

SCIENCE IN SCHOOLS- ENERGY LIVE SHOW

Demonstrations include:

1. Ethanol Rockets
2. Egg Drop
3. Gauss Cannon
4. Balloon Popping Race
5. VDG with Pie Dishes & Butane Bowl
6. Angle Grinder
7. Paint Tin Steam Pop
8. Butane Bubbles
9. Hand Generator with Microdet

Likelihood		Severity of impact		Current risk	
Certain	5	Death or total destruction	5	Multiply Likelihood and Severity of impact to get Current Risk rating	
High	4	Major injury or damage	4		
Medium	3	Serious injury or damage	3		
Low	2	Minor injury or damage	2		
Very low	1	Negligible	1		

Action Rating	
10 and above	The work is too dangerous and should not be undertaken
8 or 9	The work is high risk. Those undertaking the work must be fully competent and experienced for the type of work, equipment to be used and fully understand all risks present.
5 or 6	Moderate risk Workers must be fully competent for the type of work and risks present, or under competent supervision.
4	Low risk. Those undertaking the work must be aware or be made aware of the risks and mitigation measures required.
2 or 3	Slight risk. Those undertaking the work should be aware or be made aware of the risks and mitigation measures required.
1	Insignificant risk. Activity suitable for all workers

ACTIONS NEEDED BY VENUE:

1. Where possible, isolate Smoke/ Fire Alarms in vicinity of demonstrations
2. Ensure 1 x Fire Extinguisher is on Stand-by (only to be used in emergencies- should be either dry powder, or CO₂ extinguisher)
3. Ensure presenter knows Fire Evacuations procedures
4. Ensure presenter knows location of nearest fire extinguishers
5. To inform presenter/ Ri (at least 24hr prior to performance time) if any of the attendees suffer allergies to latex, eggs or has a heart condition.

Risk assessed by: Dan Plane

Date of last review: March 2024

Review date: February 2025

Demonstration 1: Ethanol Rockets

Method: A long pipe is used as the rocket launcher. Some designs have holes drilled at certain points along the pipe’s length and straps attached so it can be shoulder-mounted.

One litre PET bottles has an approx 5mm hole in its base. With your finger over the hole, a small pour of ethanol is added to the bottle (approximately 50ml max, or use 25 sprays of ethanol from the spray bottle). The bottle is then shaken for at least 30 seconds and the excess ethanol poured out by turning the bottle completely upside down and allowing it to flow out from the lid (there may not be any excess if using the spray bottle). It may be necessary to repeat this several times, to ensure that all liquid has been thoroughly emptied.

The lid of the bottle is then replaced. The ethanol bottle lid is replaced and the bottle of ethanol put away. The rocket bottle is then wiped dry and tape (air tight gaffer) placed over the hole with the end of the tape folded over to form a tab, for easy removal later. The rocket bottle is then stored away (at least 50cm) from sources of ignition.

When ready to fire, the presenter wears heatproof gloves and a face mask, the tape is removed from the hole and the bottle is placed into the pipe launcher hole end first. Making sure no part of their body is directly behind the bottle, the presenter uses a long handled gas lighter without a guard (in a gloved hand) the ethanol vapour in the bottle is lit at the hole. This causes the bottle to fly out of the pipe. The launcher will be aimed into the space above the audience so that the bottle will fall into the audience space.

(A trick to making the ethanol evaporate well is to heat the bottle up just before firing- this can be done using a hairdryer, heat lamp or by putting the bottle under your armpit).

Those at risk (please tick)	Ri Staff	On-Stage Volunteers	Audience	Non-Ri Workers	Others
	Y		Y		

PPE Requirements

Item		Item		Item		Item	
Flameproof overalls		Gloves contact	Y	High visibility		Waterproof clothing	
Hardhat		Dust Mask		Gloves chemical		Wellington boots	
Hearing protection		Mask chemical vapour/mist		Safety shoes			
		Laboratory Coat		Eye protection	Y		

