SAPEMA

Southern African Protective
Equipment Marketing Association



SAPEMA TECHNICAL HANDBOOK:
FOOT PROTECTION

DISCLAIMER

The South African Protective Marketing Association (abbreviated to SAPEMA) has drawn up the sections of the Handbook published herein to give a broad guideline to the categories of protective apparel and equipment applications, specifications and reference documentation which may be consulted. Due to the considerable variables of scope, environments and conditions it is only possible to provide very broad references to what is required in the Handbook sections, and the contents of the Handbook are limited in scope and application.

It is the responsibility of the user to consult with a competent and suitably qualified person in the field of safety protection related to the potential risk in the intended environment in which work or activities are undertaken.

Prior to any commencement of work or the entering of a risk area a comprehensive risk assessment is to be conducted to meet statutory and other legal requirements to ascertain the potential risk, taking into account scope, environment and duration. Consideration should also be given to alternatives which could possibly eliminate the provision of personal protective apparel or equipment.

The risk assessment should be carried out by a suitably qualified person or health and safety practitioner.

Cognizance should be taken of the risk assessment findings and evaluation done to eliminate and/or mitigate / reduce risk to levels where the use of personal protective equipment will prevent potential accidents and harm.

In all cases where personal protective apparel or equipment are intended for use, the original equipment manufacturers instructions and specifications should be thoroughly studied by a suitably qualified person or safety practitioner for suitability to the intended applications and use.

The supporting information and documentation of the Handbook sections is based on information which was available at the time of compilation of the Handbook or revisions thereto and it is incumbent upon the person consulting the Handbook to ensure that cognisance has been given to any amendments to legislation, specifications, standards or procedures that may have been amended subsequent thereto.

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Technical Handbook of Personal Protective Equipment Footwear version 1 Dated 23.03.2021

Foreword

The purpose of this presentation is to give you a brief overview of the most important factors to consider with regards to Safety Footwear.
All reasonable steps were taken to ensure that the reference guide is correct. SAPEMA cannot be held responsible for any omissions or errors that may have occurred during the compilation hereof.

1. Leathers

1.1 Full grain Leather

Traditionally natural leather was always used for the upper, but international leather shortages and escalating prices have led to the introduction of synthetic and coated leathers.

The best quality natural leathers are known as Full Grain leathers.

Full grain leather is often used in its natural state, which gives the leather character, but often uneven coloring and marking - such as Crazy Horse leather

Full grain leathers are also often treated to give the leather a different finish - such as an oiled finish to give it a smooth and even look, or a brushed finish as in Nubuck leather.

1.2 Split leather & Suede

Hides that aren't good enough for Full Grain leather are used for Split leather.

In order to get the most out of natural leathers the leather is split into thinner layers.
Split leathers are available in different thicknesses and with different finishes, but are still genuine leathers.

The outer layer of split leather is the better quality and is often scarred and marked, so this leather is treated or coated, and is then either embossed or kept Smooth.

Split leathers can get specialized coatings which will offer additional properties, such as Water-Resistance or Acid-Resistance.

The bottom layer of split leather is thinner and of a poorer quality. In its natural state it is called Suede, which has a soft, furry appearance.

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1.3 Action Leather

If the bottom split layer is too thin or the quality poor, then it is sent through a series of PU or foil coatings, to create Action Leather
Action leathers cut off the normal breathability of natural leather, do not cope in high temperature areas too well and do not polish well.

1.4 Bonded Leather

Instead of wasting all the leather off-cuts in the industry, all these pieces of leather are shredded and bonded together with a glue and rolled out into flat sheets, known as Bonded Leather - which is still classified as genuine leather.

1.5 PU & VINYL

Technology has allowed the development of synthetic materials such as PU and Vinyl, which look similar to leather and are used for collars & tongues. However, these materials are increasingly being used in the uppers of low cost footwear.

2. Toe Caps

Safety standards specify that a toe cap needs to be able to withstand:
an impact force of 200 Joules
- In other words, if a 36.6 Kg object is dropped vertically on it from a height of 0.56m.

a compression force of 15kN (Kilo-Newton)
- In other words, if a stationary weight of 1529.57Kg is placed on top of it. There are two principal materials used for toe cap protection:

Steel
Non-Metallic Composite / Carbon

3. Outsoles

3.1 Types of outsole

Direct Injection Moulding:

It's a chemical process where 2 components heats up due to a chemical reaction between the components and a reacting agent that causes carbon dioxide bubbles to appears. This hot liquid PU is then directly injected onto the upper via a mould.

