



**MOTORCYCLE PROTECTIVE CLOTHING: STAGE 1
REVIEW OF LITERATURE AND DEVELOPMENT
OF A SAFETY 'STAR RATING' SYSTEM (RSD-
0299)**

Report to VicRoads

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Contents

EXECUTIVE SUMMARY	III
1. INTRODUCTION	3
1.1 BACKGROUND	3
1.2 PROJECT OBJECTIVES.....	3
1.3 STRUCTURE OF THE REPORT	3
2. REVIEW OF THE LITERATURE	3
2.1 KEY TYPES AND FEATURES OF PROTECTIVE CLOTHING THAT COULD FORM THE BASIS OF A SAFETY ‘STAR RATING’ SYSTEM	3
2.1.1 Jackets and pants or one piece suits	3
2.1.2 Gloves.....	3
2.1.3 Boots.....	3
2.2 THE INJURY PROTECTION MECHANISMS OF DIFFERENT ITEMS OF PROTECTIVE CLOTHING	3
2.2.1 Impact protectors (or body armour)	3
2.3 NEW PRODUCTS, FABRICS AND TECHNOLOGIES.....	3
2.3.1 Impact protectors.....	3
2.3.2 Neck braces.....	3
2.3.3 “Airbag” jackets.....	3
2.3.4 New fabrics	3
2.4 RECENT RESEARCH INTO THE SAFETY QUALITIES OF PROTECTIVE CLOTHING.....	3
2.4.1 Other recent injury research.....	3
2.5 USE OF PROTECTIVE CLOTHING BY AUSTRALIAN RIDERS	3
2.5.1 Information on use of protective clothing from NSW Motorcycle Council Survey	3
2.5.2 Observational study of protective clothing on Mt Nebo, Brisbane	3
2.5.3 Conclusions from Australian studies of use of protective clothing.....	3
2.5.4 What is being sold?	3
3. STANDARDS AND GUIDELINES FOR MOTORCYCLE PROTECTIVE CLOTHING	3
3.1 THE CAMBRIDGE STANDARD, ISSUE 2, 1999.	3
3.2 THE EUROPEAN STANDARDS FOR MOTORCYCLE PROTECTIVE CLOTHING	3
3.3 A COMPARISON OF THE STANDARDS AUSTRALIA GUIDELINES AND THE EUROPEAN STANDARD	3
3.3.1 Scope	3
3.3.2 Structure in terms of levels and zones	3
3.3.3 Voluntary/mandatory.....	3
3.3.4 Test procedures	3
3.4 RECENT AUSTRALIAN MOVES TO A VOLUNTARY INDUSTRY STANDARD	3
3.5 CONSUMER TESTS BY RIDE MAGAZINE	3
3.5.1 Consumer tests for motorcycle jackets, pants or suits.....	3
3.5.2 Consumer tests for motorcycle gloves.....	3
3.5.3 Consumer tests for motorcycle boots	3
4. CONSIDERATION OF A SAFETY RATING SYSTEM FOR MOTORCYCLE PROTECTIVE CLOTHING.....	3

4.1 UNDERLYING CONCEPTS OF CONSUMER RATING SYSTEMS AND STANDARDS	3
4.1.1 Regulatory framework.....	3
4.1.2 Updating standards and consumer rating systems.....	3
4.2 CHARACTERISTICS OF SAFETY RATING SYSTEMS.....	3
4.3 POTENTIAL CHARACTERISTICS OF A SAFETY RATING SYSTEM FOR MOTORCYCLE PROTECTIVE CLOTHING	3
4.3.1 Predictive or retrospective systems	3
4.3.2 Assessment of safety performance for calculating ratings	3
4.3.3 Dimensions of a potential rating system.....	3
4.3.4 Safety rating systems or standards or both?.....	3
5. RECOMMENDATIONS	3
5.1 THE MODELS FOR THE PROPOSED SYSTEM.....	3
5.1.1 Model 1 – Voluntary industry star rating system.....	3
5.1.2 Model 2 – Independent star rating system.....	3
5.2 POTENTIAL CRITERIA TO BE USED FOR MEASURING SAFETY PERFORMANCE	3
5.2.1 Overall star rating or individual components?.....	3
5.3 ISSUES RELATED TO PROMOTION OF THE SYSTEM TO RIDERS.....	3
5.3.1 Rider concerns	3
5.3.2 Promotion to increase rider awareness	3
5.3.3 Educating riders about when protective clothing is beneficial	3
REFERENCES.....	3

Figures

FIGURE 1 RIDERS PROTECTED FROM MINOR INJURY BY CLOTHING IN MAIDS STUDY (ACEM, 2004).	3
FIGURE 2 AGE OF SURVEY RESPONDENTS COMPARED TO REGISTERED OWNERS IN NSW, 2005.	3
FIGURE 3 RESPONDENTS MOTORCYCLE COMPARED TO REGISTERED OWNERS IN NSW, 2005.....	3
FIGURE 4 PROTECTIVE CLOTHING WORN ON LAST OF EACH TYPE OF RIDE.....	3
FIGURE 5 PROTECTIVE CLOTHING WORN ON LAST RECREATIONAL RIDE.	3
FIGURE 6 MOTORCYCLE INJURY PATTERNS 1987 VS 2004.....	3
FIGURE 7 INJURY RISK ZONES (WOODS, 1996)	3

Tables

TABLE 1 TEST SPECIFICATIONS FOR MOTORCYCLE JACKETS AND TROUSERS OR ONE PIECE SUITS FOR THE CAMBRIDGE STANDARD.....	3
TABLE 2 TEST SPECIFICATIONS FOR MOTORCYCLE JACKETS AND TROUSERS OR ONE PIECE SUITS (EN 13595-1:2002).....	3
TABLE 3 AN EXAMPLE OF ALLOCATION OF STARS BASED ON TEST PERFORMANCE OF ZONE 1 SECTIONS OF GARMENT – FOR JACKETS, PANTS AND SUITS.	3

EXECUTIVE SUMMARY

Little information is available to Australian riders regarding the likely level of protection provided by different brands and types of protective clothing. Australian manufacturers and importers are not subject to any mandatory standards in relation to protective clothing except for helmets. For these reasons, VicRoads is funding a project to investigate the possibility of a system in Australia whereby consumers have access to information about some of the key safety characteristics of protective clothing, which they may then use in making purchasing decisions. This project addresses the first component, the literature review and development of a model for a safety 'star rating' system for protective clothing. Later stages will include a market research study and a research study into the feasibility of implementing a 'star rating' system for protective clothing.

This review of the literature addressed the following issues:

1. The key types and features of protective clothing that could form the basis of a safety 'star rating' system
2. The injury protection mechanism that operates with use of different items of protective clothing
3. Any new products, fabrics and technologies that did not exist when the Standards Australia 'Motorcycle protective clothing: guidelines for manufacturing' was published in December 2000
4. Any research into the safety qualities of protective clothing after this date

Key elements

The key elements to be considered in evaluating the injury protection functions of motorcycle clothing are:

- The structurally strong layer(s) of material(s) in terms of abrasion, cut, tear or burst resistance. Some textile garments may be constructed of multiple layers of fabrics which, individually, do not meet the requirements of the standards, but collectively provide the required performance.
- The material and construction of the inner lining should be a full and separate inner shell of fabric to reduce sheer forces on body tissue from the structurally strong layer(s) during impact or while sliding over the ground.
- The construction in terms of the strength and integrity of seams and fastenings to ensure they do not burst on impact.
- The design in terms of comfort, fit and ease of movement that does not create safety hazards.

Physical testing is required to determine the extent to which a particular item of clothing performs these functions, it cannot be determined by inspection. Appropriate tests have been devised to support the European Standards for Motorcycle Protective Clothing.

The key elements to be considered in evaluating the injury protection functions of motorcycle gloves include:

- Abrasion, cut and burst resistance.

- Coverage of the full hand and wrist
- Fastenings that prevent the gloves from being pulled off.
- Abrasion resistant material on the base of the palm and wrists.
- Impact protection over the knuckle
- No potential tear points such as uncovered cooling vents on the back of the hand.
- The construction and means by which any additional layers of material are attached as double stitched on top of the main protective layer, rather than inserted into the shell as a separate double section.
- Absence of any hard seams or other sharp edges such as studs, staples or buckles penetrating the protective layer of the glove.
- Inclusion of features such as webbing between the little finger and the next finger to prevent twisting injuries in an impact with the road.

The key elements to be considered in evaluating the injury protection functions of motorcycle boots include:

- Height to cover foot, ankle and shins.
- Impact protection for the shins, instep and ankles.
- Fastening that prevents the boots from being pulled off.
- The abrasion and cut resistance of the upper material.
- The crush resistance of the sole.
- The strength of the bond attaching the sole to the upper.
- The thickness of the sole and the depth of cleats/tread.
- The clearance from the edge of the sole to the upper to prevent the foot from overhanging the edge of the sole.
- The fuel oil resistance of the soles

The injury protection mechanisms of different items of protective clothing

Research into protective clothing has followed two paths. One has been to identify the features of the optimal materials to protect the riders body in the event of a crash, the other has been to explore the options for absorbing or deflecting the energy forces of an impact.

The injury protection mechanisms of materials relate to:

- Abrasion resistance to determine how long the material will last in a fall when being abraded against a hard metallised road or track surface in a typical 50 km/h crash.
- Tear and cut resistance, required to ensure the material cannot be cut, penetrated or torn by sharp objects in a crash.
- Burst strength to ensure that seams, fastenings and the material itself will not split open on impact.
- Reduction of shear forces on body tissues by the use of lining fabrics which permit movement between the lining and structurally strong layer(s), but which do not move across the surface of the wearer's skin, in response to lateral forces from direct impacts or while sliding along the road.
- Retention of garment in place during an accident.

The other path has been the search for a way to shield the rider from the impact of a collision. Helmets have demonstrated the feasibility of achieving this for the head, but it

has proved a far more difficult task to develop effective armour for the rest of the body. While clothing cannot be expected to absorb impact energy, forces can be reduced. Impact protectors are designed to attenuate the energy of an impact by spreading it across a wider surface at a less damaging rate.

New products, fabrics and technologies

New products include impact protectors, neck brace systems and airbag jackets. Developments in textile science have enhanced the performance of motorcycle clothing products in areas such as abrasion resistance, water proofing and temperature regulation.

Back protectors are a type of body armour which has been gaining acceptance over the past two or three years, particularly since the issuing of the EU standard for back protectors in 2003. Neck braces aim to decelerate the head in a controlled manner, while at the same time reducing dangerous ranges of head movement in order to reduce the bending forces (torque) on the cervical spine. A limiting factor in the development of neck braces and body armour has been the need to ensure it does not detract from the wearer's fitness to ride either in terms of comfort or manoeuvrability.

Several companies are developing and marketing "airbag jackets" that inflate when the rider is thrown from the motorcycle. At this stage research suggests that while the concept of airbag jackets is appealing, there are many challenges still to be solved before they should be commercialised. There are a number of important limitations to the potential injury reduction benefits of these products.

Both the CSIRO and a British firm, d3o, are developing flexible polymer-based materials that harden immediately upon impact and are currently investigating the possibility of application to motorcycle protective clothing.

Developments that make protective gear more comfortable to wear in hot weather are important to increase wearing rates. New synthetic materials are being developed that incorporate high abrasion resistance and improved wearer comfort across a wide range of ambient temperatures. "Smart textiles" with PCM (Phase Change Materials) are being incorporated into clothing and interact with the skin's temperature to provide a buffer against temperature swings. As the body temperature increases, the excess energy is absorbed by melting the PCM. As the body temperature drops, the PCM turns solid and releases the stored energy. New tanning treatments have also been developed that diminish the warming effect of sun on leather.

Recent research

The Motorcycle Accident In depth Study was the most comprehensive recent contribution to knowledge about motorcycle crash injuries and motorcycle protective clothing. The MAIDS investigators concluded that motorcycle protective clothing prevented or reduced injury for between 95% (head and hands) and 84% (lower torso) of protected riders. It prevented injury for between 49% (head) and 15% (lower torso) of protected riders. While such studies affirm the general benefits of protective clothing, they do not distinguish between the specific features of items that provided effective protection from those that failed.

Recent Australian observational studies show that riders are more likely to wear jackets than pants (despite the high probability of lower limb injuries in crashes) and that riders of

sports bikes (and others on longer rides) appear more likely to wear protective clothing than riders of scooters. Pillion riders are less likely to wear protective gear than riders.

The European Standards for Motorcycle Protective Clothing

Under the European Directive on Personal Protective Equipment (1989) any clothing claiming to provide protection from injury must be tested and labelled as complying with the requirements of this legislation. European Standards are the normal mechanism for determining a product's compliance, and conforming products will bear the "CE" (Conformité Européenne – European Conformity) mark. This applies to all safety equipment not just for motorcycle apparel. Under the directive, a product can only be described as "protective" if it provides protection from injury, the term cannot be applied to products that provide protection only from non- extreme ambient weather conditions.

The first standard to be issued for motorcycle gear was for impact protectors, which was released in 1997 (EN 1621-1). Standards have since been issued for gloves (EN 13594), boots (EN 13634), jackets and pants (EN 13595 Parts 1 – 4) in 2002 and lastly for back protectors (EN 1621-2) in 2003. Each has a different number and clothing that complies must have been tested and labelled with the CE mark and the appropriate standards number.

The Standards specify the test process and equipment upon which they must be performed. The tests measure performance in relation to two levels of performance in providing protection against road impacts.

Level 1: Clothing designed to give some protection whilst having the lowest possible weight and ergonomic penalties associated with its use.

