STATIC GENERATION

TRAINING PROGRAMME

This Manual is to be read in conjunction with the individual Generator and Electrode training manuals and operating instructions.

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FRASER Anti-Static Techniques

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1. BACKGROUND

Static generation is closely connected to static control. There is a large overlap in technology, customers and applications.

Traditionally 90 % of our (Fraser) sales have been in static elimination and only 10 % in static generation. However, our competitors Simco and Eltex are more successful in static generation and it accounts for 30 % of their sales.

In the past two years Fraser has invested a lot of time and money in developing new products to increase our sales in this market - not only because it should also be 30 % of our sales, but also because it is a fast growing market with a lot of potential.

The static generation market uses high voltage to stick two or more materials together for temporary adhesion.

The reasons for this market growing are:

Clean: It is often better than using agents like adhesives or water. Electrostatic attraction is hygienic and non-contaminating.

Low Cost: No consumables are needed. It has a very low running cost - typically the same as two light bulbs. The required machinery is relatively low-cost and does not need a lot of maintenance.

Controllable: It is easy to turn on and off, and can be integrated into the process through the PLC or fieldbus.

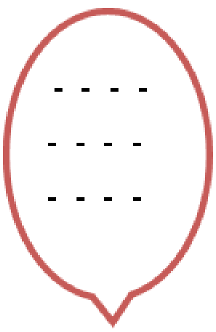
Safe: Modern static generation equipment has been designed for safety. Fraser static generators have many levels of internal safety and the electrodes are resistively coupled. It is also usual to interlock with machinery.

2. TEMPORARY ADHESION

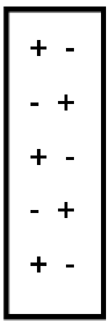
Children rub balloons against their pullover and then use the static charge generated to stick the balloon to the wall. This is has all of the elements of temporary adhesion.

What is happening?

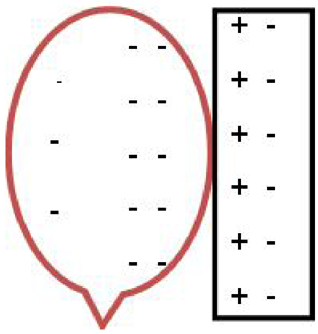
Rubbing against the pullover creates a static charge in the balloon, or an imbalance of ions.



Charged Balloon (polarity not important)



Wall with neutral static charge



The balloon attracts the oppositely charged ions in the wall and repels the negative ions.

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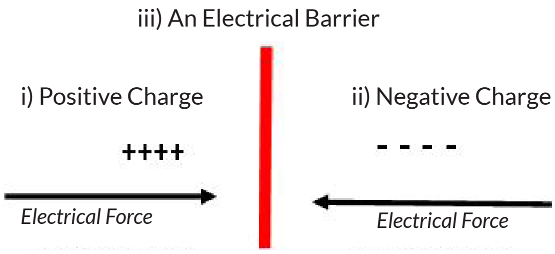
2. TEMPORARY ADHESION

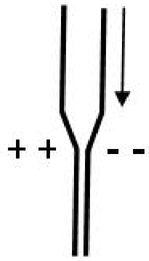
When the balloon is placed close to the wall its negative charge attracts the positive ions and repels the negative ions. This attraction between the balloon's negative charge causes the balloon to stick to the wall.

The negative charge in the balloon does not travel to the negative charge in the wall because the rubber of the balloon is not conductive and will not allow the charge to flow towards the wall. Even if the wall was a conductive metal the adhesion would be similar.

This shows the three essential parts for temporary adhesion:



2.1 Types of Temporary Adhesion



In practice there are two types of temporary adhesion:

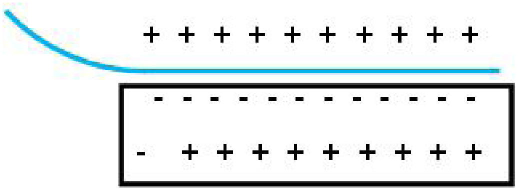
a) Sticking insulative materials together, typically:

- sticking plastic films together,
- holding an insert or label onto a mailer
- holding stacks of paper, or magazines together
- putting protective film or paper onto glass or other non-conductor

  Ions of the opposite polarity are needed on each side of the materials. See the next page for options for creating these

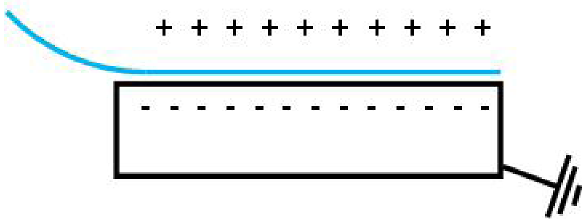
b) Sticking an insulative material to a conductive material, e.g.

