HANDBOOK OF PRACTICAL QUALITY TESTING METHODS FOR THE MOSQUITO NET MANUFACTURER

Prepared by:

Dan J. McCreight
Geert De Clercq

Version 2.0
November 5, 2004

USAID NetMark Africa Regional Malaria Program
59B Kyalami Boulevard, Kyalami Business Park
Midrand, South Africa 1685
Tel. 27-11-466-5573 or 0238 Fax 27-11-466-0579
www.netmarkafrica.org

Table of Contents

Table of Contents (continued)

Foreword

This handbook contains test methods for the measurement of yarn and fabric properties that are important to the manufacturer of mosquito nets. Some tests that will normally be performed by an outside commercial laboratory are not included such as the tests for colorfastness to light and washing and for flammability. The handbook is not intended to be all-inclusive, so some tests have been excluded in this first collection of test methods. A small number of tests have been excluded because no suitable ISO test method could be identified at this time, and several tests are not yet included because of the complexity of those tests. A table of suggested initial quality control testing and frequencies is presented first in this handbook. In the appendices are general guidelines for setting up the warp knitting machine and the stenter frame for the processing of polyester netting fabrics.

Test Method Versus Product Specification

The test methods are generally referred to as standards. This should not be confused with the actual measurable attributes of the textile product. For example, ISO standards referred to are internationally approved and accepted methods for testing in order to determine the magnitude of a measurable property of the product. Similarly, other organizations compile and publish standards for testing. Among them are the official standards organizations of individual countries. Targets for the outcome of these tests on the textile materials are ultimately decided by market forces.

Focus of This Handbook

The reason for assembling and simplifying the text of the test methods contained in this handbook is to provide a guide to practical testing at the textile manufacturing site to enhance process control. Some of the methods described therefore are not suitable for testing for commercial acceptance. Others are suitable for that purpose. Methods for onsite testing of the following attributes are presented in the main sections of this handbook:

- Yarn count,
- Yarn skein shrinkage,
- Fabric mass per unit area,
- Fabric mesh count,
- Fabric dimensional stability (shrinkage),
- Fabric air permeability, and
- Fabric bursting strength.

A COMPLETE QUALITY CONTROL TESTING SYSTEM

The table provided contains the tests that should be considered for self-sufficiency in a complete Quality Control system at a mosquito net manufacturing company. Suggestions are provided for each process step from polymer receipt to the baling of packaged nets.

Net Manufacturing Suggested Quality Control Tests and Testing Frequencies

Area	Test	Initial Frequency Suggested
Polymer	Viscosity	Each new lot
	Moisture content	Each new lot
Yarn Extrusion	Yarn count	Each extrusion line, 1 doff/shift
	Yarn tenacity & elongation	Each extrusion line, 1 doff/shift
	Yarn spin finish	All deliveries each shift
	Visual package surface	All bobbins
	Spinning speed	Each winder daily
Texturing Process	Yarn count	6 advancing consecutive positions from each machine daily
	Yarn dyeability	Each machine, 1 doff/shift minimum
	Yarn skein shrinkage	2 advancing consecutive positions from each machine daily
	Yarn frictional properties	Each machine, 1 doff weekly
	Yarn tenacity & elongation	6 advancing consecutive positions from each machine daily
	Yarn spin finish or oil content	2 advancing consecutive positions from each machine daily
	Texturing winding speed	Each machine daily
Yarn Purchased	Yarn count	Each new lot
	Yarn dyeability	Each new lot
	Yarn skein shrinkage	Each new lot
	Yarn frictional properties	Each new lot
	Yarn tenacity & elongation	Each new lot
	Yarn spin finish or oil content	Each new merge
Warping	Visual package surface	All packages as creeled
	Yarn tension in creel	Monthly and at yarn supplier or yarn specification change
	Beam winding hardness	Each warper monthly and after maintenance
Knitting	Fabric weight and mesh	After start-up of each new set of beams
	Operator visual inspection	Continuously, option to sew small holes
Inspection	Knit fabric inspection	100% of greige fabric, cut out defects, sew holes

Net Manufacturing Suggested Quality Control Tests and Testing Frequencies, Continued