Level 2: Clothing providing a moderate level of protection, higher than that provided by level 1. There are however, weight and restriction penalties in providing this level of protection.

The requirements for performance in the impact abrasion, impact cut and burst strength, are higher for level 2 than for level 1; however the requirements for tear strength and impact resistance are the same for each level. The standards also include detailed requirements as to the placement of impact protectors and the fit and ergonomics of the whole garment.

The Cambridge Standard, on which the European Standards were based, has a Level 3 for higher performance in protecting the rider.

Consumer testing

The UK motorcycle magazine, Ride, conducts and publishes consumer tests on motorcycle protective gear which are based on the European Standards. For motorcycle jackets, pants and suits, the results of testing are reported with separate scores for Abrasion, Burst resistance, Impact, Warmth and Waterproofing and an overall combined score. The test results for gloves have separate scores for Palm abrasion, Knuckle impact, Seam strength, Wrist restraint and Road testing and an overall combined score. The results for boots have separate scores for Protection, Waterproofing, Warmth and Road testing and an overall combined score.

Models for the proposed rating system

Leaving aside the difficulty in introducing mandatory standards in Australia, it is considered that mandatory standards such as those in Europe are unlikely to bring about a marked improvement in motorcycle protective clothing without substantial allocation of resources to enforcement of the standard which has not occurred in Europe and is unlikely to occur in Australia. Therefore two models for a star rating system are proposed.

Model 1: A voluntary star rating system where manufacturers or distributors can display the claimed star rating on a swing tag on the garment so that the potential purchaser is provided with information about specific items at the point of sale. This would need to be accompanied by some publicity regarding the star rating system that explained the system and encouraged purchase of items with many stars (and not purchasing unrated items). The publicity would also encourage manufacturers/distributors to participate in the scheme. Random audits of the compliance of the items with the test procedures would be required and could potentially be funded by a licensing fee associated with participation in the rating system.

Model 2: A system in which the accrediting body purchases and tests garments and publishes the safety ratings. This would be similar to the Australian New Car Assessment Program. Like ANCAP, it could utilise European findings where the same item is sold in Australia and Europe.

An example of a star rating system for jackets, pants and suits is provided in the report. The example is simplified because it does not set out different requirements for different zones of the garment. The two star rating is broadly based on the requirements for EN 13595 Level 1 clothing, whereas the four star rating is broadly based on the Level 2 requirements. The five star rating is based on the requirements of Level 3 of the Cambridge Standard. The one star rating corresponds to the requirements for EN 13595 Level 1 clothing but for Zone 3 in that Standard. The three star rating is intermediate between EN 13595 Level 1 and Level 2.

It is proposed that a star rating would be based on safety performance, weather protection and ergonomic performance. Otherwise, a disregard of weather protection (thermal control and waterproofing) and ergonomic performance (whether the rider can actually ride while wearing the product) could quickly damage the credibility of the star rating system as a useful guide for consumers.

One of the issues to be addressed in the next stage of this research is whether the star rating should be presented as an overall score, or whether riders should be provided with the star ratings for the individual criteria. If an overall star rating was chosen, then how the results from the different tests were combined would need to be considered. The way in which the weather protection and thermal comfort tests would be incorporated as part of the star rating system would depend on whether there was an overall star rating or whether stars were awarded for individual components.

1. INTRODUCTION

1.1 BACKGROUND

Motorcyclists are among the most vulnerable road users, in Australia and internationally. Motorcycle riding is much more likely to result in injury than car travel, and the resulting injuries are likely to be more severe for motorcyclists than for vehicle occupants. Fatality and serious injury rates have been found to be more than 20 times greater for motorcyclists than car drivers, with brain and orthopaedic injuries prevalent.

The factors that have been identified as contributing to the over-representation of motorcycles in serious crashes include:

- Vulnerability to injury
- Inexperience or lack of recent experience
- Driver failures to see motorcycles
- Instability and braking difficulties
- Road surface and environmental hazards
- Risk taking

The aim of protective clothing is to reduce the vulnerability of motorcyclists to injury, particularly in crashes at lower speeds. A large number of studies since 1976 have confirmed that protective clothing can reduce the frequency and extent of abrasions and lacerations of the skin and soft tissue in motorcycle crashes (reviewed in de Rome & Stanford, 2006). These findings have led road safety agencies to encourage riders to wear full protective clothing (gloves, boots, and jacket and pants, or suit). Yet little information is available to Australian riders regarding the likely level of protection provided by different brands and types of protective clothing. Australian manufacturers and importers are not subject to any mandatory standards in relation to protective clothing except for helmets. Standards Australia published its 'Motorcycle protective clothing: Guidelines for manufacturing' in December 2000, but these guidelines apply only to clothing (not gloves, impact protectors and boots). There is little incentive for manufacturers to apply the Guidelines as there is no regulatory requirement nor means of demonstrating compliance to their customers. The Guidelines were essentially based on the draft European standards, however rather than require the construction of specialised test equipment; the authors applied testing methods that were available in Australia. In particular the abrasion tests undertaken using the locally available Martindale test equipment, were found to be less than ideal as that equipment cannot replicate the impact shock, friction heat nor directional abrasive demands of a road crash.

For these reasons, VicRoads is funding a project to investigate the possibility of a system in Australia whereby consumers have access to information about some of the key safety characteristics of protective clothing, which they may then use in making purchasing decisions. One way of providing this information is by means of a safety 'star rating' system, but other potential approaches will also be investigated.

There are three components to the overall project: i) a literature review and development of a safety 'star rating' system, ii) a market research study and iii) a research study into the feasibility of implementing a 'star rating' system for protective clothing. This project addresses the first component, the literature review and development of a model for a

safety 'star rating' system for protective clothing. The second and third components will be conducted under separate contracts.

1.2 PROJECT OBJECTIVES

The aims of the project are:

- to identify the important features of motorcycle protective clothing; and
- to develop a safety 'star rating' system (or an alternative system) to help consumers with their purchasing decisions.

1.3 STRUCTURE OF THE REPORT

This report begins with a review of the literature pertaining to motorcycle protective clothing, then discusses the usefulness of standards versus safety rating systems as methods for providing consumers with access to information about the safety performance of items of protective clothing. It finishes with recommendations for the remaining stages of this project.

2. REVIEW OF THE LITERATURE

This review of the literature addresses the following issues:

1. The key types and features of protective clothing that could form the basis of a safety 'star rating' system
2. The injury protection mechanism that operates with use of different items of protective clothing
3. Any new products, fabrics and technologies that did not exist when the Standards Australia 'Motorcycle protective clothing: guidelines for manufacturing' was published in December 2000
4. Any research into the safety qualities of protective clothing after this date

The methods used in this review included the traditional literature review methods, supplemented by consultation with importers, distributors and manufacturers of protective clothing and importers and distributors of fabrics.

This review also summarises recent research into patterns of purchase and use of protective clothing in Australia to provide an insight into the factors to be considered when providing information to Australian riders.

The scope of this report is largely restricted to on-road motorcycling. However, where some developments or features in protective clothing for off-road riding are of potential application to on-road riding, these are discussed.

2.1 KEY TYPES AND FEATURES OF PROTECTIVE CLOTHING THAT COULD FORM THE BASIS OF A SAFETY 'STAR RATING' SYSTEM

Any discussion of motorcyclist clothing should first distinguish between the different protective purposes for which it may be worn. Motorcyclists' clothing may:

1. Prevent or reduce injury in the case of a crash,
2. Protect from the elements – wind, rain, cold and heat,
3. Draw the attention of other motorists (conspicuity).

Our focus is on protection from injury, although protection from the elements and conspicuity are also safety issues for motorcyclists.

Protection from the elements acts as a safety feature by reducing the effects of dehydration and physiological stress which can increase crash risk. Physiological stress occurs when the body has to work to counteract the effects of discomfort. Symptoms include distraction, loss of sensation and thereby operational control, dulled responses and reaction times, impaired motor responses and fatigue (Woods, 1986, EEVC/CEVE, 1993).

The potential for clothing to increase a riders' visibility to other motorists is less well established. However it is an issue that every rider needs to consider, because failure of the other driver to see the motorcyclist is a primary contributing factor in many motorcycle crashes. Failure to see the motorcyclists was the primary contributing factor in 37% of all motorcycle crashes investigated in the Motorcycle Accident In-Depth Study - MAIDS (ACEM, 2004). Although the researchers found no apparent contribution of garments to

the conspicuity of the rider in 65% of crashes, they did report that dull or dark clothing may have decreased conspicuity in 13% of cases.

Protective clothing generally includes a long sleeved jacket and long pants, or one piece suit, gloves and boots, made of leather or other fabric with high abrasion and tear resistance. Most modern protective clothing also includes some impact protectors which are designed to attenuate force at specific impact points. The challenge for manufacturers is to provide protection from injury as well as from the elements (wind, rain, cold and heat) without restricting ease of movement or creating stress fatigue.

2.1.1 Jackets and pants or one piece suits

Leather has been the traditional choice of motorcyclists because of its reputation for high abrasion resistance. However the protective quality of any leather product depends on the type and grade of leather, how it has been treated and on the design and construction of the garment (Woods, 1996). What appear to be similar leathers may perform very differently when tested due differences in the age and condition of the animal, post-slaughter deterioration of the skin prior to tanning and tanning method (Woods, 2004).

There are also a number of modern textiles now being promoted by clothing manufacturers as abrasion resistant, that have the added benefits over leather of being lightweight, flexible and providing better ventilation and waterproofing. However, the only way to determine whether a particular material (leather or fabric) is suitable is to physically test it. Appropriate tests have been devised to support the European Standards for Motorcycle Protective Clothing (see Section 3.2). Testing performed by accredited facilities on behalf of consumer magazines indicate that the majority of such textile garments do not perform as claimed in the impact abrasion and impact cut tests, and fall substantially below the requirements of the European Standards [Ride 2004].

The key elements to be considered in evaluating the injury protection functions of motorcycle clothing are:

- The structurally strong layer(s) [footnote: defined in clause 3.5 of EN13595-1:2002] of material(s) in terms of abrasion, cut, tear or burst resistance. (Note: some textile garments may be constructed of multiple layers of fabrics which, individually, do not meet the requirements of the standards, but collectively provide the required performance).
- The material and construction of the inner lining should be a full and separate inner shell of fabric to reduce shear forces on body tissue from the structurally strong layer(s) during impact or while sliding over the ground. Lining should ideally also have a high melting point to prevent it from melting into the skin from fire or friction heat.
- The construction in terms of the strength and integrity of seams and fastenings to ensure they do not burst on impact. Fastenings must ensure the garment stays in place and not in themselves cause injury. For example zippers and buckles may penetrate the rider's body under impact unless appropriate manufacturing practices are adopted to prevent this.
- The design in terms of comfort, fit and ease of movement that does not create safety hazards. For example, jackets with external pockets or straps may snag on the motorcycle or other vehicle in a crash. An uncluttered external surface, free of protrusions, is therefore desirable.

The key elements to be considered in evaluating the weather protection provided by motorcycle clothing are:

- Provision to allow insulation from cold temperatures and ventilation in heat.
- The design and fit of openings (neck, wrists and waist), coverage of zippers, seams and other fastening points to prevent wind entry and heat loss.
- The design and fit to reduce flapping and wind buffeting which forces warm air out.
- Waterproof breathable fabrics to protect the rider from rain, without sweating which can quickly result in heat loss.
- Waterproof seams, pockets, cuffs and neck openings.

2.1.2 Gloves

About 57% of motorcyclists in crashes sustain an impact to their hands or wrists (ACEM, 2004). Motorcycle gloves need to be sufficiently robust to provide protection from injuries in a crash without restricting the rider's ability to operate the controls. There is evidence that gloves can reduce or prevent some injuries (ACEM, 2004). The key elements to be considered in evaluating the injury protection functions of motorcycle gloves include:

- Abrasion, cut and burst resistance.
- Coverage of the full hand and wrist
- Fastenings that prevent the gloves from being pulled off.
- Abrasion resistant material on the base of the palm and wrists.
- Impact protection over the knuckle
- No potential tear points provided by features such as uncovered cooling vents on the back of the hand.
- The construction and means by which any additional layers of material are attached as double stitched on top of the main protective layer, rather than inserted into the shell as a separate double section.
- Absence of any hard seams or other sharp edges such as studs, staples or buckles penetrating the protective layer of the glove.
- Inclusion of features such as webbing between the little finger and the next finger to prevent twisting injuries in an impact with the road.

Other important features include:

- Comfortable fit without feeling tight or too loose. Pressure, such as from tight straps, can affect blood flow.
- Compliance with ISO 11642 which is a test of colour fastness to water to avoid the rider's hands being stained every time the gloves get wet [also. Some dyes used in products manufactured in "developing nations" may contain chemicals banned from use for reasons of public health in the target markets].
- Insulation to reduce or prevent heat loss.
- Breathable materials to prevent sweating.

2.1.3 Boots

Over 56% of motorcyclists in a crash sustain an impact to their feet (ACEM, 2004). However there is evidence to suggest that good boots can significantly reduce the risk of foot injuries (Otte et al, 2002, ACEM, 2004). The key elements to be considered in evaluating the injury protection functions of motorcycle boots include:

- Height to cover foot, ankle and shins.
- Impact protection for the shins, instep and ankles.
- Fastening that prevents the boots from being pulled off.
- The abrasion and cut resistance of the upper material.
- The crush resistance of the sole.
- The strength of the bond attaching the sole to the upper.
- The thickness of the sole and the depth of cleats/tread.
- The clearance from the edge of the sole to the upper to prevent the foot from overhanging the edge of the sole.
- The fuel oil resistance of the soles

The key elements to be considered in evaluating the weather protection provided by motorcycle boots are:

- Water proof material
- Fastenings such as zips or laces must have flaps or other waterproofing.
- Insulation to reduce or prevent heat loss.
- Venting or breathable materials to prevent sweating
- Compliance with ISO 11642 which is a test of colour fastness to water [also. Some dyes used in products manufactured in “developing nations” may contain chemicals banned from use for reasons of public health in the target markets].

