NSW CENTRE FOR ROAD SAFETY

Motorised Bicycle Tests

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MOTORISED BICYCLE TESTS

Contents

1. Executive Summary

Motorised bicycles can be used on NSW roads without requiring registration or without the rider requiring a licence providing they comply with the definition of *power assisted pedal cycle* within the Commonwealth *Motor Vehicles Standards Act 1989*, which has been incorporated into NSW regulations. Some motorised bicycles are being supplied for sale that do not meet the definition of power assisted pedal cycle (in particular, their motor produce more than the maximum allowed 200 watts of power), and these are being used on the road without being registered or without the rider holding a motorcycle licence. Apart from being an illegal motor vehicle, these vehicles may pose a significant road safety risk to their riders.

Of most concern are standard bicycles fitted with petrol engines. A fatal crash in October 2013 involving a 14 year old boy riding one of these vehicles prompted the Centre for Road Safety to carry out a series of tests on a number of petrol-powered motorised bicycles. The purpose of the tests was to determine whether the petrol-powered bicycles met the definition of a power assisted pedal cycle, and to compare these with an electrically powered bicycle marketed as a power assisted pedal cycle of the “pedalec” variety.

The engines used in petrol-powered bicycles produce more than 200 watts of power, but some are sold with a limiting device that restricts their power output, and these are marketed as power assisted pedal cycles. Because of this, three different petrol-powered motorised bicycles were tested, including one fitted with a restricting device to limit its power to 200 watts. Two types of tests were done – dynamic tests to measure the bicycles’ speed and braking capabilities; and static tests to measure their power output.

The results found that the petrol-powered bicycles were capable of being driven without the need for the rider to pedal other than at start-up; all the petrol-powered bicycles were able to obtain higher speeds than the pedalec; all the petrol-powered bicycles took longer to stop than the pedalec; the unrestricted engines produced far in excess of the maximum power allowed; and although the restricted engine was under the maximum power limit, the restricting device could be easily removed or bypassed in less than five minutes.

An assessment of the bicycles found that the brakes fitted to the petrol-powered bicycles were typical of those fitted to cheaper bicycle models, and were not commensurate with dealing with the speeds the petrol-powered bicycles could reach; the braking system itself was complex and could lead to incorrect application; and there were a number of exposed moving parts and hot components that posed an additional risk to the riders.

Overall, the results of the tests and the assessment show that the petrol-powered motorised bicycles tested do not comply with the legal definition of power assisted pedal cycle, even if the engine is fitted with a restricting device, and their performance capabilities pose a high road safety risk.

A review of the websites of a number of suppliers of petrol-powered bicycles found that they all openly advertised petrol-powered bicycles that did not comply with the legal definition, and some sold models with devices fitted that limited their power output to 200 watts, which

suggests the suppliers are aware of the legal requirements for power assisted pedal cycles in Australia. Despite this, only some sites had a warning that the petrol-powered bicycles may not be legal for road use, and to check this with the road authorities.

This internet review demonstrates the need for increased action to ensure current regulations are effective in managing the road safety risk of motorised bicycles and preventing petrol-powered bicycles being sold for use on the NSW road network.

2. Introduction

Under NSW road transport legislation, the type of motorised bicycle known as a *power assisted pedal cycle* is deemed to be a standard bicycle. It can be used without the need to comply with vehicle standards or for it to be registered, or for the rider to be licensed; and the rider is subject to the same road rules as one riding a conventional bicycle. Despite having a motor, being classed as a bicycle means that there is no age restriction on using a power assisted pedal cycle.

Power assisted pedal cycles must meet the definition within the Commonwealth *Motor Vehicles Standards Act 1989* (the Act). This allows for two types of power assisted pedal cycle to be supplied to the Australian market – the first being a bicycle to which is fitted one or more auxiliary motors that have a total power output not exceeding 200 watts; and the other being a *pedalec* manufactured to the European Standard EN 15194:2009 or EN 15194:2009+A1:2011 *Cycles - Electrically power assisted cycles - EPAC Bicycles*.

Importantly, this definition specifies that a power assisted pedal cycle is a form of *bicycle*, which, according to the definition in the Act, means it must be designed to be propelled solely by human power. This means that the primary source of power must come from the cyclist, with the motor used to provide assistance, such as when cycling into a strong headwind or up a steep hill, or if the cyclist is not fit enough to sustain a certain effort over an extended period.

Pedalecs are a newer type of power assisted pedal cycle. Although they are have more power than older types of power assisted pedal cycles – 250 watts compared to 200 watts – this is offset by enhanced safety features: the rider must pedal for the motor to activate (with the exception that they may run up to 6km/h without pedalling to facilitate low-speed start-up), and the motor must cut out once a speed of 25km/h is reached, or sooner if the rider stops pedalling.

