supported by a relevant physical test.

Active ingredient content

The target dose of alpha-cypermethrin is 4.5 g/kg with a tolerance of $\pm 25\%$. Data provided by the manufacturer on 97 net samples showed that the measured active ingredient content fully complies with this limit, with a very good homogeneity of the active ingredient content between the net pieces (RSD = 4.4%).

The CIPAC methods 454/LN/M/2 & 3.2 published in Handbook M are fully applicable for identification and determination of alpha-cypermethrin content in MiraNet. The content of alpha-cypermethrin is determined by capillary gas chromatography using flame ionisation detection (GC-FID) and dioctyl phthalate as internal standard, after extraction by refluxing with xylene and 10% citric acid solution for 30 minutes. Citric acid is added to avoid the epimerization of alpha-cypermethrin both during the extraction and in the inlet of the GC.

The WHOPES Phase I testing and evaluation of MiraNet showed that alpha-cypermethrin content in the unwashed nets fully comply with the target dose of 4.5 g/kg ($\pm 25\%$), and a good homogeneity of the active ingredient distribution within and between the nets. The within-net variation, expressed as the relative standard deviation (RSD) of the alpha-cypermethrin content found on the 5 pieces taken from each side and roof of the same net ranged from 0.5% to 4.3%. The between-net variation, expressed as the relative standard deviation (RSD) of the alpha-cypermethrin content found on 4 different nets, was 1.0% (CRA-W 2013, WHO 2015).

The WHOPES Phase II trials conducted in Thailand, Tanzania and Côte d'Ivoire showed that MiraNet complies with the target dose of 4.5 g/kg $\pm 25\%$ (n = 8) and a good homogeneity of the distribution of alpha-cypermethrin within the nets. The within-net variation, expressed as the relative standard deviation (RSD) of the alpha-cypermethrin content found on 5 different net pieces cut from each 8 nets ranged from 0.9% to 8.2% (CRA-W 2014, CRA-W 2015, WHO 2015).

Active ingredient wash resistance index

An adequate amount of the active ingredient must be present at the surface of the LN, for efficacy reasons, whereas the majority must reside within the LN, to avoid excessive losses during washing and to provide a reservoir from which the surface is replenished with active ingredient. Depletion of total active ingredient content by washing is accomplished by analyzing separate washed and unwashed pieces of the same fabric (wash resistance index).

Where the active ingredient is incorporated into filaments, rapid loss of active ingredient is not likely to occur during washing but, if re-equilibration to the surface is too slow, the product may be ineffective for an unacceptable period of time after washing. Alternatively, if the re-equilibration is too rapid, the surface concentration could become higher than expected, leading to higher losses of active ingredient during washing and possibly increased user exposure to the active ingredient.

The method MT 195 for determination of wash resistance index of LN was adopted as full CIPAC method in 2013. This method is a further standardization of the WHO washing method published in the "WHO Guidelines for laboratory and field testing of long-lasting insecticidal mosquito nets", document WHO/CDS/WHOPES/GCDPP/2005.11 (WHO 2005). Briefly, the wash resistance index is determined by analyzing net samples in triplicate representing wash points 0 and 4 for total active ingredient content and calculating the average wash resistance index per wash using the

equation for a free migration stage behaviour. A wash resistance index per wash of 95% indicates that at least 95% of the insecticide or synergist present in samples washed 1 to 3 times is still present after an additional wash step. The wash resistance index applies to the average obtained from triplicate tests performed on net pieces removed from the same net or batch of netting (CIPAC 2013).

The manufacturer provided data on 25 net samples unwashed and washed 4 times according to the CIPAC method MT 195. The wash resistance index ranged from 99.0% to 100.0% with a RSD of 0.3%. The manufacturer proposed to specify a range of 98% to 99%. This range was considered by the Meeting to be too narrow considering the uncertainty of measurement of the CIPAC method MT 195 and the potential inter-laboratory reproducibility. The manufacturer and the Meeting finally agreed to specify a range of 95% to 101%.

The WHOPES Phase I testing results on alpha-cypermethrin content and associated biological efficacy of MiraNet washed up to 25 times (according to the WHO washing method) showed an exponential decay of the alpha-cypermethrin content in function of the number of washes (free-migration stage behaviour). The overall alpha-cypermethrin retention after 20 washes was 95.7%, corresponding to an average wash resistance index of 99.8%, as estimated by the exponential regression curve (CRA-W 2013, WHO 2015).

Relevant impurities

There are no relevant impurities identified in the existing WHO specification 454/TC for alpha-cypermethrin (January 2013).

Physical properties

The specification for netting mesh size of minimum 20 holes/cm² as average and minimum 18 holes/cm² as minimum value are supported by data provided by the manufacturer on 5 different batches.

Data for dimensional stability to washing provided by the manufacturer on several samples prove that MiraNet fully comply with the maximum 5% shrinkage / expansion standard given in the LN guideline of the FAO/WHO Manual.

The manufacturer proposed to specify a lower limit of 470 kPa for the bursting strength and this limit was supported by data on fabric and seams of several samples of MiraNet.

