



ARTIFACT GUIDE

Printed Circuit Board Films

*Protecting
Your Images*

INTRODUCTION

Printed Circuit Board Films – Artifact Guide

Minimizing artifacts to maximize quality

While many factors can affect image quality, microscopic defects known as artifacts degrade film images. If the images are seriously degraded, it's likely that the printed circuit boards made from those images will be rejected.

Rejected boards can't be sold. They cost you money. And doing them over wastes time and resources. Your productivity suffers. You lose capacity.

To make sure you achieve the highest quality images – and operate cost-effectively – it is critical to minimize the number and types of artifacts that appear on processed films. The solution is simple – **Proper film handling practices will prevent nearly all artifacts that cause rejects on printed circuit board films.**

Film defects fall into two main categories:

- D-max Artifacts – a clear mark in the black part of the film
- D-min Artifacts – a mark in clear areas of the film

We have also included a third section describing less common varieties of physical artifacts which may be found anywhere on the phototool.

In all cases, artifacts can be drastically reduced with proper care and consideration of your:

- Facility set-up – Cleanliness is critical in darkrooms and photoplotter rooms.
- Film handling and processing methods – Keep equipment and workspaces clean. Rigorously maintain film processors and handle film with care.

This guide will help you identify a wide variety of artifacts and show you how to avoid each of them.

Each of the following pages explains one type of artifact. Examples are shown along with a description of how and where that type of artifact may form. Detailed troubleshooting procedures are offered to help you prevent similar artifacts in the future.

We hope you find this useful. If you have any questions, please e-mail us at pcbproducts@kodak.com or visit www.kodak.com/go/pcbproducts

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Film handling practices in cleanroom environments

To minimize the possibility of creating artifacts, make sure your darkrooms and photoplotter rooms are clean, maintain film processors regularly, and always handle films with care and common sense. Artifacts can be virtually eliminated by following these guidelines.

Film handling

- *Be careful of metal surfaces.*
- *Handle film only by its edges.*
- *Use the fingertips of both hands.*
- *To carry a single sheet, fold film in half and hold it in a "3-point grip" between thumb and middle finger, with index finger in the center to keep film surfaces separated.*
- *Give yourself room to spread out.*
- *Carry film flat in trays or boxes.*
- *Wear gloves.*
- *Avoid jewelry that may have sharp edges.*
- *Clean film as recommended*
 - *Wipe in one direction, not in a circular motion.*
 - *Use cleanroom wipes, environmentally safe film cleaners, TEKNEK (or equivalent) Rollers.*

In the photolab

- *Be careful removing raw film from the original package as well as taking film in or out of humidity conditioning racks.*
- *Avoid sharp burrs or grit on racks.*
- *Only use pre-conditioning cabinets with a circulating fan and HEPA filters such as those available from DEXON.*
- *Keep the inside of the humidity conditioning cabinet and inside of the photoplotter free of dust – vacuum weekly.*
- *Load cassettes with care.*
- *Minimize exposure to dirt and dust when handling and transporting film.*
- *Carefully package and deliver film to the resist imaging dept.*
- *Store film in its original foil bag. Do not bring cardboard boxes into cleanroom.*

In resist imaging

- *Exercise care when:*
 - *Removing films from packaging during setup.*
 - *Carrying films from worktables to work stations.*
 - *Positioning the phototool in exposure frames.*
 - *Removing the phototool from register pins.*

In resist imaging – continued

- *Cleaning the phototool between exposures.*
- *Lifting film off pins.*
- *Repackaging phototool after use.*
- *Removing two-sided sticky tape.*

Avoid:

- *Copper burrs, resist chips, laminate slivers.*
- *Sharp edges of panels.*

Make sure to:

- *Replace wipes often.*
- *Clean TEKNEK Rollers after use.*

Film processing

Make sure you are processing film at the recommended development time and temperature. Kodak recommends 35° C at 45 seconds for all KODAK ACCUMAX photoplotter films. Underdeveloping will cause low dmax and affect line quality. Also make sure processor guides and rollers are properly aligned and crossovers adjusted correctly. Clean tanks of bioslime and maintain the processor to avoid:

- *Dirty entrance rollers.*
- *Dirty top rollers.*
- *Salt crystals on crossover guides.*
- *Dirty squeegee rollers at entrance to dryer.*
- *Particulates on dryer rollers.*

Developer and Fixer Filtration	Use 10µm filter. Change weekly.
Water Filtration	10µm filter is best. Change weekly. No larger than 25µm.
Daily Maintenance	Clean all top rollers, entrance rollers, crossovers, wash to dryer squeegee rollers.
Weekly Maintenance	Remove all racks, developer, fixer, and clean with high-pressure hot water. Use Brushes to clean. Avoid scratching stainless steel with SCOTCHBRITE Pads.
KODAK Roller Transport Cleanup Film 4955	Use daily to remove particles. Especially important to use immediately after cleaning racks and after systems cleaning.

