The Technical Basis of the Examination of Textile Materials and the Influence of Moisture Thereon

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Most mills make it a point to test very carefully the yarn they purchase before starting to work it up. This examination extends to checking the weight of the goods and the tare of the tubes, the correctness of the yarn number, the cleanness of the yarn and its evenness, the twist, the strength, and the elasticity of the yarn, the moisture content, the quality of the raw material used, the ash and fat content, and, when dealing with mixed yarns, the percentage of each present.

This examination is necessary, because otherwise unpleasant surprises may be expected when the yarn is advanced or even being finished, and faults discovered which cannot be made good as it is then too late to lay a claim for loss or damage. Every spinning mill in fact should examine its yarn with like thoroughness before delivery, which would practically obviate complaints by the consumer.

Everyone who has to do with the acceptance or delivery of yarn must be fully conversant with the methods used for testing yarn and the customs as between producer and consumer which have been developed in the course of time. It is also of value for experts and judges who have to decide commercial cases to have a good knowledge of these facts.

Whatever form the examination may take, it is based upon trade usages and customs which have been developed in actual practice. But besides this the material in question must meet certain definite requirements if it is to be manufactured into goods which are irreproachable in appearance and condition.

To carry out an examination of this extent each mill would of course have to be equipped with all the instruments and apparatus of precision required. But this would be an unfair demand and public material testing offices fitted with all the latest technical equipment have been set up in a number of centres of the textile industry for the purpose of carrying out such tests, and the Government has empowered these testing houses to draw up and issue documents which are legally binding.

The most important apparatus and instruments to be found in every testing office are as follows:

1. An analytical balance sensitive to 1 milligram and accurate gram weights.
2. A precision balance for technical use sensitive to 0.1 milligram.
3. Conditioning apparatus for testing regain.
4. Apparatus of different construction and strength for testing strength and extensibility.
5. Apparatus and balances for determining the yarn number and silk count.
6. Precision reels for various types of yarn and yarn counts.
7. Tensioning apparatus with device for measuring extensibility.

8. Rubbing testing machines.
9. Apparatus for determining the purity and evenness of yarn.
10. Balance for determining the weight per square metre.
11. Apparatus for determining thickness with micrometer scale.
12. Hygrometer for measuring atmospheric humidity.
13. Apparatus for counting threads accurately with device to tension the fabric.
14. Shallow dishes of platinum or quartz glass with blowpipe arrangement for ash tests.
15. Extraction apparatus for determination of the fatty content.
16. Microscope and microphotographic apparatus with the requisite optical accessories.
17. Airtight tins for transporting the material.
18. Apparatus for testing permeability by water and air.
19. Hank hooks.
20. A textile chemical laboratory.

And other equipment.

Even if such a testing office is completely furnished with all these instruments, the work can only be carried out accurately and with precision when the investigator has not merely scrupulously considered all the factors that can in any way influence the progress of the tests and their results, but has faithfully observed and weighed them with the greatest objectivity.

The results of control tests never agree completely, whecher made in the same office or elsewhere and with the same instruments or with others. This is due to differences in the nature and sharpness of subjective observation and to the more or less accurate functioning of the apparatus and instruments employed. For this reason a margin of divergence must always be recognized as permissible, all the more as it is impossible to observe the same material twice under precisely identical conditions, e. g. in the ash test.

The result of tests depends very often upon the varying humidity of the atmosphere, for all textile materials are very hygroscopic, and are inclined to adapt their moisture content to that of the surrounding air wherever they are in process of manufacture, or in storage, or being tested.

A definite humidity of the air is often called for in workrooms and storerooms, and various systems have been devised for conditioning the air or defogging it to meet this requirement.

The relative humidity of the atmosphere varies in Central Europe between 65° and 80°, and is much higher in countries such as England with an ocean climate. It is said that this naturally higher relative humidity in England alone makes it much easier than in Central Europe to spin the very finest cotton yarn numbers.

On account of the extremely many-sided effect of atmospheric humidity this aspect of the question will be dealt with more fully in the following lines.

The amount of vapour actually present in one cubic metre is known as the absolute humidity. But air, as a rule, is never completely saturated with moisture. By observing and measuring atmospheric humidity, it has been found that a definite relationship exists between temperature and degree of saturation, one cubic metre of air saturated with water vapour containing

at — 5° C	. . .	3.5	grams	per	cubic	metre
„ 0° C	. . .	4.9	„	„	„	„
„ + 5° C	. . .	6.8	„	„	„	„
„ +10° C	. . .	9.4	„	„	„	„
„ +15° C	. . .	13.0	„	„	„	„
„ +18° C	. . .	15.3	„	„	„	„
„ +20° C	. . .	17.0	„	„	„	„
„ +50° C	. . .	30.0	„	„	„	„

If one cubic metre of air contains more vapour than shown in this table, the superfluous moisture must be precipitated in the form of dew, mist, or rain.

The percentage proportion of the amount of water vapour actually contained in one cubic metre of air at a given temperature to the quantity of moisture required to produce saturation is known as the relative humidity. Its calculation can be explained by the following example. What is the percentage of the relative humidity if air at a temperature of 18° C needs 15.3 grams per cubic metre for saturation, but actually contains only 10 grams per cubic metre. This gives us the following equation

10 grams per cub. metre : 15.3 grams per cub. metre = x : 100

$$x = \frac{10 \cdot 100}{15 \cdot 3} = 65{,}36\,\%.$$

That is to say, the relative humidity is 65.36 per cent.

Conditioning and the influence of the relative humidity upon the results of conditioning.

The relative humidity of air has a far-reaching influence upon the properties of textile materials, and this influence, as I intend to show, is much greater than generally supposed or admitted.

