BICYCLE HELMET RATING PROGRAM

DEFINITIONS, TEST AND TEST RIG SPECIFICATIONS AND PROCEDURES

Version 1.1

28 June 2024

Contents

Bicycle Helmet Rating Program

Rules, Definitions and Test Specifications and Procedures 2024

1. INTRODUCTION

A feasibility study on the establishment of the Bicycle Helmet Rating Program had been completed with the outcomes have been accepted by Transport for NSW. This document sets out the specifications and the procedures on how to test bicycle helmets.

2. DEFINITIONS

AIMS	Angular impact management system
ATD	Anthropomorphic Test Device, aka crash test dummy
AS/NZS 2063	Australian/New Zealand Standard 2063: *Helmets for use on bicycles and wheeled recreational devices*. 2020 version is current.
CM	Centre of mass
CRASH	Consumer Rating and Assessment of Safety Helmets
Headform	An ATD component or individual head used for impact testing, which come in different sizes and masses
Helmet categories in report	Children, Mountain bike (MTB), Skateboard/Bicycle (Wheeled recreational device AS/NZS 2063), Road, General.
Hybrid III; HIII	The Hybrid III is an ATD originally designed for frontal impact motor vehicle crash tests.
Oblique	An impact with components oriented towards the head's CM and tangential to head's CM.
PLA	Peak linear acceleration (g)
PRA	Peak rotational (angular) acceleration (rad/s^2)
PRV	Peak rotational (angular) velocity (rad/s)
SD	Standard deviation

WRD	Wheeled recreational device
α	The symbol for rotational (angular) acceleration
ω	The symbol for rotational (angular) velocity
g	One gravity = 9.81 m/s^2 is a unit of acceleration

3. HELMET SIZE

For bicycle helmets designed for adult, a medium size helmet is to be selected. Medium sizes are in the size range of 53 to 59 cm.

For helmets designed for children a small size (48 to 54 cm) and extra-small size (45 to 49 cm) is to be selected

4. TEST ORDER

The helmet must be tested in the order as shown in Table 1. This process is repeated twice or thrice on some helmet models. No helmet is impact tested more than once at one site. Helmet mass is also measured on three helmets.

Helmet #	Test order
1	a) Helmet coverage. b) Dynamic stability forward and rear @ 175 mm c) Low level impact energy attenuation on four sites. Impact speed = 3.96 $^{+0.1}_{0}$ m/s (Nominal drop height = 800 mm) d) Load distribution on one site Impact speed = = 5.42 $^{+0.1}_{0}$ m/s (Nominal drop height = 1500 mm)
2	a) Impact energy attenuation test as stipulated in Clause 7.4 of AS/NZS 2063:2008 test requirements on four sites. Impact speed = = 5.42 $^{+0.1}_{0}$ m/s (Nominal drop height = 1500 mm) b) Dynamic strength of the retention system test as stipulated in Clause 7.6 of AS/NZS 2063:2008 requirements. c) Load distribution on one site Impact speed = = 5.42 $^{+0.1}_{0}$ m/s (Nominal drop height = 1500 mm)

3	a) Dynamic retention strength test as stipulated in Clause 7.6 of AS/NZS 2063:2008 requirements b) Impact energy attenuation on four sites Impact speed = = 6.26 $^{+0.1}_{0}$ m/s (Nominal drop height = 2000 mm) c) Load distribution on one site Impact speed = = 5.42 $^{+0.1}_{0}$ m/s (Nominal drop height = 1500 mm)
4	Oblique impact tests x 2

Table 1. Test order for each helmet mode.

5. HEADFORM SIZE

For energy attention drop tests: the ISO 'J' headform is used for adult helmets; the ISO 'E' headform is used for small sized child helmets; and the ISO 'A' headform is used for XS child helmets.

For oblique impact tests a 50th percentile HIII head-neck assembly is used for adult helmet sizes and a 5th percentile HIII head-neck assembly for child helmets.

6. TEST SITES

Test sites for each testing are described individually in Section 9.