Processor maintenance

Controlling bioslime growth

- *Minimize bioslime which is a major cause of pinhole emulsion pick off.*
- *Daily addition of 30mL (1-oz) of household bleach will help to dissolve gelatin particles, preventing redeposits and minimising bioslime growth.*
- *WASHCLEAR, from Rothtech Ecological, has also proven to be very effective.*
- *PHOTOBROME, from Raynostix, is also effective with a convenient auto-feed dispenser to the processor.*

Cleaning film for phototooling applications

To clean film, use only isopropyl alcohol (91 percent) or heptane.

Soft, lint-less, absorbent cotton pads, WEBRIL Handi-Pads, or their equivalent should be used. Never use water because it will soften the gelatin.

- *Apply cleaner to the cleaning wipe, not directly to the film.*
- *Wipe film in a single up-and-down direction, NOT in a circular motion.*
- *Fold the cleaning wipe frequently to keep dirt particles away from the film surface.*
- *Change wipes often.*

Cleanroom conditions: practice and maintenance

Cleanroom practice may be considered under several categories:

Materials

- *Exterior packages should conform to a certain clean standard to be admitted to the cleanroom.*
- *Avoid shedding materials such as paper, or cardboard boxes.*
- *Use intermediate containers to transport materials to cleanroom, such as plastic containers.*
- *Decontaminate larger items in a preparation room before entering clean area.*
- *Material transportation equipment should conform to the same cleanroom standard.*
- *Avoid large storage areas near to the cleanroom.*
- *Practice Just-In-Time delivery.*

Equipment

- *Should not generate contaminants – such as rust.*
- *Should not interfere with filtered air flow and/or cause turbulence.*
- *Surfaces should be easy to clean. (e.g. smooth, glossy, no crevices)*
- *Perform maintenance outside the clean environment when possible.*
- *Use trained maintenance personnel with awareness of cleanroom requirements.*
- *Stainless steel tables and wire coated racks are good choices for use in cleanrooms.*

Physical layout

- *Locate equipment to optimize process flow. Steps of the workflow should physically follow each other and not traverse back and across the work area.*
- *Minimize traveling from area to area by optimizing the flow of people and materials.*
- *Control access to areas that are frequently used during the process.*
- *Operations that require cleanest conditions should be performed closest to filtered air supply.*
- *Maintenance personnel should be able to work with minimum access to the cleanroom.*

Controlled access

- *Tacky mats should be used at the entrances of both support rooms.*
- *All personnel should be required to change shoes or wear shoe covers before entering the clean area.*
- *Use intercom system to facilitate communications in the cleanroom and minimize personnel movements.*
- *Establish written policies to control cleanroom access for people, materials, and equipment.*

Training

- *Operators should understand why the cleanroom is necessary and how they can contribute to keeping it clean.*
- *Encourage people to spot problems and provide solutions to maintain cleanroom standards.*

Clothing

- *Wear cleanroom clothing in cleanroom only.*
- *Cleanroom clothing should be worn properly – coats buttoned, hair inside cap, etc.*
- *Use the recommended cleanroom clothes for the specified cleanroom level.*

Personal habits

- *Avoid use of products that generate airborne particles, e.g., body powders, talc, baby powder, foot powder, etc.*
- *Avoid use of products that give residual contaminants, e.g., hand and body lotions or creams.*
- *Avoid use of products that give off vapors and/or particulates into the air, e.g., colognes, perfumes, after-shave, cosmetics, nail polish, or hair sprays.*

Supplies

- *Use special covered notebooks, made of special paper for cleanrooms.*
- *Use pens rather than pencils.*
- *Detergents and other cleaning supplies must meet cleanroom specifications.*
- *Give special attention to waste disposal.*