Air yields moisture to all hygroscopic bodies, such as vegetable fibres, and, to an even higher degree, animal fibres, especially wool, more easily and more rapidly the nearer it has approached its saturation point, that is to say, the higher the relative humidity and the drier the goods are.

In the various customary regulations for the control of the yarn trade is laid down also the technical basis of the conditions under which textile materials must be tested for moisture. There is also settled what percentage of moisture may be contained in each of the different kinds of yarn in order to show the normal humidity, and how the moisture is to be tested for, or how the conditioning is to be carried out.

First of all the conditioning apparatus (Figure 1) will be more closely described so as better to understand how atmospheric moisture can affect the conditioning.

This apparatus is equipped as a rule for being heated electrically or by gas and consists of a predryer and a main dryer. In dryness testers of the Schopper type so much used the predryer consists of the following parts:

1. A heating chamber H provided with two independent gas burners, one being a ring burner and the other an end burner. If heated by electricity the current can be regulated at 30 amperes.
2. A chamber for heating the air (L) streaming in through a pipe from the main heater.
3. Three chambers for predrying the yarn.
4. Three baskets (d) with thermometers (t_1) to hold the material to be dried. (Only two are shown in the Figure.)
5. Three thermometers (t_2) to measure the dry air.
6. An outlet pipe for the moist air (m).
7. An outlet pipe for the combustion gases, if heated by gas (n).

The main dryer consists practically of the same parts as the predryer, but it contains only one drying chamber (R) and one basket (d) which is suspended directly in a precision balance W, so that weighing can be done during drying in the drying chamber itself. This is very important, because otherwise it would be impossible to weigh absolutely dry material accurately in normal moist air.

Two pipes lead from the main dryer to the predryer, one being for the exit of the gases of combustion (o) which must not come into contact with the material to be dried. Otherwise the goods would absorb moisture again, because much water is produced as a gaseous combustion product when illuminating gas is burnt.

The second pipe (p) serves to conduct away the moisture escaping from the material being dried. This moisture is swept forward by the fresh air entering at the side, which itself always contains a certain amount of relative humidity. The escape of this moisture can be hastened by the use of an electric ventilating fan. Thus a large amount of hot, relatively very dry air is led uninterruptedly to the material to be dried. The hot air escaping from the main dryer is led into the predryer and there utilized once more. The hollow axle of the basket contains a thermometer (t_1) and other thermometers (t_2) can be suspended in the predryer either at the front or in the rear.

Before beginning the testing the constants must be settled (by Schopper's method), that is to say, the heating is so adjusted that the temperature in the drying chamber remains constant at 105—110° C.

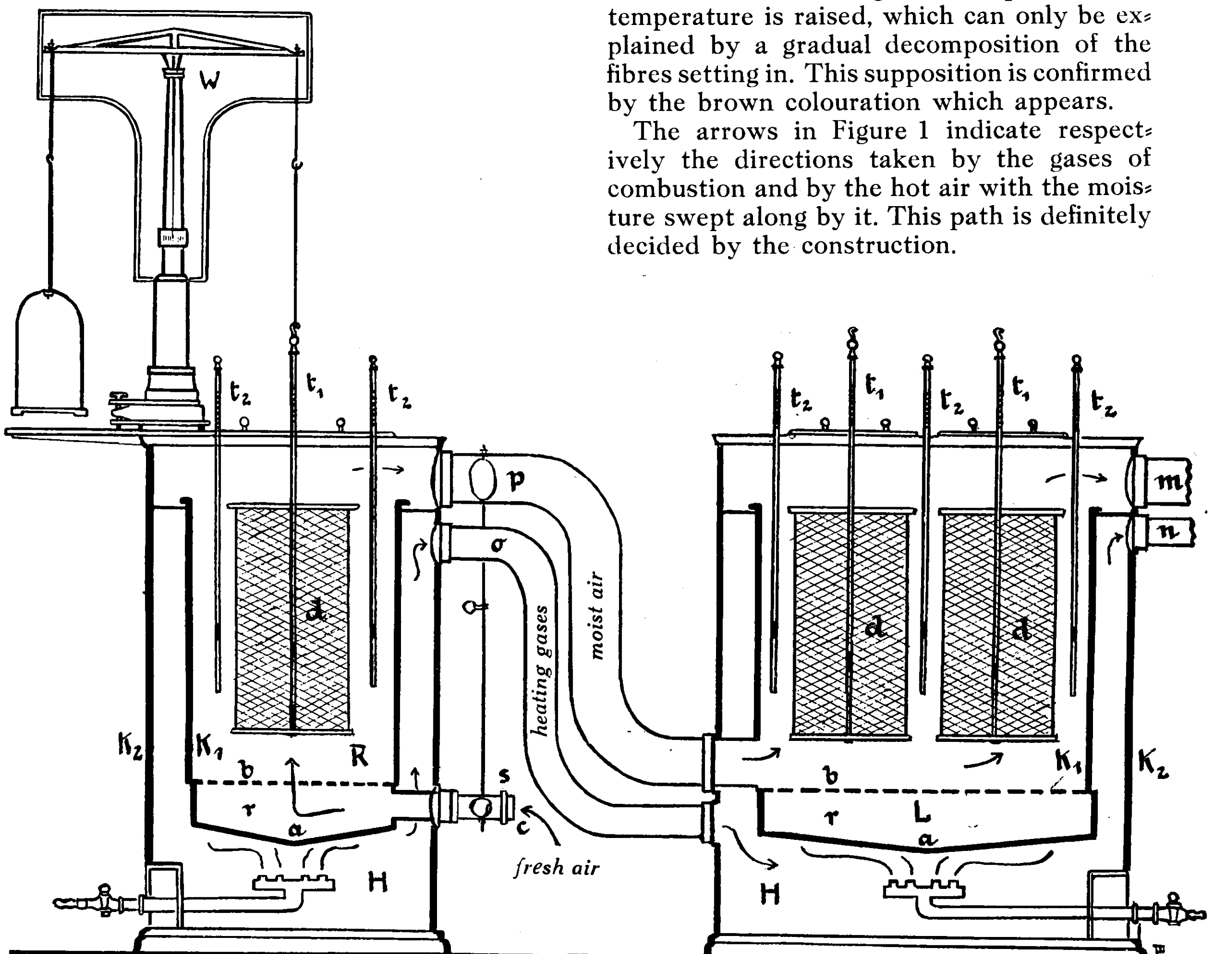
For this purpose both burners are allowed to burn for about 20 minutes until the thermometers at the sides indicate 70° C. Then the end burner is turned off and the ring burner alone provides the heat. The flame is turned down till the gas pressure of about 2.5 centimetre water column is indicated. In about 10 minutes a temperature of about 105—110° C is reached and this is then maintained.

