SOME NEW IDEAS ON PINPOINTING THE CAUSE OF HORIZONTAL PRINTING STREAKS

By John MacPhee* and Larry E. Lester**

Abstract: A rational procedure for identifying the source of horizontal printing streaks is presented in the form of a troubleshooting flow diagram. As a prelude to explaining the logic underlying the diagram, various methods for categorizing streaks are identified and the three basic mechanisms by which streaks are generated are described. Although the construction of the flow diagram was stimulated by the authors' firsthand experience in troubleshooting horizontal streaks on sheetfed presses, the final form given in the paper also encompasses like problems on web presses. The flow diagram itself is in the form of a decision tree wherein a question is posed at each node. Progress along the many possible diagram paths is governed by the investigator's answers to the node questions. Each path ends at a node which identifies the most likely location in the press where the particular streak originates. Much of the paper is devoted to explaining the rationale behind the multitude of questions which constitute the troubleshooting flow diagram. In addition to the specific directions provided by the troubleshooting guide, the paper also includes some general advice and suggestions on the subject as well as a discussion of various potential causes of streaks.

INTRODUCTION

Unwanted streaks are a problem that almost all printers have encountered at one time or another. This group of print defects is especially troublesome for three reasons:

(1) Because the human eye is extremely sensitive to abrupt changes in the appearance of an image, it only takes a very small unwanted change in print density to produce a streak. In fact, such changes may be so small that they cannot be measured with a standard densitometer. Thus since print density is in turn a function of both ink film thickness (solid density) and dot area, a minor disturbance in either or both of these print elements can produce a streak. (One of the reviewers pointed out that there are two additional disturbances which have

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produced streaks: small changes in dot spacing and small changes in gloss.)

(2) The task of troubleshooting streaks is complicated and confused by the fact that there are a tremendous number of possible causes.

(3) Although for example GATF has published several excellent books which discuss streak problems (Latham, 1963, Reed, 1968; and Jorgensen and Lavi, 1973) there has been very little information published which explains the basic mechanisms involved in the generation of streaks or which provides hints on how to pinpoint where in the press a given streak originates.

Thus, when streaks appear, much time is often lost in finding and eliminating the cause.

The main purpose of this paper is to outline some techniques which can be employed to develop a more organized or systematic approach to locating where in the press certain types of streak problems originate. The particular kinds of streaks to be discussed appear as horizontal lines or bands, i.e. are parallel to the axis of the plate cylinder. The concepts outlined here began to take form during the authors' work in troubleshooting streaks on sheetfed presses in the early 1980's. Subsequently they were put into the more organized final form which appears here. Although some effort was made to expand the paper to include web presses, the reader should realize that only a very superficial treatment is given here to the exceedingly complex subject of web press dynamics.

The material to be presented consists of three parts: an introductory discussion, troubleshooting guides, and a summary. The introductory discussion of the problem includes general information on two different ways for categorizing streaks, reviews the basic mechanisms which account for the generation of streaks, and lists the many many possible causes. This material also underlines why it is generally not possible to solve a given problem simply by observing and analyzing the defect(s) or streak(s).

The section on troubleshooting is concerned with two broad topics: some general advice and suggestions, and a recommended procedure for the orderly tracking down of the location in the press where a streak originates.

DISCUSSION OF THE PROBLEM

For purposes of this discussion the problem of streaks will be represented as a phenomenon characterized by three elements: (1) a streak generating process or mechanism which responds to (2) an input or cause, to produce (3) an output or streak. This representation is shown diagramatically in Figure 1. Based on this portrayal,

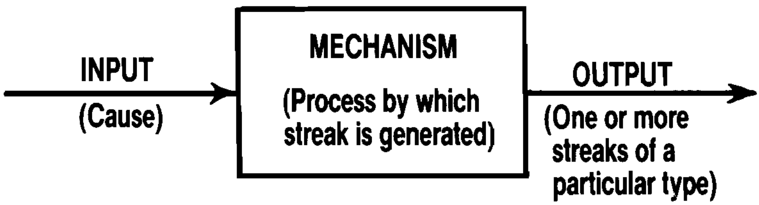

FIGURE 1 Model Used as a Basis in Discussing Streaks

each element of the problem is discussed below starting with the righthand element and proceeding along Figure 1 to the left. In other words, this section of the paper is divided into discussions on how streaks are classified, streak generating mechanisms, and causes. However, to avoid misunderstandings later on, the differences between the first two elements (causes and mechanisms) will be clarified first.

In order to discriminate between causes and mechanisms, consider the analogy of a musical instrument such as a guitar, which has as its end product or output a musical note. Here the process or mechanism is a taut string which is caused to vibrate, by being plucked or struck. Put another way, it can be said that the musical note (output) is produced by the vibrating string (the mechanism) as a result of an impulse of force (the cause) applied to the string. If the analogy were expanded, it also could be said that there are only three basic mechanisms or processes for producing musical notes: vibrating strings (stringed instruments) vibrating membranes (percussion instruments) and vibrating air columns (wind instruments). In contrast there are a myriad of ways (causes) in which musical notes can be initiated (as for example by striking with a hand, pick, bow, piano hammer, stick, or padded club). As will be seen, there are also only three basic processes for producing streaks while there are many many events which can initiate them or cause them to occur.

A. Classification of Streaks

Print streaks are unwanted products and thus constitute a problem. As in the case of many problems, a better understanding often can be obtained by defining the various ways in which the problem manifests itself - in this case by listing the various types or classifications of streaks. Broadly speaking, there are two ways to classify streaks: by geometry or by the nature of the print defect, and these are listed in Table I.

TABLE I TWO METHODS FOR CLASSIFYING STREAKS

Methods of Classification	Types of Streaks Within Classification
By Shape or Geometry	1. Stripe (a) Single Stripe - a band having a density different from that of the region in which it is located. (b) Periodic Stripe - equally spaced bands each of which is similar to a single stripe streak. 2. Runout - a line which constitutes a boundary between regions of different densities. (a) Image/Non-image (b) Gap/Non-image
By Nature of Print Defect	1. Ink Film - an unwanted variation in ink film thickness. 2. Dot Structure - an unwanted variation in dot shape or size. 3. Composite - both of the above.

1. By Shape In the first method, which is used in this paper, the streak is classified by its geometry as either a stripe (a band) or a runout (a boundary). Figure 2, which illustrates these two categories, indicates that there is a clear and distinctive difference in appearance between a stripe and a runout. In practice, unfortunately, the distinction is not always so clear, because two or more closely spaced runouts can occur and when they do, they may be indistinguishable from a stripe. As indicated in Table I, stripe type streaks can appear as a single

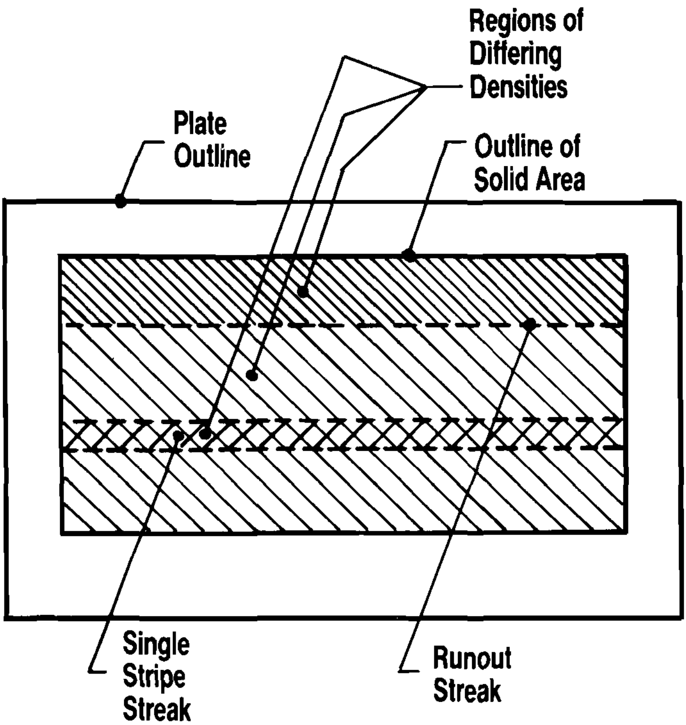

FIGURE 2 Diagram Illustrating Difference Between Appearance of Stripe and Runout Type Streaks

disturbance or as a series of periodic disturbances, in which latter case they are generally (and usually incorrectly) referred to as gear streaks. This is unfortunate in that it suggests that all periodic stripe type streaks are caused by defective gears, which is definitely <u>not the case</u>.