The recent demand for more efficient, environmentally-friendly vehicles has seen a growth in the market for power assisted pedal cycles. This demand has seen a number of motorised bicycles entering the market that are not genuine power assisted pedal cycles, but a form of moped or even small motorcycle. Typically, the primary source of power on these motorised bicycles is from the motor not the rider (many models cannot be ergonomically set up to be ridden as a bicycle, and some even have inoperable pedals); and/or the motor produce more power than the 200 or 250 watt limits. These vehicles are not illegal providing they meet the necessary mandatory safety and performance standards specified in the Act for mopes or motorcycles, and are issued with an identification plate by the Commonwealth Department of Infrastructure and Regional Development. They must be registered and their riders must hold a motorcycle licence and obey the road rules applicable to motorcycles.

Of these types of motorised bicycles, there have been particular road safety concerns about bicycles fitted with petrol engines due to the amount of power these engines can produce. A petrol engine capable of producing a maximum of 200 watts has a capacity of about 4cc, which is the size of a standard medical syringe. In contrast, the engines used on the petrol-powered bicycles have different capacities, and range from 48cc to 90cc. These engines are capable of producing comparatively high speeds, with some claiming a top speed of 80km/h. Some of them are fitted with limiting devices in an attempt to restrict their power output to 200 watts and therefore meet the definition of a power assisted pedal cycle, but there is anecdotal evidence that the limiting devices can be easily removed or circumvented. In addition, there seems to be little control on the sale of any petrol-powered motorised bicycles, and little advice on their legality for use on roads or road related areas, and young children are using them without any training or without appropriate head protection.

There has been a history of crashes involving petrol-powered bicycles in NSW, including a number of crashes where the bicycles ignited. As a result of a fatal crash involving a 14 year old boy riding a petrol-powered bicycle in October 2013, the Centre for Road Safety decided to investigate petrol-powered bicycles to assess their status under road transport legislation and the road safety risk they pose.

Three petrol-powered bicycles were purchased from internet suppliers; one with a 48cc engine fitted with a restricted device to limit its power to 200 watts; one with an unrestricted 48cc engine; and one with a 66cc engine. These were chosen as the 48cc model represents the smallest engine fitted to bicycles, and the motorised bicycle involved in the October 2013 fatal crash was fitted with a 66cc engine. In addition, a restricting device was obtained for independent analysis. A pedalec-type power assisted pedal cycle that was marketed as complying with the definition of a power assisted pedal cycle was also purchased, from a retailer in Sydney to compare against the petrol-powered bicycles.

A series of dynamic tests were done to determine the bicycles' performance capabilities, and their respective power outputs were established by static tests on a dynamometer. Further tests were done to establish the effectiveness of the restricting device. The tests were done on 16 December 2013, with the road tests done at the Roads and Maritime Services' Crashlab, Huntingwood, and the dynamometer tests at S & R Pro, Penrith. The tests were recorded, and a series of films produced to complement this report.

In addition to the tests, a review of the websites of a number of suppliers of petrol-powered bicycles was done to find out the range of bicycles available to the public and the advice purchasers were given about their legal status.

3. Motorised Bicycles Tested

3.1 General

The Centre for Road Safety purchased the following types of motorised bicycles for testing:

a) A pedalec; see Figure 1.

b) A Malvernstar fitted with a restricted 48cc petrol engine; see Figure 2.

c) A Malvernstar, fitted with a 48cc unrestricted petrol engine; see Figure 3.

d) A Viper K2500 fitted with a 66cc unrestricted petrol engine; see Figure 4.

A summary of the bicycles' specifications is given in Table 3.1

Item	Bicycle			
	Pedalec	48cc Restricted	48cc Unrestricted	66cc Unrestricted
Mass (kg)	27	24	24	25.5
Motor	Panasonic 250W electric	48cc petrol engine with limiting device	48cc petrol engine, no limiting device	66cc petrol engine, no limiting device
Frame	Custom made	Malvernstar	Malvernstar	Viper K2500
Front chainring:	Shimano Nexus 7 speed internal transmission			
No. of chainrings		3	3	3
No. of teeth		28-48	28-48	24-42
Rear cluster:				
No. of sprockets		6	6	6
No. of teeth		14-28	14-28	14-28
Gear ratio [1] max-min	1.582-0.647 [2]	3.628-1.000	3.628-1.000	3.000-0.857
Wheel & tyre diameter (mm)	711	600	600	600
Max distance travelled per pedal revolution (m)	3.533	6.839	6.839	5.655

Notes:

1: Gear ratio is taken as the number of teeth on the driving chainring divided by the number of teeth on the driven sprocket

2: Taken from Shimano website

Table 3.1 Summary of specifications for each motorised bicycle

Figure 1: Pedalec

Figure 2: 48cc restricted petrol-powered bicycle

Figure 3: 48cc unrestricted petrol-powered bicycle

Figure 4: 66cc petrol-powered bicycle

In addition to the motorised bicycles, a kit designed to be retrofitted to a 48cc engine intended to limit its power to 200 Watts was also purchased from; see Figure 5.