If too much heat is present, the gas supply through the burner must be reduced or the current of air accelerated.

The baskets are first carefully tared and the material, which has been accurately weighed, is put into them and they are hung up. Then the inlet and outlet valves are opened and the hot air cooled in passing over the baskets until almost all the moisture has been expelled. Consequently the thermometer in the basket always indicates a lower temperature than that indicated by the thermometers placed at the sides which then serves to regulate the heating.

Weighing can be started when the thermometer in the basket shows 100° C.

The German cotton contract terms provide that drying must be continued until the reduction of weight between two weighings within 10 minutes is less than 0.05%, that is, until the material can be regarded as being theoretically absolutely dry. Strictly speaking, however, conditioning is not really finished until the last weighings give absolutely identical results. Under no circumstances should



Main dryer Figure 1. Conditioning apparatus Predryer

the last weighing read higher than the previous one.

It is, however, impossible to gauge accurately the precise moment when complete dryness is reached, because at that very moment the relative humidity, amounting to about 55—65%, of the air entering the drying chamber by the lower inlet-port makes itself unpleasantly noticeable. In spite of the high temperature, the absolutely dry material at once absorbs moisture and the weight rises quite considerably. This increase may be as much as several tenths of a gram if the bunner has been turned down. After having been dried for about two hours the weight of the material will have become fairly constant and then the weight must be uninterruptedly and accurately kept under observation, so as not to overlook the state of absolute dryness.

If the weight has increased, a further considerable loss of weight takes place if the temperature is raised, which can only be explained by a gradual decomposition of the fibres setting in. This supposition is confirmed by the brown colouration which appears.

The arrows in Figure 1 indicate respectively the directions taken by the gases of combustion and by the hot air with the moisture swept along by it. This path is definitely decided by the construction.

The main dryer consists of two boilers K_1 and K_2, the larger of which encloses the smaller concentrically, so that each is a completely closed space by itself. A stout cast iron plate (a) is fitted directly above the flame and a little higher up a perforated plate (p). The fresh air from outside passes through the tube (c), which can be more or less completely closed by means of a slide (s), into the space (r) between the two plates. It is warmed by the heat rising from the castiron plate, becomes thereby specifically ligther, rises, passes over the basket (d) containing the material to be tested, penetrates the material itself, and carries with it the moisture which has been converted into steam at from 105—110° C. A supply of fresh air is continually brought in by suction. The air laden with moisture which passes through the tube (p) into the predryer heats this in turn and is carried off by the suction at m in the outlet shaft. Through this arrangement, as can be seen from the sketch, the gases of combustion, which contain much water vapour, do not come into contact with the material to be dried; they merely pass round the hollow space between the two boilers in the predryer, pass through the tube (o) and unite with the heating gases originating there, then pass round the inner boiler again and pass through the tube (n) into an air shaft or the chimney.

In order to make the conditioning results independent also of any chance external influence of moisture, the German cotton contract terms provide that the samples of each lot of material must be sent to the Testing Office in hermetically sealed tins or glasses.

It is further provided that the samples taken in the way prescribed are to be divided into three portions and weighed accurately to one-tenth gram. Two of these lots are dried at 105—110° C. Silk and artificial silk, on the other hand, are dried at a higher temperature. The valid commercial weight is calculated from the dry weight by adding the permissible regain. The maximum divergence or the limit of error between the two results has been fixed at 0.5% (for silk one-third per cent.).

If the loss of weight in the two parcels agrees to within one-half per cent, the drying can be regarded as having been sufficient, but if the difference is more than 0.5%, but less than 1%, then the third lot also must be dried. If the maximum difference between the results of the three dryings does not exceed one per cent, then the average of all three dryings is taken as the commercial weight.

If a control test by another Testing Office does not differ from the result of the first test by more than 0.5%, then the result of the first test is held to be authoritative, otherwise the average of the two. If the result is to be controlled by another Testing Office, fresh samples must be taken; it is not permissible to weigh and dry the same sample a second time.

The following calculation may serve as a technical basis for conditioning to settle the valid commercial weight:

net weight of one lot .... 480.000 grams

Readings of the last four weighings:

	Time hours	min.	dry weight	moisture grams	moisture %
1.	4	10	442.600	37.400	8.450
2.	4	20	442.390	37.610	8.502
3.	4	30	442.270	37.730	8.533
4.	4	40	4422.70	37.730	8.533

Found on the first reading	8.450 %
„ „ „ second „	8.502 %
difference	0.052 %

The difference, that is to say, amounts to more than 0.05%, so that a third reading is taken after 10 minutes.

