D03405

Distr.
LIMITED

ID/WG.58/14
29 April 1971

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Expert Group Meeting on Quality
Control in the Textile Industry
Prague, 6 - 9 July 1970

QUALITY CONTROL IN THE CLOTHING INDUSTRY 1/

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id.71-2186

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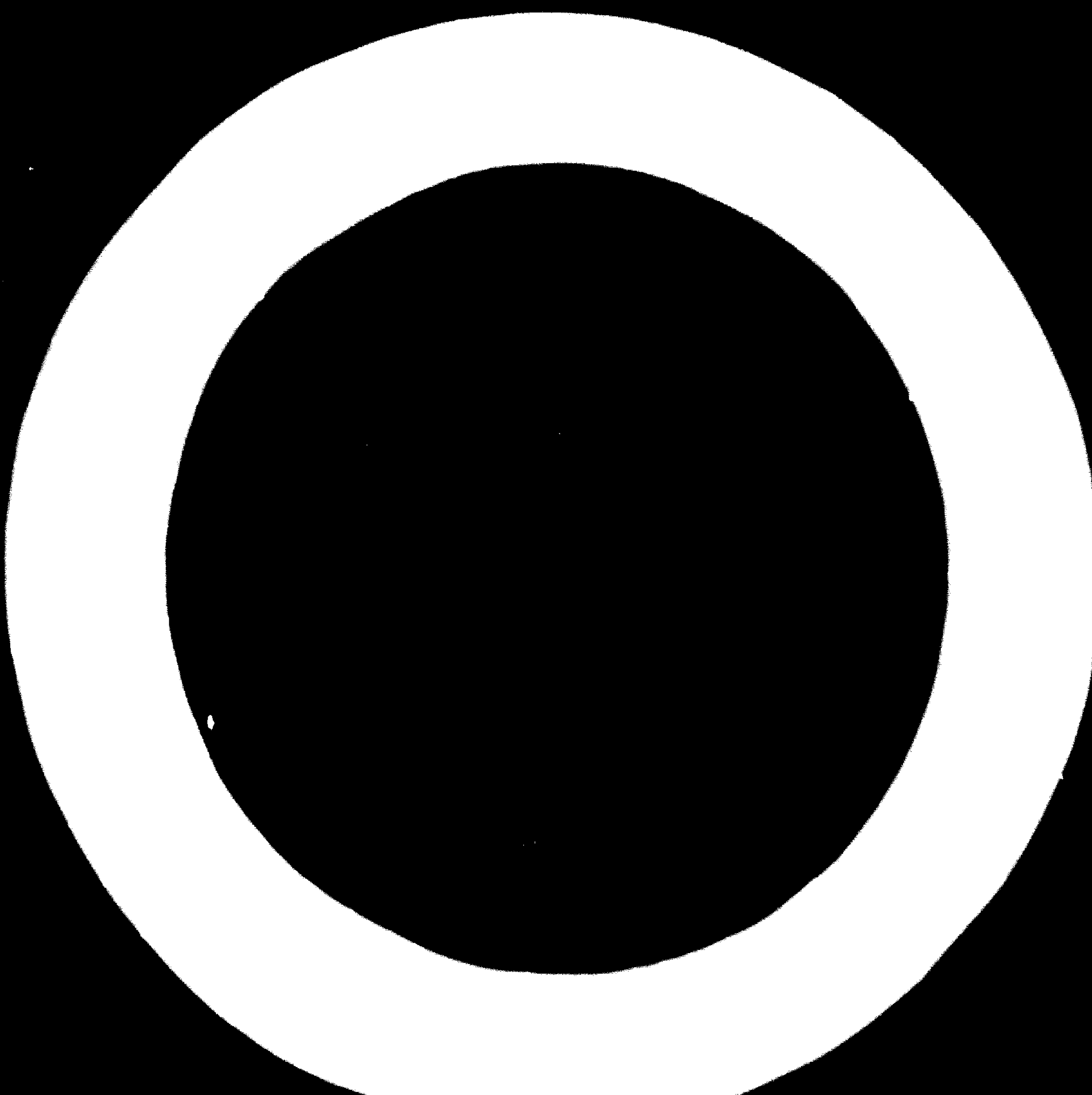