Hazards and risks	Mitigation	Likelihood	Severity of Impact	Current Risk
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<p>Incorrect working with Ethanol/ Bioethanol can cause a fire or skin/respiratory irritation</p> <p>UN1170 (they have the same UN number)</p> <p>Safety data sheet can be found here; https://ekofuel.org/sds</p>	<p>The ethanol used will be obtained from a reputable supplier.</p> <p>The smallest amount of ethanol needed will be used, and kept away from extreme heat and naked flames (until needed for the demonstration)</p> <p>To extinguish an ethanol related fire any of the following fire extinguishers can be used: Alcohol resistant foam, dry powder or carbon dioxide.</p> <p>Goggles and nitril gloves will be worn. Breathing in of vapours will be avoided.</p>	2	3	6
<p>Incorrect transportation, storage and disposal of Ethanol could create fires, spill hazards and injury to persons</p>	<p>It will be stored in a non-conductive box (to prevent the build up of static electricity). It will be stored in areas that are well ventilated, cool and dry. It will be protected from direct sun and stored away from sources of ignition with containers kept closed when not in use. It will be kept separate from oxidising agents (potassium chlorate).</p> <p>Excess ethanol will not be disposed of in places where it can add to the water or soil supply, therefore if necessary to be disposed of it will be burnt in a controlled manner, on a fire retardant surface.</p>	2	3	6
<p>Intentional ignition of ethanol vapour could create fires and injury to persons</p>	<p>Burns could occur from either the lighting of the ethanol or contact with the bottle when lighting.</p> <p>To prevent the presenter being burnt they will wear heat proof gloves as they light the ethanol. And although the bottle will be warm after the burning, it will not be hot enough to cause injury.</p> <p>The audience are warned that the bottle may be hot, as that is the purpose of the demonstration.</p> <p>A face mask will be worn by the presenter throughout.</p>	2	2	4
<p>The bottle rocket may hit audience members, causing injury</p>	<p>The bottle is launched out the pipe at speed, however the bottle will be aimed in the area above the audience rather than at the audience themselves. This means a lot of the speed of the bottle will dissipate by the time the bottles fall into the audience (and so won't have enough speed to cause injury). In addition, the audience will be warned to protect themselves if the bottle falls towards them.</p> <p>A countdown to be performed, so that all are prepared for the bottle rocket.</p>	2	1	2

<p>Incorrect performance of the demonstration could create fires, spill hazards and injury to persons</p>	<p>(Bio)Ethanol vapour is flammable, therefore there is risk of fire. To negate the risks involving flammable materials we will do the following:</p> <ul style="list-style-type: none"> - The ethanol will be stored within the appropriate lidded container. With the lid always being replaced at the earliest opportunity. - Once poured into the bottle rocket and poured back out, both the ethanol bottle and the beaker of excess, if using, will be positioned at least 1m away from the launcher. - A fire extinguisher/ fire blanket will be on stand by. - The presenter will position the firing end of the bottle away from their leg, so that the fire fallout goes to the side of the presenter. <p>If ethanol is spilled, it will be mopped up using paper towels, the presenter ensuring that they do not get any on their clothes, ensuring that the paper towels are disposed of in the bin.</p> <p>If the ethanol is spilled in excess onto the clothes of the presenters, they should change clothes before conducting fire-based demonstrations. If not possible they should instead wear a lab coat for all fire-based demonstrations.</p> <p>The presenter will wash their hands after performing this demonstration, before eating.</p>	<p>2</p>	<p>3</p>	<p>6</p>
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Demonstration 2: Egg Drop

The presenter drops different eggs from various heights with the difference in damage to the egg being noted.

Those at risk (please tick)	Ri Staff	On-Stage Volunteers	Audience	Non-Ri Workers	Others
	Y	Y	Y		

PPE Requirements

Item	Item	Item	Item
Flameproof overalls	Gloves contact	High visibility	Waterproof clothing
Hardhat	Dust Mask	Gloves chemical	Wellington boots
Hearing protection	Mask chemical vapour/mist	Safety shoes	
	Laboratory Coat	Eye protection	

Hazards and risks	Mitigation	Likelihood	Severity of Impact	Current Risk
The eggs may cause an allergic reaction	<p>The teacher/ organiser is to notify the presenter/ the Ri at least 24hours prior to the performance if any of the attendees are severely allergic to eggs (i.e. cannot be in the same room as them).</p> <p>If notified of a severe allergy a rubber egg will be used instead.</p> <p>It will be ensured that the presenter does not have an allergy to eggs. If they do an alternative will be found.</p>	1	4	4
Cracked egg and contents can create a slip hazard	Major spills on the floor is to be cleaned up as soon as possible.	1	2	2

Demonstration 3: Gauss Cannon

A wooden track with 4 magnets on has 2 ball bearings attached to one side of each magnet. A 9th ball bearing is gently rolled towards the empty side of one magnet, causing a chain reaction that results in the furthest ball bearing flying from the end of the track much faster than the first one was rolled.

