Processing Asbestos Fibres: Effects Upon Physical Properties

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Introduction

ASBESTOS as received by the manufacturer of asbestos products is in the form of either crudes or milled fibres processed to different degrees of texture. Frequently, the manufacturer finds that the fibres as he buys them are not adaptable to his plant processes, and, therefore, it is necessary for him either to contact the mine supplying the material and request a specific texture for the fibre or to re-process the fibre in his own plant.

When the mine or mill manager is requested to change his milling equipment to produce a special grade of fibre with a specific texture, he would like to comply. However, if he began to make special fibre grades for each customer, he would be in the position of constantly rearranging his milling technique, adding more equipment, or building a new mill. In the end, his mill would be producing hundreds of different fibre grades of varying degrees of texture, which is a difficult accomplishment if he desires to maintain any quantity of production.

Viewpoint of the Miner

It is well known that asbestos fibres as produced at the Canadian mines fall into definite groups, such as crudes and milled fibre. Each of these groups has a number of sub-divisions, and many of the fibres have different textures such as crudy, semi-crudy, open, and well opened. No doubt these several degrees of texture have been established after many years of experience based upon the general demand of the customer. Therefore the mill tries to maintain a set of standard fibre mixtures, with gaps between the different grades for future expansion if the demand is sufficient. In some instances, the customer demand for a particular fibre grade is great enough to warrant special milling techniques. In such a case, the mill places this specially prepared fibre in its regular production line. Each time it decides to produce a special fibre, several important points must be considered, such as: (1) Will this special fibre require new processing equipment or can existing equipment be used? (2) Will the over-all capacity of the mill be reduced? (3) Does this special fibre have specific physical properties that cannot be matched by present fibres offered to the public? and (4) Can the extra production cost be recovered?

Fibre milling is a technique that differs somewhat with each plant. All producers are continually making mechanical changes in order to improve their products while maintaining their production schedules. This problem is no easy one, and it requires full co-operation between the Sales staff and the Mill Department.

Viewpoint of the Customer

The customer has an established plant which produces a certain line of asbestos products and probably at one time he set up his plant with the minimum of equipment necessary for utilisation of the regular grades of fibre as produced at the mines. After a number of years of competition and new developments, his products possibly did not meet the newer specifications, and the first question that came up for discussion was asbestos fibre. Was he using the proper fibre, or should he install equipment to re-process the fibre in order to change its characteristics? At this point, the Research and Development Engineer should step in and review the entire problem with the production department and decide whether the fibre must be changed to fit existing equipment, or whether the equipment should be modernised to handle the fibre. Since many manufacturers of asbestos products purchase their asbestos from more than one source — Canada United States, Africa Russia, and Australia — it is important for them to know how to handle the several fibres properly. This is particularly true when fibres of the same grade are purchased from two or more different sources and consequently, may have entirely different physical characteristics.

To illustrate some of the problems facing the manufacturer of asbestos products, typical shipments of asbestos have been obtained from different sources and the effects of willowing upon the physical properties of these fibres have been investigated.

African Blue (Crocidolite)

This variety of asbestos would be difficult to use in its raw condition, as received in the United States, because of its crudy nature, quantities of unopened bundles of fibres, and the presence of pieces of rock of varying size. Therefore, the customer must either have some type of processing equipment to convert this fibre to the proper condition for use in his products or he must try to convince the miner in Africa to process his fibre to the customer specifications. Years of experience have shown that the easiest answer to this problem is for the customer to re-process the fibre himself, because he knows exactly what he wants.

African Blue fibre is strong but harsh, and by successive willowing action the fibre becomes bulky and loses length.

A normal Quebec-screen test, after one willowing action, shows that approximately 13 ounces of the total 16 ounces remain on the top screen. Successive willowing stages do not change this result sufficiently to show what is happening to the physical properties of this fibre.

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By a careful water elutriation method, a definite indication can be obtained of reduction in fibre length after each willowing action. Figure 1 shows that, for five willowing actions, the +14 mesh fibre dropped from 52.6 per cent to 30.6 per cent, a length reduction of 40 per cent.

Coincident with decrease in fibre length, there is also an increase of fines (—200 mesh) from 30.4 per cent to 45.4 per cent or an increase of 49 per cent. Therefore, to willow this fibre successfully, a minimum amount of willowing action should be used in order to avoid a loss in length of fibre and the formation of fines which would be lost in later stages of processing or product formulation.

