MOTOCAP

Test and rating protocols for the Motorcycle Clothing Assessment Program (MotoCAP)

November 2021 | Version: 1

Acknowledgements

The Motorcycle Clothing Assessment Program (MotoCAP) is managed by a consortium of government agencies and organisations from across Australia and New Zealand. The aim of the program is to reduce the risk and severity of motorcycle crash injuries by increasing the usage and effectiveness of motorcycle protective clothing. The objective is to create a well-informed rider market that will increase demand for garments that are protective and suitable for use in Australian and New Zealand climates. This in turn will encourage industry to invest in the production of such garments.

Led by Transport for NSW, the members of the MotoCAP Steering Group include:

- Accident Compensation Corporation (ACC), New Zealand.
- Australian Motorcycle Council
- Department of State Growth, Tasmania
- Department of Transport and Main Roads (TMR), Queensland
- Department of Transport, Victoria
- Insurance Australia Group (IAG)
- Lifetime Support Authority (LSA), South Australia
- Motor Accident Insurance Commission (MAIC), Queensland
- Road Safety Commission, Western Australia
- Royal Automobile Club of Victoria (RACV)
- State Insurance Regulatory Authority (SIRA), New South Wales
- Transport Accident Commission (TAC), Victoria

The test and ratings protocols for MotoCAP were developed by Liz de Rome and Christopher Hurren (Deakin University), Tom Gibson (Human Impact Engineering) and Paul Varnsverry (PVA-PPE Group).

The protocols describe the procedures for: testing and rating garments on injury protection and breathability based on those specified in the relevant industry standards, and for testing the performance of garments claimed to be water-resistant. The document also details the protocols and procedures to be followed for the test facility’s market surveillance and to ensure independent random sampling and purchase of test products from retail stores.

Contents

Author:	Liz de Rome (Deakin University), Christopher Hurren (Deakin University), Tom Gibson (Human Impact Engineering) and Paul Varnsverry (PVA-PPE
Date:	November 2021
Version:	1
Reference:	
Division:	
Review date:	

1 Introduction

The Motorcycle Clothing Assessment Program (MotoCAP) is the outcome of many years of research in consultation with riders and industry. Crash studies have established that motorcycle protective clothing can prevent or reduce the most common injuries sustained in motorcycle crashes.[1,2] However there is also substantial evidence that many products, sold as protective, may not be fit for purpose and could fail under crash conditions.[1,3] In addition, many jackets and pants are thermally unsuited for use in hot conditions.[4-7] The challenge for riders is to find effective protective clothing that is suitable for use in average Australian/ New Zealand summer conditions.

The aim of MotoCAP is to reduce the risk and severity of motorcycle crash injuries by increasing the availability of effective protective clothing and encouraging greater rider usage. Consultations indicate that market engagement would be more productive and cost-effective than regulation for achieving these goals.[8] The objectives are to:

- Enable riders to make well-informed decision about the gear they buy and wear, by
- Providing them with independent, scientific information on the protective and thermal management performance of motorcycle protective jackets, pants and gloves, thereby
- Creating an assured market for industry to invest in the production of garments that are protective and suitable for use in hot conditions, which in turn should
- Increase the supply of effective protective clothing for all motorcycle riders.

1.1 Overview of the MotoCAP Test Protocols

MotoCAP tests 10% of the motorcycle protective jackets, pants and gloves that are designed for on-road riding and currently available in the local market. The specific products to be tested each quarter are randomly selected by computer program from a database of all products available in the Australia and New Zealand retail markets.

Two or more of each product are required for testing and each must be purchased from different stores including at least one physical and one on-line retail outlet. Purchasing is conducted covertly so that neither retailers nor manufacturers are aware of their products selection.

The flowchart in Figure 1.1 illustrates the order of each stage in the MotoCAP process from selection of test products through documentation, testing and reporting.

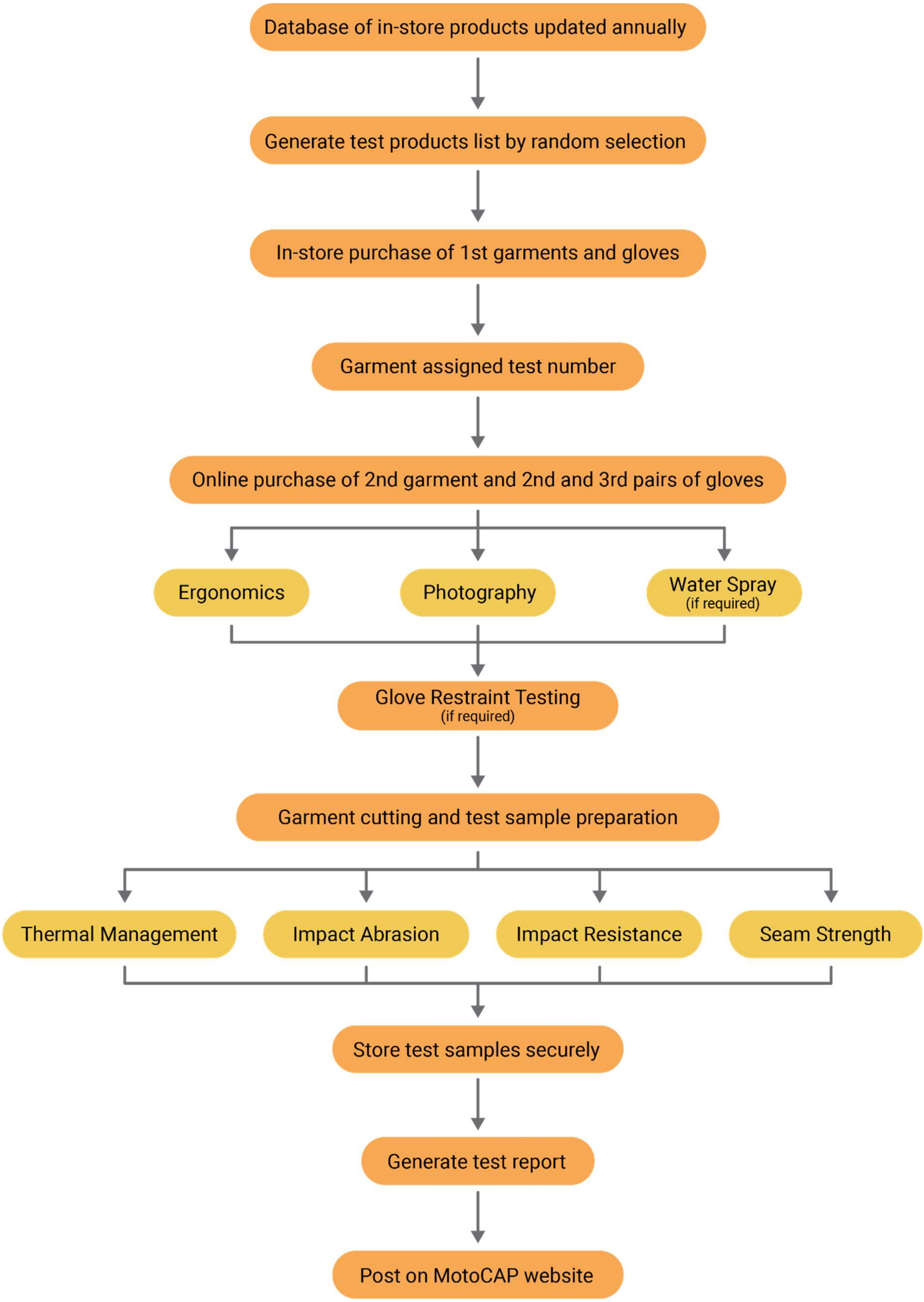

Figure 1.1 Sequence of the MotoCAP procedure for procuring, testing and rating garments

The European Standard (CE) certification process tests material samples prepared by the relevant manufacturer from pre-production material rolls. The MotoCAP program differs from this approach by testing samples cut from completed garments sourced from retail outlets. This approach does not change the validity of the test results but does ensure test samples represent the same products as are sold to riders.

Garments are tested and rated on two functions – injury protection and breathability – using test methods from the relevant industry standards. Garments, which are advertised as ‘water resistant’, are also tested for water penetration. Water resistance results are reported separately and not included in the rating for breathability, due to potential conflicts between achieving water resistance and user thermal comfort.

The test protocols were trialled over 12 months prior to the launch of the program, to refine and ensure they validly represented the relative performance of the garments tested. Results are reported on-line at **www.motocap.com.au** and **www.motocap.co.nz**. The protocols for the assignment of ratings are detailed in Section 2.

Section 3 describes the protocols for testing and rating jackets and pants for impact abrasion resistance, burst strength and impact protection.

Sections 4 describes the protocols for testing and rating jackets and pants on breathability by testing thermal and moisture vapour resistance to calculate their scores on the relative vapour permeability index.

Section 5 describes the protocols for testing and rating gloves for impact abrasion resistance, tensile testing of seams strength, glove restraint removal resistance and impact energy attenuation. Gloves are not currently tested for breathability.

Section 6 describes the procedure for assessing and rating water resistance for jackets, pants and gloves which the manufacturer has identified as being water resistant.

Section 7 describes the protocols used to randomly select the motorcycle protective jackets, pants and gloves to be tested from those available in the Australian and New Zealand retail market.

2 The ratings and allocation of stars

Garments are rated on two functions: Injury Protection and Breathability.

2.1 Injury Protection – Jackets and pants

The ratings for Injury Protection are calculated from the weighted scores for impact abrasion (50%) impact protection (30%) and burst strength resistance (20%). The formula to calculate the injury protection scores from test scores is provided below (Formula 1). The protective performance level corresponding to each star rating is presented in Table 2.1.

Formula 1. Calculating the Injury Protection Score

$$\text{Injury protection score} = (0.5 \times \text{ARS} \times 10) + (0.3 \times \text{IPS}) + (0.2 \times \text{BRS}/20)$$

Where:

- ARS is the abrasion resistance score for the garment,
- IPS is the impact protection score, and
- BRS is the burst resistance score.

Scores on each criteria are ranked from 1-10.

If any of the individual criteria (AR, IP or BR) are ranked 3/10 or lower, the garment cannot exceed a two-star protection rating.

Table 2.1 Performance level requirements for the Injury Protection rating – Jackets and pants

Star rating	Protection scores
★★★★★ (5)	> 64.0
★★★★ (4)	63.9 – 52.0
★★★ (3)	51.9 – 40.0
★★ (2)	39.9 – 28.0
★ (1)	27.9 – 13.5
½★ (½)	< 13.5

2.2 Breathability – Jackets and pants

The ratings for breathability are based on the garment's ability to allow heat and moisture vapour (sweat) to pass through the material layers to the external environment. The ratings are based on tests of dry heat resistance and moisture vapour resistance to calculate scores on the relative vapour permeability index (I_{mt}) on a scale of 0.0 – 1.0 (ISO11092:2014). The formula for the calculation of the breathability score from the test scores is provided below (Formula 2). Table 2.2 shows the cut off points for the breathability ratings of the garment. The full procedure is detailed in Section 4.

The breathability rating is based solely on the thermal management properties of the garment materials. The contribution of design features such as vents are not included in the assessment due to a lack of appropriate mechanisms to consistently rate such features. These design features are noted in the test reports and are visible to consumers to assess for themselves.

Formula 2. Calculating the Breathability Score.

$$\text{Breathability score } (\mathrm{I_{mt}}) = \left(\mathrm{R_{ct}}/\mathrm{R_{et}}\right) \times \mathrm{S}$$

Where:

- I_{mt} is the relative vapour permeability index,
- R_{ct} is the thermal resistance,
- R_{et} is the moisture vapour resistance and
- S is a constant (=60Pa/K).

Table 2.2 Distribution of ratings based on Breathability scores- Jackets and pants.

Star rating	Breathability score (I_{mt})
★★★★★ (5)	> 0.65
★★★★ (4)	0.53 – 0.64
★★★ (3)	0.41 – 0.52
★★ (2)	0.29 – 0.40
★ (1)	0.16 – 0.28
⯨ (½)	< 0.16

2.3 Injury Protection – Gloves

Gloves are rated for injury protection but not breathability due to the difficulties of assessing the breathability of gloves. The injury protection ratings are based on the weighted scores for impact abrasion (50%), impact protection (30%) and seam strength (20%).

Formula 3. Calculating Glove Injury Protection Score

$$\text{Injury protection score } = (0.5 \times \mathrm{AR}_G) + (0.3 \times \mathrm{IP}_G/3) + (0.2 \times \mathrm{SSR}_G/5)$$

Where:

- AR_G the abrasion score for the glove,
- IP_G is the impact score rating, and
- SSR_G is the seam strength score.

If the score for any individual criteria (AR_G, IP_G or SSR_G) is 3/10 or lower, the garment cannot exceed a two-star protection rating. The values given in Table 2.3 provide the performance levels for the Injury Protection rating for gloves.

Table 2.3 Performance level requirements of the Injury Protection rating – Gloves

Star rating	Protection scores
★★★★★ (5)	> 5
★★★★ (4)	4 – 5
★★★ (3)	3 – 3.9
★★ (2)	2 – 2.9
★ (1)	1 – 1.9
⯪ (½)	< 1

2.4 General comments

Other ergonomic factors intrinsic to rider comfort including ventilation and water resistance, are also reported but not included in the breathability rating. This is to ensure that the risk of physiological heat strain is treated as a critical factor in rider safety because it is different to other causes of discomfort, which can be more easily addressed.

Most motorcycle protective garments are constructed with two or more layers of materials, each of which may perform a different function. The range of materials used may include leather, foam, membrane or textiles. All layers of material, as present in the complete garment, are tested together in all tests. The term ‘material layers’ and ‘material combinations’ are used to describe the combined layers of all material present at test sites within the garment.

3 Injury protection: test protocols for jackets and pants

3.1 Impact abrasion resistance – Ratings and test methods

3.1.1 The ratings procedure for impact abrasion resistance

The areas of the body that are most exposed to impact and abrasion risk and therefore require the greatest levels of protection are labelled as Zones 1 and 2 in Figure 3.1.[9]

In order to provide effective impact abrasion resistance, the garment must provide:

- High impact resistance in risk Zone 1,
- High abrasion resistance in risk Zones 1 and 2,
- Moderate abrasion resistance in risk Zone 3, and
- Low abrasion resistance in risk Zone 4, in addition to
- Appropriate stretch and ventilation to be comfortable for use in Zones 3 and 4.

The abrasion rating system measures the effectiveness of abrasion resistance in seconds (s) from the first point of impact to material failure (hole) at 28 km/hr. Test samples comprise all layers of material present in the garment as worn. In the rating scheme, different weights are assigned to scores from each risk Zone to allow for their different levels of risk. The objective is to encourage high abrasion resistant materials in the highest risk areas, where it will not significantly impact the functionality of the garment.

