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Sewing Threads & their Technical Applications

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Abstract

Sewing threads are especially engineered threads to satisfy the requirements of the end product. The overall performance in terms of strength, durability and usefulness of the substrate depends on the sewing thread. Though the consumption of sewing thread is not more than 1% of the textile to be sewn, they are of considerable importance. These threads find the end use applications in almost every technical textile sector i.e. Indutech, Hometech, Meditech, Sporttech, Protech, Packtech, Clothtech etc. The present paper deals with the introduction to the different types of sewing threads along with their compositions, specifications and properties & also different end use applications.

Keywords: Sewing threads, Compositions, Properties & Application

1. Introduction [1]

History of sewing threads goes back to 2500 years ago when man used to make threads from animal hairs by rubbing and twisting. Later on jute, silk, linen, were used. Then cotton threads became so popular. Today is the era of synthetic threads where these threads are specially engineered to satisfy the functional requirements of the end products.

Processes and materials used for joining depend on the structure and properties of the substrate being joined and the properties required of the joint. Stitched seams predominates because the resulting seam is flexible, can be extensible can be unpicked and reformed and because stitching can be carried out on variety of substrates. Fusing, adhesive sealing and welding, the stitch less joining processes are limited to thermoplastic substrates or components. Stitch less joint is also tending to be stiff and

inextensible, these properties narrowing further the range of applications in which they are appropriate.

Sewing threads may be defined as smooth, evenly spun, hard-twisted ply yarn, treated by the special finishing process to make it resistant to stresses in its passage through the needle eye and through material involved in seaming and stitching operation. It joins the different components of the substrate by forming a seam that primarily provides uniform stress transfer from one piece of substrate to another, thus preserving the overall integrity of the assembly.

Threads for the high temperature applications are required to withstand and hold the seams secure in their position in extreme temperature conditions between 260ºC- 1100ºC. Threads are usually made from glass, carbon, polytetrafluoroethylene, steel and aramide fibres. Polyesters, Polypropylene, Nylon6, Nylon6.6, are widely used for low temperature applications such as car upholstery, leather industry, packing like cement and fertilizer bags. Medical sutures are used for wound closure and are specially design and sterilized to fulfill the end applications.

2. PTFE coated fiberglass sewing threads [1, 2]

PTFE coated fiberglass sewing threads Fig.1 is made from continuous filament yarns, resulting in a strong, chemical resistant textile sewing thread. Uniform PTFE coating completely encapsulates the thread, enhancing resistance to build-up of contaminates and repelling attack by most acids and alkalis. Smooth PTFE coating enhances the flexibility of the fiberglass yarn, making it suitable for many industrial applications and minimizing the tendency to kink, strip-back or break like other very high temperature threads. PTFE coated fiberglass can be categorized according to the temperature range i.e. S2 Grade Fiberglass, E Grade Fiberglass, Beta Grade Fiberglass These threads offer high temperature resistance, high strength, chemical resistance and suitable for temperatures up to 538 °C to maximum of 760 °C.

Fig.1 PTFE coated fiberglass sewing thread

Applications:

Aerospace: - radomes, thermal shields, micrometeorite debris shields, ceramic-matrix composites, metal-matrix composites, polymer-matrix composites

Industrial:-Furnace linings, galvanized steel furnaces, porcelain furnaces, furnace zone dividers, door seals, tube seals**,** gaskets, expansion joints sealing & insulating products, safety clothing & gloves.

3. Alumina-silica sewing threads [3, 4]

Alumina-silica yarn Fig.2 is made up of thousands of filaments, giving it excellent flexibility and stability for transformation into textiles, without the aid of other organic or metal fibres. A boron-free alumina-silica fibre that is composed of Al_2O_3 72% and SiO_2 28%, Table1 which is commonly known as a representative stable metal oxide material. It is a polycrystalline filament whose crystal type is gamma alumina and amorphous silica with a fine filament diameter of 7 micron. Textile properties include good chemical resistance, thermal shock resistance up to 1200 ºC and superior insulation properties. They are also corrosion-resistant and do not absorb moisture. Filaments are inherently colourless, but can be coloured with inorganic pigment red, black and blue. Pigments are stable up to 700/800°C.