The last ball bearing can be used to knock over a pyramid or tower of empty drinks cans.

Those at risk (please tick)	Ri Staff	On-Stage Volunteers	Audience	Non-Ri Workers	Others
	Y		Y		

PPE Requirements

Item		Item		Item		Item	
Flameproof overalls		Gloves contact		High visibility		Waterproof clothing	
Hardhat		Dust Mask		Gloves chemical		Wellington boots	
Hearing protection		Mask chemical vapour/mist		Safety shoes			
		Laboratory Coat		Eye protection			

Hazards and risks	Mitigation	Likelihood	Severity of Impact	Current Risk
Strong Magnets present a finger trap risk	Only presenters to handle this equipment. Magnets are fixed to the track in position. Should they ever become loose, equipment should be fixed as soon as possible.	2	2	4
Ball bearings on the floor present a slipping risk	Any ball bearings, most likely the last one, that end up on the floor should be picked up immediately.	3	1	3

Demonstration 4: Balloon Popping Race

Specially adapted hard hats are placed on the heads of two volunteers. These hats each have a bicycle pump attached with outlets in the top of the hats. Two balloons are attached onto these two pipe outlets. The 2 volunteers then race to over inflate the balloon until one of them pops.

Those at risk (please tick)	Ri Staff	On-Stage Volunteers	Audience	Non-Ri Workers	Others
	Y	Y	Y		

PPE Requirements

Item		Item		Item		Item	
Flameproof overalls		Gloves contact		High visibility		Waterproof clothing	
Hardhat		Dust Mask		Gloves chemical		Wellington boots	
Hearing protection	Y	Mask chemical vapour/mist		Safety shoes			
		Laboratory Coat		Eye protection	Y		

Hazards and risks	Mitigation	Likelihood	Severity of Impact	Current Risk
Balloons may cause latex allergy reaction	<p>The teacher/ organiser is to notify the presenter/ the Ri at least 24hours prior to the performance if any of the attendees are severely allergic to latex (i.e. cannot be in the same room as it).</p> <p>It is clear from the presenters instructions that balloons are involved in the demonstration volunteers are being asked for and it is unlikely someone will volunteer themselves for such a demo.</p> <p>It will be ensured that the presenter does not have an allergy to latex. If they do an alternative will be found.</p>	1	3	3
It takes effort to make the balloons inflate to their popping point; this may cause overexertion	<p>The balloons used will be only 6 inch diameter.</p> <p>If the volunteers seem to be over-exerting themselves at any point, the presenter will pause the activity until recovery has occurred</p>	1	2	2
The loud pop from the balloon popping could cause hearing damage	The popping balloon making a noise louder than is expected, therefore both volunteers will wear ear defenders (attached to the hard hat)	1	2	2

Eye Injury from Popping Balloon	As the balloons are in close proximity to the volunteer's eyes, goggles will be worn by both volunteers during this demonstration.	1	1	1
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Demonstration 5: Van De Graaf Generator with Pie Dishes and Bowl of Butane

A Van de Graaf generator is used by the presenter to create some sparks.

Then the discharge ball is replaced with a metal wand on a wire.

Some (approx. an 8cm high pile) small metal pie dishes are placed on the large dome of the Van de Graaf generator.

The wand is put in contact with the large dome, the Van de Graaff is turned on, and the wand removed from the dome. The pie dishes will all gracefully fly off. The Van de Graaff is switched off.

Then a wire from a pyrex bowl, placed on top of a heat proof tile or fire blanket, is plugged into the top of the Van de Graaff generator. This wire has a bare metal end which sits in the bowl.

The presenter sprays butane into the bowl for 7 seconds and then holds the wand to the dome and turns on the Van de Graaff generator.

The wand is brought close to the bare metal end of the wire in the bowl to create sparks causing the butane to ignite. It may take a few attempts and moving along the length of the wire in the bowl may help.