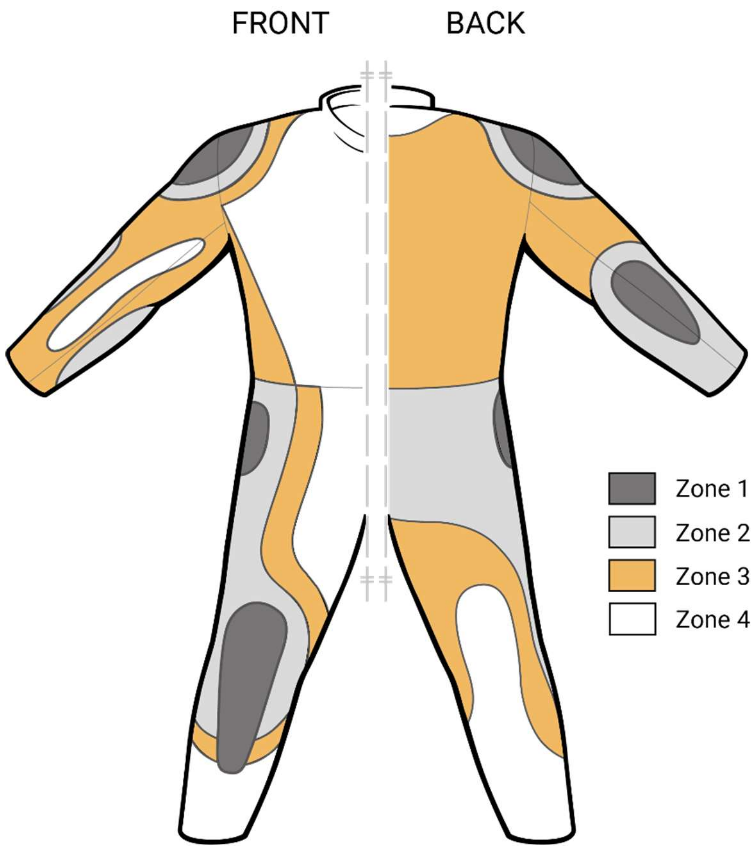

Figure 3.1 Injury risk zones diagram (EN 13595-1:2002)

The abrasion resistance rating for a garment is calculated in a series of stages as illustrated in Figure 3.2.

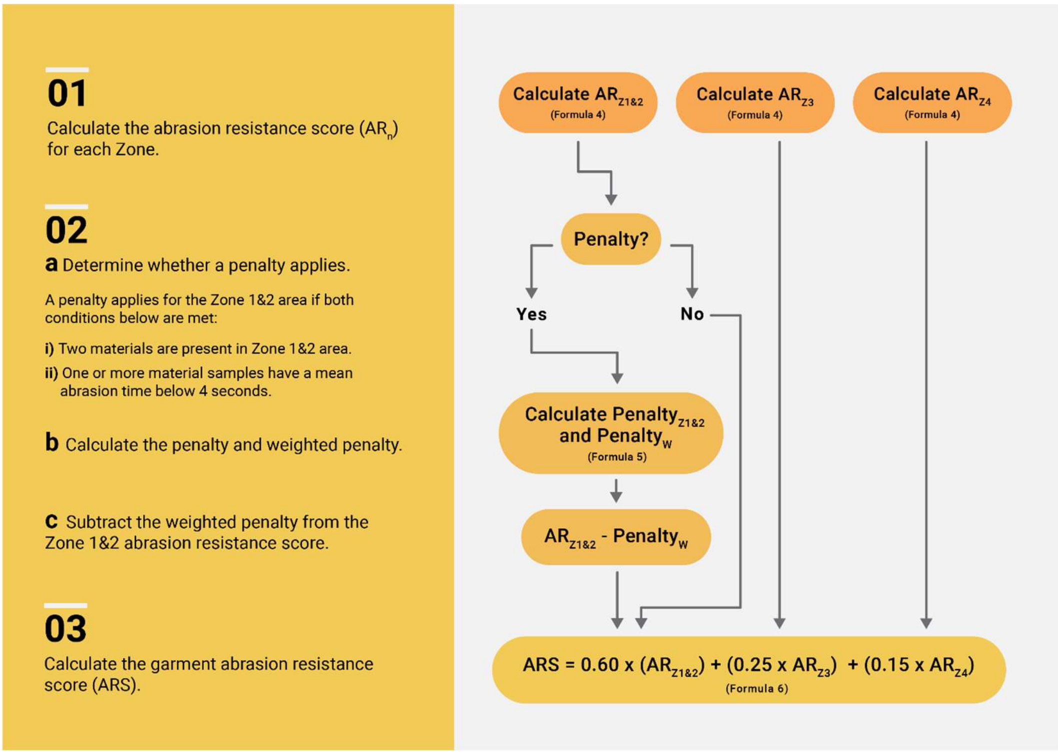

Figure 3.2 Illustration of the steps for calculating the Abrasion Resistance Score for jackets and pants.

Step 1. Use the Zone Equation (Formula 4) to calculate abrasion resistance (AR) for the material layers present in each Zone separately.

Where combinations of different material layers are present within a Zone, then six samples of each combination are to be tested. The results for each combination are then weighted according to the proportions of the zone area that is covered by each combination.

If more than two different combinations are present, then the scores of the two combinations representing the highest and lowest abrasion resistance are used to calculate abrasion resistance (Figure 3.3). The total areas of the third and additional combinations are combined and assigned the score of the lowest performing combination for calculating the abrasion resistance score.

Note: The Zone 1 and Zone 2 (Z1&2) areas are combined for testing and rating because they have the same abrasion resistance requirements.

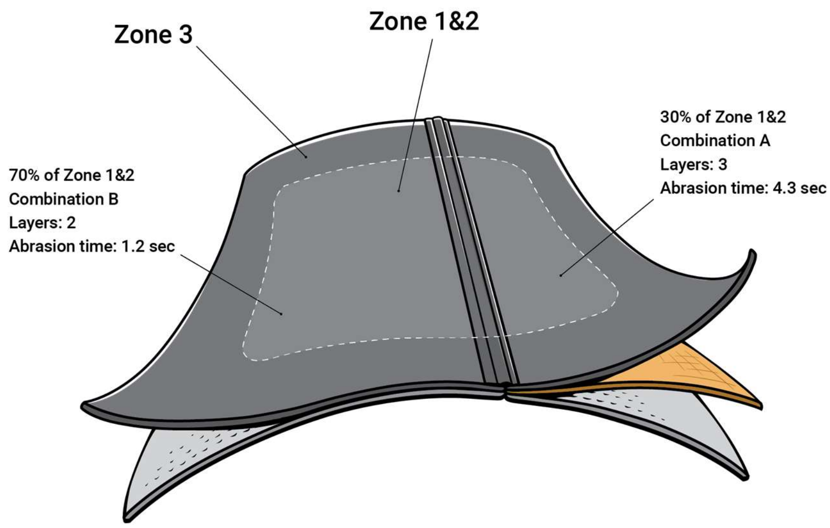

Figure 3.3 Illustration of two fabric combinations within the one Zone area.

Formula 4. Zone equation (Calculated for each Zone separately)

$$AR_{Zn} = \left(\mu_{Zn\ \mathrm{Abrasion\ high}} \times \%A_{Zn\ \mathrm{high}}\right) + \left(\mu_{Zn\ \mathrm{Abrasion\ low}} \times \%A_{Zn\ \mathrm{low}}\right)$$

Where:

- The Zone number (n) identifies the Zones; 1&2, 3 or 4,
- AR_{Zn} is the abrasion resistance for the Zone n area,
- μ_{Zn} Abrasion high is the corrected mean abrasion time in seconds for the higher protection level Zone n material tested,
- $\%A_{Zn}$ high is the percentage area of the higher protection level Zone n material tested expressed in decimals,
- μ_{Zn} Abrasion low is the corrected mean abrasion time in seconds for the lower protection level Zone n material tested, and
- $\%A_{Zn}$ low is the percentage area of the lower protection level Zone n material tested expressed in decimals.

The percentage area measure is expressed in decimals, for example an area of 61% will be expressed as 0.61. The percentage area of each combination of material layers in a Zone will have a value between 0 and 1. Where only one material combination is present, it is treated as the higher protection level material with a 100% (1.0) percentage area. The lower protection level percentage area will then be zero (0) providing a zero result for the lower protection level part of the equation.

Step 2 Determine whether a penalty should be applied for the Zone 1&2 area according to the following criteria.

A penalty applies to the Zone 1&2 abrasion resistance score if both of the following conditions are met:

- There are two or more material combinations used in the Zone 1&2 area, and
- One or more of the material combinations present in the Zone 1&2 area has an abrasion resistance time below 4 seconds.

The penalty is based on the proportion of the Zone 1&2 area covered by the material combination with the lowest abrasion scores and the difference between the highest and lowest abrasion levels of the combinations. The penalty is calculated with the following equation (Formula 5) and then subtracted from the overall abrasion resistance (AR) score for Zone 1&2.

No penalty is applied when there is only one material combination in Zone 1&2. The purpose of the penalty is to encourage full coverage with high abrasion resistant materials in Zone 1&2.

When more than two materials combinations exist within Zone 1&2, then the areas of the lower abrasion resistance materials are added together and assigned as the percentage area for Zone 1&2 low ($\%A_{Z1\&2\ low}$). The lowest mean abrasion resistance value of the lower abrasion protection materials in Zone 1&2 is used for the mean abrasion resistance low value ($\mu_{Z1\&2\ Abrasion\ low}$).

The penalty is only applied to garments where the lowest abrasion resistant material combination in the Zone 1&2 area has a mean abrasion resistance below 4 seconds. The penalty decreases as the low abrasion resistant material combination approach 4 seconds.

If a penalty applies it is calculated and weighted using the two formulas described in Formula 5 below. The weighted penalty is then subtracted from the Zone 1&2 abrasion score (AR) calculated previously in Step 1 using Formula 4.

Formula 5. Two steps calculating the Zones 1 and 2 abrasion penalty

$$Penalty_{\mathrm{Z1\&2}} = -2 \times \%\mathrm{A}_{\mathrm{Z1\&2}\ low} \times \left(\mu_{1\&2\ Abrasion\ high} - \mu_{\mathrm{Z1\&2}\ Abrasion\ low}\right)$$

$$Penalty_w = \mathrm{Penalty}_{\mathrm{Z1\&2}} \times \left(\frac{4 - \mu_{\mathrm{Z1\&2}\ Abrasion\ low}}{4}\right)$$

Where $Penalty_w$ is the penalty weight to be subtracted from the Zone 1&2 Abrasion Resistance (AR) score when more than one abrasion resistant material is used in the Zone.

Step 3 The Abrasion Resistance Score (ARS) is calculated by Formula 6 using the Abrasion Resistance (AR) scores for each Zone (Formula 4), where the AR for Zone 1&2 may have been modified by a penalty calculated by Formula 5.

Zones 1 and 2 are given a higher weighting in the final Abrasion Resistance Score (ARS) equation because they have the highest level of impact risk.[1] Zone 4 has the lowest weighting, as this area is least likely to be the location of abrasion injury. The lower risk exposure of Zone 4 allows the use of this area for comfort features such as stretch panels and venting.

Formula 6. Calculating the Abrasion Resistance Score

$$ARS = (0.60 \times \mathrm{AR}_{\mathrm{Z1\&2}}) + (0.25 \times \mathrm{AR}_{Z3}) + (0.15 \times \mathrm{AR}_{Z4})$$

Where:

- ARS is the abrasion resistance score for the garment,
- $AR_{Z1\&2}$ is the abrasion resistance of the Zone 1 and 2 area combined and calculated using the Zone equation (Formula 4) plus penalty where applicable (Formula 5),
- AR_{Z3} is the abrasion resistance of the Zone 3 area calculated using the Zone equation (Formula 4), and

- AR_{Z4} is the abrasion resistance of the Zone 4 area calculated using the Zone equation (Formula 4).

If the abrasion resistance score for either Zone 3 (AR_{Z3}) or Zone 4 (AR_{Z4}) is less than 0.6, then 6/10 is the maximum abrasion performance rank that the product can achieve. The values given in Table 2.1 provide the performance levels for abrasion resistance.

Table 3.1 Performance level requirements of the impact abrasion resistance rating

Performance rank (1-10)	Abrasion scores
10	> 7.2
9	6.4 – 7.2
8	5.6 – 6.3
7	4.9 – 5.5
6	4.2 – 4.8
5	3.5 – 4.1
4	2.8 – 3.4
3	2.0 – 2.7
2	1.3 – 1.9
1	< 1.3

3.1.2 Impact abrasion resistance – Test methods

The method for the measurement of impact abrasion resistance is a modified version of EN 13595-2:2002.[9] The CE certification process uses test samples of each material layer combination, which have been provided in flat sheets by the manufacturer. By contrast, the MotoCAP program uses test samples cut from finished garments bought from retailers. The source of test samples does not influence the accuracy of the test results. Harvesting test samples from completed garments increases the validity of test results, because they represent the products sold to riders. The following notes describe the process used to gather materials.

3.1.2.1 Test sample selection

The number of different material combinations and their percentage coverage (±5%) within each of the Zone 1&2, 3 and 4 areas are noted and recorded.

Impact abrasion resistance samples of each combination of different material layers are collected. Samples must represent every combination of materials in each panel of the garment with all layers of material present at the sampling point and excluding removable impact protectors.

Where possible, each impact abrasion resistance test sample should be 160 mm in diameter. The sample must contain all material layers present and held together in the orientation as found in the complete garment. Where samples of 160 mm diameter cannot be harvested, smaller samples of 20 mm x 40 mm may be taken and tested on the glove impact abrasion testing head (refer to Section 5).

Where a garment is constructed of a single material type across multiple Zones only one set of tests is required. However, the test samples should be from a number of different panels within the garment to ensure conformity of protection levels within the garment.

Where permanently fixed, hard impact protectors are present, they are allocated a nominal 10 second abrasion resistance time and their scores weighted according to their area coverage as a proportion of the Zone 1&2 template.

3.1.2.2 Sampling from jackets and pants

Textile motorcycle jackets and pants are often composed of two or three protective materials with varying abrasion resistance. In some cases, materials will cross Zone boundaries. Two of each garment shall be available for harvesting test samples, and samples shall be taken from each. There should be at least six (6) samples tested for abrasion resistance from the Zone 1&2 areas, six (6) from the Zone 3 and six from Zone 4.

If a second abrasion resistant material/materials combination is present in either Zone 1& 2, Zone 3 and/or Zone 4, then the abrasion resistance of both material combinations should be measured. Test samples shall be taken from several areas in the Zone 1&2 area to ensure conformity of protection levels within the garment.

Samples must incorporate all layers within the location and should be abrasion tested together in the same layer orientations as that in the garment. Abrasion test samples should not include seams or pockets or other decorative or additional surface features not consistent with all samples from that Zone. Figure 3.4 illustrates the locations from which samples should be harvested.

