

Nonwoven Fabrics

Edited by

Wilhelm Albrecht

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Foreword

When in 1981 the world's first authentic and complete handbook on Nonwovens was published, the authors Albrecht and Lünenschloß already noted that these initially relatively simple substitution products had become an independent and technically sophisticated industry in its own right. Nonwovens owed their growth to an unusual multiplicity of raw materials and process options.

Since than 20 years have passed. Sales, distribution and diversity of an originally young and modest industry, whose focal points were clearly in Europe and USA, have multiplied. Experts expect a worldwide production of approx. 3.3 mio. tons at a market value of approx. US\$ 14.6 billion in the year 2000. This means more than 5% of conventional textile production will already be represented by Nonwovens. In numerous market segments, Nonwovens already play a leading role. In certain areas they have assumed genuinely novel functions – for example in textiles for personal and medical care.

Without doubt, the Nonwovens industry has also suffered during the course of its 50-years maturing process. Several markets are not longer growing or do not allow economically acceptable returns on investment any more. In a number of regions and market segments indiscriminating investments and the availability of turn-key technology have done severe harm to the industry.

For the qualified and responsible producer, however, the Nonwovens industry continues to offer endless new challenges and opportunities. Not many other fields of endeavour offer such creative diversity of raw materials and processes as well as a limitless variety of finishing and application possibilities in order to fulfil customer demands with tailor-made solutions. In this respect innovative Nonwovens producers can have confidence in a successful future.

In this spirit I welcome the new up-dated and extended version of the Nonwovens handbook and wish both, the authors and the publishers, the success they deserve. We all shall stand to benefit.

A handwritten signature in black ink, reading "H.N. Dahlström". The signature is written in a cursive, flowing style with a prominent loop at the end.

H.N. Dahlström

Preface

Twenty years ago, the reference book “Nonwovens” was kindly received by all concerned with textile manufacturing. In that book, more than 20 authors described in detail the raw materials, their processing into a wide range of nonwoven products, the characteristics of the products and the testing techniques then in use. “Nonwovens” was much asked for in industry, education and, with regard to new products, in R&D. Meanwhile, the quantity of nonwovens made worldwide has grown, the range of goods based on nonwovens is much wider, the technical equipment, the raw materials as well as the auxiliaries used have been further developed. Therefore, the idea did not come as a surprise to revise the book. This meant to find a team of authors fully conversant with the current state and the quantitative and qualitative developments going on in a field of industry which is – as hardly any other industry – run on a worldwide scale. A sophisticated project like this called for specialist co-ordination, which was provided by Sächsisches Textilforschungsinstitut in Chemnitz, a research institute preferably dealing with questions of nonwoven production and innovation in the field of nonwovens. This institute works closely together with companies that make or process nonwovens as well as with the suppliers of fibres, the manufacturers of the relevant equipment and the producers of auxiliaries, which has been very helpful.

Today, the nonwoven-producing industry is best characterized as an industry that has accomplished a rise in product quality which the user can see and feel. Its range of products has become ever larger. This has been achieved by creative work and successful co-operation with the suppliers of raw and auxiliary materials as well as the manufacturers of equipment. Based on this co-operation, there are good prospects for novel products coming. Future developments will, in the widest sense of the word, continue to focus on best-possible functionality and low-est-possible consumption of resources. To this end, it will be important all concerned work together even more closely. The editing team give their views of ways to go and aims to reach in the future in the last Chapter of this book headlined “outlook”, thus outlining the potential which is still waiting to be exploited. This book is supposed to contribute to developing the nonwoven-producing industry.

We have been lucky one of the editing team has been in a position to do all the work in detail required to prepare this reference book. This meant spending much time talking to the authors of the single Chapters and co-ordinating them.

More help was provided by Wiley VCH Publishers, who will, except for the German edition, publish the book in English and Chinese, too. We are grateful to Dr. Böck for comprehensive advice. Thanks to her efforts, the book includes advertisement which will help the nonwoven-producing industry to deliver best quality and to develop new products. Our thanks go to all authors and those who have contributed in whatever way.

Today, nonwovens are part of what is known as the world of textiles. Due to their tailor-made characteristics, they are highly suitable to meet a wide diversity of requirements. Thus, nonwovens are more than products which are up-to-date. They give evidence that it is possible to master the challenge of the future.

We hope the reader can make good use of this book.

Wilhelm Albrecht
Hilmar Fuchs
Walter Kittelmann

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Introduction to nonwovens

G. MASSENAUX

Whilst the first production of a “nonwoven fabric” in Europe goes back to the thirties, the existence of a recognizable nonwovens industry in Europe can be dated to the mid-sixties.

