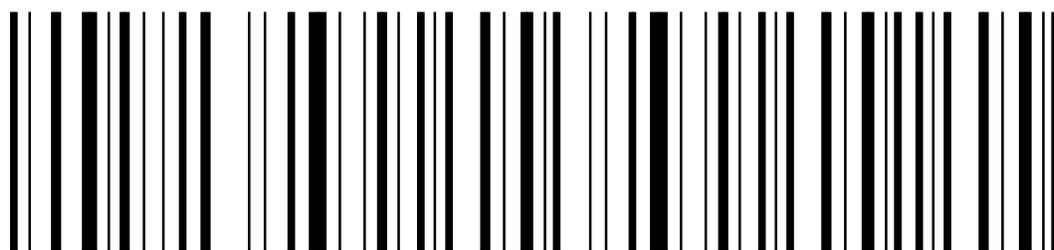


Quality Assurance Steps for Preventing Label Printing Problems



APPLICATION WHITE PAPER



Zebra Technologies



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I n t r o d u c t i o n

There is more to ensuring quality bar code label printing than using quality printers. Even the most reliable printers need regular maintenance, just as the finest cars need regular oil changes.

Unfortunately, print quality is often overlooked until it causes a problem. For suppliers who must abide by trading partner compliance labeling requirements, print quality problems are very expensive. Compliance labeling infractions have cost suppliers millions of dollars in chargebacks and losses from refused shipments, plus untold damage to customer satisfaction.

These costs are as preventable as they are painful. Most print quality problems can be avoided if the labeler has a quality assurance program in place. To help avoid print quality problems and their costly consequences, this white paper will:

- Introduce print quality issues as they relate to compliance labeling;
- Summarize how thermal label printers work;
- Teach users how to detect and correct common print quality problems;
- Outline the steps to creating an effective quality assurance program; and
- Highlight other resources for label printing and quality assurance assistance.

B a r C o d e Q u a l i t y a n d C o m p l i a n c e L a b e l i n g

Compliance labeling programs provide specific guidelines on the size, format, content and placement of shipping labels, and set strict quality requirements for suppliers. Suppliers must meet all the label requirements to be in compliance, but bar code quality is the leading source of non-compliance and resulting chargebacks.

The compliance requirement will also specify which bar code languages, called symbologies, can be used on the label. Bar code symbologies are governed by their own standards to ensure interoperability and quality, and consistency in encoding, printing and reading. These symbology specifications usually aren't included in the compliance labeling guideline, but are available as published standards from AIM Global (www.aimglobal.org), the Uniform Code Council (UCC) (www.uc-council.org) and EAN International (www.ean-int.org). The American National Standards Institute (ANSI) (www.ansi.org) also has bar code print quality standards that many companies use as a basis for their own quality standards.

Symbology standards cover the width of bars and the space between them, the ratio of narrow elements to wide ones, the contrast between dark and light elements (print contrast signal, or PCS), length-to-width ratio and other technical characteristics. Environmental conditions, including sunlight, heat, moisture, abrasion and exposure to chemicals, all impact label quality. Many bar code labels are readable at the time they were printed, but become non-compliant during normal usage conditions. Ensuring bar code print quality requires knowledge of item handling, storage, logistics and usage environments so that the appropriate printing method and materials can be selected.

Users also need a basic understanding of how thermal bar code printers work so they can recognize potential problems and establish effective quality assurance programs.





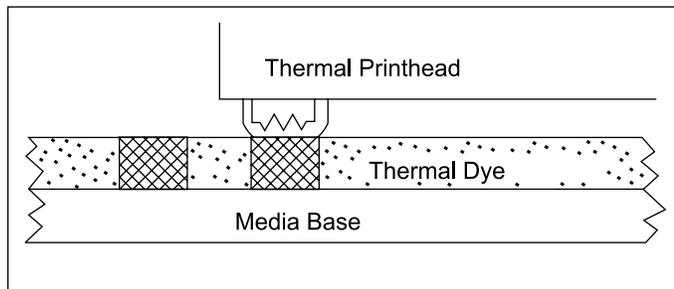
Thermal Printing Technology

There are two thermal printing methods: direct thermal and thermal transfer. Each method uses a thermal print-head that applies heat to the surface being marked. Thermal-transfer printing uses a heated ribbon to produce durable, long-lasting images on a wide variety of materials. No ribbon is used in direct-thermal printing, which creates the image directly on the label material.