Fig. 2 Alumina-silica sewing threads

Table 1 thread specifications

Filament Diameter(µm)	7 - 10
Chemical Composition (%) Al_2O_3 : SiO_2	72:28
Density(g/cm^3)	2.9
Tensile strength (kgf/mm^2)	200
Tensile modulus (kgf/mm^2)	17000

Applications:

High temperature textiles, safety spray shields, braided sleeving, insulation jackets thermal insulation pads, high temperature gaskets, kiln seals, welding blankets, heat shields.

4. Carbon fibre sewing threads [4]

Carbon fibers are the closest to asbestos in a number of properties. Each carbon filament thread is a bundle of many thousand carbon filaments. A single such filament is a thin tube with a diameter of 5–8 micrometers and consists almost exclusively of carbon. Carbon fibre gives high strength and temperature resistance (up to 1100ºC) properties.

Table 2 thread specifications

Tex	Strength (Mpa)	Modulus (Gpa)	Elongation (%)
200	3450	230	1.5
400	3450	230	1.5
800	3450	230	1.5
1200	4000	240	1.6

Application: sports cars, super bikes, aerospace, marine.

5. Kevlar sewing threads [5, 6]

These threads are schappe-spun meta-aramide sewing thread. Threads made of Kevlar retain much of their strength at high temperatures, they can help the seams and tape edges stay sealed and keep out flames. Kevlar threads have excellent strength (Table3) and good thermal stability retaining a high percentage of room temperature properties at temperatures up to 300°C. It does not melt, or support combustion, but will oxidize to a cinder at 400-430°C. offer other properties like low thermal conductivity, will not burn or smolder, will not stretch or shrink high strength-to-weight ratio, resistant to sparks & welding spatter, superior resistance to abrasion, resistant to most chemicals, excellent flexibility up to 300°C.

Table 3 thread specifications

Tex	Breaking Strength (Kg.)	Elongation (%)
42	4.8	3.0
63	7.7	4.0
84	10.4	4.0

Applications: Safety clothes, pilot's overalls, defense uniforms, low flammability textiles

6. Nomex sewing threads [7]

These threads are schappe-spun meta-aramide sewing thread. Mainly used to over lock the fabrications (prevent fraying at edges), Nomex thread is known for its 'flame resistant properties, and is used extensively in protective textiles. Nomex does not melt and has extremely low flammability. At temperatures above 371°C, the fibre degrades to a char. Nomex has excellent resistance to chemicals, low thermal conductivity, non-combustible, dimensionally stable at elevated temperature, high strength-to-weight ratio, resistant to abrasion, good dielectric properties, resistant to acids and alkalis, excellent flexibility.

Table 4 thread specifications

Tex	Breaking Strength (Kg.)	Elongation (%)
48	1.7	21.0
85	3.1	22.0

Applications: Protective clothing and gloves for firefighters, industrial filtration felts, smoke curtains for naval vessels, protective clothing for petrochemical workers, heat insulation tape for sleeving, aviator and racecar driver uniforms, thermal insulation felts and batts.

7. Stainless steel spun yarn with PTFE or cotton (Fig.3) [1, 8]

For High Temp products required to go above 550°C, this thread is used as the main reinforcing stitch. It has excellent resistance to high temperatures up to 800°C. For cotton coated thread the cotton burns off at relatively low temperatures to leave the stainless steel thread as the main reinforcing material. Typical thread with diameter of 0.035mm gives tensile strength of 925-1100 Mpa with 30% elongation to break.