Found on the second reading	8.502 %
„ „ „ third „	8.533 %
difference	0.31 %

The difference now amounts to less than 0.05%, so that the drying can be considered as completed, since no loss of weight can be found even after 10 minutes.

If a further increase in weight were found again after another 10 minutes, that would be a proof that the material was absolutely dry. The result of the last weighing must not be higher than that of the one before.

As indicated above, two parcels of the material must always be dried and the results of the two weighings must not differ by more than 0.5% as shown by the following two examples.

The drying of a lot of woollen yarn in two parcels gave the following results:

	first parcel	second parcel
net weight	518.880 grams	511.680 grams
dry weight	440.750 grams	440.300 grams
moisture in grams	74.130 grams	71.380 grams
moisture in %	16.600 %	16.211 %

The difference is 0.389% and is thus less than 0.5%; the limit of error is not exceeded so that the third parcel need not be dried.

As can be seen from the above, the moisture content of textile materials is very dependent upon the relative atmospheric humidity, but it could very easily be raised to a greater extent than is allowed, to the loss of the purchaser. On the other hand, the vendor has the right to take the usual regain allowed in the trade as a basis for payment, so that a conditioning is often absolutely necessary. For many classes of goods excessive moisture can otherwise be injurious also and this must be taken into account in tropical countries overseas where the action of atmospheric moisture is enhanced by the salt content of the air. It is therefore provided that goods which are sensitive in this respect must be packed in hermetically closed and soldered zinc containers which in turn are packed in wooden cases.

The influence of atmospheric humidity on the yarn number.

In the trade a yarn count is held to be correct when the yarn has the prescribed moisture content.

To determine the number of yarn supplied in the form of cops or hanks, as large lengths of yarn as possible must be wound on an accurate reel and measured, so as to cancel variations in thickness. Even during winding the yarn loses a few grams in weight, because the rapid motion of the swift causes a loss of moisture. Storage in rooms of different humidity can also influence the calculation of the yarn number by raising or lowering the weight. If the yarn is moist, the pressure between the fibres caused by their swelling up always rises.

First of all the exact length of the yarn must be found, but even this is not very easy. The length depends upon a number of factors, which may be summarized as follows:

1. Whether the yarn was wound parallel on the swift, or was wound crossways on a cross reel.
2. The tension of the yarn running to the swift; this tension must be measured.
3. The twist of the yarn. The extension of sharply twisted and fine yarns is less than that of coarse, weakly twisted, soft spun, long-fibred woollen yarns.
4. The crinkling of the fibres and the extension caused by the pull.
5. The rate of revolution of the swift. If the rate of speed is too high, soft spun, long-fibred woollen yarn tends to stretch very much and can only be removed with difficulty from the swift. Wool and cotton yarn is wound at the rate of 250 metres per minute, silk yarn at 50—75 metres per minute.
6. The manner in which the yarn is guided under the action of the braking and clearing motion.
7. The way the cops are creeled and the axial and radial course of the yarn from the cops.
8. The form of the cops and the progressive unwinding of the yarn from them.

For these reasons it is advisable to calculate the mean number of from five to ten series of tests, so as to attain approximate accuracy. Besides this it is customary in the trade to allow a certain definite toleration upwards and downwards for yarns of different materials.

The yarn number always refers to the raw yarn and should always be calculated from the valid commercial weight with the normal moisture content. The following allowances are made for loss in bleaching linen yarn: for a full bleach 20%, for a three quarter bleach 18%, for a half bleach 15%. The loss in bleaching cotton is from 2 to 5%. Suppose 500 metres raw linen yarn weigh 25 grams and lose in a full bleach 20%, that amounts to 5 grams.

The metrical number for this bleached yarn is therefore $500 : 20 = 25$ metres.

The metrical number for the unbleached yarn is $500 : 25 = 20$ metres.

If the yarn has been dyed, from 2 to 5% is added to the count according to the colour dyed. For sized yarn the addition is from 4 to 8 per cent.

The following calculation shows what an influence moisture has on the yarn number, the same yarn length with too much moisture having a lower number and a too high number with less moisture.

For instance let

N represent the valid commercial weight with the correct regain;

N_1 the number of the yarn with too much or too little regain;

G the weight of one metre yarn with normal regain;

G_1 the weight of one metre yarn with too much or too little regain.

Then the number $N = \frac{1}{G}$ and the moisture or dry number $N_1 = \frac{1}{G_1}$. Then

$$N : N_1 = \frac{1}{G} : \frac{1}{G_1}$$

from which follows that $N_1 = \frac{\frac{N \cdot 1}{G_1}}{\frac{1}{G}} = \frac{N \cdot G}{G_1}$.

$$N_1 = \frac{N \cdot G}{G_1} = \text{the dry or moisture number.}$$

$$N = \frac{N \cdot G_1}{G} = \text{the valid commercial number.}$$

For instance, 400 kilograms 60s yarn lose 10 kilos weight in storage, what is the number of the too dry yarn?

$$N_1 = \frac{60 \cdot 400}{390} = 61{,}52 \text{ (metric).}$$

Twenty bobbins taken from a damp yarn store (78/2 worsted yarn) weighed 1124 grams and showed the number 77 (metric). After conditioning a commercial weight of 1109.60 grams was found; what is the commercial number?

$$N = \frac{77 \cdot 1124}{1109 \cdot 60} = 75/2 \text{ (metric)}.$$

It is important to know in dealing with bundled yarn whether the bundle contains the proper yarn length or yarn number. Although the weight of the bundle is in order the conclusion cannot be drawn that the length or the yarn number corresponds exactly with the yarn number invoiced, for any loss in weight can easily be replaced by more moisture.