2.2 THE INJURY PROTECTION MECHANISMS OF DIFFERENT ITEMS OF PROTECTIVE CLOTHING

Research into improving the effectiveness of protective clothing has followed two paths. One has been to identify the features of the optimal materials to protect the riders body in the event of a crash, the other has been to explore the options for absorbing or deflecting the energy forces of an impact.

As noted earlier the challenge has been to meet the multiple requirements for motorcycle clothing to provide protection from injury as well as wind, rain, cold and heat without restricting ease of movement or creating stress fatigue. Much of the work in relation to the features of materials has been done by Roderick I. Woods (e.g. Woods, 1983, 1986, 1996, 1999).

The injury protection mechanisms of materials relate to:

- Abrasion resistance to determine how long the material will last in a fall when being abraded against a hard metal road or track surface in a typical 30 mph / 50 km/ph crash (Woods, 1999).
- Tear and cut resistance, required to ensure the material cannot be cut, penetrated or torn by sharp objects in a crash.
- Burst strength to ensure that seams, fastenings and the material itself will not split open on impact.
- Reduction of sheer forces on body tissues by the use of lining fabrics which permit movement between the lining and structurally strong layer(s), but which do not move across the surface of the wearer’s skin, in response to lateral forces from direct impacts or while sliding along the road.
- Retention of garment in place during an accident.

2.2.1 Impact protectors (or body armour)

The other path has been the search for a way to shield the rider from the impact of a collision. Helmets have demonstrated the feasibility of achieving this for the head, but it has proved a far more difficult task to develop effective armour for the rest of the body. While clothing cannot be expected to absorb impact energy, forces can be reduced.

The term impact protector is generally used to refer to shields that are worn over the key joints, elbow, shoulder, hip and knee. In order to be effective, it is essential that impact protectors are fitted and held in place so that they will not move during a crash.

- Impact protectors are designed to attenuate the energy of an impact by spreading it across a wider surface at a less damaging rate.
- Essentially the objective is to devise a means of absorbing and distributing the energy in an impact to divert pressure and bending stress on the skeleton, and to provide crush resistance particularly for the feet and ankles and prevent penetration by sharp objects.
- Protection is required over specified high impact areas of the body and must remain in place during an impact.
- The soles of boots should be sufficiently rigid to provide some protection from being crushed in a side impact or if trapped under the motorcycle during a sliding impact.

2.3 NEW PRODUCTS, FABRICS AND TECHNOLOGIES

Given the commercial nature of developments in motorcycle protective clothing, it is likely that information regarding many new products, fabrics and technologies will not have been published in open literature. To gather information about these developments, discussions were held with protective clothing manufacturers and importers and others with an interest in motorcycle protective clothing.

New developments in motorcycle protective equipment fall into two general categories. There are new products and there are enhancements of existing products. New products include impact protectors, neck brace systems and airbag jackets. Developments in textile science have enhanced motorcycle clothing products through performance in areas such as abrasion resistance, water proofing and temperature regulation.

2.3.1 Impact protectors

Impact protectors for the limbs and joints may be considered new products, although they have been gaining acceptance since the publication of the EU Standard EN 1621-1 in 1997. Back protectors are a relatively new concept which have been gaining acceptance over the past two or three years, particularly since the issuing of the EU standard for back protectors in 2003. More recent developments include products such as neck braces and airbag jackets.

A limiting factor in the development of body armour has been the need to ensure it does not detract from the wearer's fitness to ride either in terms of comfort or manoeuvrability. Dietmar Otte has done much of the published work in relation to impact protectors, particularly in relation to legs and feet (e.g. Otte et al, 1987 & 2002).

An impact protector is a shield worn within clothing that is designed to absorb and/or spread the energy of a blow to the body. Impact protectors work by slowing down the rate of transfer of the forces in an impact to a less damaging or non-damaging level. This is called impact “attenuation”. There is evidence to suggest that impact protectors may reduce the severity of an impact, such that a fracture may still occur, but it is more likely to be a simple fracture that is easier to treat compared to a complex fracture (Otte et al, 2002). They may also prevent some apparently minor injuries such as chipped elbow, shoulder or knee bones, which can be more debilitating and require longer rehabilitation than fractures.

Back protectors are a similar type of shield which may be strapped to the body inside a jacket or inserted into the lining of a jacket. Back protectors are intended to provide protection against impacts against edges such as kerbing. However, while some 13% of motorcyclists sustain back injuries in crashes, the majority of these injuries are due to blows to the head or to bending and twisting of the back. A back protector will not prevent these types of injury. Less than 1% of injured riders suffer serious injuries from direct blows to the spinal area, however back protectors will provide protection from more minor injuries such as bruises and strains (EN 1621-2, p. 4).

2.3.2 Neck braces

The basic principle with neck brace products is to decelerate the head in a controlled manner, while at the same time reducing dangerous ranges of head movement in order to reduce the bending forces (torque) on the cervical spine. While such injuries are relatively rare (1.7%, ACEM, 2004), they are associated with between 3-11% fatal head and neck injuries (Geisinger, Diehi-Thiele, Kreitmeier, Bachmann, Muller and Leatt, 2006).

One such product is a titanium carbon fibre neck brace being developed by BMW. Simulations using crash dummies indicate that this neck brace system does reduce neck axial forces and could be expected to prevent or reduce bending forces on the cervical spine (Geisinger et al, 2006). The designers claim that once riders become accustomed to wearing such a device, they do not complain of any discomfort.

A similar product that has been under development is a ‘bolster collar’ that is designed to support the rider’s neck and head during a crash (Nawrocki, Demus, Maklewska, & Mielicka, 2004). This product was specifically designed to reduce injury to the brachial plexus, which involves the disconnection of nerves from the spinal cord when a rider’s shoulder and head are abruptly shunted in opposite directions. Nawrocki et al. (2004) report that motorcycle crashes are the most common cause of such injuries. To combat this they have developed a collar made of micro-porous rubber, Kevlar, and acrylic resin to protect against back and side deflection of the head in a crash. Whilst rider tests have been conducted for comfort and functional usability, no crash tests have been reported regarding the effectiveness of this product.

2.3.3 “Airbag” jackets

A number of companies worldwide are manufacturing and/or distributing “airbag” jackets. These are jackets with pockets and small gas cylinders and a cable attaching the jacket to the motorcycle. When the rider is thrown from the motorcycle, the cable is jerked from the motorcycle which signals the gas cylinders to inflate and thus provide a protective “airbag” to protect the neck, chest and back of the rider. The systems are available incorporated into jackets or as part of vests which can be worn over a motorcycle jacket.

Research into the development of airbag jackets for motorcyclists focuses on devising an effective system for activating the air bag to ensure it deploys at the appropriate moment prior to the rider's impact with the road. At this stage the researchers suggest that while the concept of airbag jackets is appealing, there are many challenges still to be solved before they should be commercialised (Bellati, Cossalter Lot and Ambrogi, 2006). There are number of important limitations to the potential injury reduction benefits of these products.

These jackets only provide a potential benefit to riders in crashes where they are thrown from the motorcycle. They are less likely to be suitable in collisions with other vehicles or in situations where the rider does not become separated from the motorcycle. Activation systems need to be developed that are sensitive to the varying crash situations to prevent riders' safety from being compromised by the airbag. The abrasion and impact resistance performance of the airbag shell are also critical to ensure the airbag chambers are not punctured and their protective values lost.

The volume and the inflation pressure of the bag is critical to achieve the desired impact protection without causing the rider to bounce, potentially creating another impact hazard. This may be achieved with the inclusion of overpressure valves, damping at the same time the "bouncing" movement of the rider by dissipating the energy with the air outflow.

While a number of motorcycle clothing manufacturers are working on the development of such products, concerns have been voiced that some of the garments available in the market have been developed directly from marine applications. These products might not be appropriate for use by motorcyclists as the neck cushion may interact poorly with the rider's helmet and could increase the risk of fatal or disabling neck injuries.

We know of only two such products that have been tested and comply with the EU standards. DPI Safety s.r.l "Motoairbag" complies with EN 1621-2 and the Sumitomo "ZO2" jacket (not in production) meets EN 13595 and EN 1621-2. But such compliance is no indication of the effectiveness of the injury protection features of the airbag itself in a crash, as those standards only relate to the abrasion, cut, tear and impact resistance.

2.3.4 New fabrics

Developments in materials science have brought a range of products that are potentially of great value to motorcyclists. Most of these developments relate to features that improve the comfort of the rider, which as noted earlier is also a safety issue. However there are also some new fabrics which have the potential to prevent or reduce injury in a crash impact.

Until very recently there were no textile fabrics with the abrasion resistance performance to equal leather. While fabrics like Cordura were widely promoted as abrasion resistant, the claimed abrasion resistance was not replicated when tested against the EU Standard (SATRA, 2004). Textile clothing products needed to be constructed in layers with different materials used to perform different tasks in order to provide injury protection in an ergonomically viable suit.

One such new material is a polymer-based material under development by the CSIRO that is chemically treated to harden immediately upon impact (Cranston, personal communication). The CSIRO are currently investigating the possibility of its application to motorcycle protective clothing.

Another similar flexible material that hardens on impact is d3o (refer www.d3o.com) which has been applied to ski suits to absorb the impact of high speed crashes in downhill racing. The manufacturers of d3o state that it meets EN impact standards and have expressed interest in regard to the possible inclusion of their new material into any rating system for the Australian market (Gough, personal communication). The d3o lab is currently negotiating with motorcycle apparel manufacturers in regard to its commercial viability in the industry.

Kevlar is an Aramid fibre developed by Dupont®, which has high heat resistance and tensile strength. It can be produced as a hard shield for use in body armour or as a woven or knitted fabric which provides both cut and abrasion resistance. Kevlar is used in a range of protective clothing including motorcycle boots, gloves and clothing. While kevlar jeans and other products have been available for some years, until recently, none had been certified under EN 13595. In 2005 a model of kevlar lined jeans produced by an Australian company (Draggin Jeans) were tested and certified as complying with EN 13595. This is an important development as a key issue in promoting the use of protective clothing, has been the lack of motorcycle clothing that was both protective and functional for usage other than riding.

HI-ART® is a terry cloth-woven polyester fabric which provides high abrasion resistance to level 2 (>7 seconds) under the EN 13595. This fabric is used as an inner shell worn with a separate outer jacket selected according to temperature and weather conditions (Jofama, 2006). The product was developed in collaboration with a leading UK police force and has undergone extensive trials across a wide spectrum of weather and temperature conditions. Anecdotal evidence indicates significant improvements in wearer comfort, compared to other types of motorcyclists' clothing, in ambient temperatures ranging from below 0 °C to as high as + 40 °C.

OUTLAST® is one of a class of "Smart textiles" with PCM (Phase Change Materials) which are incorporated into clothing and interact with the skin's temperature to provide a buffer against temperature swings. The PCMs in OUTLAST® are minute capsules containing paraffin. The paraffin changes from a solid to fluid state according to whether the wearer is giving off or needing heat. As the body temperature increases, the excess energy is taken up by the microscopic capsules melting the paraffin within. As the body temperature drops, the paraffin turns solid and gives off the stored energy. The technology was originally developed to protect astronauts against extreme changes in temperature but is now available for civilian use. (Outlast Technologies Inc, 2006)

TFL COOL Leather® is the result of a tanning treatment which diminishes the warming effect of sun on leather. Whereas temperatures of over 50°C are attained with "normal" leather, TFL claims that their COOL Leather remains nearly 20°C cooler. The TFL COOL SYSTEM® is based on practical physics. Dark colours absorb sun radiation and therefore heat up more strongly than light colours, which reflect up to 95% of the light energy and thus remain cooler. The visible range of the human eye is between 400 and 700 nm (0.4 - 0.7µm). The spectral distribution of the sunlight however goes far beyond that range. Humans cannot see in the UV and Near InfraRed sector (NIR range goes from 700-25000nm). In the near infrared region the light energy absorbed by dark surfaces is transferred into heat energy, which heats up the material and then radiates as warmth. Materials and surfaces which employ the TFL COOL SYSTEM® do not absorb rays in NIR but rather reflect it. As a consequence especially darker surfaces will heat up much less (TFL,2006). Manufacturers using Cool Leather include BMW, Jofama and M-Tech.

Functional membranes (eg Goretex, DryWay etc) are breathable, waterproof fabrics that keep water and wind out, but allow perspiration to escape. The process by which this occurs uses the body heat to transfer moisture (e.g perspiration) from inside clothing through a very fine membrane. Surface tension makes it impossible for water drops from the outside to penetrate the membrane unless the internal temperature is lower than the external temperature. Motorcycle clothing including underwear is available in these fabrics.

2.4 RECENT RESEARCH INTO THE SAFETY QUALITIES OF PROTECTIVE CLOTHING

The injury reduction potential of motorcycle protective clothing has been well established for at least 30 years (Feldkamp, et al 1976; Zettas et al, 1979; Hurt, Ouellet & Wager, 1981; Schuller et al., 1982 & 1986; Otte & Middelhaue, 1987; Hell & Lob, 1993; Otte et al 2002; ACEM, 2004).