QUALITY CONTROL IN THE CLOTHING INDUSTRY

1. INTRODUCTION

Grosberg (1) has defined quality control as "the regulation of the degree of conformity of the final product to its specification". This definition is straight forward and unexceptionable when it is applied to a product which can be accurately and completely specified by a number of parameters all of which are susceptible of accurate (and preferably rapid, or even automatic) measurement. Consider the case of a plant producing steel balls for ball bearings. The individual unit can be specified by its diameter, sphericity, hardness, surface finish or polish, etc., and possibly by the chemical composition of the steel from which it is made. All these properties can be quickly and accurately assessed, and the values obtained for them will normally vary between a higher and a lower limit, the manufacturing tolerance limits. In order to be sure that a given fraction of the total output will have properties that lie within a certain range, termed the acceptance range, within the manufacturing tolerances, it is necessary to test only a fraction of the total output. The properties of this sample can then be related statistically to the properties of the population from which the sample is drawn, so that it is possible to state that a certain fraction, which may be 99%, or 99.9%, depending on the widths of the manufacturing tolerance and the acceptable limits, shall be within these acceptance limits. If it is found by such an exercise that the percentage of the final product which lies between the acceptance limits is too low, say 90%, then it becomes necessary to overhaul the production processes so as to narrow the manufacturing tolerances and so bring a greater proportion of the total output within the acceptable limits.

Quality control under these circumstances resolves itself into accurate sampling, accurate mensuration of the parameters concerned, and sound statistical treatment of the results, and the aim of the plant engineer is to reduce manufacturing tolerances until they coincide with acceptance limits. If this happens (which it rarely does), the whole of the product is acceptable and there are no rejects.

The whole matter is less clear-cut in the case of the clothing industry, for several reasons. First, the raw material for the manufacturing process is far more variable than the steel ingots which serve as input raw material for the manufacture of steel balls. Textile fabrics are produced from textile yarns, which in turn are spun from fibres, some of natural origin (e.g. wool, cotton, linen, silk) and some produced from synthetic high polymers such as polyamides, polyesters, and acrylic compounds. The natural fibres, being seasonal crops, vary in properties from year to year and from place to place, and the manufacture of synthetic polymers has not yet reached such a state that absolute uniformity can be guaranteed between manufacturers, or indeed between separate batches produced by the same manufacturer. The production process therefore begins with inherently variable raw materials, the variations being inherent in the materials, so that it is not possible to reduce them, as might be the case with steel bars, by closer control in the manufacturing processes. Furthermore, the clothing manufacturer does not start his production with fibres, the fundamental raw materials, but with fabrics, so that a considerable amount of extra variation has already been introduced by agencies outside his control, consisting in general of the processes of spinning, knitting or weaving, and finishing.

Second, the selection of parameters to specify a given garment is by no means a straightforward proposition. Consider the case of a man's suit or a woman's coat. The sizes, both of the garment as a whole and of the individual parts such as sleeve, trouser legs, etc. can be measured and specified (though the accuracy of the measurements is by no means as high as with metal objects, because fabrics are inherently extensible, and alter their dimensions under load, so that for instance the length of a coat as measured when the garment is suspended vertically from a coat-hanger is not necessarily the same as that of the same garment lying flat on a horizontal table). The acceptability or otherwise of a garment, however, rests on a good deal more than its correct size, and unfortunately a large number of the properties concerned cannot be quantitatively measured. How, for instance, does one quantify the set of a lapel or pocket flap, the waviness of a hem, the accurate matching of checks, the pucker of seams or its absence, the whole of the complex set of properties which are contained within the terms "cut" and "style"? Yet the quality of the garment, its commercial acceptability and saleability to the consumer, depend very largely on such factors. This is not really remarkable, when one remembers that clothes have always been worn for two separate purposes, ornament and utility, and whilst the utilitarian properties or parameters, such as fabric weight and thickness, heat retention, waterproofness, etc. can in general be determined on samples of the fabric from which the garment is made, the ornamental properties comprised under the term "fashion" are almost entirely visual and inherent in the garment itself, and as such are not susceptible of quantitative measurement.