For example, the yarn of a bundle weighing 5 kilos may have a moisture content of 7.83% of its normal weight or 8.5% of its dry weight; 7.83% of 5 kilos = 391.5 grams, consequently the dry weight of a 5 kilos package = 5000 grams — 391.5 grams = 4608.5 grams.

But if the dry weight of a bundle were only 4400 grams, this would correspond only to a valid commercial weight of 4774 grams with a moisture content of 8.5%.

A 5 kilo bundle of 40s cotton (metric) must have 200,000 metres; if these show a valid commercial weight of 4774 grams, then the correct number is 200,000 : 4771 = 41.89 (metric).

A deviation of only 4.5% is allowed for yarns above 40, but 4.5% of number 40 amounts to 1.8, so that the deviation is more than allowed and the yarn can be placed at the disposal of the vendor.

In a 5 kilos package of 40s bundled yarn (metric) there are 40 knots of 200 hanks of 1000 metres each, i. e. 200,000 metres, which must weigh 5 kilos. One hank weighs 25 grams, two weigh 50 grams and are 2,000 metres long. If two hanks are missing in a bundle, then the whole bundle has a length of only 198,000 metres and the bundle would be 50 grams too light, that is, it would weigh 4950 grams, the normal humidity of which (7.83%) would be 387.585 grams.

The permissible dry weight is 4950 grams — 387.585 grams = 4562.415 grams, but if the weight of the two missing hanks is replaced by 50 grams water, the net weight of the bundle is actually 5000 grams, but the permissible dry weight is only 4562.415 grams. The moisture content would be 437.415 grams = 9.59% of the dry weight, so that the goods have 9.59% — 8.5% = 1.09% moisture too much.

Now if 198,000 metres including water weigh 5,000 grams, the number would be 39.6, while the valid commercial number of the bundle would be 198,000:4945 = 40 (metric).

In a 10 pound bundle of 40/1 (English) = 10 hanks of 840 yards each go to a pound. Ten hanks make one knot, so that 40 knots contain 400 hanks of 840 yards amounting to 336,000 yards and weigh 10 pounds.

If the valid commercial weight of a 5 pound bundle is 4536 grams, the corresponding dry weight is 4180.83 grams, that is 7.83% of the normal weight of 4536 grams. The yarn has the proper moisture content of 8.5% and the correct English count 40.

But if the dry weight were only 3991 grams, that would give 339 grams regain at 8.5% and the valid commercial weight would be 3991 + 339 = 4330 grams and the yarn count would be 41.9 instead of 40 (English).

If the dry weight amounts to 4085 grams with a net weight of 4536 grams, the moisture actually present is 4536 — 4085 grams = 451 grams, which represents as much as 11% moisture.

If, however, the dry weight is 3991 grams and the valid commercial weight 4536 grams, then the moisture is actually 13.65%.

According to the terms of the German cotton contract the purchaser is entitled to return to the vendor any cotton which contains more than 10% of moisture. The same applies to cotton above 30 (English), when the count differs by more than 4.5% from the count invoiced. In the case of 40s yarn that is 4.5% = 1.8%, consequently the yarn count 41.9 must be returned.

If the correct yarn count has been figured on the basis of the normal moisture content, it is customary in the trade to admit variations from the proper count in accordance with the fineness of the yarn and the unavoidable sources of error. As a rule a number of spinning machines work together the yarn of which is combined to form one lot, so that variations can readily arise here.

If the yarn delivered is objected to because of the number being wrong, a number of samples corresponding to the size of the lot must be taken from different sections and all examined to settle the count. The average result of all the values found is then taken as the right yarn count.

Certain yarns, however, are excluded from this average calculation. Such yarns, for instance, as show a variation from the number invoiced upwards or downwards up to 24s of 5—7% according to the rules of the Exchanges in Vienna and Prague, and 4.5—10% according to the terms of the German cotton contract.

If finer yarn is supplied than was contracted for, no compensation is made. If the yarn supplied is coarser than invoiced and the variation downwards is more than 3%, no redress can be demanded. But if the difference is more than 3%, the amount by which it exceeds 2% must be compensated according to the greater amount used in working it up.

According to the rules of the Exchanges in Vienna and Prague the following variations are not compensated: in the case of yarns up to No. 14 inclusive a variation of more than 7%; from No. 14 up to No. 24 inclusive a variation of more than 6%; above No. 24 of more than 5%.

The following variations are not compensated according to the rules of the German cotton contract:

when the variation up to No 5 is more than 10%

from No.	5	to No.	10	inclusive	8%
„ „	10	„ „	14	„	7%
„ „	14	„ „	22	„	6%
„ „	22	„ „	30	„	5%
above No.	30	„			4.5%

Effect of moisture on the weight of the tubes.

Different places have different regulations for the permissible weight of the tare of the tubes. In spinning mills the yarn is generally overmoistened in the conditioning room because it is known that part of the moisture is lost already during storage in the yarn packing room and while the cops are being packed in boxes, so that the moisture in the yarn after it has been packed for shipment has adjusted itself. But over-moistened yarn imparts its moisture also to the highly hygroscopic paper tubes. On the other hand, the outer parts of the cops in the chests dry out more strongly than the inner parts, especially when the wood of the chests is rather dry and the relative humidity in the storeroom was rather low. Besides this, hot, dry summer days during railway transit also have their effect. Under these conditions the tubes may have a higher percentage of moisture compared with the weight of the yarn which may form a ground for claims.