- pinning film to a cooling roller
- putting protective film onto metal sheets



Only one active ion source is possible. The ions of the other polarity in the conductor are mirror-image charges, created in the same way as with the balloon on the previous page.

If the conductive material was connected to earth, the positive ions would flow to earth leaving an imbalance of negative ions in the conductive material. The adhesion would not change.



Nearly all industrial static generation applications belong to one of these two types.

All clear? If yes, we can begin to look at the three essential elements for temporary adhesion.

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2.2 The three essentials for temporary adhesion.

There are three elements required for temporary adhesion:

a) Primary source of Ions / High Voltage

b) Insulative Material

c) Counter Electrode

2.2.a Primary Source of Ions / High Voltage

With the balloon example, the static charge was generated by rubbing it against a pullover. This is called 'triboelectrification' or charging by rubbing against a suitable material.

In most industrial application this is not usually possible - you need a constant and controllable source of static charge. This is provided by a high voltage static generator.

We have an excellent range of static generators.

The static generation Bars connected to the generator are often called 'Electrodes'. Electrodes is a better name, because many do not look like bars. In this document 'Bars' and 'Electrodes' have the same meaning.

Fraser has a wide range of electrodes, from single points to long bars.

2.2.b The Insulator

At least one of the materials must be a good insulator. You cannot stick two conductive materials together because they will not hold the static charge. The insulator must be an electrical barrier to the static charge. Normally the insulator is a plastic film or sheet and there is not a problem with the adhesion.

With other materials, like paper, there can be a problem. Dry paper can be a good insulator, but if it becomes damp it quickly becomes more conductive and stops being an effective electrical barrier.

The critical level of surface resistivity is 10^{10} Ohms/Square. If the resistance is below this figure then good electrostatic adhesion is not possible. Above this level it begins to be an electrical barrier, but is not a good barrier until it reaches 10^{12} Ohms/Square.

Our 740 Surface Resistance Checker (in photo) is ideal for measuring this.

2.2.c The Counter Electrode

Ions of the opposite polarity are needed on the other side of the insulator to complete the adhesion. When sticking the insulator to a conductive material the ions of the opposite polarity are attracted by the electric field from the primary ions source - the generator electrode. See previous page.

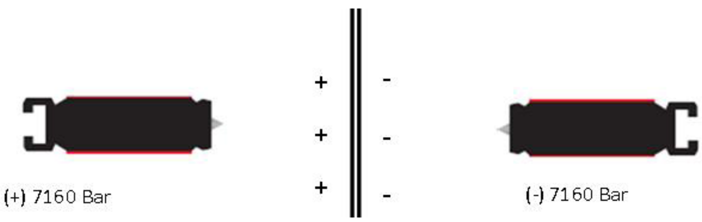
When sticking insulators together, the ions of the opposite polarity are generated by the counter electrode.

The options for the counter electrode are considered on the next page.

There are three main options for the counter electrode.

2.2.c.i Two Static Generators

This is the most powerful option - a positive generator and electrode on one side and a negative generator and electrode on the opposite side.



This gives the most powerful adhesion, but it is also the most expensive option, because it needs two generators.

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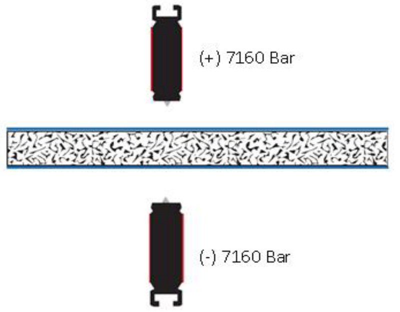
2. TEMPORARY ADHESION

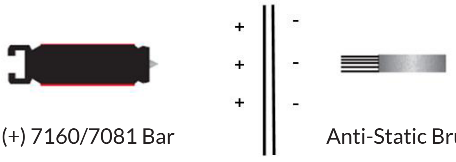
It is used in the most difficult applications such as making melamine work tops where strong adhesion is needed to hold the layers of melamine paper and wood chip together as they are being put into the heat press, below:



For difficult applications, like melamine work tops (+) 60 kV and (-) 60 kV electrodes are needed.

