Tekirdağ Namık Kemal University
Çorlu Engineering Faculty
Textile Engineering Department

# ICONWOOLF 2019

# INTERNATIONAL CONGRESS ON WOOL AND LUXURY FIBRES


# PROCEEDINGS

19 April 2019

www.icon2019.org

# International Congress on Wool and Luxury Fibres

## ICONWOOLF PROCEEDINGS (19.04.2019)

ISBN
TK NO: 978-605-4265-61-9
Vol. 2: 978-605-4265-63-3

# INTERLABORATORY TEST PERFORMANCE OF A PORTABLE FIBER TESTER

**EC. Quispe[a,d*], MJ. Rubio[a], D. Sacchero[b] and MD. Quispe[c]**

*[a]National Autonomus University of Chota, Street José Osores 418, Chota, Cajamarca, Perú.*
*[b]Textile Fibers Laboratory. National Institute of Agricultural Technology. Bariloche. Argentina.*
*[c]Maxcorp Technologies S.A.C. 855 Los Ruiseñores Street. Office 403. Santa Anita. Lima.Perú.*
*[d]Natural Fiber Tech S.A.C. 796 Felipe de Zela Street. Office 302. Santa Anital, Lima, Perú.*

**Abstract***
A stand-alone summary (125 words or less) Now 438.

The objective of this research was to construct and to evaluate a portable fiber tester (PFT) for field test use. The standard wool top (SWT) samples were used for evaluation measurement of fiber diameter using PFT comparatively in three laboratories without restricted temperature or humidity controls. Linear model with three factors was used to derive the least square means and variance components were also determined. In addition, precision and accuracy were determined. The PFT is constructed to be compact and lightweight. It works using digital image technology and can evaluate the fiber diameter for each sample in 45 seconds. The results show that the average fiber diameter measured by PFT at all labs are within IWTO defined tolerance values with a high precision. There were no significant lab effect whereas, variance of labs remained low. It can be concluded that PFT is an instrument with high precision and accuracy to measure the fiber diameter of wool, which may be operated in differing conditions.
**Key Terms***
Instrument, evaluation, wool, accuracy, precision.

## 1. Introduction

Fiber production is very important for textile industry in many countries. The world wool production is about 2 million tons each year. The countries of Australia, New Zealand, China, and Russia are the main producers of wool. In luxury fiber, Peru is a main producer of alpaca and vicuña fiber, China and Russia of cashmere, Tukey, USA and South Africa of mohair, China and France of Angora hair, and China and Mongolia of camel hair[1, 2]). For these reasons, wool and luxury fiber production involves many people and it has a strong economic impact..

Fiber diameter is a principal factor of the wool quality determination for fleece production, wool trading, and textile processing [3]). In many genetic improvement programs for sheep, camelids and goats, the principal objective is to decrease average fiber diameter, because it is a factor that determine the price of fibers and breeding animals for commercialization. Fleeces and animals with fine fiber have a high price compared with fleeces and animals with coarser fibers. Likewise, fiber diameter value is an indicator of the fineness with which a yarn can be spun. Consequently, finer wools can be processed into yarns which are aptly suited for high value apparel textile end uses. Thus, finer wools can produce fabrics of characteristically light weight, soft, with superior handle and drape[4].

Therefore, it is important to measure fiber diameter of wool samples with a high accuracy, precision and quickness[5]. Currently, there are a few instruments in use to measure fiber diameter of either greasy or clean wool samples at wool center laboratory and warehouse[6]; however, those lack portability, price affordability, measurable limitation, and inflexibility of field use on farms. OFDA, FIBER EC and Laserscan are instruments currently used but they are not portable and are very expensive[7]. FibreLux is a portable instrument that is easy to use on farm but has a limited measuring range and only works in wool[8].

So, the objective of this research was to design and to construct a portable fiber tester (PFT), to evaluate with accuracy and precision a laboratory test under conditions without restricted temperature or humidity controls.

## 2. Experimental

### 2.1. Location and Materials

The design and construction of the PFT was implemented at Autonomus National University of Chota, and Maxcorp Technologies SAC of Lima, Peru, between November 2015 and December 2016. The design has four sub components (optical, mechanical, electronic, and software) that were directed at measuring average fiber diameter (AFD) objectively in various regions of the fibers, which also allowed for measurement of the standard deviation of AFD (SDAFD).
The PFT inter-laboratory test was carried out simultaneously at three conventional laboratories, located in Lima, Chota and Cusco, Peru in a setting without a restricted temperature or humidity controls.. Some environment indicators are shown at Table 1.