Cemented:

The sole is moulded separately. This outsole is then cemented/glued onto the upper (sometimes the sole is also stitched down and it is known as Goodyear Welted.

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Vulcanized:

The term "vulcanized" refers to a manufacturing process - which is chemical in nature - that transforms rubber into polymer.
Today, the most common sole available on the market is a Dual Density PU (Polyurethane) sole.
Dual Density means the PU is injected in 2 different densities i.e. the top layer has more air bubbles, thus giving more comfort and the bottom layer, less air bubbles thus being harder, offering greater durability.

Traditionally, Single-Density PVC soles were used but these were incredibly hard and uncomfortable. New technology has allowed for a more comfortable and durable single density sole to be fitted.

A more recent development has been a Dual-Density PU/Rubber sole, which not only offers the benefits as mentioned above, but also the Heat Resistant Properties of rubber the reduced cost of manufacturing and the decreased weight of the product (PU is much lighter than rubber).

Yet another development has been the introduction of TPU (Thermoplastic Polyurethane), which is just an advanced version of PU, which is granular in its raw material form, thus easier to store & transport.

3.2 Heat resistance of outsoles

PU, Rubber & TPU are Oli, Acid and Slip Resistant to a certain degree. However, Rubber offers greater resistance than the other 2 compounds. TPU has greater Abrasion Resistant properties than PU.
PU can be used in temperatures of approximately 60-90°C.
TPU can be used at approximately 120°C
Carbon Rubber can be used up to 200°C.
Nitrile Rubber is used for higher temperatures up to 300°C

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4. COMPONENT FEATURES & BENEFITS OF FOOTWEAR



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4.1 Eyelets:

More eyelets means less tension across laces.
Less tension across bridge of foot minimizes "burning feet". Eyelets are often rust proof (alloy).

4.2. Padded Tongue / Gusset Tongue

Minimizes pressure across bridge of foot.
Less pressure & tension minimizes "burning feet".
Sometimes the tongue get closed up to the sides of the shoe. This exist is 'FULL', ¾ or ½.
The closed tongue improves water proofing capability of a boot.

4.3 Padded collar

Increased support and Increased comfort

4.4 Shank

A shoe shank is a flat piece of material located above the outer sole at the waist, or narrowest, middle-part of the shoe located between the heel and ball area of the foot just below the arch. A shank is needed to help add extra support to the arch area of the shoe. Can be made from Steel or composite. Composite if often needed as non-metal detector necessity or heat proof. As composite does not transfer heat as easy as steel

4.5 fully lined inner

Approximately 70% of SA workforce don't wear socks at work.
Moisture-wicking lining keeps feet drier and prevents moisture pooling inside boot. For a waterproof boot a membrane in the shape of a boot is inserted between the upper and lining. This membrane doesn't let water come through but is breathable for outflow of moisture from the feet.

4.6 anti-static properties

All excess static electricity will be dissipated through the footwear, due to anti-static compound in sole, anti-static woven insole board and anti-static stitching on sock liner. The risk of sparks and ignition will be minimized, especially in higher risk areas

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4.7 Stitched down insole board

Due to lack of socks, failure to allow footwear to dry out properly, failure to rotate footwear & harsh working environments, the insides of safety shoes get wet & worn.
Insole boards that are stitched down will not move & roll up, causing discomfort. This technique is called strobed or California stitching.
Anti-Static woven insole board assists with outflow of excess static electricity.

4.8 Full, padded, removable sock liner

Additional Comfort throughout foot. Can be removed, washed & replaced.
Anti-Static stitching assists outflow of excess static electricity.

5. CERTIFICATION, STANDARDS & CATEGORIES

SABS – The South African Bureau of Standards is a testing facility to ISO-SANS 20345 standards (they Certify versus standard, but they do not approve safety footwear to be able to sell in South Africa!).
SABS Certification mark is voluntary, not compulsory. Adopted ISO 20345: 2011 known as SANS 20345 in 2014. SANS – South African National Standards.

