Intelligent Insect Control

Mémorandum

À : RBM and the Bednet users/buyers

De : Intelligent Insect Control

CC : Whopes

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Objet : Strength of nets

Data available and how to compare

During the last year, there has been a lot of debate on the strength of long lasting nets after a report from WHO that long lasting nets in polyester were probably not so long lasting because the nets were too weak. This resulted in an outcry from the producers of Long Lasting polyester nets as well as in several reports created to show that this was not correct. Nevertheless one of these producers had already delivered two new types of polyester net to WHOPES for evaluation with enforced lower sides, which is made exactly to compensate for the lack of strength of traditionally made polyester net as shown on a poster in ASTMH in US in 2007. The poster showed that most damages in Permanet occurred in the lower part, so that part will now be amplified, meaning more yarns per square meter and that is not for free. This indicates the reports from WHO were right.

Please find below first data from a white book presented at the Gates Foundation/WHO organised meeting in Antwerpen 2008. Then the conclusions from a report arranged by Netmark on polymers and nets. Finally, data that IIC obtained from CITEVE simple by purchasing nets of the type Permanet 2.0, 75 Denier (the most sold polyester net from the Company Vestergaard-Frandsen), Interceptor (from BASF, also 75 Denier), Olyset Net (Sumitomo Chemicals, 150-200 Denier), Netprotect 136 mesh (standard Netprotect from BestNet Europe, 115 Denier) and Netprotect 200 mesh (sandfly net from BestNet Europe, 100 denier). IIC has developed the nets for BestNet Europe and Permanet 2.0 for Vestergaard-Frandsen.

Before starting these comparisons a few things must be made known because the technical parameters compared may not be understood easily. This may be a major reason for the confusion caused by various papers.

Tenacity is a strength measure that calculates strength per size of yarn. Strictly defined it means the breaking force measured in gram per unit denier (or tex) of a yarn or filament. **Denier** is the weight of 9000 m yarn, tex is the weight of 10.000 m. Since High Density polyethylene used for yarns has a specific density around 0,95 g/cm3 and polyester a specific density around 1,30 g/cm3, ***a 100 denier monofilament yarn of polyester is thinner than a 100 denier polyethylene net***. The tenacity measure compensates for this by comparing on denier and not per diameter.

Bursting strength measures the ability of a material to resist rupture by pressure. In the textile industry it is used for materials like felt, non woven and some knitted materials. For other textiles, tensile strength is used. When measuring burst strength the material is fixed in a frame and a rod is pressed down to make it rupture. For a simple comparison, it corresponds to pressing the thumb into the net to make it break.

Tensile strength measures the strength it takes to tear apart a material of a given width. The problem with a knitted net is that it is not evenly strong in the two directions. During knitting, parallel yarns are knitted together in the direction of the length of the textile and this is the strong direction, the warp. Perpendicular direction, meaning across the textile, is the weft. In this direction, the net is hold together in the cross points of the yarns, the nods, and the strength in this direction is much influenced by the knitting pattern. Therefore, when referring tensile strength, values should be given for warp and weft.

Tensile strength is measured with two clamps or two hooks, but IIC convinced CITEVE also to measure with one hook and one clamp. Opposite to the rest, this is not an ISO method, but it is carried out almost like the other methods for tensile strength. We think it is a very relevant method.

Tear strength means the material ability to resist a tear in the directions parallel to main axes. This is how it used in the paper industry and many other industries. But in the textile industry it is measured in a different way. A piece of textile is fixed by two clamps and a cut is made in the material between the clamps and then the tear strength is measured. As for tensile strength, this tear strength is very different in the warp and weft.

While all these parameters can be measured it is important to determine which of them are relevant. Or, which kind of destruction forces are net exposed to in the field? People like me who have collected nets in the field and examined them have found holes of different sizes and origins. Except for a few, big burn holes most of big holes originate from tears. Nails in the bed-frame or other pointed obstacles hook the net and when the user pack away the bed net for the day it is torn. These tear holes grow as the net is handled daily. If left unrepaired they will give free access for mosquitoes to enter.

Now to the data presented recently.