Table I also breaks down runout streaks into two types: image/non-image and gap/non-image. Insofar as appearance is concerned, there is no point to listing these two subcategories because such streaks look alike. However, this distinction is worth making because it stems from how the streaks are generated, which is something that will be discussed in more detail in the section on streak mechanisms.

2. By Nature of Defect The second method of classifying streaks is by the nature of the defect, i.e. as either an ink film thickness variation, a variation in dot structure, or both. At first, this might seem to be less ambiguous because a defect produced by an unwanted variation in ink film thickness is markedly different from a defect produced by an unwanted change in dot size or shape. However, streaks are not always clearly discernible and for this reason the reader is cautioned not to draw any hard conclusions solely from the character of the streak in this regard.

B. Streak Generating Mechanisms

A listing of the basic ways in which streaks can be produced is the second avenue of understanding which will be reviewed. The reason for doing this is that it will help in explaining the various causes of streaks and it will also be of help in devising solutions to streak problems.

No matter how they are initiated or caused, streaks are almost always generated within a few nips of the plate cylinder. In fact a streak which has the same position from one impression to the next always will be found to originate at a point touched by one or more of the following press elements: a form roller, the plate cylinder, the blanket cylinder, or the paper itself. Broadly speaking, there are only three mechanisms or processes for generating streaks as follows:

(a) Relative Mechanical Movement
(b) Non-uniform Ink Transfer to the Plate
(c) Non-uniform Water Transfer to the Plate

A few examples will be cited to illustrate each of these.

1. Relative Mechanical Movement. Consider first a single stripe type of streak generated by a form roller when it encounters the on-ramp of the plate cylinder. This is illustrated in Figure 3 (a), which shows that, depending on stripe settings and roller condition, the form roller may momentarily change speed the moment it contacts this ramp. This produces a disturbance A at the nip formed by the form roller and vibrator. This disturbance is subsequently transferred to the plate at A', and in turn will appear as a stripe type of streak on the print.

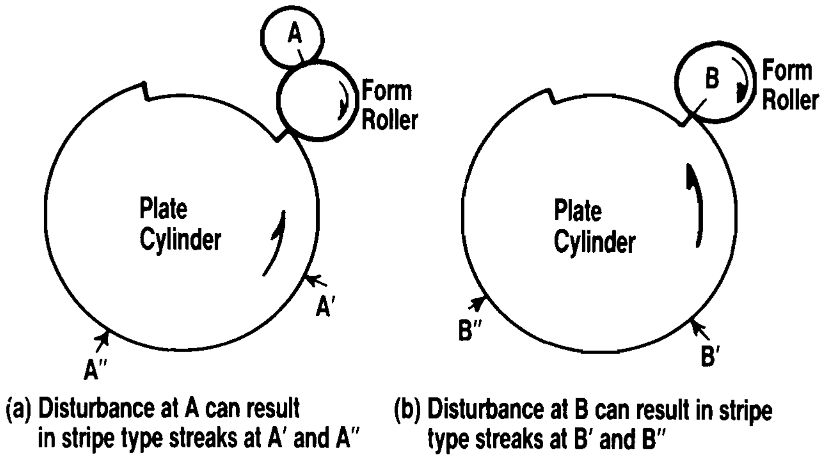

FIGURE 3 Diagrams Showing How Relative Movement of Form Roller, Caused by Contact with Lead Edge of Plate, Can Produce Streaks

Worse yet, the streak may repeat at A", which is distant from A' by one form roller circumference. The primary mechanism is said to be relative mechanical movement because this is how the streak originates. It is to be noted that the particular streak referred to in Figure 3 (a) would also be classified as an "ink film" type of streak because dot structure would be unaffected. On the other hand, streaks generated by relative mechanical movement of the paper or blanket cylinder would be expected to affect both ink film thickness and dot structure - although both defects might not be apparent to the eye.

It's also possible for the type of streak just discussed to be generated at a form-roller-plate-cylinder nip, at the time the form roller contacts the on-ramp of the plate. This is shown in Figure 3(b), which illustrates that in this case the streak would appear at a distance from the leading edge of the plate equal to the form roller circumference.

In the case of web presses, "relative mechanical movement" encompasses the phenomenon of doubling, which is a common source of streaks on this type of press. This problem is a very complex one in that it can involve both the dynamics of individual printing units and the dynamics of the entire press. It is a subject that is not treated here in any detail.

2. Non-uniform Ink Transfer to the Plate. Generally, streaks produced by this mechanism appear as runouts - an abrupt unwanted change in print density - and are a form of starvation or mechanical ghosting in that the non-uniform ink transfer is generated by a ghost or memory of an image on a form roller. This memory or image retention property of form rollers is inherent in long inking trains and is a limitation of them which can never be completely eliminated. In fact, it is this limitation which explains why several ink form rollers are used - the principle being that ghosts transferred to the plate by the first ink form roller will be filled in by the form rollers which follow. Figure 4 illustrates this basic ghosting phenomenon wherein a form roller is shown to be retaining a memory of image area "A". In actual practice, the form

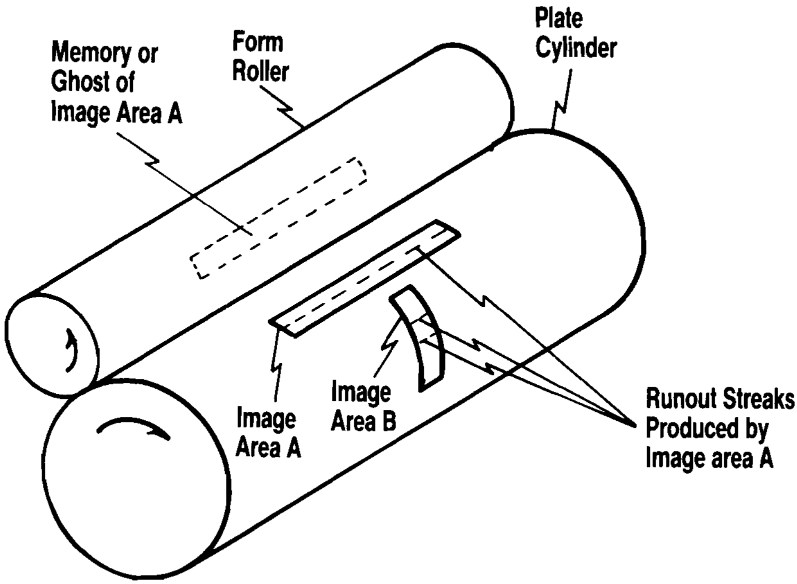

FIGURE 4 Simplified Diagram Showing How a Form Roller and the Plate Cylinder Interact to Produce Runout Streaks. Small image areas have been shown for clarity. In actual practice they probably would not produce runout streaks.

roller will bear many ghosts of this image and these ghosts will produce uneven transfers of ink to the plate. Thus, as shown in Figure 4, the horizontal boundaries of ghost images of area "A" on the form roller may result in runout streaks in both image area "A" which generated the ghost and other image areas, such as "B", on the plate and print.

Before proceeding, there are a number of points about Figure 4 which must be emphasized. First in constructing this illustration very small image areas were used for the sake of clarity. In actual practice it is highly unlikely that such small image areas would produce runout streaks, especially on themselves. Thus, this (correctly) infers that the larger the image area, the more likely is it that runout streaks will occur.

Another extremely important point is the fact that there are two types of mechanisms for generating a memory on a form roller which in turn can produce a runout as follows:

(i) Image/Non Image: a horizontal boundary between an image and non-image area, as shown in Figure 4.

(ii) Gap/Non-image: both the leading and trailing edges of the plate.

These subcategories were referred to in Table I and will now be explained in more detail.

The first mechanism is familiar to most printers. However, because the second mechanism may come as a surprise to some*, it will be given more attention here. Consider the arrangement of a plate, which has a large solid image area, as it is wrapped around the plate cylinder. This is shown in Figure 5.

