V K Consulting
Regulatory and scientific expertise for the electronic cigarette industry
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Background

E-Burn considers that their product offers superior security features, when compared with more typical disposable cigarettes. In order to demonstrate this, they approached V K Consulting Ltd (VKC) to design and implement a series of tests to assess the security aspects of the products. The design of the tests was conducted by VKC, based on their knowledge of e-cigarette products, without input from E-Burn.

VKC considered that relevant areas of concern were:

- the ease with which the product could be refilled, to allow the use of illegal drugs or Novel Psychoactive Substances (NPS);
- the ease with which dismantling would make the contents available for self-harm/harm of others;
- the ease with which the product could be dismantled to allow for use as an ignition source for other materials;
- the potential for the device to be dismantled and used to conceal contraband materials;
- the potential for the device to be used for deliberate fire starting/arson; and
- the potential for the product to be used as weapon.

Since VKC expected variation in the design of the products, it was considered inappropriate to test the products in exactly the same way, but rather to examine the devices to exploit any weaknesses in design.

VKC's intention was to produce a series of tests which would assess the difficulty of tampering with these products, starting from simple tests using easily available materials, increasing in complexity, and finishing with the use of materials which, while contraband, are known to be available in the prison environment. These tests represent the assessment of VKC who are experts in the design of e-cigarettes, but not experts in prison environments nor in security testing, and so more appropriate tests may exist.

The testing was designed and conducted by Tom Pruen, VKC's Scientific Director.

Tests

1. Refilling

Test solution: The test solution should be made using water and a UV-reactive tracer dye so that the extent to which liquid can be transferred can be easily identified. In the case of products where the filler is obscured, this will require dismantling of the product.

1.1 Using a standard e-liquid bottle, apply liquid to the end of the cartomiser (both ends if accessible).

1.2 Attempt removal of end caps to aid filling. Assess the extent to which this is apparent.

1.3 Using a proxy container, such as a cartomiser endcap, tube or pen lid, attempt to transfer liquid to the cartomiser by immersion. The product's own packaging should be the first source of these proxy containers.

1.4 Use a sharp point, or a hot wire, heated by a cigarette lighter, or dismantled cartomiser coil to melt a hole in the device to be tested.

1.5 Attempt to fill using a hypodermic needle and syringe.

2. Dismantling

Test will assess the ease with which the product can be dismantled, and the extent to which this is obvious *post facto*.

2.1 Dismantle device using only brute force/manipulation to assess the extent to which the element can be exposed to use as a source of ignition and the extent to which the refill liquid is made available.

2.2 Determine if, or to what extent, the dismantled device can be used to conceal other items.

3. Incendiary potential

3.1 Placing the device over a solid right angle corner, firmly strike it with hand or foot to attempt to break the battery cylinder. Assess if, or to what extent, a fire risk is generated.

4. Weaponisation

Test will assess the ease with which the product can be made into a weapon, capable of inflicting puncture wounds, using a fixed, documented force of blow, and a flesh analogue to estimate depth of penetration (simulating potential stab wounds, using plasticine, because of its uniform consistency and measureability).

Each sample will be tested for puncture wound potential in the following circumstances:

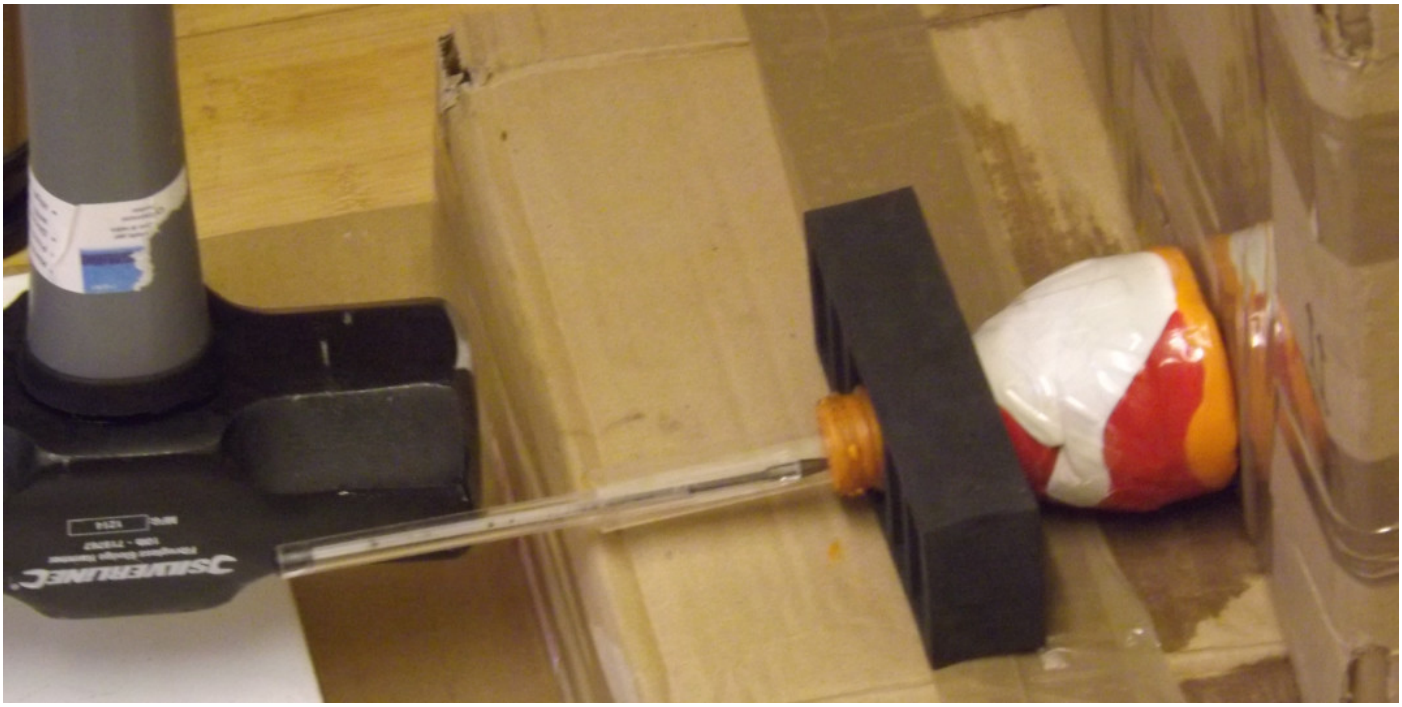
4.1 as is
4.2 with end caps removed
4.3 broken, using only brute force, to create new surfaces/edges
4.4 after abrasive sharpening on concrete surface, and brute force reshaping, if practical

Samples will be tested by using a 10lb sledgehammer suspended from a clamp stand, with a fixed travel of swing to provide the force, and plasticine to simulate flesh. The hammer was drawn back to the bar clamped to the left of the main rig, providing a fixed force of blow. The depth to which the object is driven will then be determined by measuring the depth of the resulting hole. A standard plastic biro will be used as a control, for comparison.

Test rig

The backstop consists of a concrete block. Cardboard is used to protect the working environment, and allow for ease of making calibration marks so all the components can be placed in the correct location.

Control test: standard plastic biro



The use of high force to deliver the blow resulted in the pen being shattered, so the power was reduced by clamping the bar closer to the main rig, resulting in a level at which the pen survived. The pen used penetrated an average of 25.2mm. This adjusted distance of sledgehammer travel was used for all the samples tested.

Supply of samples

Since all samples were supplied by E-Burn, this testing reflects the properties of the samples supplied, and the extent to which this can be generalised is uncertain. All products were supplied in unopened retail packaging.

Results are reported on a per product basis, against the criteria of that test, with images provided where appropriate.

