WHITE PAPER

spencerLAB DIGITAL COLOR LABORATORY

Thermal InkJet Cartridge Reliability

HP's TIJ 1.0 Industrial Print Cartridge

Executive Summary

HP TIJ 1.0 (Thermal InkJet) cartridges are widely used throughout the world in critical banking and financial transaction applications, such as in ATMs, at bank teller stations and in check franking equipment. They can see extreme temperatures (ranging from sub-zero winter cold to blistering summer heat) and heavy duty cycles – and are still expected to print legibly and consistently, day in and day out. Original HP sets a high standard; HP estimates a TIJ 1.0 reliability of 99.98% over its 28 year life.

The *spencerLAB* division of Spencer & Associates Publishing, Ltd., was commissioned by the Hewlett-Packard Company (HP) to perform a detailed assessment of the Reliability of the TIJ 1.0 print cartridges. *SpencerLAB* has established a premier reputation in the evaluation of print quality, performance, and cost, as well as reliability over more than two decades.[1] Our in-depth assessment of the C6602 and the 51604 TIJ 1.0 cartridge reliability was facilitated by HP granting access to their Singapore and Malaysian manufacturing facilities to observe production first-hand, and interview design and manufacturing engineers as well as management.

On the surface, the HP cartridge appears to be a rather simple device, but the surprisingly complicated and sophisticated manufacturing processes we observed made it clear that much goes into its design and manufacture. For example, one notable area that caught our attention was the tremendous effort HP puts into eliminating any trapped air in the ink. Air-in-ink is one of the biggest reasons why cartridges prematurely fail or print intermittently or illegibly. HP goes to great lengths in the manufacturing process to prevent trapped air and employs many tests and double-checks to screen it out. It seems virtually impossible for a cartridge to slip through HP's quality process and cause problems in the field.

This white paper documents many other aspects of HP's manufacturing process that contribute to HP's 99.98% reliability number, as well as shares *spencerLAB's* independent test results. Recently non-HP versions of the HP cartridges have appeared in the market. *SpencerLAB* performed an accelerated storage test that HP passed with zero problems; *40% of the non-HP cartridges experienced failures such as leaking, excessive ink evaporation, early failure, even printheads falling off.*

1. As an example of specifically related work, *spencerLAB* recently tested and evaluated cost-effectiveness of refilled HP TIJ 2.5 thermal inkjet print cartridges for the mail-addressing market. The white paper "Are Refilled Print Cartridges Really Cheaper for Mail Addressing?" is publicly available at http://www.spencerlab.com/reports/SpencerLab-HP-TIJ-2.5_WhitePaper_Feb2012.pdf

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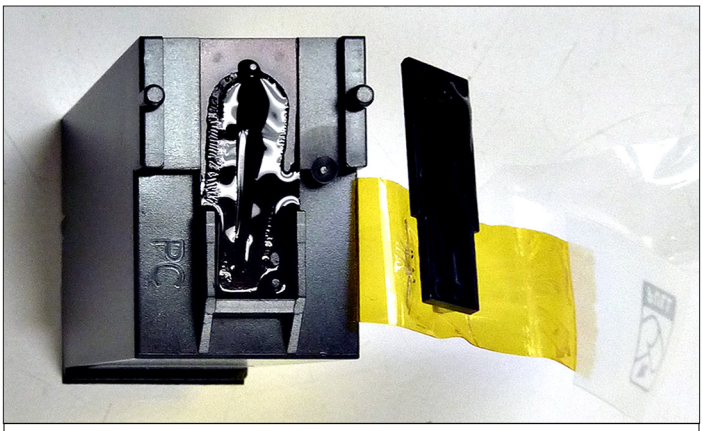
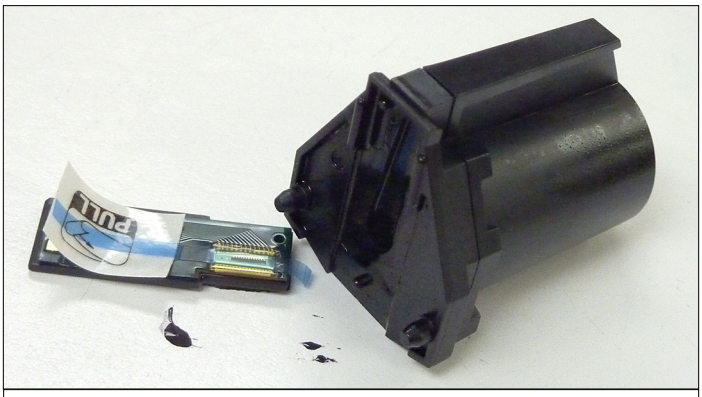
The hidden cost to a financial institution of low quality like this is many times greater than the mere replacement cost of the cartridge – service calls, damage to printing equipment, getting fewer prints per cartridge – all greatly outweigh any savings on price.