Area	Test	Initial Frequency Suggested
Coloration	Received fabric width	Each fabric roll
	Shade match to standard	Each dye lot
Stentering	Received fabric width	Each fabric roll
	Fabric weight and mesh	At beginning and end of each delivered fabric roll
	Fabric shrinkage	Fabric from each stenter daily
	Fabric bursting strength	Each stenter, each fabric style weekly
	Flammability	Each fabric style quarterly
	Colorfastness to light	Each fabric style quarterly
	Colorfastness to washing	Each fabric style quarterly
Cutting	Received fabric width	Each fabric roll
	Fabric weight and mesh	Randomly as a check on stentering
	Visual fabric inspection	100% as fabric laid on table, cut out defects
Sewing	Shade matching	Each set of fabric tops, panels, and loops
	Seam strength	Each net style weekly, cycling through all sewing operators as often as possible
Final Inspection	Visual net inspection	100%, hoist or hang nets, also gauging the length and width dimensions
Packaging	Labeling accuracy	Each net packed
Baling	Visual style confirmation	Ensure each net to be baled is of the same style
	Quantity of nets	Ensure accuracy of count in each bale
Nets	All specifications	Each net style quarterly at outside laboratory

Note: Any tests performed daily, weekly, or monthly would preferably be done onsite. Tests performed quarterly or at longer intervals could be done at an outside laboratory.

YARN COUNT TESTING

This test covers the determination of linear density of yarns that stretch less than 5% when tension on the yarn is increased from 0.25 to 0.75 cN/tex.

Summary of Test Method

Specified lengths of yarn are wound on reels as skeins, conditioned, and then weighed. The linear density of the yarn in skein form is computed from the mass and length of the skein.

Apparatus Required

- A hand reel or motor driven reel having a preferred perimeter of 1 m or 1.5 yd with a tolerance of 0.25%. The reel is fitted with a traversing mechanism that will avoid bunching of the successive wraps of the yarn. The reel is usually fitted with an indicator of the length of yarn wound. It is advisable that one of the arms of the reel be collapsible to allow for ease of removal of the wound skeins. The reel is also fitted with a system for controlled tensioning of the yarns at 0.5 cN/tex.

- A balance of suitable capacity that is graduated in either grams (g) or grains (gr) with a sensitivity of 1 part in 1000 of the mass of the skein.

Sampling Recommendation

As a lot sample for acceptance testing, take at random 5 packages from at least 10% of the shipping units or boxes of yarn. Otherwise, sample as agreed between purchaser and supplier. Test one skein per yarn package to form the laboratory sample. Since the variation in yarn linear density is usually higher between packages than within packages, no appreciable improvement in precision can be expected by testing more than one skein from each package. Some filament yarns may be the exception since there can be consistent differences in the yarn linear density between yarn on the outside of the package compared to that of the yarn on the inside of the package. If such a difference is expected, test more than one skein per package and take the skeins at intervals throughout the package.

Sample Conditioning

After reeling the test skeins, condition the yarns in skein form in the standard atmosphere (i.e., $20 \pm 2\ ^{o}C$ and $65 \pm 2\%$ RH, or other atmosphere, but always according to ISO 139) for a minimum of 1 hour; or before reeling the skeins, condition the yarn packages in the standard atmosphere for a minimum of 3 hours.

General Test Procedure

- Reel all skeins at a consistent speed, avoiding jerks and undue acceleration or deceleration.
- Weigh each skein separately so that variation in linear density can be calculated.

Calculations

Calculate the average mass of the skeins and then calculate the yarn linear density from the mass and length of each individual skein. The equation to be used for calculating the yarn linear density depends on skein length, the units of mass (grams or grains), and the yarn numbering system used. For calculating yarn count to be expressed as denier, use the following general equations:

$$yarn\ denier = \frac{skein\ mass, g}{skein\ length, m} * \frac{9000\, m}{1\, g}$$

$$yarn\ denier = \frac{skein\ mass, g}{skein\ length, yd} * \frac{9842\, yd}{1\, g}$$

$$yarn\ denier = \frac{skein\ mass, grains}{skein\ length, yd} * \frac{9842\, yd}{15.423 grains}$$

$$yarn\ dtex = \frac{skein\ mass, g}{skein\ length, m} * \frac{10000\, m}{1\, g}$$

Remarks

The standard balance can be replaced by a special scale directly displaying the value in count values (e.g., Zweigle or Uster balances).

YARN SKEIN SHRINKAGE TESTING

This test method is used to determine the shrinkage of yarns in skein form when treated with boiling water or dry heat. Other options are to treat the skeins with saturated steam or a suitable solvent. Only the first two options are detailed here.

This is not recommended for elastomeric yarns or those that stretch more than 5% under the loading tensions prescribed.