In the production of asbestos products by wet methods, the density of the opened fibre as well as its ability to remain in suspension are important factors. The buoyancy of a fibre can be determined from a slurry of fibre in water, with a definite weight of fibre in a constant and definite volume of water. After thorough mixing, the slurry is allowed to settle, and the rate of settling is read in cubic centimeters for a given time. In most cases, the settling reaches equilibrium after one hour. The density can be determined by filling a standard measure with a capacity of say, a cubic foot, and obtaining the weight of its contents. The results are then expressed as pounds per cubic foot.

Figure 2 shows that the buoyancy of the Blue fibre increases rapidly for the first willow pass, and that after the second pass the slope of the curve decreases. Conversely, the curve for the density values shows that the density decreases rapidly for the first pass and after the second pass changes only slightly.

An interpretation of the buoyancy and density curves indicates that this particular Blue fibre reached a high degree of opening at two passes through the willow and that further willowing, at added expense, would effect relatively little improvement in the quality of the fibre.

During the process of willowing a fibre there is another important change taking place in its surface area. This change, also, is indirectly reflected in the buoyancy and the density measurements.

Samples of the Blue fibre were measured for surface area by the air permeability method, using the Bowen apparatus and following the Lea and Nurse technique (1). A number of methods have been advocated for determining the surface area of solids and each has advantages and disadvantages. However, after considerable experimentation, it is thought that the method used in this investigation, while not giving absolute values, shows the general trend and indicates physical changes to the fibre after each processing action. Since it is known that willowing action on a fibre will open bundles into thinner cross-sections, reduce length, and create fines, there should result a cumulative measure of these effects by obtaining the surface area measurements.

Figure 3 shows the surface area measurements of the Blue fibre in its original state and after each willowing action. The results are expressed in square centimeters per gram of fibre, and the data, expressed graphically, yield a curve which shows that: (1) the surface area is increased after each willow action; and (2) this measurement shows a greater change per willow pass than the tests for buoyancy and density, because of the change in fibre length and the formation of fines.

The conclusions that can be drawn from these test data on opening African Blue are: (1) the fibre length decreases after each willowing pass, with resulting increase of fines; (2) the buoyancy and density values of the fibre show only small changes after two passes through the willow; (3) surface area measurements show that, after each willow pass, the area is increased; (4) a total of two passes through this particular willow would be the maximum treatment to produce a fibre for use in a plant; (5) one willow pass would be acceptable, since it produced a fairly open fibre with the minimum of length loss and creation of fines.

Rhodesian Fibre (Chrysotile)

This particular grade of fibre as received in the United States would also be difficult to use in most wet processes for the production of asbestos products, because of the presence of crudy fibre bundles.

The same procedure has been applied to this fibre as was used with the African Blue. The same equipment and rates of feed were adopted for all tests, so that the mechanical processing was constant in all cases.

This particular fibre was given a total of eight passes through the willow in order to determine the maximum opened condition of the fibre.

The Quebec-screen tests increased slowly to the maximum value of 12.6 ounces on the second screen at four passes, and then decreased to 11.7 ounces on this screen at the eighth pass.

The water elutriation procedure for length indicated a decrease in fibre length (+14 mesh) after each pass, and a small increase in fines (—200 mesh). Figure 4 shows the two curves, which are entirely different from those for the African Blue fibre and which do not intersect at any point.

The slope of the curve for the +14 mesh fraction begins to level off after six passes while the curve for the —200 mesh fraction shows only a small increase in fines after six passes. In other words, the +14 mesh fibre decreased in length 61 per cent, but increased only 24 per cent in the objectionable —200 mesh fines.

The buoyancy of the fibre continues to increase rapidly after each pass. Figure 5 indicates that the slope of the buoyancy curve would begin to level off at some point after eight passes.

