THE WOOLMARK COMPANY

WOOL IS RESISTANT TO FIRE

Soldiers, firefighters and the police have relied on wool uniforms for centuries due to the fibre's natural fire resistant properties. Today, others who work in high-risk environments – such as astronauts, search and rescue teams, even Formula 1 drivers – have been introduced to the benefits of wearing Merino wool next to their skin because it reduces their risk when exposed to flames.

WOOL IS RESISTANT TO FIRE

Wool textiles have the highest natural fire resistance compared to other untreated textiles, such as cotton or polyester. Wool is less likely to ignite and, if circumstances cause the fibre to burn, it does not melt or drip and will self-extinguish.

In contrast to synthetic fibres, wool's natural fire resistance and other natural comfort benefits, such as moisture management and breathability, make it the ideal base-layer fabric for use in protective wear for emergency and military personnel, first responders and others.

WOOL HAS A HIGH IGNITION TEMPERATURE

The temperature of the flame must reach a high 570-600°C before wool will ignite, compared to cotton which is flammable at just 255°C. That is, wool requires heat to be generated equivalent to twice the maximum temperature of a modern kitchen oven before it will combust, compared to cotton which can ignite in a temperature easily reachable by your average oven.

WOOL NEEDS UNUSUALLY HIGH ATMOSPHERIC OXYGEN LEVELS TO BURN

To be able to combust, wool requires an oxygen level (25.2%) that is higher than in the natural atmosphere (approximately 21%) making wool harder to ignite. This is in contrast to fibres such as cotton, rayon, nylon and polyester which require an oxygen level less than that found in the natural atmosphere so they ignite much more easily.

WOOL HAS A LOW HEAT OF COMBUSTION AND HEAT RELEASE

If conditions do enable it to burn, wool's heat of combustion (the amount of heat energy released during burning) of 4.9 Kcal/g is less than common synthetics such as polyester (5.7 Kcal/g) and nylon (7.9 Kcal/g). Although cotton (3.9 Kcal/g) has a lower heat of combustion than wool (4.9Kcal/g), cotton releases that heat at a much lower temperature (255°C) compared to wool (465-530°C) so that, at the high temperature of a fire, cotton burns much faster, releasing its heat of combustion more rapidly.

WOOL IS SELF-EXTINGUISHING

If wool does ignite, it will self-extinguish when the source of the heat or flame is removed. This is because wool fibre contains naturally high levels of nitrogen – an element commonly used as a fire retardant – and when it is heated sufficiently to combust, it tends to produce a charring layer which can prevent further spread of the flame.

WOOL WILL NOT MELT

Wool does not melt or drip and hence cannot stick to the skin. In contrast, common synthetics such as nylon melts at the very low temperature of 160-260°C, and polyester melts at 252-292°C, with the material then sticking to the skin.

This table summarises the key measures of flammability for untreated textile fibres. Wool provides the highest protection when considering all the flammability characteristics together.

FIBRE	LIMITING OXYGEN INDEX (%)	HEAT OF COMBUSTION (KCAL/G)	IGNITION TEMP (°C)	MELTING TEMP (°C)
Wool	25.2	4.9	570-600	Does not melt
Cotton	18.4	3.9	255	Does not melt
Nylon	20.1	7.9	485-575	160-260
Polyester	20.6	5.7	485-560	252-292
Rayon	19.7	3.9	420	Does not melt

Source: CSIRO Factsheet - Flame Resistance of Wool

Table 1: Key measures of flammability for common textile fibres

In a scientific study into the fire resistance of various fabrics used as base-layer garments for military and first responder personnel, it was found that the 100% synthetic fabrics (polypropylene and polyester fabrics) performed the worst due to their propensity to melt and damage the skin. Fresh pig skin was used as a simulant, as, of all domestic animals investigated in previous research, pig skin offers the most appropriate experimental model for all types of dermatological and surgical wound investigation.

