WHO Prequalification of Vector Control Products

Phys/Chem tests for ITNs: Snag strength

Factors which may affect validity of tests and results using the **snag strength method**

- incorrect identification of wales and courses of ITN fabrics;
- testing samples in the incorrect direction - the correct approach to follow is that the test occurs in the direction opposite to that of the area mounted. i.e. if the sample is folded along the course-wise (CW) direction of the knitted fabric, the force will be measured in the wale-wise (WW) direction due to the pulling direction;
- incorrect equipment set-up (jaw to jaw distance: 105 mm, clamped hook length: 78 mm, and mounted sample length: 30 mm);
- incorrect insertion of the needle hook through the apertures of the test sample;
- application of incorrect testing parameters for snag strength of ITNs;
- use of incorrect gauge metal latch needle. It should be used 3.5 gauge metal latch needle (hook height: 5.65 mm, hook distance: 5.65 mm, working length: 101.9 mm, butt width: 3.95 mm, butt height: 12 mm, and latch motion: 26.20 mm. The inner width of the hook should measure 1.1 mm +/- 0.20 mm);
- not checking regularly whether the needle hooks are damaged. This should be regularly checked;
- incorrect examination of the yarn breakages. After testing, it should be performed a correct examination of the yarn breakages to ensure that one or more yarns have been broken (not filament displacement).

1. Purpose of the Method

The purpose of the method is to assess the snag strength of open mesh fabric structures such as those used in Insecticide-treated Nets (ITNs).

2. Considerations for Use of the Method

This method is used to assess the force required to break yarns during snagging of an open mesh textile and is designed to reflect conditions that an ITN will be exposed to during normal use.

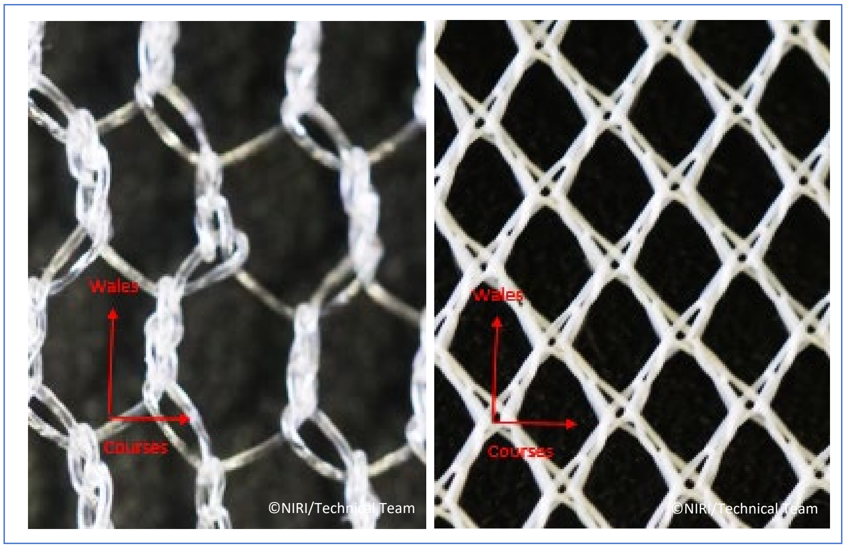
- This test method has been modified from ISO 13934-2:2014 Textiles – Tensile properties of fabrics – Part 2: Determination of maximum force using the grab method. A hook is used to catch the fabric and causes yarn breakage (failure) *(1)*.

- This test method measures the resistance to yarn breakage after being caught on a solid protuberance (snag).
- The test sample (minimum size: 120 X 100 mm) is folded lengthways and mounted in the lower jaws of the tensile tester so that the loose ends of the fabric are clamped together.
- The end of a metal latch needle is clamped vertically in the upper jaws of the tensile tester so that the hook of the needle points downwards towards the middle of the folded sample. The hook is then inserted between two adjacent apertures in the middle of the folded sample so that it catches the yarns in both sides of the fabric. The test sample in which the hook is caught is then extended at a rate of 100 mm/min by constant movement of the upper jaw of the tensile tester. This causes the yarns and surrounding fabric to extend in the region of the hook until the sample fails. Failure means yarn breakage at the hook. The force required to fail the sample is recorded. The load reading is zeroed after each test.