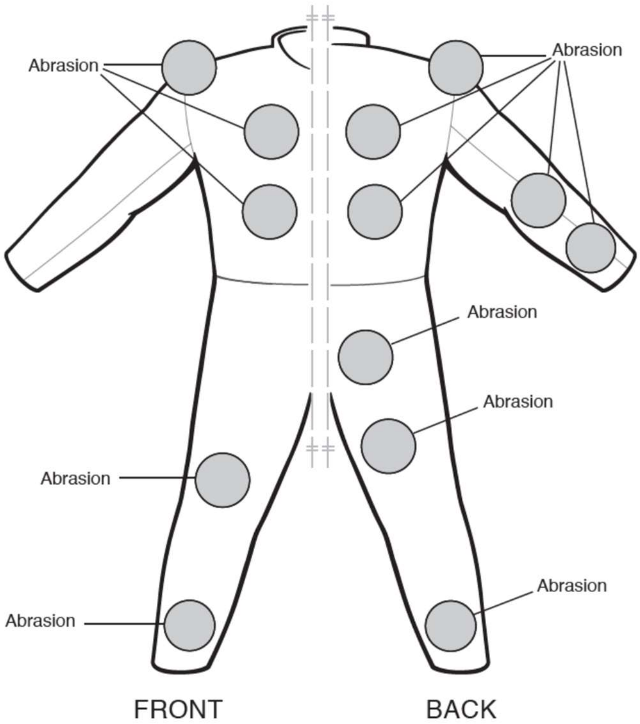

Figure 3.4 Locations of abrasion samples from upper and lower garments

Abrasion samples to be harvested from the lower garment

- Zone 1&2 area in the seat of pants
- Zone 1&2 area in front of knee
- Zone 3 area from above the knee on the back of the leg
- Zone 4 area below the knee on both the front and back of the garment.

Abrasion samples to be harvested from the upper garment

- Zone 1&2 area from the elbow
- Zone 1&2 area from the shoulder
- Zone 3 area from the body part of the back of the garment
- Zone 4 area from the body part of the front of the garment.

All locations in a Zone 1&2 area that have a different layer structure of materials to that of the remainder of the Zone 1&2 area, must also be tested in abrasion (e.g. mesh venting panels).

Samples shall include stretch panels as these can have significantly lower abrasion resistance.

3.1.3 Records for ratings calculations

The information required to calculate the impact abrasion rating is the mean abrasion time for each material combination and the percentage Zone coverage of each combination of material layers within that zone. Table 3.2 provides a simple format to log the test data as it is acquired.

Table 3.2 Data required to calculate the impact abrasion rating

Material type	Zone	Coverage of Zone (%)	Abrasion resistance per direction (s)	Calibration time (s)
	1&2 High		0° 0° 45° 45° 90° 90° μ_S	Before After μ_C
	1&2 Low		0° 0° 45° 45° 90° 90° μ_S	
	3 High		0° 0° 45° 45° 90° 90° μ_S	
	3 Low		0° 0° 45° 45° 90° 90° μ_S	
	4 High		0° 0° 45° 45° 90° 90° μ_S	

3.2 Ergonomic assessment – Test methods

Test garments must include at least one garment of size selected to fit the available male or female human test subject for the ergonomics assessment. The appropriate size to be determined in accordance with the manufacturer's sizing information. The ergonomic requirements of EN 13595-1:2002 must then be applied to ensure the garment fits the human test subject and does not introduce any hazards to the wearer. Provided the garment complies with ergonomic fit requirements, the impact protectors may then be tested for size, location and movement displacement.

The garment for assessment is inspected and details recorded in Table 3.3 including:

- The brand, model, size and its condition,
- The presence/absence of impact protectors and protector pockets in all Zone 1 areas and back of jackets,
- The sizing measurements and range for the garment,
- The relating dimensions of the test subject are measured and compared to the sizing ranges supplied by the manufacturer.

This part of the procedure does not collect any information that is directly used in the rating calculation.

The completed Table 3.3 must be retained to confirm that the assessment of the impact protectors' size, location and movement was conducted on an appropriately sized human test subject according to the manufacturer and as specified in EN 13595-1:2002.

The response of all ergonomic requirements in Table 3.3 must be "Yes". If 'No' is recorded for any question, then this is noted and explained in the description section of the test report.

Table 3.3 Participant fitting and ergonomic assessment

Clothing item(s)	Brand		Model		
Clothing sizing dimension			Garment size		
Participant					
	Shoulder	Elbw	Hip	Knee	Back
Impact protector pockts					
Impact protector present					
Coverage of Zone I area (0-150%)					
Coverage of Zone I area after displacement (0-100%)					
EN 13595-1:2002 Ergonomic Requirements			Yes	No	Comments
Inspection before wearing					
1. Free from rough, sharp or hard components, heat transfer elements, irritating features?					
2. Labelling appropriate?					
3. Putting on and adjusting					
4. Are fasteners, buckles, Velcro, straps all adjustable by wearer?					
5. Are the impact protectors in the correct location?					
6. Free from discomfort?					
7. Range of motion is adequate?					
Check when worn off bike					
8. Can walk at 2 m/s without difficulty?					
9. Can climb stairs without difficult?					
10. Can bend 90 degrees without difficulty?					
11. Can crouch to pick up object without difficulty?					
Check when worn on bike					
12. Can adopt riding position without difficulty?					
13. Can fully extend arms (turn signal) without difficulty?					
14. Can turn head fully, with hands on the grips, without difficulty?					
15. Free from tightness in knees, hips, crutch, thighs shins, ankles?					
Further comments					

3.3 Impact Protection – Ratings and test methods for limb protectors

3.3.1 The rating procedures for limb impact protection

For an impact protector to be effective in a crash, it must:

- Provide adequate attenuation of energy to reduce injury risk,
- Be of appropriate size and position to provide coverage over the areas it is intended to protect,
- Remain in place for the duration of a riders' crash and post-crash movement.

An impact protector with high energy attenuation will be ineffective if it is incorrectly located or can be displaced away from areas exposed to impact injury.

The Impact Protection (IP) rating system takes account of the energy attenuation scores, the actual area of coverage by the impact protector within Zone 1 together with any loss of coverage due to potential displacement. The critical area of coverage is defined by a template of the Type B impact protector, as specified in the Standard EN 1621-1:2012, when placed within Zone 1 of the garment.

Impact protectors must be present in Zone 1 in all garments.

- Jackets must be fitted with impact protectors at the shoulders and elbows.
- Pants must be fitted with impact protectors at the hips and knees.
- One-piece suits must be fitted with impact protectors at the shoulders, elbows, hips and knees.
- If any of the required impact protectors are not supplied and no pockets are provided for aftermarket protectors, the total impact protection score will be zero out of ten, regardless of the attenuation performance of those impact protectors that are present.
- If any of the required impact protectors are missing, but protector pockets are provided for aftermarket protectors, the total impact protection score will be one out of ten, regardless of the attenuation performance of those present.

The assessment of the garment is based on both the average transmitted force for all tests and the maximum force transmitted in any single strike (see Formula 7). The final rating is penalised by the worst performing IP in the garment. However, while all impact protectors present will be tested, and their performance reported, final scores and ratings will be penalised by the absence of protectors or pockets.

Formula 7. Calculating the Impact Protection Score.

$$IPS = \left((35 - F_{ave}) + (50 - F_{max})\right) \times S \times (0.5 + (0.5 \times M))$$

Where:

- F_{ave} is the average transmitted force in energy attenuation tests on the impact protectors,
- F_{max} is the single strike maximum transmitted force in the energy attenuation tests on the impact protectors,
- S is the proportion of the Type B protector template that is covered by the garment impact protectors, and
- M is the proportion of the Type B protector template that is covered by the maximally displaced impact protectors.

The proportion S can range from 0% to 150%. An S of 0% indicates there is no impact protector, nor any part of a protector located within the critical area of Zone 1. An S of 150% indicates that the protector is 50% larger than critical area of the Zone 1 region. Allowing a maximum value for S of 150% encourages protectors that are larger than the Type B template to improve the IP rating.

The proportion M displacement can range from 0% to 100%. An M of 0% indicates that the impact protector can be entirely displaced from the critical area of Zone 1 by the tester pulling or pushing the material covering it. An M of 100% indicates that even at maximum displacement of the protector, the critical area in Zone 1 remains covered. Even if an IP moves during the crash sequence, it may provide some initial benefit before it is displaced. In the IP rating (0.5 +(0.5 x M)), the reduced benefit of an easily displaced IP can lower the IP rating by as much as half, but not completely.

Impact protectors will be assigned the lowest possible score of 1 if the average transmitted force exceeds 35 kN or any single strike exceeds 50 kN. Garments that do not have a full complement of protectors (e.g., knee but not hip protectors) also receive the lowest score, regardless of the impact attenuation performance of the protectors. The values given in Table 3.4 provide the performance levels for impact force attenuation.

Table 3.4 Performance level requirements for impact protection

Performance rank (1-10)	Impact Protection Score
10	≥ 75.0
9	65 – 74.9
8	55 – 64.9
7	47.5 – 54.9
6	40 – 47.4
5	32.5 – 39.9
4	25 – 32.4
3	17.5 – 24.9
2	10 – 17.4
1	< 10

3.3.2 Impact Protection – Energy attenuation

Impact Protection is assessed using the energy attenuation test procedure from EN 1621-1:2012. Measurements are taken following the procedure for ambient measurement only (ambient conditions are at temperature: 23°C±2 and humidity: 50%±5). Calculation of the IP performance rating is based on:

- The maximum transmitted force obtained in a single test,
- The average transmitted force calculated from all impacts on the set of IP samples,
- The positioning and percentage coverage of the Zone 1 area,
- The percentage coverage of the Zone 1 area after displacement of the IP.

3.3.3 Impact protection – Protectors' size and location in jackets and pants

Assessment of the size, location and orientation of the impact protectors does not follow the method outlined in the EU Standard, because the EU Standard does not cover the information required for calculating the IP performance rating when fitted into a garment.

The size and the location of the IP are assessed using the Type B protector templates according to EN 1621-1:2012 and the Zone 1 as defined in EN 13595-1:2002. The following procedure outlines the method for undertaking these measurements:

1. The test requires two people. A test subject and garment assessor. The test subject must be an adult with bodily dimensions appropriate for the size of the test garment.

2. Measurements must be taken by the garment assessor from the following defined body reference points:
    a. Point of the shoulder
    b. Point of the elbow
    c. Point of the hip bone
    d. Point of the knee.
3. A small solid metal object (not greater than 10 mm x 10 mm x 10 mm) is to be taped securely to the test subject's body at the reference point in the Zone 1 area in which the test IP was fitted.
4. The test garment must be donned by the test subject over undergarments.
5. The Type B template corresponding to the protector type shall be positioned on the outside of the garment in Zone 1 as specified by EN 13595-1:2002. This position is defined by the centre of the larger circle of the protector Type B template located at the bodily reference point with the remaining part of the protector extending distally down the limb (see Figure 3.4). The small object taped to the assessor's body is used to locate the bodily reference point using a magnet through the garment.
6. Once correctly located, the area covered by the protector is measured by the assessor against the area of the Type B template and the proportion coverage recorded. Should the Type B template be completely covered, the additional area covered by the garment impact protector will be recorded.

3.3.4 Information for ratings calculation

The proportion of the located Type B template covered by the garment IP shall be recorded and used in the impact protector rating.

Figure 3.5 illustrates an example of the test procedure for assessing the size and location of the garment IP showing a size and location rating of 100% (right) and a size and location rating of 40% (left).

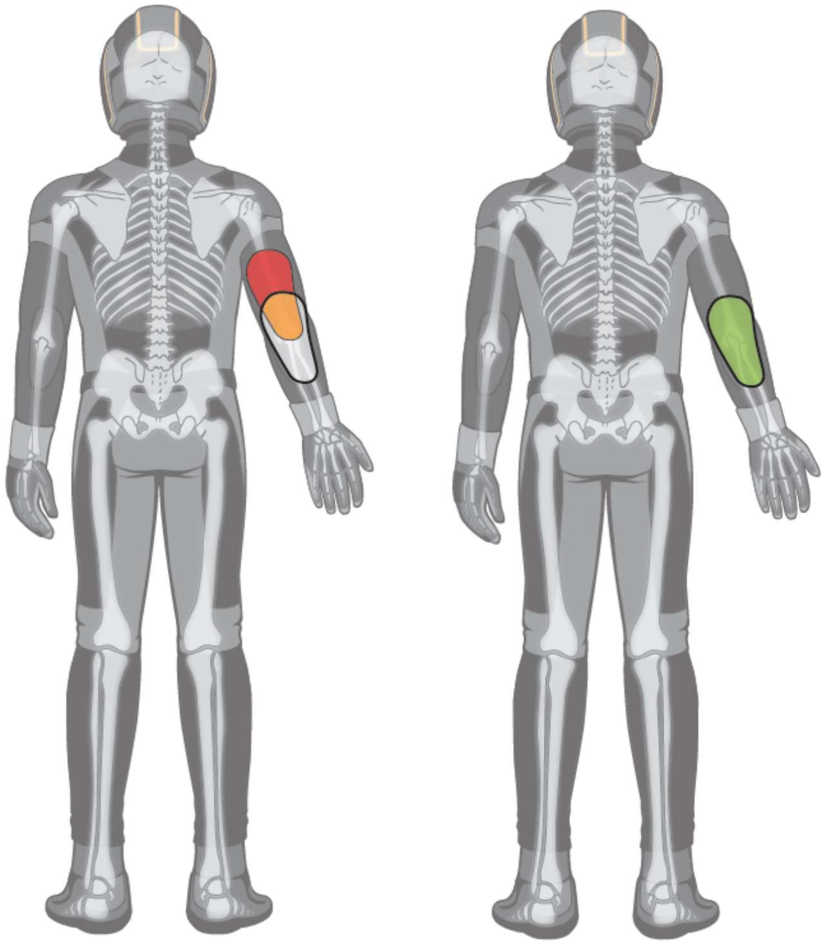

Figure 3.5 Example of the test procedure for assessing the size and location of IP

3.3.5 Impact protection – Test methods for movement within garments

The available movement of the IP is assessed using the Type B protector templates according to EN 1621-1:2012 and the Zone 1 of required impact protection according to EN 13595-1:2002. The following procedure outlines the method for making these measurements:

1. Follow the procedures in Section 3.3.3 Parts 1-4.
2. All mid-limb garment fasteners (e.g., straps) that aid in the restraint of the impact protector must be fastened and adjusted to the tightest comfortable position for the test subject.
3. The assessor places their hand pressing firmly on the material covering the impact protector and attempts to move the material and protector up, down and around the test subject's limb to the maximum achievable displacement from the template area.
4. The proportion of the Type B template that is still covered by the protector is recorded when the protector is in the position of maximum displacement in each direction in turn. The total proportion of the Type B template that is covered by the displaced IP may range from 0 to 100%.