Figure 5: 200W retrofit restricting kit

3.2 Pedalec

3.2.1 Description

A pedalec was used in the tests to compare the performance of the petrol-powered bicycles against one that is known to meet the definition of a power assisted pedal cycle. This meant its maximum power output could not exceed 250 watts, it must be pedalled for the motor to activate, and the motor must cut off at 25km/h, or sooner if the rider stopped pedalling.

The pedalec selected on the basis that it was manufactured by a reputable company and advertised as complying with European Standard EN 15194:2009 or EN 15194:2009+A1:2011 *Cycles - Electrically power assisted cycles - EPAC Bicycles* (EN 15194). It was a purpose design and built vehicle comprising a bicycle with an integral motor and battery pack.

Once activated, the motor could provide three modes of assistance to the rider, which was controlled through a panel of push buttons on the left hand handlebar (see Figure 6). Mode 1 provided the least power assistance, Mode 3 the most power assistance, and Mode 2 an intermediate level of power assistance. The pedalec's transmission was fully enclosed and comprised a single front chainring and a seven speed rear hub gear, with the gear lever fitted on the right hand side of the handlebars. The front and rear brake levers were fitted on the right and left handlebars respectively, as per standard bicycle configuration.

Figure 6: Mode selection panel for the pedalec

3.2.2 Continuous Power and Peak Power

Electric motors are designed to produce a continuous power output, which is the amount of power they generate while they operate over a prolonged period. They are also capable of producing considerably more power for a very short period, known as "peak power". Peak power cannot be maintained for more than a few seconds. Peak power does not affect the continuous power rating, and is allowed under EN 15194. This is a useful feature as it allows a rider have extra power at certain times, such as when pulling away from traffic lights or starting to climb a hill.

3.3 The petrol-powered motorised bicycles

3.3.1 Description

The petrol-powered motorised bicycles were purchased as complete units comprising engines fitted to standard bicycles from the lower end of the price-range. There was no indication that the components – brakes, wheels, gears, etc – had been upgraded to handle the high speeds the bicycles are capable of achieving with the engines fitted. Both the 48cc petrol-powered bicycles were fitted with cantilevered rim brakes, while the bicycle fitted with the 66cc engine had a combination of a front disc brake and a rear cantilever rim brake.

All the petrol-powered bicycles had a clutch lever on the left hand side of the handlebars (see Figures 7 and 8), and the right hand side handle-grip was modified into a throttle control; these were in addition to the standard gear levers and the brake levers on each side of the handlebars (see Figures 9 and 10). The clutch lever was positioned over the brake lever on the 48cc petrol-powered bicycles, and under the brake lever on the 66cc F80B petrol-powered bicycle.

The engines were all of a 2-stroke internal combustion type with an intake covered in green housing with one intake orifice, and they were fitted to the frames between the seat tube and the down tube (see Figures 11 and 12). The exhaust was fitted with a muffler internal unit. A motor drive chain connected the engine to the sprockets on the rear wheel on the opposite side of the rider's drive chain connecting the front chainring to the rear sprockets; this can be seen in many of the figures depicting the petrol-powered bicycles.

Power output from the engines was controlled by twisting the right hand grip, which was modified as a throttle, with more power generated the further the grip was twisted.

Figure 7: Left hand bicycle controls, 48cc bicycles

Figure 8: Left hand controls, 66cc bicycle

Note: The clutch is the silver lever and the clutch button the silver button where the lever attaches to the bracket. The clutch is above the brake lever on the 48cc model, and below it on the 66cc model.

Figure 9: Right hand controls, 48cc bicycles
Note: The grip has been modified as a throttle.

Figure 10: Right hand controls, 66cc bicycle

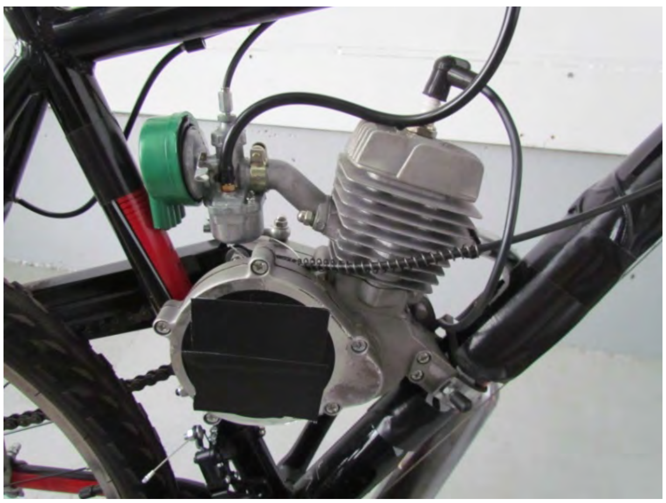

Figure 11: Motor Setup for 48cc bicycle
Note the exposed engine and components, including fuel lines

Figure 12: Motor Setup for 66cc bicycle

4. Tests

4.1 General

All the motorised bicycles were subjected to a series of dynamic tests on a flat, sealed pavement within the grounds of the Roads and Maritime Services' Crashlab road safety research facility at Huntingwood. The dynamic tests comprised –

- acceleration tests;
- top speed tests; and
- brake tests.