Under these circumstances, quality control in practice generally consists of three separate procedures, which may be termed acceptance testing, performance testing, and product inspection. By acceptance testing is meant the testing of incoming raw materials of all sorts, to see that they conform to agreed specifications, so that at least faults in the final garments due to shortcomings in the original fabrics and trimmings are eliminated. Such testing, to be of real use, must extend to all the materials used in making a garment, such for instance as buttons, zip fasteners, press studs, hooks and eyes, elasticated waistband fabrics, stiffenings, tapes, interlinings both conventional and fusible, pocketings, linings, paddings, sewing threads etc. In practice the main testing effort tends to be applied to those products which experience shows to be most in need of it, i.e. those which show the greatest variation from lot to lot. Thus, for example, it is rarely necessary to test sewing threads for acceptability, as they are fully tested by the manufacturers. Even so, the volume of testing undertaken may be considerable if the sampling procedures adopted are too generous.

Whilst in this way the input raw materials may be kept up to specification, there remain certain special properties which are not covered by such a scheme, but which are nevertheless very important in certain classes of garment. Waterproofness in swimwear, flameproofing in children's garments, fabric-to-fabric adhesion in fusible interlinings, air permeability in windproof fabrics, are cases in point. Such properties require the application of special tests, since they are not revealed during the normal run of acceptance tests. Special tests of this sort may be termed performance tests, as they relate to the performance of the fabric in special circumstances.

Acceptance and performance tests can be made to ensure that the raw materials entering the processes of garment making are satisfactory in quality and will transmit no inherent faults to the final product. Between raw materials and final product, however, lies a complicated array of cutting, assembly, and finishing processes carried out very largely by hand, since automation (or, more correctly mechanisation) is not yet widely applied in the clothing industry. During this processing, faults due to both human and mechanical causes can and do arise. To prevent such faults from reaching the final customer, a system of product inspection must be instituted. This can apply only to the final product, or may be applied at various key points along the manufacturing process, with the purpose in the latter case of preventing further work on partially made but faulty garments.

Now, it is plain that to be 100% effective such an inspection system must apply to each individual garment before it leaves the factory, and in some cases where high quality is the main aim, and the selling price of the garment will warrant it, this individual inspection is in fact carried out; but it would obviously be economically impossible to apply it to the output of a large mass-production tailoring unit. In practice, some types and styles of garment are found to be more fault-prone than others, and the maximum inspection effort tends to be concentrated on those garments where it is found to be most necessary.

These three areas of quality control will now be considered in greater detail.

2. TESTING FOR QUALITY CONTROL

2.1. Acceptance Testing

The basic parameters by which a woven fabric is normally specified are as follows:

(i) Counts and twist of constituent yarns

(ii) Fibre content of yarns

(iii) Ends and picks per inch

(iv) Weight per square yard or per running yard

(v) Width in inches

(vi) Fabric thickness (in the case of fabrics having a raised or napped surface)

(vii) Conformity to shade (in the case of piece-dyed fabrics)

(viii) Freedom from structural faults, e.g., missing or displaced picks or missing ends, barriness, skewed checks, bowed weft, etc.).

In the case of knitted structures, courses and wales per inch take the place of ends and picks, and it is frequently difficult to extract the individual yarns from the fabric in lengths sufficient to enable tests for counts and twist to be made effectively.

All the above parameters, with the possible exception of (vii) can be measured quantitatively. Freedom from structural faults is somewhat difficult to quantify. Weft faults such as missing picks can be expressed as the number of faults per 100 running yards, which gives an overall value for "faultiness" in this respect, but faults such as misplaced ends or bowed weft, which may affect the whole piece from end to end, or any part of it, are less easily dealt with.