7. TEST CONDITIONING

All tests were conducted with helmets conditioned to the CRASHLAB ambient temperature and humidity.

Note: Helmets included in the program have been selected based on claimed compliance with AS/NZ 2063. AS/NZS 2063 requires impact testing of the helmet after conditioning to hot, cold and wet. Therefore, it was deemed that this aspect of helmet performance has already been assessed.

8. TEST PROCEDURES

8.1. Assessment of helmet coverage

Helmet #1 is to be assessed on the level of the helmet's coverage. The assessment is as follow:

- The Test Line, according to AS/NZS 2512.1, is to be drawn as shown in Figure 1.
- Once the Test Line is drawn, the amount of extra protection offered by the helmet (i.e., the amount of inner liner which extends outside the test line) at the front and the rear of the helmet is to be measured.

Front

Side 1

Side 2

Rear 1

Rear 2

Figure 1. Locations for measurement of coverage. The locations are based on the Test Line as defined in AS/NZS 2512.2

8.2. Dynamic Stability Test Forward and Rear @ 175 mm

Helmet #1 is to be tested using a dynamic stability test. This test is to be performed according to AS/NZS 2512.7.2 with the following amended specifications. Figure 2 shows examples of this test.

- The test will be performed with a drop mass of 10 kg.
- The test will be performed with a drop height of 300mm.
- but tested in two directions:
    - Rear to front,
    - Front to rear.
- The angle of rotation of the helmet is to be measured.

(a) (b)

Figure 2. Examples of dynamic stability test examples. (a) Rear-to-front (forward rotation) (b) Front-to-rear (rearward rotation)

8.3. Low Level Energy Attenuation Test

Helmet #1 will undergo two low level energy impact tests using a flat anvil at sites A and B and two tests using kerb anvil at sites C and D. These sites are shown in Figure 3.

The low-level energy impact tests are to be performed according to AS/NZS 2512.3.1.

- The test is to be performed from a nominal drop height of 800mm to achieve an impact speed of 3.96 m/s.
- The acceleration of the headform is to be measured.

The intent of this test is to assess how well the helmet will protect the head against concussion in low severity impacts. The prognosis and burden associated with concussion is much less than severe traumatic brain injury, therefore its weighting factor is 14%. A 100 g lower limit corresponding to an approximate 10% likelihood of serious to severe skull and brain injury and a 50% likelihood of concussion was initially proposed. Based on helmet performance in the feasibility study this was raised to 120 g. The 140 g upper limit corresponds to an approximate 15% likelihood of serious to severe skull and brain injury and a 90% likelihood of concussion.

Site A - Flat anvil

Site B - Flat Anvil

Site C - Hazard (V) anvil

Site D – Hazard (V) anvil

Figure 3. Impact site and anvil combinations. Sites A and D are on the test line. Site B is at a location elevated above the test line by 10 mm.

8.4. Load Distribution Test

Helmets #1, #2 and #3 are to be tested using the load distribution test in accordance with AS/NZS 2512.9, however, with a nominal drop height of 1,500 mm to achieve an impact speed of 5.42 m/s. The anvil is dropped to impact site E as shown in Figure 4.

The following conditions shall be observed:

- Loading force recorded by the force transducer in Newton; and
- A record of whether the anvil is in contact the surface of the headform or not.