Check with your supplier or printer manufacturer to ensure that the proper media combination is being used or for a list of approved options. Some users try to save money by looking for the lowest cost media that they can purchase online or through discounters. This approach may save consumable costs, but often results in higher total expenses because the inferior materials may reduce the lifecycle of the printhead and may lack the quality to remain readable, leading to fines or chargebacks in compliance labeling applications.

Direct thermal and thermal transfer are the best technologies for printing bar codes because they can easily use a variety of adhesive labels materials and produce accurate, high-quality images with excellent edge definition. Each technology can produce one- and two-dimensional bar code symbologies plus graphics and text fonts at the same print resolutions and speeds. The following sections will help you understand the differences between the technologies and how to select the appropriate print method for your application.

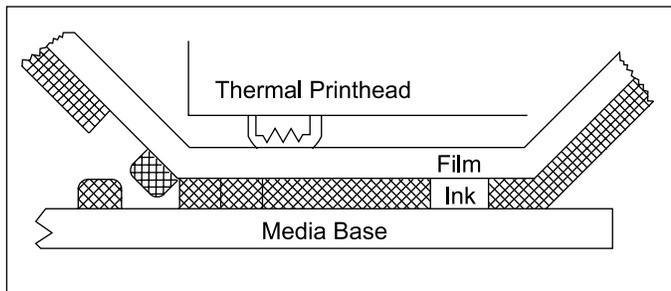
Direct Thermal



Direct thermal printing uses chemically treated, heat-sensitive media that blackens when it passes under the thermal printhead. Direct thermal printers have no ink, toner or ribbon. The simple design makes thermal printers durable and easy to use. Because there is no ribbon, direct thermal printers cost less to operate than thermal transfer models.

Direct thermal media images fade over time. If the label is overexposed to heat, light or other catalysts, the material will darken and make the bar code unreadable. The readability of direct thermal labels varies greatly depending on the usage conditions, but the technology provides ample lifespan for compliance labeling and many other common bar code printing applications. For example, direct thermal labels can easily remain scannable after spending six months in storage in a distribution center.

Thermal Transfer



In thermal transfer printing, a thermal printhead applies heat to a ribbon, which melts onto the label material to form the image. The ribbon material is absorbed into the media so that the image becomes part of the label. This technique provides image quality and durability that is unmatched by other on-demand printing technologies.

Thermal transfer printers can accept a wider variety of media than direct thermal models, including paper, polyester and polypropylene materials. Thermal transfer printers can create durable compliance labels, UL/CSA labels, tags and tickets, plus wristbands, permanent asset tags, shelf labels and other identifiers.

Thermal transfer printers use either wax or resin ribbons. Wax is the most common, less expensive option and is suitable for many labeling applications. Resin ribbons provide more heat and chemical resistance and are commonly used with synthetic label materials. Resin-enhanced wax ribbons combine qualities of each and provide outstanding performance on many label materials. The specific label material and ribbon must be carefully matched to ensure print performance and durability. The optimal ribbon choice depends on the label material, printer and environment that the labels will be used. By selecting the right media-ribbon combination, users can create quality labels that will remain readable throughout production, logistics and storage processes.

With this knowledge of how bar code printers work, users can create quality assurance and preventive maintenance programs for their equipment and troubleshoot common performance problems.

Preventing, Detecting & Correcting Problems

Monitoring and maintaining the printer, cleaning it regularly, and replacing parts as necessary is the best way to ensure print quality and consistent performance. The printhead is the most critical component to maintain and replace. Most print quality problems directly result from improper use or care of the printhead. Therefore, most problems can be avoided or easily corrected by knowing how to see the early signs of printhead performance trouble. Following is a guide to common thermal print quality problems, their causes, and the corrective action users can take themselves to resolve the issue.