Working methods

- *Restrict or minimize body movements when handling equipment.*
- *Any movement generates a flow of air that carries dust; most of it is invisible to the human eye.*
- *Avoid movements such as touching your face and then touching the product; this transfers oil, grease, and skin flakes to product.*
- *Minimize gestures and conversation.*
- *Eating and smoking must be forbidden in support rooms and cleanrooms.*
- *Provide an appropriate break room for eating and smoking.*

Facility

- *Inspect all surfaces of the facility and equipment; tables, chairs, etc.*
- *Inspect and remove rust, corrosion, and flaking paint.*
- *Repaint with epoxy paint where necessary or use high-gloss paint for easy cleaning.*
- *Use hard surface materials for flooring, never carpet.*
- *Use laminate coated ceiling tiles.*
- *Maintain cleanroom to 50% RH.*

Cleaning

- *Schedule cleaning so it does not interfere with production.*
- *Cleaners should wear appropriate garments.*
- *Cleaning should proceed from highest surface level to lowest, and from cleanest areas to less clean.*
- *Cleaning should be followed by a period of time to allow dust to settle; do this before restarting production.*
- *All materials and equipment used in the clean operations must be approved.*

Support rooms

- *Areas of access to the cleanroom.*
- *Very important in controlling contamination.*
- *Used for changing to cleanroom clothes and their storage.*
- *Use support rooms to clean materials and equipment before entering the cleanroom.*
- *Support rooms provide a boundary of near cleanroom conditions; a buffer zone.*

Facilities

- *Lighting must meet needs of the process and product.*
- *Light fixtures should not interfere with air flow and should not take significant HEPA space in an overhead laminar flow area.*
- *All piped-in services such as gases, liquids, etc. should have final in-line filtration to reduce contamination.*
- *Delivery systems and conduits should be made of non-shedding inert material.*



These defects appear as anomalous clear areas in the maximum density image areas on the film.

There are four main causes considered here:

- Actual removal of the emulsion before or after exposure*
- Dust or fibers interfering during plotting*
- Emulsion desensitization*
- Restricted processing*

D-MAX ARTIFACTS

PINHOLES – EMULSION PICKOFF

WHAT ARE THEY?



Emulsion pickoff pinholes are actual holes in the image where the emulsion has been physically picked off the polyester base. These pinholes usually have an irregular shape and sharp edges, unlike pinhole shadow images caused by dust (see page 11).

Small pinholes (less than 25 μm or 1 mil) normally will not produce an image on the final circuit board. Larger pinholes (greater than 50 μm or 2 mil) WILL produce an image.

You can use the test on page 12 to determine whether pinholes are caused by emulsion pickoff or dust.

WHEN CAN THESE OCCUR?

Emulsion pickoff pinholes can happen at just about any point in the film handling process, including:

- Pre-exposure handling
- Plotting
- Processing
- Post-process handling including resist exposure

WHAT CAUSES THEM?

A simple nick of the emulsion during pre-process handling will do it. So will an abrasion during processing, and many types of damage can occur when films are handled immediately after processing. If films are not laminated, considerable care is needed during the use of the film for phototooling. Be careful at every stage.

Here is a list of opportunities for the film to come into contact with sharp edges or abrasive materials, which could damage the film.

Pre-processing

- *Unloading film from packages.*
- *Loading film into conditioning cabinets.*
- *Removing film from cabinets.*
- *Loading film into cassettes or plotter drum/bed.*
- *Unloading film from plotter.*
- *Transferring film to processor.*

Processing

- *Dirt on processor rollers.*
- *Misaligned film guides.*
- *Salt on crossover guides.*
- *Bioslime in wash tank.*

Post-processing

- *Removing film from drying bin.*
- *Dirt on light table.*
- *Burrs on microscope base.*
- *Grit in plastic bags.*
- *Burrs or grit on cutting boards.*

Resist exposure

- *Placing or removing film in exposure frame.*
- *Adjusting alignment of film in exposure frame.*
- *Placing or removing board in exposure frame (usually a problem only with manual exposure units).*
- *Dirt in exposure frame .*

