Personal protection: HPT Aracore® gloves for protection against thermal and mechanical hazards

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The 100 % para-aramid yarns are used to manufacture gloves and sleeves to provide protection against thermal and mechanical risks (abrasion, cut, tear and puncture). The paper discusses the designed range of HPT Aracore® yarns to achieve better performance than that of 100 % para-aramid yarns.

Introduction

Our hands are most frequently injured as compared to other body parts while performing industrial tasks such as cutting, slicing, assembling, painting, foundry work, grinding, sewing, loading parts, lifting trays, etc. These can be prevented from injuries by paying more attention and using suitable personal protective equipment such as gloves and sleeves. This is well established fact that hand and finger lacerations are the most common workplace related injuries which can be reduced with the use of right set of gloves. The industrial cut and heat resistant gloves and sleeves (Figure 1) are manufactured using various 'inherent' flame-retardant fibres such as para-aramid (e.g., *Kevlar®, Twaron®, Heracron®*), meta-aramid (e.g. *Nomex®, Conex®, Arawin®*), modacrylic (*Protex®*), polyamide-imide (*Kermel®*), semi-carbon, FR viscose to name a few. These gloves are used in various industries such as mechanical, automotive, construction, machine or compartment assembly, recycling, glass handling, animal handling, electrical work, meat packing, processing and heat work environments for protection of hand, fingers, arms, wrists against injuries due to contact with sharp objects/equipment (e.g., involving metal, sharp plastics or shattered glass). The gloves made-up of para-aramid fibres offer higher cut-protection (level 2 or 3 as per EN 388 and ISO 13997) in comparison with cotton, nylon, polyester or other blended fibres. Depending on the end-user requirements, these gloves can also be coated with different polymers (such as latex, neoprene, nitrile, polyvinyl chloride and butyl rubber) or even stitched with leather or metal meshes. Additionally, the para-aramid based gloves and sleeves also provide protection against thermal hazards such as with edge or surface burning, contact heat, radiant heat, and convective heat when tested for a short duration as per EN 407.

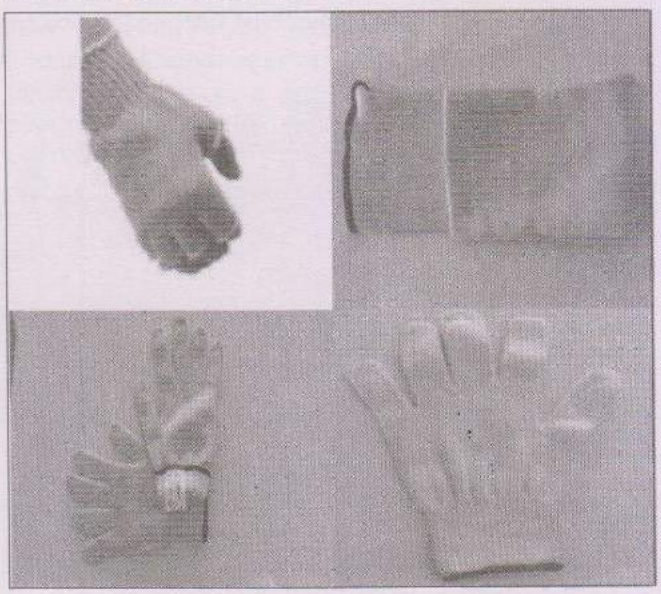

Figure 1 : Para-aramid gloves and sleeves

Over the last decade, hybrid or reinforced para-aramid yarns in combination with stainless steel wire or with e-glass or other filaments have been developed to achieve highest level of cut protection (level 4 and 5 as per EN 388 and ISO 13997) in comparison with 100 % para-aramid gloves. Culimeta-Saveguard Ltd, U.K. Group company specialises in the manufacturing of technical composite yarns for Personal Protective Equipment (PPE) market, specifically for hand protection for global gloves industry. Their HPT Aracore® yarns have been uniquely designed and developed in India keeping above points in mind. The HPT Aracore® yarns are manufactured using unique innovative technology where filaments are incorporated during spinning. Further, these yarns can be used to manufacture seamless gloves and sleeves or other protective equipment (such as socks, balaclava, cuffing, aprons or jackets as well as sporting wear for sports such as fencing, ice-hockey, etc.) for protection against heat and cut while retaining softness and comfort to the touch.