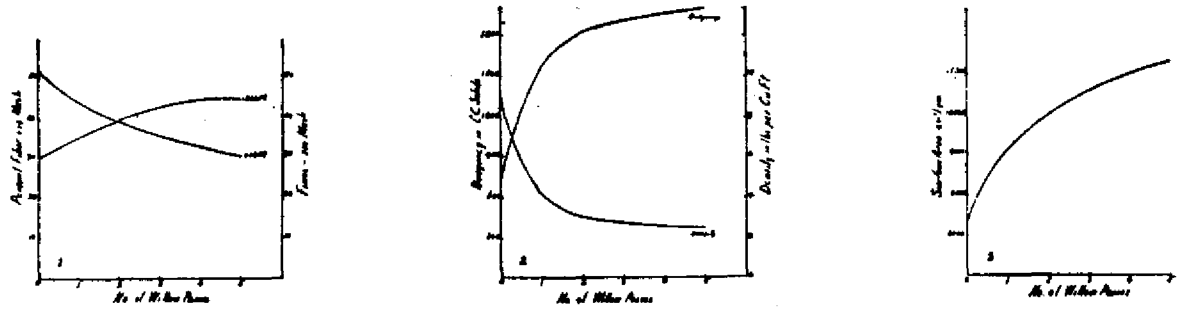
Density measurements show that the density of the Rhodesian fibre decreases rapidly for the first two passes and thereafter at a lesser rate, with indications that it would probably reach its minimum density after eight passes.

Surface area measurements made on this fibre show that it has less surface area than the African Blue after each pass through the willow. The curve (Figure 6) has a lesser slope than that for the Blue fibre, which would indicate that this fibre does not break down into shorter fibre lengths as rapidly as the latter. In other words, it resisted destructive action better than the African Blue under identical tests conditions.

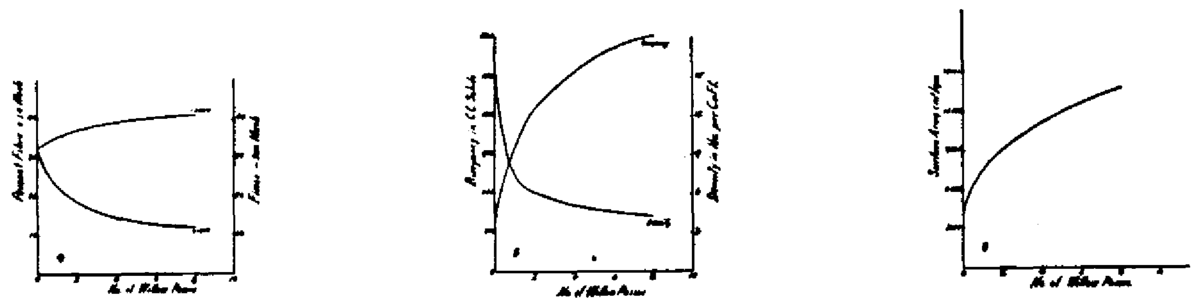
Canadian Chrysotile — Semi-Harsh

A quantity of Canadian semi-harsh fibre was obtained and subjected to numerous willowing actions to determine its resistance to fibre length destruction. This particular fibre contains considerable quantities of crudy fibre bundles that should be opened before it is usable in an asbestos product; therefore, it was subjected to a total of ten willow treatments.