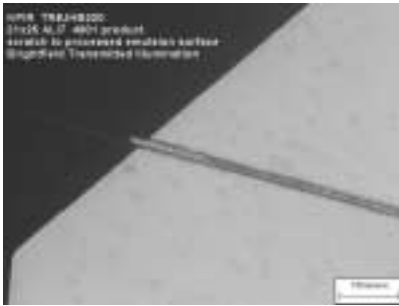
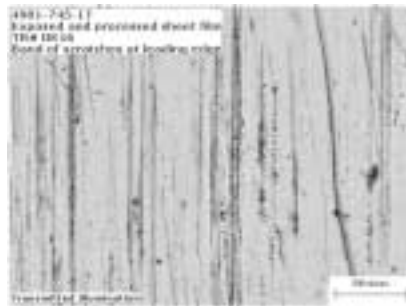
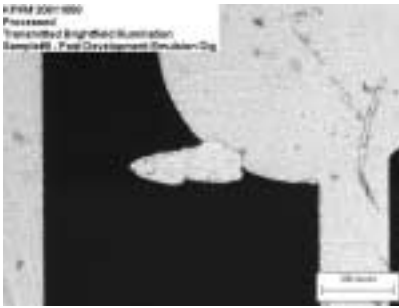
HOW CAN THEY BE PREVENTED?

- *Take care when handling film near metal surfaces.*
- *Handle film only by the edges.*
- *Avoid jewelry with sharp edges.*
- *Practice good processor maintenance to eliminate buildup of dirt, salt, and bioslime; maintain film guides.*
- *In post-process handling, eliminate dust and burrs in areas where you handle, inspect, cut, retouch, and expose film.*

D-MAX ARTIFACTS

ABRASION LINES – GOUGES AND SCRATCHES

WHAT ARE THEY?



These are basically the same as emulsion pick off pinholes except on a larger scale. You may be able to see them with the naked eye or a hand lens. A scratch line that has removed emulsion can generally easily be distinguished from a fiber, which causes a shadow image.

Superficial scratches that have not removed emulsion are usually not a problem, as they will not image on the final circuit board.

WHEN CAN THESE OCCUR?

The film surface can be scratched or gouged at almost any point in the film handling process. See Emulsion pickoff pinholes (page 8).

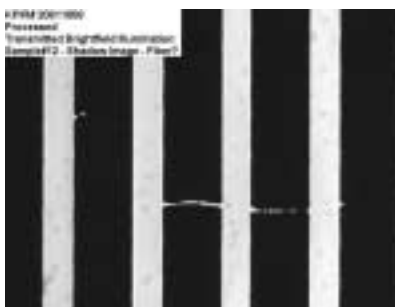
WHAT CAUSES THEM?

Abrasion from sharp surfaces at any stage in the production and use of the film.

HOW CAN THEY BE PREVENTED?

The simplest and most effective way is to practice good housekeeping anywhere and everywhere you store or handle film. See film handling practices (page 1).

WHAT ARE THEY?



Sample 2 - minor density curved line in shadow image of fiber on the emulsion surface when the film was flushed in plottter. Fiber was removed from emulsion in processing.



These image “holes” are caused when dust on the film prevents exposure of the emulsion. Like emulsion pickoff pinholes, they have an irregular shape. Unlike pickoff pinholes, they tend to have soft, diffused edges. Quite often they are clearly caused by fibers.

The size of these defects can range from microscopic to easily visible with the naked eye.

The test on page 12 will help you determine whether pinholes are caused by pickoff or dust.

WHEN CAN THESE OCCUR?

Dust is primarily a problem during two key processes:

- Pre-exposure handling
- Plotting

WHAT CAUSES THEM?

During pre-process handling, problems arise due to:

- Dust particles from packaging.
- Dust accumulation in conditioning cabinets.

During plotting, most artifacts are caused by:

- Accumulation of dust in cassettes or the plotter drum/bed.
- Particles of dust inside the plotter.

D-MAX ARTIFACTS

PINHOLES—DUST & SHADOW IMAGES

HOW CAN THEY BE PREVENTED?

The simplest and most effective way is to practice good housekeeping anywhere and everywhere you store or handle film prior to processing.

- Weekly vacuuming of the inside of the photoplottter and film cassette is especially important.

Review all cleanroom operations – see page 3 on cleanroom practice and maintenance.

Pinhole Diagnosis Test

To determine whether pinholes are caused by emulsion pickoff (page 8) or a shadow image produced by dust or fibers (page 11), apply food coloring to the film you want to test.