All the motorised bicycles were also tested on a chassis dynamometer, at S & R Pro at Penrith, to determine their maximum and continuous power outputs, top speeds and continuous speeds.

A competent person, with a current NSW motorcycle licence, rode the different motorised bicycles for the dynamic tests, and rode the pedalec for the dynameter test.

Notes:

1. A dynamometer is a device principally for measuring the power output of an engine or motor, and can also measure the speed of a device driven by the engine.
2. The pedalec needed to be ridden for the dynamometer tests to activate its motor.

The power limiting kit was assessed as part of the tests.

The tests were recorded. Some of them can be found on the Centre for Road Safety website.

4.2 Acceleration test

To measure the acceleration, a GPS-based data acquisition device was fitted to each motorised bicycle; Figure 13 shows the device fitted to one of the 48cc petrol-powered bicycles and being calibrated by a laptop computer. The data acquisition device recorded top speed and the time elapsed to reach it for each test, from which the acceleration was calculated. The data from the test runs were transferred from the data acquisition device to a laptop computer for analyses.

Each motorised bicycle was ridden vigorously along the test path to achieve maximum speed in the shortest possible time (the petrol-powered bicycles were warmed up prior to the test). The test was carried out twice for each motorised bicycle and the acceleration rate calculated from the average results.

Figure 13: Data Acquisition Setup for Acceleration Tests
Note: The device is fitted to one of the 48cc petrol-powered bicycles and is connected to a laptop computer for calibration.

4.3 Top speed test

To determine their top speeds, each motorised bicycle was taken to their maximum speeds and ridden across a sensor line as shown in Figure 14. The speed was calculated by measuring the distances between set points on the front and rear tyres, and the time taken for them to pass the sensor line. The test was done twice for each motorised bicycle, and the top speed taken as the average of the two readings.

The petrol-powered bicycles were warmed up for several minutes prior to the test. The rider built up to the top speed without pedalling. The tests were carried out for the pedalec where the rider pedalled as fast as possible without losing power assistance from the electric motor.

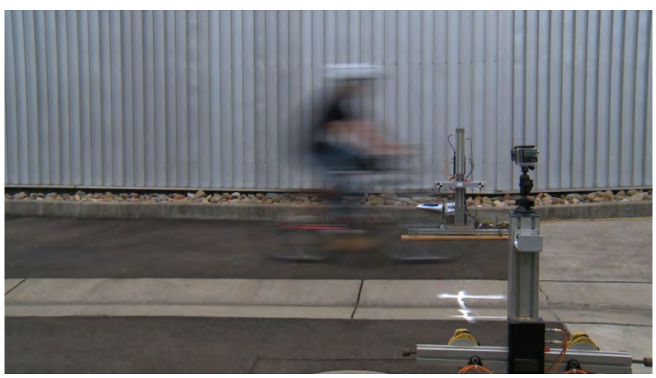

Figure 14: Speed sensor setup

4.4 Brakes test

The brakes test was done to establish the braking distances for the different motorised bicycle. For each test, the motorised bicycle was taken to its top speed, and the brakes applied when the centre of the front tyre passed a specified yellow line marked on the path, as shown in Figure 15. The braking distance was the distance between the braking line and the centre of the front tyre when the bicycle came to a complete stop.

For all the motorised bicycles, their maximum braking capacity was measured by applying the brakes with as much force as the rider was capable of generating. As this caused the petrol engines to stall, additional tests were done on the petrol-powered bicycles to control the braking without stalling the engines. This required the rider to depress the clutch before pulling the brake levers.

Figure 15: Braking Test Setup
Note yellow braking line

4.5 Dynamometer tests

A series of tests were done for each motorised bicycle using a dynamometer usually used for testing motorcycles, and the following readings recorded:

- maximum power output (W);
- average power output (W);
- top speed (km/h); and
- average speed (km/h).

Each petrol-powered bicycle was warmed up prior to testing, and then mounted on the dynamometer so the drive wheel was in contact with the dynamometer roller drum, and run for up to 5 minutes; this set up is shown in Figure 16. The throttle was then opened to obtain maximum power for some minutes prior to recording the outputs.