Seamless gloves knitting

The seamless gloves (Figure 2) are manufactured as per EN 420 having general requirements as per below

- the gloves themselves should not impose a risk or cause injury to the end users;
- the pH of the gloves should be as close as possible to neutral;
- the leather used for reinforcement of palm or fingers should have a pH value between 3.5 – 9.5;
- the highest permitted value for chromium is 3 mg/kg (chrome VI) in case of leather used;
- specific details of any substance used in the glove which is known to cause allergies should be clearly marked with the product;
- glove size chart (Table 3) should be followed for hand and fingers dimension.

Figure 2: Seamless gloves knitting machines

Table 1 : Glove size chart as per EN 420

Glove size	Hand size (mm)	Hand length (mm)	Min glove length (mm)
6 (XS)	152	160	220
7 (S)	178	171	230
8 (M)	203	182	240
9 (L)	229	192	252
10 (XL)	254	204	260
11 (XXL)	279	215	270

Table 2 : Description of seamless gloves (Single Ply)

Dimensions (mm) / Weight Parameters (gram)							
		Gauge 10 Gloves			Gauge 7 Gloves		
Dimensions (mm)	Tolerance	Aracore® E 110	Aracore® W 120	100 % p-aramid	Aracore® E 110	Aracore® W 120	100 % paramid
Palm Width	±5	100	103	100	100	100	103
Thumb Length	± 3	61	63	62	62	60	60
Index Finger Length	± 3	75	75	74	73	75	74
Mid Finger Length	± 3	84	81	83	82	82	84
Ring Finger Length	± 3	76	75	75	74	76	75
Little Finger Length	± 3	68	70	69	70	69	68
Cuff Length	± 5	64	65	64	66	66	63
Total Length	± 5	250	252	250	253	254	254
Glove Weight (gram/pair)	± 5 %	60	63	60	113	112	115

Table 3 : Description of glove size chart (Double Ply with cotton gloves as inner liner)

Dimensions (mm) / Weight Parameters (gram)				
		Gauge 7 (Yarn)		
Dimensions (mm)	Tolerance	Aracore® E 110	Aracore® W 120	100 % p-aramid
Palm Width	± 5	112	114	115
Thumb Length	± 3	60	60	61
Index Finger Length	± 3	65	64	64
Mid Finger Length	± 3	79	80	80
Ring Finger Length	± 3	65	64	65
Little Finger Length	± 3	55	54	55
Cuff Length	± 5	60	58	59
Total Length	± 5	260	262	263
Glove Weight (gram/pair)	± 5 %	168	172	170

The gloves were knitted using seamless knitting machines Gauge 7 and Gauge 10 using HPT Aracore® yarns as below:

a. HPT *Aracore®* E 110: The HPT Aracore® E 110 yarns are

manufactured using an innovative yarn manufacturing technology where p-aramid fibres are reinforced with high strength multifilament component in the core of the yarn to achieve the highest level of cut resistance as per EN 388 and ISO 13997 [1]. The innovative manufacturing technology ensures that the core component is not damaged and is well covered inside the fibres. The glove is plaited with cotton in the inner side to provide comfort while used for longer duration.

b. HPT *Aracore®* W 120: This yarn is manufactured using special high grade metallic wire in the core of the para-aramid yarn. The innovative manufacturing technology ensures that the metallic wire is well covered inside the fibres which never come in contact with skin of the end users. The glove is plaited with cotton to provide comfort while being used for longer duration. These gloves are ambidextrous and can also be supplied in green, dull yellow and grey colours to hide dirt.

c. 100 % para-aramid: The gloves are also knitted using multiple ends of 100 % para-aramid ring spun yarns for a comparative study. The Table (Table 4) below shows physical properties of ring spun yarn used.

Table 4 : Physical properties of 100 % p-aramid ring spun yarn

Items	Unit		Specifications
Yarn Count	C.C.	20S/2	20 +/- 0.5
Breaking Strength	CN		3921 Min
Tenacity	CN/TEX		66.40 Min
Breaking Elongation	%		<= 4.3
Twist (First)	T/Inch		13.86
Twist Direction		Z	
Twist Multiplier	T.M		3.1
Twist Second	T/Inch		7.27
Twist Direction		S	

Results and Discussion

Mechanical hazards

The mechanical hazards such as abrasion, cut, tear and puncture resistance of gloves and sleeves are tested as per European standard EN 388 (the cut performance was compared as per ISO 13997 which is recommended for higher cut resistance gloves such as level 4 and 5). It is also important to understand that cutting gloves or sleeves with a pair of scissors involves two sharp blades applying force in both directions which is different from the slicing type of cut or lacerations faced during industrial applications. The scissors test cannot be compared with cut-resistance test performed on industrial gloves, sleeves or other personal protective equipment. It is also worthwhile to mention that no gloves and sleeves can be 'cut-proof', i.e., any cut-resistant gloves or sleeves would allow a sharp-edged object to pass through when enough pressure is applied. Tables 5 and 6 show that the cut performance of Aracore® gloves (both Gauge 7 and 10) is higher than that of 100 % p-aramid based gloves for similar weight and dimensions. This is mainly due to reinforcement of stainless steel and multifilament component in the core of Aracore® yarns. The abrasion and tear performance remains same as that of 100% p-aramid yarns, although Aracore® E 110 showned slightly better tear resistace.