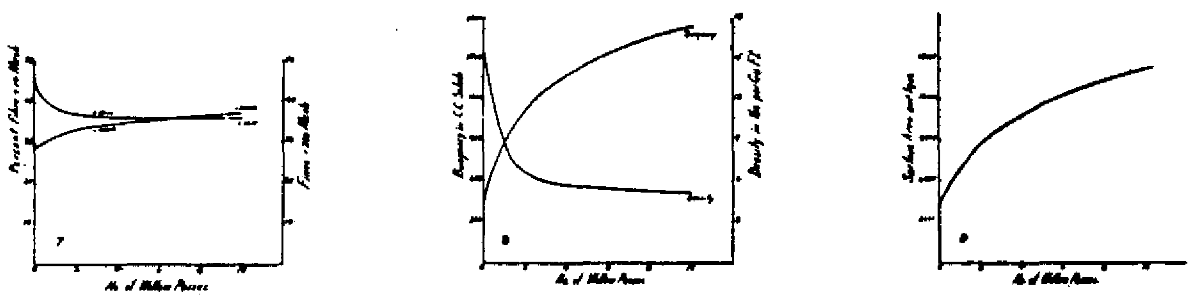
The Quebec-screen test indicated



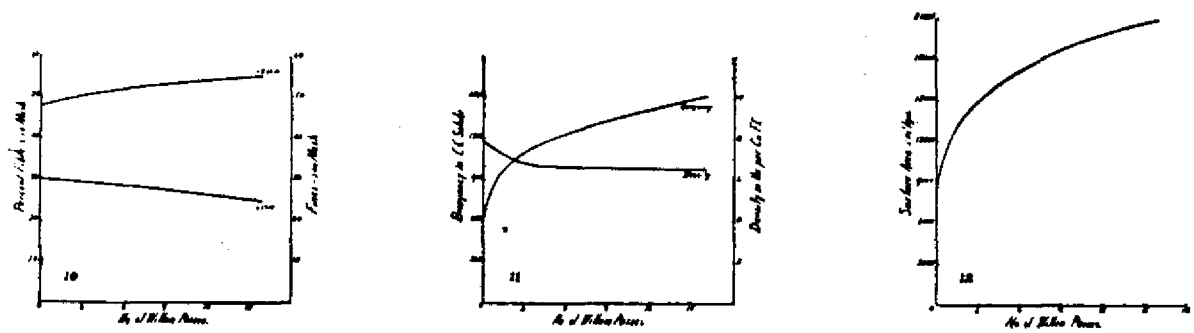
Figures 1, 2, and 3.—African Blue.



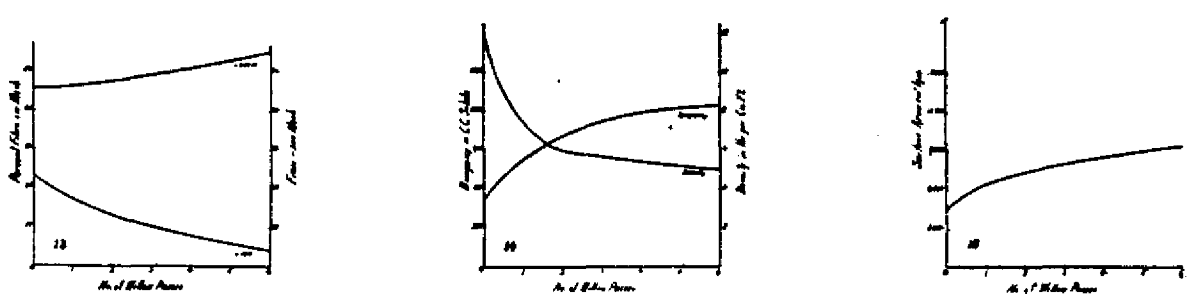
Figures 4, 5, and 6.—Rhodesian.



Figures 7, 8, and 9.—Canadian Semi-Harsh.



Figures 10, 11, and 12.—Canadian Soft.



Figures 13, 14, and 15.—Canadian Harsh.

a large increase on the second screen for the first pass, and only small increases for each succeeding pass up to six. From that point up to ten passes, the test indicated minor changes only.

The water elutriation test indicated an $18\frac{1}{2}$ per cent decrease in length for the +14 mesh fibre for the first two passes. Examination of the curve (Figure 7) reveals that the remaining willowing actions from two passes to ten had only minor effects upon the destruction of the fibre length. The fines (—200 mesh) show a 14 per cent increase for the first two passes and only a slight increase for the remaining treatments. From these data it can be concluded that this fibre resists destructive action and remains in good condition even after ten passes through the willow.

The buoyancy value of this fibre, as shown by Figure 8, increases rapidly for the first four passes, and then the slope of the curve begins to decrease.

The density values (Figure 8) show a large change for the first two passes and only minor changes for the remaining tests.

Surface area measurements are not increased as rapidly as in the case of either the Rhodesian or the Blue fibre. Figure 9 illustrates the increase in surface area and, as will be noted, the slope of the curve is less than for the two African fibres.

From the test data obtained on this Canadian fibre, it can be stated that willowing action is not detrimental to its physical properties and that it resists destructive action better than the African Blue or the Rhodesian fibre.

Canadian Soft Chrysotile Fibre

A typical Canadian soft, silky fibre was willowed a total of sixteen times in order to determine its resistance to the action of a willow.

The Quebec-screen test indicated a change on the second screen after the first pass. This same screen began to indicate a decrease after nine passes and, at sixteen passes, had decreased to a value slightly above that at the starting point.

The water elutriation curves (Figure 10) show that this fibre, although it lost length and some pulverizing took place, did not disintegrate; therefore, it can be considered highly resistant to processing equipment. It would probably be satisfactory for use in its original state unless an increased fibre buoyancy was desirable for some specific usage.

