NHTSA'S Motorcycle Helmet Testing Research Program

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Research Objectives

- All motorcycle helmets sold in the U.S. have to comply with FMVSS No. 218 performance requirements. Performance tests in FMVSS No. 218 include impact attenuation test, quasi-static retention test, and a penetration test using a DOT standard headform.
- NHTSA conducted research to evaluate the performance of motorcycle helmets sold in the U.S. when subject to certain tests and test procedures in other standards. Specifically, NHTSA focused on:
  - **Impact attenuation test using the ISO headform** to evaluate the impact attenuation capability of the helmet.
  - **Dynamic roll-off stability test** to evaluate the ability for the helmet to be retained on the head in a dynamic event.
  - **Face shield penetration test** to evaluate the penetration resistance of face shields.
  - **Chin bar impact attenuation test** to evaluate the ability of the chin bar to cushion impacts.

Motorcycle Helmet Types Tested

Half, Partial, Beanie

3/4, Full, Open Face

Complete, Full Face

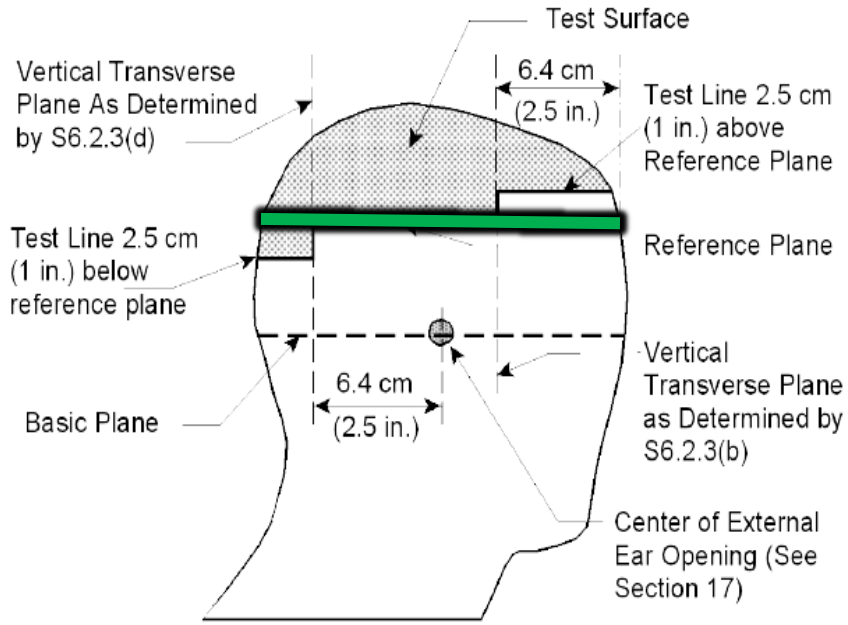
Modular Helmet

- 49 helmet models were used in the test program.
  - 13 were half, 15 were open face, 12 were full face, and 9 were modular.

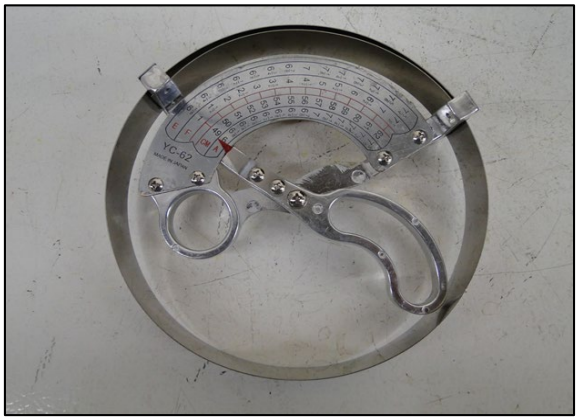
Discrete Size Measurement

Scissor Style Sizing Tool

- Developed to measure the interior circumference of a helmet at the reference



NOTE: Solid lines would correspond to the test line on a test helmet.