Four boundaries are identified, two (b-b and c-c) between image and non-image areas and two (a-a and d-d) between non-image areas (which carry water) and the gap of the plate cylinder (which carries neither ink nor water). As a consequence of these latter boundaries, there will be corresponding regions remembered by the ink form rollers, i.e. boundaries on the form rollers demarking regions with more water (corresponding to the image region on the

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* One of the authors (MacPhee) was initially incredulous when this mechanism was first disclosed to him by Leonard Kosiba of Advanced Litho in San Francisco.

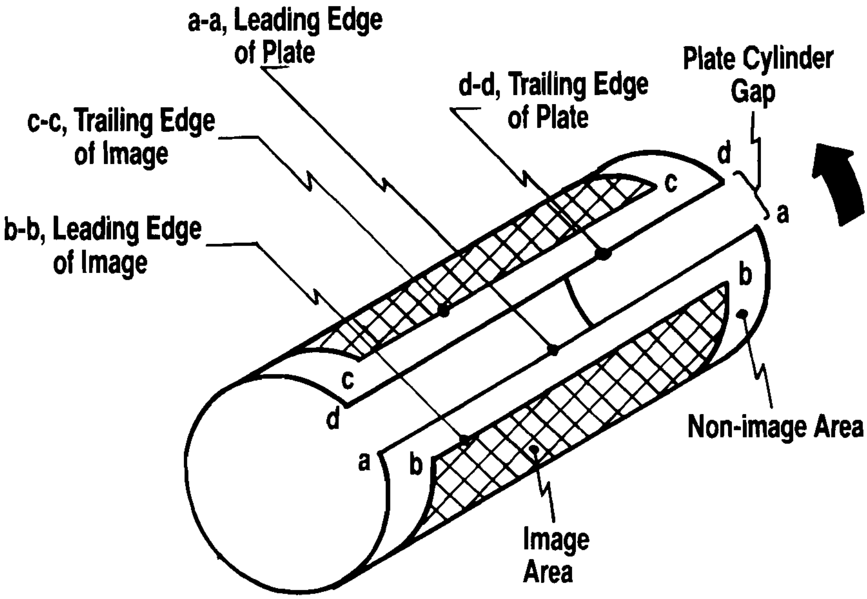

FIGURE 5 Orientation of a Plate with a Large Image Area, When Mounted on The Press. Runout streaks can be produced by the memory of transition a-a, b-b, c-c, or d-d, on a form roller.

plate) and regions with less water (corresponding to the plate cylinder gap). Because water interferes with ink transfer, these latter boundaries, remembered by the ink form rollers, can also produce runout type streaks on a print. This is illustrated in Figure 6, which shows a plate with a very large solid image area. In order to provide contrast, the leading and trailing edges of the solid area in Figure 6 have been skewed. Based on the first type of mechanism explained in Figure 4, runout streaks b-b and c-c may occur. These are skewed since they stem from the respective memories of the leading and trailing edges of the solid. Contrasting these is runout streak a-a, which can be produced by either the memory of the leading or trailing edge of the plate. Notice that if the edges of the solid had not been skewed, all three runouts in Figure 6 would appear similar (another source of confusion in troubleshooting streaks).Thus, skewing the

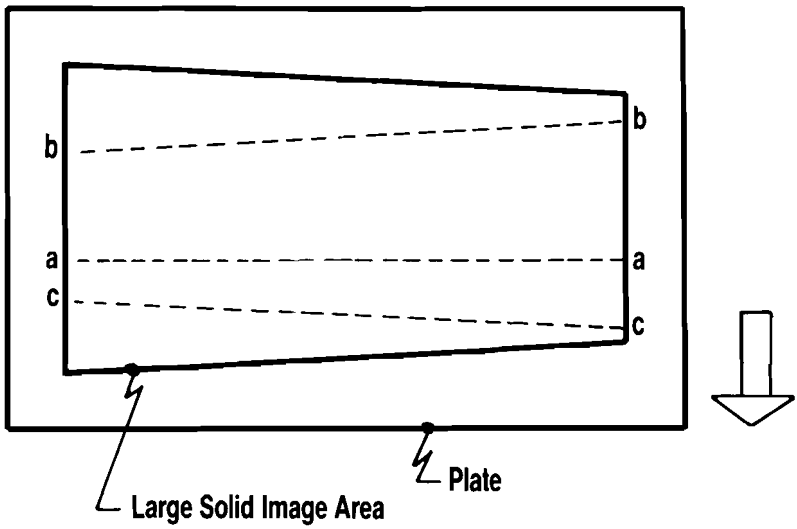

FIGURE 6 Diagram of Plate Showing Two Types of Runout Streaks. Leading and trailing edges of plate have been purposely skewed for clarity. Runout a–a can be produced by form roller memory of either leading or trailing edges of plate. Runout b–b is from memory of leading edge of solid and runout c–c from trailing edge of solid.

edges of a solid on a test plate is one way to aid the task of troubleshooting streaks. More will be said about this in the section on troubleshooting guides.

3. Non-uniform Water Transfer to the Plate. The third mechanism which accounts for the generation of streaks is non-uniform transfer of water to the plate. The reason why this is a streak generating mechanism is because ink transfer is impaired in the presence of water. Thus, a non-uniform water film on the plate can in turn cause a non-uniform ink transfer. An example of this is sometimes experienced on presses equipped with conventional dampening systems. If the dampening form roller is set too tight to the plate, a bead of water may collect along either the leading or trailing edge of the plate. This

bead in turn can be partially transferred to an ink form roller creating a ghost which will appear as a stripe type streak.

C. A Litany of Causes

It has already been mentioned that there is a myriad of faults or malfunctions which can cause streaks to be generated by one of the three basic mechanisms just discussed. In general these causes can be grouped together as either operator, process, mechanical, or design problems. Twenty four different causes which the authors know of have been listed accordingly in Table II and are also briefly discussed in the following paragraphs. It must be remembered that this list probably is just a sampling of causes and that the cause of the next streak problem to be encountered by the reader may well not be given here.

TABLE II Some Potential Causes of Streaks

GROUPING	CAUSE	MOST PROBABLE TYPE OF APPEARANCE
1. Operator Based	(a) Roller stripes not set properly	Runout or Stripe
	(b) Ink feedrate too low	Runout
	(c) Water feedrate too high	Runout
	(d) Alcohol concentration in fountain solution too low	Runout
	(e) Loose Blanket	Single Stripe
	(f) Cylinders packed improperly	Periodic Stripe
	(g) Back cylinder pressure too high	Single Stripe
	(h) Incorrect bearer pressure	Single or Periodic Stripe
2. Process Based	(a) Ink Emulsification	Runout
	(b) Ink Roller Stripping or Blinding	Runout
	(c) Glazed rollers	Single Stripe
3. Mechanical Based	(a) Form Roller Bounce	Single Stripe
	(b) End Play in Dampening Form Roller	Single Stripe
	(c) Assynchronous or Uneven Paper Transfer	Single Stripe
	(d) Shock Load on Drive System	Single Stripe
	(e) Worn Roller or Cylinder Bearings	Single or Periodic Stripe
	(f) Worn or Dirty Cylinder Gears	Periodic Stripe
	(g) Worn Bearers	Single Stripe
	(h) Excessive Wear in Drive Train Components	Single or Periodic Stripe
	(i) Cylinder Vibrations	Periodic Stripe
	(j) Drive Train Vibrations	Periodic Stripe
4. Design Based	(a) Inking System Layout/Roller Complement	Runout
	(b) Ink Transparency	Runout
	(c) Layout of Form	Runout

1. <u>Operator Based Causes</u> The friendliest type of streaks are those caused by operator error - because they are relatively easy to correct.

(a) Roller Stripes Not Properly Set. If ink roller stripe settings are too light ink may not transfer properly to the plate, leading to runout streaks. Alternately, a form roller on a sheetfed press which is set too lightly to a vibrator may slow down while in the plate cylinder gap, producing a stripe type streak, as illustrated in Figure 3(a). Conversely, too heavy a stripe to the plate can also produce a stripe type streak, as shown in Figure 3(b).

(b) Ink Feedrate Too Low. Traditional lithographic inking systems do not apply a perfectly uniformly thick film of ink to the plate because of the memory or mechanical ghost effect discussed above and illustrated in Figure 4. If the ink feedrate and thus print density is too low, this ghosting effect will be aggravated, possibly leading to runout streaks.

(c) Water Feedrate Too High. This can have the same effect as too low an ink feedrate, as discussed immediately above.