Non-HP C6602 Cartridge: Dead-on-Arrival
Post-Storage Printhead Separation



Non-HP 51604 Cartridge: Dead-on-Arrival
Post-Storage Printhead Separation, Ink Leakage

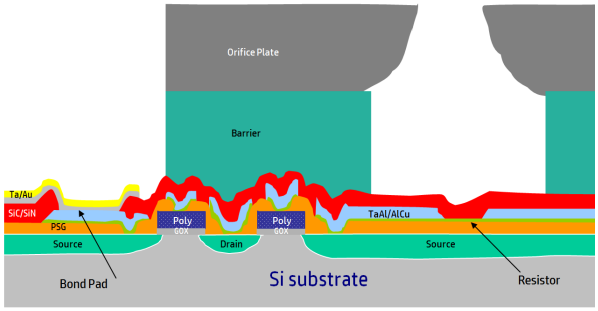
*Spencer*LAB is pleased to go on record with these results, documenting the individual as well as technical commitment to Quality and Reliability that we observed.

This complete white paper is available for free download at http://www.spencerlab.com/reports/

TIJ 1.0 Cartridge Architecture

In order to assess the reliability of these thermal inkjet cartridges, we had to understand their architecture – what they are made of, and what the critical components are. *Spencer*LAB was granted access to the confidential research and manufacturing facilities where HP develops and produces their TIJ cartridges, including the TIJ 1.0 cartridge series (C6602 and 51604) that are the focus of this assessment.

The Printhead Cross-section

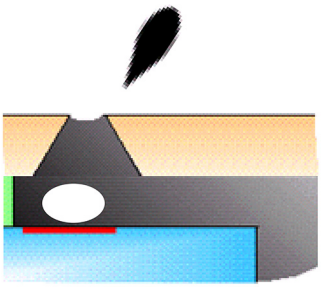


Brains of the Operation – the Printhead

The printhead is a beautiful example of MEMS technology at work. While it appears to be a sliver of glass adorned with some printed circuit wires, at the micro-scale level it becomes much more interesting. The substrate upon which the printhead is built is now silicon – which is more durable than glass, adding to reliability.

As may be visible in the following cross-sectional drawing, a series of materials are constructed in an extremely precise manner to create the electrical circuit that fires the pulse ejecting the precise amount of ink to form a properly sized dot at the correct place on the paper.

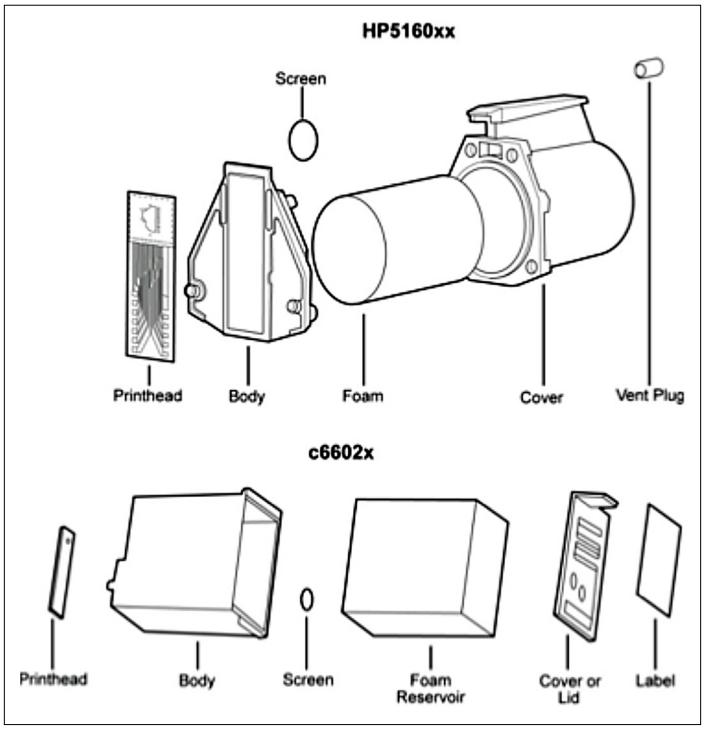
The firing chamber (as illustrated above) consists of a barrier with an opening only about 100 µm across (less than twice the width of a typical human hair), capped by an orifice plate. It defines the ink inlet as well as the firing chamber volume. The critical design must control ink flow rate and other parameters while avoiding bubble traps as well as electrical shorts. Precise slots through the printhead allow ink to properly flow from the cartridge body to the firing chambers. The orifice nozzle must have a convergent bore shape.



Any misalignment in attaching the orifice plate can change the trajectory of the ink, causing an error in its location on the paper; shrinkage or expansion can also cause puddling of ink and/or small or inconsistent dot sizes; all effecting the output print quality.