DOT and ISO Headform

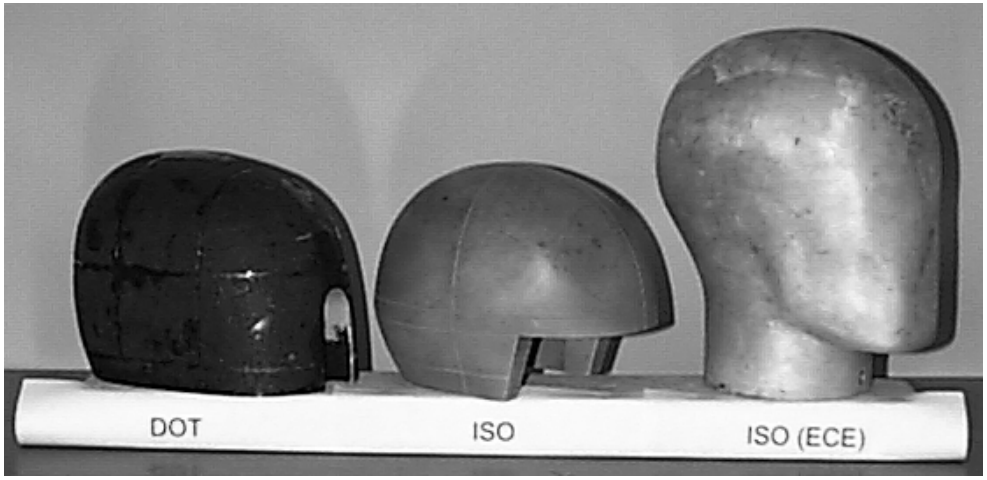
The DOT headform is used in FMVSS No. 218 while all other standards use the ISO headform. The ISO (ECE) full headform is identical to the ISO headform but includes a continuous face, chin, and neck region.

Headform Size Selection

- Helmet size (circumference) was determined by the size measurement tool.
- Appropriate ISO and DOT headform sizes were selected for each helmet based on its circumference.

DOT / ISO Size	Medium / J	Large / M	Medium / M
No. of helmets	30	11	8

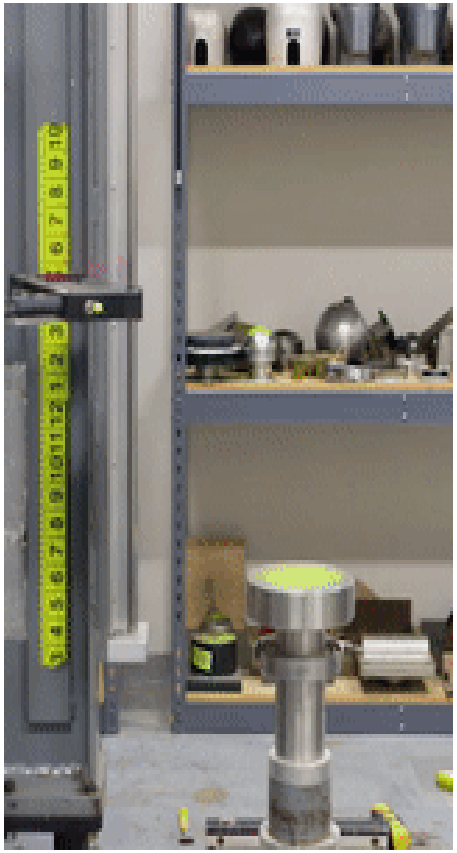
- For 41 of the 49 helmets tested, the selected ISO headform was slightly lighter than the selected DOT headform.