Over 20 years ago, Schuller reported that injured riders, who had been wearing leathers, spent on average 7 days less in hospital, and returned to work 20 days earlier than unprotected riders. The protected riders were 40% less likely to have suffered permanent physical defect. It was concluded that protective clothing can prevent or reduce 43% of injuries to soft tissue and 63% of deep and extensive injuries (Schuller et al, 1986). More recently, Otte found that impact protectors reduced the incidence of complex leg fractures and reported significant injury reduction for riders wearing high boots (Otte et al, 2002).

Most research has described the injury reduction benefits of protective clothing in relation to soft tissue injuries. Protective clothing has also been found to prevent or reduce injuries such as cuts and abrasions, exhaust pipe burns, friction burns and the stripping away of skin and muscle. Protective clothing may also reduce the risk of infection from wound contamination and consequent complications in the healing of severe injuries. (e.g. Schuller et al, 1986, Pegg & Mayze, (1983) Otte & Middelhaue, 1987; Hell & Lob, 1993).

There are, of course, limits to the extent that clothing can prevent injury, particularly in high impact crashes. However there is also evidence that most motorcycle crashes are not high impact.

The European Experimental Vehicles Committee's review of research into motorcycle accidents, found that the majority of motorcycle collisions take place at fairly low speeds, the average impact being at between 30 and 45 km/h (EEVC, 1993). Consistent with this, the recent MAIDS (Motorcycle Accident In depth Study) found that 75% of all motorcycle crashes occur at speeds of 50 km/h or less (ACEM, 2004).

The MAIDS study also reported that some 40% of riders tumbled, rolled or slid along the road from the point of the crash without any further impact with another object (ACEM, 2004). Overall, almost half (49%) of all the injuries recorded in MAIDS were rated to be minor or Level 1 on the Abbreviated Injury Scale (AIS 1).

Crashes where the rider slides along the road surface without impacting a fixed object are less likely to result in severe injuries and are the types of crashes where protective clothing can offer the greatest injury reduction (Hell & Lob, 1993, Otte et al, 1987).

The MAIDS investigators tried to establish whether clothing had reduced or prevented minor injuries such as cuts, gravel rash, friction burns etc. Figure 1 illustrates the proportion of riders considered to have been protected from minor injury by their clothing. It includes only those riders who were wearing protective clothing and sustained a direct impact that could have caused an injury to that part of the body. For example, the column for the upper torso indicates that clothing prevented superficial injury for more than a quarter (26%), and reduced injuries for over half (62%) of these riders. Only 11% or just over 1 in ten riders sustained injuries to the upper torso despite their clothing.

While such studies affirm the general benefits of protective clothing, they do not distinguish between the specific features of items that provided effective protection from those that failed.

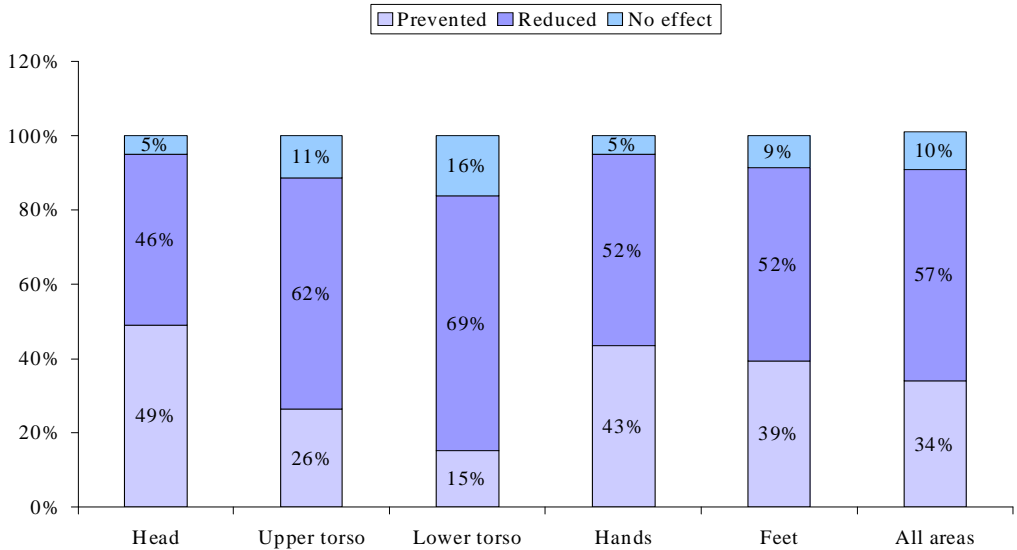


Figure 1 Riders protected from minor injury by clothing in MAIDS study (ACEM, 2004).

2.4.1 Other recent injury research

Recent research in Singapore confirms the ongoing pattern of lower limb injuries for on-road motorcyclists (58% of all injuries) and reaffirms past calls for increased use of protective clothing by riders and pillions (Lateef, 2002). Half of the lower limb injuries in the study were fractures. Notable injury to other body regions was head (18%), face (14%), upper limb (9%), abdominal (3%), and chest (3%). Interestingly, the study noted that 28% of all injuries were related to the motorcyclist skidding along the ground, which further highlights the possible role for protective clothing in such crashes as noted earlier.

Similarly, an examination of over 30,000 motorcycle-related hospitalisations in the United States (84% transport related) reported lower limb fractures as the most common injury (Coben, Steiner, & Owens, 2004). In contrast, Kraus, Peek-Asa, and Cryer (2002) reported considerably different injury patterns for fatally injured motorcyclists compared to non-fatally injured, with head and chest injuries predominant. Whilst the efficacy of motorcycle protective clothing for injury prevention may be limited in more severe crashes, this highlights the potential role for further development in terms of targeting injury severity reduction. For example, the study found that that sternum fractures were related to many fatal injuries including heart, lung, liver, and spleen contusions and lacerations.

Developing effective protection for such anatomical regions and promotion of its use is therefore paramount.

Unfortunately, none of the above studies distinguished injury patterns between those who were wearing protective clothing on particular body regions and those wearing no protection. Such reporting (as in the MAIDS study) would assist in clarifying the potential benefit of protective clothing for motorcyclists, although the level of quality of the garments used would still remain in question.

Burns from motorcycle exhausts have also been noted in several recent publications (Lai et al., 2002; Matzavakis, Frangakis, Charalampopoulou, & Petridou, 2005; Roberts, Kelson, Goodall-Wilson, & Kimble, 2002). From these studies it appears that the majority of motorcycle-related burn victims are pillions wearing shorts or skirts during summer months. Some victims were wearing long pants and sand shoes, although this appeared to offer minimal protection in these cases. Importantly, most of the victims appear to be under 25 years of age (many adolescents), with some suffering severe burns.

Patterns of injury severity in relation to speed also affirm results from previous studies. For example, Lin, Chang, Huang, and Pai (2003) examined 1889 on-road motorcycle crashes in Taiwan and reported that 47% of minor injury crashes occurred at 40km/h or less, with 81% occurring at 60km/h or less.

2.5 USE OF PROTECTIVE CLOTHING BY AUSTRALIAN RIDERS

This section summarises recent surveys and observational studies of use of protective clothing by Australian riders and information collected as part of discussions with importers and distributors of motorcycle apparel.

2.5.1 Information on use of protective clothing from NSW Motorcycle Council Survey

In 2006 a survey was undertaken on behalf of the Motorcycle Council of NSW (MCC). Surveys were distributed through the MCCs member network at motorcycle club meetings, attached to motorcycle handle bars in public parking areas, through motorcycle shops and as an insert in a motorcycle magazine. An internet version of the survey was also provided on the MCC web site. The survey was conducted over a four week period in May 2006. Completed paper questionnaires were returned by mail or fax to the MCC. There were 1,299 survey returns including 742 paper copies and 557 from the website (de Rome, 2006). While descriptive results were presented, no tests of statistical significance were undertaken.

Ninety two percent of respondents were residents of NSW. Compared to the population of registered owners in NSW, they included a higher proportion of women (12% vs 9%) and also more young riders aged under 25 and between 25-39 compared to the population (see Figure 2).

Respondents to the survey were more likely to own larger capacity motorcycles than the population of registered owners, however they were likely to be more representative of the road riding community than it would appear from Figure 3. Under the Australian Road Rules, most off road bikes are now required to be registered. As off-road vehicles comprise half of all motorcycles sold and account for a substantial proportion of the under 250cc group. (personal communication, FCAI, 2006), many of the registered motorcycles under 250cc may actually be off-road motorcycles (not included in the survey).

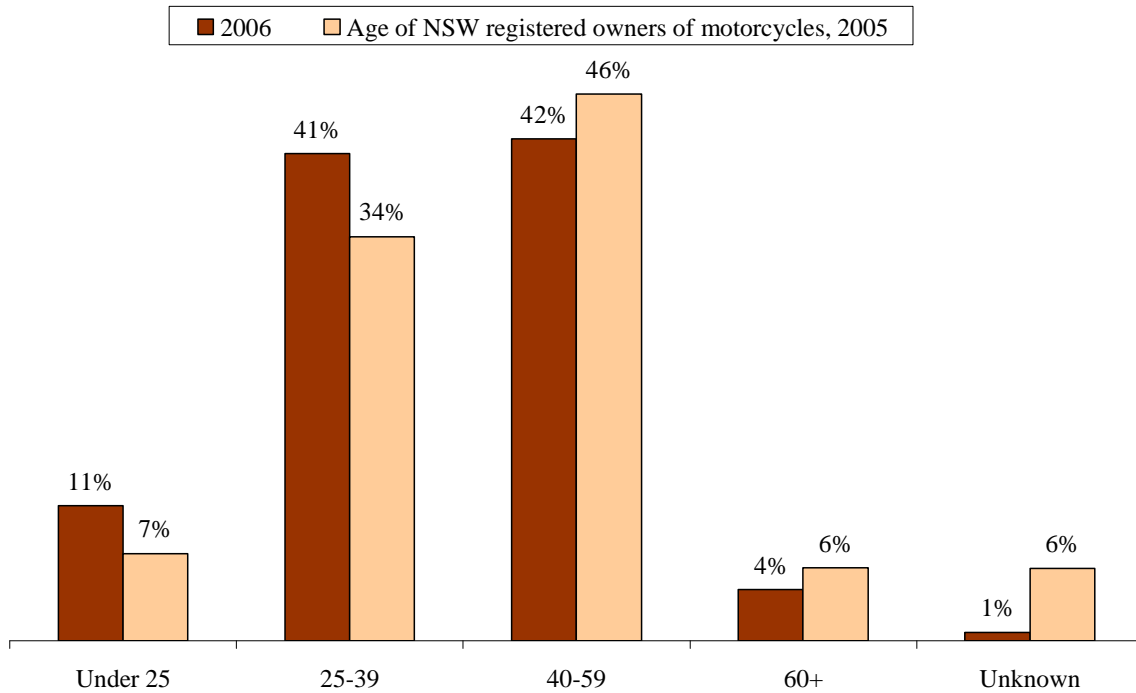


Figure 2 Age of survey respondents compared to registered owners in NSW, 2005.

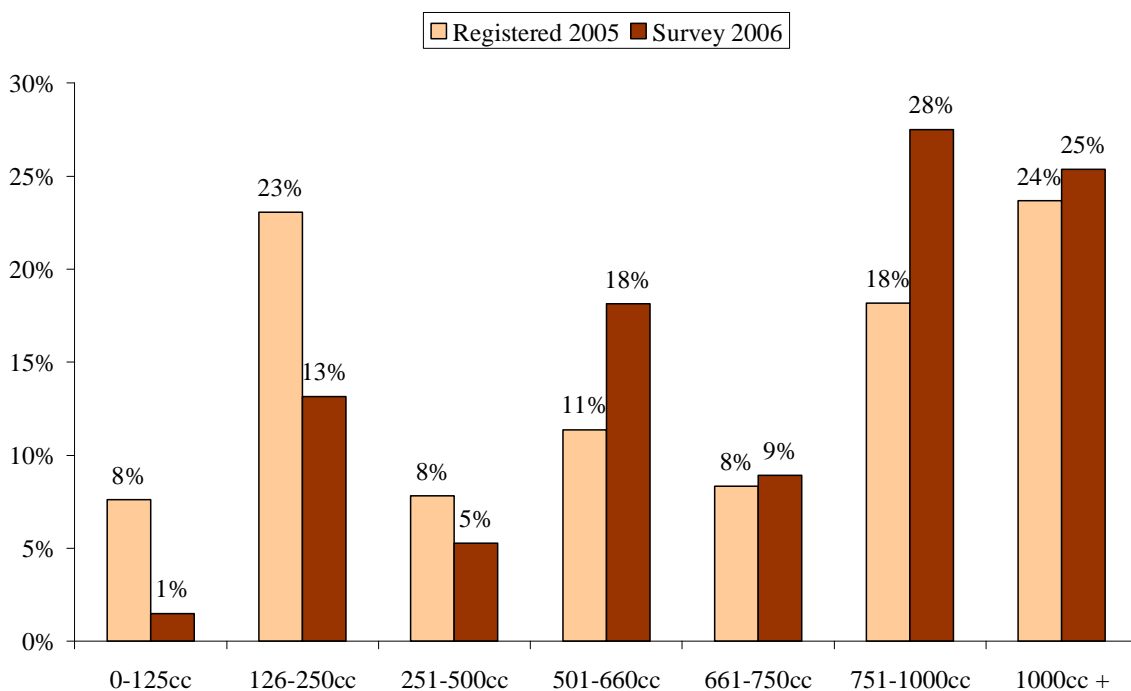


Figure 3 Respondents motorcycle compared to registered owners in NSW, 2005.