The +14 mesh fibre decreased 20 per cent after sixteen passes, and the —200 mesh fines increased $14\frac{1}{2}$ per cent for the same number of passes, a further proof that this fibre resisted the destructive action of the mechanical equipment.

The buoyancy of this fibre, as illustrated by Figure 11, shows a rapid increase for the first two to three willowings and only a gradual increase by subsequent treatments. However, the buoyancy values are all lower than those for the three fibres previously discussed, which shows that this fibre is relatively free from crudy fibre bundles and is fairly well opened.

The density values decrease for the first two to three passes and then practically level off, with only minor changes brought about by further processing.

A total of two willow passes would probably be sufficient to place this fibre in good open condition. From the curve obtained (Figure 10), it can be concluded that this number of willowing actions did little harm as regards destroying fibre length or pulverizing the fibre. The curve also indicates that the quantity of unopened bundles was small and that the fibre was fairly well opened at the asbestos mill prior to shipment to the customer. Therefore, this fibre can be used in its original condition as received from the mine, without further processing on the part of the purchaser.

Surface measurements on the Canadian soft fibre are given in Figure 12. The fibre in its condition as received presents a greater surface than any of the other fibres discussed in this investigation. This would indicate that the combination of fibres of various lengths and fines created a large surface area.

The surface area of this fibre at any given pass is greater than that of any of the other fibres so far dealt with. Therefore, if a manufactured product requires a fibre of great surface area, this one should fit the specification. However, since this physical property is only one of many to be recognized, we must balance it against the other factors before reaching a final conclusion.

Canadian Chrysotile Harsh Fibre

This harsh fibre of the chrysotile variety has some interesting characteristics from the viewpoint of its physical properties.

It was subjected to a total of six passes through a willow, and, in the Quebec-screen test, each pass indicated an increase on the second screen. The crudy fibre bundles opened easily and became fairly bulky, so that most of the fibre remained on the second screen.

Water elutriation tests indicated a definite length loss in the +14 mesh fibre after each pass through the willow (see Figure 13). After six passes, this decrease in length amounted to 81 per cent and the quantity of fines (—200 mesh) showed an increase after each willow action. However, the amount of this increase is only 22 per cent, which would not be considered alarming. These data indicate that the long fibre will not resist flexing ation by willowing, and that shorter lengths were produced without pulverizing to dust. Therefore, any mechanical re-processing of this fibre after shipment to a customer should be extremely mild, or the fibre should be used without additional processing.

The buoyancy value of this fibre (see Figure 14), while showing an improvement after each pass, does not equal that of the other fibres discussed up to this point.

The density shows a rapid improvement for the first two willow passes and only minor changes after subsequent passes.

Therefore, for re-processing of this fibre, from the viewpoint of buoyancy or density, a minimum of two passes, or even one pass, would be considered sufficient. However, there is an important loss of length after one or two passes, and it might be advisable to avoid any further processing of this fibre.

Surface area measurements on this harsh fibre, shown graphically in Figure 15, indicate a smaller increase in area than for any of the other fibres tested in this investigation. In other words, this fibre maintains low surface area and low buoyancy, although it loses length, in processing. For certain products these properties are important and should not be overlooked; for other products, great care must be exercised in handling the fibre before and during its use.

The surface areas of all fibres tested are charted in Figure 16, which enables a direct comparison to be made between the several fibres for the same number of passes through the willow. The two extreme fibres are the soft, silky chrysotile of large surface area, and

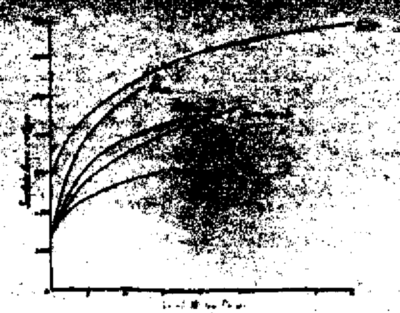


Figure 16.—Effect of willowing on surface area, various fibres.

the harsh chrysotile, having small surface area.

Effects of Willowing Upon Filterability of Fibre

When a fibre is opened by mechanical means, a fibre of greater surface area results. Figure 17 shows, for each of the fibres investigated, the effects of four willow passes upon its filterability.

The soft, silky chrysotile fibre rapidly becomes more difficult to de-water after each opening process, with the result that plant production is retarded.