2.2.c.ii Static Generator and Anti-Static Brush

Anti-static brushes work by using the electric field to ionise the air and produce ions of the opposite polarity. They are an effective counter-electrode in many medium and light duty static generator applications.



It is also possible to use a static eliminator as a counter electrode, but the performance is not much better than an anti-static brush and the cost is considerably higher.

2.2.c.iii Metal Rod

A normal metal rod can serve as a counter electrode in some light duty applications. The ionising performance is not as good as an anti-static brush, but it will withstand dusty applications and harsh treatment better.

The sharper the metal rod, the better the performance.

A grounded metal rod may serve as a light duty counter-electrode.

A sharper edge, or a saw blade would be more efficient.

They all must be earthed.

Before we go deeper into the technical requirements it is useful to look at typical applications.

Sticking an insulative material to a conductive material

This photo shows one of our OEM customers, Dolci, using a 7093 to pin the edges of film to a cooling roller.

The object is to stop the film shrinking as it cools.

A 7093 is used because the ambient temperature is over 100 °C and the emitter pins need to be replaceable because it is a dirty and a high wear application.

The metal cylinder is naturally earthed because of the internal water cooling system.

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2. TEMPORARY ADHESION

Sticking insulative materials together

This photo shows a 7160 Bar and 7360 Generator on a Müller Martini bindery line.

It is a high speed line where a magazine with inserts and a loose label are travelling to a station where they are inserted into a plastic envelope.

The 7160 bar is needed to hold the label to the magazine. Otherwise it would slide off.

The counter electrode is a 660 Brush below the open conveyor.

Summary so far:

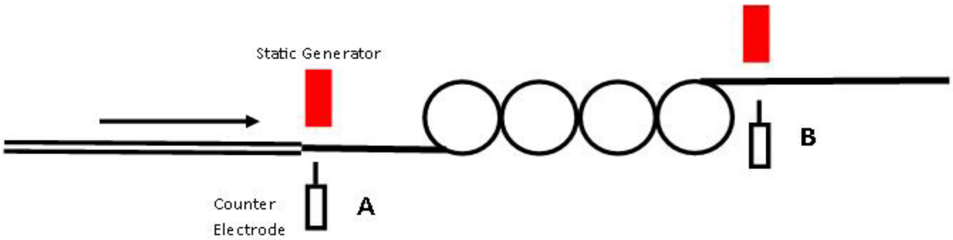
Two main applications:	a) sticking insulator to a conductor (metal).
	b) sticking two or more insulators together.
Three essentials	a) high voltage source.
	b) insulator.
	c) counter electrode.

3. INSTALLATION FACTORS: MECHANICAL

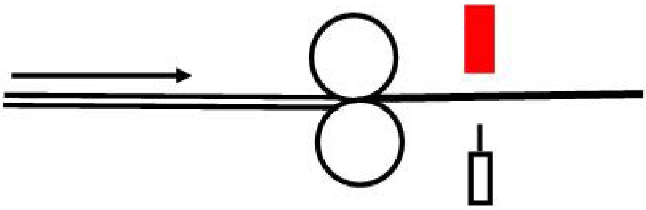
Installation usually needs some adjustment to get the best results. The factors which influence performance are:

3.1 Position

Usually there is only one position - for example if sticking film to a cooling cylinder, you want to stick the film as soon as it touches the cylinder.



If there is a choice of positions, then the closer to the critical area, the better. For example, if the films (above) are pinned together in position A and then have to pass through rollers, the rollers could break the electrostatic bond. In this case it is best to pin the films together after the rollers in position B.



Similarly if the material passes through a pair of nip rollers, the best position for the pinning is after the rollers.

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3. INSTALLATION FACTORS: MECHANICAL

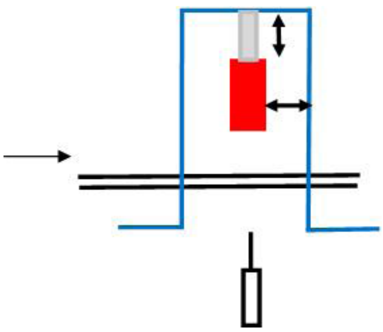
3.2 Distance from Machine Parts.

The distance between the static generator and metal parts of the machine should be at least 50 mm for 30 kV systems and 100 mm for 60 kV systems.

This is important. If metal machine parts are closer than 50 / 100 mm there is a high risk of electrical breakdown and failure of the electrode.

This rule also applies to how the electrode is mounted. The nylon bolts supplied should be used and metal parts kept at the required 50 / 100 mm.