(d) Alcohol Concentration in Fountain Solution Too Low. In presses equipped with continuous contact type dampening systems (MacPhee, 1981) runout streaks will be aggravated if the alcohol concentration in the fountain solution is too low. This is attributed to an incorrect water content in the inking train and it has been reported elsewhere as well (Jorgensen and Lavi, 1973).*

(e) Loose Blanket. It was recognized many years ago (Kuehn and Sites, 1953) that blankets tend to be stretched by passage through a nip in which they are deformed. It is for this reason that blankets must be tensioned or tightened after they have been installed. That is, if a blanket is too loose, it can slide back and forth on the cylinder surface and this relative motion can produce one or more stripe type streaks. One possible scenario for this is illustrated in Figure 7.

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* The problem actually discussed in this reference is mechanical ghosting, but runout streaks are a form of such ghosting.

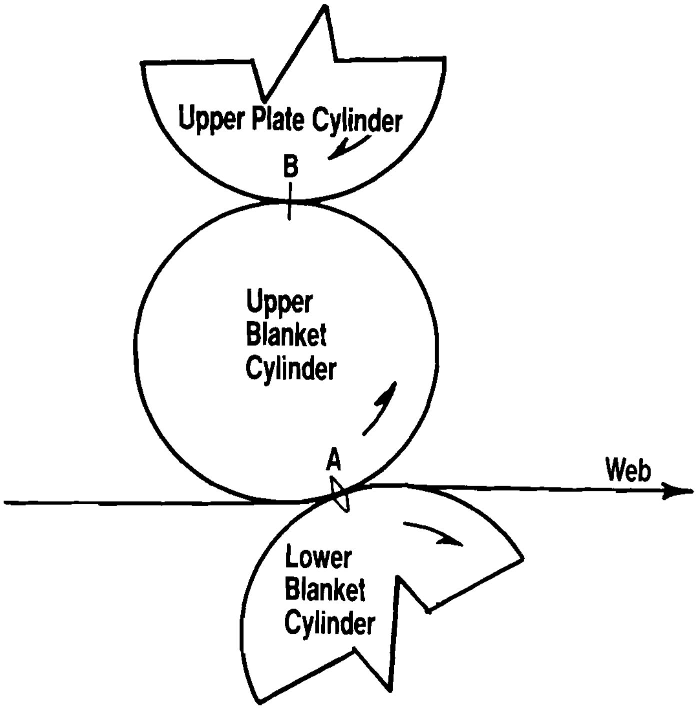

FIGURE 7 One Possible Scenario for Explaining How a Streak Can Be Caused by a Loose Blanket. As blanket on upper cylinder of web press passes through nip at A, blanket is stretched due to rolling action. When trailing edge of blanket reaches A, blanket tension is momentarily released. Resultant movement or slippage of loose blanket produces streak at B.

(f) Cylinders Overpacked. If the plate and/or blanket cylinders are overpacked, periodic stripe type streaks can be generated. When such streaks have regular spacings which coincide with the pitch of the cylinder gears they are referred to as "gear streaks" by most people. Such a general labeling is considered erroneous by the authors because it incorrectly implies that the problem is always caused by bad gears. An example will now be cited to show why this is not the case.

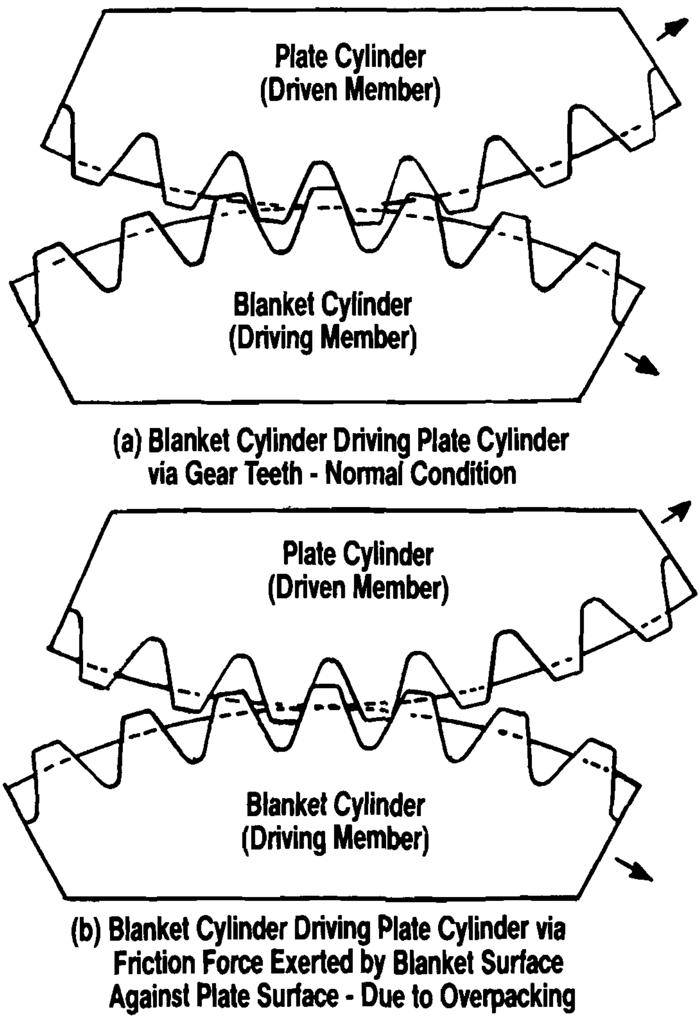

FIGURE 8 **Enlarged Views of Blanket-Plate-Cylinder Nip With Drive Gears Superimposed. Views show two different backlash takeup conditions.**

Consider first the enlarged view of the plate-blanket-cylinder nip, shown in Figure 8 (a) with the tooth pattern of the drive gears superimposed. In practice the surfaces of the plate and blanket never travel at the same speed, even if the gears are perfectly made and mated so that both cylinders travel at the same rotational speed. Thus, there is continuous slippage between the plate and blanket surfaces in the nip. For the common packing practice shown in Figure 8 (a) the friction force between blanket and plate is such that the blanket would try to drive the plate faster. With normal packing, this friction force is modest, and as a result the two surfaces slip continuously and the teeth on the blanket cylinder drive gear continually press against those on the plate gear so as to drive it as shown in Figure 8 (a). However if the blanket cylinder is overpacked, the friction drive force may increase to a value large enough for the blanket cylinder to overdrive the plate cylinder. If this is indeed the case, the plate will speed up until the gear backlash is taken up in the opposite direction, as shown in Figure 8 (b). At this point, the gears will take over and slippage will then occur between plate and blanket. Since the coefficient of friction (when slipping) will now be lower*, the gears can overcome the friction force and again drive the plate cylinder so as to reverse the backlash and take up the positions shown in Figure 8 (a). If this happens, again momentarily, there will be no slippage. Consequently, the friction force will increase, the blanket will overdrive the plate and the process will repeat itself. Thus the plate cylinder will chatter back and forth producing multiple stripe type streaks.

While the above explains how such "gear streaks" are generated, one additional fact must be invoked to explain why these streaks have the same periodicity as the gear teeth. This additional fact is that gears are never perfect and thus transmit motion imperfectly, i.e. a small periodic variation is induced in the speed of the driven gear as shown in Figure 9. For obvious reasons the period of this speed variation corresponds to the period of the gear teeth. Although it cannot be proven, it is the authors' contention that the speed variations of the driven gear, shown in Figure 9, act to synchronize this stick-slip phenomenon. Specifically it is believed that the gears shown in Figure 8 will shift from position (a) to position (b) as the driven gear is speeding up, and from (b) to (a) as the driven gear is slowing down.

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* This argument is based on the principle that in a given system the dynamic or sliding coefficient of friction is much lower than the static or at-rest coefficient of friction.

Because these speed variations of the driven gear are in time with the gear teeth, so will be the resultant stripe type streaks.