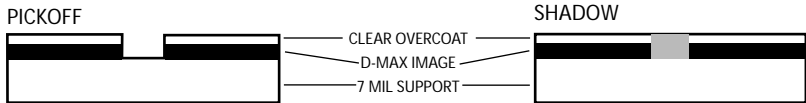
1. Apply dye to the pinhole with an artist's brush or a cotton swab.
2. After 10 seconds, blot excess dye. Wipe the film gently with a soft cloth.
3. Examine the pinhole to see whether it stays clear or absorbs color.
 - If the pinhole stays clear, no gelatin is present to absorb the dye. This indicates a pickoff pinhole.
 - If the pinhole turns the color of the dye, gel is present to absorb the dye. This indicates a pinhole caused by a dust shadow.

If a Pinhole is due to: **pickoff**

- No gelatin is present to absorb dye
- Pinhole stays clear

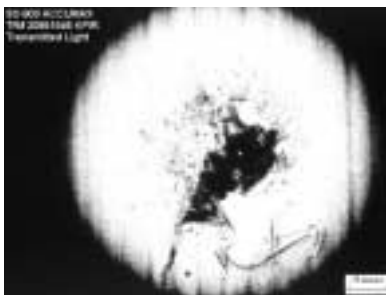
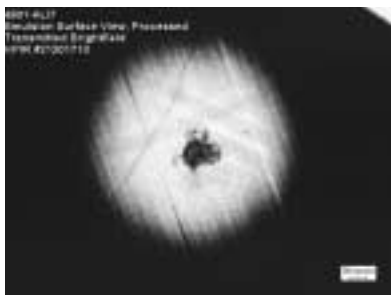
If a Pinhole is due to: **shadow image**

- Gelatin is present to absorb dye
- Pinhole turns color of dye

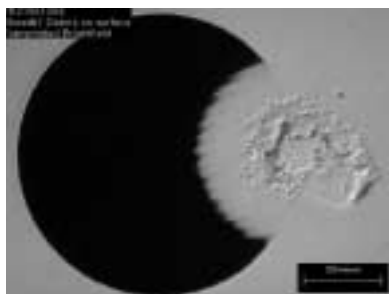


Note: Images not to scale (emulsion layers are only 5 μm thick; the base is 178 μm thick)

WHAT ARE THEY?



Iron spot contamination is characterized as a perfectly clear circle with a diameter up to a few hundred microns. If examined microscopically, the circle has fuzzy edges and evenly spaced lines at the edge. These are raster lines from imaging in the plotter. Sometimes the rust particle can still be seen stuck on the surface of the film.



Desensitization due to other chemicals may also occur. Spots may not be perfectly circular and may be much larger than those due to iron – up to several millimeters in extent.

WHEN CAN THESE OCCUR?

These types of contamination happen before the development stage in the processor.

WHAT CAUSES THEM?

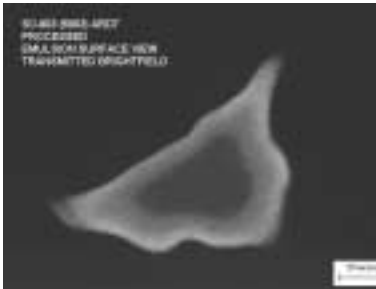
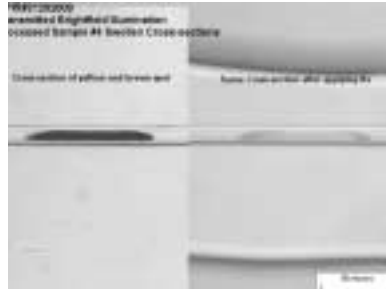
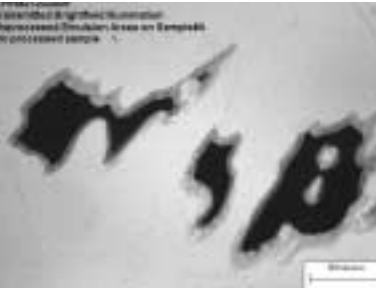
In exposed areas the image should be perfectly black (D-max). However a rust spot has contaminated the film; iron has diffused out from the contamination and desensitized the silver halide grains making them unresponsive or only partially responsive to the laser exposure. It is the partially responsive areas that are responsible for the faint images of the raster lines at the circle's perimeter. This type of contamination is rare.

