

Developing Common International Standards for Wildland Firefighters Personal Protective Equipment

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Background

The International Organisation for Standardisation (ISO) has established a new ISO committee known as ISO/TC 94/SC 14/WG 3 – Wildland Firefighters Personal Protective Equipment. This committee held its first formal meeting in Berlin, Germany on the 29 April 2002 with its second meeting held in Winnipeg, Canada on the 9 April 2003. The scope of this ISO working group is to continue to work in co-operation with firefighters, researchers, textile and product manufacturers, designers, testing laboratories, regulators and other interested parties on personal protective equipment (PPE) worn during wildland firefighting and associated activities; by ensuring that standards developed minimize the risk of injury to the wearer, that the appropriate liaisons are maintained and performance requirements meets the firefighter needs. The working group is currently harmonising existing standards and developing new standards for wildland firefighters PPE where none exists. It is also developing selection, care, use and maintenance deliverables for wildland firefighters PPE where none exists. The first attempt to harmonise wildland firefighting standards was the issuing of ISO/CD 16073 – *Wildland Firefighting Personal Protective Equipment – Requirements and Test Methods* by ISO/TC 94/ SC 14/WG 3 as an ISO committee draft (CD) in December 2002. This CD received a number of negative votes which required it to be discussed at length at the ISO/TC 94/ SC 14/WG 3 meeting on the 9 April 2003. A number of changes were agreed by the countries present and a 2^d CD has now been prepared for voting and comment.

Benefits

The benefit from standards prepared by this ISO working group on wildland firefighters PPE will assist countries and fire authorities around the world with the provision of integrated systems of PPE that will improve wildland firefighters safety.

Objectives

- To ensure the health, safety and effectiveness of wildland firefighters through the establishment of minimum acceptable standards on wildland firefighters PPE for the various functions or duties they perform.
- To move away from prescriptive-based requirements in standards to a performance-based approach in all areas of wildland firefighters personal safety. This is particularly evident in the area of wildland firefighter protection where there have been many advances in testing methods and procedures.
- To have in place ISO Standards for all major classes of wildland firefighters' PPE.
- To prepare and maintain in a timely and cost effective manner ISO Standards and other ISO deliverables concerned with wildland firefighters PPE, for which a need has been identified.

- To ensure as far as practical the safety of persons using the wildland firefighters PPE.
- To ensure as far as practical the appropriateness of product function and performance.
- To provide means for the integration of various items of wildland firefighters PPE.
- To provide a basis for testing, certification, and when necessary regulation of products.
- To minimize obstacles to international trade.
- To promote the participation of fire services in the development of standards.
- To provide guidance on selection, care, use and maintenance used for wildland firefighters PPE.
- To wherever practical to ensure compatibility and consistency between components of wildland firefighters PPE.

ISO 16073 - Wildland Firefighting Personal Protective Equipment – Requirements and Test Methods

This standard provides minimum acceptable performance requirements for wildland firefighters PPE designed for use for extended periods during wildland firefighting and associated activities. Wildland firefighting involves work primarily in summer temperatures, for many hours during which the firefighter may develop high levels of metabolic heat. As a consequence, the PPE must be light, flexible and commensurate with the risks to which the firefighter may be exposed in order to be effective without introducing heat stress to the wearer. Accordingly, a risk assessment should be undertaken to determine if the PPE covered by this standard is suitable for its intended use and the expected exposure. This standard does not cover PPE for use in risk situations where PPE complying with ISO 11613 or ISO 15538 is more suitable, nor does this standard cover PPE to protect against chemical, biological or radiation hazards.