Respondents were asked to give details of the type of protective clothing they wore the last time they went on each of the following types of journey: commuting to work or education, on a recreational ride and on a short trip to the local shops. Figure 4 illustrates that riders in general were more likely to wear full protection, particularly on their legs and feet, when

on recreational rides and least likely for short rides to the local shops (Unpublished data, de Rome, 2006).

Full protection was defined as the full body coverage by motorcycle specific gear. For example, to be rated as wearing a high level of protection for the head, the rider had to be wearing a full face helmet or open face with visor or goggles.

However the pattern of usage also varied with the class of motorcycle ridden. Scooter and cruiser riders were least likely to wear high levels of protective clothing. Sports, Tourers and Naked motorcycle riders had the highest levels of protection.

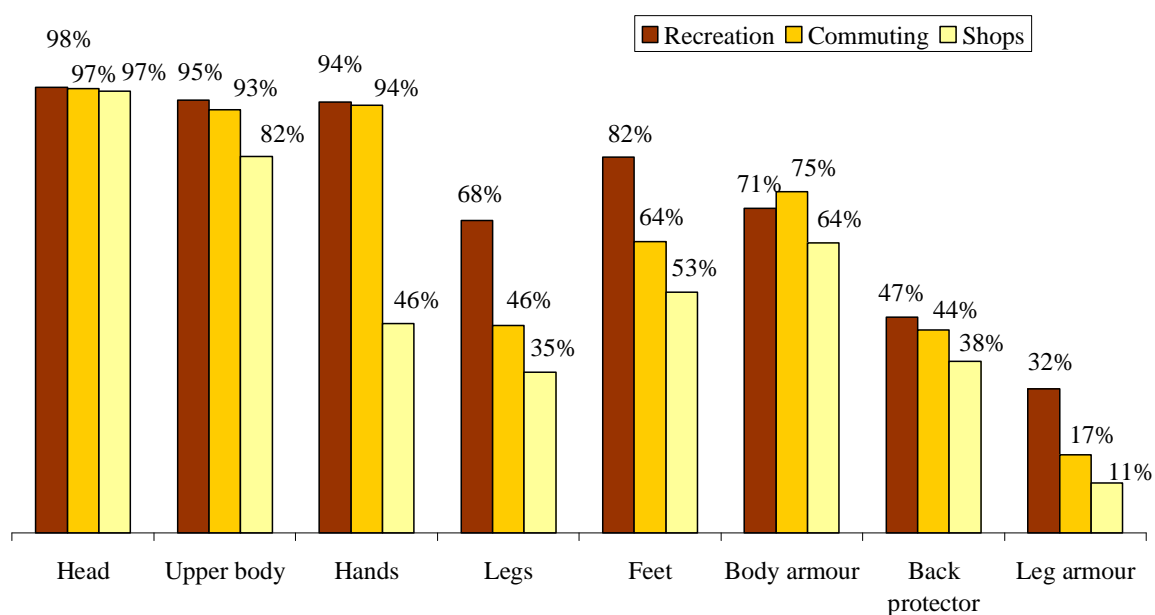


Figure 4 Protective clothing worn on last of each type of ride.

Figure 5 shows the proportion of riders by class of motorcycle and whether they wore high levels of protection to each part of their body when on recreational rides. High level of protection is defined as helmet with eye protection, motorcycle specific gloves and boots, and motorcycle jackets and pants with impact protectors (Unpublished data, de Rome, 2006).

Cruiser riders were most likely not to wear motorcycle pants and were less likely to wear a motorcycle jacket with impact protectors compared to other riders other than scooter riders.

While there were only 39 scooter riders in the sample, the pattern of their usage is consistent with other work (de Rome et al, 2003). Scooter riders were most likely to wear an open face helmet without visor or goggles. They were also least likely to wear motorcycle protective pants or boots. This is perfectly understandable in the fashion sense, because scooters are promoted by the industry as machines that do not require the rider to wear protective clothing. For examples, see magazine editorial photographs and advertisements for (e.g. Bolwell, Honda, Hawk brands) in Two Wheels Scooter, 2005.

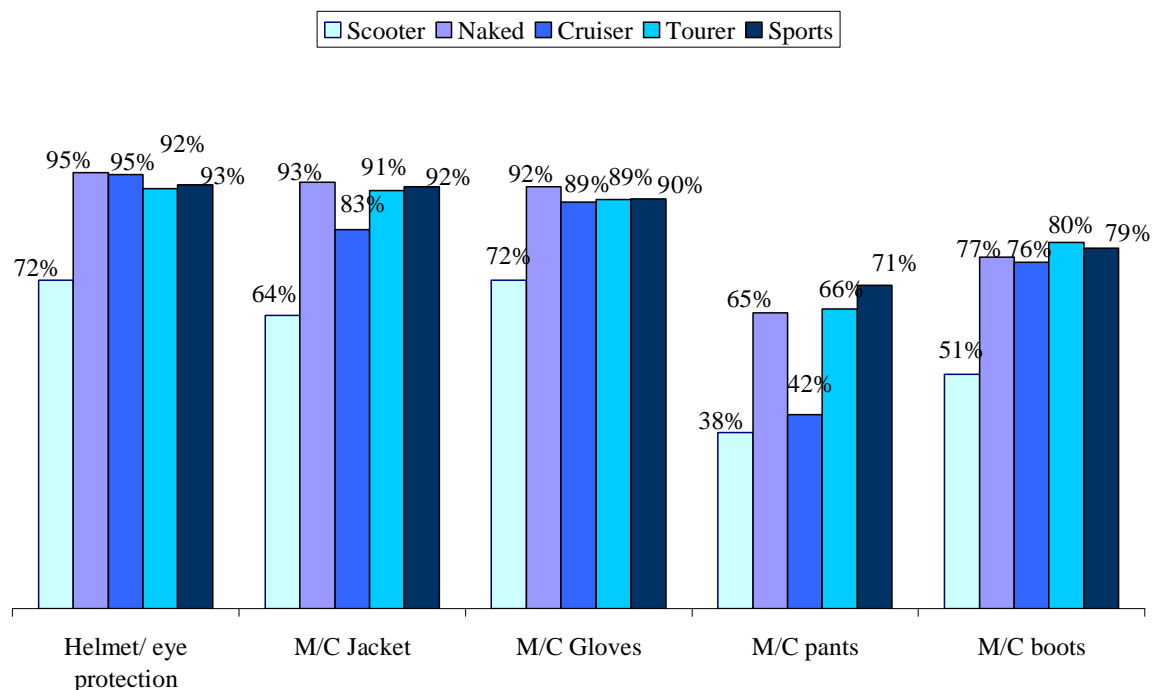


Figure 5 Protective clothing worn on last recreational ride.

2.5.2 Observational study of protective clothing on Mt Nebo, Brisbane

A team from CARRS-Q conducted an observational study of the use of protective clothing by largely recreational riders on Mt Nebo, west of Brisbane on a weekend in late October 2005 (Wishart, Tunnicliff, Watson & Schonfeld, 2005). The majority of the 118 motorcycles were high capacity sports bikes.

All riders wore helmets (mostly full face), but almost one quarter (22%) of motorcyclists were not wearing any protective gloves. Overall, 83% of riders were wearing some form of appropriate safety clothing on their upper body, either a leather jacket or a motorcycle jacket specifically designed as protective apparel. In contrast to the high proportion of motorcycle riders wearing motorcycle appropriate protective clothing on the upper body, almost three quarters of the motorcycle riders were wearing only jeans, shorts or street trousers on their lower body. Approximately two thirds of riders observed were wearing motorcycle or leather boots. Although no riders were observed wearing thongs or sandals, 34% were wearing joggers or street shoes.

Pillions showed helmet use similar to riders, but were less likely to be wearing gloves, especially full gloves. Only 9 of the 14 pillions wore some form of motorcycle protective apparel on the upper body with either a leather jacket or motorcycle specific clothing, although they were less likely than riders to wear leather, while 5 pillions wore no jacket or a tracksuit type garment. Twelve of the 14 pillions wore jeans. No pillions wore motorcycle specific protective clothing on the lower body. Only 2 pillions wore motorcycle appropriate boots, while 12 pillions wore joggers, sandals, or street shoes.

2.5.3 Conclusions from Australian studies of use of protective clothing

Australian riders show a very high level of wearing of motorcycle helmets, but are less likely to protect other parts of their bodies. Motorcycle pants and boots were used

considerably less often than jackets. Yet in 1993, the European Experimental Vehicles Committee recognized that the legs are the area most frequently injured in a motorcycle crash (EEVC, 1993). Similar patterns of injury by body part have been documented by a range of crash studies in the USA, UK and Germany (Hurt et al, 1981; Craig et al, 1983; Schuller et al, 1986; Otte & Middelhaue, 1987).

Figure 6 illustrates a comparison of the distribution of rider injuries in 1987 (Otte & Middelhaue) with that of the recent MAID Study (ACEM, 2004). It reveals a remarkably consistent pattern despite changes in vehicle and equipment safety in the intervening decades.

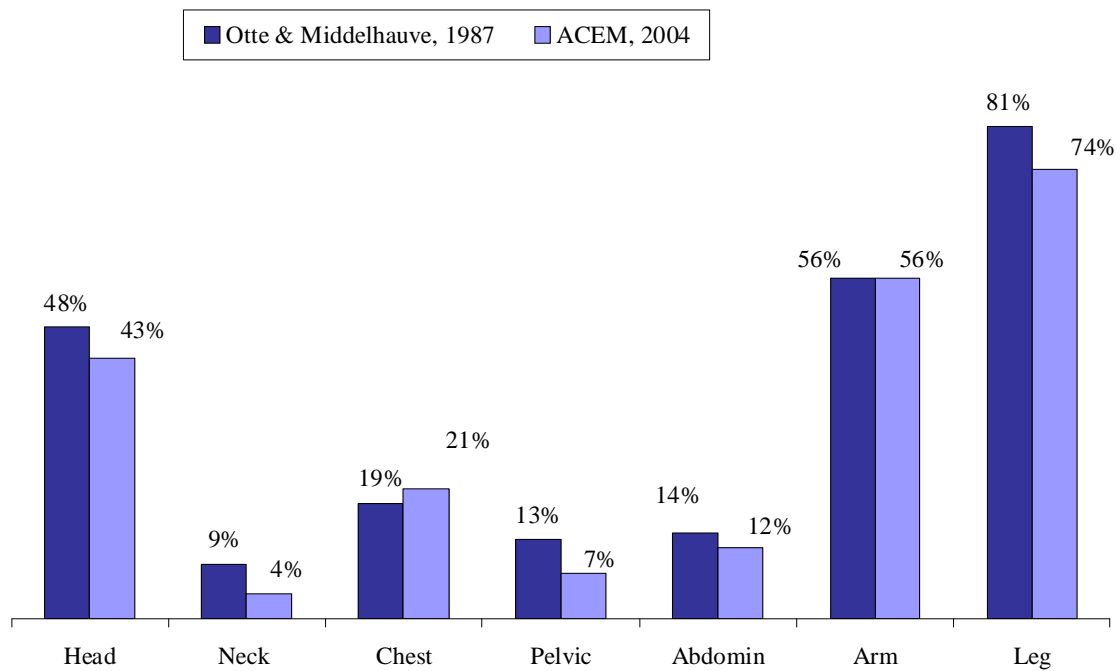


Figure 6 Motorcycle injury patterns 1987 vs 2004.

Despite such patterns having been long established by crash researchers, this information does not appear to have filtered through to riders. Although the research demonstrates that the legs are the area most at risk in motorcycle crashes, it is their legs that are least likely to be protected by rider.

The reasons many riders do not wear appropriate protection, particularly on their legs, is not clear. However, it may also be due to the way the motorcycle industry promotes different images of riders. Motorcycle clothing tends to be designed to suit particular styles of motorcycle and therefore specific sectors of the motorcycle market. An informal review of advertisements for motorcycle apparel in Australia suggests that the motorcycle clothing market is segmented for different styles of road riding. Clothing that is promoted as providing injury protection tends to be styled in the image of the race track and is aimed at sports bike riders. Clothing that provides protection from the elements tends to be touring oriented. There is relatively little motorcycle protective clothing that is suitable in terms of fashion or convenience for general road riders, cruisers, commuters or scooter riders (de Rome & Stanford, 2006).

2.5.4 What is being sold?

Discussions with motorcycle apparel importers and distributors confirmed the finding of the studies discussed earlier that trends in sales for various products reflect the particular market segment that individual distributors are targeting. For example, some riders appear to be highly image conscious and new products must therefore endeavour to incorporate safety and image for this market (Heath, personal communication).

Traditional leather is favoured by some riders where the traditional rider image is important and uptake of relatively new materials such as Kevlar lined pants is slow compared to sales for leather jackets, boots, and gloves. In contrast, other market segments have a high demand for new materials. Such products as textile jackets that are specifically developed for hotter climates are in popular demand in Northern regions of Australia (Moto National, personal communication). Materials such as DuPont's "Cool Max" (a phase change material) used in the lining of jackets target this 'summer jacket' market.

Mesh jackets are also being sold for summer riding but these have not been tested for abrasion and cut and tear resistance. There are anecdotal concerns that mesh may weld to the skin under the extreme heat engendered by the friction in sliding along the road surface.

Motorcyclists are not a homogeneous group and different rider groups (e.g. sports bike riders compared to cruiser riders) are likely to vary in the extent to which they wear protective clothing and the types of protective clothing they wear. The review sought to identify particular groups where targeted initiatives could be most beneficial (or where the emphasis in promoting protective clothing might need to be tailored to the group e.g. scooter riders). One of the major issues in the market is the lack of provision of protective clothing that is perceived to suit some styles of riding. The issue of fashion is not entirely trivial. Motorcycle clothing can be very expensive and one of our objectives with this project is to try to help riders distinguish between clothing features that are just fashion and those that have some genuine protective merit.