Table 1. Altitude, temperature, and humidity environment indoor at each laboratory were measured at each location where the Portable Tester Fiber was used..

| Laboratory location | Altitude[1] m.a.s.l. | Environment temperature (°C) | Environment humidity (%) |
|---|---|---|---|
| Lima | 161 | 20±0.8 | 54±2.1 |
| Chota | 2388 | 21±1.2 | 62±2.2 |
| Cusco | 4338 | 17±1.8 | 46±1.9 |

[1]Expresed in meters above sea level

### 2.2. Construction of Portable Fiber Tester

The mechanical and electronic sub components consisted of an industrial USB digital camera, with sensor CMOS and speed programmable exposure. It was used to capture the images to be processed with a zoom lens (objective and ocular) engaged with spacers.An LED lamp as light source, and an Atmel ATmega328 microcontroller for displacement of the XY coordinate table were also used. The microcontroller also receives signals from the environmental humidity and infrared temperature sensor (Model DHT22), which was connected to the electronic board. Those readings were then sent to a computer (laptop HP i3), where all signals were processed.

The images with fiber captured by a preconfigured digital camera with its SDK were improved (pre-processing enhancement) by converting to grayscale (to distinguish poorly lighted fibers), followed by segmentation and smoothing, then images were binarized to distinguish background shows (1 = displayed, 0 = bottom). Morphological erosion and dilation operations were performed to remove unwanted contaminants and residues, thus providing homogenized images of the fibers. The skeletonization of the fiber images, a process that involved removing a pattern (fiber images) of the greatest possible number of pixels without affecting its general form, was carried out to obtain a line (skeleton) of a single pixel. It was then connected, evaluated, and located in the center and along each fiber image. To find outgoing branches of the skeleton, Hough transform was used to find straights along the curvature of the fiber samples from these images. Then, edge detection algorithms were developed to define the distance of the fiber diameter in pixels.

The case housing was prepared with acrylic sheet of 4mm thick. Mechanical, electronic, and óptical subcomponents were mounted within it.

**2.2. Procedures**

Eight International Standard Tops (ISTOPS) of known AFD and SDAFD, obtained from the Testing Fiber Laboratory-INTA, Bariloche, were used for calibration and evaluation of the PFT. Each one ISTOPS were prepared in snippets and divided in three subsamples. These were sent at each laboratory for inter-laboratory test with PFT.

A calibration process was mandatory because the unit of measure of PFT is pixels. The calibration was performed in according to the procedure of IWTO-47[9], before PFT evaluation. Each subsample of ISWOTOPS at each laboratory was divided in three sub subsamples and were measured with PFT.

For measurement, a fiber holder slide (FHS) was used. This accessory was made up of two sheets of glass. The sheet size was 7 x 7.3 cm with 1.5 mm thickness. The glass sheets were held together by adhesive tape on one end. The wool snippets were spread over a surface of one glass sheet using a spreader dispositive, at a controlled density, then covered with the second glass sheet, according to the procedure of POFITEST[5]. The prepared FHS with snippets was placed on the holder of the PFT and it was s measured using the computer software.

The test precision was determined using standard deviation of the average of three standard deviations, each one calculated using two measurement of the same subsample. Precision was calculated for one of 8 ISTOPS. Whereas, test accuracy was assessed using deviation of measurements, which were obtained with PFT from data reference of standard wool top measurement values. The test precision and accuracy was carried out at each laboratory location.

**2.3. Statistical analysis**

Data of AFD obtained by PFT were analyzed following the statistical procedure of R v 3.5.2. Linear model with three factors including effect of lab, sample, and subsample were used to derive the least square means. Variance components were determined also. In addition, it was evaluated in each laboratory according to the average of AFD using bars and plots diagrams. Software R version 3.3.0 and Excel were used for statistical analysis.

**3. Results and Discussion**

The new design of PFT (called MINIFIBER) features compact size and is lightweight. The weight is 3.95 kg and the dimensions are 21.5 cm x2.15cm x 27.5 cm. PFT operates using digital image capture and analytical owner program, which measures the fiber diameter values and captures digital data for per sample within 45 seconds. Information about measures (AFD, SDAFD, number of measures, temperature, environmental humidity and other information) are saved in an Excel file (Figure 1a).