Those at risk (please tick)	Ri Staff	On-Stage Volunteers	Audience	Non-Ri Workers	Others
	Y	Y	Y		

PPE Requirements

Item	Item	Item	Item
Flameproof overalls	Gloves contact	High visibility	Waterproof clothing
Hardhat	Dust Mask	Gloves chemical	Wellington boots
Hearing protection	Mask chemical vapour/mist	Safety shoes	
	Laboratory Coat	Eye protection	Y

Hazards and risks	Mitigation	Likelihood	Severity of Impact	Current Risk
Electrical fault with the equipment could cause electrical shocks	Ensure van de Graaff is in fully working order. Ideally the Van de Graaff will either be brand new (less than 6months old) or will be PAT tested. It will be visually inspected by the presenter on a regular basis	1	1	1
Loose cables can cause a trip hazard	Wires and cables to be kept tidy. Where it is necessary for them to cross walking areas they must be gaffer taped down as neatly as possible.	1	1	1
Incorrect use of the Van der Graaf can cause a static shock	Only the presenter will be on stage when the Van de Graaf is switched on. All the presenters are fully trained in how to use a Van de Graaff generator and will ensure that the earthing globe/ earthing wires are used when necessary. They have no heart conditions or health equipment that prevent them from using such equipment. The Van der Graaf will only be turned on when in use.	3	1	3

<p>Working with High Voltage Apparatus can cause electric shock injury</p>	<p>As this machine uses high voltage it should not be used near those with pace makers or other electrical based health equipment therefore the audience will be warned that if they do have a pacemaker or other electrical based health equipment to stand back at least 3metres</p>	1	5	5
<p>Intentional ignition of butane could lead to accidental fires, and injury to persons</p>	<p>The butane in the bowl burns for 3-30 seconds. It will be ensured that the immediate area is clear of flammable products including the butane canister just used. The bowl used will be Pyrex so it can withstand the heat produced by the burn. In addition, the bowl will be placed on a heat proof tile or fire resistant blanket. The Pyrex bowl will be visually inspected for damage before the show.</p> <p>The butane MUST be squirted into the bowl BEFORE the VDG is switched on to ensure there is no risk of a spark igniting the gas and igniting the canister. The canister will then be placed at least 50cm from VDG.</p> <p>If the fire burns for a prolonged period of time (which it shouldn't) a second heat proof tile or lid will be provided to place over the bowl to starve it of oxygen.</p> <p>The fire/ smoke alarms in the venue should be isolated.</p>	1	4	4
<p>Poor practice of the demonstration can cause a burn when setting the butane alight</p>	<p>Presenter is experienced in this demonstration and has extensively practiced it so knows when to remove hand/ arm to ensure no serious burn occurs. This demo will ONLY be performed by the presenter.</p> <p>The bowl will be allowed to cool before being removed. The audience will not be allowed to touch it.</p> <p>The presenter will wear goggles throughout this demonstration.</p>	2	3	6
<p>Incorrect working with Butane can create fires and injury to persons</p> <p>The Butane used will be from domestic canisters: UN2037</p> <p>Safety data sheet can be found here; http://www.farne ll.com/datasheets /1801831.pdf</p>	<p>The butane used is available domestically, it is used as a lighter refill, however it should still be treated with respect. It will be sourced from a reputable supplier and canisters inspected for damage before use.</p> <p>Butane can be extinguished using either dry powder or carbon dioxide extinguishers, though these will only be used in an emergency, with oxygen restriction being used as the preferred method.</p>	1	4	4
<p>Incorrect storage and Transportation of Butane can create fires and injury to persons</p>	<p>It will be stored in a non-conductive box at a temperature below 50°C and away from sources of ignition.</p> <p>There will be a maximum of 8 canisters stored at one point, but mostly only 4, unless a high number of shows are needed.</p> <p>Due to the butane being domestic canisters and the small volume carried/ stored no special license or</p>	1	3	3

	<p>labelling is needed. Ideally the box containing the butane will be lockable, so if left unattended the gas cannot be accessed by others.</p>			
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Demonstration6: Angle Grinder

An angle grinder is turned on and used to cut into a steel pole of a retort stand, creating sparks

Those at risk (please tick)	Ri Staff	On-Stage Volunteers	Audience	Non-Ri Workers	Others
	Y		Y		

PPE Requirements

Item		Item		Item		Item	
Flameproof overalls		Gloves contact	Y	High visibility		Waterproof clothing	
Hardhat		Dust Mask		Gloves chemical		Wellington boots	
Hearing protection	Y	Mask chemical vapour/mist		Safety shoes			
		Laboratory Coat	Y	Eye protection	Y		