Fig.3 Stainless steel threads coated with PTFE

Table 5 thread composition

Chemical composition							
C	Si	Mn	P	S	Cr	Ni	Mo
≤0.03	≤1	≤2	≤0.045	≤0.03	16-18	12-15	2-3

Applications: Heat shield curtains and high temperature textiles.

8. Poly Propylene Sewing Thread [1, 8, 9]

Polypropylene fibre have some good inherent characteristics such as high tensile strength, high chemical and abrasion resistance, weather resistance, neutrality to odors, dirt

repellence, no tendency to pilling and rot resistance. Polypropylene fibres have limitation of melting temperature which is 165-170ºC. These threads can be applied for technical textiles where they are not subjected to the high temperatures. High Tenacity Polypropylene twisted yarn is also available in raw white or mass-dyed colors on industrial cones, king spools or metered bobbins for sewing threads and technical applications.

Table 6 thread specifications

Composition (dtex)	Breaking Strength (Kg.)	Elongation (%)
446x2	6.5	21.0
660x2	10.0	19.0
660x1x3	13.0	21.0
880x3	20.0	22.0
1100x1x3	26.0	25.0
660x2x3	27.0	24.0

Applications: Inherent hydrophobicity makes them ideal sewing threads for fertilizer bags, Geotextiles, cement bags, Upholstery, filtration, packaging, bulk container and furnishing industry

9. Nylon 6 bonded or non-bonded continuous filament Sewing Threads [1, 10]

These threads are made up of 100% continuous Nylon 6 (Polyamide 6) yarn of high tenacity. Nylon 6 threads have very good elastic recovery at low stresses they recover almost 100%. Nylon 6 shows high resistance to alkali, and weak acids. Nylon 6 gives high abrasion resistance.

Applications: like following types (Table7) of threads can be used for leather shoes, uppers, leather garments, footwear, wallet, sports goods, gloves, bags, light leather goods, mattresses, upholstery, automobile seats, industrial filters, carpets, parachutes, airbags etc.

Composition (dtex)	Tex (Normalized)	Strength (Kg.)
235/2	53	2.9
235/3	79	4.1
235/4	107	5.5

Table 7 thread specifications

For applications like high strength is require(Table 8) heavy stitching of leather goods, ornamental stitching of leather shoes/goods, saddlery, tarpaulin, tents, jeep hoods, safety belts etc. following threads can be used.

Table 8 thread specifications

Composition (dtex)	Tex (Normalized)	Strength (Kg)
470/3	158	8.0
700/3	240	11.3
940/3	340	15
1260/3	485	23

10. Nylon 6, 6 bonded or non-bonded continuous filament threads [1, 10]

Polyamide 6.6 is semi crystalline polyamide and excels in applications where high strength, impact resistance and toughness are required.Bonded is made from 100% Continuous Polyamide 6, 6 high tenacity yarns. Thread after twisting and dyeing (as required) is coated with specially formulated Bonding finish.

Advantages of the bonded threads are:

1. Excellent performance of multi-directional sewing operation as the plies stays together, due to the bonding of plies.
2. Exceptionally high abrasion resistance due to coating of specially formulated bonding chemical.
3. High Melting point of above 260° C, thus preventing thread melting at needle eye while sewing.
4. Low stretch and excellent recovery properties resulting in very neat seams.

Applications (Table9): Ladies shoe uppers, Shoe lining where decorative work is important rather than strength.

Table 9 thread specifications

Composition (dtex)	Tex (Normalized)	Strength (Kg)
117/3	36.5	2.3

Applications (Table 10): leather shoes, uppers, leather garments, footwear, wallet, sports goods, gloves, bags, light leather goods, mattresses, upholstery, automobile seats, industrial filters, carpets, parachutes etc. where high strength is important higher counts can be selected.

Table 10 thread specifications

Composition (dtex)	Tex (Normalized)	Strength (Kg)
235/2	53	3.3
235/3	79	5.0
310/3	107	6.6

Applications (Table11): Heavy stitching of Leather Goods, Ornamental Stitching of Leather Shoes, Saddlery, Tarpaulin, Tents, Jeep Hoods, Safety Belts etc. where very high strength is required for good serviceability.