DOT	Mass	Circumference	ISO	Mass	Circumference
Small	3.5 kg	490 mm	**A**	3.1 kg	500 mm
			C	3.6 kg	520 mm
			E	4.1 kg	540 mm
Medium	5.0 kg	560 mm	**J**	4.7 kg	570 mm
Large	6.1 kg	600 mm	**M**	5.6 kg	600 mm
			O	6.1 kg	620 mm

Impact Attenuation Test

Flat Impact

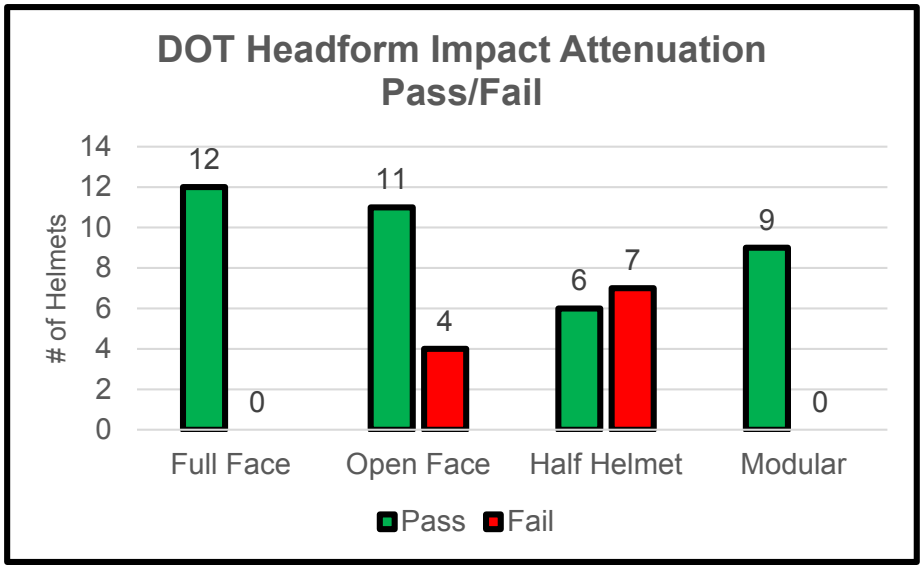


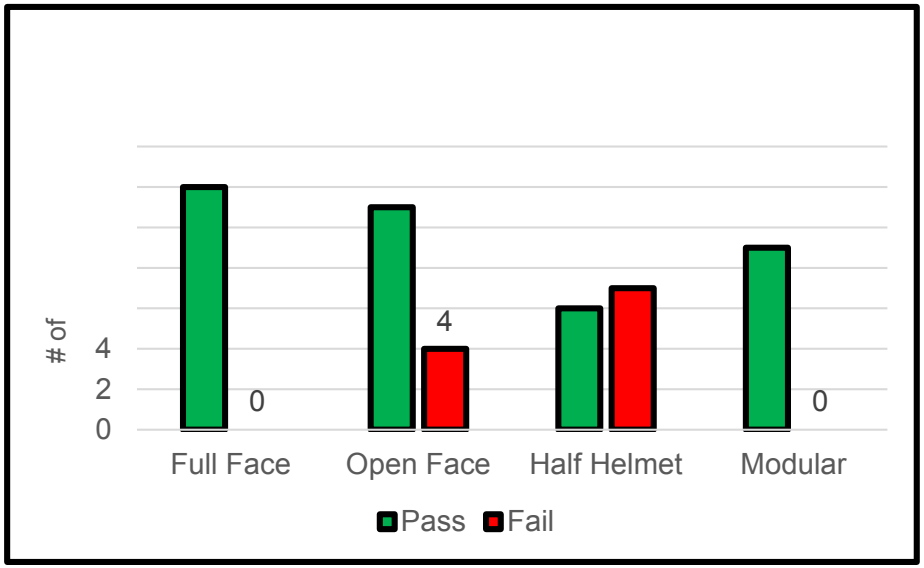
Hemi Impact

Tests conducted in accordance with FMVSS No. 218

- Helmet pre-conditioning (4 helmets per model)
  - Ambient Temperature (16°C to 26°C)
  - Low Temperature (-15°C to -5°C)
  - High Temperature (45°C to 55°C)
  - Wet Temperature (16°C to 26°C)
- We chose four impact locations on each helmet:
  - Left Front, Right Rear, Right Front, Left Rear
- Two successive identical impacts per test location
- Impact surfaces and impact velocities
  - Two impact locations on flat steel anvil: 6 m/s
  - Two impact locations on hemispherical steel anvil: 5.2 m/s
- Testing both ISO and DOT headform per helmet model
- This resulted in 64 impact tests per helmet model