Storage stability

The manufacturer provided data on several samples of MiraNet showing that after storage at 54°C for 2 weeks, the average alpha-cypermethrin content is higher than 95% of the average content found before storage, and that the wash resistance index, dimensional stability to washing and bursting strength remain unchanged.

ANNEX 1: REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
	A to Z Textile Mills Ltd.	2013	MiraNet : insecticide content, wash resistance index and physical characteristics. Data package submitted to JMPS. A to Z Textile Mills Ltd., October 2013.
	A to Z Textile Mills Ltd.	2014	Physico-chemical properties of MiraNet. Additional data submitted to JMPS. A to Z Textile Mills Ltd., May 2014.
	CIPAC	2013	MT 195. Wash resistance index of LN, available at http://www.cipac.org/prepubme.htm
RE/13/U10/23372	CRA-W	2013	Determination of alpha-cypermethrin in MiraNet from the WHOPES Phase I testing and evaluation of MiraNet. Test report RE/13/U10/23372 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, October 07, 2013.
RE/14/U10/23507/1	CRA-W	2014	Determination of alpha-cypermethrin in MiraNet and MAGNet from the WHOPES Phase II testing and evaluation of MiraNet in Thailand. Test report RE/14/U10/23507/1 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, October 29, 2014.
RE/14/U10/23507/2	CRA-W	2015	Determination of alpha-cypermethrin in MiraNet and MAGNet from the WHOPES Phase II testing and evaluation of MiraNet in Tanzania. Test report RE/14/U10/23507/2 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, March 09, 2015.
RE/14/U10/23507/3	CRA-W	2015	Determination of alpha-cypermethrin in MiraNet and MAGNet from the WHOPES Phase II testing and evaluation of MiraNet in Tanzania. Test report RE/14/U10/23507/3 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, March 02, 2015.
	FAO/WHO	2010	Manual on development and use of FAO and WHO specifications for pesticides. Second revision of the 1 st edition. FAO, Rome and WHO, Geneva, November 2010 (internet publications).
	WHO	2015	Determination of fabric strength of long-lasting insecticidal nets. Report of a WHO consultation, Geneva, 20-22 August 2014. WHO, Geneva, document WHO/HTM/NTD/WHOPES/2015.1.
	WHO	2015	Report of the Eighteenth WHOPES Working Group Meeting, WHO/HQ, Geneva, 29 June - 1 July 2015.

WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN

FAO/WHO EVALUATION REPORT 454/2014.1

Recommendations

The Meeting recommended the following:

The minimum bursting strength limit of the existing WHO specification 454/LN/2 for alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net (LN) should be revised from 500 kPa to 450 kPa.

Appraisal

Shobikaa Impex Private Limited, manufacturer of alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net (LN) of the trademark Duranet requested the Meeting to revise the minimum bursting strength limit of the existing WHO specification 454/LN/2 from 500 kPa to 450 kPa.

The manufacturer provided the Meeting with data on 5 net pieces from 4 samples of Duranet from the same batch where the bursting strength was measured using the method ISO 13938 - Part 1 (hydraulic method) and the method ISO 13938 - Part 2 (pneumatic method). It appeared that the bursting strength measured using the pneumatic method is systematically lower (50 kPa on average) than this measured using the hydraulic method. This difference in results between the two methods was confirmed by additional data on 20 net samples. As the bursting strength value measured by the pneumatic method is very close to the limit of 500 kPa of the existing specification, the manufacturer argued that the existing limit of 500 kPa was too borderline and asked the Meeting to revise it to 450 kPa.

The Meeting agreed with this proposal considering the following elements:

- The result for bursting strength can vary depending on the method used (hydraulic or pneumatic), the production batches and the laboratories.
- The revised limit of 450 kPa is still well above the limit currently adopted in the existing WHO specifications for other LNs of the same fabric (250 to 350 kPa).
- As the new proposed limit is less stringent than the existing one, there is no adverse impact for the other manufacturers producing MAGNet and Royal Sentry for which the equivalence with Duranet was granted. Moreover WHO was informed by these two other manufacturers that they fully support this change.

ANNEX 1: REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
	Shobikaa Impex Private Limited	2014	Bursting strength of Duranet. Data submitted to JMPS. Shobikaa Impex Private Limited, April 2014.
	WHO	2005	Technical consultation on specifications and quality control of netting materials and mosquito nets. 29 November - 02 December 2005. WHO Headquarters, Geneva, Switzerland.

WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN

FAO/WHO EVALUATION REPORT 454/2013

Recommendations

The Meeting recommended the following:

- (i) The wash resistance index tolerance of the existing WHO specification 454/LN/2 for alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net (LN) using the new CIPAC washing method MT 195 should be revised to the range of 95% to 101%.
- (ii) The revised specification should get the status of full WHO specification.