Table 11 thread specifications

Composition (dtex)	Tex (Normalized)	Strength (Kg)
470/3	158	9.0
700/3	240	14.8
940/3	340	19.4
1260/3	485	29.1

11. Polyester bonded, non bonded Continuous Filament Thread [1, 10]

Polyester have good tenacity, very good elastic recovery, stable at quite high temperatures, hydrophobic nature, resistance to acids and alkali make polyester ideal member for the sewing threads. Pre stabilized 100% continuous filament polyester with specially formulated bonding chemical finishes gives excellent performance on multi-direction machines & automatic machines as the plies do not open during sewing.

Bonding also provides very high resistance to abrasion due to protective bonding chemical coating.

Applications (Table12)**:** ladies shoe uppers, shoe lining etc. where high strength is not required and the use is for only decoration

Table 12 thread specifications

Composition (dtex)	Tex (Normalized)	Strength (Kg)
113/3	37.5	2.2
138/3	50	2.8

Applications (Table13): where higher strength is required following threads can be used, like leather shoes, uppers, leather garments, footwear, wallet, sports goods, gloves, bags, light leather goods, mattresses, upholstery, automobile seats, industrial filters, carpets, parachutes, zips etc.

Table 13 thread specifications

Composition (dtex)	Tex (Normalized)	Strength (Kg)
190/3	64	3.4
226/3	75	4.2
280/3	89	5.5

Applications (Table14): where very high tensile strength is required like heavy stitching of leather goods, ornamental stitching of leather shoes, saddlery, tarpaulin, tents, jeep hoods, safety belts etc. following threads can be applied.

Table 14 thread specifications

Composition (dtex)	Tex (Normalized)	Strength (Kg)
440/3	150	8.8
550/3	190	10.4
1100/3	395	22.0
1100/4	435	32.0

12. Polished polyester / cotton core spun sewing thread [1, 8, 10]

These threads are made from high tenacity polyester filament covered with cotton during spinning. After spinning special chemical treatment and process are given to give it an extremely smooth surface & bright luster. These threads give very high resistance to heat due to heat cover. Threads give strength of high tenacity polyester with softness & feel of cotton, combine with very good luster due to the Special Polishing Treatment.

Applications (Table15)**:** following threads are used where decoration is required leather jackets, coats, wallets, belts, garment lining etc.

Table 15 thread specifications

Composition (dtex)	Tex (Normalized)	Strength (Kg)
50/2	45	1.85

Applications (Table16): like, leather jackets, gloves, handbags, leg guards, all types of leather goods, raincoats, umbrellas, brushed shoe uppers etc. higher counts are generally preferred.

Table 16 thread specifications

Composition (dtex)	Tex (Normalized)	Strength (Kg)
50/3	68	2.80

13. 100% Spun Polyester Sewing Thread [1, 10]

These threads are made from high tenacity Spun Polyester Yarn. Thread is highly supple, rot proof, UV Resistant, waxed, and polished. Micromolecular lubrication are given for very smooth high speed sewing operation

Applications (Table17): highly suitable for foot ball, basket ball, sole stitching, saddlery etc.

Table 17 thread specifications

Composition (Ply/Count, Ne)	Breaking Strength (Kg)
10/5	41.00
8/5	32.00
6/5	25.00

14. High tenacity lubricated polyester braids (fig 4) [10]

These are thick threads (Table18) and can be used for heavy functional, decorative seams. Performance in any condition, high speed or different materials is granted by the special structure and lubrication, imparting a good gliding and needle cooling. Can be used on all heavy sewing machines for shoe soles, rand, automatic units, two needles. The primary use is for coarse functional seams and decorations by heavy stitching machines.