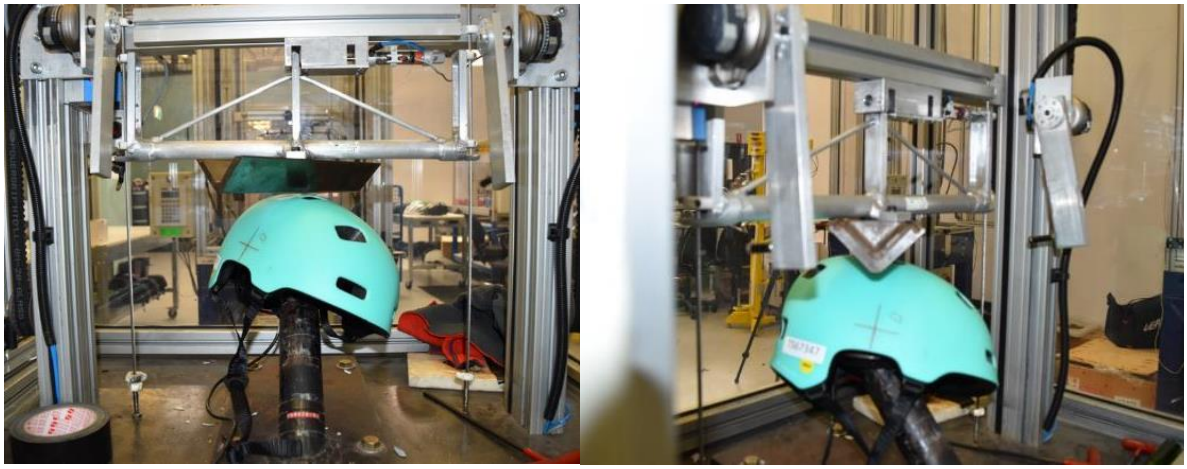


Figure 4. Site E – Load distribution test

8.5. AS/NZS 2063 Impact Energy Attenuation Test

Helmet #2 is to be tested using an impact energy attenuation test as stipulated in Clause 7.4 of AS/ NZS 2063:2008 test requirements on four sites (A^{AUDIT}, B^{AUDIT}, C^{AUDIT} and D^{AUDIT}). All tests are to be done using a flat anvil only. The nominal drop height is 1,500mm to achieve an impact speed of 5.42 m/s.

Below is the procedure to determine the test sites for this test:

a) Draw the Test Line as described in Clause 5 of AS/NZS 2512.2.2006. The helmet supplier normally sets the positioning index (PI). This is the pitch angle that the helmet sits at when the Test Line is marked. If the helmet sample does not have a PI, Crashlab staff can determine the PI based on a reasonable wearing position (pitch angle).

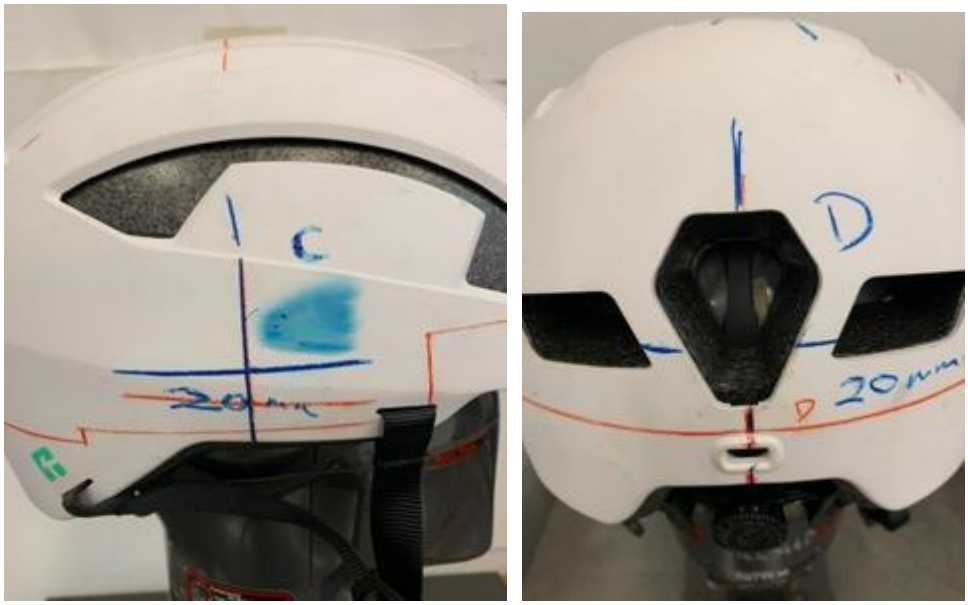
b) Mark the four sites relative to the test line, these are:

   A^{AUDIT} - Centre front 30 mm above the Test Line.
   B^{AUDIT} - Left side, 10 mm rear of end of initial Test Line component and elevated 20 mm. This test site might encroach on the retention system attachment area.
   C^{AUDIT} - Right side, 20 mm above midpoint of Test Line on side.
   D^{AUDIT} - Rear. 20 mm above the Test Line.

