by **Dr. Wolfgang Reick** | TB Acessorios do Brasil Ltda.

The Importance of Blue Tape Application in Refilling Inkjet Cartridges

Applying blue tape is part of the daily work of inkjet cartridge refillers. During production of new HP cartridges this blue-colored and almost transparent adhesive is applied to seal the cartridge against ink leakage during storage and transportation. But while practically no leakage is observed in new cartridges, this problem can still be found in some refilled cartridges. It may cause ink contamination of the inner cartridge package, as well as ink cross-contamination in color cartridges, which results in an unusable product.

The goal of this article is to contribute to the understanding of the function of blue tape and the differences that exist between new and refilled cartridges. The results of scientific investigations allow some recommendations for avoiding the cartridge leakage problem, even during longer cartridge storage periods and air transportation.

Figure 1. Overview of the 629 cartridge print head.

Basic Properties of Blue Tape

Blue tape consists of a PVC-type film about 60 to 70 micrometers thick, with an acrylic-based adhesive layer about five to 10 micrometers thick. This adhesive layer allows the blue tape to adhere to the cartridge surfaces. The adhesion force to metallic surfaces is about 80 to 90 cN for a 20-millimeter-wide tape (a relatively low value in comparison to other adhesive tapes) in order to guarantee easy tape removal without leaving residue on the cartridge. The blue PVC film has special properties with respect to its plastic deformation behavior. A slight application of tension leads to permanent plastic deformation, and the film can be elongated up to 240 percent. These mechanical properties are necessary to permit adaptation to local surface roughness near the cartridge print head. See Figure 1. Without this high plastic deformability, the blue tape would be subject to elastic deformation after fixing on the cartridge, and consequently could come loose from the print head.

For these reasons, any blue tape used in ink cartridge refilling processes should have adhesion and mechanical properties as similar as possible to the original HP blue tape. Today, adequate blue tape can easily be found in the supply market.

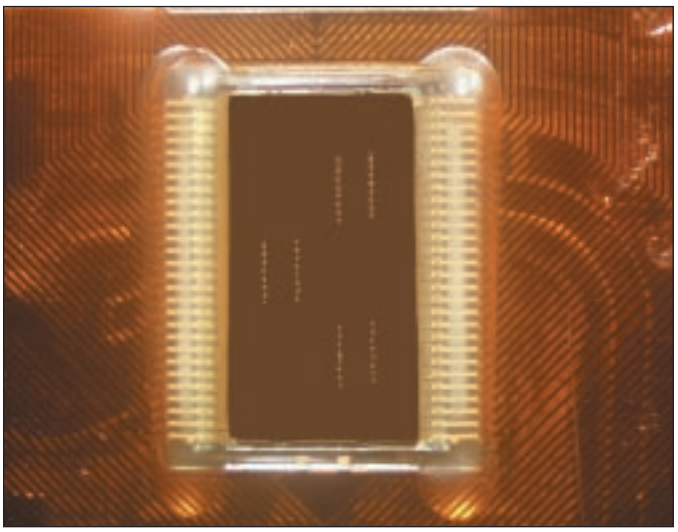

Figure 2a. Stereo microscopy showing print heads and nozzle plates of a new HP 625A cartridge.

Blue Tape Adhesion in New and Refilled Cartridges

There is a considerable difference in blue tape application between new and refilled ink cartridges, due to the different surface conditions of the nozzle plates. While the new cartridge's nozzle plate is completely smooth, the used nozzle plate is covered with micro-scratches. See Figures 2a, 2b, 2c and 2d. These scratches are a result of the printing process, when the print head slides against particles between itself and the paper, for example, wood splinters of microscopic dimensions or dirt particles from the air that accumulate on the paper. Most of the scratches are

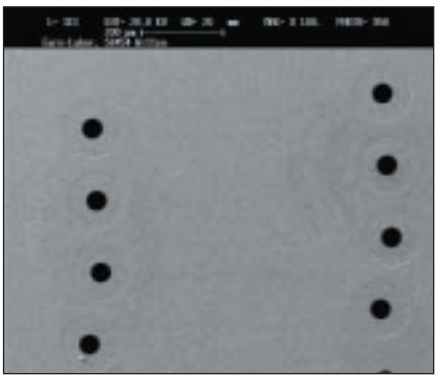

Figure 2b. Scanning electron microscopy of a new HP 625A cartridge.