In addition to the tests on the standard motorised bicycles, the power limiting kit was fitted to the 48cc unrestricted petrol-powered bicycle, and the bicycle submitted to the speed test to compare in its performance with the dealer-supplied 48cc restricted petrol-powered bicycle.

The kit was then removed, along with the muffler piece from the exhaust. The bicycle was re-tested in this configuration.

As the pedalec had no throttle, the rider was required to mount it and pedal while on the dynamometer. The rider pedalled as fast as possible without losing power assistance from the electric motor.

Figure 16: Dynamometer Test Setup with 48cc unrestricted petrol-powered bicycle

4.6 Power limiting device

The kit for limiting the power of the output of the 48cc petrol engine was assessed to determine how easy it is to fit to, and remove from, the engine.

5. Detailed Observations of the Motorised Bicycles Tested

5.1 Pedalec

The motor and a battery pack were designed to be an integral part of the pedalec and were properly contained with no moving or sharp components in proximity to the rider (see Figures 4 and 17).

EN 15194 requires that the motor could only assist while the rider was pedalling, and that the engine cut-out once the pedalec reached 25km/h, or sooner if the rider stopped pedalling. These were verified by the tests – the engine could only be activated once the pedals were turning, and as the speed increased, the power assistance decreased with the motor cutting-out at approximately 23 km/h, or as soon as the rider stopped pedalling.

The pedalec's operation meant that the rider had to keep pedalling for the motor to provide assistance. It was found that once a rider has familiarised themselves with the assistance provided by the electric motor, it could be ridden like a conventional bicycle. As the pedalec's speed increased the power provided by the motor decreased progressively until it stopped altogether close to 25km/h. The pedalec could continue at higher speeds but all the motive power had to come from the rider. For starting off, the gears could be put in the highest ratio setting as the electric assistance enables starting off with ease in this ratio, especially if peak power is engaged during the initial pedalling motion. Although the pedalec's gears did not need to be changed during the tests, they did contribute to the rider's efficiency, and it is anticipated that they would be regularly changed if the pedalec was ridden on undulating routes or for longer periods.

Figure 17: Pedalec's motor and battery integrated unit

5.2 Petrol-powered bicycles

Riding the petrol-powered bicycles was more complicated than a standard bicycle or the pedalec. To engage the engine, a fuel flow regulator first needed to be switched on, and then the engine was turned on via a button fitted to the right handlebar. The rider needed to pedal prior to engaging the clutch, to avoid stalling the engine and then engage the clutch by pulling the clutch lever while simultaneously depressing the clutch button (refer to Figures 7 and 9).

Once the engine was activated, the power output was controlled by twisting the right hand grip which was modified as a throttle; the further the grip was twisted, the more power the engine provided and the faster the petrol-powered bicycle went. The petrol engines functioned independently from the pedalling operation so, once the engine was engaged, the rider did not have to pedal to propel the vehicle, nor was it necessary to change the gears and they could be left in a particular setting for a ride. Indeed, the gearing on these petrol-powered bicycles meant that, except when starting the engine, it was unnecessary for the rider to pedal at all. The engine was the primary source of power at low speeds and became the only source as the speed increased.

Controlled braking proved difficult as the clutch needed to be disengaged just prior to pulling the brake levers to avoid stalling the engine. This required pulling in the clutch lever while pushing the clutch button, which caused a delay in pulling the left brake lever that operates the rear brake with a corresponding increase in the stopping distance.

The alternative is to pull both brake levers simultaneously and not release the clutch. This results in an uncontrolled braking operation, and also causes the engine to stall. Similarly, in emergency braking where there in not sufficient time to disengage the clutch, the engine stalled and the rear wheel locked up.

It is anticipated that further problems would be experienced by children and other riders with small hands as they would have considerable difficulty operating the clutch with one hand. Instead the other hand would need to be released from the handlebar to push the button. In such a scenario, it would not be possible to simultaneously pull both brake levers, and the rider could lose control of the petrol-powered bicycle.

To add to the problem, a rider has to remember which lever is the clutch and which is the brake and accidentally pulling the brake lever before releasing the clutch also results in an uncontrolled braking and the engine stalling.

The position of the combustion chamber units, in the frame between the seat tube and the down tube, meant that they are immediately beside the rider's lower legs (see Figure 18). The test rider reported it was difficult to avoid contacting the hot units around knee region. (Indeed, the rider tore his trousers when they caught on a engine component of one of the petrol-powered bicycles.)

Additionally, the fuel hose fitted by the supplier to the engine for the 48cc unrestricted petrol-powered bicycle was in contact with the top of the engine housing, next to the spark plug (see Figure 11). This could cause heat damage to the hose, especially after long term exposure. The 48cc petrol-powered bicycles also had various cable loops in front of the handlebars, which can be seen in Figures 1 & 2, that had a risk of snagging objects; these could have been better secured to the frames, as they presented a potential snagging hazard.