Hazards and risks	Mitigation	Likelihood	Severity of Impact	Current Risk
Electrical fault with the equipment could cause electrical shocks	<p>Ensure the angle grinder is in fully working order. Ideally, the Angle Grinder will either be brand new (less than 6months old) or will be PAT tested.</p> <p>The presenter will ensure that the lead of the angle grinder is well away from the cutting area so they do not cut the electrical lead by mistake.</p> <p>A circuit breaker will be used to plug in the angle grinder so if a shorting occurs, power supply will be cut.</p>	1	1	1
Spinning disc could come loose and cause injury to the presenter	The disc of the angle grinder should be tightened before each show as a habit to ensure that it never becomes loose	1	2	2
Loose cables can create a trip hazard	If the wires are trailing over the stage they will be secured with gaffer tape.	1	1	1
Flying sparks from cutting the steel pole can cause burn injuries to persons	<p>Only the presenter will operate the angle grinder. To prevent these sparks causing harm to the presenter they will wear gloves, labcoat, facemask and ear defenders.</p> <p>The surrounding area can be protected by a fire blanket if needed</p> <p>Please note: although the sparks look hot are not actually that hot and will not burn the surfaces on which they fall</p> <p>The presenter will position themselves, so they arc of the sparks is parallel or away from the audience. Presenters are trained and practiced at controlling the direction of the sparks</p> <p>This demonstration will be performed at least 2.5m away from the audience.</p>	3	1	3

Demonstration 7: Paint Tin Steam Pop

1-2 tablespoons of water is placed in a 250ml tin can in a heat proof (cork lined) retort stand and clamp. A butane (or gas mix-propylene/MAP gas) powered blow torch is then used to heat up the water. The water in the can will boil and produce steam until eventually the lid pops off.

(note- when referring to Butane it also applies to a Butane/ Propane mix)

Those at risk (please tick)	Ri Staff	On-Stage Volunteers	Audience	Non-Ri Workers	Others
	Y		Y		

PPE Requirements

Item		Item		Item		Item	
Flameproof overalls		Gloves contact	Y	High visibility		Waterproof clothing	
Hardhat		Dust Mask		Gloves chemical		Wellington boots	
Hearing protection		Mask chemical vapour/mist		Safety shoes			
		Laboratory Coat		Eye protection	Y		

Hazards and risks	Mitigation	Likelihood	Severity of Impact	Current Risk
The blow torch produces a sustained flame, and could cause unwanted fire	<p>Flammables items will be placed at least 1m away from the blow torch. A fire extinguisher and fire blanket will be on stand by.</p> <p>The blowtorch will only be turned on just before the start of the demonstration, and turned off immediately afterwards.</p> <p>The smoke alarms in the venue can be isolated if present.</p>	1	5	5
The flying lid could create an Impact Injury	<p>As the lid of can becomes a projectile there is risk of injury. To prevent this, the demonstration will be performed at least 2m from the audience. It will be ensured that the lid of the tin is not angled towards the audience. The presenter will not- at any time place their face over the lid of the can. The lid used is so light that it will not cause injury on impact from falling.</p> <p>If it is performed under an angled ceiling it is to be ensured that tin is positioned such that the flight of the lid will not be towards the audience.</p> <p>The audience will be warned to cover their faces if the lids does fall towards them. In addition, the lid will be inspected for sharp edges with any being sanded smooth or a new lid used.</p>	1	2	2

<p>The hot water/steam or blow torch can cause burn injuries</p>	<p>Those using the blow torch will be fully trained and confident in handling it, it will not be used by a volunteer. The blow torch will be switched off as soon as possible.</p> <p>The tin can will be attached onto a retort stand and in the unlikely event that it needs moving whilst still cooling, the retort stand will be used to carry it, rather than contact with the can itself.</p> <p>As hot gasses and water may escape from the can when the lid pops off, the presenter will perform the demonstration with the blow torch at arms' length, wearing a facemask, labcoat and heat proof gloves on.</p> <p>By the audience being at a distance of 2m no escaped hot water will reach them</p> <p>In addition, as the arm of the clamp holding the tin can twist slightly, ensure that it is set up in such a way that if it does twist (from the force of the lid popping off) that it twists AWAY from the audience.</p>	2	2	4
<p>Incorrect working with Butane or Butane/ Propane mix can create fires and injury to persons The gas used will be from domestic canisters: UN2037 Safety data sheets can be found here; Butane: http://www.farneil.com/datasheets/1801831.pdf Butane/ Propane mix: http://www.partinfo.co.uk/files/2500%20Cartridge.pdf</p>	<p>The butane used is available domestically, it is used as a lighter refill, however it should still be treated with respect. It will be sourced from a reputable supplier and canisters inspected for damage before use.</p> <p>Goggles will be worn when using the blowtorch.</p> <p>Butane can be extinguished using either dry powder or carbon dioxide extinguishers, though these will only be used in an emergency, with oxygen restriction being used as our preferred method.</p>	1	4	4
<p>Incorrect storage and Transportation of butane and butane/ propane mix can create fires and injury to persons</p>	<p>It will be stored in a non-conductive box at a temperature below 50°C and away from sources of ignition.</p> <p>There will be a maximum of 8 canisters stored at one point, but mostly only 4, unless a high number of shows are needed.</p> <p>Due to the butane being domestic canisters and the small volume carried/ stored no special license or labelling is needed.</p> <p>Ideally the box containing the butane will be lockable, so if left unattended the gas cannot be accessed by others.</p>	1	3	3