Summary of Test Method

The loop length of a properly conditioned skein of yarn is measured under a specific tension, which is sufficient to straighten but not stretch the yarn. This tension-free skein is immersed in boiling water or is exposed to dry heat and is then reconditioned and re-measured. The change in length is expressed as a percentage of the length before immersion or exposure.

Apparatus Required

- A hand reel or motor driven reel having a preferred perimeter of 1 m or 1.5 yd with a tolerance of 0.25%. The reel is fitted with a traversing mechanism that will avoid bunching of the successive wraps of the yarn. The reel is usually fitted with an indicator of the length of yarn wound. It is advisable that one of the arms of the reel be collapsible to allow for ease of removal of the wound skeins. The reel is also fitted with a system for controlled tensioning of the yarns at 0.5 cN/tex.

- Measuring length scale mounted vertically with a top hook from which to hang the skein.

- Metal hook of known weight to hang from the bottom of the skein, shaped to receive tensioning weights.

- Container sufficient to hold a bath with a 40:1 ratio of water to material.

- Heat source for heating the water bath.

- Heating oven for the dry heat method.

- Drying oven for drying the wet skeins (if no oven is available, for internal tests the skeins can be dried with a hair drier).

Sampling Recommendation

As a lot sample for acceptance testing, take at random 10 packages from among the cartons that define a shipment. Otherwise, sample as agreed upon between the purchaser and supplier. Test one skein per package.

Sample Conditioning

After reeling the test skeins, condition the yarns in skein form in the standard atmosphere (i.e., 20 ± 2 ^{o}C and 65 ± 2% RH, or other atmosphere, but always according to ISO 139) for a minimum of 1 hour; or before reeling the skeins, condition the yarn packages in the standard atmosphere for a minimum of 3 hours.

General Test Procedure

- Reel an 80-wrap skein using a uniform tension of not over 1 cN/tex.
- Identify each skein separately.
- Condition the prepared skeins for 24 hours in the standard atmosphere, or until the weight of a skein no longer fluctuates, defined as not changing more than 0.1% between successive weighings on the same skein at 2-hour intervals.
- Make all measures of the skein loop lengths in the standard testing atmosphere.
- Determine the linear density of the yarn if unknown as described in the section "Yarn Count Testing" in this handbook. This is for the purpose of selecting the correct amount of tensioning weight to hang on the skeins.
- Measure the loop length of the skein hung as described above with sufficient mass added for tensioning inclusive of the mass of the hook on which the weights are hung.
- After 30 ± 3 seconds, measure and record the inside length of the skein to the nearest 1 mm.
- After it is weighed, twist each skein into a figure 8 and form a two-coil loop by bringing the ends together. Repeat to form a four-coil loop.
- Continue as described below depending on the choice of boiling water or dry heat for treating the yarn.

Boiling Water Exposure

- Wrap each skein in cheesecloth and secure the cheesecloth by sewing or tying to prevent the entanglement of yarn in actively boiling water.
- Make up a distilled or demineralized water bath that is 40 times the mass of the wrapped skeins to be immersed in it, and that contains a 0.05% wetting solution by weight.
- Bring the bath to a continuous rolling boil and immerse the skeins for 30 minutes.
- Allow the bath to cool to at least 50 ^{o}C before decanting the solution from the specimens.
- Do not cool the bath by overflowing or rinsing the specimens.
- Use a centrifuge or roll wringer to damp dry the wrapped skeins.
- Remove the skeins from the cheesecloth and complete drying them at room temperature or for 1 hour in a drying oven at 65 ± 3 ^{o}C.
- Recondition the samples as described above.
- Re-measure the skeins identically as they were measured before immersion into the water bath.

Dry Heat Exposure

- Preheat oven to the agree-upon temperature or to 75 ^{o}C.
- Switch off the oven fan, quickly open the oven door, and suspend the skeins in the oven. Hang the skeins in the oven preventing their touching the bottom or the sides of the oven.
- Close the oven door as quickly as possible and restart the fan. When oven has returned to the set temperature, begin measuring the agree-upon exposure time or use 1 hour at the 75 ^{o}C temperature.
- At the end of the exposure period, shut off the oven fan and remove the skeins.
- Recondition the samples as described above and re-measure the skeins identically as they were measured before exposure to the dry heat.

Calculations

Calculate average shrinkage for each package and for the shipping unit or yarn lot.

$$shrinkage, \% = 100\% * \frac{original\ loop\ length - final\ loop\ length}{original\ loop\ length}$$

FABRIC MASS PER UNIT AREA (GSM)

Part of ISO 3801 specifies a method for determining the mass per unit area of woven fabrics. Other standards describe methods for determining this attribute for most fabric types including warp knit fabrics. Two options presented here are for testing a full-width sample or a small swatch of the fabric.