Appraisal

The CIPAC method MT 195 for determination of wash resistance index of LN was adopted as full CIPAC method in 2013. This method is a further standardization of the WHO washing method published in the “WHO Guidelines for laboratory and field testing of long-lasting insecticidal mosquito nets”, document WHO/CDS/WHOPES/GCDPP/2005.11, WHO, Geneva, 2005 (WHO 2005). Briefly, the wash resistance index is determined by analyzing net samples in triplicate representing wash points 0 and 4 for total active ingredient content and calculating the average wash resistance index per wash using the equation for a free migration stage behaviour. A wash resistance index per wash of 95% indicates that at least 95% of the insecticide present in samples washed 1 to 3 times is still present after an additional wash step. The wash resistance index applies to the average obtained from triplicate tests performed on net pieces removed from the same net or batch of netting (CIPAC 2012 and 2013).

The Meeting requested the manufacturers producing alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net (LN) to generate new wash resistance index data using the new CIPAC washing method and to propose a revised wash resistance index clause based on these data. Supporting data and information were provided by Shobikaa Impex Private Limited, V.K.A. Polymers Pvt. Ltd. and Disease Control Technologies LLC (LN).

In a letter dated 30 April 2012, Clarke Mosquito Control Products, Inc. (USA) informed WHOPES that it had sold Duranet product to Shobikaa Impex Private Limited, India, effective 26 March 2012.

Shobikaa Impex Private Limited

The data provided by Shobikaa Impex Private Limited on white and blue Duranet washed 4 times according to the new CIPAC washing method MT 195 showed a wash resistance index in the range of 100% to 101%.

V.K.A. Polymers Pvt. Ltd.

The data provided by V.K.A. Polymers Pvt. Ltd. on MAGNet washed 1, 3, 5, 10, 15, 20 and 25 times according to the new CIPAC washing method MT 195 showed a wash resistance index in the range of 97% to 99% (99% after 3 and 5 washes).

Disease Control Technologies LLC

The data provided by Disease Control Technologies LLC on white and blue Royal Sentry washed 4 times according to the new CIPAC washing method MT 195 showed a wash resistance index in the range of 99% to 100%.

The three manufacturers proposed to maintain the current limit of 95% to 99% of the existing specification of their LNs. Nevertheless, as observed in some data provided by the manufacturers, the measurement of the wash resistance index can sometimes lead to values slightly higher than 100%. It does not mean a too slow release of the active ingredient on the surface of the net, but it is due to the uncertainty of measurement of the CIPAC method MT 195. The Meeting agreed also that in order to meet the objective of the wash resistance index test, a range of values instead of a minimum value should be specified for the wash resistance index. The Meeting concluded that the wash resistance index tolerance of the existing WHO specification 454/LN/2 for alpha-cypermethrin (incorporated into filaments) LN using the new CIPAC washing method MT 195 should be revised to the range of 95% to 101%.

ANNEX 1: REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
	Butenhoff Andy	2013	Wash resistance index data on Royal Sentry using CIPAC method 4827/m. Data from Disease Control Technologies LLC for JMPS, January 16, 2013.
	CIPAC	2012	MT 19X. Wash resistance index of LN, CIPAC method 4827/m.
	CIPAC	2012	MT 19X. Wash resistance index of LN, small scale collaborative trial, CIPAC report 4828/R.
	CIPAC	2013	MT 195. Wash resistance index of LN, available at http://www.cipac.org/cipacpub.htm
	CIPAC	2013	Wash resistance index of LN - Validation of the new CIPAC Washing Method, CIPAC report 4909/R.
	FAO/WHO	2010	Manual on development and use of FAO and WHO specifications for pesticides. Second revision of the 1 st edition. FAO, Rome and WHO, Geneva, November 2010 (internet publications).
	Natarajan Ramanathan	2012	Wash resistance index of MAGNet following CIPAC method 4827/m. Report of V.K.A. Polymers Pvt. Ltd. for JMPS, December 23, 2012.
CH:GL:3110051 4-70 to 80	SGS	2013	Alpha-cypermethrin content in Royal Sentry. Reports CH:GL:31100514-70 to 80 of SGS for Disease Control Technologies LLC, December 20, 2012.
7191044960- CHM12/01 to 12-CSY	Sihai Li	2013	Analysis of insecticide treated nets. Reports 7191044960-CHM12/01 to 12-CSY of TÜV SÜD PSB Singapore for Shobikaa Impex Private Limited, October 22, 2012.
	Sivasamy Marappan	2013	Wash resistance index data on Duranet using CIPAC method 4827/m. Data from Shobikaa Impex Private Limited for JMPS, January 28, 2013.
	WHO	2005	Guidelines for laboratory and field testing of long-lasting insecticidal mosquito nets. Document WHO/CDS/WHOPES/GCDPP/2005.11. WHO, Geneva, 2005.

WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN

FAO/WHO EVALUATION REPORT 454/2011.2

Recommendations

The Meeting recommended the following.

The existing WHO interim specification 454/LN/2 for alpha-cypermethrin (incorporated into filaments) LN should be extended to encompass the corresponding product of Disease Control Technologies LLC.

Appraisal

Supporting data and information for alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net (LN), provided by Disease Control Technologies LLC, were considered by the Meeting for extension of the existing WHO interim specification 454/LN/2 (October 2009).