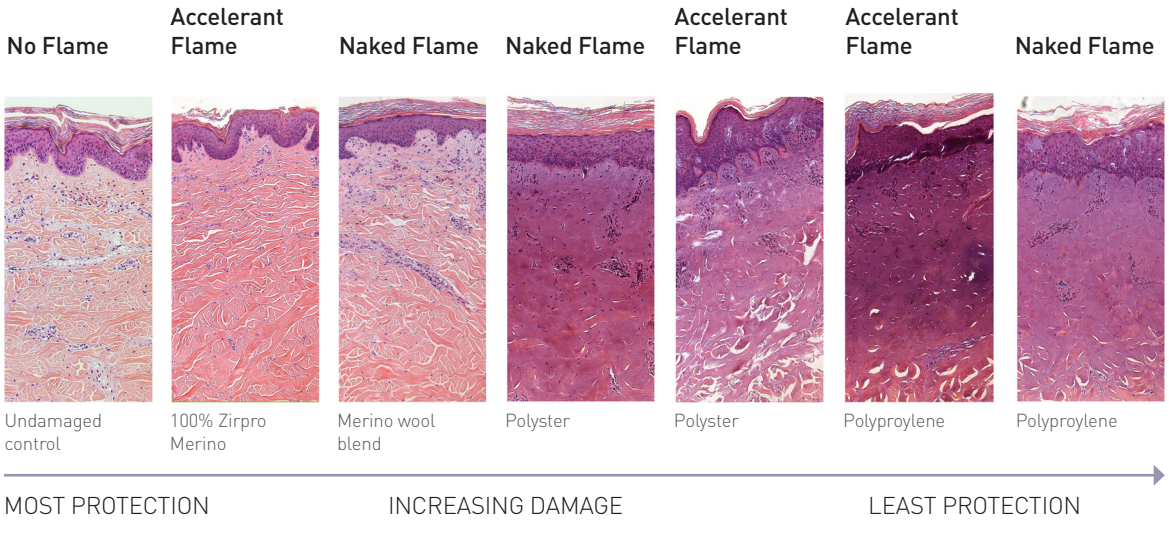

Figure 1: Simulated exposure to naked flame ignition and accelerant fuelled threat

REFERENCES

The temperature of the flame must reach a high 570-600°C before wool will ignite

- CSIRO Factsheet: Flame resistance of wool

cotton which is flammable at just 255°C

- CSIRO Factsheet: Flame resistance of wool

Wool requires an oxygen level (25.2%) that is higher than in the natural atmosphere (approximately 21%) making wool harder to ignite. This is in contrast to fibres such as cotton, rayon, nylon and polyester which require an oxygen level less than that found in the natural atmosphere so they ignite much more easily.

- CSIRO Factsheet: Flame resistance of wool.
- Shaid, A., L. Wang and R. Padhye (2018) Textiles for firefighting protective clothing. In Firefighter's Clothing and Equipment: Performance, Protection and Comfort. Taylor & Francis, CRC Press, USA. ISBN-13: 978-1498742733.
- Gordon PG, 1981, 'Flame retardants and textile materials', Fire Safety Journal, 4: 109-123.

wool's heat of combustion (the amount of heat energy released during burning) is 4.9 Kcal/g, polyester's (5.7 Kcal/g), cotton's (3.9 Kcal/g) and nylon's (7.9 Kcal/g).

- CSIRO Factsheet: Flame resistance of wool

Wool is self-extinguishing

- J.M. Cardamone (2013) 9 - Flame resistant wool and wool blends, In Woodhead Publishing Series in Textiles, Handbook of Fire Resistant Textiles, Woodhead Publishing,2013,Pages 245-271,ISBN 9780857091239,https://doi.org/10.1533/9780857098931.2.245. https://www.sciencedirect.com/science/article/pii/B9780857091239500092
- Gordon PG, Logan RI, 1986, 'The effect of elevated temperature on flame-retardant treated wools and other fibres', Fire and Materials, 10: 137-140.

Wool does not melt or drip and hence cannot stick to the skin. In contrast, common synthetics such as nylon melts at the very low temperature of 160-260°C

- CSIRO Factsheet: Flame resistance of wool

Table 1: Key measures of flammability of common textile fibres:

- CSIRO Factsheet: Flame resistance of wool

It was found that the 100% synthetic fabrics (polypropylene and polyester fabrics) performed the worst due to their propensity to melt and damage the skin.

- Hodgson A (2020) Wool as a last line of Defence. Ag Research Technical Bulletin. https://www.wool.com/about-awi/media-resources/news/wool-protects-skin-from-flames/

Fresh pig skin was used as a simulant, as, of all domestic animals investigated in previous research, pig skin offers the most appropriate experimental model for all types of dermatological and surgical wound investigation.

- (Vardaxis et al., 1997) https://onlinelibrary.wiley.com/doi/pdfdirect/10.1046/j.1469-7580.1997.19040601.x

Figure 1: Simulated exposure to naked flame ignition and accelerant fuelled threat

- Hodgson A (2020) Wool as a last line of Defence. Ag Research Technical Bulletin.