3. STANDARDS AND GUIDELINES FOR MOTORCYCLE PROTECTIVE CLOTHING

This section describes the Cambridge Standard which was the precursor of the European Standard, the European Standard and then, based on the findings of the literature review and consultations outlined in the previous section, reviews the Standards Australia guidelines handbook. The review addresses the findings of updated technologies or products since its publication in 2000 and its potential future role in relation to systems for providing information about the performance of motorcycle protective clothing that may be developed as part of this project.

3.1 THE CAMBRIDGE STANDARD, ISSUE 2, 1999.

The Cambridge Standards was developed by Dr Roderick Woods and formed the basis of the subsequently adopted European Standards. The Cambridge Standard provided three levels of test severity in order to place garments into one of four performance categories relating to risk assessments.

The performance categories were:

Inadequate Performance. Where clothing did not meet Performance Level 1 in one or more tests. Such clothing is considered not adequately protective for riders of any powered two wheeler.

Low Performance. Clothing meeting at least Performance Level 1 in all tests is considered to meet the criteria for low performance. Such clothing would be intended to give some protection in low speed accidents whilst having the lowest possible weight and ergonomic penalties associated with its use. This clothing is considered more suitable for use on mopeds/ scooters than on larger motorcycles.

Normal Performance. Clothing would be required to meet at least Performance Level 2 on all tests in order to be considered suitable for normal performance use. Such clothing is intended to provide adequate protection in typical 30 mph accidents. Such clothing would not be expected to be reusable after a high speed crash, but would be adequate for most riders on the public roads.

High Performance. Clothing meeting at least Performance Level 3 on all tests would be considered to have met the criteria for high performance use. This would equate to a high level of protection in high speed road surface impacts and would be expected to be reusable following inspection and repair after most accidents. There may be heat, weight and movement restriction penalties incurred in this level of protection.

The test requirements for the Cambridge Standard are summarised in Table 1.

Table 1 Test specifications for motorcycle jackets and trousers or one piece suits for the Cambridge Standard.

	Zones 1 and 2	Zone 3	Zone 4
Abrasion resistance	Seconds	Seconds	Seconds
Level 1	4.0	1.8	1.0
Level 2	7.0	2.5	1.5
Level 3	12.0	4.0	2.5
Maximum knife penetration*	Millimetres (drop height 400mm)	Millimetres (drop height 200mm)	Millimetres (drop height 200mm)
Level 1	25	30	35
Level 2	15	25	30
Level 3	10	20	25
Minimum burst strength	kPa	kPa	kPa
Level 1	700	500	200
Level 2	800	600	200
Level 3	1000	800	500

* Note: In impact cut testing, the less the penetration of the blade, the higher the performance of the specimen.

For the linings, the minimum mean bursting strength is 200 kPa for all zones and levels. For the impact energy transmission test, the mean of the peak transmitted forces shall be below 25 kN, with no single value above 37.5 kN. The impact energy in joules is 40 J for Level 1 and 2 and 60 J for Level 3.

3.2 THE EUROPEAN STANDARDS FOR MOTORCYCLE PROTECTIVE CLOTHING

Under the European Directive on Personal Protective Equipment (1989) any clothing claiming to provide protection from injury must be tested and labelled as complying with the relevant standard. This applies to all safety equipment not just for motorcycle apparel. Under the directive, a product can only be described as “protective” if it provides protection from injury, the term cannot be applied to products that provide protection from the weather.

The European Directive became law in 1989, but it took some time for the standards for motorcycle clothing to be developed. The first standard to be issued for motorcycle gear was for impact protectors, which was released in 1997 (EN 1621-1). Standards have since been issued for gloves (EN 13594), boots (EN 13634), jackets and pants (EN 13595 Parts 1 – 4) in 2002 and lastly for back protectors (EN 1621-2) in 2003. Each has a different number and clothing that complies must have been tested and labelled with the CE mark and the appropriate standards number.

The development of the Standards has provided objective tests for measuring the protective performance of motorcycle clothing products.

The tests are largely based on the work of Roderick I. Woods who published a specification for motorcycle protective clothing in which he defined the injury risk and protection requirements for each part of the body (see Figure 7). This was based on the analysis of 100 crash damaged motorcycle suits, and the resulting specifications tested on a dummy in simulated crash incidents (Woods, 1996a & 1996b).

- Zone 1 High risk - needs impact protectors & high abrasion resistance
- Zone 2 High risk - needs high abrasion resistance
- Zone 3 Moderate risk - moderate abrasion resistance
- Zone 4 Relatively low risk.

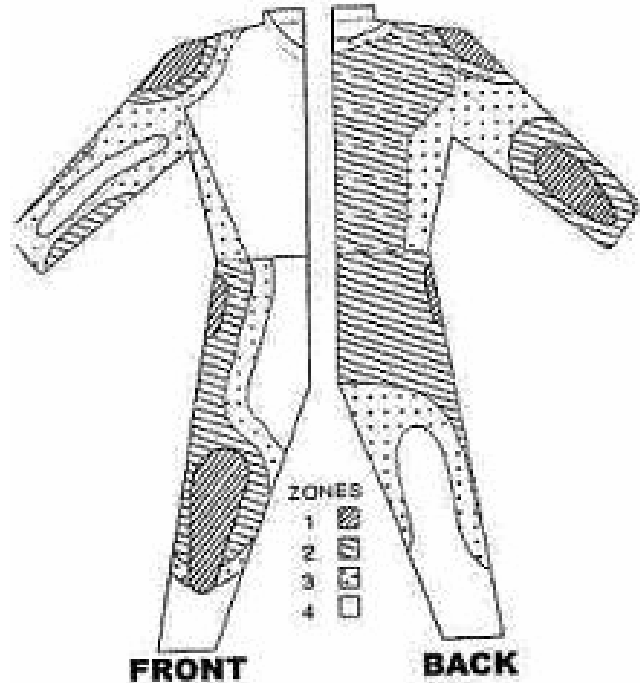


Figure 7 Injury risk zones (Woods, 1996)

The Standards specify the test process and equipment upon which they must be performed. The tests measure performance in relation to two levels of performance. The two levels are specified for clothing providing protection against road impacts.

Level 1: Clothing designed to give some protection whilst having the lowest possible weight and ergonomic penalties associated with its use.

Level 2 clothing providing a moderate level of protection, higher than that provided by level 1. There are however, weight and restriction penalties in providing this level of protection.

The requirements for performance in the impact abrasion, impact cut and burst strength, are higher for level 2 than for level 1; however the requirements for tear strength and impact resistance are the same for each level. The standards also include detailed requirements as to the placement of impact protectors and the fit and ergonomics of the whole garment.

Table 2 provides the minimum requirements for abrasion, impact cut and burst resistance under the EU standards for motorcycle jackets and trousers or one piece suits. For example, Level 1 requires a minimum abrasion resistance of 4 seconds in Injury Risk Zones 1 and 2, 1.8 seconds in Zone 3 and 1.0 second in Zone 4.

The standards for motorcycle gloves, boots, impact protectors and back protectors provide similar levels of detailed requirements.

Table 2 Test specifications for motorcycle jackets and trousers or one piece suits (EN 13595-1:2002)

	Zones 1 and 2	Zone 3	Zone 4
Abrasion resistance	Seconds	Seconds	Seconds
Level 1	4.0	1.8	1.0
Level 2	7.0	2.5	1.5
Impact cut resistance	Seconds	Seconds	Seconds
Speed of knife	2.8	2.0	2.0
Maximum knife penetration*	Millimetres	Millimetres	Millimetres
Level 1	25	30	35
Level 2	15	25	30
Minimum burst strength	kPa	kPa	kPa
Level 1	700	500	200
Level 2	800	600	200

* Note: In impact cut testing, the less the penetration of the blade, the higher the performance of the specimen.

3.3 A COMPARISON OF THE STANDARDS AUSTRALIA GUIDELINES AND THE EUROPEAN STANDARD

The Standards Australia Guidelines and the European Standards can be compared in terms of:

- The scope of items covered
- Structure in terms of levels and zones (only for pants/jackets/suits)
- Voluntary/mandatory
- Test procedures

3.3.1 Scope

The Standards Australia s ‘Motorcycle protective clothing: Guidelines for manufacturing’ apply only to clothing. The Guidelines drew on the Cambridge Standard which also provided the basis for EN 13595 Parts 1-4. However, there are additional European Standards that apply to gloves (EN 13594), impact protectors (EN 1621-1 and boots (EN 13634).

The Guidelines do, however, include tests of the suitability of the clothing for various weather conditions and discuss issues related to testing for thermal comfort which are not specifically included in the European or Cambridge Standards. The Guidelines also include

tests of durability which are quality rather than safety issues, but the durability of zip fasteners is also covered and that is a safety issue (Reference AS 2332 specifications for slide fasteners).

The weather protection tests proposed are:

AS 2001 Methods of tests for textiles. This standard covers a range of relevant tests.

AS 2001.2.17 Determination of resistance of fabrics to water penetration – Hydrostatic pressure test (This tests fabrics and seams resistance to water penetration)

AS 2001.2.16 Determination of water repellency of textile surfaces – Spray rating. (This test wet pick up of fabric, refers to the amount of moisture a material retains after wetting.)

ISO 11092 Textiles – Physiological effects. Measurement of thermal and water vapour resistance under steady state conditions (sweating, guarded hotplate test). Resistance to Evaporative Heat Transfer. This is the breathability (moisture vapour transmission) of a garment or fabric.

While the Guide discusses options for testing heat exchange it does not suggest any means nor refer to any existing standards.

There are four European Standards that relate to suitability of protective clothing for certain weather conditions but which are not specifically mentioned in relation to motorcycle protective clothing:

EN 342:2004 "Protective clothing - Ensembles and garments for protection against cold" Note definition of 'cold' is: *"environment characterized by the combination of humidity and wind at air temperature below - 5 degrees C"*.

EN 343:2003 "Protective clothing - Protection against rain" Note: uses the hydrostatic head test, plus a method for assessing moisture vapour permeability.

EN 14058:2004 ""Protective clothing - Garments for protection against cool environments" Note: definition of 'cool' is: *"environment characterized in general as a possible combination of humidity and wind at temperatures of - 5 degrees C and above"*);

EN 14360:2004 "Protective clothing against rain - Test method for ready made garments - Impact from above with high energy droplets".

3.3.2 Structure in terms of levels and zones

The European Standards specify the test process and equipment upon which they must be performed. The tests measure performance in relation to two levels of performance. The two levels are specified for clothing providing protection against road impacts.

Level 1: Clothing designed to give some protection whilst having the lowest possible weight and ergonomic penalties associated with its use.

Level 2 clothing providing a moderate level of protection, higher than that provided by level 1. There are however, weight and restriction penalties in providing this level of protection.

The Australian Guidelines consider the levels of protection in terms of four “end use categories”:

- A Strong enough for racing
- B Strong enough for sports road riding
- C Strong enough for commuting
- D Not strong enough to offer crash protection

3.3.3 Voluntary/mandatory

The Standards Australia Guidelines are not compulsory for manufacturers to follow and there is no requirement for marking the garments that comply with the Standard.

The European Standards are mandatory for manufacturers if they wish to claim that their equipment is “protective”. However, many manufacturers are in direct violation of the Standards because they claim their equipment is protective but have not had the items tested and they are not marked with the CE mark to identify their compliance with the Personal Protective Equipment Directive. Other manufacturers carefully word their claims to imply that there is a likely reduction in injury to riders wearing their equipment but refrain from using the word “protective” and have not had the items tested against the relevant Standard.

3.3.4 Test procedures

The test procedures in the Australian Standards’ Guidelines were selected from according to the tests that were available locally, rather than those specified in the European Standard EN 13595.

The abrasion test in the Australian Guidelines has been discredited as providing an appropriate basis for assessing abrasion resistance for motorcycle clothing. The Martindale test apparatus provides a low speed multi-directional abrasion under pressure. The system does not allow for the effects of friction induced heat which may, for example, melt some fabrics or yarns. Nor does the repeated movement over the abrading source allow for the effects of clogging, which would not occur in a real world slide across a road surface. These factors are accounted for in the testing methods specified under the EU Standards. The Martindale test was selected for pragmatic reasons because unlike the EU test apparatus, it was available in Australia at the time. There is now a testing facility in Sydney that has costed and is considering installation of the approved testing apparatus.

3.4 RECENT AUSTRALIAN MOVES TO A VOLUNTARY INDUSTRY STANDARD

Some headway has already been achieved with the motorcycle apparel industry in Australia through an industry seminar funded by the Motor Accidents Authority in NSW and coordinated by the Motorcycle Council of NSW (MCC) (de Rome, 2005).

The seminar, named **Gearing Up: A seminar on Motorcycle Protective Clothing** was designed to inform the industry on motorcycle protective clothing and consumer protection in Australia. It complemented an earlier MAA funded project for the MCC to produce a

web based consumer's guide to promote the use of protective clothing by motorcycle riders.

The primary objectives were to:

- A. Raise awareness of the features of effective motorcycle protective clothing.
- B. Explore the options and gain broad support for establishing a process for ensuring motorcycle protective clothing sold in Australia is demonstrably fit for purpose.