3.3.6 Information for rating calculation

The proportion of the located Type B template covered by the maximally displaced impact protector will be recorded for each movement with and without restraint fastened.

3.3.7 Aftermarket impact protection

The majority of limb impact protectors, which are provided fitted into jackets and pants, are removable and can be replaced or upgraded by the rider. The testing and rating of aftermarket impact protectors will allow riders to make well informed choices when selecting replacement protectors for their jackets or pants.

There are four types of limb impact protectors used in garments, these are for: knees, hips, elbows and shoulders. The aftermarket impact protector is only measured for impact energy attenuation and the proportion of area covered by the Type B template. Displacement is not measured as it is only relevant to garment mounted impact protectors. The test method followed is for limb protectors EN 1621-1:2012. The injury protection score for aftermarket limb impact protectors is calculated using Formula 8.

Formula 8. Calculating the Impact Protection Score for aftermarket limb impact protectors.

$$IPS_{AIP} = \left((35 - F_{ave}) + (50 - F_{max})\right) \times S$$

Where:

- IPS_{AIP} is the injury protection score for aftermarket limb impact protectors when not fitted to a garment,
- F_{ave} is the average transmitted force in energy attenuation tests on the impact protectors,
- F_{max} is the single strike maximum transmitted force in the energy attenuation tests on the impact protectors, and
- S is the proportion of the Type B protector template that is covered by the aftermarket impact protector.

The proportion S can range from 0% to 150%. An S of 150% indicates that the protector is 50% larger than critical area of the Zone 1 Type B template. Allowing a maximum value for S of 150% encourages protectors that are larger than the Type B template to improve the IP rating. The template is placed directly on the armour in order to calculate the area of coverage.

Impact protectors receive the lowest possible score of 1 if the average transmitted force exceeds 35 kN or a single strike exceeds 50 kN. The rating table used for assigning ratings to garment fitted IP (Table 2.4) is also used to provide the performance levels for impact force attenuation of aftermarket IP.

3.4 Burst resistance – Ratings and test methods

3.4.1 The rating procedure for burst resistance

In order for a garment to provide effective protection, it must stay intact throughout the course of a crash. To achieve this, garments should:

- Be constructed with seams that have high burst strength (seam burst resistance).
- Have appropriate stretch and ventilation without compromising the structural integrity of the garment (hierarchical seam burst resistance).

A garment must remain intact in the initial and subsequent impacts to protect the wearer from direct contact with the road surface. The seams in the high impact zones are assigned greater weight in the burst resistance equation as these will have a higher risk of failure in a crash. The structural seams within the body of the garment, particularly the side seams in a jacket and pants, also require high burst resistance, as tensile loads can be transmitted through the body on impact.

The burst resistance rating system applies a risk-based hierarchy of weights for rating the garment, in order to allow for comfort features (vents and stretch fabric) in appropriate locations. See Formula 9. The seams within and on the edge of Zones 1 and 2 are assigned the highest risk weight, whereas body seams in Zones 3 and 4 are assigned a quarter of the weight assigned to the higher risk seams.

Formula 9. Calculating Burst Resistance Score.

$$BRS = (0.80 \times \mu_{\mathrm{Z1\&2}}) + (0.20 \times \mu_{\mathrm{Z3\&4}})$$

Where:

- BRS is the burst resistance score for the garment,
- $\mu_{Z1\&2}$ is the corrected mean burst resistance of seams in the Zone 1 & 2 area,
- $\mu_{Z3\&4}$ is the corrected mean burst resistance of seams in the Zone 3 & 4 area.

The Zone 3 and Zone 4 areas, shown in Figure 3.1, are tested and rated together as Zone 3&4 area because they have the same requirements for burst strength performance. If the average burst resistance of the body seams ($\mu_{Z3\&4}$) is less than 400 kPa, then the garment cannot achieve a protection rating above two stars. The values given in Table 2.5 provide the performance levels for the burst resistance rating.

Table 3.5 Performance levels of the burst resistance rating

Performance rank (1-10)	Burst scores
10	≥ 1000
9	900 – 999
8	800 – 899
7	700 – 799
6	600 – 699
5	500 – 599
4	400 – 499
3	300 – 399
2	200 – 299
1	< 200

3.4.2 Burst Resistance – Test methods

The method for evaluating burst resistance follows the test protocols in the European Standard EN 13595-3:2002.[10] As noted earlier, for the purposes of the MotoCAP rating scheme, the CEN procedure has been modified to allow for samples to be harvested from finished garments bought from retail stores as detailed in 3.1.2.

3.4.3 Sampling from jacket and pants

Burst testing should be conducted on each of the critical seams within a garment. Critical seams are external seams that hold the outer shell of the garment together. Figure 3.6 illustrates the testing points for each test procedure on jackets and pants.

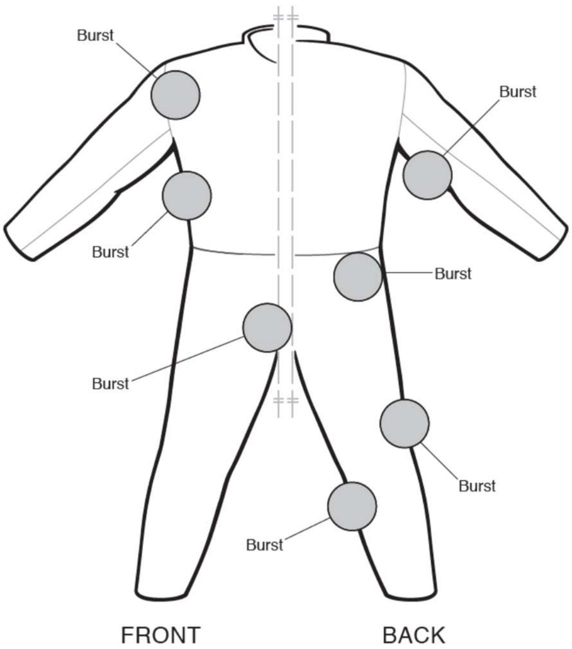

Figure 3.6 Locations of burst samples from jackets and pants garments

The Zone 1&2 template as defined in Annex C of EN 13595-1:2002 shall be placed on the garment to determine the nature of the risk to the seam. Figure 3.7 is an illustration of the placement of a Zone 1&2 template onto a pair of pants. Samples should be marked with their location sampled from within the garment along with a Zone 1&2 if the seam was within or on the edge of a Zone 1&2 location as these seams will be treated differently in the rating algorithm.

Figure 3.7 Illustration of placement of a Zone 1&2 template onto a pair of pants.

The critical seams in pants are detailed as follows:

- Leg inseam on the edge of Zone 1&2,
- Leg outer seam on the edge of Zone 1&2,
- Seat patch critical seam/s in the Zone 1&2 area holding the outer shell together,
- Rear of waist – covering seam joining the waistband and the seat of pants,
- Opened vent areas (with zip open) exceeding 80 mm in length in the leg region,
- All other protective layer or outer shell joining seam/s in a Zone 1&2 area not detailed above.

The critical seams within the jackets are detailed as follows:

- Arm inseams,
- Body side seams in Zones 3&4,
- Arm to shoulder attachment seam in Zone 1&2 area,
- Protective layer to mesh attachment in or on the edge of Zone 1&2 areas,
- Opened vent areas (with zip open) exceeding 80 mm in length in arm region,
- Any protective layer or outer shell joining seam/s in a Zone 1&2 area not detailed above.

Burst resistance samples shall represent all of the critical seams of the garment with all layers of material present at the sampling point collected, excluding removable impact protectors.

Each seams test sample will be marked with its position in relation to the protection zones using:

- *"1&2"* for seams within the Zone 1&2 protection area
- *"3&4"* for seams within the Zone 3&4 protection area.

Notes:

- The protective layer may be an independent layer or the outer shell fabric in the case of single layer products.
- The seams of outer shell fabrics occurring within the Zone 1&2 or on the transition between Zones 3&4 should be collected and tested even if a separate protective layer underneath has no join.
- The dimensions of each burst resistance sample should be at least 160 mm in diameter with all material layers collected and stapled together in the orientation they were in within the garment.
- Fixed and removable impact protectors should be excluded from the burst test sample.

3.4.4 Records for ratings calculations

Table 3.6 provides a simple format to log the test data as it is acquired to calculate the burst rating. The equation uses the corrected mean burst resistance of each of the critical seam zones.

To obtain the corrected mean, six seam samples from the zone are measured for burst resistance which is the pressure at which burst is recorded as their Burst Pressure (BP). The scores of all samples are averaged to achieve the uncorrected mean BP. The diaphragm is then inflated, without a sample in place, to the height represented by the uncorrected mean and the BP at that height is recorded as the Diaphragm Compensation Pressure. The DCP is then subtracted from the uncorrected mean BP to provide the corrected mean BP.

Table 3.6 Data collected for burst resistance calculation

Test number	Zone 1&2 Pressure (kPa)	Zone 3&4 Pressure (kPa)
1		
2		
3		
4		
5		
6		
Uncorrected mean		
Diaphragm Compensation Pressure DCP		
Corrected mean BP		

4 Breathability: test protocol for jacket and pants

4.1 Breathability – Ratings and test methods

For motorcycle protective clothing to be effective, it must be comfortable to wear under the conditions for which it is used. While comfort is a subjective sensation, heat discomfort may become a serious health issue when due to thermal strain, which is caused when the body is unable to maintain stable core body temperature.

Motorcycle garments require effective thermal insulation to prevent body heat loss in cold conditions or excessive heat gain in hot conditions. However, insulation can also block the transmission of moisture vapour (sweat) and heat from the body, restricting the natural regulation of core body temperature. If a rider's core temperature increases even slightly, this may cause thermal physiological strain with potential consequences for the rider's safety including impaired reaction times, fatigue and mood..[4]

Many motorcycle garments have optional ventilation ports which may be opened to provide air flow for cooling. There are currently no standard tests for assessing the effectiveness or safety of such vents. The presence and exact location of vents in relation to the impact risk zones should be noted and included in the comments in the MotoCAP report on the garment.

The rating system for the breathability of motorcycle garments is based on objective measures of the garment's ability to expel heat and moisture vapour when all ventilation ports are closed. Samples of all component material layers are tested for dry heat and moisture vapour resistance and those results used to calculate scores on the Relative Vapour Permeability Index.[11]

Moisture vapour resistance is temperature-dependant in most materials, so calculation of the Relative Vapour Permeability Index will enable evaluation of the garments ability to expel heat and moisture relative to the ambient temperatures. Formula 2 shows the equation used to calculate the garments score on the Relative Vapour Permeability Index. Note: Formula 2 as detailed in Section 2.2 has been repeated in this section for ease of referencing. The table of performance scores for the thermal performance rating (Table 2.2) is provided in Section 2.2.

Formula 2. For calculating the Breathability Score.

$$\text{Breathability Score } (\mathrm{I_{mt}}) = \left(\mathrm{R_{ct}}/\mathrm{R_{et}}\right) \times \mathrm{S}$$

Where:

- I_{mt} is the Relative Vapour Permeability Index,
- R_{ct} is the thermal resistance,
- R_{et} is the moisture vapour resistance, and
- S is a constant (=60Pa/K).

Thermal and moisture vapour resistance measurements are used to calculate the Relative Vapour Permeability Index (I_{mt}) for the garment's breathability rating. These tests must be conducted on the garment without the presence of any removable liners, such as water-resistant or thermal liners. Where a removable water-resistant liner is supplied with a garment, an additional series of thermal and moisture vapour resistance tests are to be repeated with that liner present. The thermal management rating result with the liner present should be presented separately in the garment description section of the test report.

4.2 Thermal and moisture vapour resistance – Test method

Thermal and moisture vapour resistance is measured using a sweating guarded hotplate under steady state conditions as detailed in ISO 11092:2014.[12] For the purposes of the MotoCAP ratings scheme, additional protocols are specified below for the harvesting and preparation of test samples.

4.2.1 Sampling procedure

Samples must represent every combination of materials in the panels of the garment with all layers of material present at the sampling point, excluding removable impact protectors.

For jackets, the samples should be harvested from the front of the jacket and include shell materials, water resistant membranes, pockets, protective layers and mesh where they are present.

Where there is insufficient material to cover the test area from the front of a jacket, materials may be harvested from the back and combined to make a test sample representative of the materials in the front of the garment.

For pants, the sample should be taken from the trunk of the garment. Only if there is insufficient material in the trunk, may further samples be harvested from the legs to provide a complete test sample representative of the materials in the trunk.

4.3 Ratings calculation

The Relative Vapour Permeability Index is calculated from the test results for thermal resistance (R_{ct}) and moisture vapour resistance (R_{et}) for each composite panel. Two measurements are conducted for the thermal resistance and moisture vapour resistance of each composite panel and the results averaged. Formula 2 is used to calculate the Relative Vapour Permeability Index, which is a scale from 0.0-1.0, and hence the breathability rating.

5 Injury protection: test protocols for gloves

5.1 The ratings procedure for gloves

Gloves need to provide high impact protection and abrasion resistance during a crash because the hands are frequently the first point of contact with the road's surface.[13] Glove must also remain intact and in place during a crash event to ensure the wearer's hands are not exposed to the road surface. Glove seams must have adequate tensile strength to prevent them from bursting or tearing open. The gloves must also have secure fastening systems to prevent them being caught on projections and pulled off during the crash. In addition to providing protection, gloves must be sufficiently flexible to enable the rider to operate the vehicle controls comfortably.

Gloves are rated for injury protection including abrasion, impact and seam strength and retention, but not for breathability due to the difficulties of assessing the latter. The injury protection ratings are based on a weighted combination of scores for impact abrasion (50%), impact protection (30%) and seam strength rating (20%) as provided in Formula 10. Seam strength scores are penalised for gloves which have inadequate glove retention systems. The details for each test and calculation of ratings on each criteria are provided in the following pages.

Formula 10. Calculating Glove Injury Protection Score

$$\text{Glove injury protection score} = (0.5 \times \text{AR}_G) + (0.3 \times \text{IP}_G \ \ 3) + (0.2 \times \text{SS}_G/5)$$

Where:

- AR_G is the abrasion score for the glove,
- IP_G is the impact protector score, and
- SSR_G is the seam strength score.

If any of the individual criteria (AR_G, IP_G or $SSR_{G)}$ achieve scores of 3/10 or lower, the garment cannot exceed a two-star protection rating. The values given in Table 5.1 provide the performance levels for the Injury Protection rating for gloves.

Table 5.1 Performance level requirements of the Injury Protection rating

Star rating	Protection scores
★★★★★ (5)	> 5
★★★★ (4)	4 – 5
★★★ (3)	3 – 3.9
★★ (2)	2 – 2.9
★ (1)	1 – 1.9
⯪ (½)	< 1

5.2 Risk zones for gloves

Gloves need to provide high abrasion protection in the high-risk areas of the hand and wrist. For the purposes of MotoCAP, impact and abrasion risk zones have been identified based on an analysis of the evidence of impact damage and injuries sustained on gloves worn in a study of serious motorcycle crashes. The study documented the incidence and type of crash contact and associated levels of damage due to abrasion, tear, burst or crush impact forces.[13] The zones are illustrated in Figure 5.1.