This is a universal rule in our industry. All of our competitors have the same rules.



There should be no machine or mounting parts within the blue line:

↔ = 50 mm for 30 kV
100 mm for 60 kV

3.3 Distance from the Material

The object is to use the lowest voltage necessary to achieve the desired adhesion. A starting point for distance between the electrodes and the material is:

Minimum distance between electrode or counter electrode and insulator at 30 kV is 20 mm.
Then add 2 mm per extra 1 kV e.g. for 45 kV the distance would be 50 mm.

The best distance will be achieved by experiment and experience.

There is a close relationship between distance from material, speed and thickness of the material.

- The thicker the material, the higher the voltage or closer the material.
- Faster speeds need closer distances.
- Thicker materials need closer distances.
- Very thin materials could be punctured if the distance is too close, or the voltage too high.

3.4 Support and Installation of Electrodes

In all static generation applications it is important that the electrode emitters are parallel with the counter electrode and the insulator material. There is a risk of variable adhesion if it is not parallel.
Two nylon mounting bolts are supplied for electrodes up to 1 m in length, then an additional bolt for every extra 500 mm, or part thereof. Use all of the nylon mounting bolts supplied.

4. INSTALLATION FACTORS: ELECTRICAL

4.1 Polarity of Generator

On a two Bar system, one negative and one positive generator are required.

On a one Bar system the choice of polarity depends on the natural charge of the material. Polymeric materials tend to become negatively charged, so negative is the most popular polarity with plastics.

Some materials, like paper, tend to have a positive charge and so a positive generator is usually preferred.

The polarity tendencies of materials is generally shown on the triboelectric series.

In many cases there is no noticeable difference between polarities. If in doubt, choose negative.

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4.2 Existing Static Charge in Material

It is important to neutralise any existing static charge in the insulator materials, because this could affect the quality of the adhesion.

Typical problems would be uneven attraction and air bubbles between the materials.

Short range static eliminators should be used. They should be positioned as far upstream as practical to prevent ions being attracted to the generator electrode.

4.3 Voltage Required. 30 kV or 60 kV?

Fraser manufactures Static Generators working at 30 kV and 60 kV. Which voltage should you use?

30 kV covers about 90 % of applications.

60 kV should be used for longer distances between the electrodes and counter electrodes - for example where thick stacks of paper are being pinned together, or where the material needs more force to hold together - such as melamine wood laminate manufacturing.

At the time of commissioning the system in a factory, set the voltage at about 60 % of full voltage and then adjust the voltage up or down until you reach the lowest voltage which achieves the required performance. This is fully explained in the operating instructions.

Fraser has two 30 kV Static Generators, the lower power 20 Watt IONFIX Compact and the higher power 150 Watt IONFIX Pro. The Choice between the 30 kV IONFIX Compact and the 30 kV IONFIX Pro will be considered later.

4.4 Routing of High Voltage Cable

The high voltage cable is protected by a plastic conduit, but care must be taken to avoid sharp bends. The minimum bend radius is 70 mm.

4.5 Current Limitation

Current limitation is a safety feature on Fraser Generators. Some of our competitors also offer current limitation, but the Fraser system is much easier to use with a seamless transition between constant current and constant voltage modes.

All Fraser electrodes are resistively coupled so there is considerable safety built into them, but current limitation is still a valuable safety feature. How does it work?

When the appropriate high voltage has been set - see 4.3 above, the current being drawn is shown on the generator display.

The photo on the left shows that the generator is operating at 30 kV and drawing 0.1 mA of current.

If the insulator is no longer present - for example if there is a web break - then the generator bar would ‘see’ the counter electrode and the current would increase dramatically. This would result in intense current flow from the generator Bar which could result in damage to the metal counter electrode, if it is a coated cylinder, through ‘spark erosion’ and increased wear on the emitters. If the electrodes were not resistively coupled there would also be a potential fire risk - many competitive electrodes do not have resistive coupling.

To avoid this happening, the current limit can be set just above the operational current level. If the current being drawn by normal operation is 0.1 mA, as above, then the current limit can be set at 0.12 mA - as shown in photo on left.

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If the insulator is no longer present, the generator tries to draw more current, but is limited to 0.12 mA.

This forces the voltage to drop to a safer level - the photo on left shows that the voltage has dropped to the safer level of 21.0 kV.

The Current Limit LED illuminates to show that the Generator is in constant current mode (yellow arrow).