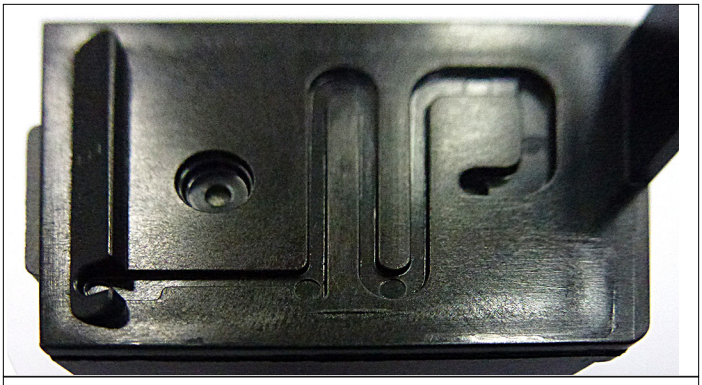
Simple yet Complex – the Body & Cover

The body, key components, and cover for both evaluated TIJ 1.0 cartridge types are illustrated below.



The body is designed with datum surfaces from which accurate distances and positions can be ascertained. The printhead is secured to the body in precise alignment with these datums. The screen is a high-performance filter attached to the body that assures ink passing to the printhead is pristine. The high-density foam provides for smooth, consistent ink flow; it is precisely sized to fit without allowing any air pockets. Entrapped air can cause bubble formation, resulting in premature cartridge failure.

The cover and label of the C6602 have an interesting relationship. We learned that the label has a rather important functional role as well as its informative one. Positioning of the label on the cover is a critical parameter, since together they form a labyrinth (column 2 above) that maintains proper air pressure within the cartridge, allowing a controlled flow rate of incoming air to replace the ink as it is ejected.



C6602 Cartridge Cover Awaiting Label

Just like when you hold your finger on top of a straw filled with water and the water doesn't come out, insufficient air would create a partial vacuum, limiting the flow of ink, and potentially causing cartridge drool (leakage) and/or entrapped air. Bottom line, if the label was not put on correctly, the cartridge may not work properly.

Match made in Heaven – the Ink

As previously noted, ink is much more than just colorant and water. In addition to additives to control absorption, bleed, clogging, etc., the ink must be manufactured to HP's exact specifications and be devoid of contaminants.

Perhaps it is obviously important to note that the ink is safe, stable, lightfast, and biocidal. HP freely and easily provides the MSDS (Material Safety Data Sheet) through internet download; a user does not need to call the manufacturer to inquire if there is such a document and, if so, wait for it to be sent. There is nothing to hide, the information is readily available to the public. It is apparent that HP is a US company and is compliant with US regulations and goes above and beyond providing what is legally required.

We were impressed to learn of all that goes into the development of the HP ink; it's a complex interplay of fluid dynamics, chemistry, and engineering. Among the long list of components and processes that go into the making of the ink, one of the most interesting items to us is the addition of biocides to the HP ink to protect the ink against bacterial infestation and growth, which can decrease the shelf-life of the ink – like a prophylactic antibiotic so to speak.

We were surprised to learn that ink can damage the firing resistor. Ink is in contact with the resistor and can leave a residue that builds up over the cartridge life. This can become quite problematic, particularly on the larger-capacity C6602 cartridge. The residue changes the thermal performance of the resistor, thereby changing the performance of the firing circuit. This change tends to cause a reduction in the resultant drop size, in turn creating a smaller, less dense dot on the paper – and resultant print quality degradation, or even the inability to print at all – not what you want or expect of the cartridges you buy. HP's ink formulation includes proprietary additives that inhibit build-up and corrosion of the printhead electrical circuits and dissolves this residue before it can become a problem.

Bottom line, even if a Non-HP cartridge with Non-HP ink initially printed acceptably, the ink might cause sufficient loss of print quality to create premature cartridge failure.

Design and Production Issues

"Every pen ships with one quarter million man-hours of experience"

– Aidan Feighan, HP Specialty Printing Systems Applications Engineer

Each part that goes into the HP TIJ 1.0 cartridge is designed, formulated, and tested many times over to assure the HP cartridge reliability. This is evident again and again while at the design and production facilities.

Keep it Flowing – Air-in-Ink

Trapped air is the enemy of reliable ink flow. Just like a siphon has to be filled with liquid – primed – the ink in a cartridge requires continuous flow. (Surface tension creates capillary action, the tendency of a liquid in a tube or absorbent material to flow – an air pocket breaks the surface tension.)

Air bubbles in an ink cartridge can cause havoc. The cartridge may stop printing with plenty of ink remaining; or the cartridge prints intermittently and the bank teller, for example, doesn't know if it is going to print or not; or the cartridge produces a low quality print with illegible or even missing characters. Imagine your $100 deposit printing as $10!