Obviously, to carry out all the tests enumerated above on every piece which enters the warehouse would prove prohibitively costly and time-consuming. A sampling procedure is therefore necessary, and this must be statistically adequate, i.e., the chance of a faulty piece being missed due to inadequate sampling must be acceptably low. A further difficulty that besets this type of determination is that very often samples for test are cut from near the ends of the pieces, in order to avoid wastage of fabric; but such end samples often are not representative of the piece as a whole. In general, it is found that, for the most effective use of testing resources, the available effort is best concentrated more on the types of fabric most liable to contain faults. Thus, a boldly-striped, thick, soft ladies' coating or checked mens' suiting, are more likely to contain weaving faults or to be off width than, say, a nylon/cotton plain weave pocketing. In any case, a structural fault in the latter case would be of no importance whatever, since the fabric is not on view in the final garment, whereas a missing end occurring in a stripe of the ladies' coating might quite easily render the garment unsaleable.

It is thus not possible to lay down a hard and fast rule as regards sampling of the raw material (fabric) intake for acceptance purposes. In some qualities it may be advisable to reperch every piece that enters the warehouse (and this is done by some firms) whereas for other materials such as linings and pocketings the determination of weight and width, with possibly ends and picks per inch, on every sixth or tenth piece, depending on the known reliability of the weavers and finishers, may suffice.

The acceptance testing of accessory products such as zip fasteners, buttons, trimmings, tapes, interlinings and pads, sewing threads for seaming, button-holing etc. constitutes another important aspect of quality control. Some, such as buttons, can be readily characterised by dimensions, weight, colour and surface finish, whilst others, such as zip fasteners, are much more difficult to deal with from a testing point of view, as the question of length [illegible] that a faulty [illegible] effectively [illegible] such of [illegible] in the [illegible] of free and satisfactory [illegible].

In general, each [illegible] should be [illegible] as an analytical [illegible], the likelihood of [illegible], the [illegible] and testing procedure set up, as it is felt to be necessary.

Finally, an efficient system of recording and filing the results of tests, and of tracing the [illegible] to which they refer, is necessary if information is to be readily available and a good deal of effort is not to be wasted. It is reasonable to retain tests results for [illegible] on file for a period approximating to the [illegible] life of the garment after it leaves the factory, in case of complaints arising during wear. Such storage is almost certainly better carried out via the memory banks of a computer than in a card index system, however efficiently operated.

4.6 Performance Testing

Acceptance testing [illegible] part of [illegible] or [illegible], which helps [illegible] the [illegible] production process, and so avoids [illegible] in the making up of garments which [illegible]. It does not follow, however, that because a fabric has passed this test, it will of necessity be suitable for the production of saleable garments. In some cases, fabric properties which do not lie within the normal range of acceptance testing may nevertheless be of decisive importance in deciding whether the fabric shall be accepted or rejected for the intended end use.

[illegible] types of performance, the more important ones may be listed as follows:

(a) Water repellency, in the case of rainwear fabrics.

(b) Flame-resistance, in the case of fabrics intended for children's wear, and particularly children's nightdresses.

(c) Air permeability, in the case of "windproof" fabrics such as grenfell cloth.

(d) Abrasion resistance, in the case of linings, pocketings, and fabric for children's knitwear such as school uniform fabrics.

(e) Dimensional stability to repeated low-temperature laundering.

(f) Drape and handle.

(g) Crease resistance and recovery.

(h) In the case of laminated textiles, including fusible interlinings, the strength of the bond between the two layers of the laminate, and its resistance to washing or wetting, dry-cleaning, and repeated mechanical flexing.

(i) Sewability, i.e. the ability to be joined satisfactorily by seams made with commercial sewing machines.

Tests are available for all these fabric properties, some of which have been approved as British Standard Tests. They are considered in greater detail below.