This is also when the terms nonwovens or *Vliesstoffe* got used, preferably to others, in a small circle of manufacturers and converters.

Since then, the manufacture of nonwovens has expanded rapidly and the use of such products has penetrated many aspects of industry and of private life. Nonwovens are found in hygiene and health care, in roofing and civil engineering, household and automotive, in cleaning, filtration, clothing, food wrap and packaging, to name only a few end-uses. Confusion or ignorance about nonwovens remains large though. The present book comes out therefore at the right time to give a comprehensive view of what is to be understood by nonwovens, their manufacturing process, applications and possibilities. Presenting in a coherent way the present state of the art of nonwovens manufacturing and end-uses will be an invaluable help to all those within the industry or outside of it who deal with nonwovens or might get the opportunity to do so.

It is to be hoped that this book will also have a seminal influence in attracting young talents to this growing industry, where so much still is needed in order to further develop machinery, raw materials and properties of nonwovens to their best use.

0.1

Definition of nonwovens

The term used to designate the products generally known as nonwovens, was coined in most languages in opposition to woven fabrics, which implicitly were taken as a reference. A nonwoven was something that was not woven.

Even the German name “*Vliesstoffe*” wasn't clear either as it could be confused with ceramical material and in any case remained ambiguous in its unusual spelling. Only specialists know that nonwovens are unique engineered fabrics which offer cost effective solutions as e.g. in hygiene convenience items, or as battery separators, or filters, or geotextiles, etc.

There is a formal definition of Nonwoven: ISO 9092¹⁾ which has been adopted by CEN (EN 29092) and consequently by DIN or AFNOR or any standardization office in the EU. Various legal or regulatory implications derive from it²⁾.

As a main characteristic the CEN definition indicates that a nonwoven is a fabric made of fibres, that is consolidated in different ways. Nonwoven fabrics are made out of fibres, without any restriction, but not necessarily from fibres. These can be very short fibres of a few millimetres length as in the wetlaid process; these can be “ordinary” fibres, as used in the traditional textile industry, or then very long filaments etc. Properties and characteristics of a nonwoven fabric depend for a large part from the type of fibre it is ultimately made of. These fibres can be natural or man-made, organic or inorganic; the characteristic of a fibre being that it is longer than its thickness, or diameter. Such fibres can also be produced continuously in connection with the nonwoven process itself and then cut to length, or then extruded directly e.g. from polymer granules into a filament and then fibrous structure.

To make good measure the ISO definition also excludes various types of fabrics to which, voluntarily or not, one might compare nonwovens. Nonwovens are not paper and indeed, when made out of very short, cellulose fibres, they essentially differ from paper because there aren't any, or hardly, hydrogen bonds linking such fibres together³⁾.

Nonwovens, as indicated by their English or French name, are neither woven fabrics, nor such other textiles as knitted fabrics. Behind these statements lies a fundamental characteristic of nonwoven: contrary to woven or knitted fabrics, fibres that ultimately make up the nonwoven fabric need not to go through the preparatory/transitory stage of yarn spinning in order to be transformed into a web of a certain pattern.

Some will remark that other textile fabrics were created in the past besides the weaving and knitting process, e.g. felting (which is also yarnless) or more recently stitchbonding. For this reason as well – especially in the early days – some have tended to literally classify as nonwovens all textile fabrics that are outside the weaving/knitting domain. Matters have settled since then and the reflexions at

- 1) A manufactured sheet, web or batt of directionally or randomly orientated fibres, bonded by friction, and/or cohesion and/or adhesion, excluding paper and products which are woven, knitted, tufted, stitch-bonded incorporating binding yarns or filaments, or felted by wet-milling, whether or not additionally needled. The fibres may be of natural or man-made origin. They may be staple or continuous filaments or be formed *in situ*. (This definition is completed by various notes.)
- 2) The CEN nonwovens definition is adopted by EDANA, the European nonwovens industry association. INDA, the North American Association has a slightly different, wider definition which has the merit of apparent simplicity: a sheet, web or batt of natural and or man-made fibres or filaments excluding paper, that have not been converted into yarns and that are bonded together by any of several means (such means are then listed).
- 3) There remain marginal cases with respect to paper or other fabrics which the ISO/CEN definition tries to deal with in its notes but we won't bother the reader with it. Like in nature there are some areas which can be contested between sea and terra firma and where the final accepted limit is somewhat arbitrary; or like in the plant/animal realm where the final distinction depends from the criteria that are finally adopted...

ISO and CEN helped clarify this. As far as textiles go, nonwovens are only part of a category of fabrics that exist besides weaving and knitting.