<p>Incorrect working with Propylene/ MAP gas (High Temperature Gas Mix) can create fires and injury to persons</p> <p>UN1077</p> <p>Safety data sheet can be found here;</p> <p>https://www.tool-ed.com/artwork/ProdPDF/2599.pdf</p>	<p>The gas mix used is available domestically. It will be sourced from a reputable supplier and canisters inspected for damage before use and transport. The head of the blow torch will always be removed from the bottle for storage and transport.</p> <p>Goggles will be worn when using the lit blow torch.</p> <p>High temperature gas mix can be extinguished using dry chemical powder, Carbon dioxide (CO2), or Foam. Do not use water jet as an extinguisher.</p>	1	4	4
<p>Incorrect storage and Transportation of propylene/ MAP gas (High Temperature Gas Mix) can create fires and injury to persons</p>	<p>Ideally the canisters will be stored in a non conductive box and at temperatures not exceeding 49°C/120°F. They will be kept in a cool, dry place out of direct sunlight and away from heat, sparks and open flames.</p> <p>Empty canisters will not be pierced and will be returned to the Ri for appropriate disposal. Ideally the box containing the propylene will be lockable, so if left unattended the gas cannot be accessed by others.</p>	1	4	4

Demonstration 8: Butane Bubbles

A plastic bowl is half filled with water with a little bit of washing up liquid. Butane is dispensed from a domestic canister into that soapy water such that butane bubbles are created. These bubbles are lifted by a long handled frying scoop and set on fire using a long handled gas lighter. A volunteer from the audience will be holding the frying scoop.

Those at risk (please tick)	Ri Staff	On-Stage Volunteers	Audience	Non-Ri Workers	Others
	Y	Y	Y		

PPE Requirements

Item		Item		Item		Item	
Flameproof overalls		Gloves contact	Y	High visibility		Waterproof clothing	
Hardhat		Dust Mask		Gloves chemical		Wellington boots	
Hearing protection		Mask chemical vapour/mist		Safety shoes		Face shield	Y
		Laboratory Coat	Y	Eye protection	Y		

Hazards and risks	Mitigation	Likelihood	Severity of Impact	Current Risk
Intentional ignition of butane presents a risk of accidental fires and burns to people	<p>The butane will be lit on a long handled frying scoop. It will not be lit overhanging the remaining butane bubbles. Flammables items will be placed at least 1m away from the bubbles. The headspace above the bubbles will be checked for flammable items, including the ceiling (3m clearance minimum). A fire extinguisher and blanket will be on standby.</p> <p>The smoke/ heat alarms should be isolated if present.</p> <p>In addition, the table on which this demonstration is performed will be covered in a fire blanket. The volunteer will be wearing a face shield and heat proof gloves. They will be verbally warned that the fire will be relatively long lasting and that they are to keep hold of the panel.</p> <p>If the venue ceiling is particularly low, then this demonstration can be performed with the fire blanket on the floor if necessary.</p>	1	5	5