The Rhodesian fibre remains fast filtering up to four passes through the willow, at which point it begins to show a trend toward more difficult filtration. However, after this number of willow passes, the fibre would still be considered satisfactory for any wet process.

Of all the fibres tested in this investigation, the filtration characteristics of the two identified as "semi-harsh' and 'harsh' are least affected by the willowing process. Both would be considered ideal for sweetening poor filtering fibres, even if they had been highly opened by mechanical processes.

The filterability of African Blue fibre is only slightly affected by the willowing process and at four passes it is still considered a fast filtering fibre.

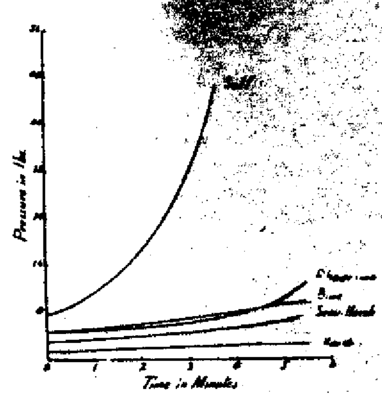


Figure 17.—Effect of willowing on filterability of various fibres.

Correlation of Test Data

In general, there is good correlation between buoyancy and surface area values at a given number of willow passes. When the surface area data and buoyancy values are expressed graphically, most of the points fall upon a straight line, indicating that either test can be used as a guide for determining the degree of opening of a given grade of fibre.

When the surface area measurements and the decrease in +14 mesh fibre expressed in percent are shown graphically for each willow pass for each kind of fibre, there appears to be a fairly good correlation, since most of these points also fall upon a straight line. This is an indication that the surface area of processed fibres is greatly influenced by the destructive action of willow hammers.

Application of Test Data

The manufacturers of some asbestos products require that asbestos fibres meet certain specifications as to date of filtration, fibre strength, length, buoyancy, density, and surface area. In a previous paper on filtration, presented at the 1949 Annual General Meeting of this Institute (2), it was pointed out that, by opening a fibre, the rate of filtration is decreased. In all of the investigations discussed in the present paper, each fibre shows a trend to become more difficult to filter after each willowing action. Therefore, some decision must be made on the basis of the general over-all effect a willowing action has upon physical properties of the fibre.

Fibre strength (3) is important, and soft, silky fibres retain their strengths better than harsh fibres when processed by mechanical equipment.

If filtration is the most important factor government the production rate of an asbestos product, then, given a fibre of satisfactory strength, a minimum amount of willowing should be used.

If a low density or a high buoyancy value is required and filtration is not important, then the fibre should be well opened to obtain its maximum fluffing condition.

If a fibre is required to have strength and high surface area with a minimum loss of fibre length and minimum formation of fines by a willowing action, then it is necessary to select a fibre or a blend of fibres that will meet these requirements.

The Research or Development Engineer should make a thorough study of the available fibres. Then, knowing the fibre specifications required for a given asbestos product, he should make definite recommendations to the manufacturer as to the kind of fibre and type of re-processing necessary to obtain the maximum value of the fibre for the specific utilization.

Conclusions

(1) Asbestos fibres as received by the manufacturer of asbestos products usually require some type of re-processing before they can be used to best advantage in a product.

(2) Any fibre re-processing method adopted by a manufacturer will produce changes in physical properties, such as a lowering of fibre strength, loss in length, formation of fines, different degrees of buoyancy, changes in density, increase in surface area, and a tendency to become more difficult to filter.

(3) The soft chrysotile fibres resist the destructive action of a willow fairly well, but have the greatest surface area and are the most difficult to filter at any given number of willow passes.

(4) African Blue fibre loses length, increases rapidly in surface area, becomes relatively buoyant after each willow pass, and filters rapidly.

(5) Rhodesian fibre loses length, increases in buoyancy has less surface area than either the Canadian soft fibre or the African Blue fibre, and its filtration characteristics remain good even after four willow passes.

(6) The semi-harsh fibre resists the destructive action of the willow fairly well, but is less resistant to willowing action than the Canadian soft fibre, increases rapidly in buoyancy, is rapid filtering, and has less surface area than the Blue, Rhodesian, or Canadian soft fibre.

(7) The harsh fibre loses length rapidly, increases in buoyancy slowly, has the lowest surface area of all fibres studied in this investigation, and remains fast filtering after each willow stage.

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