

# **Advances in Contact Cleaning for Flat Panel Display Materials**

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## **INTRODUCTION**

A growing market for coated films is the manufacture of Flat Panel Displays (FPDs) which are integrated into many consumer products from mobile phones through digital cameras to LCD televisions. Increasingly FPD manufacturers face technological challenges to meet more demanding customer requirements such as greater brightness which requires higher aperture ratios and better resolution requiring smaller pixel size. These increasingly stringent technological parameters are overlaid by a need for increased quality while producing the displays at lower costs.

A problem confronting all producers of FPDs has been the cost of undetected defects on a panel which result in costly repairs and scrap. Inspection and repairs count for 40% of the cost of FPD production. A significant proportion of these defects can be attributed to particulate contamination even though much of the manufacture is done in clean rooms.

In this marketplace improving yield is a commercial imperative and this paper explores Contact Cleaning, a key technique in contamination control, which is being widely used in Asia both in film coating and in FPD assembly to increase yields.

## **TYPES OF DEFECT**

- 1 Electrical pixel defects are caused by failures in the driver circuitry on the backplane of the FPD. These normally take the form of short or open circuits largely caused by contamination affecting the integrity of the conductors during processing. These defects can be repaired if detected early in the process.

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- 2 Visual pixel defects are caused by microscopic contamination trapped within the layers of the FPD during manufacture can result in a dark stain covering one or more sub pixels. Under magnification the shape of the particle of contaminant can be clearly seen
- 3 Mura defects and mottling occur when the LCD cell is of uneven thickness sometimes caused by the inclusion of a particle of contamination of larger diameter than the spacer beads within the cell.
- 4 Polariser dents and scratches can be caused by contamination on processing roller or within the film reel at rewind.

The number of defects contained in an FPD supplied to a customer is defined by International Standard ISO13406-2. This categorises FPDs into a series of classes with different numbers of permitted pixel defects of differing types as shown in the Table 1. Most display manufacturers are operating to Class II.

**TABLE 1**

<b>Definition of Pixel Fault classes - Maximum number of faults per <i>million</i> pixels</b>					
<b>Class</b>	<b>Type 1</b>	<b>Type 2</b>	<b>Type 3</b>	<b>Cluster with more than one Type 1 or Type 2 faults</b>	<b>Cluster of Type 3 faults</b>
<b>I</b>	0	0	0	0	0
<b>II</b>	2	2	5	0	2
<b>II</b>	5	15	50	0	5
<b>IV</b>	50	150	500	5	50

Type 1: number of always lit pixels

Type 2: number of always unlit pixels

Type 3: number of subpixels either always lit or always unlit

Cluster 1: more than one Type 1 or Type 2 defects in a 5 pixel by 5 pixel square

Cluster 2: Type 3 faults in a 5 pixel by 5 pixel square

### **CONTAMINATION CONTROL**

To achieve this rigorous standard FPD manufacturers require scrupulously clean base materials and to ensure that the contamination control protocols throughout their manufacturing process are implemented to the highest standards. Most FPD manufacturers in Asia specify that the coated films for their products are cleaned both before coating to remove any particulate which might affect the functional integrity of the film. Many of the coatings in FPD films are extremely thin and incorporate nanoparticles making them extremely sensitive to even microscopic

particles of contamination. They are also after coating but before rewind to ensure that any loose particles are not going to cause dents in the film. Any roller, such as diverter rollers and support rollers within the coater which contact the film must also be completely free of any contamination.

There are several types of cleaning techniques currently employed in the coating industry but this paper will focus on Contact Cleaning, the benefits it can offer and recent developments targeted specifically at FPD manufacture.