Bars are too light (underburn)

If dark bars print too lightly they will not provide enough contrast to the light spaces. This condition is reflected in the Print Contrast Signal measurement specified in the ANSI print quality guidelines. There are several potential causes of underburn:

- Uneven or insufficient pressure is being applied from the printhead to the material. This is remedied by adjusting the printhead pressure.
- The heat is not set high enough to properly change the direct thermal stock or melt the ribbon for thermal transfer printing. Heat settings are adjustable and should be changed until optimal contrast is attained.

Overburn

When heat settings are too high, overburn results and bars become too thick, which is also called bar growth. This causes the bar code to be out of spec and probably become unreadable because the required wide/narrow ratio cannot be maintained. Overburn is usually corrected by lowering the heat setting.

Unwanted diagonal lines appear

An unwanted diagonal printed line or white streak is a sign that the ribbon is not loaded or feeding correctly. Visually inspect the ribbon to see that it is smooth. Also make sure that label material is loaded correctly within the guides and is feeding into the printer smoothly and evenly.

Spots or voids present in the image

Spots and voids often correspond to dirt, abrasion or burned out elements on the printhead. Burned out elements prevent heat from transferring, resulting in dead spots on the label. Dirt or abrasives could also block or redirect the heat or ribbon transfer, resulting in voids or spots that could make the bar code unreadable. Regular cleaning will prevent dirt and abrasion problems, but burned out elements require replacement of the printhead.

A wrinkled ribbon may also cause streaks or dead spots where printing is supposed to appear.

- Ribbon wrinkle may indicate not enough tension, which can be tightened.
- If ribbons wrinkle consistently, the print speed may have to be reduced.

Another possible cause of spots or voids is media with improper top coating or other defects. Test a new roll of media to see if the problem persists.

Unable to sustain wide/narrow ratio

As referenced previously, underburn and overburn can lead to an unacceptable ratio between wide and narrow elements within a bar code symbol. A general tip to ensure good bar code print quality is to create symbols with the highest wide-to-narrow ratio that label space or the specification allows. As symbols become smaller, reading tolerances become more acute. Wide/narrow ratios can be made more consistent and improved by increasing the print resolution.





Poor edge definition

Bar code readers require sharp, well-defined edges to differentiate between bars and spaces and properly decode symbols. One of the reasons thermal is the best technology for bar code printing is because of the straight, sharp edges it produces. Rounded or fuzzy edges can often be corrected by reducing the print speed. Poor edge definition may also indicate low-quality label or ribbon material, or that the ribbon and media aren't properly matched for use with each other. Printing bar codes in vertical (ladder) orientation can also cause edge definition problems, so the horizontal (picket fence) orientation should be used whenever possible.

Many of these quality conditions can be monitored by visually inspecting labels regularly or by printing test labels each time the printer is started, at the beginning of each shift and every time the label media or ribbon are replaced. These proactive steps prevent problems from occurring, forming the basis of an effective quality assurance program.

Quality Assurance and Preventive Maintenance

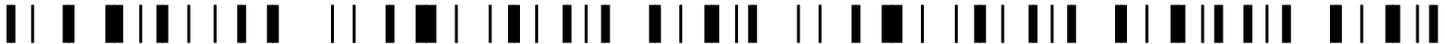
The problems described in the previous section can usually be detected and prevented by a quality assurance program and trained operators who know how to recognize the warning signs. An early sign of a potential quality problem is inconsistency in the label output, which can be detected by operators who use the printers every day. Detection and preventive maintenance provide a proactive approach to quality management that prevents out-of-compliance labels and reduces downtime for repairs.

Media, environmental conditions and operator usage all play a role, but most quality issues are related to the printhead and are preventable through regular maintenance. Because the printhead is the single most important factor in bar code print quality, printhead maintenance should be at the heart of quality assurance procedures. When you take care of the printhead, quality practically takes care of itself.