Overall, the fact that the petrol engine and components are retrofitted to standard bicycles, rather than petrol-powered bicycles being manufactured as a discrete unit, has resulted in many of the parts not being properly housed which either means they pose a risk to the rider during normal activities or they can damaged to such an extent that they present a risk to the rider, for example if the fuel hose becomes punctured due to localised contact with heat, and the engine drive chain, that rotates at a considerable speed, is fully exposed

Figure 18: Rider position on a petrol-powered bicycle

6. Results

6.1 Dynamic tests

The results are of the dynamic tests are given in Table 6.1 below; refer to Appendix A for more detailed results.

Test	Motorised bicycle			
	Pedalec	48cc RES	48cc UNR	66cc
Top Speed (km/h)	21.3	23.4	33.7	34.4
Controlled Brake Stop (m)	4.95	8.6	12.9	13.2
Emergency Brake Stop (m)	N/A	4.6	6.6	8.6
Acceleration (ms^{-2})	0.42	0.28	0.45	0.51

Table 6.1 Results of the Dynamic Tests

6.2 Dynamometer Tests

The results of the dynamometer tests are given in Table 6.2 below; refer to Appendix B for more detailed results.

Test	Motorised bicycle				
	Pedalec	48cc RES	48cc UNR	66c	48cc UNR nm
Max Power (W)	596.56 [1]	521.99	1267.69	521.99	n/a
Continuous Power (W)	74.57	149.14	447.42	298.28	970
Top Speed (km/h)	19	24	34	38	46
Continuous Speed (km/h)	18	22	32.6	37	43.2

1: High peak power due to the rider's pedalling effort, possibly at the start of test

Table 6.2 Results of the Dynamometer Tests

Key to tables:

Pedalec: Pedalec

48CC RES: Petrol-powered bicycle comprising a 48cc engine with a power limiting device fitted to a Malvernstar bicycle

48CC UNR: Petrol-powered bicycle comprising a 48cc engine fitted to a Malvernstar bicycle

66CC: Petrol-powered bicycle comprising a F80B 66cc engine fitted to a Viper K2500 bicycle

48CC UNR nm: 48cc engine with a power limiting device, fitted to a Malvernstar bicycle, but with the device removed and additional modifications made to the engine

6.3 Power limiting device

The kit for limiting the power output from the petrol engines was found to consist of gaskets with smaller orifices to restrict intake and exhaust fluid flows, an air intake cover with more flow restrictions, and an exhaust pipe muffler with more restricted flow (see Figure 5).

The limiting device was easily fitted to the 48cc unrestricted bicycle engine in a matter of minutes using nothing but a simple Philips screwdriver. It was just as easy to remove the limiting device, returning the engine to its original, unrestricted condition. This process took less than five minutes.

An examination of the engine components showed that to assist air flow into and out of the combustion chamber, further modifications could be easily performed by drilling additional orifices onto the air intake cover, and removing the muffler component of the exhaust, also using a basic screwdriver. These simple procedures increased the power provided by the engine, and as shown in Table 6.2, greatly increased the performance of the 48cc unrestricted petrol-powered bicycle, with its speed and power approaching that of a small motorcycle.

6.4 Summary of results

6.4.1 Regulations

The tests found that the pedalec complied with the performance standards specified in EN 15194, namely it required pedalling for the motor to activate; the motor cut out once the pedalec reached just under 25km/h or sooner if the rider stopped pedalling; and the power provided by the motor decreased proportionally as the pedalec's speed increased.

The continuous power from the pedalec was below 200 watts, even with the rider pedalling. Although its peak power exceeded 250 watts, this legal maximum only applies to continuous power. As explained in Section 3.2.2, all electric motors are capable of producing additional power for a very short period (peak power), and this is within the scope of EN 15194. Indeed, it is considered to be a safety benefit as it enables a person pull away quicker from a standing start than would otherwise be possible under the 250 watts continuous power.

The tests found the petrol-powered bicycles needed to be pedalled to start the engines, but once started, they could be ridden without any further pedalling by the rider.

All the petrol-powered bicycles were capable of travelling faster than the assisted speed provided by the pedalec.

The continuous power produced by unrestricted petrol-powered bicycles greatly exceeded the 200 watt limit set by the regulations; see Table 6.2.

Although the power output from the restricted petrol-powered bicycle was less than the 200 watt limit, the restricting device that limited the power was easily removed, and once it was removed, the power exceeded 200 watts.

A minor modification to an engine on one of the petrol-powered bicycles further increased its continuous power output and maximum speed.