Zone 1. High risk of impact and abrasion. The area includes the knuckles (metacarpals) and the palm/heel of the hand (carpals).

Zone 2. High risk of abrasion. The area includes the tips of the fingers (distal phalanges) and all exposed areas of the little finger and thumb.

Zone 3. Medium risk of abrasion. The area includes the upper palm, proximal and intermediate phalanges of the fingers, wrist and back of the hand.

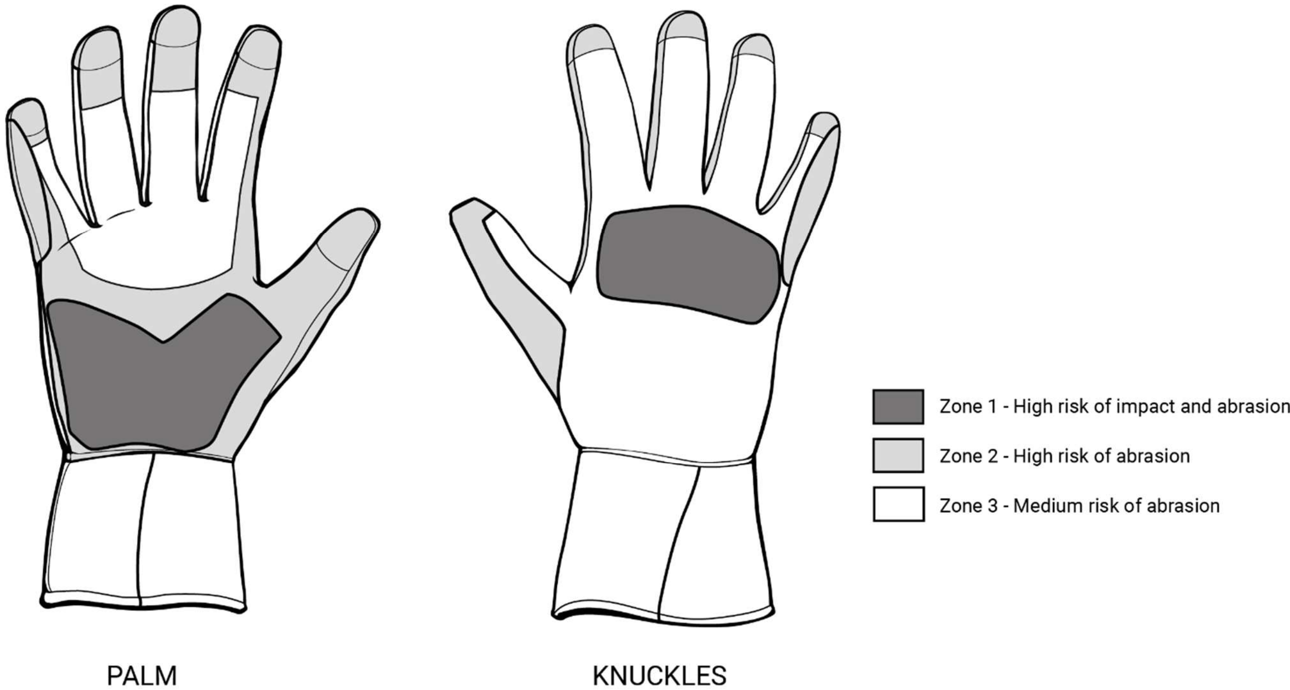

Figure 5.1 Locations of crash impact risk zones

5.3 Impact Abrasion – Test methods for gloves

Gloves need to provide high abrasion resistance without restricting the rider’s control. The abrasion rating for gloves is based on abrasion resistance, measured as the time in seconds to form a hole at 28 km/hr. Those scores are then weighted according to the relevant impact risk zone. When more than one material is present, a penalty may apply if one of the materials has poor abrasion performance. This is intended to encourage manufacturers to provide high abrasion resistance only in the high-risk zones, to avoid significantly impacting the functionality of the glove overall.

The abrasion resistance score for gloves is calculated in a series of steps as illustrated in Figure 5.2.

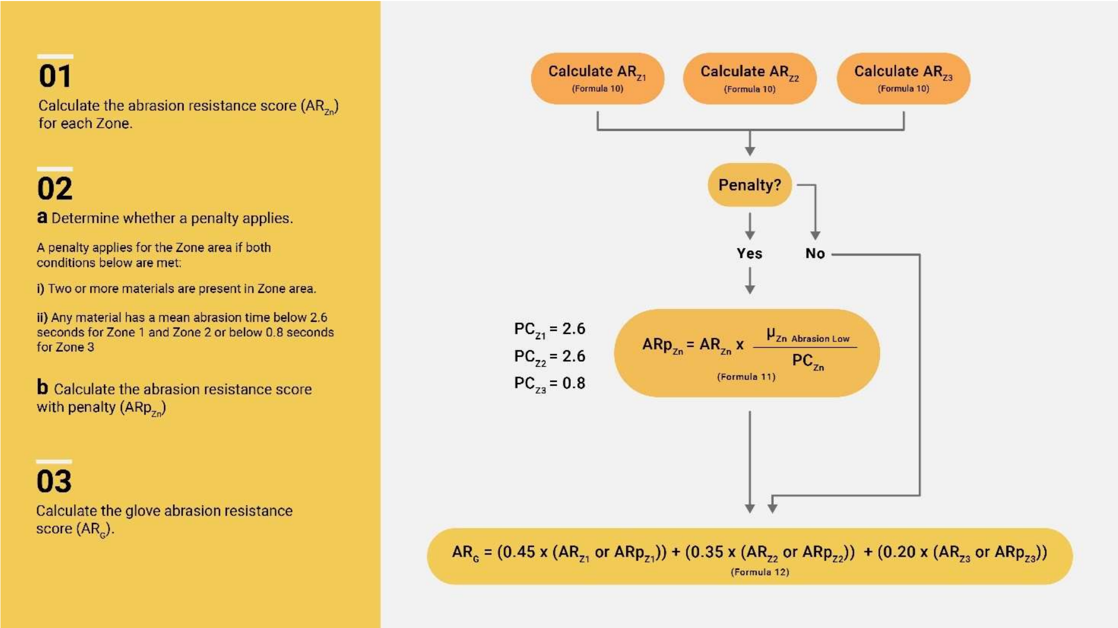

Figure 5.2 Illustration of the steps for calculating the Abrasion Resistance Score for gloves.

Step 1. Use the Zone Equation (Formula 11) to calculate the Zone abrasion resistance score for the material layers present in each Zone separately. All of the details outlined for jackets and pants in Section 2.1.1 Step 1 are applied in the same way for gloves using the three glove abrasion risk Zones detailed in Figure 5.1.

Formula 11. Zone equation (Calculated for each Zone separately)

$$AR_{Zn} = \left(\mu_{Zn\ \text{Abrasion high}} \times \%A_{Zn\ \text{high}}\right) + \left(\mu_{Zn\ \text{Abrasion low}} \times \%A_{Zn\ \text{low}}\right)$$

Where:

- The Zone number (n) identifies the Zones; 1, 2 and 3,
- AR_{Zn} is the abrasion resistance for the Zone n area,
- μ_{Zn} Abrasion high is the corrected mean abrasion time in seconds for the higher protection level Zone n material tested,
- $\%A_{Zn}$ high is the percentage area of the higher protection level Zone n material tested expressed in decimals,
- μ_{Zn} Abrasion low is the corrected mean abrasion time in seconds for the lower protection level Zone n material tested, and
- $\%A_{Zn}$ low is the percentage area of the lower protection level Zone n material tested expressed in decimals.

Step 2. Determine whether a penalty should be applied for the glove Zone areas according to the following criteria.

A penalty applies to the Zone 1 and Zone 2 abrasion resistance scores if both of the following conditions are met:

- There are two or more material combinations used in the Zone 1 and Zone 2 areas, and
- One or more of the material combinations present in the Zone 1 and Zone 2 areas has an abrasion resistance time below 2.6 seconds.

A penalty applies to the Zone 3 abrasion resistance score if both of the following conditions are met:

- There are two or more material combinations used in the Zone 3 area, and
- One or more of the material combinations present in the Zone 3 area has an abrasion resistance time below 0.8 seconds.

When more than two materials combinations exist within a Zone, then the lowest mean abrasion resistance value of the lower abrasion protection materials in the Zone is used for the mean abrasion resistance low value ($\mu_{Zn\ Abrasion\ low}$)

The Zone 1 and Zone 2 areas are each classified as high risk of abrasion and incur the same penalty constant (PC_{Zn}) of 2.6. The penalty constant for Zone 3 with a medium risk of abrasion is 0.8.

If a penalty applies, then the Zone abrasion resistance score with penalty (ARp_{Zn}) value is calculated using Formula 12.

Formula 12. Glove penalty equation (calculated for each zone separately)

$$ARp_{\mathrm{Zn}} = \mathrm{AR}_{Zn} \times \frac{\mu_{Zn\ Abrasion\ low}}{PC_{Zn}}$$

Where:

- μ_{Zn} Abrasion low is the corrected mean abrasion time in seconds for the lower protection level Zone n material tested, and
- PC_{Zn} is the penalty constant for Zone n.
- Note: PC_{Z1}=2.6, PC_{Z2}=2.6 and PC_{Z3}=0.8.

Step 3 The abrasion resistance score for gloves (AR_G) is calculated using Formula 13 with the AR_{Zn} value from step 1 where a penalty did not apply or the corrected ARp_{Zn} value from step 2(b) where a penalty does apply.

Formula 13 Calculating Abrasion Resistance Score for gloves.

$$AR_G = \left(0.45 \times (AR_{Z1}\ or\ ARp_{Z1})\right) + \left(0.35 \times (AR_{Z2}\ or\ ARp_{Z2})\right) + \left(0.20 \times (AR_{Z3}\ or\ ARp_{Z3})\right)$$

Where:

- AR_G is the abrasion resistance score for the glove,
- AR_{Z1} is the abrasion resistance of the Zone 1 area,
- AR_{Z2} is the abrasion resistance of the Zone 2 area, and
- AR_{Z3} is the abrasion resistance of Zone 3 area.
- ARp_{Z1} is the penalised abrasion resistance of the Zone 1 area,
- ARp_{Z2} is the penalised abrasion resistance of the Zone 2 area, and
- ARp_{Z3} is the penalised abrasion resistance of Zone 3 area.

The primary reference used by this protocol for gloves is EN 13594:2002, which specifies the minimum abrasion resistance across the entire glove when tested in accord with EN 13595-2:2002.[9,14] The MotoCAP protocol further refines this approach, by providing different abrasion resistance requirements based on the different risk zones for hands, as outlined in Section 5.2.

Note: Test protocols from EN 13594:2015, which specifies an abrasive belt with 120-grit, should not be used with the MotoCAP protocols. Instead, the 60-grit specified in EN 13595-2:2002 is required for MotoCAP testing because it allows the comparison of abrasion times between jackets, pants and gloves, which is easier for the consumer to understand.

If an area of hard armour, such as a metacarpal protector or palm slider, is present in the Zone 1 area, then the abrasion time will be set at a maximum of 10s for the area of the Zone covered by that armour.

If the Abrasion resistance score for Zone 2 (AR_{Z2}) and Zones 3 (AR_{Z3}) is less than 0.6s then 6/10 is the maximum abrasion performance rating that the product can achieve. The values given in Figure 5.2 provide the performance levels for abrasion resistance. The rating performance levels required for gloves are lower than those for jackets and pants as a compromise for the flexibility required to operate the motorcycle controls.

Table 5.2 Performance level requirements of the impact abrasion resistance rating for gloves

Performance rank (1-10)	Abrasion scores (s)
10	≥ 5.0
9	4.5 – 4.9
8	4.0 – 4.4
7	3.5 – 3.9
6	3.0 – 3.4
5	2.5 – 2.9
4	2.0 – 2.4
3	1.5 – 1.9
2	1.0 – 1.4
1	< 1.0

5.3.1 Sampling from gloves

The minimum sampling points for abrasion resistance measurement from a glove are shown in pink on Figure 5.3.

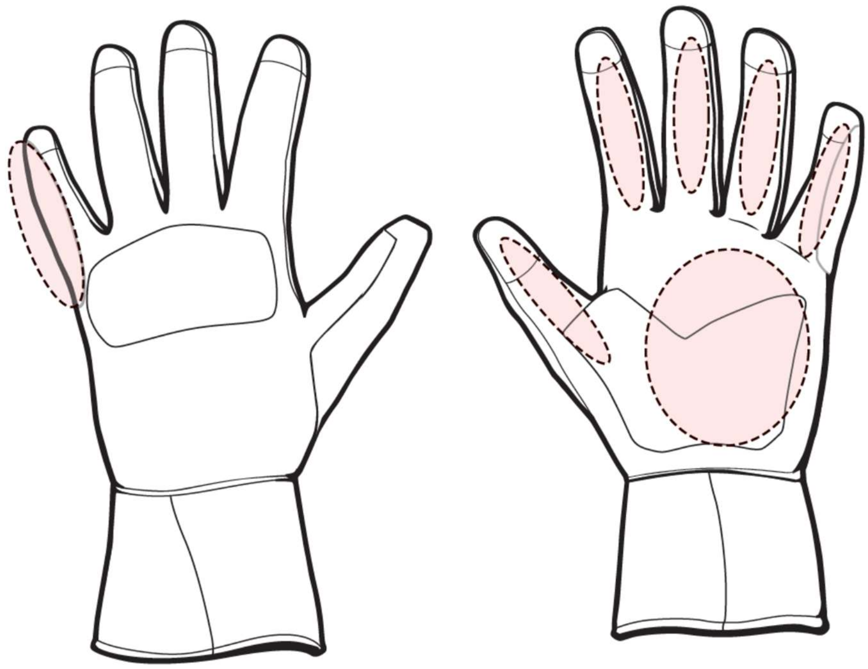

Figure 5.3 Positions of measurable critical abrasion points on a glove

The critical abrasion zones within a glove are detailed as follows:

- Any material represented in the Zone 2 parts of the fingers,
- Any materials represented in the Zone 1&2 parts of the palm,
- Any materials represented in the Zone 1 area of the back of the hand,
- Any materials represented in the Zone 2 part of the thumb,
- Any protective layer material not measured above that makes up part of the Zone 3 area of the glove.

5.4 Tensile testing for gloves

Tensile seam strength testing is conducted according to the European Standard EN 13594:2002 [14] test method, with some modifications in sampling and gauge length to enable sampling from completed gloves. Tensile seam strength testing shall be conducted on each of the critical seams within a glove. Critical seams are external seams that hold the outer shell of the glove together. The critical test points on gloves are illustrated in pink in Figure 5.4.