Fig 4. Polyester Braids

Table 18 thread specification

Thread Dia. (mm)	Breaking Strength (Kg)
0.4	6.7
0.6	12.5
1.6	57.2
1.8	66

15. PTFE Sewing threads [11]

Filter bags, cartridges, and other sewn filter media are exposed to extreme temperatures chemicals, abrasives, and, occasionally, moist environments, for extended periods. These conditions degrade the filter media and thread, and the thread often gives out first. In some cases the thread is not appropriate for the application, or it simply wears out from chemical, temperature, or abrasive attack before the filter media. Sewing thread, made from 100 percent expanded PTFE and engineered specifically for the demands of filtration applications, withstands exposure to chemicals, high temperatures, abrasives, and moist environments. These threads are manufactured by the paste extrusion process, PTFE resin is processed into membrane, tape, and fibers by combining extrusion and thermal elongation processes. Known as expanded PTFE shortened to ePTFE materials.

The extrusion process typically delivers much better tensile performance (up to 4g/d), with lower shrinkage (3–5 percent)

Advantages of the PTFE threads

1. Chemically inert to acids, caustics, solvents and hydrocarbons (0-14pH)
2. Temperature resistant from -350ºF to 550ºF (-212ºC to 288ºC)
3. Non contaminating - will not shed or cause contamination
4. Low shrinkage at high temperatures
5. Non-aging
6. Unaffected by moist environments

Table 19 thread specification

Size (d.tex)	Nominal breaking strength (N)
13.3	35.6
26.7	66.7

TENARA Sewing Thread is a long-lasting thread which enhances the life of the outdoor and marine products in which it is used. Conventional seam threads on awnings and other outdoor fabric products suffer from exposure to wind and weather. After a few years they can become brittle and break. Ordinary polyester threads break down over time due to exposure to UV sunlight, cleaning agents, saltwater and extreme weather. Resistance to sunlight is a key requirement for high quality outdoor products. These sewing threads maintain their strength even after regular exposure to UV sunlight. Remain flexible even in extreme of temperature or frost. It gives outdoor fabric products the kind of strength that withstands severe weather conditions – even after years of exposure. PTFE is unaffected by acids, alkaline solutions and cleaning chemicals. Due to its chemical characteristics it is highly suitable for use in manufacturing processes involving contact with aggressive media. High resistance to UV rays, chemical and atmospheric agents. Up to 15 Years threads remains unaffected by the U.V. Radiation

Applications (Fig.5)

PTFE thread can improve the performance of a variety of products where seam life and integrity are of the utmost importance. This thread will not break down due to exposure to the elements, and therefore it is ideally suited for use in a variety of outdoor and marine fabric applications like Protective fabrics, sails, boat-covers, cabriolet, Awning, umbrellas, Artificial turf installation, hunting blinds, Gliders, Marine Bimini tops, Swimming pool covers, Hot air and weather balloons, Convertible tops, Gliders etc..

Fig.5 Applications of PTFE Sewing threads

16. Surgical Sutures [12, 13, 14]

Surgical sutures are one of the most commonly used devices for wound closure(fig6) and tissue approximation. In the US, approximately 50 million open surgical procedures a year are performed requiring the use of sutures. Surgical sutures can be broadly classified as absorbable and non absorbable sutures depending on the material used for the manufacturing.

Fig.6 Wound closure with suture thread

16.1 Absorbable sutures

Absorbable sutures are made of materials which are broken down in tissue after a given period of time, which depending on the material can be from ten days to eight weeks. They are used therefore in many of the internal tissues of the body. In most cases, three weeks is sufficient for the wound to close firmly. The suture is not needed any more, and the fact that it disappears is an advantage, as there is no foreign material left inside the body and no need for the patient to have the sutures removed.

Absorbable sutures were originally made of the intestines of sheep, the so called catgut. However, the major part of the absorbable sutures used are now made of synthetic polymer fibers, which may be braided or monofilament; these offer numerous advantages over gut sutures, notably ease of handling, low cost, low tissue reaction, consistent performance and guaranteed non-toxicity. In Europe and Japan, gut sutures have been banned due to concerns over bovine spongiform encephalopathy (mad-cow disease). Occasionally, absorbable sutures can cause inflammation and be rejected by the body rather than absorbed.