When the insulator returns, the current draw returns to 0.1 mA and the voltage returns to the 30 kV originally set.

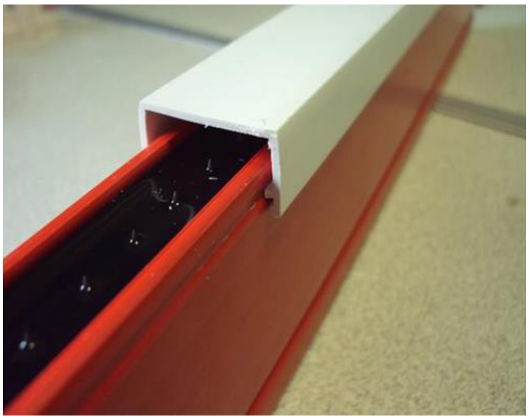
4.6 Masking Emitters

Ideally the generator electrode should be the same size as the insulator material, but in practice the customer may use materials which are shorter than the electrode.

If the electrode is close to the counter electrode or metal cylinder/rollers the current flow from the exposed emitters will increase and it is possible that damage could occur to the surface of the cylinder and possibly increase emitter wear.

To avoid this we have a plastic extrusion which clips onto the 7160 Electrode.

It is part 715003 which can be supplied in 1 m lengths and cut by the customer as required.



The 7081 Bar does not have a clip-on cover, but insulation tapes can be used to achieve the same result.

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5.1. Resistive Coupling

All Fraser electrodes / bars have a resistive coupling between the high voltage and the emitters. It is important to understand the benefits.

Resistive coupling is a safety feature, reducing the current available to give a shock to an operator if he/she touches an emitter. It also prevents the electrode from sparking, which could be a fire hazard.

It is also important for the operation of the electrode, giving an even distribution of charge along the length of the electrode. If there is no resistive coupling, then one emitter could discharge more of the current available if it were closer to the material than the other emitters - for example if the electrode is not parallel.

The resistors on the 7160 (previously 7130 and 7150) are custom-made to our specification.

Each emitter has an individual resistor - even where the emitter pitch is every 5 mm, as on the T5 models. See photo on left.

This design is expensive but ensures the highest quality emission in addition to the safety aspects.

The yellow arrows show the individual resistors for each emitter.

The models with individual resistors for each emitter are:

- 7160 (and previous models 7130 and 7150) Bars
- 7093 Claw Electrode
- 7095 All models from May 2017.

The models where resistors serve more than one emitter are:

- 7081
- 7090

5.2 Tungsten Emitters

The performance of generator electrodes depends on the sharpness of the emitters. The emitters are subjected to intense spark erosion, which can reduce the sharpness. So it is important that the emitters are made from the best material available. Fraser uses pure tungsten emitters.

If the emitters are not the best material, the electrodes will need to be replaced more frequently.

We have made long-term tests with various materials, using actual emitters from our competitors - tungsten carbide from Eltex, titanium from Meech and the ‘special alloy’ (hastalloy) from Simco. In all of these tests Fraser tungsten emitters were easily the best.

As an example of this testing, Fraser tungsten emitters and Meech titanium emitters were subjected to an intensive sparking at 30 kV over a 4 week period.

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		Fraser Tungsten Emitter	**Meech Titanium Emitter**
At start of test:	Tip diameter:	0.1 mm	0.224 mm
	Length:	7.0 mm	7.0 mm
			
At end of test:	Tip diameter:	0.184 mm	0.88 mm
	Length:	6.86 mm	6.0 mm

The Fraser emitter was still effective after the severe test. The Meech emitter was blunt and unusable.

The only Fraser electrodes which do not use tungsten emitters are the 7081 Bars, which we reserve for lighter duty applications where emitter wear is less.

5.3 Emitter Pitch

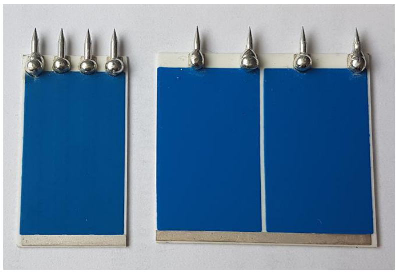
Our standard emitter pitch on 7160 and 7081 Electrode Bars is 10 mm.

In some cases customers want an even closer pitch for a homogenous application of charge.

For these customers we have developed a 5 mm pitch: T5.

The T5 option is available on 7160 and 7081 Bars.

On the T5 versions each emitter pin is individually resistively coupled.



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