Impact Attenuation Test Results





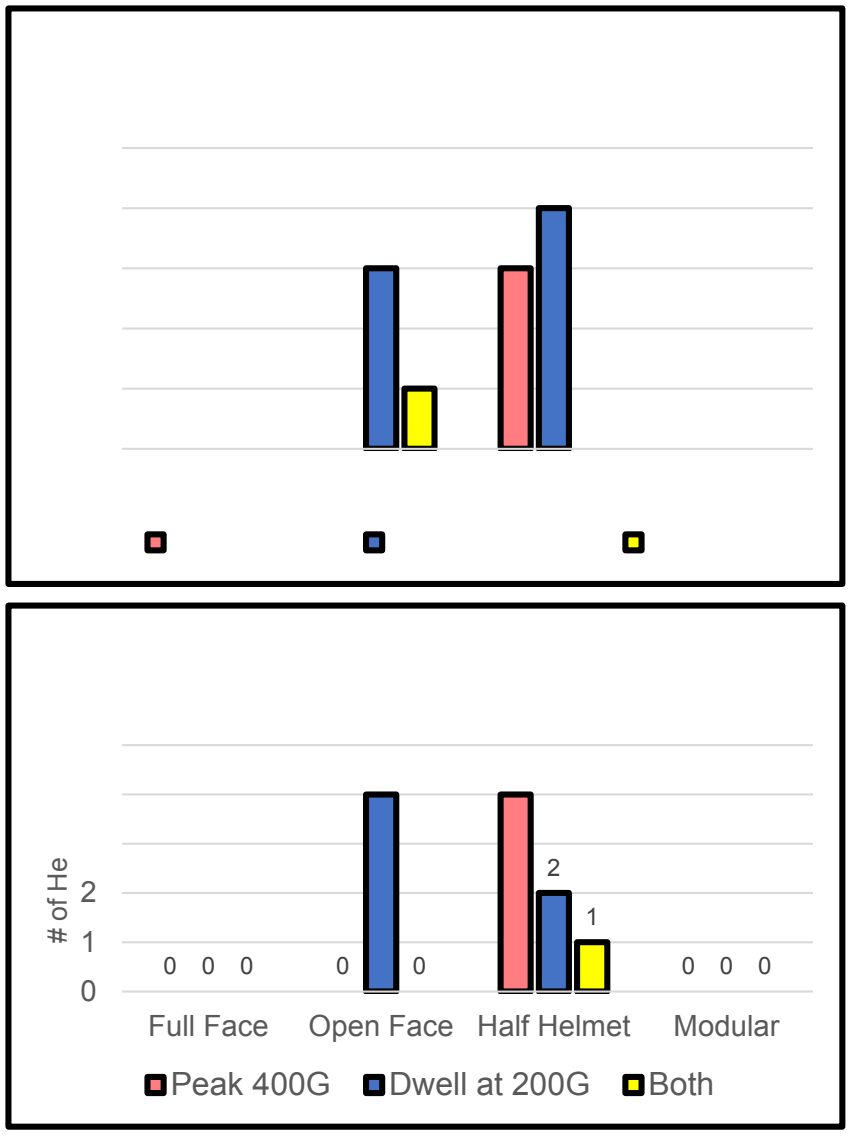
Failure Criteria specified in FMVSS No. 218

- Peak Acceleration > 400 g
- Dwell Time > 2 ms for accelerations > 200 g
- Dwell Time > 4 ms for accelerations > 150 g