The National Regulator for Compulsory Specifications Act (Act 5 of 2008) was promulgated in Government Gazette 31216 on 4th July 2008 and took effect on 1st September 2008. The Act transferred the Regulatory Division of the South African Bureau of Standards (SABS) and all regulatory functions of the SABS to a new statutory Department of Trade and Industry (DTI) institution - **the National Regulator for Compulsory Specifications (NCRS).**
Visit this link as reference: https://www.sabs.co.za/Sectors-and-Services/services/NRCS/

NRCS Uses compulsory specifications called VC's and these are Government Gazetted – Referred to as VC9002:2015. NRCS approves footwear to VC9002:2015 which makes reference to ISO/SANS20345. Products must/shall meet all the basic requirements of 20345 before it is approved by the NRCS. This EN ISO certification can be obtained by many international certification houses, the largest in the world are INTERTEK and SATRA. With the EN ISO certification the NRCS Certification can be obtained and mandatory before importing or manufacturing the product. A levy is payable per pair sold.
A CE certificate is valid within Europe only, and states that the product meets the necessary standards. In SA the CE mark & CE certificate is relatively meaningless.
An ISO EN certificate states that not only has the product been approved, but the manufacturing process as well. two of the largest testing facilities in the world are SATRA and Intertek, amongst others.

Both of these organizations will produce an ISO EN certificate after the appropriate testing and evaluations.
The certificate should state the following:

-Issuer, to whom the certificate is addressed
-The Manufacturing plant, where it will be manufactured.
-The date of issue
-The expiry date
-Certificate number
-Description of product
-Category which the product qualified for
-Signatures of assessor and certification manager

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The meaning of the category descriptions are listed below:

SB	Toe protection tested with 200J impact and 15kN compression force.
S1	SB + Anti-Static + Resistance to fuel and oil + Energy absorption of the seat region (Electrical resistance between 0.1 & 1,000mΩ)
S1P	SB + S1 + Anti-Penetration (Outsole resistant to penetration force ≥ 1,100N)
S2	SB + S1 + Water-Resistant Upper Leather.
S3	SB + S2 + Anti-Penetration

OTHER CATEGORIES:

HRO	Heat Resistant Outsole (300°C for 60 seconds)
M	Metatarsal Protection (100J impact energy on top of foot)
CR	Cut-Resistant Upper (Cut-resistance index to exceed 2.5)
C	Conductive with Electrical Resistance ≤ 100kΩ
CI	Insulation against Cold (30 minutes @ -17°C)
HI	Insulation against Heat (30 minutes @ 150°C)

These categories have been determined by the safety risks evident in the various industries where these products are used. Prior to offering safety footwear to an end-user - be sure to first identify
1) the specific industry where the product will be used and then
2) the potential risks & hazards the end-user will be exposed to.
Your recommendation can then be made based on your findings.

6. SLIP RESISTANCE

There is no product available whatsoever that is slip-proof. In order to obtain an ISO EN approval, the soles' resistance to slip has been tested over various surfaces, at various angles, and with various "slipping" compounds added.
One of the most critical features of a slip-resistant shoe is the design of the outsole. The cleats/lugs need to be designed in such a manner that any trapped liquids and oils can be dispersed easily.
There are three classifications for slip resistance:
SRA (Resistant on ceramic + Sodium Lauryl Sulphate)
SRB (Steel + Glycerol)
SRC (SRA & SRB)

7. OIL AND ACID RESISTANCE

The first question that we've got to ask is "Are we talking about the sole or the upper?"
Outsoles:
Most soles available in the market are Polyurethane (PU) - and PU is naturally resistant to oil & acids (however, be aware of high concentrations of acids).
Rubber-soled products are more resistant to oil & acids.
Upper:
The Uppers of leather products do not resist oils and acids too well.
If the end-user is going to be standing in pools of acid or oil - it is recommended that he/she rather wears PVC or Rubber

Gumboots. Regular cleaning and care with products such as polish or dubbin will increase the leathers' resistance to oils, acids and water.

8. PU & RUBBER CHEMICAL RESISTANCE CHART

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Acetic Acid	E	E
Acetone	P	G
Aluminium Chloride - 10% Solution	E	E
Ammonia	E	E
Ammonium Chloride - 10% Solution	E	E
Ammonium Hydroxide	E	E
Aniline	P	P
Animal Fat	E	E
ASTM - Fuel A	E	E
ASTM - Fuel B	G	G
ASTM - Fuel C	F	F
ASTM - Oil 1	E	E
ASTM - Oil 2	E	E
ASTM - Oil 3	E	E
Battery Acid	E	E
Benzene	P	P
Benzyl Alcohol	NR	NR
Bleach	E	E
Brake Fluid	E	E
Butane	G	G
Calcium Chloride - 40% Solution	E	E
Carbon Disulphide	F	F
Carbon Tetrachloride	F	F
Caustic Soda - 10% Solution	E	E
Chlorobenzene	P	P
Chloroform	P	P
Chromic Acid	P	P
Citric Acid	G	E
Creosote	F	G
Cyclohaxanone	P	P
Cyclohexane	E	E
Decalin	F	P