Contamination by other chemicals such as strong alkali may decolorize the light-sensitive dye, preventing image formation during the plotting stage. The silver halide crystals no longer respond to the light.

HOW CAN THEY BE PREVENTED?

Contamination of the film usually occurs in the steps prior to photoplotting. Inspect film storage areas and inside the photoplotter for evidence of corrosion. Review film handling practices on page 1 of this guide.

WHAT IS IT?



This defect appears as a clear patch(es) or streak(s) in the D-max area of the film. The shape is always irregular and the edges will probably not be sharp. These artifacts are usually visible with the naked eye.

WHEN CAN IT OCCUR?

The contamination will have happened prior to processing, during film handling before plotting, or perhaps in the plotter itself. Oily substances are the most likely contaminants.

WHAT CAUSES IT?

It occurs when some substance or contamination on the surface of the film has prevented penetration of the developer during processing.

HOW CAN IT BE PREVENTED?

- *This defect can be avoided by careful film handling procedures as described at the beginning of this document and well-maintained cleanroom facilities.*
- *Do not underdevelop the film. Short processing times will increase the likelihood of restricted development artifacts. A minimum 45 seconds of development time is strongly recommended.*

III. D-MIN ARTIFACTS



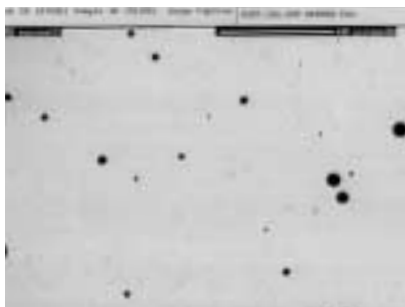


These defects appear as marks in the clear areas on the film.

There are six main causes considered here:

- *Pepper fog spots*
- *Chucking abrasions*
- *Photo abrasions*
- *Kinking*
- *Static marks*
- *Splash marks*

WHAT ARE THEY?



Pepper fog is made up of perfectly round dark spots, 5 to 30 micrometers in diameter, which resemble pepper.

WHEN CAN THESE OCCUR?

Pepper fog occurs during processing.

WHAT CAUSES THEM?

The spots are the result of spontaneous development of silver halide grains in the emulsion.

Pepper fog is usually caused by problems in processing, such as:

- *Developer temperature too high*
- *Under replenishment of developer*
- *Oxidized developer due to low utilization/tank turnover*
- *Development time too long*
- *Developer contaminated by fixer*

Pepper fog can also be caused by poor safelight conditions.

HOW CAN THEY BE PREVENTED?

- *Make sure that you process film according to the correct specifications for time, temperature, and replenishment. These are described in the film data sheets.*
- *In periods of low processor turnover, adjust replenishment to compensate for oxidation and evaporation. Evaporation is best managed by adding water into the tanks.*
- *Avoid contamination of the developer with fixer. When adding fixer directly into the processor, cover the developer section with a splash guard or piece of film to catch spatters.*
- *Inspect safelights and make sure there is no "white-light" leakage in the darkroom. Cover plotter display panels when film is being loaded into the plotter.*

WHAT ARE THEY?



These defects can have a highly variable appearance and have been described as zigzag patterns, lightning bolts, or paint splashes. They are not usually detected with the naked eye but are seen in AOI scans or microscopic examination of processed films.

The whole defect is usually no more than a few hundred micrometers across and consists of spots of developed silver connected wholly or partially by developed silver lines.

WHEN CAN THESE OCCUR?

Chucking abrasions usually happen during film transport, but may also result from film handling before processing.

If films are not vacuum-sealed in their bags, it is possible that film surfaces rub against each other during transit. Usually only the films near the top and bottom of the stack, near the outer edges of the sheets, are affected. It is more likely to occur in non-vacuum sealed packages where films can more easily rub against each other.

D-MIN ARTIFACTS

CHUCKING ABRASIONS

WHAT CAUSES THEM?

If tiny particles of grit are trapped between sheets that rub against each other during transit, the abrasion or pressure of the particle can physically fog the silver-halide grains. When the film is processed, a developed silver image of the particle's path is seen.

HOW CAN THEY BE PREVENTED?