   Figure 5 shows an example of these four test sites.

Site A AUDIT

Site B AUDIT



Site C AUDIT

Site D AUDIT

Figure 5. Test sites for audit purposes

The headform acceleration for each test is to be measured and recorded.

8.6. Dynamic Retention Strength Test

After the completion of the AS/NZS 2063 energy attenuation tests, helmet #2 is to be tested using a dynamic retention strength test in accordance with the AS/NZS2512.5.2 test procedures.

- The test will be performed with a drop mass of 10 kg and a drop height of 250mm.
- Raise the drop mass to the drop height and allow it to fall and impact the end stop. Measure the maximum dynamic displacement.
- After 30 seconds, measure the permanent displacement of the chin strap stirrup.
- Release the load and then ascertain whether or not the retention system can be released by normal operation.

Regarding helmet #3, the dynamic retention strength test is to be performed before any other test is conducted on this helmet.

8.7. High Level Energy Attenuation Test

Helmet #3 is to be tested using a high-level energy attenuation impact test. The test is to be done using a flat anvil at each of two sites (A & B) and using a kerb anvil at each of two sites (C & D). These sites are shown in Figure 3.

The high-level energy impact tests are to be performed according to AS/NZS 2512.3.1, and as follows:

- The test is to be performed from a nominal drop height of 2,000mm to achieve an impact speed of 6.26 m/s.
- The acceleration of the headform is to be measured for each test.

This test denotes how well the helmet will protect the rider from serious head injury and severe traumatic brain injury in a severe impact. The 200 g lower limit corresponds to an approximate 20% likelihood of serious to severe skull and brain injury and a 100% likelihood of concussion. The 300 g upper limit corresponds to an approximate 50% likelihood of serious to severe skull and brain injury and a 100% likelihood of concussion.

8.8. Oblique Impact Test

Test rig, instrumentation and method

The test rig and instrumentation as well as the test method for the oblique impact test is the one described in the report *Oblique Helmet Testing: Commissioning and Evaluation, 23 February 2017* which was developed for the Consumer Rating and Assessment of Safety Helmets (CRASH) program. An example of this test is shown in Figure 6

Figure 6. An example of oblique impact test

However, for this program the test specifications are as follow:

- Helmets designed for adults:
    - horizontal speed of the striker plate = 25 km/h and drop height = 1,400 mm
    - 50th%ile Hybrid III head and neck assembly shall be used.
- For children helmets:
    - horizontal speed of the striker plate = 15 km/h and drop height = 800 mm
    - 5th%ile Hybrid III head and neck assembly shall be used.

Each helmet sample (helmet #4) is to be dropped in two oblique impact test sites (O_A and O_C). Figure 7 and Figure 8 show these two oblique impact test sites.