The LN under consideration (Royal Sentry) is a warp knitted fabric netting material made from 150 denier monofilament yarn composed of high density polyethylene containing technical alpha-cypermethrin. The manufacturer confirmed that the active ingredient incorporated into the LN is from a source compliant with the existing WHO specification for alpha-cypermethrin TC (Tagros).

Royal Sentry was tested and evaluated by WHOPES who concluded that the bio-efficacy and wash resistance is comparable to the reference product (DuraNet). WHOPES recommended also the extension of the WHO specifications for alpha-cypermethrin (incorporated into filaments) LN to Royal Sentry, subject to satisfactory assessment of the physical and chemical properties of the product by JMPS (WHO 2011).

Description clause

The Meeting concluded that the description of Royal Sentry consisting of 150 denier monofilament, high density polyethylene fibres, incorporating technical alpha-cypermethrin complies with the existing WHO interim specification 454/LN/2.

Active ingredient identity and content clauses

The declared alpha-cypermethrin content is 5.8 g/kg. Data provided by the manufacturer and generated by an independent laboratory on 3 nets showed that the measured active ingredient content complies with the existing WHO interim specification 454/LN/2.

Special attention needs to be paid to control random variations in the distribution of the insecticide within the net and between nets. The spatial variation data provided by the manufacturer and generated by an independent laboratory (active ingredient content on 5 individual net pieces taken according to the Figure 1 of the specification) showed a good homogeneity of the active ingredient content within the net (within-net RSD = 2.15%, n = 5).

WHOPES Phase I data showed that alpha-cypermethrin content in Royal Sentry complies with the target dose of 5.8 g/kg ($\pm 25\%$) and that the between-net variation of alpha-cypermethrin content is very low (RSD = 2.5-4.2%, n = 4) (WHO 2011).

The CIPAC method 454/LN/M/3.2 (alpha-cypermethrin incorporated into filaments) published in the CIPAC Handbook M and involving extraction by heating under reflux for 30 minutes with xylene in presence of citric acid, addition of dioctyl phthalate as internal standard, and determination by gas chromatography with flame ionization detection (GC-FID), was used for the studies and is fully applicable for Royal Sentry.

Alpha-cypermethrin retention index clause

An adequate amount of active ingredient must be present at the surface of the LN, for efficacy, whereas the majority must reside within the LN, to avoid excessive losses during washing and to provide a reservoir from which the surface is replenished with active ingredient. Depletion of total active ingredient content by washing (retention index) is accomplished by analyzing separate washed and unwashed pieces of the same fabric. As the diffusion processes in solid materials are significantly slower than in solution, a certain time period is necessary to re-establish the equilibrium level of the active ingredient at the surface of polymer.

Currently (2011), CIPAC is developing a wash method for the determination of the retention behavior of long-lasting insecticidal mosquito nets. This method is a further standardization of the WHO washing method published in the "WHO Guidelines for laboratory and field testing of long-lasting insecticidal mosquito nets", document WHO/CDS/WHOPES/GCDPP/2005.11, World Health Organization, Geneva, 2005. Briefly, the retention index is determined by analyzing net samples in triplicate representing wash points 0 and 4 for total active ingredient content and calculating the average retention index using the equation for a free migration stage behavior.

The WHOPES Phase I study performed according to the WHO washing method (using Marseille soap at 2 g/L) showed that decreasing proportions of the remaining alpha-cypermethrin are removed from the polymer by successive washings with aqueous soap (free-migration stage behavior), with an average retention index per wash in the range 0.99 to 1.00 for wash cycles 1 up to 25, and that the wash curve is similar to this one of the reference product (DuraNet).

The manufacturer also provided data generated by an independent laboratory on 3 nets washed 1, 3 and 5 times (according to the draft CIPAC washing method using ECE-A non-phosphate reference detergent at 2 g/L) showing an average alpha-cypermethrin retention index per wash in the range 0.96 to 0.99.

On basis of these data, the Meeting concluded that the alpha-cypermethrin retention index of Royal Sentry complies with the clause of the existing WHO interim specification 454/LN/2 (0.95 to 0.99).

Physical properties clauses

The manufacturer provided study reports generated by an independent laboratory showing that Royal Sentry fully complies with the clauses of the existing WHO interim specification 454/LN/2 for netting mesh size, dimensional stability of netting to washing and bursting strength.

Storage stability clause

The manufacturer provided data generated by an independent laboratory after storage at 54°C for 2 weeks and after storage at 40°C for 8 weeks showing that the loss of alpha-cypermethrin is less than 5% (2% and 5% respectively) and that the retention index remains unchanged (average alpha-cypermethrin retention index per wash for wash cycles 1 to 5 in the range 0.96 to 0.99 and in the range 0.98 to 0.99, respectively). The manufacturer also provided data showing that the netting mesh size, the dimensional stability of netting to washing and the bursting strength remains unchanged after storage at 54°C for 2 weeks and after storage at 40°C for 8 weeks. The Meeting agreed to keep the storage clause of 54°C for 2 weeks in the specification and concluded that Royal Sentry complies with the existing WHO interim specification 454/LN/2.