- *If an opened film bag needs to be transported, make sure that the bag is tightly wrapped so that sheets do not rub against each other.*
- *Make sure that all film handling areas are free from dust. Remove packaging from film handling areas.*
- *Handle film carefully to reduce the risk of sheets sliding against each other. Do not jog the film stack.*
- *Cut film bag down the center and fold open the bag to reveal an undisturbed stack of film. Carefully lift the entire film stack and load into the plotter – be careful not to allow the stack to slide.*
- *Never load a partial stack of film into the plotter – always load an entire foil package of film at a time to eliminate excessive film handling. Use a large film loading table in the darkroom to accomplish this task.*

WHAT ARE THEY?



These are short (maybe up to a few millimeters) curved black lines in the D-min area of the film.

WHEN CAN THESE OCCUR?

They can happen at any time during film handling prior to processing.

WHAT CAUSES THEM?

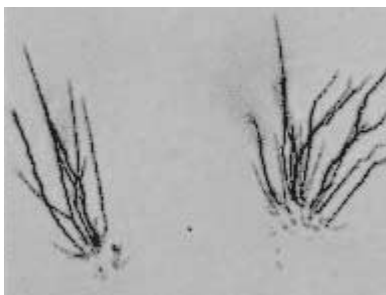
Bending or folding the film around a small radius causes these marks. The intense pressure of these events fractures the silver halide grains, leading to their development as silver grains during film processing.

HOW CAN THEY BE PREVENTED?

Careful film handling, especially of large sheets, will prevent kink marks. Handle film only by the edges, using the fingertips of both hands.

- *Carry film flat in trays or boxes.*
- *To carry a single unprocessed sheet, fold the film loosely in half and hold it in a three-point grip, i.e., between your thumb and middle finger with your index finger in the center to keep the film surfaces separated.*
- *Allow plenty of room to spread out materials in the darkroom.*

WHAT ARE THEY?



Two types occur; one is almost circular with very fuzzy edges, the other consists of short, fuzzy lines. Both are microscopic and will be picked up only by AOI. These marks are extremely rare.

WHEN CAN THESE OCCUR?

They can happen at any time during film handling prior to processing, but most likely during removal of film from packaging or loading of the plotter.

WHAT CAUSES THEM?

An electrostatic discharge acts like light, causing silver halide grains to develop into metallic silver during processing.

HOW CAN THEY BE PREVENTED?

Today's films have anti-static protection that helps to prevent such discharges. Customers should follow the plotter manufacturer's recommendations for operating humidity (usually 50 to 60% RH).

D-MIN ARTIFACTS

SPLASH MARKS

WHAT ARE THEY?



Black circular or drop-shaped marks, possibly visible to the naked eye, in the D-min areas of the film.

WHEN CAN THESE OCCUR?

These can occur anytime prior to processing.

WHAT CAUSES THEM?

Typically they are caused by minute splashes of developer or other sensitizing chemical on the unexposed/unprocessed film.

HOW CAN THEY BE PREVENTED?

Good film handling procedures and adherence to cleanroom practice will prevent these defects. Most manufacturers keep the processor and associated chemicals separate from the plotter and film handling areas, and this practice is recommended.

IV. OTHER PHYSICAL ARTIFACTS

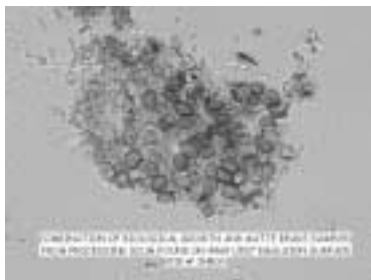
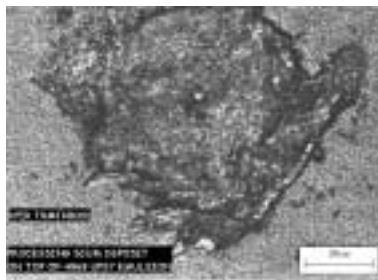


These artifacts may be found anywhere on the film but tend to be more visible in the D-min areas.

There are three main causes considered here:

- *Bioslime*
- *Water spots*
- *Lamination bubbles*

WHAT IS IT?



Bacteria and fungi feed on gelatin in wash water solutions. These microscopic contaminants can accumulate to the point where they appear as dirt and slime. These particles can adhere to film and form an image that results in a rejected circuit board.