In our research we've learned about a number of places where air can be trapped in the cartridges. Both HP design and production pay special attention to identifying and eliminating these situations.

As an example, the foam is designed for a precise fit within the cartridge, minimizing the possibility of surrounding air inside the cartridge. During production it is compressed before insertion, and the air is replaced with carbon dioxide (nearly 100 times more soluble in ink). Its final size is confirmed with 0.0002" precision (human hairs being some dozen times larger) to assure proper insertion and proper contact with the screen.

As another example, filling ink cartridges is more than pouring ink from a 55-gallon drum into individual cartridges. Although, some companies may truly operate that way, we saw that at HP each ink color is separately processed through three stages to filter out entrained air prior to insertion. Even the insertion needle is uniquely designed to penetrate the foam without creating any air pockets.

HP TIJ 1.0 cartridge construction and manufacturing procedures prevent air bubbles from getting into the ink cartridge, and then perform a number of inspections and tests to confirm that each is "bubble-free".

In summary, trapped air within an ink cartridge can result in poor print quality, unhappy customers, or an "early failure" before the cartridge is at "end-of-life", stranding usable ink in the cartridge.

Thou Shalt Not Leak

Rule in effect at HP for over 20 years:

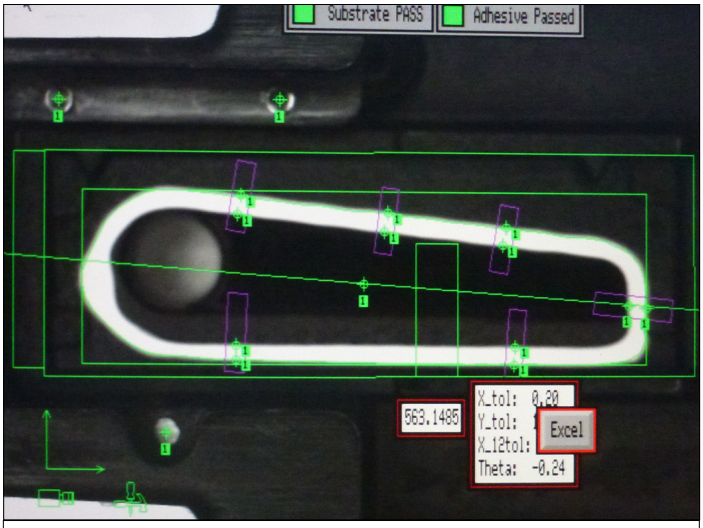
'Always design so that customers don't get ink on their hands'

– Greg Merten, founding HP inkjet division manager

HP considers ink on a user's hands to be a terrible sin as well as resulting in less usable ink.

Ink leakage has become essentially non-existent in HP TIJ cartridges. The body-cover interface is secured with a high-pressure, permanent seal. Similarly, the vent plug is inserted with the intent that it will never be removed.

Securing the printhead to the body is a much more critical operation. An exact amount of adhesive is dispensed in a precise pattern by a robotic arm. It is just the right volume and size to create a uniform wall to channel the ink as it flows to the printhead; the adhesive wall must be high enough to securely adhere the printhead to the body, but not so thick as to impede the ink flow. The adhesive is photographed and critical dimensions are measured *on every single cartridge* to assure proper application.



Printhead Adhesive Photometric Confirmation

Automated Production Factories

HP employs world class materials and automated production for the complex construction of its TIJ 1.0 cartridges. Raw materials are chosen for their robustness and compatibility. HP turns to world-class ISO 9001 certified suppliers to assist on the manufacture of the product[2]. The entire process is fully automated and provides for stringent testing, resulting in consistent manufacturing and output. HP's in-production and post-production multi-point quality assurance testing verifies a consistently high quality cartridge at each production level.

Ink is manufactured to HP's proprietary specifications at an ISO 9001 facility in New Jersey (USA). Printheads are manufactured in HP's own production facilities in Singapore. Final assembly and test has recently been moved to an ISO 9001 facility in Malaysia, where HP has taken the opportunity to incorporate its latest upgrades in the production line.

Mixology – Ink Production

Although *spencerLAB* has not had an opportunity to visit the facility tasked with HP's ink production (where it is manufactured to HP's proprietary specifications), our prior dealings with those onsite have been extremely professional and impressive.

HP long-term production engineers informed us that there has not been a quality control issue within their memory with any of the inks supplied.