Some typical absorbable synthetic sutures are as follows:

1. PGA (polyglycolic acid, multifilament)
2. PGA Quick (short term absorbable braid)
3. PGLA (Polyglycolide-co-L-lactide) braid
4. PDO (polydioxanone, monofilament)

Fig. 7 Absorbable sutures

These sutures provide advantages such as high initial tensile strength, guaranteed holding power through the critical wound healing period. Smooth passage through tissue, easy handling, and excellent knotting ability, secure knot tying.

16.2 Non-absorbable sutures

There are several materials used for nonabsorbable sutures. The most common is a natural fiber, silk, which undergoes a special manufacturing process to make it adequate for its use in surgery. Other nonabsorbable sutures are made of artificial fibers, like polypropylene, polyester or nylon; these may or may not have coatings to enhance their performance characteristics. Finally, stainless steel wires are commonly used in orthopedic surgery and for sternal closure in cardiac surgery.

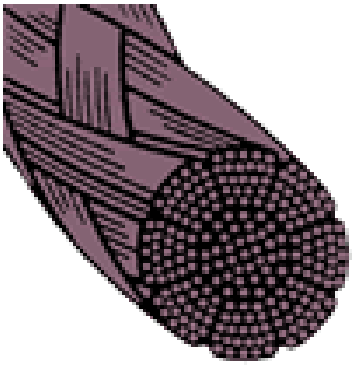

Fig 8 Nonabsorbable sutures.

Chitin's properties as a flexible and strong material make it favourable as surgical thread. Its biodegradability means it wears away with time as the wound heals. Moreover, chitin has some unusual properties that accelerate healing of wounds in humans.

Non-absorbable suture threads are as below:

1. Silk braided, untreated, waxed, siliconed
2. Polyester braided, untreated, waxed, siliconed and teflon coated
3. Nylon monofilament
4. Polypropylene monofilament
5. Norefil (PVDF-polyvinylidefluoride) monofilament
6. Linen
7. Steel wire

Table 20 thread specification

Synthetic absorbable suture dia. (mm)	Synthetic non- absorbable suture dia (mm)
0.02	0.01

0.03	0.02
0.04	0.03
0.70	0.40
0.80	0.80

17. Soluble sewing threads (fig.9) [15]

Synthetic polycarbonate threads and polycarbonate threads has been developed to replace conventional basting or tacking threads and is use to stitch the material in usual manner finished products are treated with dry cleaning solvent, when agitated, reduce thread cohesion until fracture is initiated and the broken fragments are shaken away from the fabric. These threads can be used to for Tacking thread for sanitary laundry bags, sewing fabrics with long stitches like tarpaulin, before sewing to hold it in position and then after sewing removed by dissolving them.

Table 21 thread specification

Type	**Multifilament**			
Temperature for dissolving treatment	95°C	85°C	80°C	90°C
Tenacity (Dry) (CN/T)	3.3 ~ 4.3	2.7 ~ 4.1	2.7 ~ 3.9	3.8 ~ 5.0
Elongation (%)	12 ~ 18	10 ~19	11 ~ 21	10 ~ 16

Fig 9 Soluble PVA sewing threads

18. Conductive Threads (fig 10) [16]

There are occasions where the quality of newly created product could get a real boost and advantage this product had the capability to lead away electrostatic charges. This ability

would solve a lot of static charges problems and does allow you to design innovative new solutions to meet the ever changing market demands.

Static Problems

The unintended consequences of static discharge can cause serious problems in a number of environments. Explosions in grain storage facilities often are cited as one of the most prominent examples. However, static discharge also can cause shock due to static charge in car, prevent production machinery from operating properly, are just some of the places where static-control textiles have served market demand. In the automotive industry, product applications include seatbelts and upholstery. Bulk bags, conveyors and paper-forming belts make manufacturing safer and more efficient. The commercial environment can be benefited from antistatic engineered upholstery and flooring products using conductive threads.