Table 5 : Comparison of mechanical hazards of Gauge 10 gloves as per EN 388

	Gauge 10 Gloves		
	100 % p-aramid	Aracore® W 120	Aracore® E 110
Abrasion Resistance	1	1	1
Cut Resistance	2	5	5
Tear Resistance	4	4	5
Puncture Resistance	X	X	X

Table 6 : Comparison of mechanical hazards of Gauge 7 gloves as per EN 388

	Gauge 7 Gloves					
	100 % p-aramid		Aracore® W 120		Aracore® E 110	
	Single Ply	Double Ply	Single Ply	Double Ply	Single Ply	Double Ply
Abrasion Resistance	1	1	1	1	1	1
Cut Resistance	2	2	5	5	5	5
Tear Resistance	4	4	4	4	5	5
Puncture Resistance	X	X	X	X	X	X

Thermal hazards (heat and fire)

The protective gloves should also be tested for protection against thermal risks such as fire, contact heat, convective heat and radiant heat. The testing against small splashes or large splashes of molten metals (aluminium and iron) would be part of subsequent papers. Our Aracore® ranges of gloves are tested as per EN 407:2004 for fire, contact heat, convective heat and radiant heat in comparison with 100 % para-aramid gloves. The fire or burning behaviour was tested as per EN ISO 6941, the contact heat testing was done as per EN 702, the convective heat was tested as per EN 367 and the radiant heat as per EN 6942. Tables 7 and 8 show that the burning behaviour of Aracore® gloves are comparable to that of 100 % p-aramid yarns for both gauge 7 and 10 gloves. This is mainly due to presence of p-aramid fibres which neither melts nor supports combustion. Additionally, the contact, convective and radiant heat results of Aracore® gloves are also comparable to that of 100 % para-aramid gloves. The gauge 7 gloves provide better contact heat than that of gauge 10 as the gloves are heavier than that of gauge 10 gloves.

Table 7 : Comparison of thermal hazards of Gauge 7 gloves as per EN 407

	Gauge 7 Gloves					
	100 % p-aramid		Aracore® W 120		Aracore® E 110	
	Single Ply	Double Ply	Single Ply	Double Ply	Single Ply	Double Ply
Burning behavior	4	4	4	4	4	4
Contact heat	2	2	2	2	2	2
Convective heat	3	3	3	3	3	3
Radiant heat	3	3	3	3	3	3

Table 8 : Comparison of thermal hazards of Gauge 10 gloves as per EN 407

	Gauge 10 Gloves		
	100 % p-aramid	Aracore® W 120	Aracore® E 110
Burning behavior	4	4	4
Contact heat	1	1	1
Convective heat	1	1	1
Radiant heat	1	1	1

Conclusions

The 100 % para-aramid yarns are commonly used to manufacture seamless gloves and sleeves to provide protection against thermal hazards (burning, contact heat, radiant heat, and convective heat) and mechanical risks (abrasion, cut, tear and puncture). The recently developed HPT Aracore® yarns are reinforced with multifilament core for better protection than that of 100 % para-aramid based yarns. The multifilament core component can be selected as per risks involved, e.g., for applications where serrated edges are being handled, the gloves reinforced with stainless steel perform better whereas for smooth edges, or short exposure cuts, the gloves with special grade multifilament filament core is used in combination with para-aramid fibres. These gloves and sleeves can be used in various industrial applications e.g., chemical, mechanical, steel industry, handling hot and sharp objects, metal stamping, machine and compartment assembly to name a few.

Further work is required to train safety officers of Indian manufacturing units for right glove selection and not to ignore cut/slash protection issues for both skilled and unskilled workforce. The risk assessment should be performed if there is any involvement with the sharp objects present at the work station, so that right set of gloves is selected for the workforce. There is growing need to design and customize protective gloves as per local industrial requirements

References

1. BS EN 388 Standard "Protective gloves against mechanical risks", England: British Standards Institution, (2003).