Figure 1. Portable Fiber Tester working at farm condition. The image of left side (Figure 1a) show the small dimensions. The image of right side show the portability

The compact size and light weight make the PFT highly portable. These features allow the PFT to fit inside a backpack (Figure 1b), for the added ease of using it on farm. The portability is very important, because in many countries with low-input systems, travel is very difficult between farms because they lack infrastructure[10]. One person can move the PFT by foot, to arrive at a farm, to work in farm conditions and to give results in-situ, because in addition the PFT includesa thermal printer.

Table 2. Accuracy and Precision Portable Fiber Tester (PFT) of average fiber diameter (AFD) in three laboratories at interlaboratory test. Accuracy is the difference between AFD of each laboratory minus AFD of ISTOPS.

| AFD of ISTOPS (µm) | Accuracy* of PFT in three laboratory | | | Precision* of PFT in three laboratories | | |
|---|---|---|---|---|---|---|
| | Lab 1 | Lab 2 | Lab 3 | Lab 1 | Lab 2 | Lab 3 |
| 17.34 | 0.00 | 0.30 | -0.15 | 0.02 | 0.01 | 0.01 |
| 18.58 | 0.10 | -0.22 | -0.20 | 0.03 | 0.04 | 0.05 |
| 20.40 | -0.77 | -0.30 | -0.58 | 0.04 | 0.02 | 0.01 |
| 23.61 | -0.49 | -0.58 | -0.38 | 0.04 | 0.05 | 0.03 |
| 26.84 | -0.32 | -0.55 | -0.55 | 0.02 | 0.05 | 0.07 |
| 30.57 | -0.73 | -0.25 | -0.59 | 0.13 | 0.05 | 0.11 |
| 33.10 | -0.81 | -0.65 | -0.99 | 0.11 | 0.08 | 0.03 |
| 37.02 | -1.28 | -0.73 | -0.73 | 0.09 | 0.08 | 0.05 |

*Accuracy is expressed by the difference between AFD of each laboratory minus AFD of ISTOPS. Precision is determined by standard deviation of average of three standard deviations each one obtained two measurement of same sub subsample.

The Table 2 shows evaluation of accuracy and precision of PFT in three laboratories. The PFT accuracy is between 0.00 a 0.30 µm for tops samples with measure about 17 µm, but for top samples with AFD of 37 µm varied between -1.28 a 0.05 µm (Figure 2). It has also been when increased the fiber thickness of top samples, accuracy decrease. In general, accuracy values in all tops samples with variation from 17.34 to 37.02 µm are less than 1.00 µm. This result demonstrate that PFT has a good accuracy according at tolerance values indicated by IWTO-47 (2015).

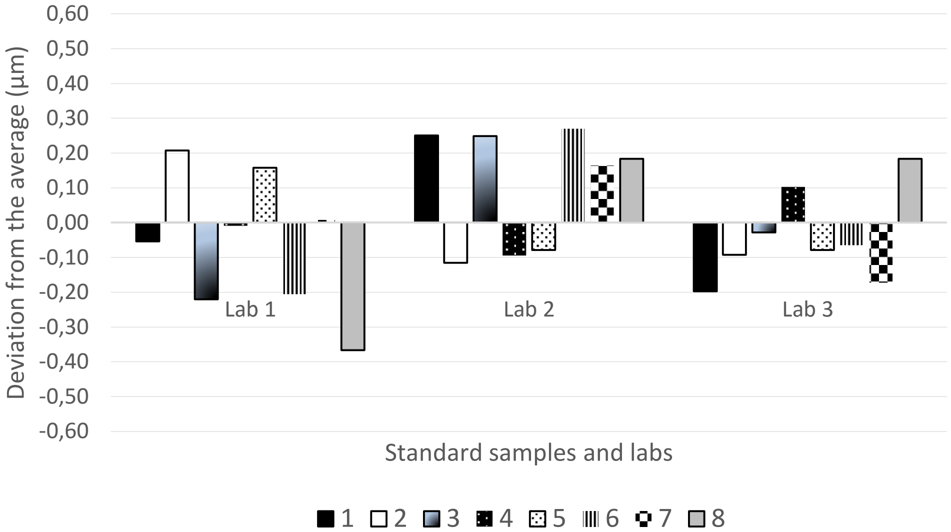


Figure 2. Deviations of average fiber diameter of each one ISTOPS using Portable Fiber Tester in three laboratories using eight ISTOPS.