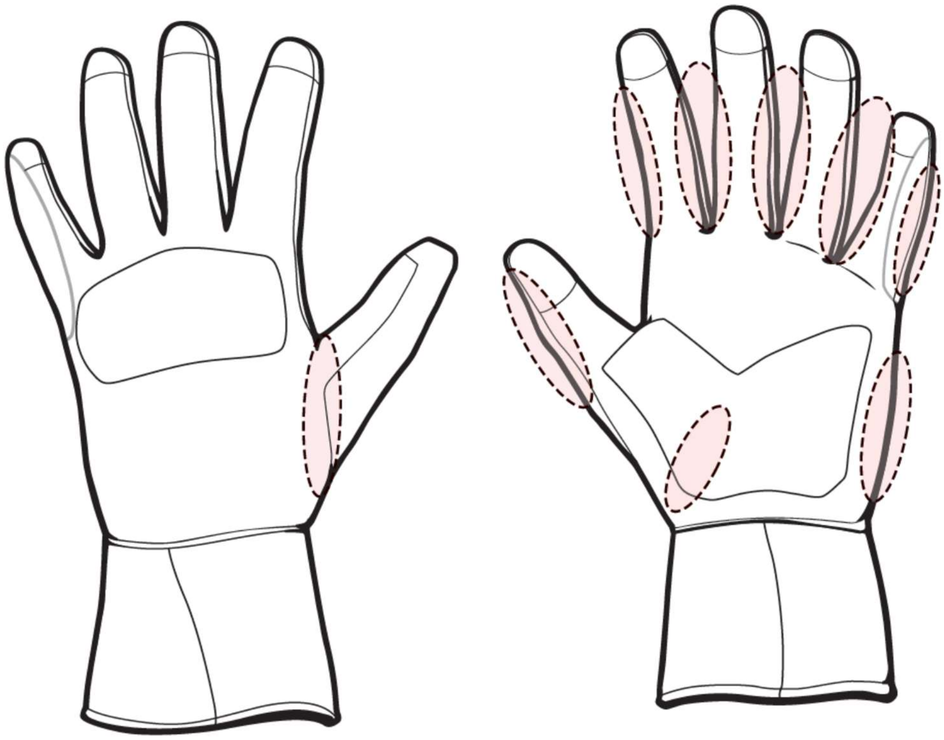

Figure 5.4 Location for tensile seam strength samples from gloves

The critical seams within a glove are detailed as follows:

- Sides of fingers,
- Side of thumb,
- Side of palm,
- Seams attaching thumb to palm and side of glove,
- Any protective layer or outer shell joining seam/s not detailed above that if failing would expose the hand to abrasion injury.

5.4.1 Removal resistance – Test methods for glove

Removal restraint is tested to estimate the force required to pull a fully fastened glove off a rider's hand (glove restraint force - GR). The test is conducted using glove restraint testing cones using the method specified in the European Standard EN 13594:2015.[14] The GR force result is used to weight the tensile seam strength results to calculate the seam strength score.

5.4.2 Ratings procedure for the tensile strength of glove seams

The rating system for gloves seam strength tests the mean tensile strength of all seams within the glove. The seam tensile strength score is then reduced by proportion in cases where the glove restrain force, (GR) is below 200 N to penalise gloves with inadequate wrist retention.

Formula 14 Calculating Seam Strength Score for gloves.

$$SS_G = {}^{\mathrm{GR}}/_{200} \times \left((0.6 \times TR_{Z1\&2}) + (0.4 \times TR_{Z3})\right)$$

Where:

- SS_G is the seam strength score for the glove,
- $TR_{Z1\&2}$ is the average seam tensile strength in N/mm for Zone 1 and 2,
- TR_{Z3} is the average seam tensile strength in N/mm for Zone 3 and
- GR is the average glove restraint force in N.

The values given in Table 5.3 provide the performance levels for the tensile strength of glove seams.

Table 5.3 Performance level requirements for tensile strength rating for glove seams

Performance rank (1-10)	Seam strength score
10	>13.0
9	12.0 – 13.0
8	11 – 11.9
7	10.0 – 10.9
6	9.0 – 9.9
5	8.0 – 8.9
4	7.0 – 7.9
3	6 – 6.9
2	5.0 – 5.9
1	< 5.0

5.5 Impact protection ratings for gloves

For an impact protector (IP) in a glove to be effective in a crash, it must:

- Provide coverage over the areas it is intended to protect (size and position), and
- Provide adequate attenuation of impact forces (energy attenuation).

Motorcycle gloves are necessarily close fitting, so the potential for impact protectors to move is low. Accordingly, the assessment of impact protection in gloves is based on the impact protector coverage of the impact risk Zone and energy attenuation achieved to determine the rating score of the IP. Formula 16 provides the algorithm for calculating impact protection scores for gloves.

Formula 16. Calculating Impact Protection score for gloves

$$IP_G = \frac{(IP_{Knuckle} + IP_{Palm})}{2}$$

Where:

- $IP_{Knuckle}$ is the impact protection score for the knuckle impact protector, and
- IP_{Palm} is the impact protection score for the palm impact protector.

There are two key impact protection areas located within a gloves coverage. These are knuckle and palm protection and are shown as Zone 1 in Figure 5.1. The impact protection score for each impact protector is individually calculated from its mean and maximum transmitted forces combined with the coverage of the Zone 1 template. The algorithm for calculating the impact protector score for the knuckle is provided in Formula 16.

Formula 16. Calculating knuckle impact protection score for gloves

$$IP_{Knuckle} = \left((8 - F_{ave\ knuckle}) + (10 - F_{max\ knuckle})\right) \times C_{knuckle}$$

Where:

- $F_{ave\ knuckle}$ is the average transmitted force in energy attenuation tests on the knuckle impact protector, and
- $F_{max\ knuckle}$ the single strike maximum transmitted force in the energy attenuation tests on the knuckle impact protector, and
- $C_{knuckle}$ is the proportion of the knuckle impact protector template that is covered by the glove impact protector in an extra-large (XL) glove.

The same basic algorithm is also used to calculate the impact protection score for the palm, as shown in Formula 17.

Formula 17. Calculating palm impact protection score for gloves

$$IP_{Palm} = \left((8 - F_{ave\ palm}) + (10 - F_{max\ palm})\right) \times C_{palm}$$

Where:

- $F_{ave\ palm}$ is the average transmitted force in energy attenuation tests on the knuckle impact protector, and
- $F_{max\ palm}$ the single strike maximum transmitted force in the energy attenuation tests on the knuckle impact protector, and
- C_{palm} is the proportion of the knuckle impact protector template that is covered by the glove impact protector in an extra-large (XL) glove.

The assessment of the glove's impact protection takes account of the average transmitted force for all tests as well as the maximum force transmitted in any single strike. If protection is not provided in one or more of the two protection zones, then 0% assigned as area coverage for that Zone.

The proportion of coverage C can range from 0% to 150%. An C of 0% indicates that either no impact protector was present, or it was incorrectly located outside the impact protector template area. An C of 150% indicates that the protector is 50% larger than the impact protector template when located in the protector region. Allowing a maximum value for C of 150% encourages protectors larger than the template to improve the IP rating.

The values given in Table 5.4 provide the performance levels for the impact protection of gloves.

Table 5.4 Performance level requirements of impact protection for gloves

Performance rank (1-10)	Impact scores
10	≥ 16.0
9	14.5 – 15.9
8	13.0 – 14.4
7	11.5 – 12.9
6	10.0-11.4
5	8.0 – 9.9
4	7.0 – 7.9
3	5.7 – 6.9
2	4.5 – 5.6
1	< 4.5

5.5.1 Knuckle impact protection template

The shape and dimensions of the knuckle template are given in Table 5.5. The two location points are the centre of the joint between the metacarpal and proximal bones of the second and fifth finger on a flat hand. This template is designed for use on an extra-large (XL) glove. Figure 5.7 shows the placement position of this template on a glove.

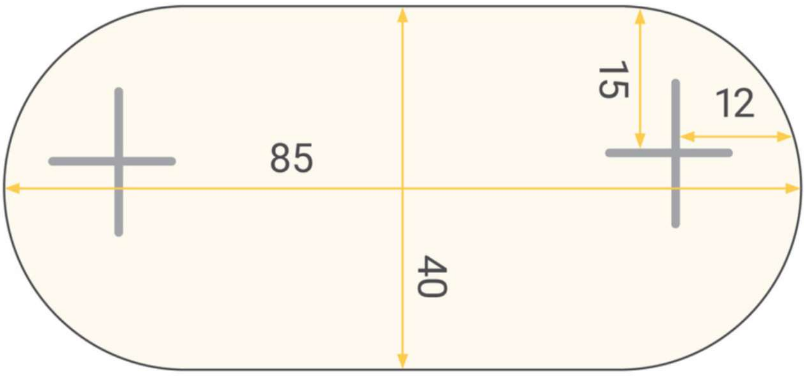

Figure 5.5 Template for assessing size of knuckle impact protector (dimensions in mm)

5.5.2 Palm template

The shape and dimensions of the palm template are given in Figure 5.6. The palm template is designed to be laid flat on the palm of an open flat extra-large (XL) glove. The vertical side edge is aligned with the side of the glove. The bottom long edge that is perpendicular to the side edge is placed on the scaphoid side of the scaphoid and radius joint parallel with the radius joint. Figure 5.7 shows the placement position of this template on a glove.

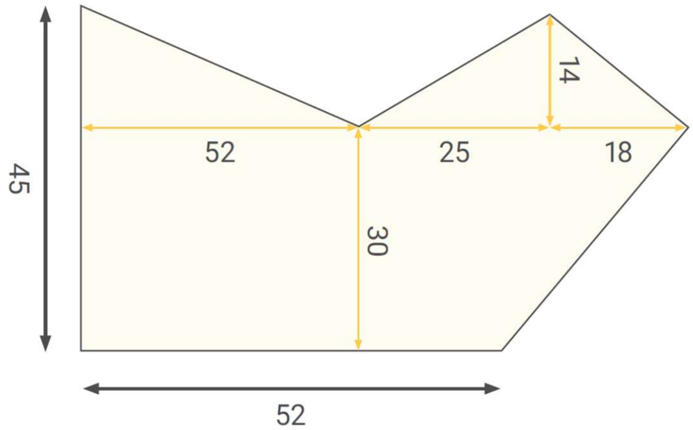

Figure 5.6 Template for assessing size of palm impact protector (dimensions in mm)

5.5.3 Template placement

Figure 5.7 shows the placement of the templates onto a pair of gloves for assessment purposes. The gloves shown have 90% coverage of impact protection for the knuckle region and 20% coverage for the palm.

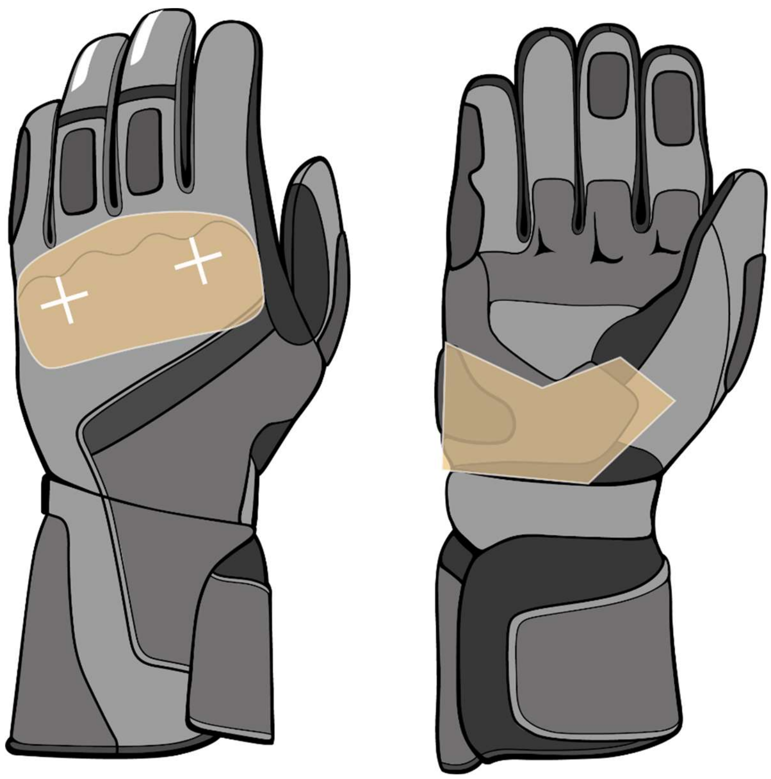

Figure 5.7 Placement of glove impact protector templates

5.5.4 Impact energy attenuation – Test method for gloves

The Impact Protection energy attenuation procedure follows EN 13594:2002 and EN 1621-1:2012 with additional requirements outlined below:

1. Testing may only be conducted on the two key impact protection areas for those gloves where energy absorbent material is present. The number of impact test strikes will be determined by the available area of material. Where possible, two or more strikes must be conducted, but no two strikes should overlap within the strike area.
2. Information required for ratings calculation
    a. The maximum transmitted force obtained in a single test in each key impact protection area.
    b. The average transmitted force calculated from all impacts on each key impact protection area.

5.6 Ergonomic assessment – Test method for gloves

Table 5.5 must be completed as a part of the MotoCAP assessment procedure. Table 5.5 information is not used in calculating the rating but is required for the generation of the test report and to retain information for further analysis of test results.

The completed Table 5.5 must be retained to confirm that the assessment of the impact protectors' size and location was conducted on an appropriately sized human test subject according to the manufacturer and as specified in EN 13595-1:2002.

The response of all ergonomic requirements in Table 5.5 must be "Yes". If a 'No' is recorded, then this shall be noted and explained in the test report.

Table 5.5 Participant fitting and ergonomic assessment for gloves

Glove items		Brand		Model		
Glove sizing dimension				Glove size		
Participant	Participant size					
		Knuckle	Palm			
Impact protector present						
Coverage of Zone I area (0-150%)						
EN 13594:2015 Ergonomic Requirements				Yes	No	Comments
Inspection before wearing						
16. Free from rough, sharp or hard components, heat transfer elements, irritating features?						
17. Labelling appropriate?						
18. Putting on and adjusting						
19. Are fasteners, buckles, Velcro, straps all adjustable by wearer?						
20. Are the impact protectors in the correct location?						
21. Free from discomfort?						
22. Range of motion is adequate?						
Check when worn on bike - EN 13594:2015 Glove Ergonomic Requirements						
23. Free from rough, sharp or hard components, irritating features?						
24. Gloves can be taken on and off easily?						
25. Can operate glove restraint system without difficulty?						
26. With eyes closed. Can feel and operate all controls and fuel tap? Free from interference?						
27. With eyes closed. Can throttle slips satisfactory?						
28. Can adjust visor?						
29. No bunching of gloves?						
30. Free from irritating features?						
31. Sizing appropriate?						
Further comments						

6 Water resistance to road spray and rain: test protocol

6.1 The water resistance rating procedure

For an item of protective clothing to be effective, it must resist rain and water spray from entering the garment and wetting the inner clothing and/or skin of the rider.