Summary of Test Method

Fabric mass per unit area is calculated from the mass of specimens for which the width and length have been measured, respectively, as directed in ISO 3933 and 3922.

An alternate method that is suitable for in-plant process control is to calculate fabric mass per unit area from the mass of circular fabric swatches with known area, preferably 100 cm^2.

Apparatus Required

- Calibrated steel rule at least 2 m in length, graduated in cm and mm for use with full-width samples.
- Scale with capacity and sensitivity sufficient to weigh the test specimen to within 0.2% of the gross weight of the test specimen. When weighing a small swatch of fabric, the scale must be accurate to 0.001 g.
- Cutting die, accurate to 1%, to enable a 10 cm x 10 cm specimen to be cut, or a circular cutter of area 100 cm^2 for the small swatch method.

Sampling Recommendation

Consider rolls of fabric to be the primary sampling unit. Take at random the number of rolls of fabric as directed in an applicable material specification or as otherwise agreed between purchaser and supplier.

As a laboratory sample for full-width portions of the fabric, cut a specimen at least 0.5 m in length from each roll to be tested if the specimen can be conditioned prior to testing. Otherwise, cut the specimen at least 1 m in length from each roll to be tested. Do not cut the specimen closer than 1 m from the end of the roll of cloth.

As a laboratory sample for small swatches of fabric, prepare at least five 100 cm^2 specimens per roll or fabric piece. Do not take these specimens closer than 10% of the fabric width to a selvedge or cut edge, and select areas for cutting the specimens so that they represent the fabric as fully as possible.

Sample Conditioning

When possible, condition the samples in the standard atmosphere for textile testing (i.e., 20 ± 2 ^{o}C and 65 ± 2% RH, or other atmosphere, but always according to ISO 139). Consider equilibrium to be reached when the difference between successive weighings made at 2-hour intervals does not exceed 0.5% of the mass of the fabric samples being weighed and conditioned in this atmosphere.

When it is impractical to condition the whole piece or the small swatch in the standard atmosphere, relax the test specimen in the prevailing atmosphere before measuring and weighing.

General Test Procedure

- Determine the length and width of the specimens of full-width fabric.
- Determine the area of the small swatches of fabric.
- Weigh the specimens.

Calculations

Calculate mass per unit area and express as g/m^2 (GSM) as is customary for mosquito net fabric.

If the 100 cm^2 swatch is used for weighings, multiply the mass in grams for each specimen by 100 to convert to g/m^2.

Calculate the mean mass of each set of specimens for a roll or fabric piece and round off the result to the nearest 1 g.

FABRIC MESH COUNTING

Part of ISO 7211 specifies methods for determining the number of threads per centimeter or per inch in woven fabrics. The ASTM standard D 3775 also covers the measurement of fabric count for all types of woven fabrics. These test methods described can also be adapted for determining the mesh count of warp knit net fabrics.

Summary of Test Methods

The number of mesh openings per specified area of fabric is determined using suitable magnifying and counting devices while the fabric is held under zero tension and free of folds, wrinkles, or creases.

Apparatus Required

- Use any suitable device such as a pick glass, rule and pointer, microfilm reader, or projection equipment.
- A counting glass may be used with an aperture width of 2 or 3 cm or 1 inch at all places. The thickness of the base of the edges of the aperture shall not exceed 0.1 cm.

Sampling Recommendation

Consider rolls of fabric to be the primary sampling unit. Take at random the number of rolls of fabric as directed in an applicable material specification or as otherwise agreed to between the interested parties.

As a laboratory sample, take a full width swatch at least 2 m long from each roll to be tested. Mesh openings should be counted at not less than five different points selected to represent the fabric as fully as possible. When counting with a rule and pointer, the distance over which openings should be counted is suggested in the following table:

Openings/cm	Minimum Counting Distance, cm	Total Openings Counted
< 10	10	< 100
10 - 25	5	50 – 125
25 - 40	3	75 – 120
> 40	2	> 80

Sample Conditioning

Fabrics of yarns having a relatively low moisture regain in the standard atmosphere for the testing of textiles (i.e., 20 ± 2 ^{o}C and 65 ± 2% RH, or other atmosphere, but always according to ISO 139), and which are not significantly affected by minor variations in different atmospheric conditions may be tested for internal process control without being conditioned. Examples are nylons, acrylics, polyesters, polyethylenes, and polypropylenes.