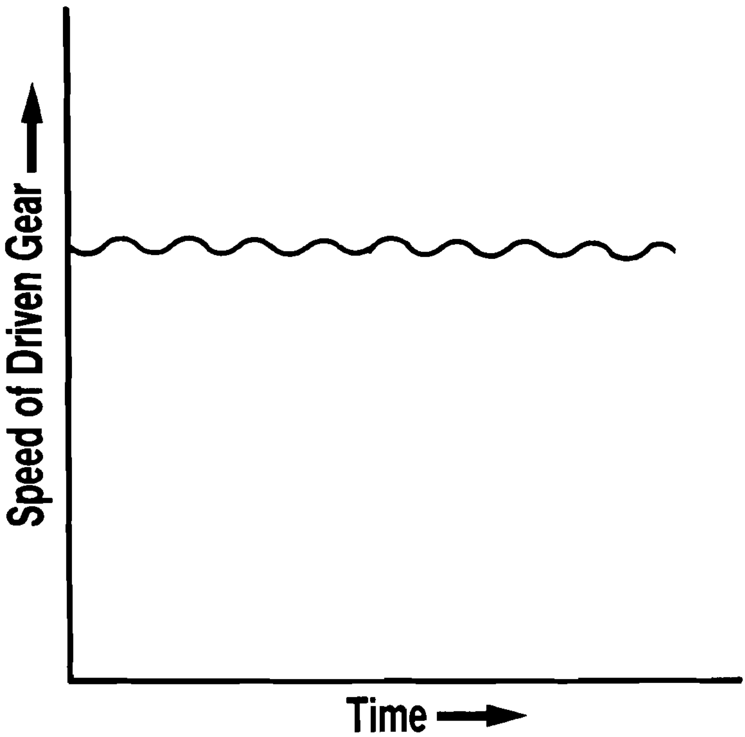
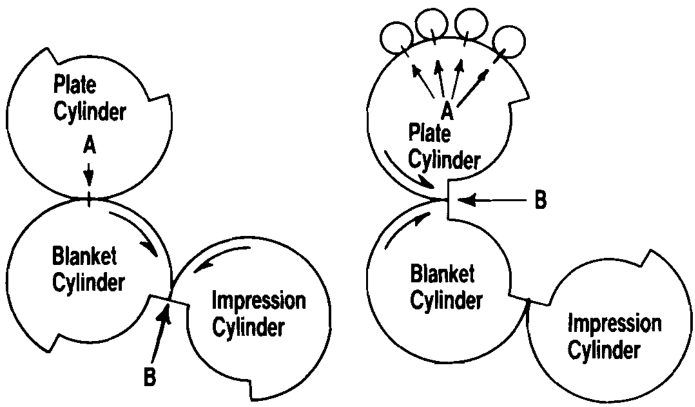


FIGURE 9 Greatly Exaggerated Plot of Speed of a Driven Gear vs. Time. Imperfections in geometry of real gears produce speed variations in driven gear each time the drive load is transferred from one pair of gear teeth to the next.

On sheetfed presses, incorrect blanket packing can also cause streaks to be generated during paper transfer. That is if the blanket is packed too high, the paper will travel faster and try to overrun the impression cylinder. The resultant slack in the paper can lead to a streak.

(g) Back Cylinder Pressure Too High. Maladjustment of the impression or back cylinder on sheetfed presses can also lead to the generation of streaks. If the pressure against the blanket cylinder is too high, a single stripe type streak can result. Such streaks are of the type often referred to as bump streaks in that they are generated by the jar or bump which occurs when the leading edge of one cylinder (in this case the impression cylinder) comes into contact with another (in this case the blanket cylinder). Similarly a bump streak can be generated when the cylinders disengage at the trailing edge. More is said about this in the next paragraph.

(h) Incorrect Bearer Pressure. Bearers, the hardened steel rings on the ends of plate and blanket cylinders*, are used to accurately hold these cylinders in position with respect to each other. This is accomplished by applying a preload to the cylinder bearings so as to develop a substantial contact force between mating bearers (Tyma, Koebler, Stoeckl, and Engel, 1982). However if the bearer preload or pressure is too low, the tendency of a press to streak will be aggravated. For example the so-called "gear streaks" which can result from improper



(a) Halfway Streak. When Bearings are Worn and Bearers Not Set Up, a Streak Will Appear at Point A from a Bump at Point B

(b) Roller Streaks. With Worn Bearings and Improperly Set Bearers, Streaks May Appear at Point A from a Bump at Point B

FIGURE 10 Diagrams Showing How Two Different Types of Bump Streak Can Be Generated in a Sheetfed Press (Latham, 1963).

* In Germany, bearers are referred to as Schmitz rings.

packing (discussed in paragraph (f) above) are much more likely to occur in this event. The same is true of the particular bump streak discussed in the previous paragraph. In fact, as shown in Figure 10, improperly set bearers can lead to more than one type of bump streak. Conversely, excessive bearer pressure can bend the cylinder journals and cause the gears to run beyond their pitch lines. In such a case true gear streaks will occur because of the incorrect gear mesh.

2. Process Based Causes Process based causes refers to streak phenomena which can be traced to certain types of problems in process chemistry. In general, such problems reduce ink adhesion leading to either impaired transfer or roller slippage.

(a) Ink Emulsification. If an ink takes up an excessive amount of water on press, its properties will be adversely affected. Such ink is said to be water logged and it becomes very short and buttery (Hartsuch, 1983). As a result it transfers poorly and tends to pile. This reduces the efficiency of the inking system and therefore may cause runout type streaks to appear.

(b) Ink Roller Stripping. Stripping or blinding of inking rollers is said to occur if the roller surface becomes densensitized or non-ink-receptive. Usually such an occurance can be traced to a fault with the fountain solution. Insofar as streaks are concerned the result is the same as the ink emulsification - loss of inking system efficiency and the likelihood of runout streaks.

(c) Glazed Rollers. The buildup of glaze on the surface of inking rollers can completely mask the velvety finish of the rubber causing a reduction in traction. Consequently the roller will have a much greater tendency to slip, making it more probable that stripe type streaks will be generated in the sequences shown in Figure 3 (a) and 3 (b).

3. Mechanically Based Causes These make up the largest group of streak causes and, in addition, include those causes which are the most difficult to identify and the most costly to correct.

(a) Form Roller Bounce. If form rollers are not securely positioned about their axes they can jump or bounce about, producing relative motion and hence stripe type streaks. Such looseness can stem from either poor design or worn components. Figure 3 illustrates two different ways in which roller bound can act to produce streaks.

(b) End Play in Dampening Form Roller. Lateral or end play in a dampening form roller can produce a stripe type streak if the form roller runs in contact with an oscillating roller - as in the case of a conventional or ductor type dampening system. This is because the form will alternately move laterally across the plate and abruptly stop. The abrupt stops result in a sudden change in relative movement with respect to the plate, which is what generates the streak.

(c) Asynchronous or Uneven Paper Transfer. If the transfer of paper to and from the blanket is not in synchronism, streaks will result because of the relative motion between paper and blanket. On sheetfed presses this problem is more likely to be manifested as one or more stripe type streaks. On web presses this is a rudimentary form of what is called doubling which can produce one or more stripe type streaks of slurred or doubled halftone dots.

(d) Shock Load on Drive Train. A shock load on the drive train can cause a momentary speed change which in turn can produce a streak. For example on some presses maladjustment of the ink ductor motion can produce just such a shock. Also, it has been reported (Quadracci, 1985) that ductor shock was a major problem that had to be overcome in achieving very high speeds on web offset presses. One press manufacturer, Baker Perkins, avoids this problem by using a continuous undulating roller in place of the reciprocating ductor roller.

(e) Worn Roller or Cylinder Bearings. Depending on their location in the press, worn bearings can produce a variety of streak problems. In the case of rollers and cylinders, the looseness or play, rather than roughness, which occurs as a result of bearing wear is what usually creates a problem. Such problems include roller or cylinder bounce and improperly meshed gears. Loss of bearing preload can also produce the same ill effects.

(f) Worn or Dirty Cylinder Gears. It has already been pointed out above that motion is not transferred perfectly to a driven gear even if very high quality gears are used. Thus, small relative periodic movements between cylinders do result, as shown in Figure 9, but they are not large enough to show up as streaks. However if the tips of cylinder gear teeth wear excessively or if the roots become impacted with debris so that the teeth bottom, periodic stripe type streaks (gear streaks) may result due to the increased relative motion imparted to the driven gear and cylinder. (The problem of debris impacted gears in mainly limited to small duplicator type presses with exposed gears.)

(g) Worn Bearers. Because the purpose of bearers is to hold the printing cylinders in very accurate position with respect to each other, bearer wear will result in relative motion and thus can result in one or more stripe type streaks.