Results for water resistance will be reported separately but are not included in the star rating for thermal management. This is due to potential conflicts between achieving water resistance and user thermal comfort.

Water may enter a garment in two main ways:

- Poor design of the waterproof barrier, seams, vents and body penetration points (water resistance to road spray and rain)
- Pressure applied between the clothing and a part of the motorcycle (hydrostatic pressure)

A rain-protective garment can be made from a material that has very high resistance to hydrostatic pressure but may leak due to failure in the design or construction of the garment. Effective water resistance requires leak-proof design of wrist and neck openings, fastenings, vents, seams and pockets. This procedure measures a garment's fitness for purpose rather than the intended performance of the materials of which it is constructed.

The method for calculating water resistance is based on the weight (grams) of the water absorbed by the under garment. In jackets and pants, this is reported by proportion (%) increase in weight (g) of the under garment. In gloves, the amount of water absorbed is reported by volume (ml) calculated from the weight increase (g) in the cotton under glove.

The percentage of wetting could not be used for gloves because the relative mass of a cotton under glove is low (30g) compared to that of a pair of long cotton under-pants (260g). In a glove, 3ml of water would represent 10% wetting, whereas the same volume in a jacket or pants would be approximately 1%.

6.2 The procedure for testing the water resistance of jackets and pants

The method for calculating the water resistance of jackets and pants is provided in Formula 18.

Formula 18. Calculating water resistance score for jackets and pants.

$$WR_{JP} = \%\mathrm{M}_U$$

Where:

- WR_{JP} is the water resistance score for jackets and pants,
- $\%M_U$ is the percentage Moisture (in decimals) of the Undergarment worn under the garment being tested.

The water resistance rating is a reverse rating. The lower the percentage of water entering the garment, the lower the value will be and the higher the rating that will be assigned to it. The performance values for the water resistance rating are shown in Table 6.1.

Table 6.1 Performance values for the water resistance rating of jackets and pants

Performance rank (1-10)	Water resistance scores (%)
10	< 1.0
9	1.0-2.4
8	2.5-4.9
7	5.0 - 7.4
6	7.5 - 9.9
5	10.0 - 12.4
4	12.5-14.9
3	15.0 – 19.9
2	20.0 – 25.0
1	> 25

6.3 The procedure for testing the water resistance of gloves

The method for calculating water resistance for gloves uses the volume of water in millilitres absorbed by the cotton glove that is present under the test glove.

Formula 19. Calculating water resistance score for gloves.

$$WR_G = \frac{V_U}{2}$$

Where:

- WR_G is the water resistance score for gloves,
- V_U is the Volume increase due to wetting (in ml) of the Under-glove worn under the glove being tested.

The amount of water absorbed by the cotton under-glove is measured as a mass change between before and after the water-spray test. The units for absorbed water for gloves will be in millilitres (ml). For conversion purposes 1.0 grams (g) of mass change in the garment after the test will be represented as 1.0 millilitres (ml) of water absorbed. The performance values for the water resistance rating for gloves are shown in Table 6.2.

Table 6.2 Performance values for the water resistance rating of gloves

Performance rank (1-10)	Water resistance scores (ml)
10	< 2.5
9	2.5-3.4
8	3.5-4.4
7	4.5 - 5.4
6	5.5 - 6.4
5	6.5 - 7.4
4	7.5-8.4
3	8.5 – 9.9
2	10.0 – 15.0
1	> 15

6.4 Water resistance to road spray and rain – Test method

This test is designed to determine the water resistance of a garment to road spray and rain when the rider is seated on a motorcycle in a tourer riding position (Figure 6.1). A fully clothed manikin, seated on a motorcycle, is exposed to horizontal water spray from an industrial pressure washer. The test must not be compromised by movement of air.

The test uses a manikin fully encased in long cotton underwear including gloves and socks, with a full ensemble of motorcycle protective riding gear including helmet, gloves and boots.

The undergarments are weighed before and after the test, to determine whether and how much water penetrates through the outer clothing. When only one item of clothing (e.g., a jacket) is to be tested, a standard set of water-resistant motorcycle outer garments is used to complete the riding ensemble as described below.

Figure 6.1 Motorcycle rider in tourer position

6.4.1 Equipment

- Pressure washer capable of delivering 18±0.5l/min. at over 2000 psi but not more than 2400 psi.
- Large size articulated manikin, sufficiently flexible to be seated on a motorcycle in tourer position.
- Long underwear pants of bleached white knitted 100% cotton (150-200 g/m^2). Sized to fit manikin.
- Long underwear shirt of bleached white knitted 100% cotton (150-200 g/m^2). Sized to fit manikin.
- Gloves of bleached white knitted 100% cotton gloves. Sized to fit manikin.
- Socks of bleached white knitted 100% cotton. Sized to fit manikin.
- Full faced helmet.
- Water resistant motorcycle protective pants designed to integrate with a motorcycle jacket.
- Water resistant motorcycle jacket designed to integrate with motorcycle pants.
- Water resistant gloves in gauntlet style to fit over the motorcycle jacket sleeves.
- Water resistant motorcycle riding boots.
- Balance scales accurate to 0.1g capable of weighing wetted long underwear.
- Fan forced drying oven capable of 105C±2°C.
- Tape measure or ruler to 8 m.

6.4.2 Sample preparation

The garments to be tested must be washed and dried according to standard wash cycle detailed on the internal laundering directions tag before testing. After drying the garment will be conditioned in accordance with the standard AS2001.1.[15]

6.5 Test procedure

6.5.1 Pre-wash and conditioning

1. Garments designed to be laundered within their life cycle are laundered once before water spray testing. This includes all garments designated as either machine-washable or hand-washable. The garment's care label where available will dictate the method of laundering.
2. Drying must comply with the method recommended on the garment's care tag.
3. Textile garments without a specified method for washing must be hand-washed and drip- dried once before testing.
4. For garments not designed to be laundered, prewashing is not required before testing.
5. Garments designed to be wiped clean with a damp cloth or dry-cleaned will not be laundered before testing.
6. The control undergarments must be dried in a fan-forced drying oven at 105°C for 1 hour while hanging unfolded on a coat hanger to allow efficient airflow through the garment.
7. After drying the control garment must be left to condition in accordance with AS2001.1.
8. After conditioning, the control undergarments must be weighed to an accuracy of 0.1 g before being placed onto the manikin.

6.5.2 Manikin preparation – control garments

The manikin must be dressed in the test cotton control undergarments in the following order:

1. Pants
2. Shirt
3. Socks
4. Gloves

6.5.3 Manikin preparation – test garments

The manikin must be dressed in the test motorcycle garments in the following order. All ventilation systems must be closed, all closure straps and fastenings must be secured on each garment as it is fitted.

1. Pants

2. Jackets to be fitted over the top of pants unless otherwise instructed by the manufacturer.
3. Gloves to be fitted over the top of jacket sleeves unless otherwise instructed by the glove manufacturer.
4. Pant legs to be fitted over the top of boots unless otherwise instructed by the pants or boots manufacturer or if they will not fit over the control boot.
5. Boots
6. Helmet

6.5.4 Test rig preparation and testing procedure

1. The spray nozzle system of the pressure washer is set up at a distance of two metres directly in front of the motorcycle and concentrated on the headlight at one metre height from the ground.
2. The pressure pump is started and the pattern of the water jet is checked to ensure that it will evenly cover all of the extremities of the garments being tested.
3. The pump is switched off and the motorcycle seat area is fully dried with a towel to ensure no preliminary wetting can occur while the manikin is being installed on the motorcycle.
4. The fully clothed manikin is placed onto the motorcycle.
5. The pump is re-started and the test to run for 20 minutes.
6. The manikin is left for 2 minutes after the pump has been turned off at the end of the test to allow excess water to runoff.
7. The manikin is carefully lifted and removed from the motorcycle ensuring that wetting of the undergarments does not occur due to the removal process.
8. After the test is completed, each item of the outer garments must be removed in the following specified order, taking care not to allow further wetting of the undergarment during the clothing removal.
9. The helmet is to be removed first, followed by the gloves, jacket, shoes and finally the pants
10. The location and approximate size of any wet patches visible on the undergarments are to be recorded noted.
11. The undergarments (gloves, shirts, socks and pants) are then removed following the same order and weighed to determine the amount of moisture transferred to the garment.

6.6 Rating calculation

The information required to calculate the resistance to road spray and rain is the percentage mass change of the undergarments. The location of wetting of the relevant undergarments under and adjacent to the garment being tested are noted for presentation in the comments section of the test report. All tests are run twice and the results are averaged over the two tests. A further test must be run if the level of wetting between the two tests differs by more than 10%.

When testing multiple garments in a single test run, the test operator should be careful to ensure that the poor performance of one garment does not unduly influence the results of an adjacent test garment worn by the manikin at the same time. For example, the poor performance of a jacket that allows water to enter through the pockets, wetting the under-shirt and, through contact, wetting the adjacent under-pants.

Where this has been suspected to have occurred, the unduly affected test garment must be tested again with a different adjacent garment. Table 6.3 provides a simple format to log the test data as it is acquired.

Table 6.3 Data collected for resistance to road spray and rain

Test garment	Dry mass (g)	Wet mass (g)	Moisture (%)	Wetting location/s
Jackets				
Pants				
Gloves				
Socks				

7 Market surveillance and test sampling protocols

In order to ensure that every eligible garment in the Australian and New Zealand market has a reasonable chance of being selected for testing, the selection process uses a random sampling plan based on the distribution of products in the market.

Each year, ten percent of the available products within each class covered by MotoCAP (protective jackets, pants and gloves) are to be selected. The methodology is based on that used by the World Health Organisation for conducting population surveys.[16]

7.1 Eligibility criteria

Garments for inclusion in the sampling plan will:

- include all motorcycle protective jackets, pants and gloves used for riding on-road, and
- be available in the Australian and/or New Zealand market.

To allow the scheme to focus on the more widely available products, garments that are known to be available only on-line or with no more than one physical retail outlet will not be included in the sampling process.

7.2 The development of sampling plans

Ongoing market surveillance and effective liaison with the industry will be required to maintain lists of the products that are currently available. The success of the scheme will rely on the sampling process being recognised as independent, transparent and fair.

Separate sampling plans will be used for each category of garment taking account of the material divisions within categories of product. There are three categories of garments (jackets, pants and gloves) and three material divisions (leather, textile and denim). For example, if 58% of jackets are textile and 42% are leather, then sampling will be weighted to ensure those proportions of each type will be tested. There are also wide variations in the number of different products/models between brands, so weights will be used in the sampling plan to ensure that the chance of selection is relative to the volume of products by each manufacturer.

7.2.1 Systematic sampling process

To develop a sampling plan for each product category:

1. Determine the Total Market (TM) – the number of different models for the product category across all brands and the required sample size (SS). i.e. SS=10%TM.
2. Sort brands in order of the number of products they have within the category Brand Product Numbers (BPN).
3. Calculate the proportion of the number of products in the total market (%TM) held by each brand BPN/TM.
4. Calculate the cumulative percentage of the market held by each brand (∑%TM).
5. Brand weight (BW) = 10%TotalMarket × (BPN)/Total Market (TM)).

6. Brands that are within the top 50% in the market by product volume per product category, or where BW ≥ 1.6 are automatically included for sampling.
7. Test N products to be randomly selected from within each brand's range using random sampling process (see below).
8. Brands whose BW < 1.6, collectively representing the remainder of the market by volume, will be included in a second ballot to randomly select the balance of test items required to obtain 10% of the market per product category.
9. Shopping lists must be prepared as part of the random sampling process. Shopping is to be conducted anonymously by secret shoppers, who will be provided with lists of specific product items to be purchased. The items having been randomly selected by brand and product model using a computer-based random sampling program. Where specified items are unavailable in a shopping area, alternative product lists from the same target brands must be generated by the centralised computer before shopping can proceed.

7.2.2 Random selection process

The same process is used to randomly select firstly, which brands and secondly, which of their product models will be purchased for each product type e,g leather jackets, denim pants etc.

The group of items are to be sorted alphabetically and then numbered sequentially. A random number generator (e.g.) shall be used to identify the required number of integers from the available range.

7.2.3 Example of a sampling plan

For this example, we assume that there is a total of 113 different models (TM = 113) provided under 9 brand names.

Step 1. Calculate test sample size: SS = 10% 113 = 11.3.

Step 2. Apply the Brand Weight equation. SS × (BPN/TM) = BrandTest N.

Brand Test N finds 3 brands meet the criteria for two or more of their products to be tested, comprising a total of 6 items. Note: these brands together also represent 48% of the market. A further 5 items are required to meet the 11 items which will represent 10% of this market.

The remaining 6 brand names are sorted alphabetically and numbered sequentially. A random number generator is used to identify 5 integers between 1 and 6. The resulting integers identify the 5 brands from which the remaining test products are to be selected. The same process is applied to select one test product from each brand. These calculations are shown in Table 7.1 below.

Table 7.1 Example of data arranged for a sampling plan

Brands	Product numbers (BPN)	% TM	Cum. % TM	Brand weight 11.2*(BPN/TM)
A	23	21%	21%	2.3
B	16	14%	35%	1.6
C	16	13%	48%	1.6
D	15	13%	62%	1.5
E	11	10%	71%	1.1
F	9	8%	79%	0.9
G	8	7%	87%	0.8
H	8	7%	94%	0.8
I	7	6%	100%	0.7
TM	113	100%		11.3

7.3 Protocol for garment purchasing procedure

This procedure is designed to be followed for blind purchasing of garments for testing. The procedure outlines the process for determining the garments to purchase, selecting the retail outlet and the conduct of the purchase.

7.3.1 Equipment

- A list of garments available on the Australian and New Zealand market.
- List of the major physical retail stores within Australia and New Zealand with the types and brands of garments that they sell,
- List of the major on-line stores within Australia and New Zealand with the types and brands of garments that they sell.

7.3.2 Inventory of products

A list of the major Australian and New Zealand retail and online stores must be assembled by the test facility and updated for currency on an annual (12 monthly) basis. A list of the garments of each type available on the Australian and New Zealand market should also be assembled by the test facility and maintained for currency on an annual (12 monthly) basis in an electronic format.

Two garments of each type of jackets and pants, and three pairs of gloves are required for testing purposes. No more than one of each item shall be purchased from any single outlet. At least one of each type of garment should be purchased in person from retail stores from each jurisdiction in turn.

Garments that are only available from one physical retail or on-line store will not be included in the test population, unless a volume of supply argument can be made by the manufacturer or retailer.