Otherwise, fabrics should be conditioned prior to testing in the appropriate standard atmosphere as defined in ISO 139.

General Test Procedures

Counting Glass

- Lay the fabric on a horizontal surface and place the counting glass on the fabric so that one of the edges of the aperture is parallel to either a course of the knit fabric.
- If possible, count every mesh opening visible in the entire area of the aperture.

Traversing Thread Counter

- As one option, incorporate a low-power microscope (X4 to X20), mounted so that it can be traversed by a screw mechanism over a graduated base that is sufficiently long to meet the minimum measuring distance requirements.
- Lay fabric flat on a horizontal surface and place the counter upon it in such a way that when the screw is turned, the microscope moves across the fabric in a direction that is parallel to a course of the knit test fabric.
- Count all mesh openings over the appropriate minimum measuring distance.
- Repeat the procedure, moving the microscope across the fabric in a direction that is parallel to a wale of the knit test fabric, being sure that the edge of the counter has been placed at a 90^{o} angle to the first counting in the course direction.

Rule and Pointer

- A heavy steel rule and suitable pointer can be used with or without the aid of a magnifying glass as needed.
- Lay fabric flat on a horizontal surface and place the rule on the fabric parallel to a course in the knit test fabric.
- Count all mesh openings over the appropriate minimum measuring distance.
- Turn the rule exactly 90^{o} from the above position and count all mesh openings over the appropriate minimum measuring distance.

Calculations

Calculate the number of mesh openings per square centimeter or per square inch of fabric.

FABRIC SHRINKAGE TESTING

ISO 5077 specifies a method for determining the dimensional change of fabrics when subjected to an appropriate combination of specified washing and drying procedures. These procedures are appropriate for testing for commercial acceptance. Procedures are provided by other testing standards organizations that can be readily adopted for in-house process control.

The method used to compare shrinkage of fabric from the heat-setting operations day-to-day does not necessarily have to be the same as the procedure required to prove that the fabric meets an industry standard. It is only essential that the methods of wetting and re-drying used for internal control be employed consistently and under the same testing conditions. However, how the results of any internal method correlate to the results of the industry required test methods should also be determined.

Summary of Test Method

A test specimen is conditioned in the specified standard atmosphere and is measured before subjection to the appropriate washing and drying procedures. After drying, reconditioning, and re-measuring of the specimen, the changes in dimensions are calculated.

Equipment options are specified in ISO 3759 and 6330. The latter standard presents 10 possible washing procedures with front-loading washing machines and 11 procedures with top-loading washing machines.

Summary of Alternate In-Plant Test Methods

If a suitable washing machine and dryer are not available onsite, there are a number of other methods for determining fabric dimensional stability that can be used for routine in-plant testing. Two methods are described in ASTM D 2646, and a third method is already popular in some net manufacturing facilities.

In all methods, the fabric test specimen is first conditioned, marked, and measured to a specific length and width. Guidelines in ISO 3759 for these steps can be used for all such fabric shrinkage tests. The specimen is then immersed in an aqueous solution, dried, reconditioned, and re-measured; or the specimen is exposed to dry heat, reconditioned, and re-measured. Shrinkage is calculated as the change in length and width, each expressed as a percentage of the respective original measurements of length and width that were made before immersion or exposure.

Apparatus Required

The following equipment and reagents are among those needed depending on the test method used:

- Metal or glass pan at least 330 mm x 330 mm and at least 25 mm deep.
- Circulating air oven.
- Rule marked in millimeters (mm) and longer than the greatest dimension to be measured.
- Marking device for making precise reference points on the fabric specimens such as indelible ink, colored sewing threads, heated wire for thermoplastic materials, or staples.
- Suitable wetting agent.
- Screen for use in the drying oven.

Sampling Recommendation and Preparation for In-Plant Test Methods

Cut 3 to 4 specimens from each fabric roll or piece to be tested, each specimen at least 300 mm x 300 mm. Do not cut specimens within 1 meter of either end of the fabric piece nor closer than 250 mm from the selvedge of the fabric. Lay out specimens without tension on a flat, horizontal surface, taking care that there are no wrinkles or creases. Place a staple or other suitable mark in the specimen about 25 mm from one edge. Measure 250 ± 2 mm directly along one principle direction of the fabric specimen and place a second staple or suitable mark. Repeat this procedure for the other principle direction of the specimen.