The Meeting agreed also to update some notes of the existing specification relating to the linear density, retention index and dimensional stability to washing to be in line with the draft guideline for LN of the November 2010 – second revision of the first edition of the FAO/WHO Manual.

ANNEX 1. REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
	Butenhoff A.	2010	Royal Sentry®. JMPS Submission Dossier for World Health Organization Approval by Extension of Specification. Disease Control Technologies, October 4, 2010.
22324-2	CRA-W	2010	Determination of alpha-cypermethrin in Royal Sentry and DuraNet [alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net (LN)]. Report WHO / RE 22324 / 2010 / 2 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, September 28, 2010.
	FAO/WHO	2006	Manual on development and use of FAO and WHO specifications for pesticides. March 2006 revision of the 1 st edition. FAO, Rome and WHO, Geneva, March 2006 (internet publications).
	FAO/WHO	2010	Manual on development and use of FAO and WHO specifications for pesticides. Second revision of the 1 st edition. FAO, Rome and WHO, Geneva, November 2010 (internet publications).
	TÜV SÜD PSB Singapore	2010	Testing of mosquito nets submitted by Disease Control Technologies LLC. Test reports No. 719180595-MEC10/01-OJD, 719180595-MEC10/02-OJD, 719180595-MEC10/07-OJD, 719180595-CHM10-02-CSY-CR1, 719180595-CHM10-03-CSY-CR1, 719180595-CHM10-05-CSY-CR3, 719180406-CHM10-01-CSY-CR1, 719180595-MEC10/03-OJD-CR01, 719180595-MEC10/05-OJD, 719180595-MEC10/06-OJD, 719180595-CHM10-04-CSY-CR1, 719180595-CHM10-06-CSY-CR3, 719180595-MEC10/09-OJD, 719180595-MEC10/08-OJD-CR01, 719180595-MEC10/10-OJD, 719180595-CHM10-07-CSY, 719180595-CHM10-08-CSY, 719180595-MEC10/12-OJD, 719180595-MEC10/11-OJD and 719180595-MEC10/11-OJD for Disease Control Technologies, August – September 2010.
	WHO	2005	Guidelines for laboratory and field testing of long-lasting insecticidal mosquito nets. Document WHO/CDS/WHOPES/GCDPP/2005.11. WHO, Geneva, 2005.
	WHO	2005	Technical consultation on specifications and quality control of netting materials for mosquito nets (untreated and treated). 29 November – 02 December 2005. WHO Headquarters, Geneva, Switzerland.
	WHO	2008	Report of the Eleventh WHOPES Working Group Meeting, WHO/HQ, Geneva, 10-13 December 2007. WHO, Geneva, document WHO/HTM/NTD/WHOPES/2008.1.
	WHO	2011	Report of the Fourteen WHOPES Working Group Meeting, WHO/HQ, Geneva, 11-15 April 2011. WHO, Geneva, document to press.

WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN

FAO/WHO EVALUATION REPORT 454/2011.1

Recommendations

The Meeting recommended the following.

The existing WHO interim specification 454/LN/2 for alpha-cypermethrin (incorporated into filaments) LN should be extended to encompass the corresponding product of V.K.A. Polymers Pvt. Ltd.

Appraisal

Supporting data and information for alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net (LN), provided by V.K.A. Polymers Pvt. Ltd., were considered by the Meeting for extension of the existing WHO interim specification 454/LN/2 (October 2009).

The LN under consideration (MAGNet) is a warp knitted fabric netting material made from 150 denier monofilament yarn composed of high density polyethylene containing technical alpha-cypermethrin. The manufacturer confirmed that the active ingredient incorporated into the LN is from a source compliant with the existing WHO specification for alpha-cypermethrin TC (Gharda Chemicals Limited).

MAGNet was tested and evaluated by WHOPES who concluded that the bio-efficacy and wash resistance is comparable to the reference product (DuraNet). WHOPES recommended also the extension of the WHO specifications for alpha-cypermethrin (incorporated into filaments) LN to MAGNet, subject to satisfactory assessment of the physical and chemical properties of the product by JMPS (WHO 2011).

Description clause

The Meeting concluded that the description of MAGNet consisting of 150 denier monofilament, high density polyethylene fibres, incorporating technical alpha-cypermethrin complies with the existing WHO interim specification 454/LN/2.

Active ingredient identity and content clauses

The declared alpha-cypermethrin content is 5.8 g/kg. Data from three different laboratories (two manufacturer laboratories and one independent laboratory) showed that the measured active ingredient content complies with the existing WHO interim specification 454/LN/2.

Special attention needs to be paid to control random variations in the distribution of the insecticide within the net and between nets. The spatial variation data provided by the manufacturer from three laboratories (active ingredient content on 5 individual net pieces taken according to the Figure 1 of the specification) showed a good homogeneity of the active ingredient content within the net (within-net RSD = 1.27-2.01%, n = 5).