7.4 In-store purchasing

On arrival at the store, the purchaser is to initially browse the store to determine which garments on the purchase list are available. If approached by a store worker, the purchaser must not disclose their purpose but ask to be fitted for at least two different garments of each product type listed for purchase. Each product to be purchased should be tried-on to ensure that it fits the wearer. In any store no more than one of each of the following articles may be purchased:

- Leather jacket
- Textile Jacket
- Textile or leather pants
- Protective denim or leather pants
- Summer gloves
- Winter gloves

The restriction on purchasing more than one item of each product type is to avoid drawing the attention of staff to the purchaser. To maintain their anonymity, the same purchaser may not return to any single store more than once every six months. They may purchase product that is not on display but is available in stock on the premises. Purchasers are not permitted to arrange for the product brought in from elsewhere by the store for later pick up.

7.5 On-line purchasing

Two of each item of jacket or pants and three pairs of gloves are required for testing. The first item shall be bought in a physical retail store to determine fit details and to ensure that the product is readily available to consumers. The second may be bought on-line from a different company, once the first item has been obtained to ensure that the exact same products have been obtained.

On-line purchasing requires care to ensure delivery details preserve anonymity. This may entail using a team of purchasers using different addresses for each purchase. The same person and delivery address should not be used more than once every year. This may also be achieved through the use of deliveries to post offices and parcel lockers to retain anonymity.

8 List of rating formulas

Formula 1. Calculating the Injury Protection Score

$$\text{Injury protection score} = (0.5 \times \text{ARS} \times 10) + (0.3 \times \text{IPS}) + (0.2 \times \text{BRS}/20)$$

Where:

- ARS is the abrasion resistance score for the garment,
- IPS is the impact protection score, and
- BRS is the burst resistance score.

Formula 2. Calculating the Breathability Score.

$$\text{Breathability score } (\text{I}_{\text{mt}}) = \left({}^{\text{R}_{\text{ct}}}/_{\text{R}_{\text{et}}}\right) \times \text{S}$$

Where:

- I_{mt} is the relative vapour permeability index,
- R_{ct} is the thermal resistance,
- R_{et} is the moisture vapour resistance and
- S is a constant (=60Pa/K).

Formula 3. Calculating Glove Injury Protection Score

$$\text{Injury protection score} = (0.5 \times \text{AR}_G) + (0.3 \times \text{IP}_G/3) + (0.2 \times \text{SSR}_G/5)$$

Where:

- AR_G the abrasion score for the glove,
- IP_G is the impact score rating, and
- SSR_G is the seam strength score.

Formula 4. Zone equation (Calculated for each Zone separately)

$$\text{AR}_{\text{Zn}} = \left(\mu_{\text{Zn Abrasion high}} \times \%\text{A}_{\text{Zn high}}\right) + \left(\mu_{\text{Zn Abrasion low}} \times \%\text{A}_{\text{Zn low}}\right)$$

Where:

- The Zone number (n) identifies the Zones; 1&2, 3 or 4,
- AR_{Zn} is the abrasion resistance for the Zone n area,
- μ_{Zn} Abrasion high is the corrected mean abrasion time in seconds for the higher protection level Zone n material tested,
- $\%A_{Zn}$ high is the percentage area of the higher protection level Zone n material tested expressed in decimals,
- μ_{Zn} Abrasion low is the corrected mean abrasion time in seconds for the lower protection level Zone n material tested, and
- $\%A_{Zn}$ low is the percentage area of the lower protection level Zone n material tested expressed in decimals.

Formula 5. Two steps calculating the Zones 1 and 2 abrasion penalty

$$Penalty_{Z1\&2} = -2 \times \%\mathrm{A}_{Z1\&2\ low} \times \left(\mu_{1\&2\ Abrasion\ high} - \mu_{Z1\&2\ Abrasion\ low}\right)$$

$$Penalty_w = \mathrm{Penalty}_{Z1\&2} \times \left(\frac{4 - \mu_{Z1\&2\ Abrasion\ low}}{4}\right)$$

Where $Penalty_w$ is the penalty weight to be subtracted from the Zone 1&2 Abrasion Resistance (AR) score when more than one abrasion resistant material is used in the Zone.

Formula 6. Calculating the Abrasion Resistance Score

$$ARS = (0.60 \times \mathrm{AR}_{Z1\&2}) + (0.25 \times \mathrm{AR}_{Z3}) + (0.15 \times \mathrm{AR}_{Z4})$$

Where:

- ARS is the abrasion resistance score for the garment,
- $AR_{Z1\&2}$ is the abrasion resistance of the Zone 1 and 2 area combined and calculated using the Zone equation (Formula 4) plus penalty where applicable (Formula 5),
- AR_{Z3} is the abrasion resistance of the Zone 3 area calculated using the Zone equation (Formula 4), and
- AR_{Z4} is the abrasion resistance of the Zone 4 area calculated using the Zone equation (Formula 4).

Formula 7. Calculating the Impact Protection Score.

$$IPS = \left((35 - F_{ave}) + (50 - F_{max})\right) \times S \times (0.5 + (0.5 \times M))$$

Where:

- F_{ave} is the average transmitted force in energy attenuation tests on the impact protectors,
- F_{max} is the single strike maximum transmitted force in the energy attenuation tests on the impact protectors,
- S is the proportion of the Type B protector template that is covered by the garment impact protectors, and
- M is the proportion of the Type B protector template that is covered by the maximally displaced impact protectors.

Formula 8. Calculating the Impact Protection Score for aftermarket limb impact protectors.

$$IPS_{AIP} = \left((35 - F_{ave}) + (50 - F_{max})\right) \times S$$

Where:

- IPS_{AIP} is the injury protection score for aftermarket limb impact protectors when not fitted to a garment,
- F_{ave} is the average transmitted force in energy attenuation tests on the impact protectors,
- F_{max} is the single strike maximum transmitted force in the energy attenuation tests on the impact protectors, and
- S is the proportion of the Type B protector template that is covered by the aftermarket impact protector.

Formula 9. Calculating Burst Resistance Score.

$$BRS = (0.80 \times \mu_{\mathrm{Z1\&2}}) + (0.20 \times \mu_{\mathrm{Z3\&4}})$$

Where:

- BRS is the burst resistance score for the garment,
- $\mu_{Z1\&2}$ is the corrected mean burst resistance of seams in the Zone 1 & 2 area,
- $\mu_{Z3\&4}$ is the corrected mean burst resistance of seams in the Zone 3 & 4 area.

Formula 10. Calculating Glove Injury Protection Score

$$\text{Glove injury protection score} = (0.5 \times \mathrm{AR}_G) + (0.3 \times \mathrm{IP}_G\ \ 3) + (0.2 \times SS_G/5)$$

Where:

- AR_G is the abrasion score for the glove,
- IP_G is the impact protector score, and
- SSR_G is the seam strength score.

Formula 11. Zone equation (Calculated for each Zone separately)

$$\mathrm{AR_{Zn}} = \left(\mu_{\mathrm{Zn\ Abrasion\ high}} \times \%\mathrm{A_{Zn\ high}}\right) + \left(\mu_{\mathrm{Zn\ Abrasion\ low}} \times \%\mathrm{A_{Zn\ low}}\right)$$

Where:

- The Zone number (n) identifies the Zones; 1, 2 and 3,
- AR_{Zn} is the abrasion resistance for the Zone n area,
- μ_{Zn} Abrasion high is the corrected mean abrasion time in seconds for the higher protection level Zone n material tested,
- $\%A_{Zn}$ high is the percentage area of the higher protection level Zone n material tested expressed in decimals,
- μ_{Zn} Abrasion low is the corrected mean abrasion time in seconds for the lower protection level Zone n material tested, and
- $\%A_{Zn}$ low is the percentage area of the lower protection level Zone n material tested expressed in decimals.

Formula 12. Glove penalty equation (calculated for each zone separately)

$$ARp_{\mathrm{Zn}} = \mathrm{AR}_{Zn} \times \frac{\mu_{Zn\ Abrasion\ low}}{PC_{Zn}}$$

Where:

- μ_{Zn} Abrasion low is the corrected mean abrasion time in seconds for the lower protection level Zone n material tested, and
- PC_{Zn} is the penalty constant for Zone n.
- Note: PC_{Z1}=2.6, PC_{Z2}=2.6 and PC_{Z3}=0.8.

Formula 13 Calculating Abrasion Resistance Score for gloves.

$$AR_G = \left(0.45 \times (AR_{Z1}\ or\ ARp_{Z1})\right) + \left(0.35 \times (AR_{Z2}\ or\ ARp_{Z2})\right) + \left(0.20 \times (AR_{Z3}\ or\ ARp_{Z3})\right)$$

Where:

- AR_G is the abrasion resistance score for the glove,
- AR_{Z1} is the abrasion resistance of the Zone 1 area,
- AR_{Z2} is the abrasion resistance of the Zone 2 area, and
- AR_{Z3} is the abrasion resistance of Zone 3 area.
- ARp_{Z1} is the penalised abrasion resistance of the Zone 1 area,
- ARp_{Z2} is the penalised abrasion resistance of the Zone 2 area, and
- ARp_{Z3} is the penalised abrasion resistance of Zone 3 area.

Formula 14 Calculating Seam Strength Score for gloves.

$$SS_G = {}^{\mathrm{GR}}/_{200} \times \left((0.6 \times TR_{Z1\&2}) + (0.4 \times TR_{Z3})\right)$$

Where:

- SS_G is the seam strength score for the glove,
- $TR_{Z1\&2}$ is the average seam tensile strength in N/mm for Zone 1 and 2,
- TR_{Z3} is the average seam tensile strength in N/mm for Zone 3 and
- GR is the average glove restraint force in N.

Formula 15. Calculating Impact Protection score for gloves

$$IP_G = \frac{(IP_{Knuckle} + IP_{Palm})}{2}$$

Where:

- $IP_{Knuckle}$ is the impact protection score for the knuckle impact protector, and
- IP_{Palm} is the impact protection score for the palm impact protector.

Formula 16. Calculating knuckle impact protection score for gloves

$$IP_{Knuckle} = \left((8 - F_{ave\ knuckle}) + (10 - F_{max\ knuckle})\right) \times \mathrm{C}_{knuckle}$$

Where:

- $F_{ave\ knuckle}$ is the average transmitted force in energy attenuation tests on the knuckle impact protector, and
- $F_{max\ knuckle}$ the single strike maximum transmitted force in the energy attenuation tests on the knuckle impact protector, and
- $C_{knuckle}$ is the proportion of the knuckle impact protector template that is covered by the glove impact protector in an extra-large (XL) glove.

Formula 17. Calculating palm impact protection score for gloves

$$IP_{Palm} = \left(\left(8 - F_{ave\ palm}\right) + \left(10 - F_{max\ palm}\right)\right) \times \mathrm{C}_{palm}$$

Where:

- $F_{ave\ palm}$ is the average transmitted force in energy attenuation tests on the knuckle impact protector, and
- $F_{max\ palm}$ the single strike maximum transmitted force in the energy attenuation tests on the knuckle impact protector, and
- C_{palm} is the proportion of the knuckle impact protector template that is covered by the glove impact protector in an extra-large (XL) glove.

Formula 18. Calculating water resistance score for jackets and pants.

$$WR_{JP} = \%\mathrm{M}_U$$

Where:

- WR_{JP} is the water resistance score for jackets and pants,
- $\%M_U$ is the percentage Moisture (in decimals) of the Undergarment worn under the garment being tested.

Formula 19. Calculating water resistance score for gloves.

$$WR_G = \frac{\mathrm{V}_U}{2}$$

Where:

- WR_G is the water resistance score for gloves,
- V_U is the Volume increase due to wetting (in ml) of the Under-glove worn under the glove being tested.

9 References

1. de Rome L, Ivers R, Fitzharris M, et al. Motorcycle protective clothing: Protection from injury or just the weather? *Accident Analysis and Prevention.* 2011;43(6):1893-1900.
2. de Rome L, Ivers R, Fitzharris M, Haworth N, Heritier S, Richardson D. Effectiveness of motorcycle protective clothing: Riders' health outcomes in the six months following a crash. *Injury: International Journal of the Care of the Injured.* 2012;43:2035-2045.
3. Meredith L, Brown J, Ivers R, de Rome L. Distribution and type of crash damage to motorcyclists' clothing: validation of the zone approach in the European Standard for motorcycle protective clothing, EN-13595. *Traffic Injury Prevention.* 2013;15(5):501-507.
4. de Rome L. Could wearing motorcycle protective clothing compromise rider safety in hot weather? *Accident Analysis & Prevention.* 2019;128:240-247.
5. de Rome L. *Stars or standards? A review of motorcycle protective clothing from the southern hemisphere.* https://www.racfoundation.org/research/safety/stars-or-standards-a-review-of-motorcycle-protective-clothing. London, UK: RAC Foundation 2018.
6. de Rome L, Taylor EA, Croft RJ, Brown J, Fitzharris M, Taylor NAS. Thermal and Cardiovascular Strain Imposed by Motorcycle Protective Clothing Under Australian Summer Conditions. *Ergonomics.* 2015:1-29.
7. de Rome E, Taylor E, Croft R, Brown J, NAS T. Can motorcycle riding in Australia really be that thermally stressful? *Extreme Physiology & Medicine.* 2015;4(Supplement 1: A20).
8. de Rome L, Gibson T, Haworth N, Ivers R, Sakashita C, Varnsverry P. *Improving consumer information about motorcycle protective clothing products (2012).* Sydney: The George Institute for Global Health;2012.
9. CEN. Protective clothing for professional motorcycle riders: Jackets, trousers and one piece or divided suits - Test method for determination of impact abrasion resistance. In. *EN 13595-2:2002*: European Committee for Standardisation, Brussels; 2002.
10. CEN. Protective clothing for professional motorcycle riders: Jackets, trousers and one piece or divided suits - Test method for determination of burst strength. In. *EN 13595-3:2002*: European Committee for Standardisation, Brussels; 2002.
11. Filingeri D, Fournet D, Hodder S, Havenith G. Tactile cues significantly modulate the perception of sweat-induced skin wetness independently of the level of physical skin wetness. *Journal of Neurophysiology.* 2015;113(10):3462-3473.
12. ISO. Textiles - Physiological effects- Measurements of thermal and vapour resistance under steady-state conditions (Sweating Guarded Hot Plate). ISO 11092 (EN 31092). In. Switzerland: International Organization for Standardization,; 2014.
13. de Rome L, Hurren C. Motorcycle gloves damage and riders' injury outcomes. *In draft.* 2021.
14. CEN. Protective gloves for professional motorcycle riders: Requirements and test methods. In. *EN 13594:2002*: European Committee for Standardisation, Brussels; 2002.
15. Australia S. Methods of test for textiles Method 2.3.1: Physical tests – Determination of maxmium force and elongation at maximum force using the strip method. Australian Standard AS200132.3.1-2001 In:2001.
16. WHO. The World Health Survey (WHS) Sampling guidelines for participating countries. WHO. http://www.who.int/healthinfo/survey/en/. Published 2012. Accessed 19/09/2012, 2012.