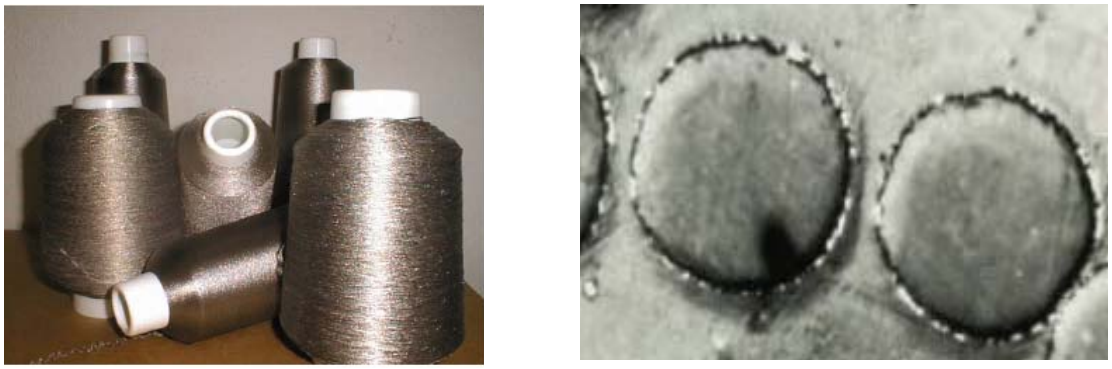

Fig.10 Conductive threads and thread cross sections

Table 22 below gives some details of conductive threads:

Table 22

Specification	Resistance	Thread Weight	Quantity
235/34 2 Ply HC Conductive Silver Thread	~ 30 ohms/foot	Fine	2 pound Cone
234/34 4 Ply HC Conductive Silver Thread	~ 14 ohms/foot	Thick	2.5 pound Cone
Conductive Thread from Lame Lifesaver	~ 30-35 ohms/foot	Medium	spool about 200 yards
Silver Plated Nylon 234/34 x 4ply	~ 14 ohms/foot	Thick	2.5 oz Spool (about 190 yards)
Silver Plated Nylon 117/12 x 2ply	~ 75-85ohm/foot (when stretched/sewn)	Fine	1oz Spool (about 150 yds)

19. Fusible Sewing threads (fig 11) [10]

Fusible threads are made up of the two components one component of the thread has lower melting point in comparison to the other component. These threads are made up of a fusible bonding fiber which is twisted with a normally melting polyester or polyamide supporting fiber. When exposed to heat the fusible adhesive component of the thread, which due to its low melting temperature is only used as lower thread, melts and forms an adhesive bond while the supporting fiber remains unchanged to form a stitched seam with the top thread. Fusible threads are manufactured in various counts from 45 to 1100 dtex and are available with melting points of 85° C and 140° C.

Application: leather industry, upholstery, seat belts

Fig.11 Fusible sewing threads

20. Conclusion

Sewing thread is a critical component in terms of the overall quality and appearance of textile structure besides impacting productivity. Sewing threads are intensively made of polyesters, polypropylene, Nylon6, Nylon66, with bonding treatments and lubricating use for automobiles, leathers, packing industry. Medical sutures have very good prospectus and they are generally made up of synthetic yarns. New suture threads are also being developed to better respond to particular surgical needs. Heat resistant sewing threads from Kevlar, Glass, Nomex are specially designed to meet their end use requirements. These threads have excellent sewability with other desirable properties like resistance to chemical, light weight etc are useful for industrial applications while carbon & steel sewing threads offers slow speed sewing with high tensile strength. Growing demand for the safety legislations open up the wide market for the heat resistant threads in spite of their high cost.

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