(a) Water repellency

The only completely waterproof fabrics are those such as oilskin or mackintosh, which incorporate a continuous layer of some waterproof substance such as rubber supported by the fabric serving as base for such a layer. Such fabrics have many disadvantages – for example they keep water in as well as keeping it out, so that they are uncomfortable in wear, and are only tolerable under extreme weather conditions where complete waterproofness is essential. Rainwear, as opposed to waterproof garments, is made from fabrics which may properly be termed showerproof, that is, they repel water drops for a considerable period of time, and so keep their wearers dry through a shower of average duration and intensity. This ability is conferred partly by the structure and materials of construction of the fabric itself, and partly by treatment with some one or other of a wide variety of showerproofing agents, of which the latest, and in many ways the most satisfactory, are the silicones and fluochemicals. The agent used, whatever its type, must ideally remain effective after successive wettings and dryings, and must not be extracted by normal dry-cleaning processes, otherwise reproofing of the garment after dry-cleaning is necessary, and this process is never wholly satisfactory.

The standard test for showerproofing in recent years has been the Bundesmann Test, but this method has not been found entirely satisfactory, particularly in regard to reproducibility of results on the same fabric as between different testing laboratories, and has never in fact achieved British Standard status. For this reason another test apparatus has recently been developed by the Wool Industries Research Association (2) which may achieve acceptance by the British Standards Institute. In the meantime it provides an alternative method of assessing showerproofness, particularly for quality control purposes, where absolute values are of less importance than variations above and below a norm fixed by the particular garment maker.

(b) Non-inflammability

It is now an offence under British Law (Statutory Instrument No.839 (1967) to sell children's nightdresses which are not flameproofed to the standard laid down in B.S. 2963. Other garments or garment material sold by the yard may not be sold as flameproof unless they also meet this British Standard Specification. It is thus absolutely essential that any manufacturer of children's nightdresses shall include, either as part of a quality control testing scheme, or separately, routine tests for flameproofing as laid down in the Specificatin quoted above.

(c) Air Permeability

This property is of importance mainly in the case of fabrics intended for the manufacture of "weatherproof" garments such as anoraks and windcheaters. It is usually determined by means of the Cambridge Instrument Company's standard air permeability test apparatus (3), but such tests will rarely be part of a quality control system except in the case of the manufacture of specialist garments for Arctic and mountaineering expeditions, where performance in this respect may be of the utmost importance.

(d) Abrasion resistance

Wherever a fabric is subjected to surface friction in wear, the question of satisfactory abrasion resistance arises. The obvious case is that of fabrics used for making pockets in men's suits, but other cases occur, and lining fabrics in general are called upon to withstand this kind of wear. Of the several types of abrasion tester available, the Martindale machine (4) is probably the most widely used. In this machine four samples can be tested simultaneously, by rubbing them against a standard abrading [illegible] (e.g. a [illegible] fabric such as a tie-lining cloth), the direction of rub relative to warp and weft being continually altered so that the sample is rubbed in all possible directions. [illegible] end-point to the abrasion process is chosen, such as the number of rubs required to break the first thread, and a counter registers the number of rubs performed from the start of the test. It is difficult to determine the abrasion resistance of a fabric in absolute terms, mainly because of the virtual impossibility of obtaining a constant and invariable abrading material, but the test can be used in a comparative sense to determine differences in abrasion resistance, and thus may prove invaluable as part of a quality control system. In such tests two of the four samples tested can be of a standard fabric whose abrasion resistance is known to be satisfactory, whilst the fabric to be tested supplies the other two samples. Any difference in abrasion resistance is thus quickly detected.