6.4.2 Performance

The pedalec's acceleration rate was faster than the petrol-powered bicycle fitted with the restricted engine, and comparable to the one fitted with the smaller, unrestricted engine. This was largely due to the efficiency of the motor and that the motor engaged instantly as soon as the rider pedalled, and this initial engagement activated the peak power for a short period of time.

The speeds achieved by petrol-powered bicycles by their engine alone exceeded the capabilities of most riders, and it is likely that only good club cyclists could maintain even the slower maximum speed of 24km/h on standard bicycles over extended periods, while the higher maximum speed of 46km/h would be outside the capacity of even elite cyclists.

The pedalec was fitted with disc brakes that was capable of bring it from maximum speed to a complete stop while retaining control of the pedalec. In contrast, all the petrol-powered bicycles were either fitted with cantilever rim brakes or a combination of a front disc brake and a rear cantilevered rim brake. Correctly operating the brakes on the petrol-powered bicycles was not intuitive, and required more than one action, namely to release the clutch prior to pulling the left hand brake lever which delays the braking operation. If a more prompt emergency braking was required and the left brake was pulled before engaging the clutch, this would cause the engine to cut out.

Note: Disc brakes are a comparatively recent innovation for bicycles and they have largely superseded cantilever brakes due to their superior performance. Road racing bikes retain lighter, callipers brakes.

The comparative quality of the brakes is shown by the fact that the heavier pedalec was brought form top speed to a complete stop in less distance than the lighter motorised bicycles doing the controlled stops, and the emergency stops.

As would be expected, the braking distances for the powerful petrol-powered bicycles reflected their comparative power, and the more powerful ones, travelling at faster speeds took longest to stop. The stopping distances were decreased considerably in the emergency stops, but this operation caused the engines to cut out. A compounding factor in the distance it took to correctly stop the petrol-powered bicycles was the complexity of using the clutch, as discussed above.

A factor in the lesser braking performance of the petrol-powered bicycles was their brakes were those that were fitted to the standard bicycle and not upgraded to deal with the higher speeds generated by the engine. It is probable that the braking performance would deteriorate further with extended use at the higher speeds.

6.4.3 Quality of components

A significant contributing factor to the inappropriate components used on the petrol-powered bicycles is that they are not manufactured as a discrete item but are simply standard bicycles with an engine and associated components fitted by the company that supplies them to the market. In fitting the engine, the standard bicycle components were not changed, and the engine and other components were simply attached to the frame and not in a dedicated housing, which resulted in exposed cables and parts of the engine snagging the ride's legs. This is in marked contrast with the pedalec, which is a purpose designed machine where the motor and associated parts are properly housed and do not interfere with the riding operation.

The risks associated with retrofitting petrol engines onto standard bicycles is not confined to vehicles sold as petrol-powered bicycles, as most suppliers also supply the engine assemblies for personal fitting to a bicycle. Indeed, this can compound the risks as most people retrofitting an engine to a standard bicycle are unlikely to have done the operation regularly and may not have developed the necessary skills to fit one properly.

6.5 Review of websites

The websites of six companies that supplied petrol-powered bicycles and/or engines that could be fitted to bicycles were reviewed. The review found that all openly advertised petrol-powered bicycles that did not comply with the definition in the regulations, yet only some sites had a warning that the bicycles may not be legal for road use, and to check their status with the road authorities. Some suppliers sold models with limiting devices fitted with a corresponding statement that they can be used on the road.

The review is summarised in Appendix B.

7. Conclusion

- Petrol-powered bicycles do not comply with the definition of power assisted pedal cycle specified in NSW legislation because –

  - The primary source of power is not from the rider but the motor. The continuous speeds generated by the engines of between 22 and 43km/h mean it is difficult for a rider to contribute to the overall motive force, meaning there is no incentive for the rider to pedal.

  - Where limiting devices are not fitted, the power exceeds the 200 watt limit.

- Devices fitted to petrol-powered bicycles to restrict their power output to the 200 watt limit can easily be removed resulting in a motorised bicycle that does not comply with the definition of power assisted pedal cycle specified in NSW legislation.

- The risks associated with petrol-powered bicycles can be increased as minor tweaks to their engines and exhausts can produce even greater power.

- In addition, some of the characteristics pose a risk to the riders, namely –

  - The maximum continuous travel speed of up to 43km/h far exceeds that capable of being produced by even elite cyclists for prolonged periods, and is comparable to the speeds produced by mopeds and small motorcycles for which a licence is required to operate.

  - Given that these petrol-powered bicycles are in effect mopeds or small motorcycles, the components fitted to them do not meet the mandatory standards applicable to mopeds and small motorcycles that are required to enable safe control of these vehicles at the speeds they can reach.

    Note: The mandatory safety standards for mopeds and motorcycles include such items as brakes, location and protection of wiring, chain guards and lights.