A good maintenance program requires a daily investment of operator time plus the periodic use of spare parts and cleaning materials. These minimal investments will extend the life of the printer, reduce the total cost of ownership for the label printing system and save untold repair time. The real value is the consistent quality and cost avoidance by preventing non-compliant labels from leaving your facility. The direct costs from a single instance of non-compliance can easily exceed the cost of a new printer and a lifetime of preventive maintenance materials and time.

Quality Assurance in Practice at Sears

Sears operates an exemplary quality assurance program called UCC128 Rehab and has agreed to share information about its processes to foster improved bar code print quality and labeling procedures. The primary objective of Sears' UCC128 Rehab program is to reduce non-compliant labels from reaching Sears receiving locations by offering suppliers the resources needed for 100% compliance. Sears partnered with a third-party service provider, Bar Code Graphics Inc., to train suppliers and receiving associates to identify, report and correct defective labels at different points in the supply chain. Since taking a proactive approach to identifying quality problems and working with suppliers to correct them, Sears has significantly improved scan rates. This has saved time and costs in its logistics processes.



The Sears distribution network includes seven U.S. distribution centers, which are referred to as Retail Replenishment Centers (RRC). The RRC facilities include a cross-dock channel which processes approximately 35 million cartons a year, with throughput of more than 5,000 cartons per hour. Cross-dock shipments are packed and labeled for Sears stores by suppliers. These cartons include the industry standard UCC-128 shipping label with an additional "Mark For" bar code to identify the specific store destination.

Upon receipt at a Sears facility, receiving associates examine a sampling of cartons to determine if the shipping labels meet Sears' requirements. Cartons containing labels in compliance are placed on conveyors traveling over 500 feet per minute. A successful scan requires both the SSCC-18 and Mark For bar code to be scanned by fixed-position scanners that can read symbols placed on the top and side of cartons. Cartons that have been successfully scanned are diverted to outbound lanes destined for specific stores within that region.

Cartons without readable bar codes labels are diverted to an overflow area and are manually re-labeled. Consequences of poor label quality have significant impact on Sears' logistics and inventory operations. Large shipments with non-compliant labels can cause a slowdown or stoppage. Major bottlenecks can develop quickly, and items being cross docked are in danger of not making their scheduled shipment. Sears issues chargebacks to offset additional costs associated with manual shipment processing. The charge is based on the number of cartons requiring additional handling.

Sears notifies Bar Code Graphics when receiving locations encounter non-compliant UCC-128 labels. Bar Code Graphics administers the process, receiving shipment details from Sears and immediately notifying the supplier of the defective label conditions. Bar Code Graphics can also provide troubleshooting and label analysis if necessary. Sears has improved its scan rates significantly after initiating the process of providing suppliers with expedited, detailed notification of non-compliant issues. This has enabled a smoother functioning logistics operations and improved relationships with its suppliers. The goal of Sears' UCC128 Rehab program is to prevent logistic problems by working with suppliers to prevent non-compliance issues and enhance the overall print quality of shipping labels.

The Cost of Quality Problems

Many large retailers levy chargebacks or may refuse the shipments altogether if cartons are identified with shipping labels that do not comply with their requirements. Suppliers who ship cartons with non-compliant labels often pay a high price for poor print quality. Chargebacks may be either a flat fee, a fixed percentage of the shipment value, or a charge of several dollars for each label that fails to meet quality standards. Seemingly small quality problems can cause suppliers to lose substantial revenue to chargebacks because of shipping volume and lags in the distribution cycle. For example, suppose dirt buildup on printhead blocks proper heat transfer that results in unreadable bar codes. Hundreds of out-of-spec cartons may be loaded onto a truck and spend two days in transit before arriving at the retailer's distribution center. The supplier may continue producing defective labels while a retailer is manually processing prior non-compliant shipments, resulting in hundreds or thousands more unreadable cartons entering the supply chain. Suppliers could easily incur five-figure chargebacks in the time that elapses from the when the initial label quality problem occurs to when it surfaces at the retail distribution center.