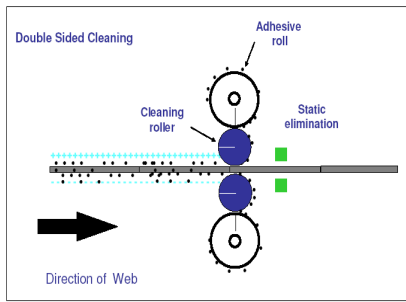
## **THE BACKGROUND OF CONTACT CLEANING**

Contact cleaning is a very well established yield improvement technique used by many high technology manufacturing operations to increase competitiveness. The process was invented over twenty years ago, initially for membrane switch production though for many years the main applications were at various stages of the printed circuit board (PCB) manufacturing process. As different configurations and widths of machines were developed the technology was incorporated into lines processing web materials such as food and medical packaging, photographic films and functional coatings on polyesters and polycarbonates. In each of these applications users have benefited from significant increases in yields through the removal of loose contamination from the web. This technique can remove particles as small as 1 micron.

## **THE PRINCIPLE OF CONTACT CLEANING**

The basic principles of contact cleaning involve a specially formulated elastomer roller rotating in contact with the web. See Figure 1. Due to its special formulation the elastomer roller picks up all loose dirt and contamination from the web and transfers it to an adhesive roll ensuring that the surface of the elastomer which comes in contact with the web is always completely clean. The adhesive comprises a paper or film base coated with a pressure sensitive adhesive and wound on a core with the adhesive side facing outwards. It is essential that the properties of the pressure sensitive adhesive are tailored specifically for contact cleaning as it must be fully compatible with the elastomer and yet have sufficient adhesive and cohesive strength to ensure that there is no risk of transfer of any of the adhesive to the elastomer roller and subsequently to the product being cleaned. The elastomer must also contain no plasticizers or surfactants which might migrate onto the material being processed.

**Figure 1 : Double-Sided Contact Cleaning**

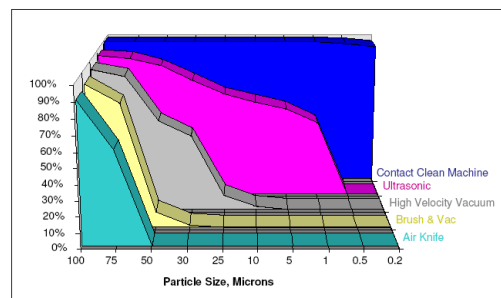


The system can be configured to clean one or both sides of the material and in some applications static control is added to the outlet of the equipment to minimise the risk of statically attracted particles recontaminating the web. See Figure 1. The equipment can be as small as 150mm (6”) wide and as large as 4000mm (13’) and can be specially designed to retrofit into an existing line.

**Figure 2 : Comparison of Cleaning Technologies**

Cleaning Method	Brush	Ultra Sonic	Air Blower	Vacuum	Contact Roller
Penetrate Boundary Layer	NO	NO	NO	NO	YES
Removal down to 1micron	NO	NO	NO	NO	YES
Analysis of Contamination	NO	NO	NO	NO	YES
Simple Installation	NO	NO	NO	NO	YES
Large Footprint	YES	YES	YES	YES	NO
Ducting, Filters	YES	YES	YES	YES	NO
Noisy	YES	YES	YES	YES	NO
High Maintenance Cost	YES	YES	YES	YES	NO

**Figure 3 : Comparison of Cleaning Efficiencies**



A comparison of the various technical parameters associated with differing cleaning technologies, including the current Teknek Contact Cleaning technology is shown in Figure 2 while the efficiency of cleaning various sizes of particles is shown in Figure 3.

**RECENT DEVELOPMENTS IN CONTACT CLEANING**

Customer feedback from Asia from FPD manufacturers and film coaters using Contact Cleaning technology suggested that the technology was not suitable for some FPD films and so Teknek has developed a new type of proprietary contact cleaning elastomer together with a new type of adhesive specifically to overcome these problems. This elastomer removes 90% of particles down to 0.4 micron in size and has enhanced the yields of the manufacturers using it by around 15%.

**CONCLUSION**

The new Contact Cleaning technology recently developed by Teknek offers significant yield improvement potential to both coaters supplying films into the FPD marketplace as well as to the FPD manufacturers themselves. This ensures they can meet the increasing demands for higher quality displays while remaining cost competitive.