(h) Excessive Wear in Drive Train Components. This heading covers a multitude of problems including worn bearings, couplings, gears, drive belts, and cams. Streaks produced by such problems can be especially hard to troubleshoot, because more likely than not the streaks will not be synchronized with the printing cylinders. That is, the streaks will not be in the same location from one impression to the next.

(i) Cylinder Vibrations. One factor which may constitute an upper limit on the speed of a given web press design is streaking due to transverse or bending vibrations of either (or both) the plate or blanket cylinders (Skipor and Bain, 1979). The presence of cylinder gaps or lockups causes a periodic disruption in the load between cylinders and these disruptions (or more correctly harmonics of these disruptions) can drive a cylinder into vibration when their frequencies coincide. As press speed increases, so does frequency of these disruptions. Although the fundamental frequency of the disruptions is always well below the natural frequency of the cylinder(s), the higher harmonics of the disruptions will at certain press speed match them. Thus at some higher press speed the cylinder(s) will be driven hard enough at its natural frequency to cause print disturbances or streaks. When such streaks occur there is very little that the printer can do to eliminate the problem except to check that bearer pressure is correctly set. Also, changing blankets or blanket packing may result in some minor improvement. In other words, cylinder streaks are more in the nature of an equipment limit, rather than a malfunction.

(j) Drive Train Vibrations. Streaks due to vibrations or oscillations of one drive component or printing unit, with respect to another, are possible. Like cylinder vibrations, they are more of an equipment limit than a malfunction.

4. Design Based Causes This category refers to causative factors which arise from inadequacies or deficiencies in inking and which therefore lead to runout type streaks. Even when in perfect working condition, traditional inking system designs do not apply uniform ink film thicknesses to the plate, because of the memory effect discussed above in connection with Figures 4, 5, and 6. The extent to which these unequal ink films show up as runout streaks depends upon the three factors discussed in the following paragraphs.

(a) Inking System Layout and/or Roller Complement. The effect of inker design on runout streaks or mechanical ghosting has been investigated for different roller arrangements and for different numbers of form rollers (Hull, 1968 and Guerrette, 1985). Usually a press with three form rollers will perform better in this respect than one with two, and a press with four form rollers will do better than one with three. However, roller arrangement is also very important so it is not possible to make any simple generalized statements other than to say that inker design is an important and limiting factor in this regard. Put another way, any inker design can be made to streak by varying the remaining two factors to be discussed.

(b) Ink Transparency. An ink is said to be highly transparent if it has a high reflectance when printed over a white background, compared to its reflectance when printed over a black background (Bisset et al, 1979). Thus, very transparent inks are more difficult to print without runout streaks, since ink film thickness variations are more evident. One remedy is to use more white pigment to make an ink more opaque - but this is not possible when printing four color process work because process printing requires very transparent inks. One reviewer commented that the problem of printing transparent inks has been aggravated in recent years by the trend of raw water to be more acid (perhaps due to acid rain). With raw water that is more acid, printers tend to use less concentrate in their fountain solution, which increases the tendency to streak.

(c) Layout of Form. The form to be printed also has an important influence on runouts, with large solid areas being especially troublesome.

TROUBLESHOOTING GUIDES

This section sets forth some general recommendations for troubleshooting streaks, along with a suggested flow diagram or check list. This latter diagram provides an orderly and organized method for identifying the most likely location in the press where the streak is generated.

A. General Recommendations

In the course of troubleshooting streaks the authors have discovered a number of tricks or techniques which have proved helpful. These are described here along with some general advice or recommended rules.

1. Establish a print standard. Because some presses and inks perform better than others it is very useful to obtain a reference or standard print when it is known that the press is in good operating condition. Thus, if at some later date a streak problem arises, a check can be made by a trial printing of the standard form. Process blue is the recommended ink because it is fairly standard and shows up streaks more than the other process colors. A large solid, with two relatively narrow screened vertical strips should be run. The purpose of the screened areas is to aid in troubleshooting streaks caused by changes in dot size or structure. A 5-10%, conventional screen is recommended for one strip because dot slurring can be readily detected using a small magnifier or loupe. For the other, two side-by-side strips are suggested consisting of a 50% lined screen - with the lines parallel to the plate cylinder axis in one area, and perpendicular in the other. The use of lined screens makes it easy to detect with the naked eye a streak caused by dot growth or slur. In order to discriminate between the different type runout streaks illustrated in Figure 6 the special test form shown in Figure 11 is recommended. The leading and trailing edges

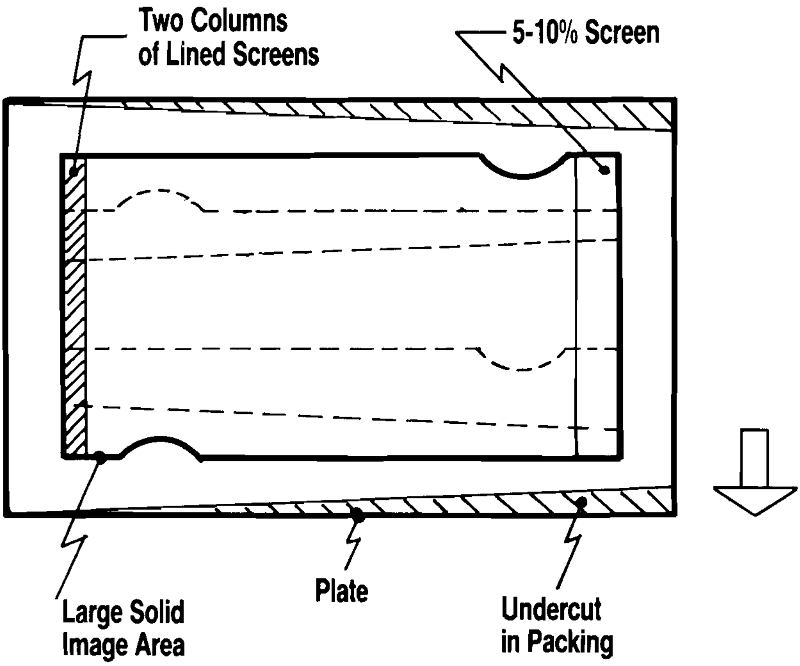


FIGURE 11 Recommended Test Form for Troubleshooting Streaks. Dashed lines show how runout streaks might appear. Indentations in solid image and skew in packing make it easy to distinguish two types of runouts described in Figure 5 and 6.

of the solid are indented while the plate packing is skewed. Thus runouts produced by these discontinuities can be identified immediately. Also, for reasons discussed below it can be very helpful to have reference prints which were run with various form rollers lifted.

2. Another standard that is very worthwhile is to obtain a measure of ink film thickness on the vibrators just above the ink form rollers - during the satisfactory printing of a job. If a streak problem arises, ink film thickness on the rollers can be checked against this standard to determine if there is a problem with the ink, ink-water balance, or roller settings. (In general ink film thickness on the vibrating rollers just above the ink form roller should be between 0.2 and 0.4 mils.)

3. Learn about the mechanical design of your presses because a detailed knowledge of the press drive and the various reciprocating motion mechanisms is often very useful. For example key items of information are the ductor and vibrating roller frequencies and whether these frequencies are some integral number of plate cylinder revolutions (on many presses they are not), and the diameters of rollers and printing cylinders.

4. If a streak problem arises, the first thing to do is to check the press setup and adjustments. The operator based causes listed in Table II constitute a checklist for this. Ink film thicknesses, as described in 2 should also be checked.

5. If a standard has not been run previous to the occurrence of a problem try the same ink, paper, and form on another press of the same model. This will establish whether the problem is with the press or the materials.

6. If difficulty is encountered in viewing a streak during the troubleshooting process, it may be possible to accentuate the streak by lifting one or more form rollers when printing test sheets. Alternately, a weaker or more transparent ink can be run to make viewing easier.

7. The appearance of streaks can be very deceiving. Therefore one should not draw conclusions regarding the cause, based solely on observations of the streak.

8. Running at significantly different press speeds may also help to locate a streak problem. That is, the occurrence of a streak(s) only at certain press speeds generally indicates some type of mechanical vibration.

9. The best strategy to follow in attempting to track down a streak is to endeavor to identify where in the press the streak originates. Once the location has been pinpointed, it is much easier to determine the exact cause.