2.1.Terminology

- **Open mesh textile**: A textile, which due to its inherent structure consists of a large number of closely spaced apertures.
- **Aperture**: An opening in the open mesh textile structure that is larger than 1 mm.
- **Snag**: Yarn pulled or plucked from the surface of the fabric resulting in yarn breakage.
- **Hole**: An opening in a textile which is not part of its inherent structure and is the result of breakage or displacement of yarns.
- **Course-wise**: In knitted fabrics courses are defined as rows of loops across the width of a flat knitted fabric *(2)*, as shown in Figure 1. Course-wise refers to the plane in the course direction.
- **Wale-wise**: In knitted fabrics wales are defined as columns of loops along the length of the fabric, as seen in Figure 1. Wale-wise refers to the plane in the wale direction. In warp knitting, the yarn is looped in the machine direction, i.e. the wale-wise direction. In weft knitted fabrics, the yarn is looped in the cross direction (width direction), i.e., the course-wise direction.

Figure 1. Directional properties of warp knit structures *(3)*.



3. Apparatus and Materials

3.1. Apparatus

- Tensile testing equipment is required capable of recording force at break at a crosshead (upper jaw) speed of 100 mm/min. The clamp size should be between 60 – 100 mm width and 20 – 30 mm depth.

3.2. Materials

- Figure 2 shows the metal latch needle used for the testing. The hook forms part of a 3.5 gauge metal latch needle used by the knitting industry. Hooks should be regularly checked and if they are damaged, should be replaced. Related dimensional parameters are: hook height: 5.65 mm, hook distance: 5.65 mm, working length: 101.9 mm, butt width: 3.95 mm, butt height: 12 mm, and latch motion: 26.20 mm. The inner width of the hook should measure 1.1 mm +/- 0.20 mm. The latch needle should have the specifications listed in Table 1.

Figure 2. A 3.5 gauge metal latch knitting needle and hook *(4)*.

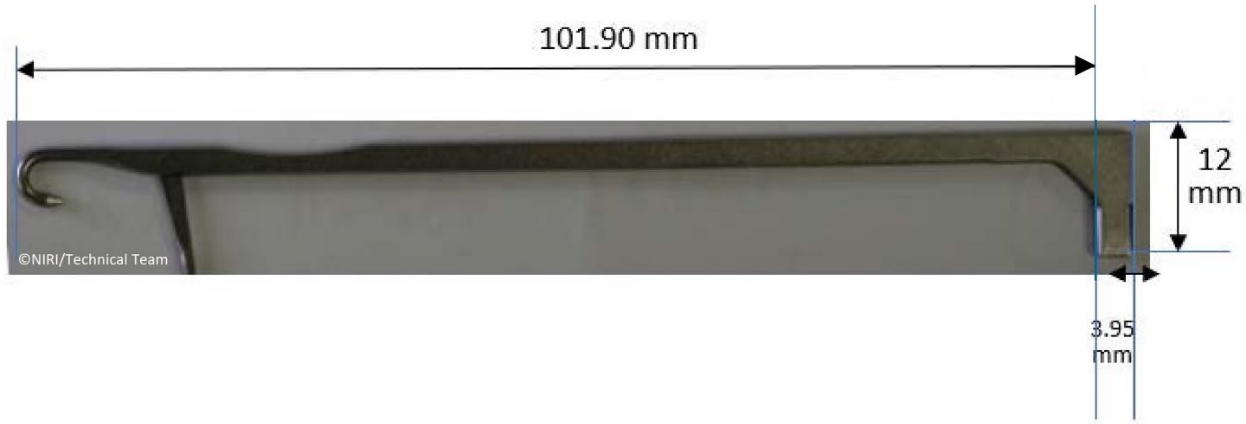


Table 1. Reference details for the 3.5 gauge metal latch needle.	
Hook height	5.65 mm
hook distance	5.65 mm
Working length	101.9 mm
Butt height	12 mm
Butt width	3.95 mm
Inner width of the hook	1.1 mm +/- 0.20 mm
Latch motion	26.20 mm