WHOPES Phase I data showed that alpha-cypermethrin content in MAGNet complies with the target dose of 5.8 g/kg ($\pm 25\%$) and that the between-net variation of alpha-cypermethrin content is very low (RSD = 1.9-2.5%, n = 4).

The CIPAC method 454/LN/M/3.2 (alpha-cypermethrin incorporated into filaments) published in the CIPAC Handbook M and involving extraction by heating under reflux for 30 minutes with xylene in presence of citric acid, addition of dioctyl phthalate as internal standard, and determination by gas chromatography with flame ionization detection (GC-FID), was used in these studies and is fully applicable for MAGNet. Gas chromatography with mass spectrometry detection (GC-MS) was also used in studies from one laboratory of the manufacturer and was found to give equivalent results than GC-FID.

Alpha-cypermethrin retention index clause

An adequate amount of active ingredient must be present at the surface of the LN, for efficacy, whereas the majority must reside within the LN, to avoid excessive losses during washing and to provide a reservoir from which the surface is replenished with active ingredient. Depletion of total active ingredient content by washing (retention index) is accomplished by analyzing separate washed and unwashed pieces of the same fabric. As the diffusion processes in solid materials are significantly slower than in solution, a certain time period is necessary to re-establish the equilibrium level of the active ingredient at the surface of polymer.

Currently (2011), CIPAC is developing a wash method for the determination of the retention behavior of long-lasting insecticidal mosquito nets. This method is a further standardization of the WHO washing method published in the "WHO Guidelines for laboratory and field testing of long-lasting insecticidal mosquito nets", document WHO/CDS/WHOPES/GCDPP/2005.11, World Health Organization, Geneva, 2005. Briefly, the retention index is determined by analyzing net samples in triplicate representing wash points 0 and 4 for total active ingredient content and calculating the average retention index using the equation for a free migration stage behavior.

The WHOPES Phase I study performed according to the WHO washing method (using Marseille soap at 2 g/L) showed that decreasing proportions of the remaining alpha-cypermethrin are removed from the polymer by successive washings with aqueous soap (free-migration stage behavior), with an average retention index per wash of 0.99 for wash cycles 1 up to 25, and that the wash curve is similar to this one of the reference product (DuraNet).

The manufacturer also provided data generated by three laboratories (two manufacturer laboratories and one independent laboratory) on net samples washed 1, 2, 3, 5, 10, 15, 20 and 25 times (according to the draft CIPAC washing method using IEC-A* reference detergent without phosphate at 2.5 g/L) showing an average alpha-cypermethrin retention index per wash in the range 0.97 to 0.99.

On basis of all these data, the Meeting concluded that the alpha-cypermethrin retention index of MAGNet complies with the clause of the existing WHO interim specification 454/LN/2 (0.95 to 0.99).

Physical properties clauses

The manufacturer provided study reports generated by three laboratories (one manufacturer laboratory and two independent laboratories) showing that MAGNet fully complies with the clauses of the existing WHO interim specification 454/LN/2 for netting mesh size, dimensional stability of netting to washing and bursting strength.

Storage stability clause

The manufacturer provided data generated by three laboratories (one manufacturer laboratory and two independent laboratories) after storage at 54°C for 2 weeks showing that the loss of alpha-cypermethrin is less than 5% (2-5%). One study showed that the retention index after accelerated storage is lower compared to the values before storage (average alpha-cypermethrin retention index per wash in the range 0.93 to 0.95 for wash cycles 3 up to 5). The lower retention index after accelerated storage was confirmed by an increase of the alpha-cypermethrin surface concentration of 283% after storage (regeneration study). Additional studies provided by the manufacturer and generated by an independent laboratory showed that the retention index, for wash cycles 3 up to 5, is in the range 0.95 to 0.97 after storage at 54°C for 2 weeks and in the range 0.97 to 0.98 after storage at 40°C for 8 weeks, and is therefore compliant with the clause of the existing specification. The manufacturer also provided data showing that the netting mesh size, the dimensional stability of netting to washing and the bursting strength remains unchanged after storage at 54°C for 2 weeks.

The Meeting and the manufacturer agreed to keep the storage clause of 54°C for 2 weeks in the specification and the Meeting concluded that MAGNet complies with the existing WHO interim specification 454/LN/2.

The Meeting agreed also to update some notes of the existing specification relating to the linear density, retention index and dimensional stability to washing to be in line with the draft guideline for LN of the November 2010 – second revision of the first edition of the FAO/WHO Manual.