<p>Butane fire can cause burn injury to persons</p>	<p>The presenter will wear goggles and perform the lighting with a long-handled lighter. The volunteer will wear a faceshield and heat proof gloves and will hold the paddle at arms' length. The presenter will be trained in how to hold the volunteer at the elbow/ hold the paddle to ensure that the volunteer does not move their arms during the demonstration.</p> <p>It will be ensured that the volunteer has no 'dangling' items such as scarf, ties or loose hair. If so, these will be removed or tied back before conducting the demonstration. Alternatively, the presenter's labcoat can be used on the volunteer.</p>	2	2	4
<p>Incorrect working with Butane can create fires and injury to persons</p> <p>The Butane used will be from domestic canisters: UN 2037</p> <p>Safety data sheet can be found here; http://www.farne ll.com/datasheets /1801831.pdf</p>	<p>The butane used is available domestically, it is used as a lighter refill, however it should still be treated with respect. It will be sourced from a reputable supplier and canisters inspected for damage before use.</p> <p>Goggles will be worn when using the blowtorch</p> <p>Butane can be extinguished using either dry powder or carbon dioxide extinguishers, though these will only be used in an emergency, with oxygen restriction being used as our preferred method.</p>	1	4	4
<p>Incorrect storage and Transportation of Butane can create fires and injury to persons</p>	<p>It will be stored in a non-conductive box at a temperature below 50°C and away from sources of ignition.</p> <p>There will be a maximum of 8 canisters stored at one point, but mostly only 4, unless a high number of shows are needed.</p> <p>Due to the butane being domestic canisters and the small volume carried/ stored no special license or labelling is needed.</p> <p>Ideally the box containing the butane will be lockable, so if left unattended the gas cannot be accessed by others.</p>	1	3	3

Demonstration 9: Hand Generator with Microdet

A hand cranked generator is used to build up a voltage which ignites a microdet. The ignition of this microdet (an off-the-shelf pyrotechnic) causes a loud bang.

Those at risk (please tick)	Ri Staff	On-Stage Volunteers	Audience	Non-Ri Workers	Others
	Y	Y	Y		

PPE Requirements

Item		Item		Item		Item	
Flameproof overalls		Gloves contact		High visibility		Waterproof clothing	
Hardhat		Dust Mask		Gloves chemical		Wellington boots	
Hearing protection	Y	Mask chemical vapour/mist		Safety shoes			
		Laboratory Coat		Eye protection	Y		

Hazards and risks	Mitigation	Likelihood	Severity of Impact	Current Risk
<p>Strong Magnets: The magnet used here is extremely powerful. It will attract magnetic objects very strongly, sufficiently to cause injury to body parts caught in the way. This can happen very suddenly and very rapidly. If two such magnets are allowed to come together, they may cause severe crushing injuries, especially to fingers, which may even be severed. Even if they fly together without trapping fingers they may shatter from the impact and project shards of magnet through the air.</p>	<p>The generator has been built by a respected prop builder and supplied to us with a full users' guide.</p> <p>During transport, storage and when not in use, the magnet will be aligned with the end plates which form the structure of the generator. That way they will stay in place and attract minimal extraneous material.</p> <p>It will also be ensured that the operator of the generator (presenter or volunteer) does not have any medical equipment on them that will be affected by strong magnetic fields. Others will be kept at a distance of 2m.</p>	2	3	6
<p>Impact Injury: As the generator is weighty, it could cause damage is it falls</p>	<p>The generator will always be placed on a stable table away from the edge</p>	1	4	4