Brainwork – Head Production

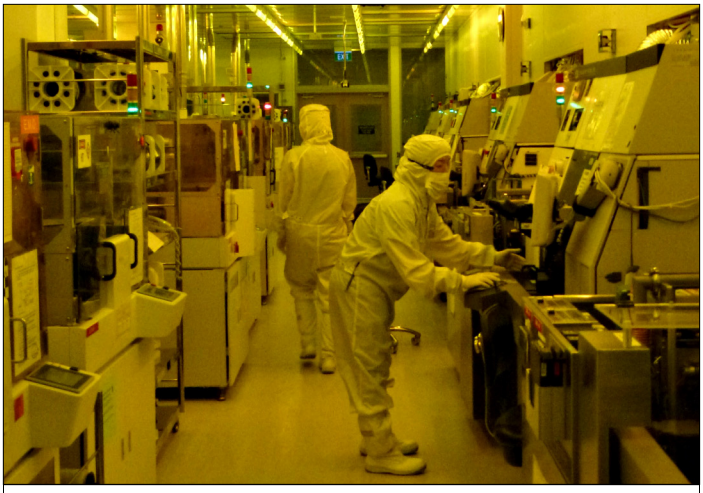
HP's Singapore printhead production facilities include a number of 1K and 10K clean rooms appropriate for state-of-the-art MEMS manufacturing.

It was rather interesting to learn about creating the 100 µm slot in the silicon substrate (through which the ink flows from the foam in the pen body to the resistor array/firing chambers). For reliable ink flow, elimination of potential air trapping debris, and consistent firing frequency response, the slot is drilled using a sequence combining a laser beam, an air jet, and a pressurized water stream.

HP's Printhead Electroplating Facility

The convergent bore shape of the orifice nozzle is achieved by a proprietary electroplating process that controls drop volume and trajectory (to achieve consistent dot sizes and placement). Many other procedures demonstrated to us had required HP's extensive research into appropriate manufacturing techniques that assure final product reliability.

2. Ink production at Fujifilm in NJ, USA; final assembly production at Celestica in Senai, Malaysia



Part of HP's Printhead Production

Before printheads are released from their production line they go through metrology to confirm channel width, alignment, and thickness. A final audit checks for residue, bridging, bubbles, etc.

Once fabricated, the printheads are placed on a tray by a programmable robot in a precise matrix for forwarding to the final assembly production line.

All Together Now – Final Assembly

HP designed, refined, and operated the final assembly and test production line in the USA over more than two decades. Production was recently relocated to an ISO 9001 contractor in Senai, Malaysia.

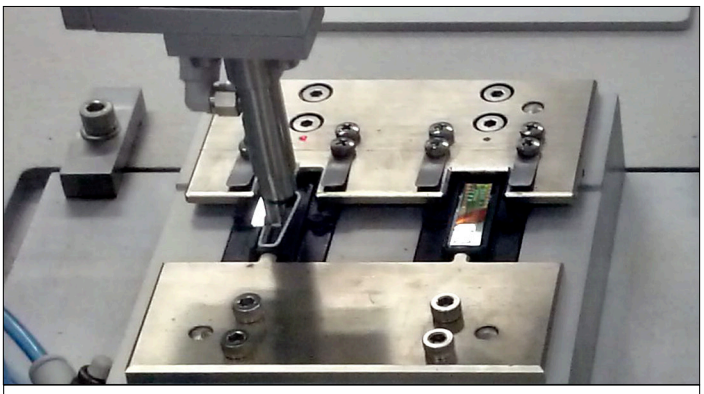
SpencerLAB visited the Senai facility and observed the production line first-hand; we interviewed design and manufacturing engineers as well as management. The automated factory process is quite impressive, as are the staff.

The facility is environmentally controlled, clean, and pleasant. Employees seem knowledgeable and comfortable in their roles. Operators are first trained, and then receive on-the-job-training for another 1-2 months (during which their decisions are confirmed after-the-fact by a fully-trained operator) before they are on the production line with full responsibility.

"[HP's TIJ Production Facility] has Black Belt-trained staff and members of ASQ."

– Aik Hong, Malaysia Site Manager

HP's automated ink cartridge production yields a consistently high quality product. The line is designed by HP engineers specifically for TIJ 1.0 production with numerous precision optical and mechanical measurement stations; we observed these mechanical measurement stations to be generally running at 0.0002" precision. Calibration is performed daily, weekly, and monthly, as appropriate to ensure that proper tolerances are maintained.



Laser-Guided Robot Placing Printhead on Adhesive

With the relocation, HP has taken the opportunity to incorporate its latest upgrades, highlights of which include the conversion to a silicon-based printhead, and the incorporation of state-of-the-art robotics.

The production facility assembles the printheads, bodies and covers, loads the ink, and packages the products. The TIJ 1.0 cartridge body and cover start life independently and are joined with the printhead during assembly.

The automated production line has minimal human interaction as needed to maintain and to calibrate the machinery, assure material is available for the line, perform certain quality assurance checks, and see the packaged cartridges on their way.