Test Results

- Pass/fail rate with ISO and DOT headforms are similar
- 15 helmet models failed
  - 7 failed both DOT and ISO headforms, 4 failed just the DOT, and 4 failed just ISO

Impact Attenuation Test Result



Observations

- 39 of the 49 helmet models tested with ISO headforms experienced peak acceleration less than 300 g
- No failures for Dwell Time > 4 ms for accelerations > 150 g for any helmet tested
- All 2 ms dwell time failures (with DOT and ISO headforms) were in the flat anvil impact tests.
- Failures were uniformly distributed among the 4 pre-conditions.
- Most helmet failures occurred in the 2nd impact
  - Some failed 1st and 2nd impact.

Headform	1st Impact	2nd Impact	Both 1st and 2nd
DOT	0	8	3
ISO	0	9	2

Dynamic Roll-Off Positional Stability Test

Pass

Fail

The American Society for Testing and Materials standard F1446-11a (ASTM F1446-11a)

- The helmet (ambient pre-conditioning) is secured on to an appropriate sized full reference headform (ISO/ECE) with its vertical axis pointing downward at a 45 degree angle from the vertical.
- A flexible strap is attached to the top far edge of the helmet rim by a hook.
- A 10 kg mass attached to the strap is dropped from a height of 0.6 meters.

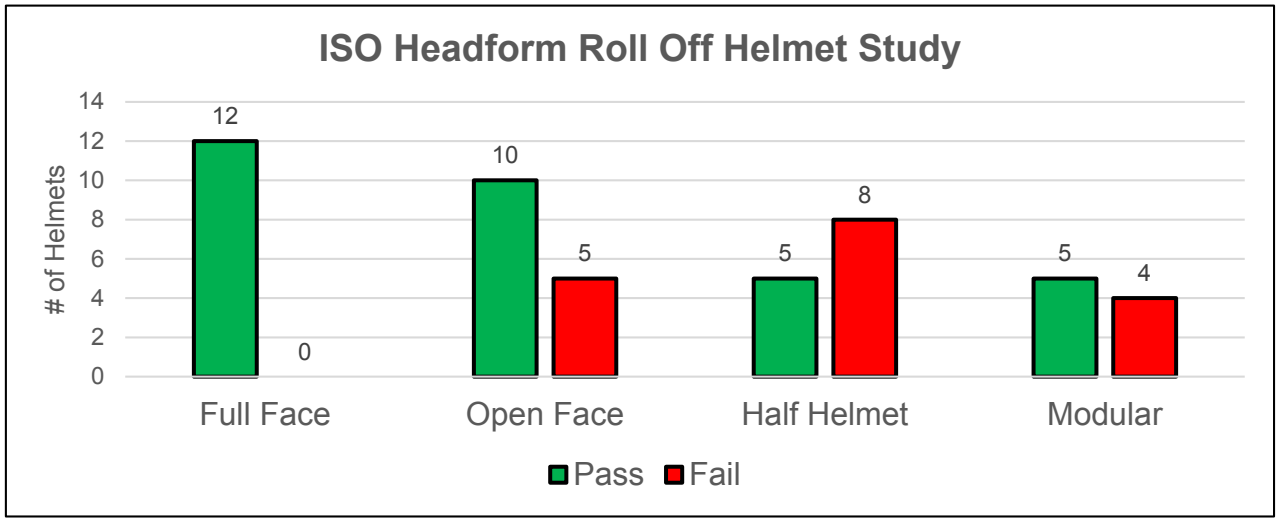
Preliminary Failure Criteria

- The helmet is not retained on the headform such that the coronal plane of the headform is exposed.

