

### Commentary on Indirect versus Direct Application of the Charge in ESA Systems

Both indirectly and directly charged ESA systems are currently available worldwide. There are some significant performance issues that are important in evaluating the two systems. The purpose of this paper is to highlight those issues and provide a foundation for accurately communicating the tradeoffs between the two systems.

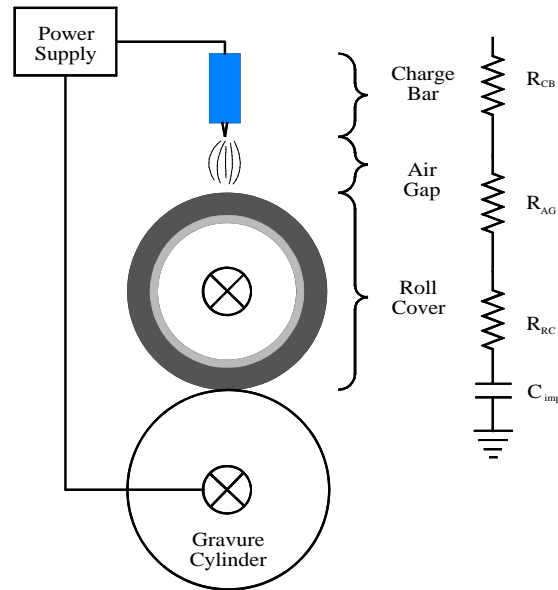
The effectiveness of ESA is primarily determined by how much the electric field in the impression deflects the ink surface in the Gravure cell. The force on the ink surface is determined by the following equation.

$$F = \frac{1}{2} E^2 / \epsilon$$

The force (F), and therefore the ink surface deflection, is proportional to the square of the electric field (E) in the impression. The electric field results from current supplied by the ESA power supply.

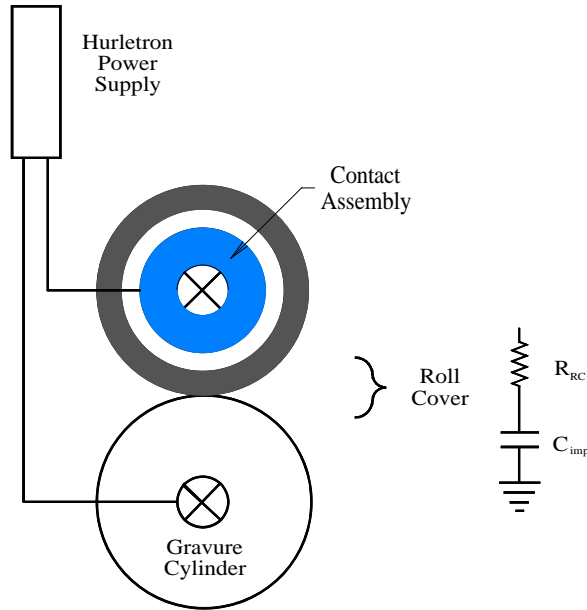
#### Current Path Issues

The above is true for any ESA system and is completely independent of how the charge is applied. However, the path the current takes getting to the impression plays a significant part in the resulting field that is developed and therefore the effectiveness of ESA.



The current path for an "Indirect Charge" ESA system is as follows.

The current path for a “Direct Charge” ESA system is as follows.



In both diagrams the impression is modeled as a capacitor. The charge bar contains a resistor, the air gap resists the current flow significantly, and the impression roll cover must be somewhat resistive or “semi conductive” to the current flow. Current flowing through the respective “resistors” causes charge to build up in the “capacitor” creating the electric field (E) that does the work.

- The current for indirect charging (as in Eltex systems) must pass through the charge bar and ionize the air in the gap. Both of these resistances dissipate significant energy and directly affect the development of the electric field.
- With direct charge systems the current passes through the thickness of the impression roll cover. The current must pass around half the circumference of the impression roll with indirect systems dissipating significantly more energy. As before, any energy lost before the current gets to the impression affects the development of the electric field.
- The current tends to pass along the surface in indirect systems (as opposed to through the semi-conductive layer). Current flow around the surface can become non-uniform as the roll surface becomes polished or otherwise ages due to continuous working of the rubber. Some believe this can lead to localized regions where there is less field.

All of these issues result in the fact that indirect systems tend not to build as strong an electric field as direct systems. Therefore, they rarely perform at the level typical of direct charge systems.