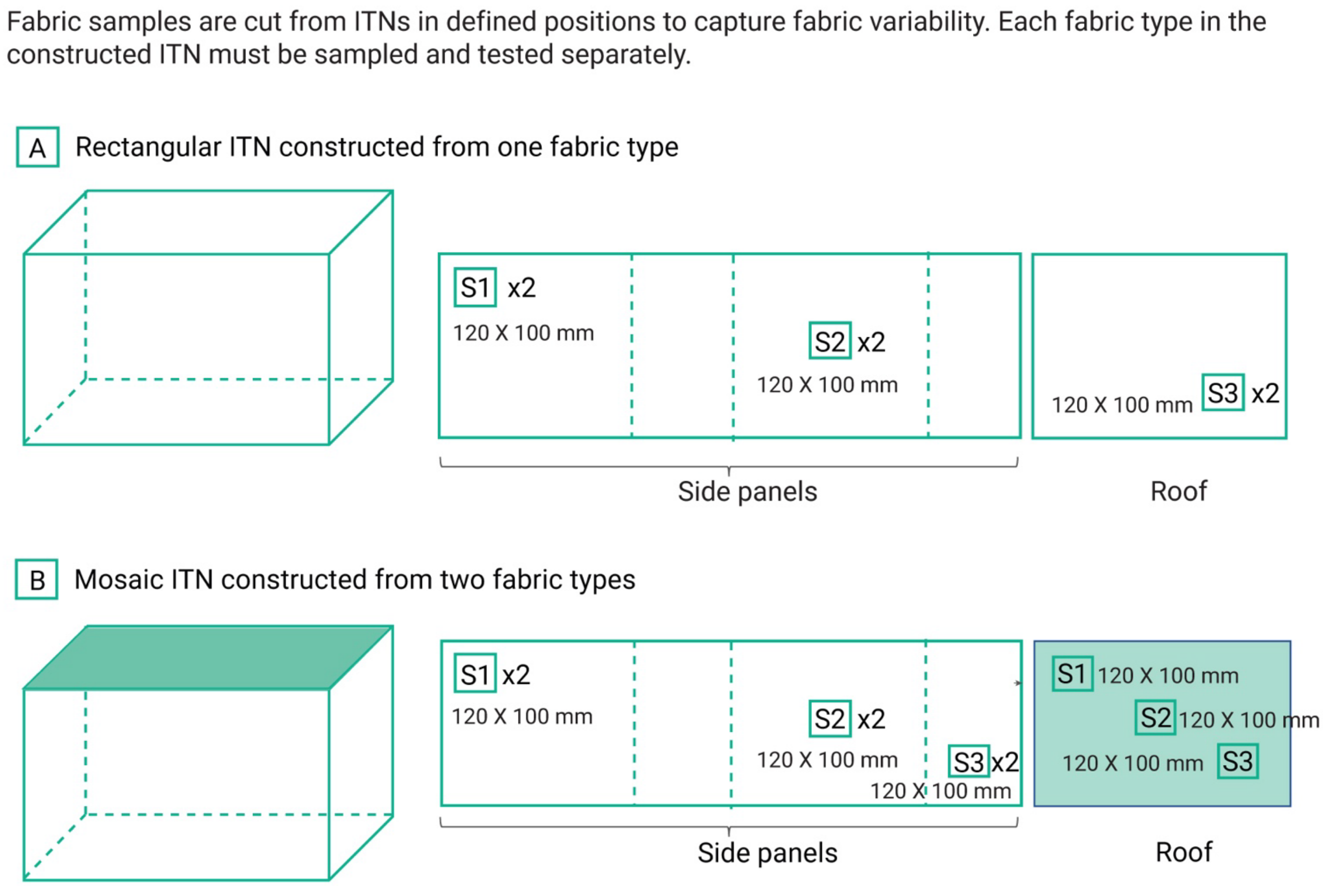
4. Sampling and Test Samples

4.1.Sampling

Sampling procedure for ITNs is dependent on the design and construction of the ITN, including the presence of multiple fabrics in the ITN design. The sampling procedure is declared in the Implementation guidance: Declaration of ITN construction and sampling and must ensure that any differing fabrics in the ITN are adequately represented. The total number of samples required is dependent upon the study and the product.

For the data generation for PQ Module 3 dossier on snag strength of ITNs, four ITNs per batch and three samples per fabric type per ITN are required for testing. Figure 3 shows an example of ITN sampling schemes.

Figure 3. Example ITN sampling schemes for snag strength of insecticide-treated nets.



Therefore, a total number of 120 samples (60 x 2) is required for the measurements of homogeneous nets:

- 60 samples are required in order to test the strength in the course-wise (CW) direction of the fabric
- 60 samples are required for the wale-wise (WW) direction of the fabric.