Prf Gert de Clerck presented a "white paper" called ***"Characteristics of polyester nets versus polyethylene nets".*** The paper presents first tenacity measures of the two polymers and then bursting strength of two polyester nets in 75 and 100 denier and a polyethylene net in 150 denier, determined in a German textile Institute, and then data he measured himself on demand from Vestergaard-Frandsen comparing to Olyset.

Polymer	HDPE polyethylene	Polyester
Tenacity (cN/tex)	30-70	30-65

It can be seen that measured in this way, monofilament yarns of polyester and polyethylene can be evenly strong, but they can also be very different, since the difference from top to bottom in both ranges is a factor 2. That means you cannot really use these numbers to know if the tenacity of a net is good or not, you will have to measure on a given net. Further, ***polyester nets are never made out of monofilament***, but out of a bunch of much thinner multifilaments that may even be texturized to make them softer. This treatment will also make them weaker since *texturized* means the surface is ripped. The commercial long lasting nets are made with such texturized nets, whereas many of the nets for dipping are not. However, this does not mean the nets for dipping are stronger since the quality of the polymers used is also of major importance.

Prf de Clerck presents two more figures that refer measurements from a German textile institute and from his own. Below, I have put these data into one table.

Note that the mesh count on the two polyester nets are not the same. The polyester net with the thicker yarn is a net with a higher mesh. Both properties contribute to net strength. A polyester net with 150 denier is not yet on the market. For the moment only 75 and 100 denier nets are and they have a mesh of 156 mesh/inch² for Permanet and Interceptor

Parameter	Standard	Unit	Polyester			Polyethylene	
Denier	DIN EN 53830	Denier	**75**	100	150	150	200
Mesh	ISO 7211/2	Holes/inch²	**157** **176**	177	 147-175	75	 62-71
Mass per unit area	DIN EN 12127	g/m²	**31** **31-32**	40	 57-58	53	 62-71
Bursting Strength	ISO 13938-2	kPa (7.3cm²)	**282** **288-364**	446	 534-620	455	 412-523
Tenacity of yarn	DIN EN 2062	cN/tex	**42**			42	

In the table above, upper values per cell are from the German textile Institute and lower values are from prf de Clerkc's institute. Those from prf Clerck Institute refers to nets provided by Vestergaard. **Only the 75 Denier net (data in bold) has a preliminary recommendation by WHO and follows the specification for Permanet 2.0**. The two other nets must be experimental or future products.

The data show that the most sold polyester long lasting bednet (Permanet 2.0, 75 Denier) has about half the bursting strength as the most sold polyethylene net in 150-200 denier (Olyset Net). The bednet buyer or user does not need to worry about strength measured as tenacity, but only about what he can buy. It is also seen that if he buys a 100 denier polyester net with a 177 mesh he gets a stronger net. Since such a net is not on the market this remains very theoretical. Those on the market just has a mesh of 157 holes/inch².

Without looking closely at the data as it is presented here and without pairing the data up with the nets that actually can be bought, it is clear how the reader can be tricked.

The study sent out from Netmark shows data of the same sort. They compare monofilament polyester yarns with monofilament polyethylene yarn without telling the reader that whereas bednet in polyethylene always are made out of monofilament yarns, nets in polyester never are. The study thus have very little practical importance, but since it is very much quoted by some net producers, please allow me to repeat the conclusions below.

First their conclusions, then my comments:

1. The durability of warp knitted nets is significantly influenced by yarn structure (monofilament versus multifilament) more than polymer type (polyester, polypropylene, polyethylene).
2. Polyolefine fibres (polypropylene, polyethylene) are gaining in popularity because their lower melt temperatures allow insecticides to be embedded in the yarns during extrusion.
3. The speed of the migration of insecticide to the surface of a polyolefin fibre following washing is very important as the insecticide may be ineffective for 2-7 days. NetMark data from 6 countries show that more than 50% of households wash their net at least once a month. Polyester LLINs do not need a regeneration period.
4. Polyester fibers typically have higher tenacity (grams/denier) than polyolefin fibers.
5. The UV stability of polyester is superior to that of polypropylene and polyethylene without UV stabilizers added.
6. Low denier multifilament polyester is a global textile commodity while low denier polyethylene and polypropylene (multi and monofilament) is difficult to source in significant volumes and therefore generally more expensive.
7. Warping equipment for 75-100 denier multifilament polyester may not be suitable for higher denier, monofilament polyethylene or polypropylene. Any manufacturer contemplating a switch from multifilament to monofilament yarn will have to make a significant investment in new equipment and factory modifications.