(e) <u>Dimensional stability</u>

During the manufacture of many garments, for instance men's suits, the garment is subjected to steam-pressing operations at numerous points as it progresses towards completion. A man's jacket, for instance, may have more than twenty such operations applied to it before it is completed. Many fabrics, particularly those made of wool, are prone to alter in size when subjected to the action of low-pressure steam, the alteration being generally a shrinkage, though occasionally a fabric may be found to expand at first when steamed. This shrinkage in steam is not wholly undesirable, as it makes possible refined tailoring, particularly in the region of sleeves and arm-holes, which would not be possible with a dimensionally stable fabric, but clothiers are not agreed as to the optimum degree of potential shrinkage in steam that a fabric should possess. This figure is probably about 2% or slightly less, and depends to some extent on the number of pressing operations required by the particular assembly process in use. It is very easy to over-tenter a piece of cloth weftways in order to finish it to some standard width, but such over-tentering invariably leads to excess weft-ways shrinkage during subsequent steam-pressing, values of 4-5% being not uncommon. Needless to say, dimensional instability of this order makes accurate tailoring almost impossible. The waistband of a pair of trousers, for instance, cut to a size of 40 ins., may finish at 38 ins. or less after pressing, with disastrous consequences.

Many different methods of measuring potential shrinkage have been proposed. They fall, in general, into two groups, those in which the fabric sample is soaked in water, either hot or cold, by floating it in a single layer in a shallow dish, and those in which the sample is subjected to low-pressure steam whilst supported on a wire frame designed to give the fabric unconstrained freedom to shrink. Clothiers in general tend to prefer the latter type of method, first because it corresponds more closely to the conditions under which shrinkage occurs in practice, and second because it is much quicker, since the lengthy drying process, to which soaked samples have to be submitted before measurements can be concluded, is avoided. The Wool Industries Research Association have recently published details of a new steaming test for dimensional stability(5) which has been accepted as a British Standard Test, and is now the preferred test method in the U.K.

(f) <u>Drape and Handle</u>

In some types of garment, particularly lingerie and women's clothes in general, the draping properties of the fabrics concerned are of considerable importance. Drape is a complex property closely allied to handle, but the latter also includes an element due to surface texture which is not concerned with the former. Both are difficult to measure and to quantify. The main operative properties in both cases appear to be the modulus of elasticity (Young's modulus) of the fabric and the shear modulus or rigidity. Probably the best approach to the measurement of drape is that provided by Chu, Cummings and Teixeira (6), later modified by Cusick (7). The apparatus and its use are described by Morkin and Chamberlain(8). Again, this method is probably most useful when applied in a comparative fashion, to detect differences in drape between a standard and an unknown fabric, rather than in an attempt to measure drape in an absolute sense.

(g) <u>Crease Resistance and Recovery</u>

One of the important properties of a garment is the ease with which it creases during wear, and the speed with which the creases subsequently disappear when the garment is hung up in a wardrobe. In general, all-wool fabrics crease less and recover more rapidly than cellulose-based fabrics such as cotton, linen, and rayon, and it has become usual to apply some non-crease finish (such as the Tootal urea-formaldehyde finish) to fabrics of this latter kind. There is a British Standard Test for crease recovery (B.S. 3086:1959) but Anderson and Settle (9) have pointed out several drawbacks associated with this test in Standard form. For instance, it cannot be applied to "very limp fabrics, very thick fabrics, or fabrics which have a marked tendency to curl. As many laminated fabrics, particularly those made from fusible interlinings, fall into the latter category, it is obvious that the Standard test is of limited application. [illegible] have proposed a modified procedure which enables the three types of fabric enumerated above to be tested satisfactorily, and Dorkin and Chamberlain ([illegible]) have described the use of this modified test in its application to fusible interlinings.

(h) Tests for bond strength of laminates

When two textile fabrics are fastened together to form a laminate, the life of the laminate is conditioned by the properties of the adhesive bond between the two components, and its ability to withstand the various vicissitudes, such as dry-cleaning, repeated flexing, etc., to which it will be subjected in normal wear. No standard tests exist for such properties, and Dorkin, Crow, Maltsoyannis and Chamberlain (8) have proposed test methods applicable primarily to fusible interlinings, but also to other laminates of this type. These tests have no British Standard status as yet, but have been found of use in assessing the performance of laminated textiles in general.

(i) Seamability

The traditional clothing fabrics, wool, cotton, linen, and silk, could all be joined by seaming, with comparative ease and very little trouble. Even the advent of high-speed sewing machines did not seriously alter this state of affairs.