Dynamic Roll-Off Positional Stability Test Result

Observations

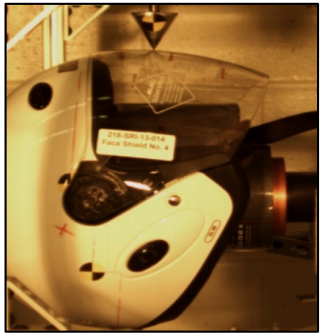
- 5 open face helmets, 8 half helmets, and 4 modular helmets failed to retain the helmet on the headform in this test.
- All full face helmets passed the test.
- Modular helmets were tested without the chin bar simulating worst case scenarios.
- Helmets that covered more of the headform were better able to retain the helmet on the headform.

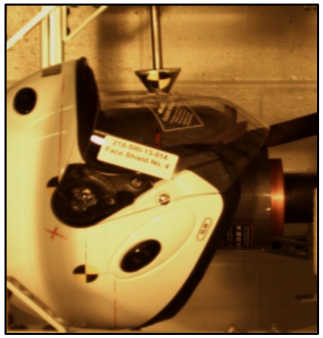


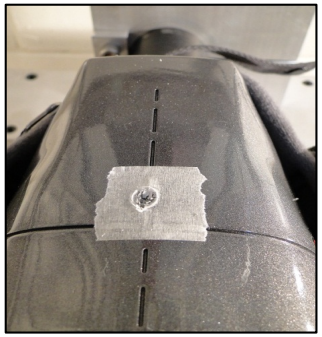
Face Shield Penetration Test

Pass

Fail







Economic Commission for Europe R.22 Standard

- Helmet (ambient pre-condition) fitted with visor is secured on the appropriate sized ISO headform with its face up (basic plane in vertical position).
- Cone shaped punch device with a mass of 0.3 kg is positioned in contact with face shield.
- Mass of 3 kg is dropped on the punch device from a height of 1 meter.