If the yarn has been wound on a swift from more than ten cops, in order to determine their weight the empty tubes must at once be shut up airtight, or weighed at once accurately to one-hundredth of a gram according to the regulations. The tare of the tubes is calculated from the weight of the tubes found in this way and the weight of the yarn plus the tubes.

If the tubes are allowed to lie open for some time in a room with a different relative humidity from the moisture of the tubes themselves, the percentage of moisture in the tubes would be raised or reduced accordingly.

According to the German cotton contract terms the weight of the paper tubes of warp cops and mule cops on short tubes must not exceed 1.5% of the invoiced weight of the cops (yarn and tubes), in the case of weft cops of normal size and larger as well as ring warp cops on light tubes and cheeses 2.5 per cent.

Warp cops are such as weigh more than 36 grams, weft cops of normal size have a tube length of 140 millimetres with a diameter of 24 millimetres with a minimum weight of 16 grams.

If the tube weight exceeds these limits, compensation must be made for the difference between the permissible and the actual weight of the tubes at the full price of the yarn. For example, a purchase was made of 1,000 kilos warp cops. The permissible tube tare is 2.5%, that is, 25 kilos, which are not compensated. But if the tube tare amounted to 2.8%, then the weight of the tubes is 28 kilos, and for the difference between the permissible tare of 25 kilos and the actual weight of the tubes compensation must be paid to the purchaser. If, however, the tubes had lost weight to as much as 0.3% by lying in too dry air before being weighed, then there would be no question of compensation, although the purchaser would be entitled to demand it.

It is therefore to the interest of the purchaser to have the tare of the tubes correctly ascertained.

Effect of moisture on the strength of the yarn.

Great variations in the temperature of the rooms where the yarn is stored, worked up, and examined, as well a sudden violent changes in the weather exercise a very noticeable effect upon the power of adhesion of the yarn fibres. The connection between moisture and the strength of yarn has often been the subject of searching investigations and articles in the literature of the trade. Unfortunately there do not exist any normal tests or regulations as to the conditions of moisture under which tests of the strength of yarns and fabrics should be carried out.

At any rate it would be very important to test all yarns in regard to strength at the moisture content allowed them. At the least

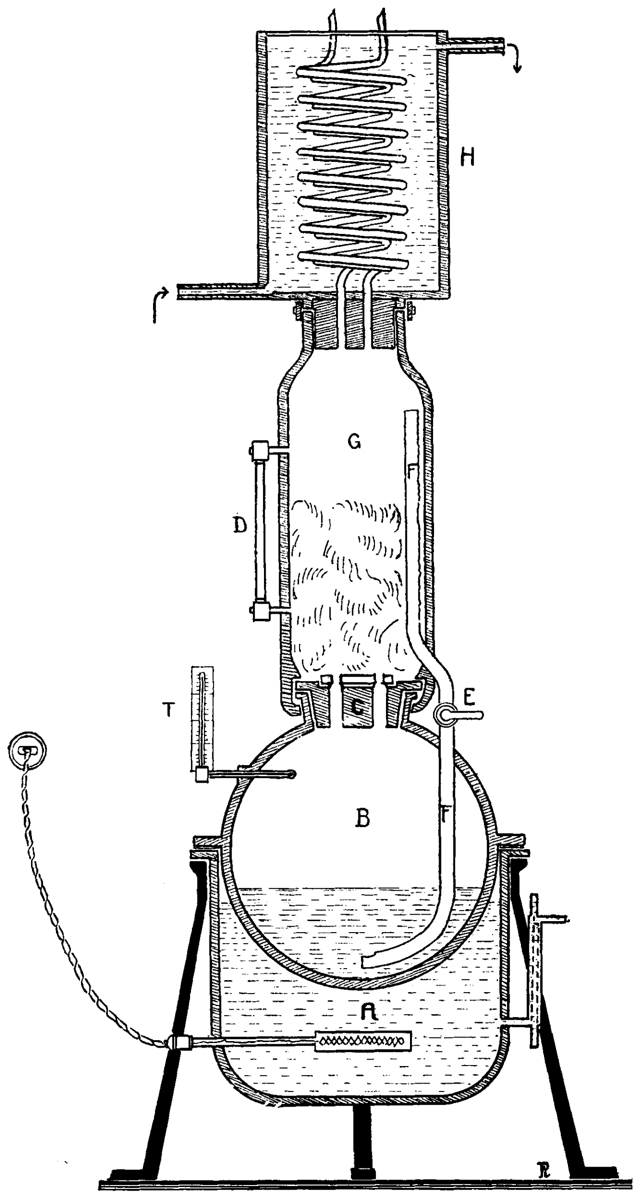


Fig. 2

it would have to be known at what room temperature, at what atmospheric moisture and for how long a yarn which is to be tested for strength would have to lie in the testing room in order to show the normal moisture content. The percentage moisture content of the yarn to be examined for strength would also have to be mentioned in the award submitted.

It is a matter of common experience that the strength increases with the moisture content. According to Fiedler cotton warp yarn (40s) showed the following strengths after prolonged storage in moist rooms:

at 6.5 %	moisture	content	a	strength	of	125	grams
„ 7.5 %	„	„	„	„	„	131	„
„ 8.5 %	„	„	„	„	„	135	„
„ 9,5 %	„	„	„	„	„	140	„

Warp yarn, on the other hand, showed the following average strength after having lain for a long time in a room with

20%	relative	atm.	humidity	210	grams	average	strength
40%	„	„	„	222	„	„	„
70%	„	„	„	244	„	„	„
95%	„	„	„	260	„	„	„

As can be seen, all fibres adapt themselves very quickly, owing to their hygroscopicity, to the conditions of humidity prevailing in the room they happen to be in.