The introduction of synthetic fibres, polyamide, polyester, and acrylic fibres, at the end of the Second World War did, however, pose problems for the garment maker. Partly because of the intrinsic strength of the new fibres, fabrics were produced whose structure was much finer than anything that preceded them, and the perforation of such fabrics by a normal-sized sewing machine needle led to the breakage of numerous threads along the track of the seam, resulting in a weakened and visually damaged seam. It is in fact true to say that it is now possible to weave, and in particular to knit, certain types of fabric which cannot be satisfactorily sewn even by hand, since the mere insertion of a needle leads to an unacceptable amount of seaming damage. Obviously such fabrics must be detected before they reach the making-up room. There is indeed a strong case for including in the general specification of a fabric a proviso that it shall be capable to give commercially acceptable seams under certain specified conditions, and failure to do so would be considered adequate grounds for rejection. Chamberlain and Dorkin (10),(11)(12)(13) and Chamberlain and Townsend(14) have made a study of seaming, both in regard to seaming damage, and also the closely-allied phenomena of distorted seams. In this latter connection seam pucker is the form usually encountered, and can render a high-class garment quite unsaleable. It cannot be over-emphasised that, in these days when the actual fibre composition of fabrics is often not disclosed, and blends of different fibres are often encountered, sewability tests should in all cases form part of the quality control system.

2.3. Product Inspection

As mentioned earlier, some degree of final product inspection must be introduced to minimise those errors associated with the actual making-up process which intervenes between the raw materials and the finished garment. Such inspection may often be associated with a check for garment size. It frequently happens that a garment may not, when finished, be the exact size that was intended from the original pattern, and may have to be reclassed as one size larger or smaller. Such errors arise from the dimensional instability of fabrics referred to above, and the potential shrinkage, both warp- and weft-ways, of some fabrics when subjected to steam pressing. When it is considered that a 2% shrinkage warpways during making-up will lift the hemline of a ladies' coat by one inch approximately, or shorten the sleeve by half an inch, the possibility of sizing errors is at once apparent.

The amount of inspection necessary is dependent on the type of garment being produced and the quality and price range aimed at. It can vary greatly, but in some cases may involve close inspection of every garment produced. Other faults that would normally be detected at this inspection are, distorted or damaged seams, uneven hemlines, mismatched checks and stripes, wavy fronts or backs, badly set sleeves, pockets and lapels, etc., any of which would justify rejection in the case of high quality garments.

It must always be borne in mind that the final judgement of quality will rest with the customer who buys the garment. Some firms indeed utilise this fact, and in effect recruit the consumer on to the quality control department staff, by letting it be known that faulty garments, even those in which the fault is more imaginary than real, will be exchanged at once and without argument. Such a system is open to a certain amount of abuse, but nevertheless the faults are recognised, returned, and traced back to their origin, and this fact may be worth the cost of such abuse.

3.. <u>GENERAL SUMMARY</u>

The clothing industry offers a rather difficult field for the application of quality control systems. This is mainly because of the operation of two factors - first, the variability of the input raw materials, (fabrics etc.) and second because of the large range and short production runs of the product. Economic considerations dictate the amount of time and labour that can be allocated to quality control in a particular factory producing a stated range of garments, and it then becomes a question of dividing up these resources among the three types of test described above, in such a way as to exercise the maximum degree of control over the quality of the final product. Normally, when a quality control system is first set up, emphasis is placed initially on acceptance testing, with product inspection used to monitor the effectiveness of such tests. Performance testing comes later, except in cases where statutory requirements exist, as in the flameproofing of children's garments. The Trades Descriptions Act in the U.K. may also lead to greater emphasis on this type of testing in the future.

The clothing industry is one in which the goodwill and reputation associated with a certain brand or name count for a very great deal with the buying public. It is precisely in the maintenance and enhancement of such goodwill that quality control, despite the difficulties, has a great part to play.

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