Nonwovens though go also beyond the limits of textiles. Fibres they ultimately are made of can be very short “unspinnable” ones like in the paper industry; the fibrous web can also originate from foils and other plastics. Nonwovens therefore share for a part manufacturing characteristics and properties with the paper industry or the chemicals/plastics industry to finally make a world of their own.

Nonwovens do not depend on the interlacing of yarn for internal cohesion. Intrinsicly they have neither an organized geometrical structure. They are essentially the result of the relationship between one single fibre and another. This provides nonwoven fabrics with characteristics of their own, with new or better properties (absorption, filtration) and therefore opens them up to other applications.

0.2

Nonwoven manufacturing processes

There are three main routes to web forming:

- the drylaid system with carding or airlaying as a way to form the web;
- the wetlaid system;
- the polymer-based system, which includes spunlaying (spunbonding) or specialized technologies like meltblown, or flashspun fabrics etc.

The lack of sufficient frictional forces however has to be compensated for by the bonding of the fibres, which provides web strength. Consolidation of the web after its formation is the second step in the nonwoven manufacturing process.

This consolidation for a large part sets the final characteristics of the fabric and therefore, if possible, ought to be chosen with the end application in mind. Such consolidation can be done by use of chemical means (chemical bonding) like binders. These can be applied uniformly by impregnating, coating or spraying or intermittently, as in print bonding. The consolidation can also be reached by thermal means (cohesion bonding), like the partial fusion of the constituting fibres or filaments. Such fusion can be achieved e.g. by calendaring or through-air blowing or by ultra-sonic impact.

Finally, consolidation can be achieved by mechanical means (frictional bonding), like needling, stitching, water-jet entangling or a combination of these various means.

Customers needs can be further met by modifying or adding to the existing properties of the fabric through finishing. A variety of chemical substances can be employed before or after bonding or various mechanical processes can be applied to the nonwoven in the final stage of the manufacturing process.

The choice of the raw material and the final constituting fibrous element, the depositing of the fibres as a fibrous material of a varying density, the choice of consolidating and finishing means, all this creates a series of parameters which can be played with in order to reach the required properties. This confirms what

was indicated earlier that nonwovens are engineered fabrics par excellence. When ingredients, web formation and consolidation are chosen in order to best meet the characteristics needed at the end application, then for sure, we have a winner.

0.3

Nonwoven properties and applications, including environmental considerations

Nonwovens are in fact products in their own right with their own characteristics and performances, but also weaknesses. They are around us and one uses them everyday, often without knowing it. Indeed they are frequently hidden from view. Nonwovens can be made absorbent, breathable, drapeable, flame resistant, heat sealable, light, lint-free, mouldable, soft, stable, stiff, tear resistant, water repellent, if needed. Obviously though, not all the properties mentioned can be combined in a single nonwoven, particularly those that are contradictory.

Their applications are multifold. Examples of their uses can be listed as follows:

- Personal care and hygiene as in baby diapers, feminine hygiene products, adult incontinence items, dry and wet pads, but also nursing pads or nasal strips.
- Healthcare, like operation drapes, gowns and packs, face masks, dressings and swabs, osteomy bag liners, etc.
- Clothing: interlinings, insulation and protection clothing, industrial workwear, chemical defence suits, shoe components, etc.
- Home: wipes and dusters, tea and coffee bags, fabric softeners, food wraps, filters, bed and table linen, etc.
- Automotive: boot liners, shelf trim, oil and cabin air filters, moulded bonnet liners, heat shields, airbags, tapes, decorative fabrics, etc.
- Construction: roofing and tile underlay, thermal and noise insulation, house wrap, underslating, drainage, etc.
- Geotextiles: asphalt overlay, soil stabilization, drainage, sedimentation and erosion control, etc.
- Filtration: air and gas, Hevac, Hepa, Ulpa filters
- Industrial: cable insulation, abrasives, reinforced plastics, battery separators, satellite dishes, artificial leather, air conditioning, coating.
- Agriculture, home furnishing, leisure and travel, school and office etc.

The origins of nonwovens are not glamorous. In fact, they resulted from recycling fibrous waste or second quality fibres left over from industrial processes like weaving or leather processing. They also resulted from raw materials restrictions e.g. during and after the Second World War or later in the communist dominated countries in Central Europe. This humble and cost dominated origin of course lead to some technical and marketing mistakes; it is also largely responsible for two still lingering misconceptions about nonwovens: they are assumed to be (cheap) substitutes; many also associate them with disposable products and for that reason did consider nonwovens as cheap, low quality, items.