With no quality assurance program in place, the scenario will be repeated numerous times, or until being notified of a chargeback. One supplier incurred more than \$50,000 in chargebacks one year, but had none the following year after implementing a quality assurance program which identified non-compliant labels and prevented defective labels from being applied to outbound shipments. Often, small steps are all that is needed to prevent costly problems. Most suppliers achieve their quality goals by giving consistent attention and care to their label printing system.



Consistent print quality and extended printhead life are achieved through regular cleaning, media management, testing, sampling and replacement of aging parts. A print quality assurance plan should incorporate each of these procedures. A well-maintained printer that receives periodic cleaning and maintenance can produce hundreds of thousands of consistent, high-quality labels. The following steps describe how to incorporate each element into a quality assurance plan.

Cleaning

Regular printhead cleaning protects against sudden failures and quality degradation over time. Abrasion is by far the leading cause of premature printhead failure—responsible for more than 80 percent according to one estimate. When dirt, dust and other contaminants accumulate on the printhead they can block heat transfer, which can cause other printhead elements to overheat and burn out, requiring replacement of the printhead. After repeated exposure to heat, the contaminants become hardened and baked onto the printhead, which can cause corrosion. Before burning out, blocked elements create print quality problems by producing voids or lighter images.

Buildup and the related problems can be prevented through regular cleaning with specialty printhead cleaning products, including pens, swabs and cards. Printer cleaning products are specially formulated to lift dirt and grease from the printhead and quickly evaporate, leaving no buildup. The applicator material is specifically designed not to stick to the printhead and leave debris.

Label printer users should make printhead cleaning part of their regular operational routine. Cleaning the printhead each time the ribbon is replaced in thermal-transfer printing, or at every media change for direct thermal printing, should be sufficient for most users. Printhead cleaning can be done quickly and conveniently with inexpensive materials. The investment in time and materials is repaid many times over because of the costly printhead failure problems it prevents.

Media Management

Media selection and handling are also highly manageable variables that effect quality.

Ensuring label material and ribbons are loaded correctly every time through thorough operator training and review will prevent many wrinkling and uneven printing problems.

Purchasing managers must also be trained about the impact media has on print quality and overall operational efficiency. Label and ribbon combinations must be matched to each other and to the usage conditions to ensure proper imaging performance. Labeling systems integrators or the printer manufacturer will recommend several acceptable options. Users will undoubtedly be able to find lower-cost options that have not been specifically certified or recommended. These cut-rate consumables may provide an initial savings, but at a risk to print quality that could cause much more expensive problems. If the media caused even one print quality problem that led to a customer chargeback, the material savings would be offset many times over by the resulting fines, returns processing expenses and lost customer confidence.

Testing

Some printers offer test routines to measure printhead performance. Zebra Technologies' Xi™ series of high-performance printers support a software application in the ZPL printer control language that tests to determine if printhead elements are performing. The test can be run through prompts on the control panel or through a network command. If burned-out elements or other problems are detected the printer will display an error message and further action will be required. Printers may also be set up to stop printing immediately and block further output until the problem is resolved, which prevents bad labels from entering the supply chain. The test is set to run after every 100 labels, but users can select their own settings to test as often as they want.





Sampling

Sampling is another method to monitor and test print quality. Operators should be trained and to perform visual label inspections daily to look for uneven images, voids, light printing or other obvious signs of trouble. Companies should also regularly schedule more rigorous quality tests and submit label samples for third-party certification. Qualified third parties can provide an unbiased analysis and recommend necessary corrective actions.

Relying solely on visual inspections is a dangerous practice that could lead to labels that look good being out of compliance. Many print quality problems are not visible to the naked eye. Using a hand-held bar code scanner to see if labels will read is also an insufficient quality check. Successfully reading a label with a handheld scanner in a controlled environment is no indication the label will read in real-world conditions. Many cartons with compliance shipping labels are processed at distribution centers that use high-speed conveyors and material handling equipment to move materials several hundred feet per minute. These conditions expose quality problems very quickly, and usually cannot be replicated in a test environment.