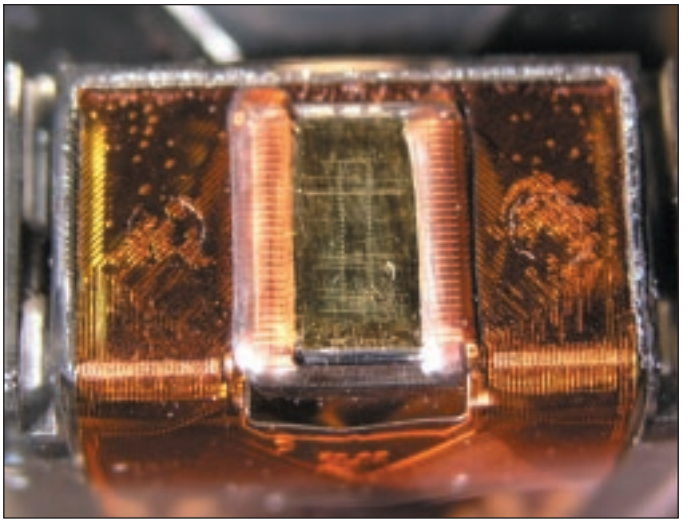

Figure 2c. Optical microscopy of used HP 629A cartridge with scratches on the nozzle plate.

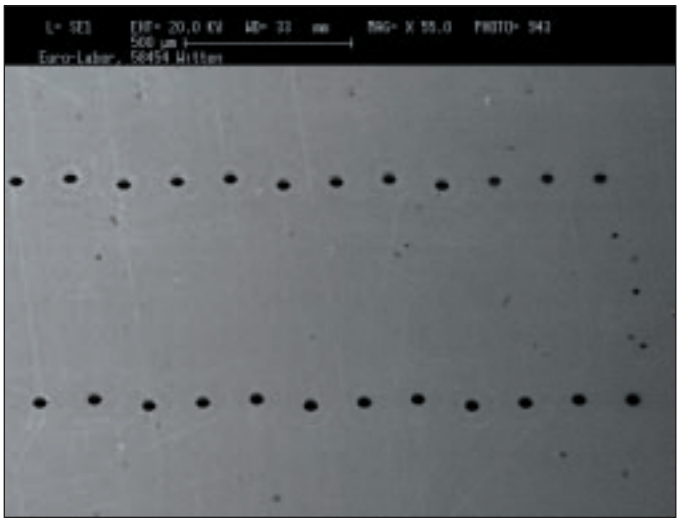

Figure 2d. Scanning electron microscopy of used HP 629A cartridge with scratches on the nozzle plate.

directed almost perpendicular to the two nozzle rows of the print head. See Figures 2c and 2d. Diagonal scratches can also be observed (see Figure 2d), which can form during the paper feeding process. Furthermore, other scratches with all directions and dimensions may be present, caused by the contact of the print head with other sharp or hard objects (sand, dust, dirt, metal edges, edges of other cartridges, etc.) after the first cartridge life cycle, during collection or due to improper storage and transportation conditions.

These form a network of scratches on the nozzle-plate surface — scratches that are all interconnected with each other. See Figure 3. What is almost impossible to see with the human eye is shown under magnification: the scratches build small "channels" (see Figures 4a, 4b, 4c and 4d) that are interconnected, thereby forming a scratch network, and that also connect the different nozzle holes with one another.

If the blue tape is not applied with adequate pressure, the scratches between the blue tape's adhesive layer and the metallic

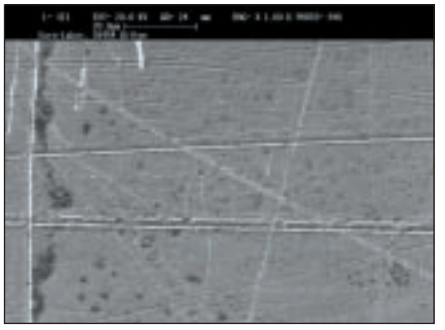

Figure 3. Scratch network on the nozzle plate surface of a used cartridge.

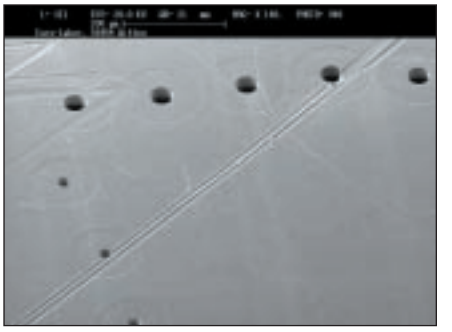

Figure 4a

Figures 4a, 4b, 4c and 4d. Scanning electron microscopy pictures taken from the nozzle plate surfaces of several used HP cartridges. The nozzle holes are frequently interconnected by scratches on the surfaces. Inadequate cartridge sealing may cause ink to flow through these micro-scratches (channels) and subsequently the blue tape can loosen and ink cross-contamination can occur.