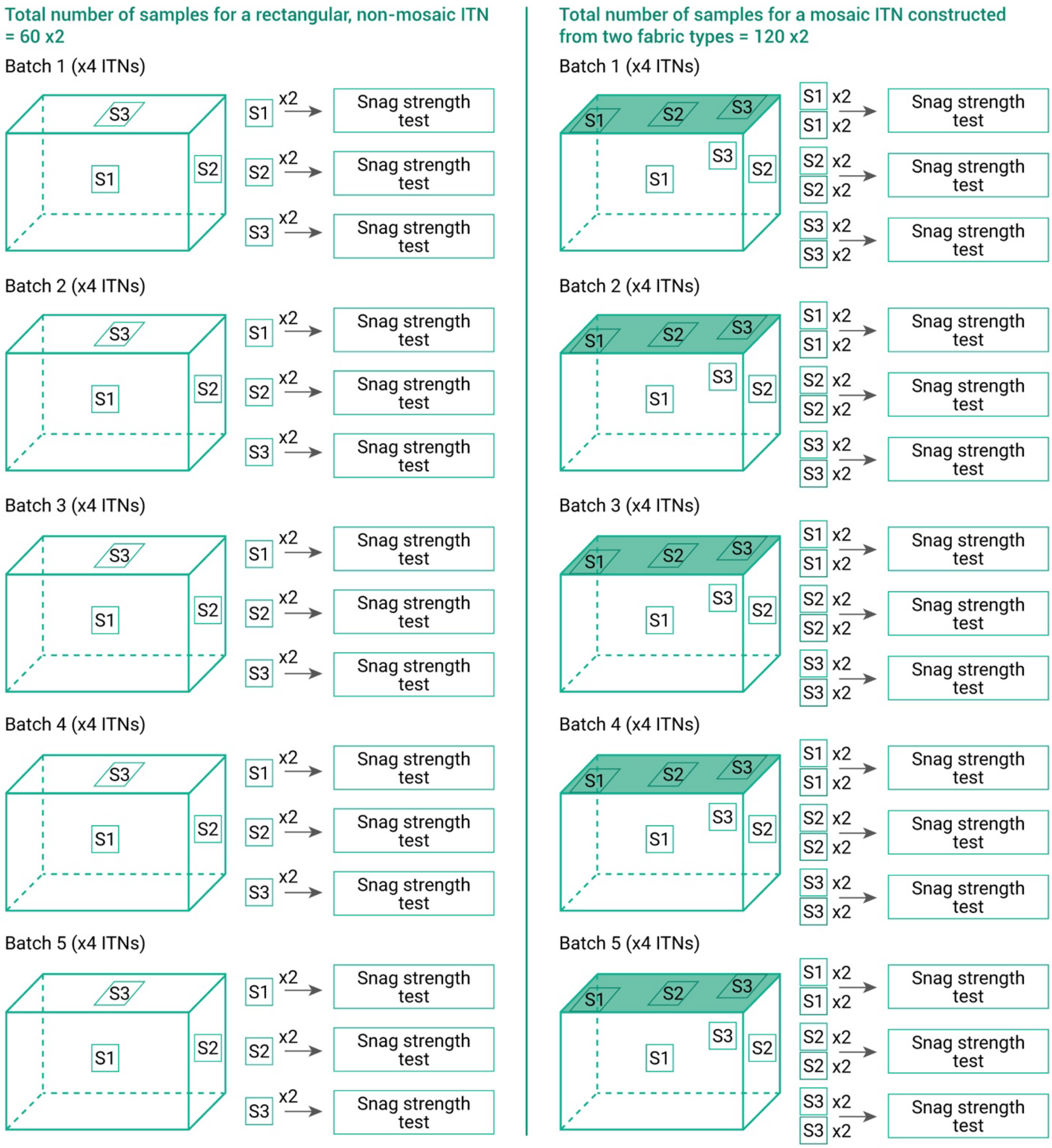
A total number of 240 samples (60 x2 fabric types x 2) are required for the measurements of mosaic nets constructed from two fabric types.

- 120 samples (60 from fabric #1 and 60 from fabric #2) are required in order to test the strength in the course-wise (CW) direction of the fabric
- 120 samples (60 from fabric #1 and 60 from fabric #2) are required for the wale-wise (WW) direction of the fabric.

Figure 4 shows an example of total number of samples required for snag strength of insecticide-treated nets.

When taking the samples for testing it is important to ensure that they do not share wale yarns.

Figure 4. Example of total number of samples required for snag strength of insecticide-treated nets.



4.2. Test Samples

1. Samples measure 120 X 100 mm (L x W). Samples are folded lengthwise in half to measure 60 X 100 mm. As noted in section 4.1, i.e. for the case of homogeneous nets, 60 samples are required in order to test the strength in the course-wise (CW) and 60 samples are required for the wale-wise (WW) directions of the fabric.
2. Sample A: 120 mm edge parallel to the course-wise (CW) direction.
3. Sample B: 120 mm edge parallel to the wale-wise (WW) direction.

5. Conditioning

The atmospheres for preconditioning, conditioning and testing are as specified in ISO 139:2005 *(5)*.

6. Procedure

6.1. Test Parameters

The test parameters for ITNs testing are given in Table 2.

Table 2. Testing parameters for snag strength testing of ITNs.