The short term objectives were to:

1. Inform the industry and other stakeholders of the MAA funded research findings on motorcycle protective clothing.
2. Alert industry to the requirements of the EU standards for motorcycle protective clothing and the implications for the Australian market of the EU standards.
3. Engage industry support for the development of a means of achieving consumer protection in Australia for motorcycle protective clothing by way of a code of practice, standards or other means.

The seminar was attended by a representative range of stakeholders including all key manufacturers, importers, distributors and major retailers of motorcycle protective clothing. The seminar achieved a general consensus of agreement:

1. To develop an industry regulated system for ensuring motorcycle protective clothing sold in Australia is fit for purpose.
2. To use the EU standards for motorcycle protective clothing as the basis of a voluntary standard.
3. To devise an industry code of practice for the application of the standard.
4. To develop an ongoing independent process for the verification of product performance standards.
5. To create a new class of products in the market place that are verified as meeting performance standards based on the EU standards.

A working party of industry and rider community representatives was nominated to undertake the establishment of a motorcycle clothing industry association to establish the system and supporting processes. The FCAI have undertaken to provide administrative support for the working party.

The members of the working party are:

Industry sector	Representative
Industry Association	Ray Newland, Manager, Motorcycle Affairs, FCAI
Riders	Guy Stanford, Chairman, Motorcycle Council of NSW
Retailers	Greg Byrnes, Manager, Motorcycle Accessories Warehouse
Importers/ agents	Chris Mooney, NSW State Manager, Monza Imports
Off shore manufacturers	Rob Casson, Managing Director, Cassons
Local manufacturers	Grant McIntosh, Managing Director, Draggin Jeans
Research	Liz de Rome, LdeR Consulting

Progress to date has focussed on the development of a draft structure for the proposed industry association. This draft has been circulated to all seminar participants for comment and approval. The next stage requires the commitment of funds and may be most likely to go forward if some support is obtained from government sources.

3.5 CONSUMER TESTS BY RIDE MAGAZINE

The UK motorcycle magazine, Ride, conducts and publishes consumer tests on motorcycle jackets, pants and suits, on motorcycle boots and on motorcycle gloves.

3.5.1 Consumer tests for motorcycle jackets, pants or suits

The description of the testing and how the results are reported below is based on an article in Ride magazine written by Mr Tony Hoare in October 2005 (p.81).

The results of testing are reported as a 50 word review with separate scores for Abrasion out of 15, Burst out of 10, Impact out of 10, Warmth of 10 and Waterproofing out of 10. Total possible score is 55. The tests for abrasion, burst and impact comply with the applicable European Standards procedures.

1. Thermal test

To test the thermal qualities the test suits are put on a sensor-covered dummy, then placed inside a large freezer set to minus 20°C. After ninety minutes, the amount and rate of temperature loss is recorded. Jackets and pants are ranked separately into three groups according to results. The warmest jackets or pants are given a score of five, the next group are scored three and the lowest received two. The total maximum score for a suit is 10.

2. Waterproof test

The suits are worn by a tester who is also wearing winter gloves and boots. They are then subjected to a five minute dousing with a pressure washer and any leak noted. Marks were awarded out of 10.

3. On the road

Suits are provided to road testers who score the suits for comfort and ease of use while riding.

4. Abrasion resistance

Three samples from each suit is tested on the abrasion rig specified in EN 13595-2:2002 for impact abrasion. The rig impacts the sample against an abrasion belt at a controlled amount of force and then measures the time it takes to wear through. Samples that lasted seven seconds or more scored five out of five. Those that scored one and half seconds, scored 1 out of 5. Total possible score for a suit is 15.

5. Seams burst

Using the rig specified in EN 13595-3:2002, seams strength is tested by clamping samples over a test rig containing a high pressure water balloon. The balloon is then inflated under the seam until the seam bursts. The rig measures how much force was required to burst the seam. The higher the pressure required, the higher the score achieved. Suits were scored out of 10.

6. Impact strength.

Using the impact strength test specified in EN 1621-1:1998, the shoulder, elbow, hip, knee and shin armour is tested to assess how much energy it absorbs. The test involves placing the armour over an anvil and dropping a striker onto it, using a standard amount of force each time. The anvil contains sensors to measure how much energy passes through the armour. Each sample is tested nine times with three strikes on each of three different areas. Under EN 1621-1:1998, the average force transmitted over the nine tests cannot exceed 35 kN and no single impact may exceed 50 kN. Armour that met this standard is scored two points. The total score for the impact strength of a suit is 10.

3.5.2 Consumer tests for motorcycle gloves

The description of the testing and how the results are reported below is based on an article in Ride magazine written by Mr Oliver Crick in April 2004 (p.54).

Test results are reported as a 50 word review with separate scores for Palm abrasion of 10, Knuckle impact out of 10, Seam strength out of 10, Wrist restraint out of 10 and Road testing out of 15. Total possible score 55. The tests for abrasion, burst and impact comply with the applicable European Standards procedures.

1. Abrasion resistance

The palm area of the glove is tested on the abrasion rig specified in EN 13594:2002 which is the same test rig as specified in EN 13595-2:2002. The rig impacts the

sample against an abrasion belt at a controlled amount of force and then measures the time it takes to wear through. Under EN 13594, gloves are required to last a minimum of 2.5 seconds. Any glove that fails to achieve 2.5 seconds is scored 0, others score higher the longer they lasted. The total possible score is 10.

2. Impact strength.

Gloves are tested to see how much energy they transmitted through the knuckles in an impact using the impact strength test specified in EN 1621-1:1998. The test involves placing the armour over an anvil and dropping a striker onto it, using a standard amount of force each time. The anvil contains sensors to measure how much energy passes through the armour. As with EN 1621-1:1998, the average force transmitted cannot exceed 4 kN. Gloves are scored out of 10.

3. Seams burst

Using the rig specified in EN 13595-3:2002, seams strength is tested by clamping samples over a test rig containing a high pressure water balloon. The balloon is then inflated under the seam until the seam bursts. The rig measures how much force was required to burst the seam. The higher the pressure required, the higher the score achieved. Seams are also subjected to a second test of a pulling force until either the stitches or the material tears. Gloves are scored out of 10

4. Wrist restraint

Straps are done up comfortably tight, then a digital balance is taped to the fingers and pulled to remove the glove. The balance records the separation force required to remove the gloves. The test is repeated three times for each glove. Under EN 13594, glove restraint systems are required to resist a force of 35 N to minimise the danger of being pulled off in a crash. Possible score out of 10.

5. Road testing

Gloves are road tested to check for feel and comfort. Testers check fit with leather sleeves and whether armour restricts movement. Each glove is worn well after its wearing-in point so it is not criticised for initial discomfort. Testers then complete a questionnaire so all gloves are assessed on the same criteria. Gloves are scored out of 15.

6. Colour-fastness

Gloves are tested for colour-fastness when wet according to ISO 11642. Gloves scoring 10 did not leak dye; nine means they lose just a tiny amount of dye. Gloves scoring four or less will stain the wearer's hands.

3.5.3 Consumer tests for motorcycle boots

The description of the testing and how the results are reported below is based on an article in Ride magazine written by Mr Tony Hoare in July 2005 (p.105).

Reported results are provided as a 50 word review with separate scores for Protection out of 40, Waterproofing out of 20, Warmth out of 10 and Road testing out of 20. Total possible score 90. Note the individual scores for abrasion resistance, impact, cut and crush

were also provided in a comparative table of all the tested boots. The tests for abrasion, impact, impact cut and sole crush comply with the applicable European Standards procedures.

1. Abrasion resistance

Two samples of the outer material is tested on the abrasion rig specified in EN 13634:2002 which is the same test rig as specified in EN 13595-2:2002. The rig impacts the sample against an abrasion belt at a controlled amount of force and then measures the time it takes to wear through. Under EN 13634, boot uppers are required to last a minimum of 5 seconds. The total possible score is 10.

2. Impact strength.

Boots are tested to see how much energy they transmitted in an impact using the impact strength test specified in EN 1621-1:1998. The test involves placing the armour over an anvil and dropping a striker onto it, using a standard amount of force each time. The anvil contains sensors to measure how much energy passes through the armour. As with EN 1621-1:1998, the average force transmitted cannot exceed 4 kN. The total possible score is 10.

3. Impact cut

This is conducted at a point on the inside of the leg, where the boots are considered to give the lowest level of protection. The samples are placed over a modelling clay base and a 1 kg mass, with a sharp blade is dropped on to the boot sample. The less penetration, the better. This test is according to EN 388:1994 as specified in EN 13634: 2002. The total possible score is 10.

4. Sole crush

Two different tests are carried out and the average of the scores taken. Test one simulates boots being crushed suddenly under a falling bike. The ball of the foot area of the boot is filled with modelling clay and then a 20 kg striker is dropped from a height of 1 metre. The amount of deformation in the clay is measured.

The second test requires the boots to be crushed between two parallel plates until they have deformed by 20 mm. The peak force required is measured to provide a score. Under EN 13634, transverse rigidity is required to be not less than 1.5 kN. The total possible score for the combined tests is 10.

5. Water proofing

A jet washer is used to drench boots for four minutes and any leakage on socks noted. A second test involves boots being soaked in ankle deep water for half an hour and any leakage points noted. These tests are more stringent than those required by EN 13634: 2002. Scored out of 10 for each test to a total possible score of 20.

6. Warmth

Each boot is filled with 4 kg of 3mm stainless steel ball bearings and exposed to -30°C conditions for 15 minutes. The temperature decreases in the foot area are measured

using temperature sensors, the lower the temperature drop, the better the insulation provided by the boots. Scored out of 10

7. Road testing

Boots are road tested to check for feel and comfort for hundreds of miles and then marked on comfort, feel and ease of use. They are scored out of 20.

4. CONSIDERATION OF A SAFETY RATING SYSTEM FOR MOTORCYCLE PROTECTIVE CLOTHING

This section discusses the issues related to consumer rating systems versus regulation as methods of achieving improved safety outcomes. It then discusses the relative merits of developing a star rating system for motorcycle protective clothing versus adopting (a perhaps modified version of) the European Standard for Personal Protective Clothing.

4.1 UNDERLYING CONCEPTS OF CONSUMER RATING SYSTEMS AND STANDARDS

Current consumer rating systems provide guidance to consumers on the relative performance of competing products, all of which are legally allowed to be sold and used. Examples include energy efficiency ratings for whitegoods and water efficiency ratings for plumbing fixtures, star ratings for accommodation and restaurants, the New Car Assessment Program (Australian, European and US variants), the Used Car Safety Ratings (Australian, European and US variants), and the Safe Tractor Assessment Ratings (STAR) system.

The concept of a rating system is to use consumer demand to promote sales of better-performing products, rather than by mandating a higher level of performance. In contrast, a standards based approach identifies a minimum acceptable level of performance for a particular product, often on a number of dimensions, and provides a way of identifying whether or not that product reaches this minimum level of performance. The pass/fail outcome in standards does not provide manufacturers with incentives to produce goods that exceed the standard or allow the public to choose the best performing products.

4.1.1 Regulatory framework

The establishment of a consumer rating system may require less evidence than is required to implement a mandatory standard. In addition, the evidence to support the nature and the need for a mandatory standard may be considerable to prevent the standard being challenged on the grounds of restraint of trade.

4.1.2 Updating standards and consumer rating systems

The characteristics of products change over time and so there is a need to update both standards and consumer rating systems periodically.

For whitegoods and for NCAP there has been the issue of how to change the rating systems as products improve in their performance. There are two general alternatives, to retain the original criteria but to add higher levels of performance and increased stars (e.g. move from 5-star to 6-star system) or to require higher levels of performance for a given star rating.

4.2 CHARACTERISTICS OF SAFETY RATING SYSTEMS

Safety rating systems (and other consumer advisory rating systems) can be classified on a number of dimensions:

- Does it apply to new or used or both?
- Is it predictive or retrospective?
- If predictive, is it based on inspection or on performance testing?
- Does it produce an indicator of overall safety performance or are there discrete indicators for particular dimensions?
- Are there particular dimensions where a failure means that the product is unsuitable?
- Does it replace or supplement regulatory standards?

There is generally a numerical score for each particular dimension that is then converted into a number of stars – so the stars are the way in which the outcomes of the rating exercise are conveyed to the public, rather than the way in which the ratings are conducted.

Requirements for a retrospective system – requires detailed information on the styles/makes/manufacturers involved in injury outcomes and this information is often not readily collected or accessible – also needs relatively large numbers for statistical purposes if this data is available

Should the design features in a rating system be confined to those that are currently available or those that are included in international standards or can they be extended to potential future features? Particularly if “there are serious injury issues that are not adequately addressed by current design features” (Day, Scott, Williams, Rechnitzer, Walsh & Boyle, 2005, p. 362).

4.2.1 Safe Tractor Assessment Rating System as an example

STARS was developed by a team from Monash University Accident Research Centre and the Kondinin Group, a farm safety organisation (Day et al., 2005). It is a predictive, design based system which assigns a score for various design features that control the injury risks associated with tractor use. STARS comprises nine major categories and on each category tractors receive a score ranging from zero stars for almost no inherent safety to five stars for the highest inherent safety. Some characteristics have been judged to make a tractor unsafe for use and thus there is an unsafe for use classification under each category. There is no overall, or total rating, because the relative importance of each of the nine categories will differ depending on the operational environment.

4.3 POTENTIAL CHARACTERISTICS OF A SAFETY RATING SYSTEM FOR MOTORCYCLE PROTECTIVE CLOTHING

Many of the issues discussed earlier in this section are relevant to the potential characteristics and usefulness of a safety rating system for motorcycle protective clothing.