Theprecision of the PFT, assessed though standard deviation, varies between 0.01 a 0.11 µm. These are low values compared with the POFITEST evaluation[5], and they indicate good precision for the PFT. That is, when measuring AFD in a same sample with the PFT the AFD is repeated.

At analysis through of model linear, there were no significant lab effect (p-value = 0.97). However, enough evidence was found to indicate that there are difference among samples and subsamples (p-value < 0.001). In addition, as shown in the Table 3, variance of laboratories was remained low (0.01%) although these tests were performed under a varied condition of humidity or temperature, but the variance of samples was much higher than variance of subsamples (99.61 and 0.38%, respectively).

Table 3. Variance components of three source of variation

| Source of variation | Absolute value ($\mu m^2$) | Relative value (%) |
|---|---|---|
| Among laboratories | 0.01 | 0.01 |
| Among samples | 43.67 | 99.61 |
| Among subsamples | 0.17 | 0.38 |
| Total | 43.85 | 100.00 |

The low absolute and relative values of variance show that instrument PFT, personnel manipulation, location and environment conditions have reduced effects on variation AFD when is used PFT. Also, subsamples variance show that if one fiber sample is divided subsamples, these will be slightly different AFD. For this reason to compare among instruments according measure AFD is conveniently to use same subsamples, otherwise in the difference could be increased for this effect.