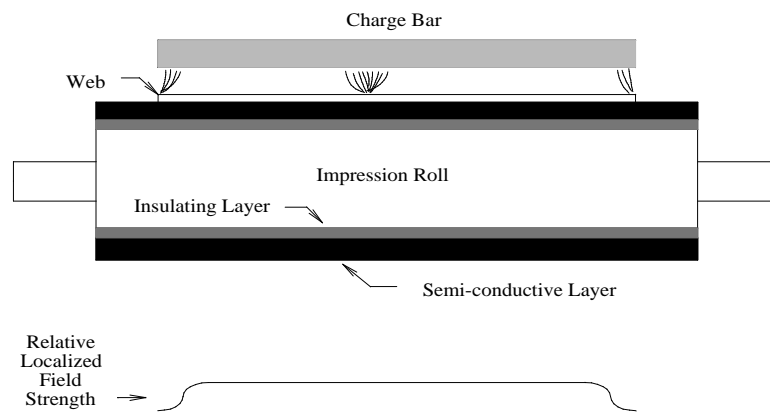
### Safety Issues

Indirect systems operate at significantly higher voltages in an attempt to overcome the power dissipation issues stated above. The typical voltage entering the charge bar is in the area of 10KV to 15 KV. However, as the voltage is increased the resistor in the charge bar must also increase in order to limit the ignition energy available at the pin. (A charge bar is a device for creating a "controlled discharge". Applied to Gravure printing, the bar must limit or "control" the discharge to make sure it is less than the ignition energy of the solvent air mixture.)

- Indirect systems rarely reach the same electric field strength as direct systems since the resistor in the charge bar must limit the current flow to restrict the discharge to a safe level. This does not imply that direct charge systems are inherently safe. They have issues also.

### Charge Bar Geometry Issues

The current distribution in an indirect system is illustrated in the following diagram



At the ends of the bar (the web edges) the current that creates the electric field only flows from the inside. The resultant field strength falls off at the edges as shown in the graph of relative localized field strength. Some installations exacerbate the problem by running with charge bars that do not extend to the web edges. (Either problem can be overcome by choosing charge bars that extend beyond the web edges but most people do not realize this.)

- Generally, albeit because of improper application, most indirect systems do not perform as well at the web edges.

### **Cleanliness Issues**

The function of a charge bar is to pass current through the air, typically to transfer charge to other objects. Generally, they can not do this preferentially. In other words, everything capable of holding a charge in the vicinity of the charge bar will become charged. Any small liquid droplets as well as any particulate matter, such as paper dust, will end up with an induced charge opposite that of the charge bar. These particles are attracted to the area of the charge bar pins and create a coating on the pins if not cleaned regularly.

- The charge bars in indirect systems must be cleaned regularly to maintain maximum effectiveness. Contact assemblies rarely require cleaning.

### **Anti-static Issues**

All indirect systems use anti-static before and or after the impression. Suppliers of these systems say indirect systems work better because they discharge the web prior to the impression or are safer because they eliminate the charge immediately after the impression. The reality is that they typically *must* discharge the web prior to the impression. Remember that indirect systems do not build up a very large electric field in the impression. Any opposing charge on the web as it enters the impression can work against the field created by ESA. This is only significant on indirect systems.

- Indirect systems typically require anti-static prior to the impression due to the limited electric field that they produce. Direct systems do not require anti-static prior to the impression.
- Indirect systems sometimes require anti-static after the impression because the very high voltages used can leave significant charge on the web after printing. Direct charge systems, operating at lower voltage leave a significantly smaller charge on the web and rarely require anti-static after the impression.
- With direct systems, anti-static before or after the impression is not typically required though it does no harm.

Anti-static is not added to make indirect systems work better or safer. Anti-static is often required to make indirect systems work as well or as safely as direct systems.

### **Impression Roll Issues**

Indirect systems require a two-layer impression roll. (See earlier diagram) The outer layer is semi-conductive and provides a current path for the ESA current. The inner layer provides an insulating layer from the impression roll shell. Direct systems only require single layer impression rolls but the entire roll must be isolated from ground.

- Two layer impression rolls, required for indirect systems, are more expensive and, over time, less reliable due to the second bonding interface between layers.
- If we are replacing an indirect system, the customer may need to replace all of their impression rolls.

### **Web Moisture Issues**

Occasionally customers have been told that indirect systems work better than direct systems when sheet moisture is relatively high. As previously noted, for any ESA system the electric field in the impression is what allows ESA to work. Whether direct or indirect, the nature of the field is the same, only the magnitude of the field is different and the magnitude with direct ESA systems is, generally, larger. Moisture does effect the field in that the capacity to build up charge is lower with higher moisture content and therefore the electric field is smaller. However, this is equally true for all ESA systems.

- While anything that makes the web more conductive, such as moisture, does adversely effect ESA, this is equally true for any ESA system. In other words, any system would have the same problem. No system would have the advantage over another.
- If the web is significantly conductive, by virtue of moisture content or web conductivity, all ESA systems have performance issues.

Clearly, indirectly charged systems, such as Eltex, do work. For some printers where the highest quality is not an issue, the performance of indirect systems may be acceptable. Industry experience shows that direct charge systems typically have performance advantages over indirect systems and are preferred where the highest quality is important.