Sample Conditioning

Condition the test specimens, before and after immersion or exposure to heat, in the standard atmosphere for at least 4 hours or until constant mass is achieved. Standard atmosphere for textile testing is 20 ± 2 °C and 65 ± 2% RH (or other atmosphere, but always according to ISO 139). Constant mass is considered reached when the measured mass of a specimen at 1 hour intervals does not show a change greater that 0.25%.

General Test Procedures

Hot Wet Test Method

- For the hot wet test method, place the specimens in the pan and cover them with a solution of 0.1% wetting agent in distilled or deionized water at 77 ± 2 ^{o}C to a depth of 25 mm.
- Soak the specimens for 1 hour.
- Drain off the wetting solution.
- Place specimens of paper towels or blotting paper to remove excess solution, but do not squeeze or press the fabric specimens.
- Place the specimens on a screen and dry in an oven at least 4 hours at 70 ± 2 ^{o}C.
- Remove and recondition the specimens.
- Re-measure the specimens in both directions between the staples or marks to the nearest 1 mm.

Hot Dry Test Method

- For the got dry test method, place the properly prepared specimens in an oven at an agreed-upon temperature for an agreed-upon time or at 125 ± 2 ^{o}C for 15 minutes.
- Remove and recondition the specimens.
- Re-measure the specimens in both directions between the staples or marks to the nearest 1 mm.

One Alternate Test Method

- As another option for testing, place the properly prepared specimens in the pan and soak them for 2 hours in water with 0.5 g/l of an effective and acceptable wetting agent at room temperature.
- Drain off the setting solution.
- Place specimens of paper towels or blotting paper to remove excess solution, but do not squeeze or press the fabric specimens.
- Dry on a flat, smooth surface at 27 ± 2 ^{o}C.
- Recondition the specimens.
- Re-measure the specimens in both directions between the staples or marks to the nearest 1 mm.

Calculations

Calculate dimensional change as indicated in the following equations and express the result for each individual specimen tot he nearest 0.1%. Express the average for the roll or fabric piece to the nearest 0.5% or as agreed upon by the interested parties.

$$length\ \ shrinkage, \% = 100\% * \frac{original\ length - final\ length}{original\ length}$$

$$width\ \ shrinkage, \% = 100\% * \frac{original\ width - final\ width}{original\ width}$$

FABRIC AIR PERMEABILITY TESTING

ISO 0237 describes a method for measuring the permeability of fabric to air and is applicable to most types of fabrics that are permeable to air.

Summary of Test Method

The rate of flow of air passing perpendicularly through a given area of fabric is measured at a given pressure across the fabric test area and over a given period of time.

Apparatus Required

- A test apparatus with measurement capability that can be confirmed according to the provisions of ISO 10012-1.
- Circular specimen holder with an orifice allowing the test to be carried out on an area of 5 cm^2, 20 cm^2, 50 cm^2, or 100 cm^2.
- Means for clamping to secure the fabric specimen without distortion.
- Guard ring device to prevent air leakage.
- Pressure gauge connected to test head with accuracy of measurement of at least 2%.
- Means for drawing a steady flow of air.
- Flow meter, volumetric counter, or measuring aperture to indicate the rate of air flow.

Sampling Recommendation

Select samples in accordance with the procedure described in the material specification for the fabric, or as agreed to between the interest parties.

In the absence of specification, take at random the appropriate number of rolls or fabric pieces from a shipment as indicated in the table below. Ensure that no piece of fabric shows signs of damage or dampness.

Number of Pieces in Shipment or Lot	Minimum Number of Pieces in the Lot Sample
< 3	1
4 - 10	2
11 - 30	3
31 - 75	4
> 75	5

From each piece selected, cut a laboratory sample of full width and at least 1 m in length. Ensure that areas that are creased or that have a visible fault are not included in the laboratory sample.

Test a recommended surface area of 20 cm^2 of each laboratory sample. Repeat this test at least 10 times at different locations on the laboratory sample.

Sample Conditioning

Condition the laboratory samples in the standard atmosphere (i.e., 20 ± 2 ^{o}C and 65 ± 2% RH, or other atmosphere, but always according to ISO 139).

General Test Procedure

- Test with a pressure drop of 100 Pa for apparel fabrics and with a pressure drop of 200 Pa for industrial fabrics.
- Mount test specimen in the holder.
- Avoid selvedges and areas with creases, wrinkles, or folded places.
- Start the means to force the air through the specimen and adjust flow of air gradually until the recommended pressure drop is achieved across the test area of the fabric.
- Record the air flow after at least 1 minute, or after steady conditions are achieved.

