

## EFFECT OF INCORPORATING DESIGN DATA INTO NEW FABRICS

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I will try to give you some idea of the complex problems which the practical textile manufacturer faces in connection with the incorporation of design data into the production of parachute fabrics. There are probably no other classes of textile fabrics in large scale production which are covered by such exacting specifications regarding so many properties. Because many of these properties are closely inter-related, the change in the requirements for any one of them is very apt to throw others out of balance and when this is done great problems develop in the textile manufacturing and processing plants. Our good friends, in the Materials Laboratory, have fortunately been keenly aware of these facts and have proceeded very cautiously when they desired to make changes or additions to specifications, and I would like to give them full credit for having done a wonderful job in respect to the development of very effective, very practical specifications, covering a considerable range of parachute fabrics.

To use an example, the present standard man-carrying parachute fabric, namely the 1.1 ounce Nylon Ripstop Fabric, covered by Specification MIL-C-7020, Type I, has to conform to specifications covering from 20 to 25 different properties, depending upon the type of coloring used. These properties are entirely independent of the normal quality inspection requirements for workmanship, which are, in themselves, an additional and very formidable list of requirements. The history of the development of this Ripstop Fabric did not start with a clearly specified list of 20 target properties. Like many other fabrics, this grew up from relatively simple beginnings and the exacting requirements of today's specifications have been built up gradually as new problems arose and as the requirements for keeping the fabric within narrow channels of approved quality became more important. Because of the experience gained by the textile designer and finisher, during the evolution of these older fabrics, it is now frequently possible to design and produce nylon parachute fabrics meeting new target property lists without too much preliminary trial work. I hasten to say that this refers to target property lists including only those properties which have previously been tested and experimented with on so many different materials, and not to the new ones which are developing importance, such as high pressure air permeability or high temperature resistance. Such new properties will require considerable amounts of research work before we understand them thoroughly. I will, therefore, now try to discuss some of the more important in our familiar list of properties of parachute fabrics, and the means by which each can be varied and controlled.

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Since nylon is at present the principal basic material for nearly all parachute cloth, and since the bulk of our experience relates to nylon fabrics, I am taking the liberty to base all of the following discussions on nylon. Many of the basic principles would apply equally well to fabrics made from other fibers.

The weight, strength and air permeability are the basic properties about which the designer must plan the construction of his fabric. Weight and strength necessarily must go hand in hand with the limitations imposed by the basic raw material available. At present, there are two types of nylon yarn manufactured - standard tenacity, which runs about 4.5 grams per denier and high tenacity, which runs 6.0 to 6.5 grams per denier. Not all sizes of nylon yarns are furnished in both tenacity ranges. Therefore, the designer must select a tenacity range which is available in the yarn sizes with which he is concerned. The air permeability of the fabric limits the choice of yarn size to an appreciable degree. A very light fabric can be made by weaving relatively coarse yarns in an open mesh weave. This fabric could have substantially the same strength and weight as a closely woven fabric, but would obviously have much higher air permeability. Parachute fabrics normally require a relatively low air permeability range, and therefore must be rather closely woven from finer denier yarns. The fabric designer has other properties to consider in a selection of yarn size. For example, both the thickness and the tearing strength are effected by the selection of denier. For reasons of costs and practical manufacturing, the designer will also have to lean toward the use of the coarser yarns as other requirements are met.

Air permeability is also independently adjusted for a given yarn size by the use of the following expedients:

(1) The number and size and shape of the cross-section of the individual filaments making up the single yarn as supplied by the yarn manufacturer. More and smaller size filaments in the single yarns will result in lower air permeability. Similarly, if the cross-section of the individual filaments in the yarn is varied, it will have an appreciable effect upon air permeability. At present, however, the yarn manufacturer does not offer much choice in the selection of standard round filament cross-section.

(2) The amount of twist in the yarns has a very great effect upon the air permeability, and this factor is one which the designer can use very effectively. Higher twists result in higher air permeability and lower twist in lower permeability. A small amount of twist is normally considered necessary for satisfactory weaving quality, especially in the warp yarns. By increasing the twist in the warp, or by adding more twist in the filling yarns, a very considerable change in permeability level can be brought about.

(3) Air permeability is greatly influenced by the designer through the use of different weaves. Weaves having the most bindings or interlacings result in minimum permeability, while the looser weaves, such as twills and satins and dobby patterns, provide for increasingly higher permeability ranges.

(4) Air permeability is influenced to a considerable extent by the amount of tension used on the yarns in weaving. A high warp tension will result in a lower porosity level.