ANNEX 1. REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
	CITEVE	2010	Physical tests on MAGNet. Reports No. 6335/2009-1 and 7510/2009-1 for V.K.A. Polymers Pvt. Ltd., October - November 2009.
22069	CRA-W	2010	Physical and chemical properties and accelerated storage stability for MAGNet [alpha-cypermethrin long-lasting (incorporated into polyethylene) insecticidal mosquito net (LN)]. Report V.K.A. Polymers / RE 22069 / 2009 of the Walloon Agricultural Research Centre, Gembloux, Belgium for V.K.A. Polymers Pvt. Ltd., January 11, 2010.
22151	CRA-W	2010	Accelerated storage stability study for MAGNet [alpha-cypermethrin long-lasting (incorporated into polyethylene) insecticidal mosquito net (LN)]. Report V.K.A. Polymers / RE 22151 / 2009 of the Walloon Agricultural Research Centre, Gembloux, Belgium for V.K.A. Polymers Pvt. Ltd., March 31, 2010.
22157	CRA-W	2010	Accelerated storage stability study for MAGNet – batch MN-1005 [alpha-cypermethrin long-lasting (incorporated into polyethylene) insecticidal mosquito net (LN)]. Report V.K.A. Polymers / RE 22157 / 2010 of the Walloon Agricultural Research Centre, Gembloux, Belgium for V.K.A. Polymers Pvt. Ltd., May 11, 2010.
22324-1	CRA-W	2010	Determination of alpha-cypermethrin in MAGNet and DuraNet [alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net (LN)]. Report WHO / RE 22324 / 2010 / 1 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, September 28, 2010.
	FAO/WHO	2006	Manual on development and use of FAO and WHO specifications for pesticides. March 2006 revision of the 1 st edition. FAO, Rome and WHO, Geneva, March 2006 (internet publications).
	FAO/WHO	2010	Manual on development and use of FAO and WHO specifications for pesticides. Second revision of the 1 st edition. FAO, Rome and WHO, Geneva, November 2010 (internet publications).
	Ramanathan N. & Samiappan A.	2010	Physical and chemical properties, accelerated and extended storage stabilities for MAGNet™ (alpha-cypermethrin incorporated into polyethylene) long-lasting insecticidal mosquito net. Report submitted to World Health Organization Pesticide Evaluation Scheme (WHOPES). V.K.A. Polymers Pvt. Ltd., August 2010.
	TÜV SÜD PSB Singapore	2009	Testing of mosquito nets submitted by V.K.A. Polymers Pvt. Ltd. Test reports No. S09MEC05349/JL/CORR2 and S09MEC05349-CSY-CORR03 for V.K.A. Polymers Pvt. Ltd., September 2009.
	WHO	2005	Guidelines for laboratory and field testing of long-lasting insecticidal mosquito nets. Document WHO/CDS/WHOPES/GCDPP/2005.11. WHO, Geneva, 2005.
	WHO	2005	Technical consultation on specifications and quality control of netting materials for mosquito nets (untreated and treated). 29 November – 02 December 2005. WHO Headquarters, Geneva, Switzerland.

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
	WHO	2008	Report of the Eleventh WHOPES Working Group Meeting, WHO/HQ, Geneva, 10-13 December 2007. WHO, Geneva, document WHO/HTM/NTD/WHOPES/2008.1.
	WHO	2011	Report of the Fourteen WHOPES Working Group Meeting, WHO/HQ, Geneva, 11-15 April 2011. WHO, Geneva, document to press.

WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN

FAO/WHO EVALUATION REPORT 454/2009.2

Recommendations

The Meeting recommended that a time-limited interim specification (until October 2012) for alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net proposed by Clarke Mosquito Control, as amended, should be adopted by WHO.

Appraisal

Supporting data and draft specifications for alpha-cypermethrin long-lasting (incorporated into filaments) insecticidal net (LN), provided by Clarke Mosquito Control Inc., were considered by the Meeting for development of a new WHO specification. Appropriate clauses, limits and methods of testing for certain parameters of this new type of formulation were also developed by the company over this period.

The alpha-cypermethrin (incorporated into filaments) LN produced by this manufacturer was tested/evaluated under the auspices of WHOPES and an interim recommendation for their use in malaria prevention and control was issued in 2008 (WHO 2008).

A provisional specification guideline for LN formulations was accepted by the JMPS in 2004 and published by WHO. The guideline for LN was subsequently amended, taking into account the recommendations of a WHO consultation on mosquito nets (WHO 2005) and published in the revised manual (FAO/WHO 2006). However, the apparent diversity of LN technologies currently requires specification clauses and limits to be tailored to individual products.

The LN under consideration is a warp-knitted fabric in which the active ingredient, alpha-cypermethrin, is incorporated into the polymer prior to the spinning process. The yarn is a high-density polyethylene monofilament. The manufacturer confirmed that the active ingredient incorporated into the LN is from a source compliant with the existing WHO specification for alpha-cypermethrin (Tagros).

Description clause

The Meeting agreed that the specification should be applied to white or coloured warp-knitted fabrics made from 150 denier monofilament high-density polyethylene yarn and that it should apply equally to made up, ready-to-use nets (rectangular and circular) or to netting in bulk.

Active ingredient content clause

The target dose of alpha-cypermethrin (5.8 g/kg) is related to the technology, in order to achieve a satisfactory biological activity. The target dose on a fabric area basis (261 mg/m²) is calculated from measurements of g/kg and fabric density in g/m². The Meeting agreed that the declared and tolerance values should be based on g/kg, with the corresponding mg/m² value being defined in a Note to the specification.