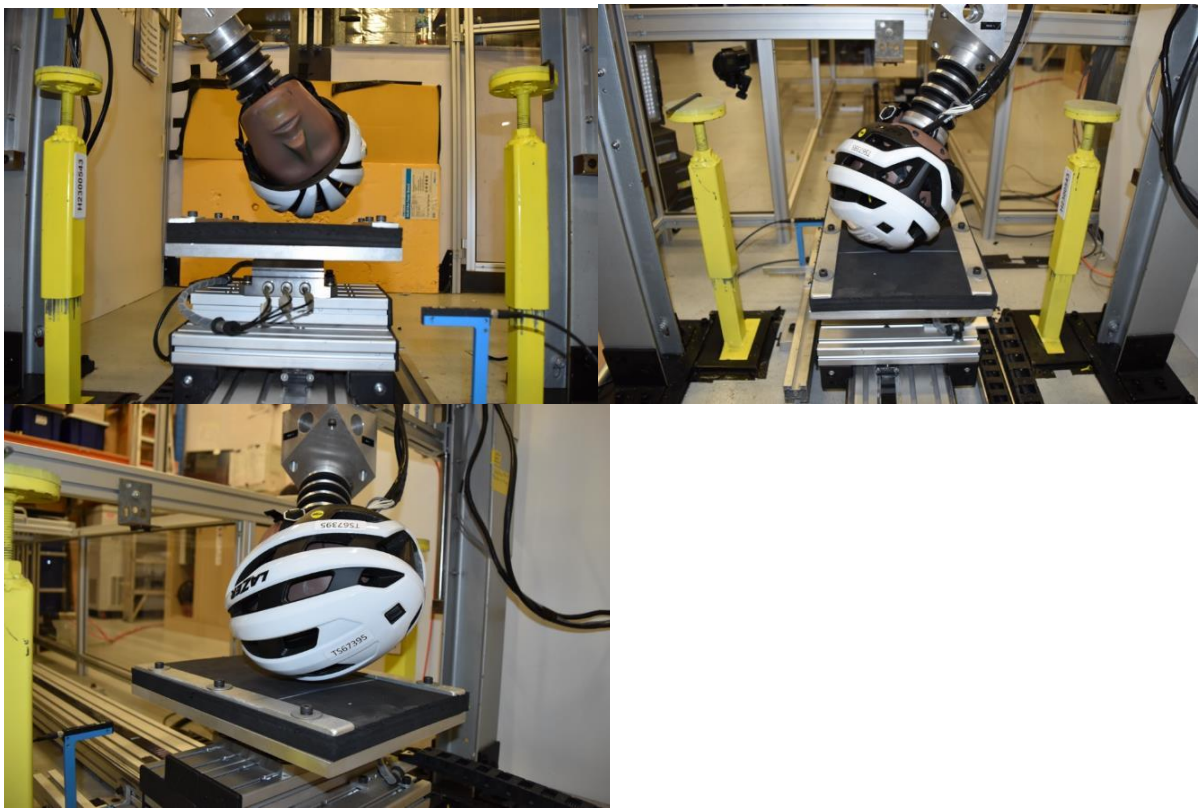


Figure 7. Oblique Site O_A. Head and neck moved into combination of extension, lateral flexion and rotation.