<p>Lifting Injury: As the generator is weighty, lifting it could cause damage is not undertaken correctly</p>	<p>It will only be lifted by our presenters, all of which are confident in the correct (bending the knees) procedure.</p>	1	2	2
<p>Squib (microdet) creates loud explosive noise on ignition</p>	<p>All audience to be advised to cover their ears ahead of explosion. Those with sensitive hearing to be advised to leave the room. Presenter to wear ear defenders.</p>	2	4	8
<p>Squib (microdet) creates an amount of shrapnel on ignition</p>	<p>Protective shield to go in front of squib to protect audience and presenter from cardboard pieces released from the shell. Audience to be at a minimum of 3 meters distance from squib (this is less than the standard as the protective shield is being used)</p>	2	4	8
<p>Working with Microdets (pyrotechnics): Microdets (also known as squibs) are small pyrotechnics. Classification 1.4G (UN0431) http://www.lemaitreltd.com/p/Microdets/0zzjc%5B%5DyA98g http://www.lemaitreltd.com/includes/images/uploads/ecommerce/documents/SDS%20Flash%20Reports,%20Maroons%20and%20Microdets%20(2017)%20-%20u5n52btf.ksd.pdf They are small cardboard tubes filled with aluminium powder, magnesium powder and an oxidizer with a remote igniter.</p>	<p>Microdets to be sourced from a reputable supplier. When handling Microdets, goggles are to be worn at all times and there will be no naked flames, smoking or eating within the immediate area. Hands are to be washed after using, before eating.</p>	2	4	8
<p>Storage and Transporting Microdets: As microdets are classified as a pyrotechnics there are rules and regulations governing their storage and transport. http://www.legislation.gov.uk/uk/si/2014/1638/contents/made</p>	<p>Microdets are classified as category 1.4G (the second lowest – safest- there is). The law states that if NEC (net explosive content) is lower than 5kg then no licence is needed. We will always ensure that the NEC is well below this limit. Each microdet has a NEC of 0.15g, therefore we could need to carry over 30,000 of them to exceed this limit (we normally carry 24 as a maximum) Microdets will always be stored and transported within a corrected labelled (1.4G) UN box. They will be kept in a cool, dry location, away high temperatures, shock, static discharge, vibrations or other physical stresses that might result in a hazardous situation. They, along with the other ‘dangerous goods’, are to ideally be placed in a locked room if left unattended whilst at a venue. If this is not possible then they are to be carried with the presenter and not left unattended.</p>	2	4	8
<p>Non-Standard Ignition System: As we are using a non-standard ignition system we need to take care to avoid premature ignition.</p>	<p>Premature ignition will be negated with the use of a ‘circuit connecting system’ or an ‘arm key extension’ box. This is a plastic box which is inserted into the hand crank generator, which contains an arm key and switch. Only when the key is in the ‘on’ position and the button pressed, *and* the magnet on the generator spinning will an electric current be able to pass through to the pyrotechnics. So, basically with the key on and magnet</p>	2	4	8

turning, until the button is pressed on this 'circuit connecting system', no connection will be made between the generator and the microdet and so no ignition will occur.

The procedure for working with the microdet will be as follows:

BEFORE SHOW:

1. With goggles on, position the microdet in laboratory retort clamp (the microdet will not be connected to anything else at this point)
2. The wires from the end of the microdet will be plugged into the 'speaker cable box'.
3. The spade connectors on the other end of this 'speaker cable box' will NOT be attached to the generator, instead they will be taped to the table near the generator.
4. Ensure the 'arm key extension' box is not plugged into the generator.

DURING SHOW:

1. Put goggles on and place the microdet into its firing position on stage. Ensuring the safety screen is between 'the microdet and the audience' and 'the microdet and you'
2. Select volunteer and get them onto stage
3. Ensuring the microdet and the 'arm key extension' box is NOT attached, show the volunteer how to use the generator. Ensure it is set up for them being either right or left handed.
4. Once mastered. Ask the volunteer to step back and give them goggles and ear defenders
5. Now, attach the spade connectors and the 'arm key extension' box to the generator
6. Ensuring the magnet is HORIZONTAL, and blocking the volunteer from being able to spin the magnet, show that even when the key is 'on' and the fire button is pressed, the microdet does not fire. (i.e. turn key to on and push button = no effect)
7. Now invite the volunteer to step forward to generator. Position yourself between the microdet and the volunteer
8. Warn the audience of the loud noise and get them to cover their ears.
9. Turn the key to 'arm', volunteer to spin magnet, and when ready push the button to fire the microdet.

Notes:

-If the volunteer is too small/ young to operator the generator, then the presenter will be in charge of operating the generator, and the volunteer the fire button.

-If (for some reason) two volunteers are used, then one volunteer will operator the generator, and the other will push the button with the presenter very much in control of the button-pusher.

IN THE EVENT OF A MISFIRE the following procedure will be followed:

	<p>1. Turn key to unarm position</p> <p>2. The system is now 'safe' and the audience can stand at ease/remove hands from ears.</p> <p>3. Taking the key with you, check all connections working your way from the microdet back to the generator. Remember that more than one connection may be loose.</p> <p>4. Repeat the firing routine above</p>			
Disposing of Microdets	<p>Once fired the microdets can be disposed of in the normal rubbish.</p> <p>If a misfire occurs and the microdet doesn't fire, it will be disposed of according to advice from the supplier. Therefore it will be immersed in water for 24 hours (ensuring that they are sunk under the surface of the water) and that any paper tops so should be pieced so that the water can easily permeate the device. After which they can be disposed of in the normal rubbish.</p>	1	2	2