The risk assessment should be used to determine what types of PPE is necessary for head, face, hands, body and feet. Firefighters should be familiar in the selection, use, care and maintenance of the PPE covered by this standard, including an understanding of its limitation. Nothing in this standard is intended to restrict any jurisdiction, purchaser or manufacturer from exceeding these minimum acceptable performance requirements. The second draft of ISO/CD 16073 - *Wildland Firefighting Personal Protective Equipment – Requirements and Test Methods* covers the following key areas:

Body Protection

Clothing shall comply with clause 5, which specifies minimum acceptable performance requirements for wildland firefighting body protection. The performance criteria for the body have been based on ISO 15384 – *Protective clothing for firefighters – Laboratory test methods and performance requirements for wildland firefighting clothing*.

➤ Clothing design

- Loose fitting clothing is as important as the fire resistance of materials in minimising the risk of injury. Clothing that is tight fitting poses a danger to the wildland firefighter from radiant heat and heat stress, while, at the same time, diminishing the firefighter's ability to perform.

- Clothing should be light and flexible in order to be effective without inducing heat stress in the wearer.
- As a guide, a suit should be provided with an interface area of a minimum of 15 cm overlap between them which should be maintained for example whilst stooping, reaching or turning movements.
- Closure systems, any label, accessory, touch and close fastener, retroreflective/fluorescent material, etc attached to the protective clothing should not adversely affect the clothing's performance.
- Pocket flaps should be able to maintain pocket as being closed. As a guide a pocket flap may be 20 mm larger than the opening in order to avoid the flap being placed inside the pocket.
- All closure systems should be designed to prevent the entry of burning debris.
- Trousers/coveralls should have a closure system, which allows the ends of the trousers to interface sufficiently well with footwear that may be used for wildland firefighting.
- Firefighters should be trained in the selection, use, care and maintenance of the protective clothing covered by this standard, including an understanding of its limitation.

The testing criteria covers:

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| ➤ Flame spread | ➤ Tensile strength |
| ➤ Face ignition | ➤ Tear strength |
| ➤ Edge ignition (Optional) | ➤ Main seam strength |
| ➤ Heat transfer (radiation) | ➤ Ergonomic and comfort requirements |
| ➤ Heat resistance | • Thermal resistance |
| ➤ Materials | • Water vapor resistance |
| • Retroreflective/fluorescent materials | ➤ Dimensional change after washing and/or dry cleaning |
| • Hardware | ➤ Retroreflective/fluorescent performance |
| ➤ Heat resistance of the main seam sewing threads | ➤ Marking |
| ➤ Retroreflective/fluorescent materials | |

Hand Protection

Gloves shall comply with clause 6, which specifies minimum acceptable performance requirements for wildland firefighting hand protection. The performance criteria for the gloves have been based on ISO 15383 – *Protective gloves for firefighters – Laboratory test methods and performance requirements - Type 1*

- Gloves shall be designed to restrict the entry of embers or foreign particles through the glove openings.
- Gloves shall be compatible with the sleeves of the firefighters' protective clothing used.
- Any labels or accessories shall not adversely affect the performance of the gloves or present a hazard to the wearer.

The testing criteria covers:

- Flame resistance
- Heat transfer (flame exposure)
- Heat transfer (radiant exposure)
- Heat transfer (conductive exposure)
- Heat resistance
- Abrasion resistance
- Cut resistance
- Tear resistance
- Puncture resistance
- Label legibility
- Dexterity
- Grip
- Donning
- Marking

Feet Protection

Footwear shall comply with clause 7, which specifies minimum acceptable performance requirements for wildland firefighting feet protection. The performance criteria for the footwear have been based on ISO 17250 – *Footwear for firefighters* - Type 1 with additional test procedures included. The testing criteria covers:

- Height of upper
- Specific ergonomic features
- Leakproofness
- Water resistance
- Heat resistance
- Metatarsal protection
- Ankle Protection
- Tear strength
- Tensile properties
- Water vapor permeability and coefficient
- pH value
- Chromium VI
- Water penetration and water Absorption
- Upper construction
- Radiant heat
- Abrasion resistance
- Flexing resistance
- Hydrolysis
- Interlayer bond strength
- Resistance to fuel oil
- Cleated area
- Flame resistance
- Upper/outsole bond strength
- Contact heat
- Slip Resistance
- Energy absorption of seat region
- Penetration resistance
- Toe cap length
- Impact resistance
- Rigidity of toe
- Compression resistance
- Corrosion resistance of metal toe caps
- Non Metallic toe caps
- Electrical Insulating footwear ?
- Antistatic footwear ?
- Insulation against heat
- Insulation against cold
- Thread/Laces Melting
- Zipper
- Eyelet & Stud Post Attachment
- Thickness of cleated outsoles
- Cleat height
- Cleat design
- Breast heel
- Thickness
- Resistance to hot contact
- Marking

Head Protection

Wildland firefighters require head protective devices to minimise the impact or penetration caused by falling tree branches as well as provide protection to the head from flames, burning

embers and radiant heat. The head protective device must also be fitted with a securing mechanisms to prevent it from being dislodged during wildland firefighting operations. Head protective devices shall comply with clause 8, which specifies minimum acceptable performance requirements for wildland firefighting head protection.

- Performance requirements

Head protective devices used for wildland firefighters must meet the performance requirements of EN 397 - *Industrial safety helmets* as well as:

- Flame resistance
- Prolonged high temperature stability
- For use in extreme high radiant heat environments
- Marking

Eye Protection

Wildland firefighters eyes are exposed to irritants such as smoke particles and off gassing chemicals, which will cause severe irritation and discomfort to the eyes. Eye protective devices should protect the eyes from the ingress of smoke particles and other irritants. The complete eyes protective device must also prevent fogging. Eye protective devices shall comply with clause 9, which specifies minimum acceptable performance requirements for wildland firefighting eye protection.

- Performance requirements

All eye protective devices shall meet the requirements of EN 166 - *Personal eye-protection - Specifications* - clause 7.1.

- Impact Tests
- Stability at an elevated temperature
- Prolonged high temperature stability
- Extreme high radiant heat environments
- Resistance to corrosion
- Resistance to ignition
- Protection against large dust particles
- Resistance to surface damage by fine particles
- Resistance to fogging
- Marking

Hearing Protection

Hearing protective devices may be required to protect wildland firefighters from mechanically generated noise produced from equipment such as; chainsaws, pumps and blowers. A risk assessment should be carried out to determine the need if any, for the provision of hearing protective equipment. Hearing protective devices shall comply with clause 10, which specifies minimum acceptable performance requirements for wildland firefighting hearing protective devices.

- Performance requirements

Hearing protective devices used for wildland firefighters must meet the performance requirements of ISO 4869-1 - *Acoustics – Hearing protection – Part 1: Subjective method for the measurement of sound.*

➤ Marking

Respiratory Protection

Respiratory protective devices shall comply with clause 11, which specifies minimum acceptable performance requirements for wildland firefighting respiratory protective devices. This clause will contain the performance requirements for Respiratory Protective Devices (RPD) for Wildland Firefighting. No suitable protection methodology has yet been identified and ISO/TC 94/SC 15 (Respiratory Protection) will provide these requirements that will be based upon respiratory environment criteria provided by ISO/TC 94/SC 14/WG 3. Until such performance requirements are available, the choice of suitable RPD to be used in conjunction with the Wildland PPE identified in this standard, should be based upon a local risk assessment and control measures adopted.

Wildland Environment Paper

A draft paper of which part is out lined below has also been developed by ISO/TC 94/SC 14/WG 3 on Wildland Fire Environment was written to provide a general overview of wildland fire and some of the potential risk that wildland firefighters may face. It will be updated as required and helps in the development of performance criteria for ISO 16073.