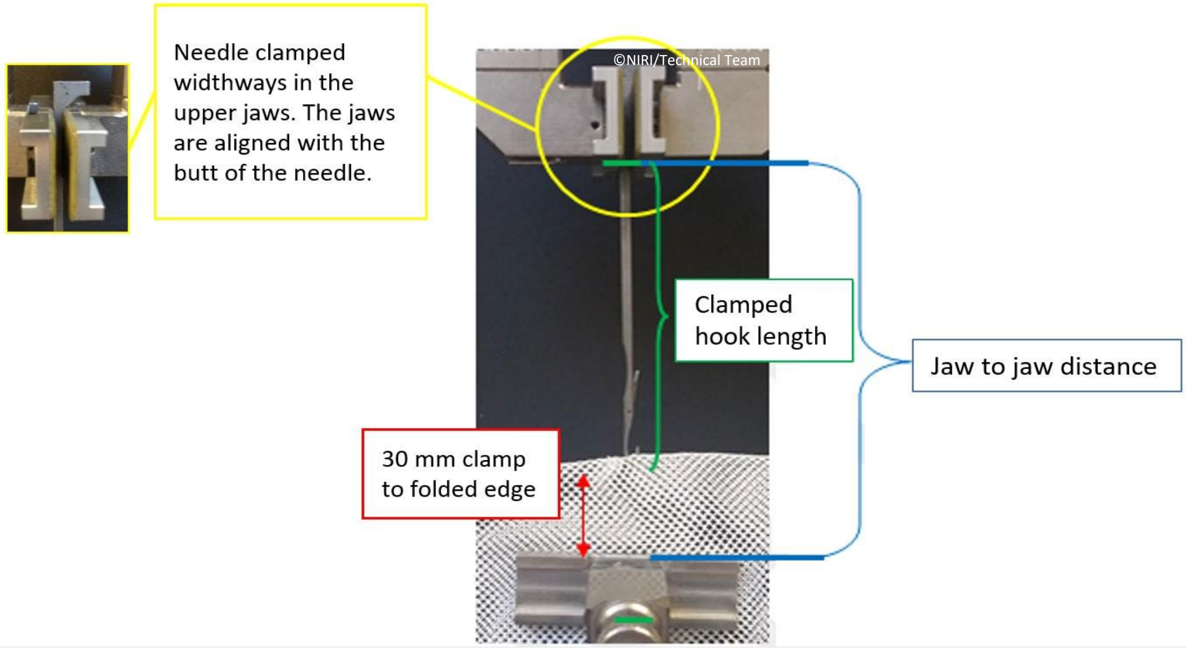
Test parameters	Cross Head Speed: 100 mm/min
End of Test	Force Shutdown Threshold: 80% of Maximum Force (termination when force decreases to 80% of maximum force at Break)
Parameters to record	Maximum Force at Break (N)

6.2. Equipment Set Up

1. Figure 5 demonstrates the equipment set-up. As highlighted, the knitting needle is clamped widthways in the upper jaws, with the top of the jaws aligned with and extending just beyond the needle butt.
2. Jaw to jaw distance: 105 mm*.
3. Clamped Hook length: 78 mm.*
4. Mounted sample length: 30 mm.

*Distance is based on a 20 mm jaw depth.

Figure 5. Example of equipment set up *(6)*.



6.3.Test Procedure

Figures 6a-6c illustrate common ITN fabric structures and their respective course and wale directions.

1. Mount the folded sample in the lower jaws with the folded edge running parallel to the jaws at a distance above of 30 mm.
2. Bring the jaws into the test position.
3. Insert the hook through the apertures of the test sample as outlined in Figures 6a-6b.
4. Undertake the test and record the maximum force at break in Newtons (N).

Figure 6. Common ITN fabric structures and their respective course and wale directions *(7)*.

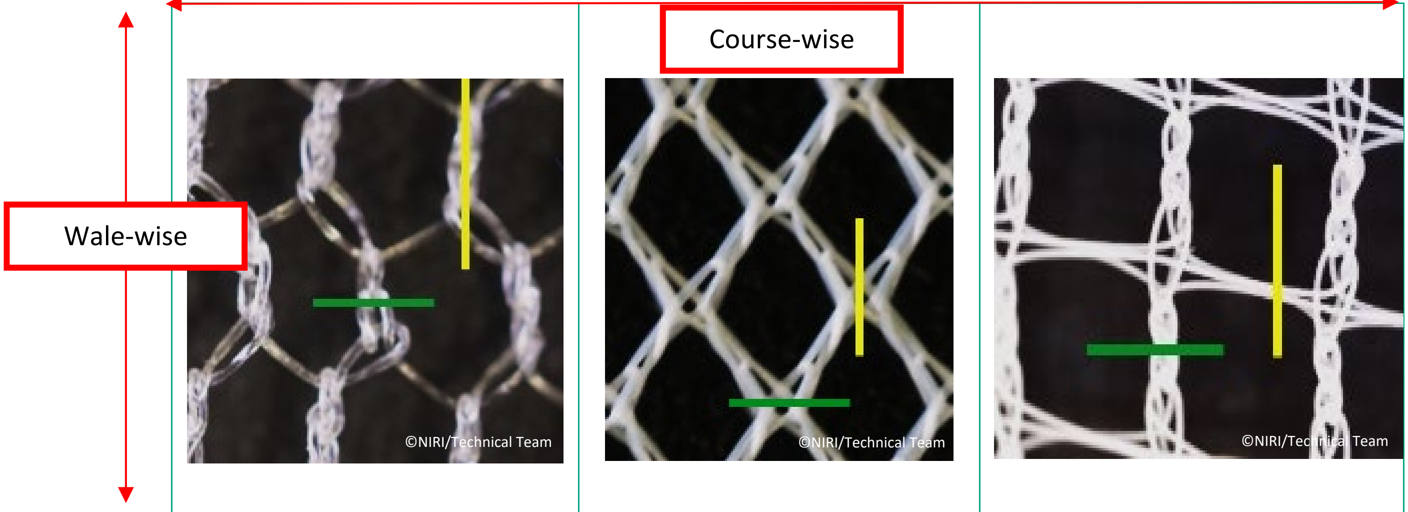
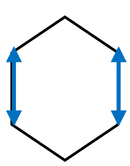
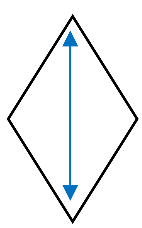
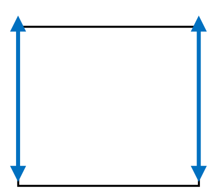
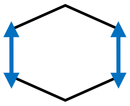