The Meeting observed that random variations in the distribution of alpha-cypermethrin may influence the variation in measured values for g/kg. The manufacturer provided between- and within-batch data, based on analysis of single 225 cm² pieces (15 cm x 15 cm) and variations in alpha-cypermethrin content following the sampling procedure as detailed in the LN guideline in the Manual, and demonstrated good precision (RSD < 5% in one experiment).

The analytical method for determination of the alpha-cypermethrin content in LN incorporated type was validated as an extension of the existing CIPAC method for alpha-cypermethrin (coated type) and adopted as full method by CIPAC in 2008 and is published in Handbook M (August 2009).

Relevant impurities

There are no relevant impurities identified in the existing WHO specification for alpha-cypermethrin TC proposed by Tagros. The clause has therefore been omitted.

Alpha-cypermethrin retention index clause

An adequate amount of active ingredient must be present on the surface of the LN, for efficacy, but the majority must reside within the fibres of the LN, to avoid excessive losses during washing and to provide a reservoir from which the surface is replenished with active ingredient. The nature of the fibre material – a high density polyethylene with a typical crystallinity of 60% – strongly influences the migration of alpha-cypermethrin to the surface when the LN is subjected to repeated washing. The Meeting agreed that also for incorporated types of LN, the retention index is the appropriate expression of the depletion and replenishment of the active ingredient on the surface of the monofilament fibre.

The manufacturer provided both theoretical considerations on the migration behaviour of the insecticide to the surface and experimental data showing that approximately constant proportions of the remaining alpha-cypermethrin are removed from the surface of the filament by successive washings with aqueous detergent. The manufacturer proposed a minimum retention index of 0.95 and a maximum of 0.99, which was agreed by the Meeting. When agreeing on limits in a specification, the sampling and analytical methods need to be properly validated so these limits can be checked and enforced by quality control laboratories if necessary. The upper limit of 0.99 was chosen for practicability reasons: the default precision requirement for content determination is ≤ 5%. Therefore, the upper limit of the retention index is lower but close to 1.0, as the WHOPES Phase I laboratory studies with good efficacy after each wash step clearly show. The errors in sampling and analytical method prevent to define a closer range of the retention index.

Sampling of alpha-cypermethrin (incorporated into filaments) LN was done by cutting a total of 5 pieces for analysis. Five pieces of net (15 x 15 cm) were cut and washed for a specified number of washes using the WHO washing method (WHO 2005). After drying, the samples were again analyzed for alpha-cypermethrin content. The recommended positions from which 5 pieces of netting were taken from a made up bed net are similar to those given in the manual (FAO/WHO 2006), as shown in figure 1, appended to the specification. The manufacturer's results showed a small decrease of alpha-cypermethrin content with each washing step, with more than 95% of total alpha-cypermethrin remaining after each wash step. As the range for the retention index is defined by the minimum of 0.95 and the maximum is close but distinctly lower than 1.0, the Meeting agreed to consider the lower limit of 0.95 and

the upper limit of 0.99 as acceptable. Using bioassays, the regeneration time required for diffusion to restore the surface concentration to full biological activity after washing was shown to be one day.

Physical property clauses

The clauses for dimensional stability to washing and bursting strength specify ISO methods. The test method for netting mesh size does not require standardization.

The Meeting accepted the manufacturer's explanation that the test for bursting strength obviated the need for a separate clause for tearing strength.

The $\pm 10\%$ tolerance on dimensional stability to washing was higher than the standard 5% given in the LN guideline (FAO/WHO 2006) but was supported by test results. The actual measurements showed a significantly better performance than 5% in most cases, with one exception.

Storage stability clause

The incorporated alpha-cypermethrin is stable over a very wide temperature range and has low volatility, providing additional protection to the active ingredient. At 54°C for 2 weeks, the loss of alpha-cypermethrin was minimal (approximately 1%) and the physical properties of the fabric were maintained. The physical tests as well as the determination of the release index met the general requirements of the Manual (FAO/WHO 2006).

ANNEX 1. REFERENCES

Reference and year	Title of report or publication details
FAO/WHO 2006	Manual on development and use of FAO and WHO specifications for pesticides, March 2006 revision of the 1 st edition. FAO, Rome, March 2006; WHO, Geneva, March 2006 (internet publications).
WHO 2005	Technical consultation on specifications and quality control of netting materials for mosquito nets (untreated and treated). 29 November–02 December 2005. WHO Headquarters, Geneva, Switzerland.
WHO 2005	Guidelines for laboratory and field testing of long-lasting insecticidal mosquito nets. Document WHO/CDS/WHOPES/GCDPP/2005.11. World Health Organization, Geneva, 2005.
WHO 2007	Report of the Tenth WHOPES Working Group Meeting, WHO/HQ, Geneva, 11-14 December 2006. Geneva, World Health Organization, document WHO/CDS/NTD/WHOPES/2007.1
WHO 2008	Report of the Eleventh WHOPES Working Group Meeting, WHO/HQ, Geneva, 10-14 December 2007. Geneva, World Health Organization, document WHO/HTM/NTD/WHOPES/2008.1.