WHEN CAN IT OCCUR?

Bioslime forms in wash tanks systems where it will contaminate film.

WHAT CAUSES IT?

Microbes that form bioslime can come from people, water, air, solutions, or equipment. Bioslime – and debris from bioslime – can contaminate film.

In addition, bioslime can form in the processor due to use of recycled wash water.

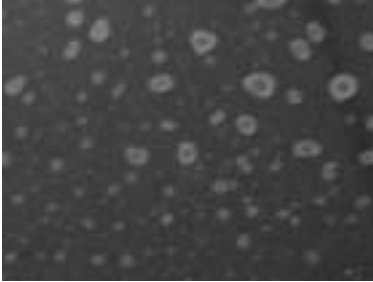
HOW CAN IT BE PREVENTED?

- Add 30 ml of household bleach to wash water tank every day (see page 3).
- Drain processor wash tank when not in use, and remove lid of processor to allow the inside of the processor to dry out.
- With recycled wash water, change out water holding tanks frequently – at least every two days.

WARNING:

DO NOT allow concentrated sodium hypochlorite bleach, e.g., CLOROX bleach or SUNNY SOL detergent, to come in contact with photoprocessing solutions – especially fixer. DO NOT process sensitized products while sodium hypochlorite bleach remains in the system – bleach will remove emulsion layers.

WHAT ARE THEY?



Water spots appear as small, often whitish rings, a millimeter or less in diameter, most visible in the D-max areas, but can also be seen by reflected light in clear areas. They are not usually a serious defect that will cause a problem.

WHEN CAN THESE OCCUR?

These marks occur during processing, in the wash and drying stages.

WHAT CAUSES THEM?

These spots are caused during the wash and dry steps during film processing as not all water is removed from the back side of the film. They are more likely to occur in a hard water area. If the final set of squeegee rollers, just prior to the dryer section, is not working efficiently, water spots are more likely to occur.

- Processing systems set up with wash water recycling are especially prone to water spots.*
- Besides hard water, fixer can carryover into the wash tank and can also cause a spotting problem when used with recycled water system.*

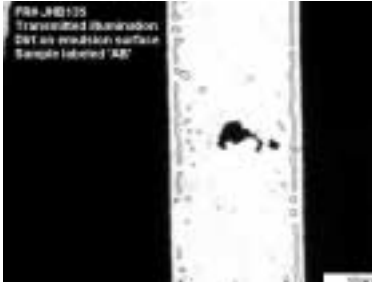
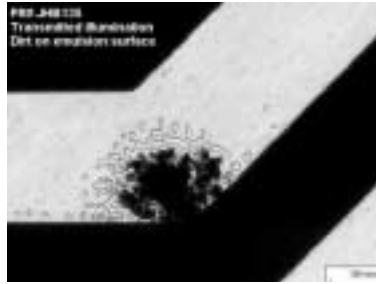
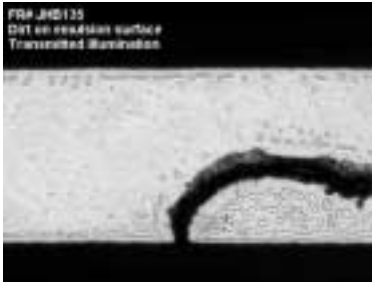
HOW CAN THEY BE PREVENTED?

Use of a water softener may help their prevention. If wash water is being recycled, a small amount of added detergent or KODAK PhotoFlow will also improve water spot-free drying.

Correct alignment or possibly replacement (if they are worn or damaged) of the final pair of squeegee rollers in the wash rack can often prevent their occurrence.

- Change wash water in holding tanks frequently.*

WHAT ARE THEY?



These are tiny (around a millimeter or less in diameter) bubbles of air trapped between the protective laminate and the emulsion surface of the film. Often there is a piece of debris that has caused the bubble.

WHEN CAN THESE OCCUR?

These arise during the application of protective laminate film to the emulsion side of the film.

WHAT CAUSES THEM?

Dust or dirt on the film will increase the likelihood of an air bubble forming.

HOW CAN THEY BE PREVENTED?

Use a tacky roller (e.g., TEKNEK roller) to clean the film before lamination. The usual recommendations mentioned in previous sections on film handling and cleanroom maintenance apply. Make sure that the laminator is operating efficiently.

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