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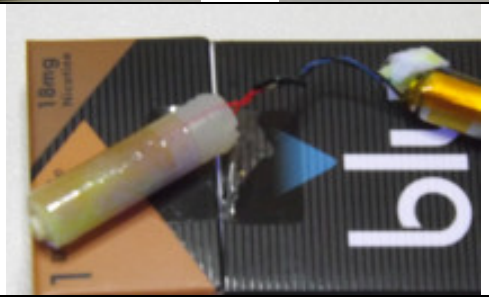
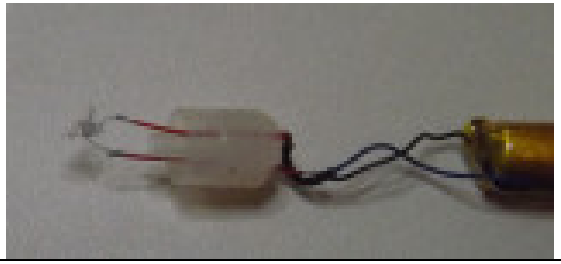
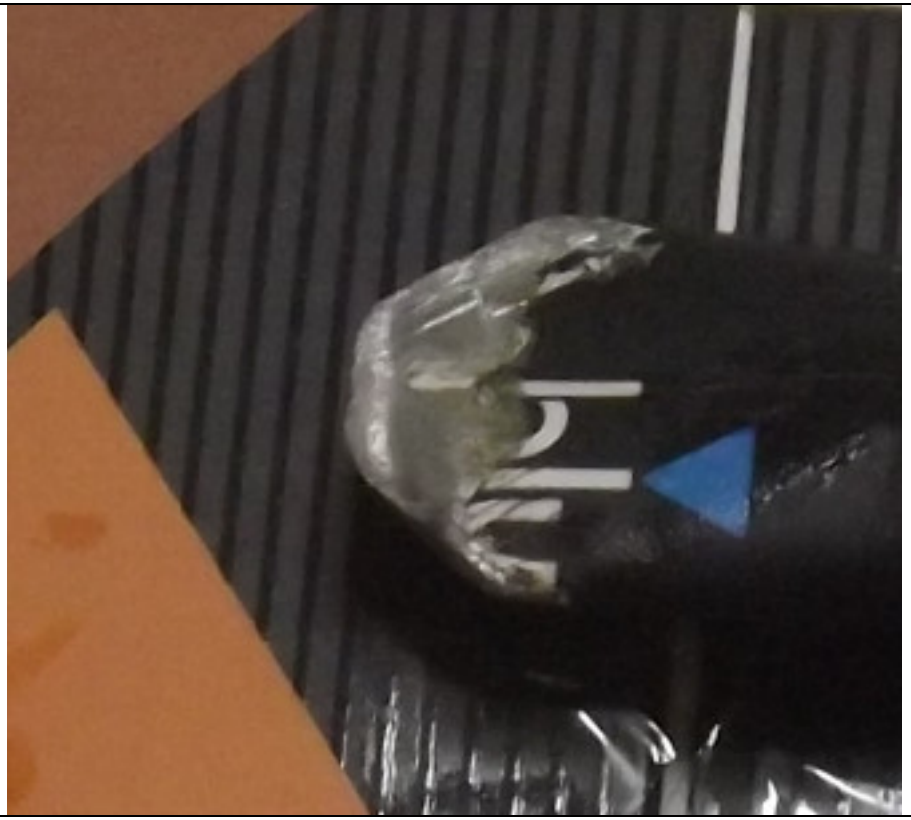
Results: Blu

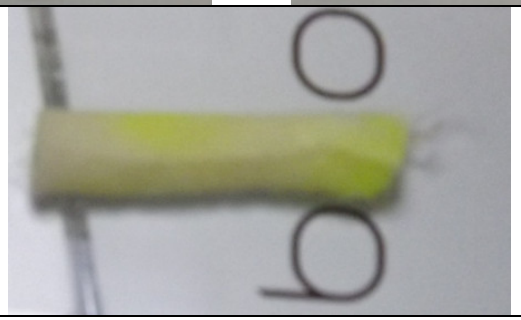
Test	Results	Photographs
Product as supplied		 
1.1 Refill *NB: Due to the non-transparent nature of the product, it required dismantling to discern the extent to which refill occurred.*	Liquid can be directly dripped into the hole in the end of the cartomiser. This can then be gently blown into the cartomiser.	