B. Flow Diagram

Because streak problems can be complex and confusing, much time can be lost if an organized approach is not followed in troubleshooting. One possible approach developed by the authors is illustrated by the diagram shown in Figure 12. This diagram portrays a procedure for orderly tracking down the most likely location in the press where the streak problem originates. Once the location has been determined, the investigator must then find the actual cause. (Hopefully the material already presented will aid the reader in this latter task.)

The diagram in Figure 12 is traced from right to left starting at the single box on the far right. Each box or block in the diagram represents a question, the answer to which determines progress through the chart. Progress along any given path proceeds until either a NO answer is obtained or a specific press area, indicated by a circle, is reached. In particular, the following procedure should be used:

(a) Assuming that a streak or streaks are present, the answer to the first question, "Streaks present?" is yes, and the analysis proceeds to the left - to boxes #1 and #2.

(b) Proceed to box #1 and determine the answer to the question "Is there some pattern to streak timing?" If the answer is no, it will not be necessary to proceed any further left along this particular path.

(c) Proceed in the above manner until the path of analysis leads to one of the nine regions of the press, given in the circled areas at the far left of the diagram.

In order to facilitate use of the troubleshooting flow diagram shown in Figure 12, a discussion of the procedures called for in each block has been included in the paragraphs below. For quick reference, the numbering of these paragraphs coincides with the numbers which appear in Figure 12. This numbering system also designates the recommended sequence to be followed in travelling through the diagram. Before proceeding to these discussions, the reader should become aware of two features of Figure 12.

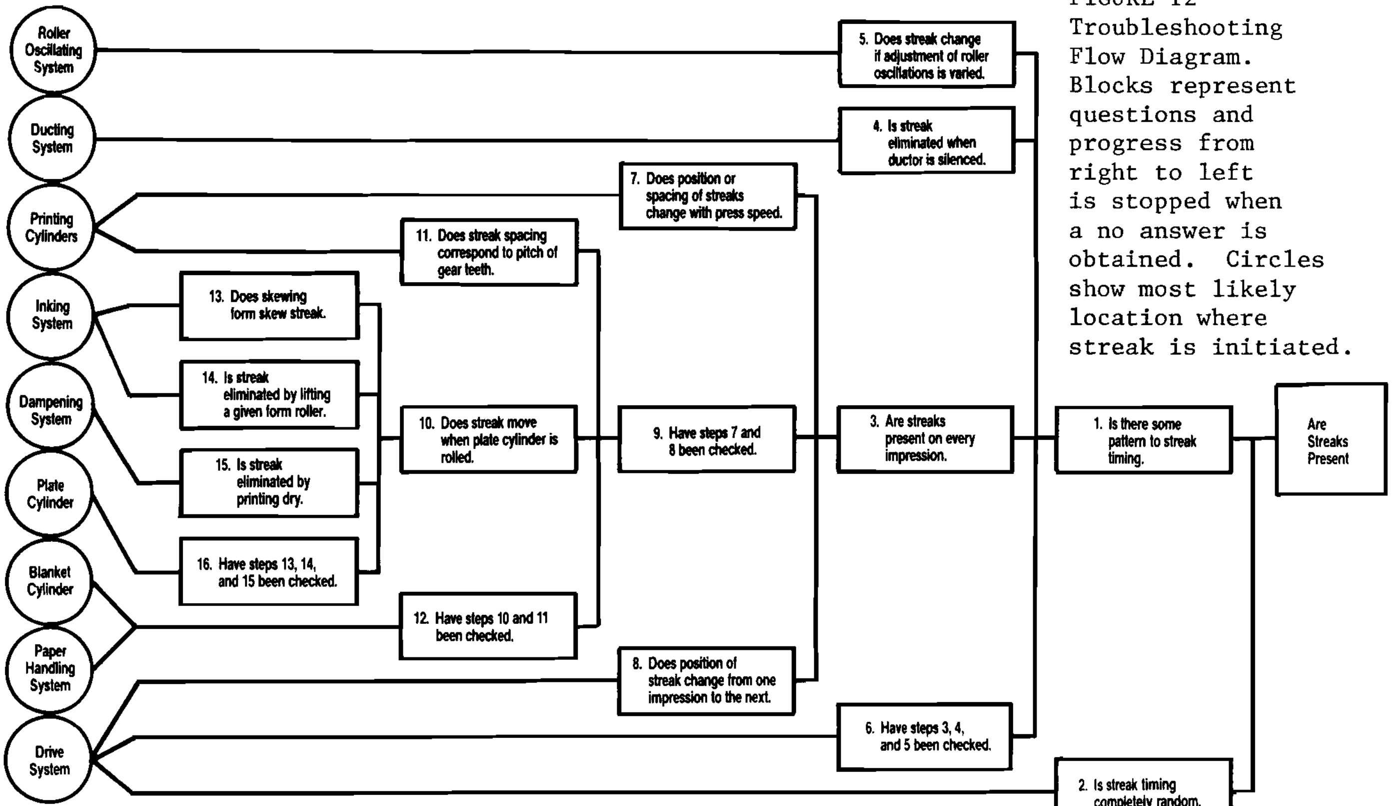


FIGURE 12
Troubleshooting Flow Diagram. Blocks represent questions and progress from right to left is stopped when a no answer is obtained. Circles show most likely location where streak is initiated.

First, Figure 12 encompasses situations where a single streak occurs and situations where two or more are present. Thus Figure 12 uses both the singular and plural of the word streak without any connotation inferred. The second feature of Figure 12 is that it was based on the assumption that both the ductor and oscillating roller motions are timed to some non-integral number of plate cylinder revolutions, greater than two. It must also be realized that there are some sheetfed press designs where this assumption does not hold in that the ductor and oscillating roller motions are timed to an integral number (most often two) of plate cylinder revolutions. In such a case the reader must modify the directions given by Figure 12 to provide for the fact that disturbances produced by the ductor or oscillating motions will have a timing pattern which is different from that assumed in Figure 12. More will be said about this in the detailed discussions of each step, given in the following paragraphs.

1. <u>Is there some pattern to streak timing?</u> When a streak problem occurs, a very important first step is to determine if there is a regularity in its appearance from one impression to the next because if there is, it indicates that the cause of the streak is synchronized in some way to the rotation of the plate cylinder. In addition, the character of the pattern or exactly how it is synchronized to the plate cylinder can provide important clues in troubleshooting. The simplest pattern is the one where the streak is present on every impression and stays in the same location. More complex patterns could involve a streak which advances or moves back in position from one impression to the next or which is only present on every other, every third, or higher multiples of impressions. One suggested method for discerning if a pattern exists is to collect and examine a sequence of 10-20 impressions for the incidence and location of streaks. If this information is plotted as a function of press travel it will be much easier to discern the presence and character of a pattern. As an example, consider a 40" x 28" sheetfed press which has a single streak which moves around and does not show up on every impression. Figure 13 shows how this data might look if plotted versus press travel. It can be seen immediately that the distance between streaks is 1.1 plate cylinder

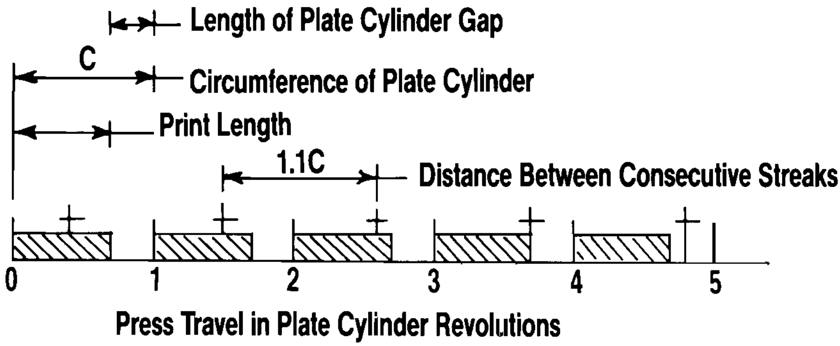


FIGURE 13 Plot of Streak Position versus Press Travel in Hypothetical Sheetfed Press. Crosses indicate streak position and shaded rectangles represent paper or print length. On each subsequent impression streak advances a distance equal to 10 percent of plate cylinder circumference.

revolutions. If the frequency of ink roller oscillations happened to be one per 2.2 plate cylinder revolutions on this particular press, this would point to end play in a form roller as a possible culprit - since the form roller would reverse its transverse motion every 1.1 plate cylinder revolutions. From this discussion it should now be realized that if the answer to this question is a yes, then further analysis aimed at narrowing down the location of the fault will be in order by proceeding to the questions to the left in Figure 12. If the answer is no, then question #2 should be addressed.