Production control limits are set tighter than design specs; extremely thorough in-line testing as well as final production tests, and contamination prevention combine to reduce the possibility of problem cartridges and the associated costs to users.

Small things matter. The nozzle tape provides ink evaporation reduction and corrosion resistance; it must be applied on a specific location. Any vapor loss is money paid for ink that basically "goes up in smoke". Additionally, ink evaporation may change overall ink composition, altering its characteristics, thereby affecting print quality, print longevity, etc.

HP TIJ Production Facility

Another example: the adhesive between the printhead and the body must be cured by controlled heat over a period of time, without allowing the printhead itself to become overheated. A twelve-stage heating assembly was developed, assuring adhesive flexibility for environmental changes (hot/cold, low/high humidity) that may occur during shipping and storage, yet providing firm attachment.

For Continuous Process Monitoring (CPM), audit operators are required to internalize the full acceptability criteria, and what requires rework.

"Software evaluation programs are used to analyze all the measurements and other data – identifying not only problems but trends that might lead to them before they happen."

– Aik Hong, Malaysia Site Manager

Packaging is performed on a separate, high-speed line.

Testing, Testing, Testing

That's what it takes to maintain the high production quality that HP delivers. We've previously mentioned testing – more than once. Testing is so pervasive and intertwined within the overall ink and cartridge design and production that it's impossible to discuss them without including some testing highlights.

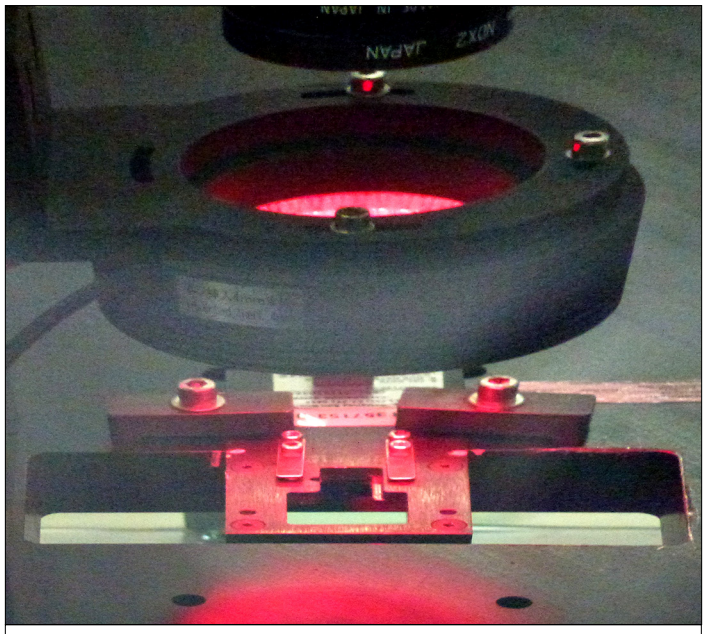
We observed three categories of tests, and performed one of our own.

100% Robot-Inspected

Printhead manufacturing includes control of critical barrier dimensions, thickness, registration, residue, and adhesion; orifice plate manufacturing includes controls for alignment, and material shrinkage and/or expansion.

The cartridge body and cover are subjected to quite a large number of checks as they progress through the automated assembly line – from simply presence in the allocated carrier to full cartridge operational performance before packaging.

Examples of in-line testing include: every foam height is measured after insertion; optical confirmation of critical adhesive dimensions and three-dimensional measurement of printhead relative location is confirmed preceding printhead attachment and heat-curing. We observed many more in-line tests (and one or two failures added credibility) assuring us that the final HP cartridges would only contain parts that meet HP's design specifications.



In-Line Optical Measurement Station

Most tests use optics or metrology. Metrological measurements are typically made with 0.0002" precision. We observed production tolerances held to 85% of spec to assure overall reliable performance.

Failure Mode and Effects Analysis is performed during the manufacturing process and verifies for 100% of the cartridges that all components are present, dimensionally in specification, in perfect position and attached and sealed properly. Checking 100% of the cartridges on the line is an exceptional number.

Checks and tests are also in place in the preparation of the ink and for filling cartridges with the correct amount of ink. We observed cartridges on the line being filled within a range of perhaps 1/10th of a gram.

Once the cartridge is fully assembled and filled with ink it goes through its final in-line test. The Automatic Print Quality Test (APQT) system verifies that *all* of the cartridges print to HP's specifications before they are packaged to be shipped. In order to proceed, each cartridge must meet full print quality specifications. During the just-completed month of July we noted the yield through APQT was 99.81%.

Auditing is Good

In addition to all the automated testing within the production lines, we noted a number of off-line quality assurance tests being performed.