1.2 Refill by removal of end caps	The end cap of the cartomiser cannot be removed using a thumbnail, but a simple tool such a paper clip or piece of stiff wire does allow removal.	
1.3 Refill via proxy container	Since the easier methods in the previous tests were successful, tests 1.3, 1.4 and 1.5 were not conducted.	
1.4 Refill by melting refill hole		
1.5 Refill by hypodermic needle		
2.1 Dismantling	Following removal of the mouthpiece end cap, the whole internals of the device could be drawn out of the external shell. Not only does this provide easy access to the nicotine contained within the device, but the coil can be exposed. Blowing into the sensor activates the coil for a short time span, during which it glows red hot. This would not easily allow a user to directly light a cigarette, but the use of tinder such as pocket lint/clothing fluff does make this a viable source of ignition.	 
2.2 Concealment	Since the internals can be removed, the whole volume of the device becomes available for concealing small items of contraband, and indeed allowing these to be transferred inconspicuously. Notably, the hypodermic needle, in its protective sleeve, that was used in the testing could be concealed in the body of the device. Replacing the end cap leaves no sign of tampering.	

3.1 Incendiary potential by battery destruction	The metal tube made this difficult to damage, and there was no discernible heat or fire.	
4.1 Puncture wound potential with sample as supplied	The body of the ecig penetrated to a depth of 20.3mm	
Control	25.2mm	
4.2 Puncture wound potential with end caps removed	The body of the ecig penetrated to a depth of 25.5mm	
4.3 Puncture wound potential with sample broken/shaped using only brute force	The steel body proved quite hard to shape, but closing it in a door formed a fairly flat tip. This penetrated to a depth of 23.1mm, surprisingly less than the tube alone.	

4.4 Puncture wound potential with sample sharpened	The flattened tip could quite easily be shaped abrasively using a concrete floor. As tested, it was shaped to a ‘chisel’ tip, but further work could reasonably be expected to produces more of a point. This penetrated to a depth of 24.3mm. The most effective sharpening method would probably be to abrade a single side.	

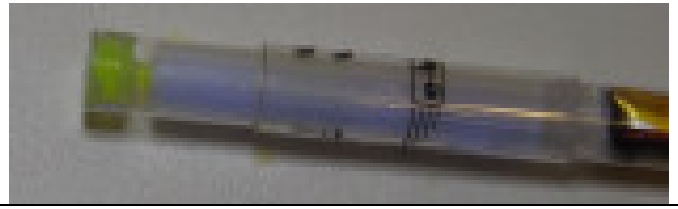
Results: Brio

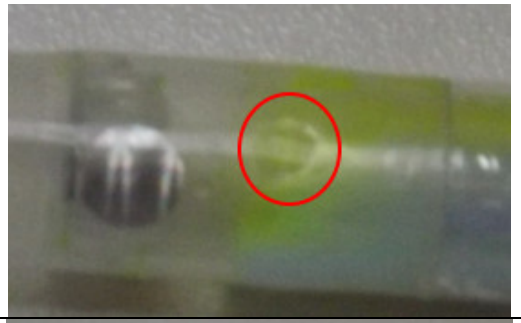
Test	Results	Photographs
Product as supplied		
1.1 Refill *NB: Due to the non-transparent nature of the product, it required dismantling to discern the extent to which refill occurred.*	Liquid can be directly dripped into the hole in the end of the cartomiser. The soft shell facilitates filling as drops can be sucked in by applying pressure to the shell.	