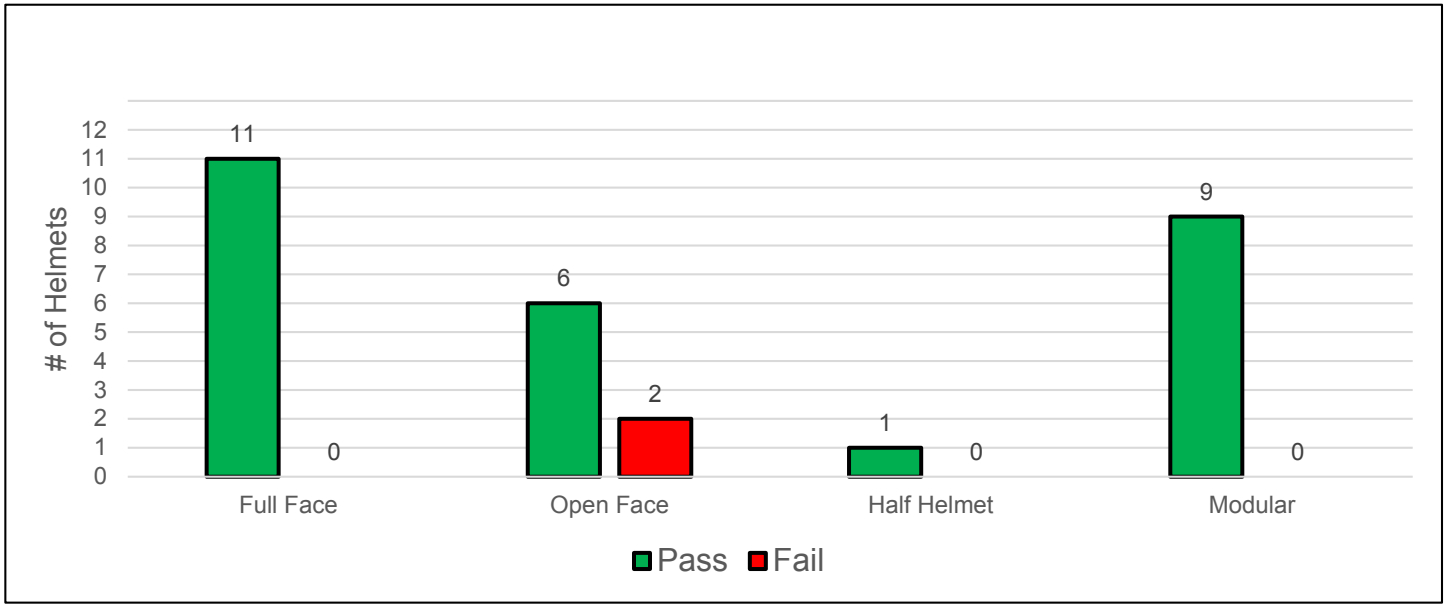
Preliminary Failure Criteria

- Face shield shattering
- Punch touching headform

Face Shield Penetration Test Result

Observations

- Face shield tests of two open face helmet models resulted in the striker punching through the face shield and touching the headform.
  - None of the face shields shattered.
- 1 full face helmet did not have a face shield.



Chin Bar Impact Attenuation Test

Pass	Fail
	

British Standard Institution 6658

- A rigid structure with an ISO/ECE complete headform (with chin) supported from its neck with the chin up and its vertical plane angled 28 degrees below horizontal.
- A helmet is secured on the headform and an adjustable block is raised to provide support to the rear of the test helmet.
- 130 mm diameter and 5 kg mass flat face striker is dropped from a height of 2.5 meters on the chin bar (7 m/s impact speed).
- Helmet models are tested in all four pre-condition states (Ambient, Cold, Hot, Wet).

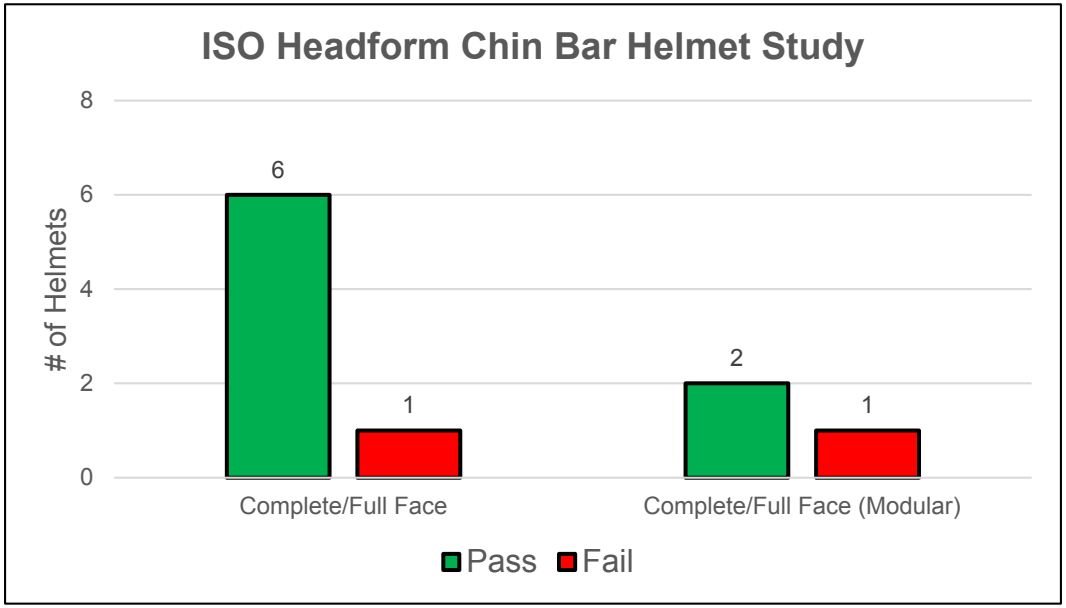
Preliminary Failure Criteria

- Peak acceleration exceeds 300 g

Chin Bar Impact Attenuation Test Result

Observations

- The chin bar test were only conducted on 7 full face helmets and 3 modular helmets.
- Chin bar impacts on 1 full face and 1 modular helmet models had striker accelerations greater than 300 g.

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Questions?