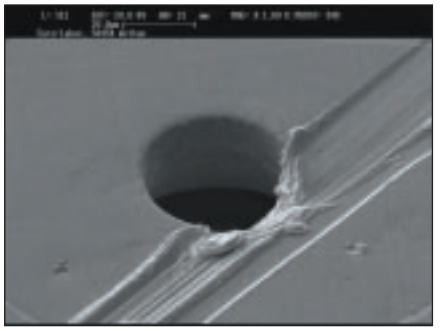

Figure 4b

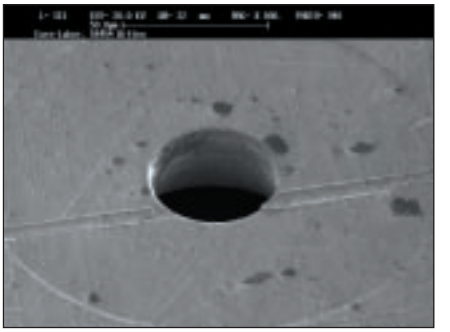

Figure 4c

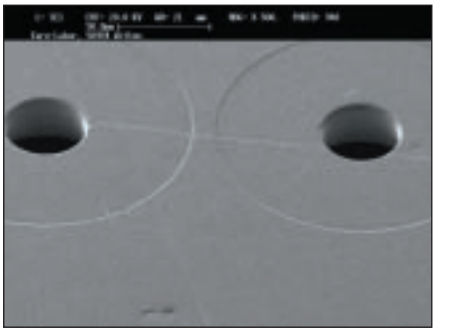

Figure 4d

nozzle plate's surface form microscopic channels that are initially filled with air. Within these microscopic channels capillarity exists, creating a physical driving force determined by surface tension that causes most liquids to enter in small tubes or capillaries. This capillarity leads the channels (scratches) to be filled with ink, starting at the nozzle holes that contain ink from the cartridge.

The ink flows through the interconnected channels and fills the whole scratch network, slowly causing a loosening of the blue tape and, consequently, an ink leak. The final result is the aforementioned ink contamination of the inner cartridge package and ink cross-contamination in color cartridges. A prolonged period of storage can cause a mutual ink exchange from one sponge to another by ink flowing through the micro-channel network, and the color cartridge will be useless.

How can this problem be avoided? Basically, you need to prevent the scratches/microchannels from filling with ink. This is only possible if the channels are filled with other matter, as, for example, with the blue tape's adhesive material. Figures 5 and 6 show different possibilities for resolving this problem.

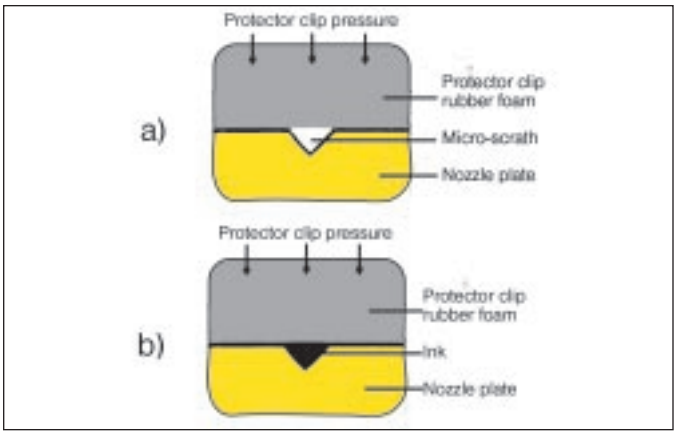

Figure 5a. Schematic representation of a transverse cut of a nozzle plate surface containing a micro-scratch. There is a protector clip applied from above causing a permanent pressure on the rubber foam (gray) and consequently on the nozzle plate. Figure 5b. Formation of a channel between rubber foam and nozzle plate containing air. Cartridge storage causes filling of the micro-scratch with ink by capillarity.