2. <u>Is streak timing completely random?</u> If a streak is completely random in its timing or occurrence, the source or cause is not synchronized to the plate cylinder. Thus the cause could be in the drive system or, worse yet, could be intermittant. For this reason, troubleshooting such streaks is extremely difficult because their random character makes it almost impossible to deduce the precise location of the fault. Fortunately only a tiny fraction of streaks are random ones.

3. <u>Are streaks present on every impression?</u> This is a very significant question because if streaks are indeed present on every impression, it indicates that the most likely source is relatively close to the plate cylinder. Generally such sources are easier to find. According to the guidelines established, if the answer to this question is yes, the investigator would bypass questions #4 and #5

and proceed directly to #7. This would indeed be correct if, as assumed in Figure 12, the roller oscillating motion is not synchronized to the plate cylinder revolutions by some integral number. However if the roller oscillating motion is synchronized to every or every other plate cylinder revolution, then question #5 should be posed even if the answer to question #3 is yes.

4. Is streak eliminated when ductor is silenced? If the timing of the streak appears to be related to the ductor motion, the fault may well be in the ducting system. This can be very easily checked by silencing the ductor for several of its cycles. If the streak goes away, then the ducting system should be analyzed for maloperation.

5. Does streak change if adjustment of roller oscillations is varied? The test suggested by this question may have an ambiguous outcome, depending on the press design. That is, this question is based on the theory that if a streak is caused by a problem associated with the roller oscillating system, making an adjustment to that motion will affect the streak in some way. On web presses, the only adjustment generally available is in the stroke of the roller oscillations. Decreasing the stroke may well decrease the severity of a streak caused by wear or shock, but it might not. On sheetfed presses, the only adjustment generally available is in the timing of the oscillations. If these occur at some integral number of plate cylinder revolutions (not assumed in Figure 12) then any streaks so caused would not change position over time. As a result, changing the timing adjustment would change the position of the streak and would therefore constitute a useful test. However, if the timing were not integral with a plate cylinder revolution, this test would have no value since a timing adjustment would have no observable effect on the position of the streak.

6. Have steps 3, 4, and 5 been checked? The direction given by an affirmative answer to this question represents a process of elimination. That is, if there is a timing pattern, if a streak or streaks are not present on every impression, and if the ductor and oscillating systems are not at fault, then all other sources except the press drive system can be eliminated as likely sources of the problem.

7. Does position or spacing of streaks change with press speed? Transverse or bending vibrations of printing cylinders are known to produce streaks in web presses as operating speeds are increased. Because the frequency, on a time basis, of such vibrations are constant for a given cylinder design, the position of and spacing between any resultant streaks will vary with press speed. Thus a positive answer to this question indicates that the source is either the plate or blanket cylinders, or both.

8. Does position of streak change from one impression to the next? A yes answer here coincides with a streak or streaks which are non-random, present on every impression, and yet which move about from one impression to the next. This points to a source which is synchronized or geared to the plate cylinder by some non-integral number. As a result the most likely source of the problem is a component in the press drive system because these conditions can exist there.

9. Have steps 7 and 8 been checked? This question represents another process of elimination step in the troubleshooting process. Thus to obtain a yes answer to this question means that the streak(s) in question is present and fixed in location on every impression regardless of press speed. A yes answer here also means that the prospects for quickly finding the location of the fault are good because the subsequent questions lead to specific locations in the press.

10. Does streak move when plate cylinder is rolled? The question posed here is what happens to the position of the streak on an impression when the circumferential print register adjustment is changed. On most presses changing this adjustment rolls the plate cylinder with respect to the blanket cylinder. (Before making this test, one should make certain that the blanket does not move when this register adjustment is changed.) This is an extremely useful test in that it further narrows where in the press the streak is occurring. If the streak moves on the paper after this has been done, it indicates that the streak was generated while the image was on the plate. (Conversely if it didn't move it indicates the streak was generated after the plate, i.e. while the image was on the blanket or paper.) On sheetfed presses the plate cylinder can be rolled by as much as one inch so the effect is easy to discern. On web presses circumferential cylinder adjustment is limited to about half that amount, which is still adequate.

11. Does streak spacing correspond to pitch of gear teeth? A yes answer here indiates a printing cylinder problem, although not necessarily defective gears. This was discussed in detail in connection with Figures 8 and 9.

12. Have steps 10 and 11 been checked? A yes answer to this question means in effect that gear streaks are not involved and that the streak position does not change when the plate cylinder is rolled. Thus the blanket cylinder and paper handling system are identified as the most likely locations of the problem.

13. Does skewing form skew streak? This question represents a test for identifying an inker runout streak. If the problem form has a large solid, skewing the leading and trailing edges of the solid, as shown in Figure 6, will skew the streak if it is a runout of one of these boundaries. Alternately, using indents as shown in Figure 11, along with skewed packing will provide an even more complete test.

14. Is streak eliminated by lifting a given form roller? There are a variety of ways in which a streak can be generated by a form roller. One way to check on this is given by this question. That is, if a given streak is eliminated by lifting a given form roller, then that form roller is at fault. When running this test it is very helpful to have a reference print to show what would be expected under non-fault conditions, when the given form roller is lifted. This is because the act of lifting a form roller can generate additional runout streaks.

15. Is streak eliminated by printing dry? Streaks caused by the dampening system can be identified by printing dry, since the streak will not appear under dry conditions. However this test should be run with care to insure that other conditions are not changed as well. Toward this end the preferred test setup is to use a standard litho plate (rather than a relief plate) with normal plate and blanket packings. If the resultant solid region (i.e. the entire plate) creates a paper-blanket release problem, sections of the blanket can be cut away or underpacked to reduce the release force which must be applied through the paper.

16. Have steps 13, 14, and 15 been checked? This last question in the troubleshooting diagram represents another process of elimination step. In effect this step concludes that if a movable streak cannot be eliminated by printing dry, lifting a form roller, or skewing the form, then the fault must lie with the plate cylinder. For example this would be the case if the plate cylinder had a flat or worn spot on a bearer which produced a bump streak.

SUMMARY

Because the subject treated here is so complex there is no way in which it can be summarized in a concise manner nor are there any simple and straightforward conclusions which can be set forth. All that can be said is that streak problems unfortunately are not uncommon in printing and the task of troubleshooting them can be confusing and time consuming. In presenting this material it is the hope of the authors that they have given their colleagues some new insights and tools and thereby helped to both ease and considerably speed their tasks in this regard.

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ACKNOWLEDGEMENT

The authors are indebted to a number of colleagues who were generous enough to spend a significant amount of their valuable time to review a draft of this paper. Included in the group were Terry Bradley of Hantscho; Julius Domotor of Advanced Litho; George Ono, Consultant;

Ray Prince of GATF; Lou Tyma of MAN-Roland USA, Rudy Valenta of Miehle - Rockwell International, and Dave Wirth of Baldwin Technology. This review process resulted in a large number of helpful and constructive suggestions which were incorporated in the final draft. Also, the valuable contributions made by Lloyd DeJidas of GATF, in discussions with the authors, are also gratefully acknowledged. Since some minor differences of opinion remain between reviewers, and between reviewers and authors, the authors assume sole responsibility for the final form and content of the paper and all errors and points of contention belong to them.

ADDENDUM

One of the reviewer's comments were received too late to be incorporated into the final draft. However, because they were considered so important and valuable, they have been included as an addendum as follows:

A. **Hard Rollers**

Form rollers in the ink and water systems of an offset press should be checked for proper durometer on a monthly basis. Rollers that exceed manufacturers specifications by 5 to 8 points in hardness will aggravate streaking and ghosting problems. Before taking durometer readings, all rollers should be in a clean and deglazed condition.

B. **Silver Ink**

Certain colors of ink will have a tendency to show streaks and run out more so than others on solids. Addition of a pre-mixed silver ink to the troublesome color will normally mask or soften these visual imperfections. Formulas of 1 to 2 ozs. of silver to a pound of color will usually be sufficient although shades of grey will tolerate more without drastically affecting the original color.

C. **Test Form**

The GATF Ladder Target (available from the Graphic Arts Technical Foundation, Pittsburgh, PA.) is a ready-made source for the lined screens on the recommended test form shown in Figure 11.