Many companies that have compliance labeling programs will gladly inspect and monitor supplier label samples, or have designated a third-party service to certify label quality. Suppliers should take advantage of these resources by regularly sending label samples for testing. Users should always have their labels tested and re-certified after any changes are made to the printing process, including the introduction of new label printers, media, software or printing locations.

Replacement

The final step in bar code label printing quality assurance is planned replacement of the printhead. Printheads are replaceable parts and do not necessitate the entire printer be replaced at the end of the printhead lifecycle. Printheads should be considered consumables, albeit expensive ones, and should be replaced as necessary.

The lifespan of a thermal printer depends on the type and quantity of images being printed, heat settings, media and other factors. Users should track the lifetime print volume of each printhead and begin monitoring quality more closely as the part nears its end of life. Volume can be monitored with counters or other built-in features offered in some printers, or by other methods such as recording and tracking media that is loaded onto the printer or calculating average monthly printing volume. To minimize disruption to mission-critical operations when printheads need service or replacement, it is good practice to have a spare printhead ready.

R e s o u r c e s

This white paper was prepared by Zebra Technologies, a global leader in delivering on-demand thermal printing solutions, Bar Code Graphics a highly experienced specialist providing bar code labeling systems, compliance labeling services and quality control tools, and Sears, Roebuck and Co.

About Zebra

Zebra provides a complete line of thermal printing solutions, including the widest range of bar code and RFID smart label printers and media, label design and management software, connectivity tools and wired and wireless networking products. More than 90 percent of Fortune 500 companies rely on Zebra® labeling solutions.

The ZebraLink™ control solution available for Zebra printers provides highly advanced remote monitoring, management and troubleshooting features to ensure print quality and maximize uptime. ZebraLink-enabled





printers on a network can automatically send alerts or error messages to operators or system administrators through any wired or wireless device capable of accepting e-mail, including cell phones, pagers, PDAs and PCs. ZebraLink can be used to inform operators that label material or ribbons need replacement, or if any other error conditions exist. The remote management features enables administrators to use a Web browser to configure printers, adjust settings, run printhead tests, troubleshoot and monitor activity remotely. For more information download *The ZebraLink Solution* white paper. Additional resources are also available on the Zebra Web site, www.zebra.com, including information about specific compliance labeling requirements, links to standards, case studies and software, printer and other product information.

About Bar Code Graphics, Inc.

Bar Code Graphics, Inc. headquartered in Chicago, IL, USA, is a leading authority on bar code print quality. Currently Bar Code Graphics is the designated third-party testing center for many retailers, including Sears, Roebuck and Co., Kmart Corporation, and The Sports Authority, Inc. The company maintains a state-of-the-art testing lab which provides accurate analysis of bar code print quality for all types of bar code symbols. In addition to assisting retailers and their suppliers with bar code compliance, the company also offers an array of products and services, which all fit under the umbrella of bar code print quality. For over 25 years, Bar Code Graphics has provided precise and high-quality bar codes to more than 20,000 companies worldwide. As a Zebra Alliance Partner and Zebra Solution Integrator, Bar Code Graphics, Inc. has developed a variety of customized print quality solutions and products designed especially for Zebra clients. For more information about Bar Code Graphics call the company at 1-800-662-0701 or visit their Web site, www.barcode-us.com.

About Sears

Sears, Roebuck and Co. is a broadline retailer with significant service and credit businesses. In 2002, the company's revenue was \$41.4 billion. The company offers its wide range of apparel, home and automotive products and services to families in the U.S. through Sears stores nationwide, including approximately 870 full-line stores. Sears also offers a variety of merchandise and services through its Web sites, www.sears.com and www.landsend.com, and a variety of specialty catalogs.



Zebra Technologies

333 Corporate Woods Parkway
Vernon Hills, IL 60061-3109 U.S.A.
T: +1 847 793 2600 or +1 800 423 0442
F: +1 847 913 8766
www.zebra.com

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