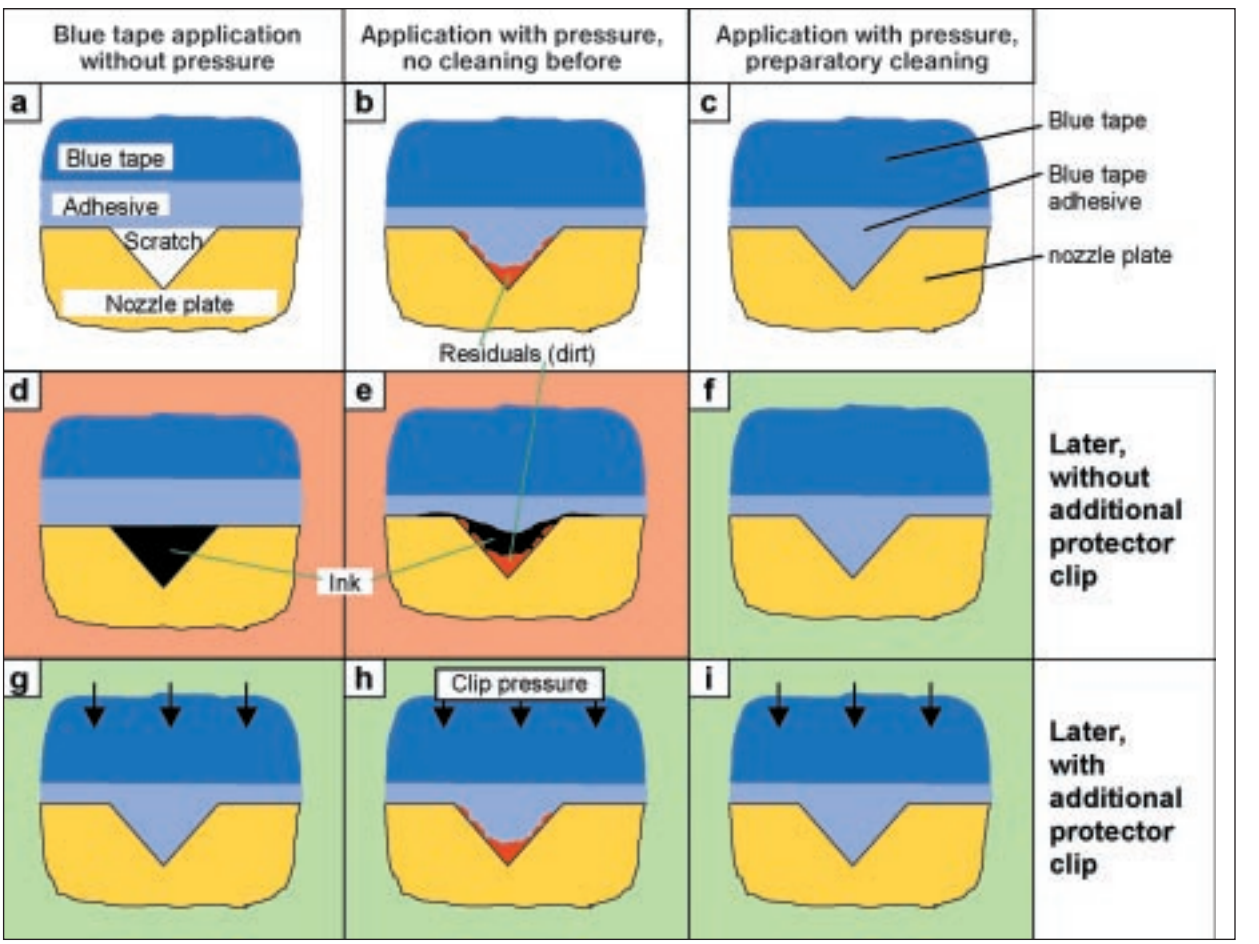

Figure 6. Schematic representation of the different possibilities for ink cartridge sealing. 6a, 6b and 6c: Three possibilities of blue tape application, just at the moment of application. 6d, 6e and 6f: Cartridge storage with blue tape, but without additional protector clip. 6g, 6h and 6i: Cartridge storage with blue tape and with additional protector clip.

Figure 5 is a schematic representation of a transverse cut of the nozzle plate containing a scratch. In this example, the print head is not sealed with blue tape, but with a protector clip (grey rubber foam) that keeps a permanent pressure on the nozzle plate. Figure 5 illustrates how the channel that forms between the nozzle plate and the rubber sponge fills with ink by capillarity. The illustration shows that a correct print-head seal cannot be achieved by using only a protector clip, because there is no material to fill the scratches and prevent ink from entering them.