Diesel Oil	E	E
Dimethyl Acetamide	NR	P
Dimethyl Formamide	NR	F
Distilled Water	E	E
Dry Cleaning Fluids	NR	P
Ethanol	F	F
Ether	F	F
Ethyl Acetate	P	P
Ethylene Chloride	G	P
Ferric Chloride - 10% Solution	G	E
Formaldehyde	G	G
Formic Acid	F	E
Freon 12	F	G
Freon 22	F	G
Fuel 1 = 100% Iso-Octane	E	E
Fuel 2 = 70% Iso-Octane 30% Toluene	G	G
Fuel 3 = 50% Iso-Octane 50% Toluene	F	F
Gear Box Oil	E	E
Glycerine	E	E
Glycol	E	E
Hydrochloric Acid	E	E
Hydrogen Peroxide - 3% Solution	E	E
Industrial Detergent	E	E
Iso-Propanol	G	E
Kerosene	E	E
Lactic Acid	NR	E
Lubricating Grease	E	E
Magnesium Chloride - 30% Solution	E	E
Methane	G	G
Methanol	G	E
Methyl Acetate	P	F
Methyl Ethyl Ketone	P	P

Methyl Glycol	P	P
Methyl Glycol Acetate	P	P
Methylene Chloride	P	P
Mineral Oil	E	E
Nitric Acid	NR	P
N-Methyl Pyrrolidone	NR	NR
Ozone	E	E
Paraffin Oil	E	E
Perchchloreothylene	P	P
Petroleum	E	E
Petroleum Ether	E	E
Phosphoric Acid	F	E
Potassium Chloride - 40% Solution	E	E
Potassium Dichromate - 10% Solution	E	E
Potassium Hydroxide	E	E
Potassium Nitrate	G	E
Potassium Permanganate - 5% Solution	P	P
Propane	G	G
Pyridine	NR	P
Sodium Bisulphate - 10% Solution	G	E
Sodium Chloride - 10% Solution	E	E
Sodium Hypochlorite (pH 13)	E	E
Sodium Sulphite	G	E
Sulphuric Acid	NR	F
Tetrachloreothylene	P	P
Tetrahydrofuran	P	P
Toluene	P	P
Trichloroethylene	P	P
Turpentine	G	G
Xylene	P	P

KEY:

EXCELLENT	E
GOOD	G
FAIR	F
POOR	P
NOT RECOMMENEDED	NR

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9. HYDROLYSIS

In both chemistry and physiology, hydrolysis is a double decomposition reaction, with water as one of the reactants. Hydrolysis can affect safety footwear. Simple terms, the oxygen atom in water bonds with the carbon atom in the polyurethane. This carbo–oxygen bond is unstable, and eventually also breaks down, leading to the gradual disintegration of the polyurethane.



Hydrolysis in safety footwear only becomes a serious issue when four factors combine to create the ideal environment:
- Water
- Temperature
- Darkness
- Time.

To simplify, after usage of product in the rain and then store the product in a dark area for a year in a hot and humid climate is, potentially, the perfect catalyst for hydrolysis.
By following a few simple steps can almost eliminate it entirely:
Rotate stock frequently on a first in, first out basis. Do not keep polyurethane soled footwear on the shelf for longer than a year. Be aware of the climate in which the footwear will be stored or worn.
Encourage the wearer to properly aerate & care for the footwear after use. Do not wear polyurethane soled footwear where gumboots would be more suitable
Often customers do ask but if the boots are wet what should I do.
Ideally, wet boots should be thoroughly dried before wearing them again.
In fact, it is unhygienic to wear closed leather boots on consecutive days. These boots build up moisture, and this moisture should be allowed an opportunity to evaporate adequately. Unfortunately, circumstances do not always allow workers to have 2 pairs of boots.
The best way to dry boots out is naturally though in the shade. Never force dry boots e.g., in an oven, against a heater or in direct sunlight.
Remove the sock liner, loosen the laces all the way to the bottom, open the bellows tongue to its widest point and allow the boots to air out for at least 8 hours.

If the boots are extremely wet, stuff newspaper into the boot overnight to absorb excess moisture, then open boot up to dry naturally.
Once the boot has dried, apply a coating of natural bee's wax to keep the leather soft and pliable.
This coating will also assist with providing the boot with additional protection against water, oil, dirt, etc. Usage / flexing of product is good to keep the glue supple.
If a boot has been force dried, the leather loses too much of its original moisture, the leather then becomes dry and brittle and the leather will start to crack.
If a boot has not been allowed to dry adequately, the flexing movement of the boot can cause the upper to split away from the sole.

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