At any rate, it is important for the strength test always to test the yarn at the same moisture content with which it was sold or worked up. Therefore it should lie for a considerable time in the room where it is to be examined at a constant atmospheric humidity of 60%. To save time, however, this is not always done.

Influence of the relative humidity on the ash test for cotton.

It is necessary to test the incombustible residue, the ash content, when preparing waste cotton for nitration.

If the waste cotton contains 8.5% moisture, the percentage weight will agree when the ash residue is determined, but it will not agree if the moisture content is higher or lower. For example, if 50 grams cotton with normal moisture content yield 0.5 gram ash, that is 1%. But if the cotton contains 5 grams more or less moisture, that is to say, if it weighs 55 grams or 45 grams, the ash residue in each case is 0.999% and in the other 1.111% per cent.

The ash itself is also hygroscopic. If it is weighed immediately, as ought to be done, the weight found is always less than when it has been allowed to stand for some time in a room with 65% relative humidity.

When using a good blowpipe, the reduction of 50 grams of cotton completely to ash occupies about one hour and a half, and care must be taken that the whole has been completely burned to ash.

All sorts of cotton waste are used in cotton waste breaking mills for the manufacture of waste cotton. Coloured material is first bleached, but any metallic mordants present are not removed and these may affect the natural ash content of the cotton to any extent.

For this reason and owing to the varying nature and origin of the raw material, a control test made in the same Testing Office or elsewhere can never give the same percentage of ash content. This affords a natural explanation even for the great differences that may be expected.

Influence of the relative humidity when testing the fatty content of fibres.

Cotton always naturally contains a small quantity of fat and this content is increased by ginning, for the crushed cotton seeds which are rich in oil give up part of it to the raw cotton.

Wool also is often treated with oils and oil emulsions in woollen and worsted spinning mills to facilitate the movement of the yarn during spinning. The additions of this nature are sometimes particularly large in the case of carded wool that is spun in oil, so that testing offices often have to test the fatty content also.

The ingenious Soxhlet apparatus is suitable for use with small quantities. But it is made of glass and is consequently fragile and cannot withstand any high gas pressure. For these reasons extreme precautions must be observed in the use of such easily inflammable fat solvents as ether and carbon bisulphide. Besides all this the apparatus permits of the examination of small quantities only, which tends to lower the accuracy of the tests.

Pinagel's extracting apparatus overcomes these difficulties in a clever manner and allows of the examination of larger quantities of wool (from 3 to 5 kilos). Apart from this, the apparatus is very handy, is wholly constructed of copper and only the screws are of brass.

As can be seen from Figure 2, the apparatus consists of the following parts.

1. A copper water-bath A with means of keeping the level of the water constant. The bath is filled with hot water or can be steam-heated.

2. A round copper container B to hold and evaporate the solvent (ether, carbon bisulphide) is set into the water-bath. It is fitted with a thermometer T mounted at right angles so that the boiling point of the ether (35° C) or the carbon bisulphide (45° C) can be accurately observed and maintained.

3. An oval container G, into which the wool to be treated is packed, is mounted on the container B by means of rightly fitting ring.

The container G is closed to the container B by means of a valvelike block C with three perforations which is fitted in the bottom of the container G. Three short tubes are inserted in the block and are very loosely filled with wool, so that the vapours of ether or carbon bisulphide can pass through.

The two vessels are connected by an external tube F provided with a cock E. The upper part of the tube inside the container G. is studded with perforations and the tube ends above the bottom of the vessel B.

A glass tube is mounted at the side of the vessel G which indicates the height of the liquid recondensing from the vapour of the solvent. By opening the valve E in the tube F the condensed solvent continually flows back into the container B, and this circulation is kept up until all the fat has been extracted, as is shown by the solvent collecting in the observation glass being clean and clear.

When the water-bath is kept at the proper temperature the solvent evaporates and its vapours pass through the three valve tubes into the wool packed in the vessel Gand extract it.

4. A cooling vessel H containing cold water from the main at from 7—10° C provided with three cooling worms is screwed onto the extraction vessel. The vapours rise up through the many windings of these coils, are condensed by the cold water, and the condensed solvent drips back into the extraction vessel and is re-evaporated by the rising vapours, hastening in this way the extraction.

The observation glass shows when the solvent has thoroughly soaked the wool and almost completely filled the space G. Then the valve E is opened again and the solvent which has collected and is saturated with oil flows back into the container B and enters into circulation once more when the valve E is closed.

This circulation accelerates the removal of the fat. With a little experience the colour of the liquid in the observation glass will serve to show when all the fat has been dissolved. Then the valve E is kept open so that the solvent can flow back into the container B.

Carbon bisulphide has the advantage of being cheaper than ether, but it is much more inflammable and poisonous. For this reason other non-inflammable solvents are used, such as carbon tetrachloride, the boiling point of which, however, is about 78° C, dichlorethylene (boiling point 55° C) and trichlorethylene (boiling point 88° C). Since dichlorethylene is not dearer than carbon bisulphide and is indifferent to all kinds of fats and oils, carbon bisulphide can now be dispensed with.

As a matter of precaution, the water-bath must not be heated by an open gas flame and it is therefore filled with hot water, which is rather tedious. For this reason I have built an electric heater into the bath. This is able to heat one litre of water from 15° C to 100° C in about 15 minutes and is arranged for a current consumption of 500 watts. If the bath, which holds about 3.5 litres, is first filled with water at from 40—50° C, the addition of heat can be provided by the electric heater, and the temperature of the water can be maintained with ease at about 50° C by employing a resistance. Even when using the very dangerous carbon bisulphide, the employment of electric heating practically eliminates any risk of explosion.