Figure 6a:	**Figure 6b:**	**Figure 6c:**
ISO 8388:2003 *(8)*; **3.5.52 Tulle** Warp knitted fabric with hexagonal openings produced by pillar stitches alternating with tricot stitches. Both stitches are reinforced by inlay threads. Can also be referred to as a Raschel knit structure.	**ISO 8388:2003*(8)*;** **3.5.50 Traverse Net** Warp knitted fabric with diamond shaped openings in which each stitch in the fabric consists of only one thread. Can also be referred to as an Atlas structure.	**ISO 8388:2003*(8)*;** **3.5.56 Marquisette** Warp knitted fabric with square openings obtained by pillar stitches that are reinforced by two sets of inlay threads lapped in opposition.
Typical shapes & tips for quick identification:		
The two parallel edges of the polygon shape are vertically oriented in the wale-wise direction. 	This knitted structure forms a diamond shape. The length of the diamond is oriented in the wale-wise direction. 	This knitted structure forms a square shaped mesh. The loops are formed in the wale-wise direction. Leading to an appearance of thicker and more intricate mesh sides in the wale-wise direction. 

Some ITNs use a modification of this knitted structure in which the polygon is shorter in the wale-wise direction. 		

Green line denotes a Wale-Wise mount

Yellow line denotes a Course-Wise mount

REMEMBER: The test occurs in the direction opposite to that of the area mounted. i.e. if the sample is folded along the course-wise (CW) direction of the knitted fabric, the force will be measured in the wale-wise (WW) direction due to the pulling direction.

6.4. Mounting Sample

Figures 7a *(9)* and 7b *(10)* illustrate the area of the ITN net structure that is mounted in the hook for testing.

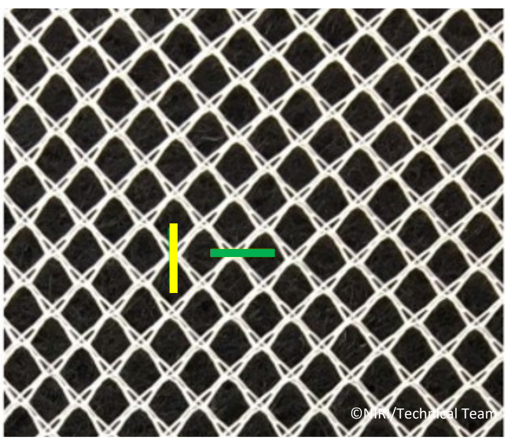


Figure 7a. Example of the area of the sample to be mounted in the hook.

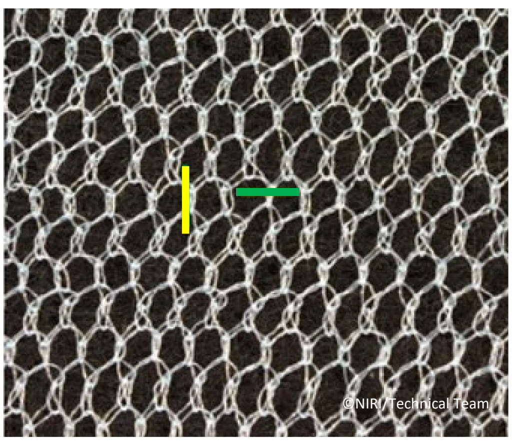


Figure 7b. Example of the area of the sample to be mounted in the hook.