Wildland Overview

Wildland firefighters generally operate for long durations (8 – 16 hours/day) exposed to a general radiant heat flux between 1 kW/m² to 8 kW/m². During increased fire activities and shorter durations of exposures, wildland firefighters may be exposed to a radiant heat flux of 8 kW/m² to 20 kW/m². During extreme fire activity and fire over-run or entrapment conditions wildland firefighters may be exposed to radiant heat flux conditions of 20 kW/m² to 100 kW/m². Temperatures can range from an ambient air temperature 25⁰C – 49⁰C up to 1200⁰C in severe fire over-run or entrapment conditions. During extreme fire activity involving fire overrun conditions, no firefighters PPE can prevent serious to life threatening injuries. As such firefighters PPE should be designed to minimise the risk of injury during wildland firefighting operations with short term exposure to increased radiant heat flux levels.

Table 1 – Wildland Firefighting Risks

WILDLAND RISKS	BODY	HANDS	FEET	HEAD	EYES	HEARING	RESP'TORY
Flame	X	X	X	X	X	X	X
Heat (radiation)	X	X	X	X	X	X	X
Extended Working Hours	X	X	X	X	X	X	X
Elevated Air Temperatures	X	X	X	X	X	X	X
Terrain	X	X	X	X			

Relative Humidity	X			X			
Water		X	X				
Retardant/Foams	X	X	X	X	X		
Abrasion	X	X	X				
Tearing	X	X	X				
Snagging	X	X	X				
Visibility	X			X	X		
Mechanical Noise						X	
Smoke (particles /off gassing)					X		X
Perspiration	X	X	X	X	X		
Metabolic Heat	X	X	X	X	X		X
Heat Stress	X	X		X			X
Falling Objects			X	X			
Tripping			X				
Slipping			X				
Strong Winds				X	X		
Ash/Embers	X	X	X	X	X		X
Tree Sap	X						
Fuel Contamination	X	X	X				
Contact Heat	X	X	X	X	X	X	X
Convective Heat	X	X	X	X	X	X	X
Sharp Objects		X	X	X	X		
Dislodging				X	X	X	X
Breathability	X	X			X		X
Mobility	X	X	X				
Ergonomics	X	X	X	X	X	X	X
Dexterity		X					
Donning & Doffing	X	X	X	X	X	X	X
Ultra Violet Exposure	X	X		X	X		
Weight	X	X	X	X	X	X	X
Insulation	X	X	X	X	X	X	X
Compatibility	X	X	X	X	X	X	X
Durability	X	X	X	X	X	X	X
Closure Systems	X	X	X	X	X	X	X
Fitting/Sizing	X	X	X	X	X	X	X
Care and Maintenance	X	X	X	X	X	X	X
Life of/Replacement	X	X	X	X	X	X	X
Refurbishment	X	X	X	X	X	X	X

Wildland Conditions

As a general guide, wildland firefighting conditions are based but not limited to the following factors:

- Fine Fuel Loads
- Fire Danger Index
- Slope
- Drought Factor
- Air Temperature
- Relative Humidity
- Wind Speed
- Fuel Size

With the main fuel component of the moving fire front will be fine fuels, mostly made up by cured grass, fallen leaves, needles and small twigs. It is primarily the top layer of fine fuel that contributes to the forward spread of a fire and the high flames of the fire front. It is assumed that the flame front (which contribute most to the radiation output of the fire front) will be a result of the rapid combustion of fine fuels, and therefore will have a residence time which varies from 5 – 12 seconds (grass fires) to 1.5 – minutes for logging slash fires with general wildland fires being in between these times. Large downed woody material (>6 mm) will not be consumed in the passage of the fire front but instead will be consumed after the fire has passed (ongoing or smoldering stage). The combustion of this material will contribute to the background heat released and will depend upon the amount of the material available to burn and its moisture content.