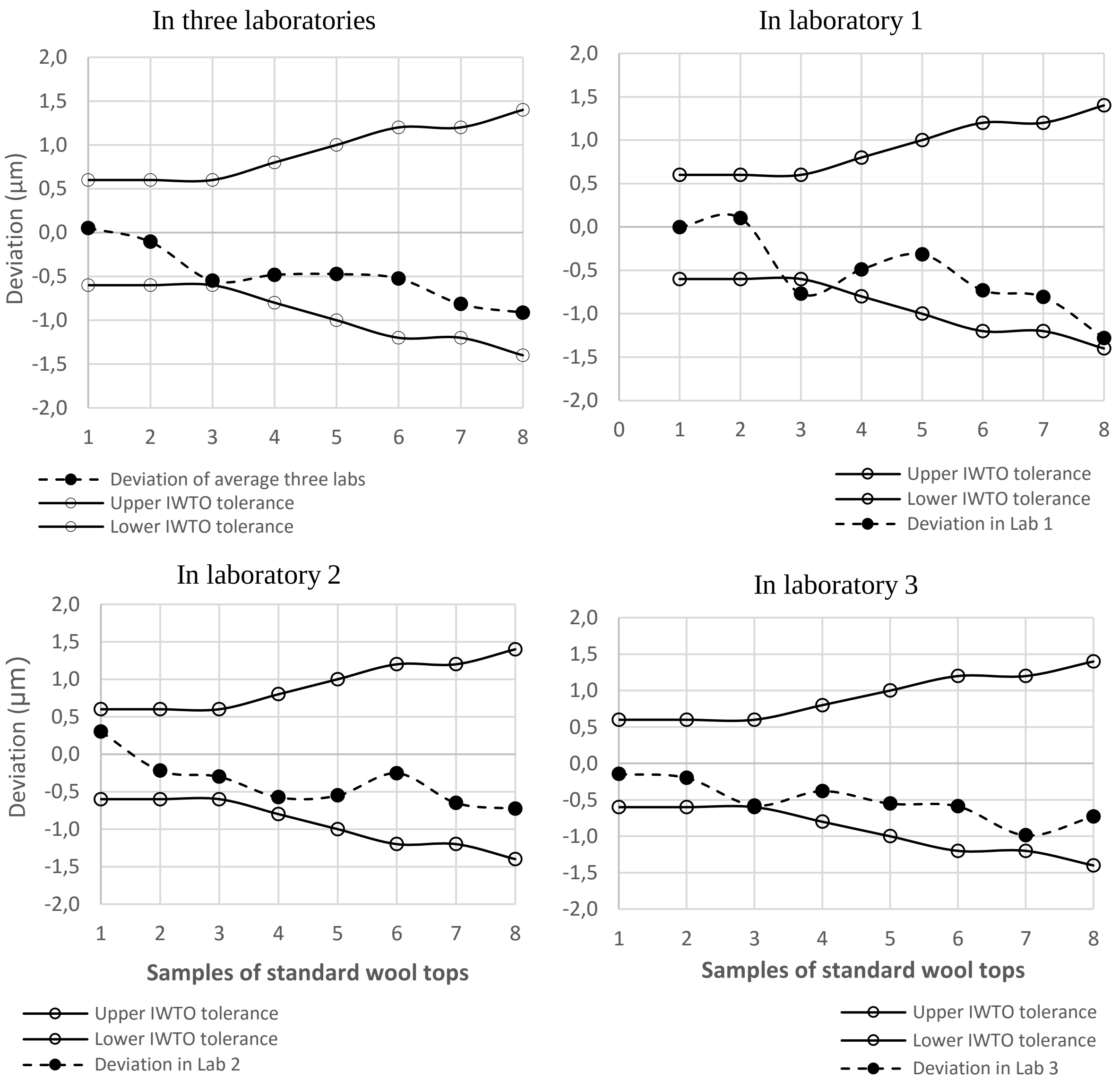


Figure 3. Behavior of measures of average fiber diameter at three laboratories together and each one of laboratories (1, 2 and 3) according upper and lower IWTO tolerance.

The evaluation interlaboratory test performance of PFT about AFD is shown at Figure 3. it was. The results show that the average fiber diameter measured by PFT at all labs and each individual lab are within IWTO tolerance values with exception for sample top of 20.40 µm. in laboratory 1. According these results at this interlaboratory test the Portable Fiber Tester show a good performance, therefore this new instrument could be used for evaluation AFD of wool samples in farm field conditions considering a range of measurement wider than the FibreLux[8], and according with OFDA and Laserscan instruments[11].

## 4. Conclusions

According to these results, it can be concluded that PFT is an instrument with a high precision and accuracy to measure fiber diameter of wool and other animal fibers, which may be operated in different ambient environmental conditions.

**Acknowledgements**

This research project was supported by the PNIA by agreement N° 026-2016-INIA-PNIA/UPMSI/IE. The authors appreciated Mr. Saúl Fonseca and Dr. Tumen Wuliji for editing and revision of the English manuscripts.

**References**

1. Hopkins, H.W. In Agriculture: Alternative animals for fibre production. Proceeding of A seminar in the Community programme for the coordination of agricultural research, October 24-25, 1991; A.J.F Russel Eds; Commission of the European Communities. United Kingdon, **1991**; 5-10.
2. McGregor, B. In properties, Processing and Performance of Rare Natural Animal Fibres: A review and interpretation of existing research results. October 2012. Rural Industries Research and Development Corporation Eds.; RIRDC Publication No. 11/150, **2012**; Melbourne, Australia
3. McGregor, B. *Small Rumin Res*. **2006**, 61, 93-111.
4. Holman, B.W.B; Malau-Aduli, A.E.O. *Annu Rev Res Biol*, **2012**, 2(1), 1-14.
5. Quispe, M.D.; Benavidez, G.; Sauri, R.A.; Bengoechea, J.J.; Quispe, E.C. *S Afr J Anim Sci*. [Online] **2017**, 47(6), 822-833. https://www.ajol.info/index.php/sajas/article/view/162641 (accessed Mar 2, 2019).
6. Cottle D.J.; Baxter B.P. *Text Prog*, **2015**, 47(3), 163-315.
7. Quispe, E.C.; Sacchero, D.; Quispe, M.D. *Rev Invest Vet Peru*. [Online] **2018**, 99, 18 – 22. (in Spanish, English abstract). http://revistasinvestigacion.unmsm.edu.pe/index.php/veterinaria/article/view/13677 (accessed Mar 2, 2019)
8. Walker, J.W.; Stewart, W.C.; Pope, R.; Spear S.L.; Ebert, M.; Murphy, T.W. *Small Rumin Res*. **2018**, 159, 31-37.
9. IWTO-47-2013. In IWTO Red Book Specifications, Brussels, Belgium, **2015**, www.iwto.org
10. Kosgey, I.S.; Okeyo, A.M. *Small Rumin Res*. **2007**, 70, 76-88.
11. Van Zyl, A.M. *Report No RWG 05*, Christchurch Meeting, IWTO, Technology & Standards Committee, Raw Wool Group, **2000**.