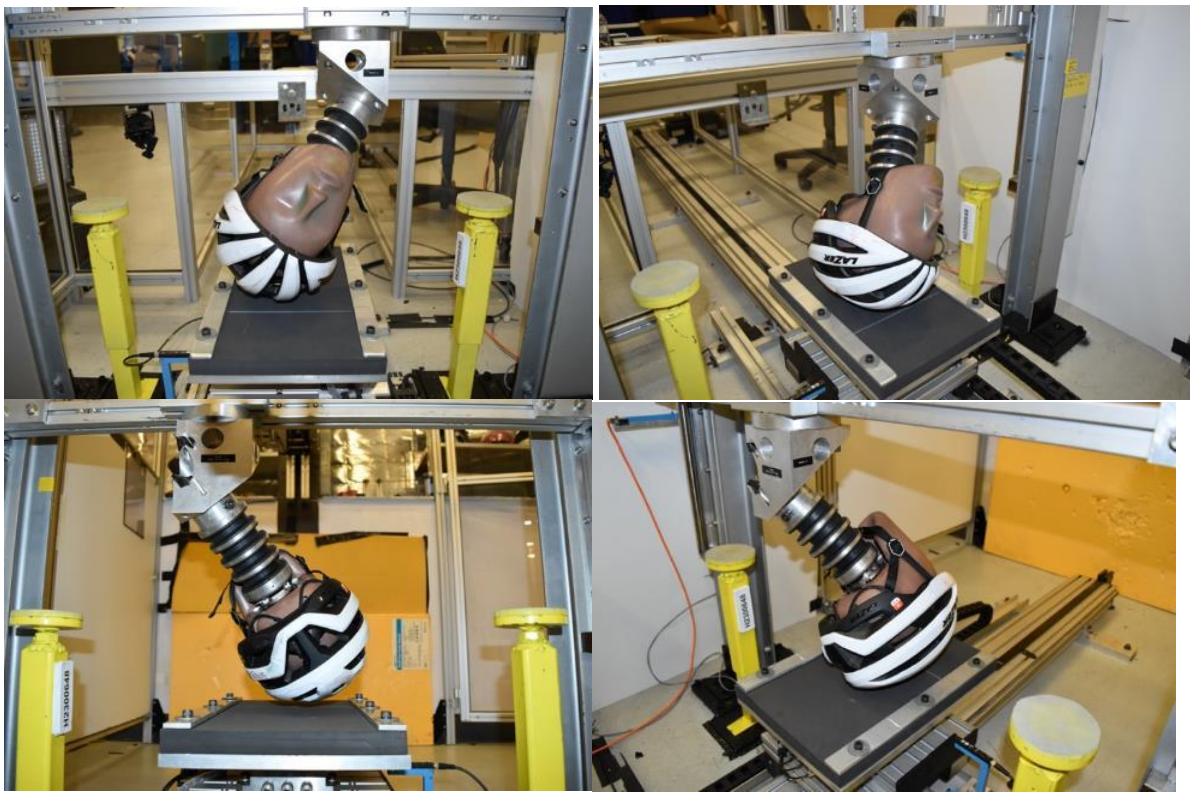


Figure 8. Oblique Site O_C. Head and neck moved into combination of flexion, lateral flexion and rotation.

The following measurements should be recorded.

- PLA (g) – three components
- PRV (rad/s) – three components
- PRA (rad/s^2) – three components
- Plate force (N)– three components

8.9. Test Summary

The summary of test procedures for each bicycle helmet model as follows:

Item Score	Tests	Primary Scoring parameters	AS/NZS 2063
Helmet mass (Informative)	Measure the average mass from 3 helmet samples (#1, #2, and #3)	Mass (kg)	Not assessed
Coverage	Extent of coverage relative to the AS/NZS 2063 test line (measured only)	Vertical measurement at five points from centre front to rear (mm)	Not assessed in AS/NZS 2063. Defined by test line for impact tests.
Impact energy attenuation drop tests	Nominal drop heights Low = 800 mm Standard = 1500 mm High = 2000 mm Tested as per AS/NZS 2512.3.1. Four test sites per helmet. Including side and rear on test line. Flat and Hazard 'V" anvils for 800 and 2000 mm tests. Flat only for 1500 mm tests.	PLA (g)	Current pass level in AS/NZS 2063 ≤ 250g for flat anvil tests only
Oblique impact test	Test rig and method as per testing requirements in CRASH. Site O_A and O_C (as per CRASH) adult helmets at 1400 mm & 25 km/h, child helmets at 800 mm & 15 km/h	PLA (g) PRV (rad/s) PRA (rad/s^2) Plate force.	Not assessed in AS/NZS 2063
Dynamic stability	Test as per AS/NZS 2063 using AS/NZS 2512.7.2, same test load, but tested. (a) Front to rear, (b) Rear to front.	Maximum angular displacement.	Current pass level in AS/NZS 2063 ≤ 45º for rear-to-front tests only in 2020 version
Dynamic strength of retention system	Test as per AS/NZS 2063: 2020 using AS/NZS 2512.5.2. Same conditions (250 mm drop).	Displacement and/or failure	Current pass level ≤ 30 mm displacement.

Load Distribution	Test as per AS/NZS 2519.9 with nominal 1500 mm drop height. AS/NZS 2063 specifies 1000 mm drop height.	Load (N)	Current pass level ≤ 500 N for 1000 mm drop
AUDIT	Star Rating adjusted on compliance with AS/NZS 2063: impact energy attenuation 1500 mm ambient, dynamic strength of retention ambient and status of helmet components (permanently attached)		