1.2 Refill by removal of end caps	The end cap of the cartomiser can be removed using a thumbnail or a simple tool. Glue is present, but this seems to vary between products, and on the products examined was not sufficient to prevent removal. This allows easy access for refilling. It does result in tearing of the end cap, and this is moderately apparent.	
1.3 Refill via proxy container	Since the easier methods in the previous tests were successful, tests 1.3, 1.4 and 1.5 were not conducted.	
1.4 Refill by melting refill hole		
1.5 Refill by hypodermic needle		
2.1 Dismantling	Following removal of the mouthpiece end cap, the cartomiser component of the device could be drawn out of the external shell. While this does provide easy access to the nicotine contained within the device, the coil cannot be exposed, as attempting to remove it invariably broke the internal wiring. The LED cap could not easily be removed.	
2.2 Concealment	Since some of the internals can be removed, part of the volume of the device becomes available for concealing small items of contraband, and indeed allowing these to be transferred inconspicuously. However, the extent to which this is possible is very limited. Replacing the end caps leaves some sign of tampering.	

3.1 Incendiary potential by battery destruction	There was no discernible heat or fire, and the plastic tube did not melt.	 
4.1 Puncture wound potential with sample as supplied	The body of the ecig penetrated to a depth of 20.6mm	
Control	25.2mm	
4.2 Puncture wound potential with end caps removed	The end cap was not removable without damaging the tube, so this test was not performed.	
4.3 Puncture wound potential with sample broken using only brute force	The plastic of the tube was not durable enough to break to a point or sharpen.	
4.4 Puncture wound potential with sample sharpened	As 4.3	

Results: E-Burn

Test	Results	Photographs
Product as supplied *Of all the supplied samples, the E-Burn is unique in having an individual serial number, uniquely identifying the individual device, and visible through the packaging. This can be expected to reduce the temptation to attempt to interfere with the device, as a record of the prisoner to whom the product was supplied can be maintained, and referred to when the device is returned. If the return of the used device is required when purchasing a replacement, this can also be expected to reduce hoarding, and limit the extent of theft from, or bullying of, other inmates to obtain their device. This would seem to be an important feature, if a system is put in place to properly utilise it.*		
1.1 Refill	Liquid cannot be dropped directly into the filler, as the holes are offset, and a one way valve is present. Attempting to use the silicon mouthpiece to 'pump' liquid through the valve only results in this being ejected around the edges of the cartridge, and no filling occurs.	 
1.2 Refill by removal of end caps	The end cap is not removable via thumb nail or simple tool (paper clip or other similar stiff wire).	

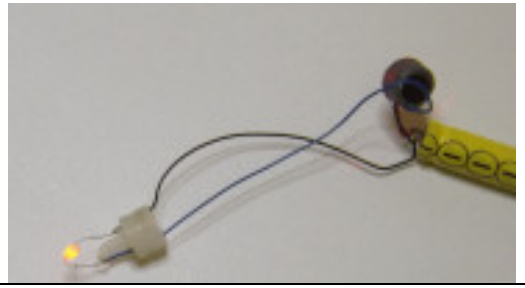
1.3 Refill via proxy container	Using the products own packaging filled with liquid did result in some transfer, however this was at the battery end of the device, and it is not clear if a sufficient amount could be transferred to the filler without destroying the battery.	 
1.4 Refill by melting refill hole	Removing the silicon mouthpiece allowed a hole to be generated using a hot wire or simple sharp rigid wire. Replacing the mouthpiece reduces the extent to which this is obvious. Hole highlighted in red on photo.	 
1.5 Refill by hypodermic needle	Removing the silicon mouthpiece allowed a hypodermic needle* to be pushed through the side of the cartridge. This left no visible signs of tampering. * *Hypodermic needles are likely to be extremely rare contraband in the prison system. As such, they are more likely to be preserved for intravenous drug use, rather than for purposes such as this, but the possibility still remains.*	
2.1 Dismantling	The mouthpiece end of the device was not removable, with either no or only simple tools. However the LED cap could be removed (with difficulty) using a thumb nail on 7/12 samples, indicating some variability in the way the end cap is secured. This made it possible to extract the battery, however it proved impossible to remove the device intact, and the filler	