Clothing Conditions

In order to provide the correct blend of protection against heat and flame and metabolic heat and heat stress, wildland firefighters protective clothing should therefore:

- Permit free evaporation of sweat and be loose fitting, light, well-ventilated and permeable to water vapour.
- Shield firefighters from radiant heat
- Completely dissipate metabolic heat
- Allow free evaporation of 1 to 2 litres of perspiration per hour
- Sustain thermal equilibrium and comfort despite wide variation in:
 - Fire intensity
 - Weather
 - Work intensity and duration
- Minimise the risk of burn injuries
- Minimise episodes of heat exhaustion

Respiratory Conditions

The components of Wildland Fire Smoke are generally made up of:

- Respirable particulates (majority 0.1µm (PM0.1) decreasing in number up to 3.5µm (PM3.5))
- Carbon monoxide
- Carbon dioxide
- Benzene
- Formaldehyde
- Acrolein

The relationship of ppm of these components to the health and safety of wildland firefighters is still being researched and there are no agreed maximum ppm exposure values set for wildland firefighters (with the exception of respirable particulate which is primarily 0.1µm up to 3.5µm) that relate to wildland firefighting. Once these values are defined, respiratory protection systems

may have to be re-evaluated. The presence of genetically modified products and the presence of pest control sprays or other additives etc; to assist disease control or growth (off gassing during combustion) has been highlighted as an issue that may need to be further investigated. As we cannot always control the temperatures reached particularly at some small fires, which may only partially destroy or decompose to produce other products, which are unknown at this stage.

Over-Run or Entrapment Conditions

Wildland fire over-run or entrapments can occur and should be considered as part of this paper. Generally good resource management and training practices, minimises the risk of fire over-run or entrapments occurring. As wildland firefighters wear primarily single layer garments, protection to minimise the risk of burn injury is generally set at a maximum of 4 seconds of direct flame contact. Wildland fire over-run or entrapment is an incident in which a firefighter may be caught in a temporary escalation in severe to extreme fire behaviour. The firefighter is usually unable to retreat and engulfed by flames. This entrapment can occur when firefighters are on foot or in a vehicle. The combination of unexpected or under-appreciated fire behaviour with long unburned fuels on slopes can quickly result in a firefighter being caught unaware and in the path of a fire front.

Wildland/Urban Interface

The wildland/urban interface can be described as an area where various structures (most notably private homes) and other human developments meet or are intermingled with forest and other vegetative fuel types. Wildland firefighters PPE can be used in a defensive role in these cases but firefighters may need to upgrade or add additional layers to their PPE when firefighters become involved in offensive property firefighting. This upgraded PPE is covered by ISO 11613.

ISO/TC 94/SC 14/WG 3 Membership

ISO/TC 94/SC 14/ WG 3 needs active wildland firefighter participation, if you and your country wish to participate in the ongoing development of ISO 16073 *Wildland Firefighting Personal Protective Equipment - Requirements and Test Methods*, then please contact me at richard.donarski@afac.com.au.

You can also approach your National Standards Organisation who will then forward the request for membership to the ISO Central Secretariat at: ISO Central Secretariat, 1, rue de Varembe, Case postale 56, CH-1211 Geneve 20, Switzerland. e-mail: central@iso.org

The ISO Central Secretariat will then forward the requests for membership to the ISO/TC 94/SC 14 Secretariat is: Mr Anthony Hayward-Bryant, Secretariat, ISO/TC 94/SC 14, Standards Australia, GPO Box 5420, Sydney NSW 2000, Australia, e-mail: anthony.hayward-bryant@standards.com.au

The ISO/TC 94/SC 14 Secretariat will then advise the ISO/TC 94/SC 14/WG 3 Secretariat of your membership as an Expert in Wildland Firefighting Personal Protective Equipment to: Richard Donarski, Secretariat, ISO/TC 94/SC 14/WG 3, Australasian Fire Authorities Council,

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Conclusion

Wildland firefighting PPE needs to provide a compromise between flame, elevated temperature exposures whilst at the same time allowing the wildland firefighter the ability to work for extended durations by minimising the buildup of metabolic heat and heat stress as well as ensure the PPE is durable to meet the conditions and terrain. Many other wildland fire factors may play a role in a wildland fire environment that may pose a risk that a firefighter may face therefore wildland firefighters need to understand the limitations of their PPE and the protection that it will provide.