Printhead barrier channel width, alignment, and thickness are confirmed via metrology, and an audit to check for residue, bridging, bubbles, etc., as mentioned above. 100% of the printhead substrates get optical and metrological inspections for drill slot dimension and x-offset, shelf length, and wettability (for its capillary force effects on flow rate). Every orifice plate bore is inspected for bore diameter and defects. After attachment to the wafer transfer system, there is full inspection of the orifice plate to the barrier and resistor array to assure its precise alignment.

Quality control of the TIJ cartridges is generally on a continuous sampling basis. The line is paused every hour and a variety of data about completed run is recorded – including the number of cartridges completed and ready for shipping. Every hour ten completed, shippable cartridges are pulled from production and tested for possible entrapped air (none had been found to date since the line moved to Malaysia). Hourly measurements also confirm that the ink loads are to spec.

Every time the packaging line is started, a sample of six packaged cartridges are taken from the line and the line is paused. The packaged C6602 cartridges are placed underwater and a vacuum is applied to the air above; the lack of any air bubbles indicates the package is securely sealed. The aluminum-packaged 51604 cartridges are briefly subjected to high temperature; the increased package volume indicates sealing integrity.

Every HP TIJ 1.0 cartridge is laser inscribed with a unique identification code and is tracked as it makes its way through the production line. Lot and date codes are also recorded for each cartridge, with date codes including the exact time of 'birth'. The corresponding 2½-year-later 'Install By' month and year is stamped on each HP cartridge package so the buyer can quickly see that supplies are fresh and within warranty.

Computer monitors display everything from the current hour's individual test yields to selected trends as data is collected and analyzed. We also observed perhaps a half-dozen charts for each C6602 and 51604 cartridge type posted to display current trend lines as well as displays showing the most recent hour's production yield for all to see.

Let's Really Make Sure

At the end of every day, one dozen of each C6602 and 51604 completed, shippable cartridges are pulled from the production line and sent to HP's test lab in Singapore for thorough system testing. We also visited this laboratory and spoke with the senior test engineer.

Every one of these 24 cartridges are thoroughly tested. These tests include Drop Weight, Drop Velocity, Print Quality, and Drop Yield. Print Quality confirms the APQT results using a more robust print file. Drop Yield utilizes a custom test fixture that allows millions of drops to be ejected at high rate; after rated yield is reached, testing is continued to measure actual end-of-life and confirm it is safely beyond rated yield (we saw cartridges yielding as much as 20% additional drops).

Should a cartridge fail any of these system tests, it is subjected to more rigorous testing and failure analysis. This includes "destructive testing", as necessary

to analyze the internal cause of failure. The need for such "autopsies" is rare, but a critically important role for the lab, since understanding the cause of any failure is absolutely key to eliminating it.

Lightfastness of output is important to clients who must retain records. HP reports that internal tests show that receipts printed with original HP C6602 inks remain legible to the human eye for 30-40 years in indoor light levels of 125 lux[3].

A *SpencerLAB* Confirmation

Original HP TIJ 1.0 cartridge packaging ensures ink is retained within the cartridge where it belongs, without drool (leakage) or air bubble infiltration – and that the cartridge is ready to print upon insertion into the printing device. HP subjects its packaged cartridges to a number of tests, including accelerated aging in order to determine optimal shelf-life. HP TIJ 1.0 cartridges are guaranteed to perform with up to 2½ years of shelf life.

As a test lab evaluating HP's TIJ 1.0 cartridges, this is an area that, on a sampling bais, *spencerLAB* could independently examine.

Based upon various Applications of the Arrhenius Equation,[4] we estimated that one year of storage at 23°C (73.4°F)[5] can be simulated by two weeks[6] of storage at 60°C (140°F) at low humidity. Therefore, a 2½-year shelf life can be simulated by five weeks of such storage.

For our test we stored 20 HP C6602 and 20 HP 51604 new HP TIJ 1.0 cartridges still in their original packaging in a chamber at 60°C, 10% RH for five weeks. We also stored the same number of Non-HP new C6602- and 51604-compatible cartridges in their original packaging along side of them.