Figure 6 gives an overview of the different possibilities for the use of blue tape for cartridge sealing, with or without the additional use of a print-head protector clip. Only the "green-colored" methods presented in Figures 6f, 6g, 6h and 6i will give good protection against leaks.

If the blue tape is applied by hand without adequate pressure (Figure 6a), the channel will rapidly fill with ink if the cartridge is not inserted immediately into a protector clip (Figure 6d). However, by using the protector clip in addition to the tape, the blue tape's adhesive fills the channels, providing a reasonable adhesion with the inner lateral channel walls and thereby preventing the ink from entering (Figure 6g). Consequently the cartridge is protected against leakage.

One important factor during blue tape application is the cleanliness of the nozzle-plate surface (Figures 6b, 6e and 6h). If there is any residual material like dirt, dried-up ink or oil/grease on the nozzle plate before blue tape application, it will remain there between the adhesive and metal surface (Figure 6b), preventing a correct adhesion of the blue tape to the nozzle plate. If there is no additional application of a protector clip (Figure 6e), the ink will slowly infiltrate the channels along the residual material and cause the blue tape to loosen. The final leakage generally occurs some weeks later or during air transportation, when the cartridge is no longer under the refiller's control. For example, during air transportation there are considerable pressure variations that may force the ink out of the cartridge, through the nozzle holes and into the micro-scratch network to loosen the blue tape. This problem can also be avoided by an additional application of a protector clip (Figure 6h), because the permanent pressure caused by the protector clip's rubber foam will inhibit the ink from entering into the scratches.

The only successful and relatively secure method of using blue tape without an additional protector clip is a careful preparatory nozzle plate cleaning and subsequent print-head drying (Figures 6c, 6f and 6i), followed by blue tape application. Cleaning with deionized warm or hot water (also hot vapor) or cleaning solution is recommended in order to guarantee total removal of residual materials from the metallic surface, followed by nozzle plate drying with warm air. Manual execution of this preparatory process is rather complicated, and therefore acquiring special automated devices for this operation is strongly recommended. There are also machines available that use deionized water vapor for this cleaning process, and additionally the vapor heat causes automatic drying of the print head. Unfortunately, automated devices for carrying out this preparatory cleaning are relatively expensive and therefore indicated only for companies with higher cartridge volumes. For smaller volumes, using an additional protector clip may be the cheaper solution.

After this preparatory nozzle-plate cleaning and drying process, the blue tape application (under pressure) will immediately cause the adhesive to come in contact with all of the metallic surfaces, including the inner lateral walls of the scratches (Figure 6c), causing a strong and durable adhesion between the blue tape adhesive and the nozzle plate. Even without an additional protector clip, this process significantly reduces, but does not completely avoid, the loosening of the blue tape during storage and transportation (Figure 6f). In practice, a few leakage problems have still been observed. As seen in Figure 6, 100 percent protection against leakage can only be guaranteed by additional use of a protector clip. Furthermore, when using the cleaning/drying method, manual application is impossible because the necessary uniform pressure on the whole nozzle plate area cannot be provided by hand. Again, special automated and relatively costly devices are needed for this operation.

Conclusions and Final Recommendations

The sealing of refilled ink cartridges using blue tape is indispensable in order to avoid ink leakage during cartridge transportation and storage.

The blue tape selected should have mechanical and adhesive properties similar to the original HP blue tape, because otherwise the applied tape could loosen in storage or could leave adhesive residues within the nozzle holes, which would clog the nozzle holes after final tape removal. Special preparatory nozzle-plate cleaning is not necessary before applying blue tape if a cartridge protector clip will also be used. When using an additional protector clip, blue tape application can be done manually without major problems.

In summary, the only relatively secure method of sealing cartridges without using the protector clip is a careful preparatory nozzle plate cleaning and subsequent drying, followed by automatic application of blue tape using specialized machines. These machines are available in the supply market, but they are relatively expensive and thereby only recommended for companies with higher cartridge volumes. Manual blue tape application is not possible in this case, because to achieve good blue tape adhesion on all of the microscopic nozzle plate surfaces (including the inner lateral scratch walls), a total uniform pressure impulse on the whole nozzle plate area is needed — pressure that cannot be executed manually. R

Contact Dr. Wolfgang Reick of TB Acessorios do Brasil at wkreick@gmx.de.