	remained in the tube. This could conceivably be removed using a tool, but since the attempt destroys the device, the coil cannot be used as a source of ignition. Tampering was extremely evident on reassembling the device, due to the visible differences in wire position created. Even just the removal of the LED cap is detectable, without further interference, due to the destruction of the tamper-evident holographic seal.  *Reassembled device (top) with original condition for comparison (bottom)* Since the potential for making the LED cap completely non-removable is demonstrated by around half of the samples, it would be expected that the current variability will be removed in future batches.
2.2 Concealment	Since the device is entirely transparent, and tampering is easily visible, there is little prospect of this.

3.1 Incendiary potential by battery destruction	There was some visible outgassing from the battery, but there was no discernible heat or fire, and the plastic tube did not melt. (Similar outgassing may have occurred with the other samples tested, but this was not apparent because they have opaque tubes.)	 
4.1 Puncture wound potential with sample as supplied	The body of the e-cig penetrated to a depth of 6.2mm, as the weak area between the cartomiser and battery sections of the e-cig bent, significantly reducing the transfer of force.	
Control	25.2mm	
4.2 Puncture wound potential with end caps removed	The body of the e-cig penetrated to a depth of 13.6mm, before the weak area between the cartomiser and battery sections of the e-cig bent.	
4.3 Puncture wound potential with sample broken using only brute force	The plastic of the tube was not durable enough to break to a point or sharpen.	
4.4 Puncture wound potential with sample sharpened	As 4.3	

Results: Vipure

Test	Results	Photographs
Product as supplied		
1.1 Refill *NB: Due to the non-transparent nature of the product, it required dismantling to discern the extent to which refill occurred.*	Liquid can be directly dripped into the hole in the end of the cartomiser. The soft shell facilitates filling as drops can be sucked in by applying pressure to the shell.	
1.2 Refill by removal of end caps	The end cap of the cartomiser can be removed using a thumbnail. This allows easy access for refilling.	
1.3 Refill via proxy container	Since the easier methods in the previous tests were successful, tests 1.3, 1.4 and 1.5 were not conducted.	
1.4 Refill by melting refill hole		
1.5 Refill by hypodermic needle		

2.1 Dismantling	Following removal of the LED end cap, the whole internals of the device could be drawn out of the external shell. Not only does this provide easy access to the nicotine contained within the device, but the coil can be exposed. Blowing into the LED end cap activates the coil for a significant time span, during which it glows red hot.	 
2.2 Concealment	Since the internals can be removed, the whole volume of the device becomes available for concealing small items of contraband, and indeed allowing these to be transferred inconspicuously. Notably, the hypodermic needle, in its protective sleeve, that was used in the testing could be concealed in the body of the device. Replacing the end caps leaves no sign of tampering.	
3.1 Incendiary potential by battery destruction	There was no discernible heat or fire, and the plastic tube did not melt.	 
4.1 Puncture wound potential with sample as supplied	The body of the e-cig penetrated to a depth of 16.1mm	

Control	25.2mm	
4.2 Puncture wound potential with end caps removed	The body of the e-cig penetrated to a depth of 8.4mm, as the end of the tube (without the reinforcement of the LED cap) crumpled.	
4.3 Puncture wound potential with sample broken using only brute force	The plastic of the tube was not durable enough to break to a point or sharpen.	
4.4 Puncture wound potential with sample sharpened	As 4.3.	