Figures 8a-9b *(11)* show examples of how the ITN structure is mounted in the wale-wise (WW) and course-wise (CW) directions.

Figure 8a. Example of WW mounting for TESTING in the CW direction.

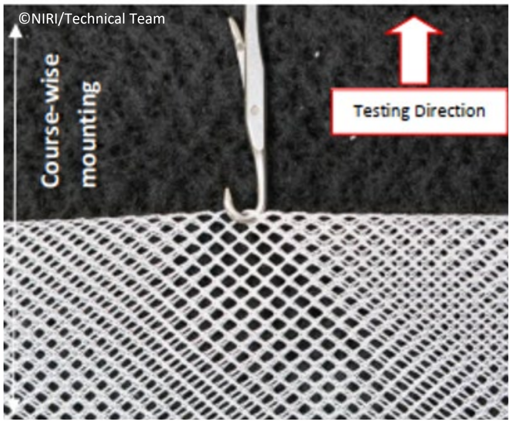


Figure 8b. Example of CW mounting for TESTING in the WW direction.

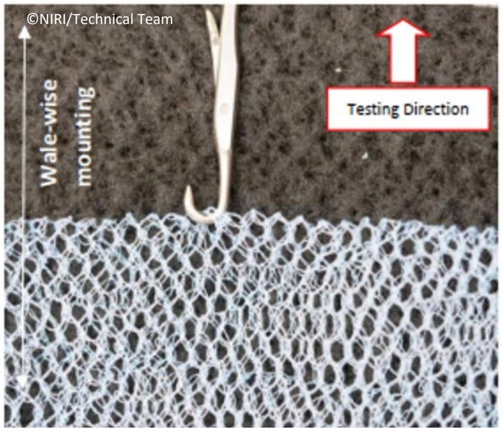


Figure 9a. Example of WW mounting for TESTING in the CW direction.

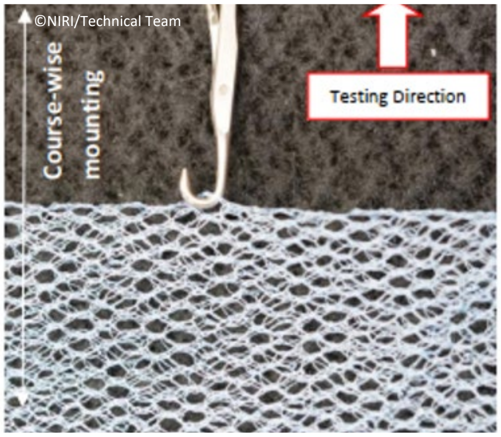


Figure 9b. Example of CW mounting for TESTING in the WW direction.

6.5. End of Test

At the end of the test, record the maximum force at break in Newtons. Remove the sample and re-zero and re-set the starting test position.

7. Results

7.1. Recording and interpretation of results

For each sample, examine the break to ensure that one or more yarns have been broken. It is sometimes possible for filaments to be displaced from the structure and not break. If this occurs, it is necessary to repeat the test.

Ensure the following parameters are recorded:

- Maximum force at break (N).

To inform the understanding of these results, please include photographs/figures of the wale-wise mount and course-wise mount used in the study. Please, declare as well the wale-wise and course-wise orientation of the fabrics used in the constructed product in the IG – Declaration of ITN construction and sampling - Template.

7.1.1. Considerations for the presentation of results

Table 3 shows an example of how the raw data for a sample should be recorded.

Table 3. Example of test data for a homogeneous ITN with a total number of 120 (60 x2) samples.

Sample Number	Wale-Wise Direction	Course-Wise Direction
	Maximum Force at Break (N)	Maximum Force at Break (N)
1	51.71	37.09
2	46.84	36.85
3	45.62	36.11
4	47.24	34.78
5	48.64	35.99
6	44.45	36.93
7	49.24	36.39
8	49.11	36.77
9	46.59	36.03
10	50.39	36.21

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Table 3. Example of test data for a homogeneous ITN with a total number of 120 (60 x2) samples.

Sample Number	Wale-Wise Direction	Course-Wise Direction
	Maximum Force at Break (N)	Maximum Force at Break (N)
11	48.25	35.84
12	52.47	36.92
13	48.08	41.14
14	46.77	36.52
15	45.28	37.45
16	52.71	38.09
17	47.84	37.85
18	46.62	37.11
19	48.24	35.78
20	49.64	36.99
21	45.45	37.93
22	50.24	37.39
23	50.11	37.77
24	47.59	37.03
25	51.39	37.21
26	49.25	36.84
27	53.47	37.92
28	49.08	42.14
29	47.77	37.52
30	46.28	38.45
31	50.71	36.09
32	45.84	35.85
33	44.62	35.11
34	46.24	33.78
35	47.64	34.99
36	43.45	35.93
37	48.24	35.39
38	48.11	35.77
39	45.59	35.03
40	49.39	35.21