(5) Air permeability is widely adjustable by finishing procedures. Hot calendering between steam heated steel rolls and compressed fabric filled rolls under pressures of one to one hundred tons has the effect of spreading out the filaments in the individual warp and filling yarns and thus causing lower air permeability. Calendering is most effective when performed on unscoured or undyed cloth, because at this time, the fabric is more sensitive to thermo setting operations, and the effect of the calendering is, therefore, greater and more permanent.

Dyeing, printing and finishing operations of various types have varying effects on air permeability, but, in general, an increased amount of warpwise tension throughout the finishing operation tends to decrease the air permeability of the finished fabric.

The tearing strength of the fabric, is, of course, inter-related with the breaking strength, the weight, the weave and the finish. Any expedient which promotes the ability of the yarns in the fabric to slip and jam together during the action of tearing, improves the tear strength of the material and the threads can jam together where it becomes necessary to break them in bunches instead of singly. When the threads are not free to slide together, they can be broken individually one at a time, and thus the tearing strength is reduced. It has been found that the use of a suitable finishing oil, to lubricate the yarns and thus facilitate the slippage condition, is a great help to tearing strength. A word of caution is needed regarding what constitutes a suitable finishing oil, however. Such an oil must be one which will not become gummy or tacky with age; if it does it will decrease the tearing strength instead of increasing it. The oil must not be one which volatilizes and disappears, thus leaving the fabric unprotected. It must, of course, be an oil which will not become rancid or acid and thus result in a degradation of the strength of the fabric. It should, if possible, be an oil which will not support any fungus or bacteria growth. From the point of view of the fabric finisher, the oil also has to be one which will provide a satisfactory emulsion for use in his operations on a closely controlled basis. The amount of oil needed, in order to provide full lubricating values, does not exceed 0.3% by weight of the dry fabric.

This is not enough to make the cloth feel oily and, if accurately controlled, does not present any problems to the user of the material.

The other properties which are incorporated in most of our specifications include requirements for thickness, elongation at the break, permanence of finish, acidity of the fabric, color fastness to dry cleaning, light, laundering, water, exact requirements for matching shade standards, and requirements regarding the tolerances for a specified width and length of cut. Each of these properties requires the exercise of precautions in finishing methods, or the use of different types of dyeing or finishing methods. The effect of each variation is immediately felt in the control of other properties. For example, a cloth which has to be dyed a bright orange shade, with acid dyestuffs, requires different finishing procedures throughout than one which is finished in the natural, white, or printed in camouflage colors. The sequence of operations and the adjustments used in each operation have to be carefully worked out for each of the different colors, so that all of the various properties are balanced simultaneously.

From what I have said about the many factors that influence air permeability, it will also be recognized that a very real problem exists with respect to close standardization and control of processes throughout, in order to insure uniformity in the finished product. In spite of all of the efforts that can be made along these lines, air permeability does vary quite widely and it is impossible to control it practically within any closer tolerances than plus or minus 20%. Even with such tolerances, it becomes necessary to reprocess an appreciable percent of total yardage for final control of air permeability to within acceptable ranges.

The designer of a parachute who lays out the original list of target properties for a new type of parachute material should limit his requirements to the smallest number of properties that will accurately accomplish his purpose, and he must also appreciate the fact that relatively wide tolerances will be needed by the textile manufacturer in connection with air permeability. Requirements respecting any property which is not basically important should be avoided, since all such requirements restrict the ability of the textile manufacturer to accomplish the main purpose in the most effective possible manner. Considerable thought should also be given to the type of tests, and the frequency of sampling that will be required in connection with any new fabric specification. Tests requiring long periods of time to complete should be avoided, since these tests necessitate holding up shipment of finished production unduly.

Exact conformance to rigid tests with excessively severe tolerances is not possible in textile materials. Textiles, of course, are not precision materials. They are not produced by precision equipment. We have always found that our friends in the Materials Laboratory have been fully conscious of these facts and very sympathetic with the problems of the textile manufacturers. They have never hesitated to seek advice or to act upon it when they felt that it was well given; nor have they hesitated to question the advice when they felt that it could be improved upon. They have set high goals of accomplishment which, a few years ago, would have seemed impossible to all of us, yet which are now being achieved. It is this type of cooperative guidance that the industry must have to enable it to improve upon parachute fabric of the future, and the industry owes a debt of gratitude to W. Corry and his predecessors for the sympathetic, cooperative guidance which they have furnished. We all think that our present fabrics are pretty good, and I am sure that they will be much better in the not too distant future.