Ad 1: Yes, and monofilament is more durable than polyfilament for the simple reason that the unit fibre is much thicker (e.g., 0,13 mm for Netprotect versus 0,02 mm for Permanet)

Ad 2: Yes, and this prevents insecticide from being rubbed off during handling or hand washing. But this is not the only reason for using polyethylene. The diffusion in polyethylenes is much larger than in polyester, and if one succeeded to put insecticide into polyester, it would stay inside.

Ad 3: This is not correct. The speed of migration is measured in a 3 minute exposure and for this short exposure, a polyethylene net may fail the test within the first days. However, the two newer polyethylene nets (Netprotect and Duranet, WHO/HQ 10-13 December, 2007) showed to be effective within 3 days after net wash up to 20 washes. And for practical concern, mosquitoes will sit longer on nets than 3 minutes, so the real effect will probably not diminish at all.

Ad 4: This is not correct as can be seen from prf de Clerck's investigation quoted above. Netmark took values from commercial yarns and not values from bed net yarns as prf de Clerck did. Since yarns made for bednets are not standard yarn, but speciality yarns, only the comparison made by prf de Clerck is valid and therefore relevant.

Ad 5: This is correct, but is easily corrected. At least Netprotect contains UV stabilisers and UV filters. Beside, the time most bednets stay outside is limited to a few hours after washing, and the pyrethroids used for bednets are quite UV stable.

Ad 6: This is not a problem to the user but to the producers.

Ad 7: This depends on the warping and knitting machines. Again; Long Lasting Insecticidal Nets are factory made, so this is not the problem of the users or buyers.

Test at CITEVE.

IIC asked CITEVE in July 2008 to compare Permanet 75 D, Netprotect, Netprotect with a fine mesh (for sandflies), Olyset and Interceptor. We asked CITEVE (the WHO textile reference laboratory) to run bursting strength, tension strength according to 3 protocols and tear strength for the products. CITEVE took 5 samples from each net according to the WHOPES method for sub-sampling from a net and the data are presented below; (we also included 4 experimental formulations that are not

shown). The polyester nets included were selected because they represent about 80 % of polyester nets sold. Two of the three commercially available Long Lasting polyethylene nets are included. We did not manage to find Duranet that also is such a polyethylene net but was impossible to find on the market.

Parameter/ Net	Netprotect	Netprotect Sandflies	Olyset 490976	Interceptor 536274	Permanet 11/2007
Mesh	136	200	75	155	155
Denier	115	100	150-200	75	75
Bursting strength	540	500	470	245	345
Tensile strength grab	260 170	260 250	290 250	110 80	120 110
Tensile strength two hooks	65 40	60 72	100 50	17 14	ND
Tensile strength Hook/clamp	33 – 72 40 – 52	88 80	97 58	16 14	12-17 14-18
Tear Strength	11-12(*) 9,7 - 10	16-24(*) 15-24(*)	16 – 19(*) 11 – 12 (*)	9 - 12 3,0 -3,4	8,9 – 11 (*) 14-16 (*)

ND means no determinations. Values given are average of 5 samples. For tear strength, maxima and minima values are given and (*) means the net samples got distorted during tearing and cross tearing interfere with the result, so these values are not reliable. Upper lines per cell are in warp (the long direction of the knitting) and lower are in weft (across).

The numbers after the names of nets refer to barcodes on the nets. Permanet also had the code 3 078 7.

The data shows that in all measurements presented, the strength of a net is not just determined by the denier (yarn thickness), but also by the mesh. It is also determined by the knitting pattern, but none of the data presented here refers to the same yarn in different knitting patterns.

In any parameter measured the polyester nets of 75 D are considerably weaker than polyethylene nets of higher denier. Netprotect Sandflies has the finest monofilament yarn (100 denier), yet it is stronger than the polyethylene nets with a higher denier. This is because the knitting pattern is more dense, so there are more yarns per square meter. A stronger net can thus be made in several ways. In this study “Netprotect Sandflies” is the strongest of the nets tested in most of the tests.

Accordingly, these data show, as did those of prf de Clerck, that among marketed products polyethylene nets are the strongest in whatever measure used.

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