Calculations

Calculate air permeability, *R*, expressed in mm/second using the following equation:

$$R = \frac{qv}{A} * 167$$

Where:

qv = arithmetic mean flow rate of air in liters/minute

A = area of test fabric being tested in cm^2

167 = conversion factor from liters/m/cm^2 to millimeters/second

For open fabrics like mosquito netting, the air permeability may be expressed in meters/second.

FABRIC BURSTING STRENGTH TESTING

ISO 13938-1 and 13938-2 describe a hydraulic and a pneumatic method, respectively, for the determination of bursting strength and bursting distension of textile fabrics. Available data suggest that there is no significant difference in the results achieved using hydraulic or pneumatic burst tester for pressures up to 800 kPa.

Summary of Test Method

A test specimen is clamped over an expandable diaphragm by means of a clamping ring. Increasing fluid or compressed air pressure is applied to the underside of the diaphragm, causing distension of the diaphragm and fabric. The pressure is increased smoothly or at a constant rate until the test specimen bursts. Bursting strength and distension are determined.

Apparatus Required

- A bursting tester with measurement capability that can be confirmed according to the provisions of ISO 10012-1.
- The diaphragm of the tester shall have thickness up to 2 mm and be highly expansive and have appropriate elasticity.

Sampling Recommendation

Select samples in accordance with the procedure described in the material specification for the fabric, or as agreed to between the interest parties.

In the absence of a fabric specification or agreed-upon plan for sampling, take at random the appropriate number of rolls or fabric pieces from a shipment as indicated in the table below. Ensure that no piece of fabric shows signs of damage or dampness.

Number of Pieces in Shipment or Lot	Minimum Number of Pieces in the Lot Sample
< 3	1
4 - 10	2
11 - 30	3
31 - 75	4
> 75	5

Test five locations of each laboratory sample, each position in a diagonal progression from one edge of the fabric towards the other edge. Test no closer than 150 mm from the edge of the fabric.

The clamping system of the tester generally permits test to be applied without cutting out test specimens.

For most fabrics, particularly knitted fabrics, a test area of 50 cm^2 is applicable. Repeat the test at least 4 additional times at different places on each laboratory sample.

Sample Conditioning

Normally, condition the laboratory samples in the relaxed state in the standard atmosphere (i.e., 20 ± 2 ^{o}C and 65 ± 2% RH, or other atmosphere, but always according to ISO 139). However, wet tests do not require sample conditioning.

General Test Procedures

Wet Testing

- For tests in the wet condition, immerse the laboratory sample for 1 hour in grade 3 water in accordance with ISO 3696 at a temperature of 20 ± 2 ^{o}C. An aqueous solution containing not more than 1 gram/liter of a nonionic wetting agent may be used instead of water.

For All Tests

- Set apparatus to achieve a testing time to burst of 20 ± 5 seconds.
- Place laboratory sample over the diaphragm so that it lies in a flat and tensionless condition with no distortions in its own plane.
- Follow apparatus operating instructions and apply pressure to test sample until the fabric bursts.
- Immediately after the burst, close off the pressure and note the bursting pressure and the height of the burst or bursting volume.
- Repeat at least 4 more times at different places on the laboratory sample.

Calculations

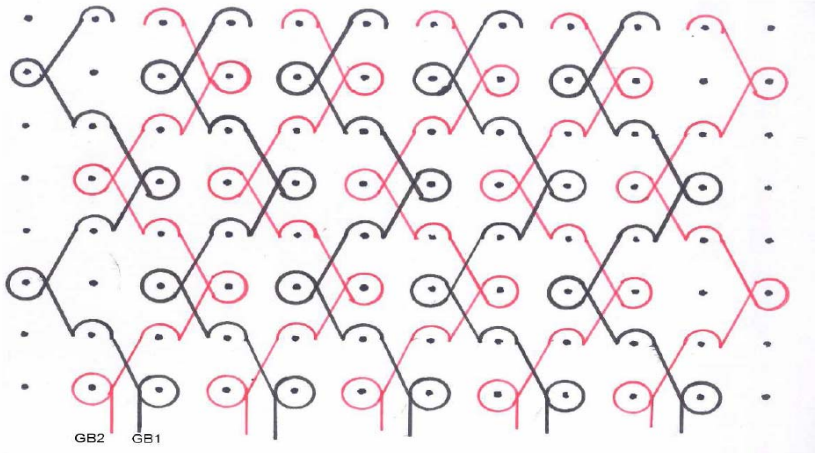
Calculate the arithmetic mean of the bursting pressure in kilopascals, kPa, for each laboratory fabric sample. From this, subtract the diaphragm pressure in kPa to obtain bursting strength. Round off the average for each laboratory sample to three significant figures.