4.3.1 Predictive or retrospective systems

The relatively poor data available about the real world performance of protective clothing in Australian crashes means that any safety rating system would need to be predictive, rather than retrospective. A predictive system is also potentially more useful for new technologies in that it does not require years of injury experience to be generated.

4.3.2 Assessment of safety performance for calculating ratings

The research suggests that the safety performance of motorcycle protective clothing cannot be assessed by inspection and requires testing of abrasion resistance, tear and cut resistance, burst strength, reduction of shear forces on body tissues and retention of the garment in the crash. Adoption of the tests used in the European Standard may be the most effective way to measure safety performance for most items of protective clothing. For some new technologies (e.g. airbag jackets), there may need to be dummy testing to fully capture any additional benefits that these items provide.

4.3.3 Dimensions of a potential rating system

Should any proposed rating system be solely restricted to criteria directly related to injury prevention (e.g. abrasion resistance, burst resistance of seams) or should some other criteria related be included? There is evidence that physiological stress including that caused by physical discomfort can have a detrimental affect on riders' attention contributing to fatigue, irritability and poor decision making (Woods, 1983, 1986).

In particular we know that riders admit to not wearing protective clothing in hot weather due to the perceptions of discomfort (Benton, 2002). Manufacturers are attempting to address this need and it would seem necessary for such factors to be included in a rating system. One example is the Halvarssons Safety Suit which is a textile suit that incorporates phase-change material (OUTLAST™) to reduce thermal discomfort. The Halvarssons suit is one of the few textile suits to pass the highest level of the European standards. This is due to its construction with an inner lining of Hi-ART, a new fabric which is a towelling-style polyester with high abrasion resistance. If garments that achieve the maximum number of stars are considered unwearable by riders, this is likely to detract from the credibility of the rating system.

If a rating system is to be developed, which items of clothing should be given priority in the development process? Should pants be given priority because of the large proportion of motorcycle injuries that occur to the lower limbs? Should boots receive a lower priority because currently the EU testing process is more expensive for boots than for other items of protective clothing? Or can the system be developed simultaneously for all types of motorcycle protective clothing? The disadvantage of giving priority to certain items of clothing in developing the system would be that it conveys the information that those items are considered more important than other items of protective clothing.

4.3.4 Safety rating systems or standards or both?

Safety rating systems and mandatory standards can co-exist. In the car safety domain, ANCAP and the Used Car Safety Ratings exist in addition to the Australian Design Rules. This is an example where the mandatory standard was considered to represent a level of performance that was unnecessarily low and a safety rating system was needed to provide more useful comparative information to consumers.

With regard to motorcycle protective clothing, the European Standards could be used as an anchor point for an Australian safety rating system. Under this concept, meeting the Level 1 requirement for the European Standards would be considered equivalent to a particular number of stars, while meeting the Level 2 requirement would be equivalent to another number of stars.

This would have the advantage of allowing protective clothing that had been tested and approved to European Standards to be rated for the Australian system without any further testing. Other manufacturers who did not wish to comply with the European Standard could have a star rating calculated for their products.

5. RECOMMENDATIONS

Based on the literature review and the review of current standards and guidelines, a set of recommendations were developed on the most effective systems for improving the information available to purchasers of motorcycle protective clothing. The recommendations cover:

- The models for the proposed system
- Potential criteria to be used for measuring safety performance
- The types of tests of protective clothing that would be required by the system
- Issues related to promotion of the system to riders (e.g. publicity, incentives, perceived value)

These recommendations have been developed with input from Mr Paul Varnsverry, the Technical Director of PVA Technical File Services Limited. Paul was a Member of the European Standards Working Group CEN/TC 162/WG9 and convenor of the WG9 project group responsible for drafting the European Standards for motorcyclists' protective garments (jackets, trousers, one and two-piece suits). Local industry consultation has not yet occurred, as it was considered that it might be unhelpful to solicit their feedback at this early stage, before consideration of the likely responses to the recommendations. However Ms de Rome's work with the industry group has informed this project with insight into the likely concerns and issues faced by manufacturers and retailers.

5.1 THE MODELS FOR THE PROPOSED SYSTEM

The proposed system needs firstly to ensure that the clothing will be effective in protecting from injury and secondly, to provide a mechanism for communicating the extent of protection to the consumer. Three alternative approaches were considered: mandatory standards, and two types of star rating systems - a voluntary industry program and an independently administered system.

This report does not recommend the introduction of mandatory standards for motorcycle protective clothing. Leaving aside the difficulty in introducing mandatory standards in Australia, it is considered that mandatory standards such as those in Europe are unlikely to bring about a marked improvement in motorcycle protective clothing without substantial allocation of resources to enforcement of the standard which has not occurred in Europe and is unlikely to occur in Australia.

The general characteristics of two proposed models star rating systems are outlined below. The criteria for awarding of stars are described in Section 5.2.

5.1.1 Model 1 – Voluntary industry star rating system

Model 1 is a voluntary star rating system (based on the criteria described later) where manufacturers or distributors can choose whether or not to participate. For participating manufacturers or distributors, the star rating would be displayed on a swing tag on the garment to provide the potential purchaser with information about specific items at the point of sale. It is assumed that manufacturers or distributors would send items for testing to local or international accredited testing facilities.

A system of random audits could be used to ensure the compliance of the items with the test procedures. A licensing fee associated with participation in the rating system could at least partly fund the compliance auditing. The options for auditors include an industry body, an independent auditing organisation or a consumer organisation. The identification of the most appropriate approach to auditing would be the subject of a later stage of this research program, if necessary.

The voluntary industry star rating system would require publicity to make motorcyclists aware of the system, explain how it works and encourage purchase of items with many stars (and discourage purchasing unrated items). The publicity would also encourage manufacturers/distributors to participate in the scheme.

This is the model currently being proposed by the industry working group under the auspices of the FCAI and MCC of NSW. It is proposed that it be an industry managed process, and that products once assessed would be listed on a website (potentially hosted by industry or MCC). The website would keep manufacturers and distributors honest by preventing any fraudulent labelling of products. It would also serve as an information source for riders seeking to identify products they can trust.

5.1.2 Model 2 – Independent star rating system

The second model is a system in which an accrediting body purchases and tests garments (as described in Section 5.2) and publishes the safety ratings on a website and in brochures etc. This would be modelled on the Australian New Car Assessment Program. Like ANCAP, it could utilise European findings where the same item is sold there.

Likely candidates for the accrediting body include independent auditing organisations, consumer organisations or a specialist body created by a consortium of organisations with an interest in reduction of injuries to motorcyclists. Identification of the most appropriate accrediting body would be the subject of a later stage of this research program, if necessary. It is assumed that the accrediting body would send items for testing to local or international accredited testing facilities.

While Model 2 would require significant input of resources from the accrediting body, it has several important advantages. It has the potential to avoid the problems that have arisen in Europe where many of the largest manufacturers have simply refused to comply with the European Standards.

With a funding base that is independent of industry, an independent star system may be more able than a voluntary industry standard to withstand pressure to water down the performance requirements for award of particular numbers of stars. Thus, the independent star system would potentially have greater safety benefits for motorcyclists.

5.2 POTENTIAL CRITERIA TO BE USED FOR MEASURING SAFETY PERFORMANCE

An example of such a star rating system for jackets, pants and suits is provided in Table 3. The example in Table 3 would allow items that had been tested to European Standards to fit into the star rating system without any further testing. The two star rating is broadly based on the requirements for EN 13595 Level 1 clothing, whereas the four star rating is broadly based on the Level 2 requirements. The five star rating is based on the requirements of Level 3 of the Cambridge Standard. The one star rating corresponds to the requirements for EN 13595 Level 1 clothing but for Zone 3 in that Standard. The three star rating is intermediate between EN 13595 Level 1 and Level 2.

The example star rating system in Table 3 is simplified because it does not set out different requirements for different zones of the garment.

Table 3 An example of allocation of stars based on test performance of Zone 1 sections of garment – for jackets, pants and suits.

Rating	Abrasion resistance of materials	Burst strength of seams and fastenings	Maximum knife penetration
0 Stars	<1.8 secs	< 500 kPa	> 30 mm
1 Star <i>(CE Level 1, Zone 3)</i>	≥ 1.8 secs	≥ 500 kPa	≤ 30 mm
2 Stars <i>(CE Level 1, Zones 1 and 2)</i>	≥ 4.0 secs	≥ 700	≤ 25 mm
3 Stars	≥ 5.5 seconds	≥ 750	≤ 20 mm
4 Stars <i>(CE Level 2, Zones 1 and 2)</i>	≥ 7.0 seconds	≥ 800	≤ 15 mm
5 Stars <i>(Cambridge Level 3, Zones 1 and 2)</i>	≥ 12.0 seconds	≥ 1000	≤ 10 mm

Under either Model 1 or Model 2, it is proposed that star rating would be based on safety performance, weather protection and ergonomic performance. It is considered that a star rating based solely on safety performance would be less useful to riders who are trying to choose the best equipment that they can afford. A disregard of weather protection (thermal control and waterproofing) and ergonomic performance (whether the rider can actually ride while wearing the product) could quickly damage the credibility of the star rating system as a useful guide for consumers. Protective clothing can only convey a benefit if it is worn

and it will be less likely to be worn if it is uncomfortable. As such, it is proposed that the weather protection and thermal comfort tests included in the Australian Standards Guidelines be incorporated as part of the star rating system.

5.2.1 Overall star rating or individual components?

One of the issues to be addressed in the next stage of this research is whether the star rating should be presented as an overall score, or whether riders should be provided with the star ratings for the individual criteria. The consumer ratings currently provided by Ride magazine present the scores on each criterion and a combined score which is the simple addition of all of the category scores (with the exception of dye fastness because this depends on the colour chosen).

If an overall star rating was chosen, then the way in which the results from the different tests would be combined would need to be considered. A stringent approach would be to base the star rating on the test with the lowest performance. Even if this stringent approach were not taken, it would need to be considered whether a fail - “no stars” - on a particular criterion should be an overall fail. If, for instance, a garment gained no stars for burst resistance, then perhaps it should have no stars overall.

The way in which the weather protection and thermal comfort tests included in the Australian Standards Guidelines would be incorporated as part of the star rating system would depend on whether there was an overall star rating or stars were awarded for individual components. For an overall rating, one option would be to subtract a star if these tests were not passed.

5.3 ISSUES RELATED TO PROMOTION OF THE SYSTEM TO RIDERS

It is apparent from the experience in Europe that a system for providing consumer information about the performance of motorcycle protective clothing may not receive the wholehearted support of the rider community and the motorcycle accessories industry. Although the Personal Protective Equipment (PPE) Directive has been in place since 1989, the issuing of the full set of standards for motorcycle apparel took over 14 years, with the final standard (EN 1621-2 for back protectors) issued in 2003. The extraordinary time delay in the issuing of the standards was largely due to the lack of cooperation from manufacturers compounded by the suspicions of the rider community.

5.3.1 Rider concerns

The standards were a contentious issue with many riders in Europe concerned that they would be used by authorities and insurance companies to set requirements for all riders. This is also a concern that has been expressed in Australia and will need to be addressed in order to persuade the rider community of the benefits of such a system.

In Europe rider groups only agreed to support the standards if leisure riders' clothing was specifically excluded, to prevent the standards from being used as the basis of further legislation to support compulsion. As a result the EU standards are expressed as being for “Professional riders”. This outcome was the result of significant work by members of the motorcycle community who recognised the benefit of establishing such standards. However, a separate item of European consumer safety legislation – the General Product Safety Directive 2001/95/EC (GPSD) – addresses the ‘migration;’ of professional use products into non-professional applications as follows:

“(10) Products which are designed exclusively for professional use but have subsequently migrated to the consumer market should be subject to the requirements of this Directive because they can pose risks to consumer health and safety when used under reasonably foreseeable conditions.”

Although we are unaware if this has been tested in a Court of Law, the GPSD does appear to negate the “Professional riders” scope of the European Standards for motorcyclists’ protective clothing.

At this point, relatively few of the European manufacturers have submitted their products for independent testing against the EU Standards, they are able to avoid the issue by carefully not mentioning safety or injury prevention in their advertising materials. However, this situation is changing as more riders are demanding quality control and verification that the protective clothing they buy is fit for the purpose. The substantial increase in the number of products that include CE marked impact protectors is evidence of this trend.

5.3.2 Promotion to increase rider awareness

There would be a need to promote the system to riders to improve rider awareness and understanding and to provide consumer pressure to encourage manufacturers to be involved. It is likely that the motorcycling press and the general consumer press would be willing to publish descriptions of the system and its results.

Less publicity would be needed if the ratings were provided on swing tags on the items (although explanatory brochures at retail outlets would be helpful) than if there was a rating system, but not display of the results on individual items.

A website may be a useful component of promoting rider awareness of the importance of motorcycle protective clothing and making riders aware of the relative performance of protective gear from different manufacturers.

5.3.3 Educating riders about when protective clothing is beneficial

Most riders’ experience of the potential benefits of protective clothing relates to watching motorcycle racing on television. There they see riders tumbling and sliding across the ground at high speed, with little apparent injury. This provides the misleading view that protective clothing is beneficial in high speed riding and, conversely, that it is less relevant to short, urban, low-speed trips. This is evident in the surveys of where riders use protective clothing. Yet the research suggests that the majority of motorcycle crashes occur at low speeds with impacts at between 30 and 45 km/h (ACEM, 2004; EEVC, 1993) and that much of the benefit of protective clothing occurs in these low speed crashes where there is no impact with a fixed object.

There is a need to educate riders about the benefits of motorcycle protective clothing in low speed crashes to increase wearing rates on short trips or trips that do not involve high speed riding to gain the largest benefit from improvements in protective clothing.

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