Extraction apparatus of this type have also the advantage that not only the fat content can be determined but also the loss caused by washing dirty wool. This can be arranged very simply by first weighing 3—5 kilos of dirty wool accurately to one-hundredth gram, then washing out the earthy impurities with lukewarm water, drying in the drying oven, dissolving the fat in the extraction apparatus, then rinsing with water, drying the wool at 105—110° C in the case of carded wool, adding 17% for moisture, in order to obtain the valid commercial weight. The difference between the first weighing and the last gives the loss by washing.

Example of the calculation of the loss caused by washing carded wool.

Weight of the dirty wool	4.515	kilograms
absolutely dry weight of the defatted and washed wool	3.005	„
loss by washing that is 33.44%	1.510	„

As regards the permissible 17% of moisture content in carded wool, the percentage calculation works out in the following way:

Weight of the dirty wool	100.00	kilos
loss by washing	33.44	„
weight of the clean washed and absolutely dry wool	66.56	„
17% added for moisture	11.32	„
valid commercial weight	77.88	„
loss by washing	22.12	„
	100.00	„

That is to say, the loss by washing amounts to *22.2%* of the weight of the dirty wool, reckoning a regain of 17 per cent.

In mixed yarns of wool and cotton the content of fat and moisture is often very irregular, but as a rule very high.

It will be seen from the foregoing that conditioning cannot be dispensed with in determining regain if it is desired to avoid the loss involved in merely estimating it. Endeavours are constantly being made to find a simpler process which is also reliable.

Influence of moisture on the weigt of fabric per square metre.

A definite weight per square metre is often stipulated for before accepting certain goods, because it is possible in this way to judge rapidly whether the goods are over or under weight, that is to say, whether the requisite quantity of material has been worked in.

For customs purposes too the weight of fabrics per square metre is distinctly defined, because duty is imposed upon the fineness of the yarn and the density of the weave, that is to say also according to the weight.

Accordingly, when settling the weight per square metre, for which purpose specially constructed dial and pointer scales are used, the regain and the valid commercial weight of the goods must also be found.

It has happened a few years ago, when textile raw materials were very scarce, that a contractor tried to beat his rivals for a supply of uniform cloth by delivering inferior cloth which he had previously rolled between moist linen cloths so as to give it to all appearance the weight prescribed by the military authorities. A conditioning disclosed the fraud and the case was brought before the criminal court.

Moisture and the quantitative determination of a mixture of cotton, wool, and silk.

In order to calculate accurately the percentage composition of such a mixture of fibres, the material is first conditioned, then the silk is dissolved out by means of a basic solution of zinc chloride and the material is washed with water, dried, and weighed. Then the wool is dissolved out by boiling with NaOH, and the material is washed again, dried, and weighed. Finally the weight of the cotton left behind is determined, bearing in mind the percentage lost in washing out the wool and the cotton, and its percentage content calculated. In order to secure accurate results, the drying must be done by conditioning on the basis of the permissible moisture content.

This process gives rapid results and can be carried out much more quickly than the tedious drying in the air, when the very different relative humidities can very easily confuse the result.

In the Testing Offices of the German Customs service the percentage of cotton present in union fabrics is determined as follows.

A piece of cotton fabric of 10 square centimetres is cut into four pieces and laid for one hour in the drying oven at 110° C, and then, while still warm, in a weighing bottle. This bottle is furnished with a glass stopper smeared with fat and has previously been weighed accurately to one milligram. The bottle is then carefully closed, weighed on an analytical balance, and, after cooling in the exsiccator, weighed on the same balance accurately to one milligram.

Then the dried and weighed four pieces of fabric are laid in a beaker holding 500 ccm, and 200 ccm of a 10% solution of caustic soda are poured over them. The beaker is placed on a sheet of asbestos over a Bunsen burner and carefully heated so that the solution is brought to the boil within 20 minutes, when it is boiled for another 10 minutes. The fabric is repeatedly pushed under the surface of the solution by a glass rod. Finally the beaker is filled to the brim with cold water, the contents are stirred with a glass rod, and the liquid carefully decanted off, taking care not to lose any fibres. Then fabric is repeatedly washed until the addition of a few drops of a tartaric acid solution of phenolphthalein no longer causes a red colouration.

Then the washing water is let off and 300 ccm distilled water to which 5—10 drops of concentrated acetic acid have been added, are poured over the fabric in the beaker, and the whole is boiled for a short time. After cooling, the liquid is poured off, the fabric rinsed in the hollow of the hand with distilled water and squeezed out. After standing for two hours in the drying oven at about 100° C, the fabric, while still warm, is placed in the weighing bottle again. The botle is well closed and weighed once more on the same balance after having cooled off in the exsiccator. The percentage weight calculated is the weight of the cotton present in the fabric.

After having now discussed the often very far-reaching influence of moisture on various textile materials and illustrated it by examples, figures could also be given to show the success actually attained by accurate measurements of moisture content.

In all yarn dealings there is a tendency to purchase the best possible, but it often happens that one of the parties has cause to lament his carelessness. Either he pays for water and paper tubes at the price of wool to his own loss when the moisture content is excessive, or the spinner gives the consumer valuable yarn instead of the moisture allowed. Then the spinner has to face the loss, although neither party would be at a disadvantage if conditioning had been properly done.

The importance of conditioning is still not recognized in many quarters and it can therefore readily be understood that quite out of the way cases of unfitness sometimes occur which are due more to criminal negligence than to an actual intention to injure the other party. On the other hand it occasionally happens that someone calculates extremely sharply, but seems to pay little or no attention to conditioning, although he claims to be up to date in every respect.