Calculate the arithmetic mean of the height at burst values for each laboratory sample in mm. Round the average to two significant figures.

If required, calculate the arithmetic mean of the volume at burst values for each laboratory sample in cm^3. Round off the average to three significant figures.

STANDARD SETTINGS FOR WARP KNITTING OF MOSQUITO NET FABRIC

For the production of warp knitted polyester net fabric used to manufacture mosquito nets, the following standard settings are used on the warp knitting machines:

Machines used	Tricot warp knitting machines	
Gauge	28 (28 needles/inch)	
Number of guide bars	2	
Yarn used	75 den f36 (±) polyester	
Threading	GB1	GB2
	1 out / 1A//	1 out / 1 B //
Chain notation	1-0/1-2/2-3/2-1//	2-3/2-1/1-0/1-2//
Lapping diagram		
Yarn run-in	1800 mm/rack (both guide bars) *[1 rack = 480 courses]*	
Courses	9.9 courses/cm (can be expanded to 11.2 in finished fabric)	
Wales	Up to 23 wales/ inch in the finished fabric	

These values are to be understood as starting values (rule of thumb). If these settings do not give the desired product, various settings can be fine tuned. Some rules are as follows:

- If changing yarn count: thicker yarn results in an increase in fabric weight (GSM).
- Courses can be changed by changing the speed of the take-up.
  Decreasing take-up speed results in the following:
  - higher stitch density,
  - lower production (less running meters of fabric),
  - lower yarn run-in (less mm/rack),
  - increased fabric weight (GSM), and
  - decreased mesh size (i.e., smaller holes and so more holes/inch^2).
- In heat-setting, overfeed/underfeed and width extension can vary both fabric weight and mesh size; also increased mesh size (bigger holes) means decreased fabric weight and vice versa.

INSTRUCTIONS FOR SETTINGS ON THE STENTER FRAME

Heat-setting of polyester net fabric is a rather delicate process as the temperature in the stenter must be at the lower end of that required for thorough heat-setting. To preserve a supple hand of the fabric, the temperature is kept around 200 °C, but should not become too low. In any case, it is best to stay over 190 °C. This means that the slightest drift of the real temperature from the set temperature can have a very significant impact on fabric quality.

It is therefore a prerequisite that the stenter is in good working condition. All sensors should be well calibrated and intensive preventive maintenance should be practiced.

A program to improve heat setting of polyester net fabrics could be the following:

1. Calibrate all the sensors of the stenter (i.e., all temperature and speed sensors must indicate the exact real value). Temperature calibration can be done using a digital pyrometer that measures the temperature in a section of the stenter. The readout of each sensor must be the same as the readout of the pyrometer; if not, fine tuning of the sensor is necessary. Also check the accuracy of the speedometer.
2. Set the temperature in the sections at 220 °C as a start point for evaluation. Temperature on the fabric should be around 200 °C with this setting.
3. Use an initial dwell time (D_t) of around 30 seconds. To calculate the initial speed v [m/min] corresponding with this D_t, take the total length of the heating sections and multiply by 2. This means that a stenter with total heating length of 20 m can be run at 40 m/min. The shorter the heating zone, the lower the speed.
4. Take at least 5 samples of fabric treated this way and check the shrinkage.
5. If the shrinkage is correct, choose between keeping these settings or trying to lower the temperature or increase the speed. Never do both at the same time. Only one parameter can be changed at a time (see also Step 8).
6. If shrinkage is too high, increase temperature by 5 °C and check again. If shrinkage is still too high, increase dwell time D_t [s] by 5 seconds. To calculate speed v [m/min] of a stenter with total length of the heating zone L [m], use the following formula:

$$v = L * 60 / D_t$$

7. Repeat step 6 until shrinkage is acceptable or until fabric hand becomes too harsh. If hand becomes too harsh, stop increasing temperature and dwell time alternatively and concentrate only on dwell time. Decrease temperature in 5 °C increments and increase dwell time in steps of 5 seconds until fabric shrinkage is acceptable.
8. If after the first test, shrinkage is lower than the specification, consider improving productivity and lowering cost by decreasing dwell time or temperature. Decreasing temperature will lead to savings in energy cost, and decreasing dwell time will increase machine yield and productivity. Decrease temperature in steps of 5 °C and dwell time in steps of 5 seconds at a time. If shrinkage becomes too high, return to the previous setting.