Table 3. Example of test data for a homogeneous ITN with a total number of 120 (60 x2) samples.		
Sample Number	**Wale-Wise Direction**	**Course-Wise Direction**
	Maximum Force at Break (N)	**Maximum Force at Break (N)**
41	47.25	34.84
42	51.47	35.92
43	47.08	40.14
44	45.77	35.52
45	44.28	36.45
46	53.71	39.09
47	49.71	35.09
48	47.62	38.11
49	43.62	34.11
50	50.64	37.99
51	46.64	33.99
52	51.24	38.39
53	47.24	34.39
54	48.59	38.03
55	44.59	34.03
56	50.25	37.84
57	46.25	33.84
58	50.08	43.14
59	46.08	39.14
60	45.28	37.45
Average	**48.06**	**36.79**

8. Test Report

The test report should include:

1. Sample details and identity.
2. Date the test is conducted.
3. Tensile testing equipment manufacturer and model.
4. The test operator.
5. The location and laboratory.

6. The conditions of testing if outside standard testing conditions outlined in this document.
7. The test results as outlined in section 7 Results.

9. Related Documents

- WHO PQT/VCP Implementation guidance - Declaration of ITN construction and sampling Procedure
- WHO PQT/VCP Implementation guidance - Data requirements table – Module 3
- WHO PQT/VCP Implementation guidance – IG - Abrasion
- WHO PQT/VCP Implementation guidance – IG - Resistance to hole formation
- Physical testing requirements for ITNs: Accreditation and compliance with international standards for the generation of data intended to be submitted to WHO prequalification

10. References

When using the normative references for physical tests, the updated version of the standard should always be used when available.

1. British Standards Institution. BS EN ISO 13934-2:2014. *Textiles – Tensile properties of fabrics – Part 2: Determination of maximum force using the grab method.* London: BSI group; 2014.
2. Farnfield CA, Alvey PJ. Textile terms and definitions, 10th Edition. Manchester: The Textile Institute; 1995.
3. Directional properties of warp knit structures. 15th December 2023, Leeds (UK), NIRI/Technical Team.
4. A 3.5 gauge metal latch knitting needle and hook. 15th December 2023, Leeds (UK), Phys/Chem tests for ITNs: Snag strength, NIRI/Technical Team, Nonwovens Innovation & Research Institute (NIRI Ltd.).
5. International Organization for Standardization. ISO 139:2005. *Knitted fabrics - Types - Vocabulary (ISO 8388:1998)*. Geneva: ISO; 2003.
6. Example of equipment set up. 15th December 2023, Leeds (UK), Phys/Chem tests for ITNs: Snag strength, NIRI/Technical Team, Nonwovens Innovation & Research Institute (NIRI Ltd.).
7. Common ITN fabric structures and their respective course and wale directions. 15th December 2023, Leeds (UK), Phys/Chem tests for ITNs: Snag strength, NIRI/Technical Team, Nonwovens Innovation & Research Institute (NIRI Ltd.).
8. International Organization for Standardization. ISO 8388:2003. *Textiles – Standard atmospheres for conditioning and testing*. Geneva: ISO; 2005.
9. Example of the area of the sample to be mounted in the hook. 15th December 2023, Leeds (UK), Phys/Chem tests for ITNs: Snag strength, NIRI/Technical Team, Nonwovens Innovation & Research Institute (NIRI Ltd.).

10. Example of the area of the sample to be mounted in the hook. 15th December 2023, Leeds (UK), Phys/Chem tests for ITNs: Snag strength, NIRI/Technical Team, Nonwovens Innovation & Research Institute (NIRI Ltd.).
11. Examples of how the ITN structure is mounted in the wale-wise (WW) and course-wise (CW) directions. 15th December 2023, Leeds (UK), Phys/Chem tests for ITNs: Snag strength, NIRI/Technical Team, Nonwovens Innovation & Research Institute (NIRI Ltd.).

11. Bibliography

- Wheldrake A, Guillemois E, Arouni H, Russell SJ. Textile testing to assess the resistance to damage of long-lasting insecticidal nets for malaria control and prevention. Malar J. 2021;20:47. doi: 10.1186/s12936-020-03571-4.
- Wheldrake A, Guillemois E, Arouni H, Chetty V, Russell SJ. The causes of holes and loss of physical integrity in long-lasting insecticidal nets. Malar J. 2021;20:45. doi.org/10.1186/s12936-020-03567-0.
- British Standards Institution. BS EN 15598:2008. *Textiles – Terry fabrics. Test method for the determination of the resistance to pile loop extraction*. London: BSI group; 2008.