  - The risks associated with the previous point are compounded as the components are typically standard components, fitted to bicycles at the lower end of the price scale.

  - The brake operation is confusing to novice riders and liable to cause the engine to stall or delay the braking operation.

  - Even for experienced riders, the braking operating will either cause the motor to stall in an emergency braking operation, or will increase the stopping distance if used correctly without stalling the engine.

  - The risks associated with the above point are compounded by people with smaller hands, such as children.

  - The location of the engine means the rider can burn themselves on exposed parts or snag their legs or clothing on components.

  - The components are exposed and some contact other parts, meaning they can snag on items or be easily damaged and pose a fire risk, which is borne out by the petrol-powered motorised bicycles that combusted in a crash.

- Petrol-powered bicycles are marketed with insufficient information to advise their prospective users of their status under NSW legislation. This can lead to persons unwittingly using prohibited vehicles on roads and road related areas in contravention of road transport regulations.

APPENDIX A DETAILED TEST RESULTS, MOTORISED BICYCLES, 16 DECEMBER 2013

In the tables below, “RES” means restricted and “UNR” means unrestricted

Bicycle type	Pedalec Mode 3 gentle pedal*	Pedalec Mode 3 hard pedal**	48cc RES	48cc UNR	66cc
Peak Speed (km/h)	21.3	28.8	23.4	33.7	34.4

** Key: Gentle pedalling simulated slow, recreational riding speeds. * ** Hard pedalling simulated faster riding speeds*

Table A1 Dynamic Speed Tests, Crashlab

Bicycle type	Pedalec Mode 3	48cc RES	48cc UNR	66cc
Controlled Stop (m)	4.95	8.6	12.9	13.15
Emergency Stop (m)	n/a	4.6	6.65	8.63

Table A2 Braking Distance Tests, Crashlab

Bicycle type	Pedalec Mode 1	Pedalec Mode 2	Pedalec Mode 3	48cc RES	48cc UNR	66cc
Test 1 (m/s/s)	0.17	0.4	0.27***	0.29	0.47	0.47
Test 2 (m/s/s)	0.26	0.43	0.42	0.27	0.43	0.55
Average (m/s/s)	**0.22**	**0.42**	**0.42**	**0.28**	**0.45**	**0.51**

*Key: *** Result not used as it was well under normal trend.*

Table A3 Acceleration Tests, Crashlab

Bicycle type	Pedalec Mode 3	48cc RES	48cc UNR	66cc
Peak Power (W)	596.56****	521.99	1267.69	521.99
Continuous Power (W)	74.57	149.14	447.42	298.28
Peak Speed (km/h)	19	24	34	38
Continuous Speed (km/h)	18	22	32.6	37

*Key: **** High peak power due to peak power from the rider's pedalling effort, possibly at the start of test*

Table A4 Dynamometer Tests, S&R Pro

APPENDIX B INTERNET RESEARCH

The internet research looked at the websites of six suppliers of petrol-powered bicycles and petrol engines for fitting to standard bicycles. The results are shown in Table B below.

Name	Website	Based	Products	Examples	Size cc	Power watts	Xs 200 watts [1]	Speed km/h	Restricted	Advice [2]
MBB Imports	www.mbbimports.com.au	NSW	10 bikes	GT1 Cruiser 2 stroke	70	3,200	16	60	No	Yes
				Karika-1	48	1,400	7	50	No	No
				GT1 Cruiser 4 stroke	49	1,120	5.6	55	No	No
Oz Bicycle Engines	www.ozbicycleengines.com.au	NSW	1 bike 3 engines	Motorised Chopper	90	2,200	11	80	No	No
				48cc engine	48	1,600	8	50	No	No
				80cc engine	80	1,860	9.3	60		No
				90cc engine		2,200	11	80		No
Zbox	www.zbox.com.au	Qld	2 engines	48cc engine	48	1,200	6	35	Available	Yes
				66cc engine	66	1,800	9.3	35	Available	Yes
DLL Moto	www.dllmoto.com.au	NSW	5 bikes	Southern 66CC	66	3,300	16.5		No	Yes
Gasman Bikes	www.gasmanbikes.com	NSW	3 bikes	Cruise Daddy	40	Not stated		38	No	No
Rock Solid	www.rocksolidengines.com.au	Qld	11 engines	RS 38CC OHC 4 stroke	39	1,200	6	25	No	Yes
				50CC standard	50	1,100	5.5	40+	No	Yes
				50CC 200 watt	50	185	0.9	25	Yes	Yes
				70CC standard	69	2,500	12.5	50+	No	Yes

Notes: 1: This represents the number of times more powerful the engine is than the 200 watt legal limit for a power assisted pedal cycle.

2: This means if advice on the legal status of the motorised bicycles is provided on the website.

Table B Summary of internet search for petrol-powered bicycles and engines