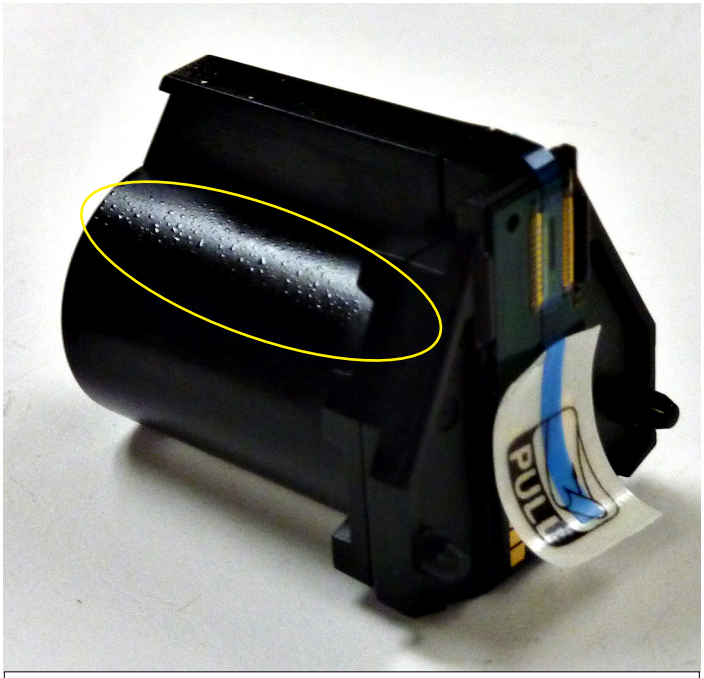
We monitored each packaged cartridge's weight change after two, four, and at the end of the five weeks. All cartridges were then removed from their packaging, observed for visible changes, and tested for print quality.

At the end of five-weeks all 40 of the HP TIJ 1.0 cartridges performed with appropriate print quality. However, ***40% (16) of the 40 Non-HP cartridges did not perform properly***, either failing mid-print or not being able to print at all. *This implies that at 95% Confidence, 24.8% – nearly one-quarter – of the Non-HP cartridges would be expected to fail!*

The Non-HP C6602 cartridges lost an average 5.7% of their estimated usable ink[7], more than 6 times the average loss experienced by the HP C6602 cartridges. More surprisingly, *the Non-HP 51604 cartridges lost an average 19% of their estimated usable ink,* ***more than 150 times*** *the average loss experienced by the HP 51604 cartridges.*

Most surprising observations of the cartridges where:

- **Some ink leakage was evident in 14 of the 40 Non-HP cartridges**



Non-HP 51604 Cartridge: Ink Leakage

3. Work areas where visual tasks are only occasionally performed http://www.engineeringtoolbox.com/light-level-rooms-d_708.html

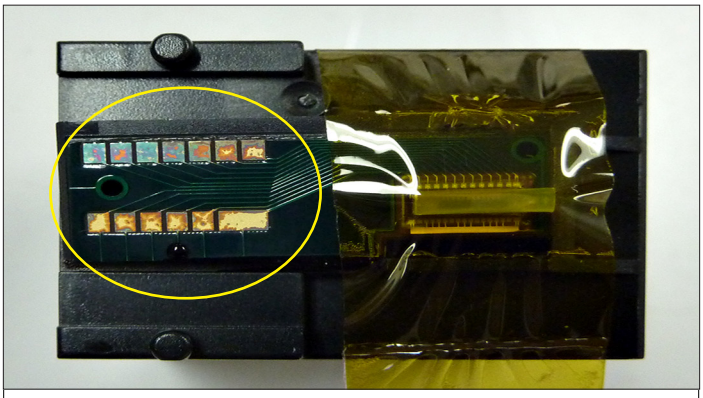
4.. http://www.intelligentformulation.org/uploads/pdf/ASAP%20Webinar%20presentation.pdf

5. ISO 24711 standard office norm

6. Various references estimate one year of storage at office ambient can be simulated by 60°C storage for 2, 3, or 3.7 weeks; although we assumed 2 weeks, all cartridges were simultaneously subjected to the same accelerated storage and the relative comparisons therefore remain valid.

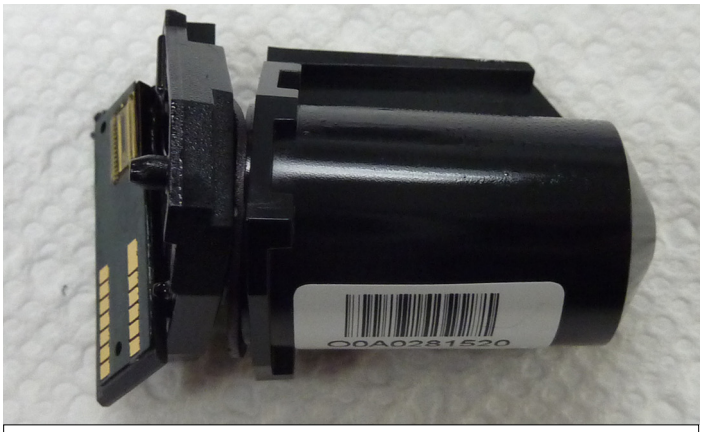
7. Estimated at 90% of the nominal ink fill.

■ **Printhead contact corrosion was evident in 9 of the 20 Non-HP C6602 cartridges**



Non-HP C6602 Cartridge: Corrosion

■ **The printhead separated from the body in 9 of the 40 Non-HP cartridges; in one occasion body and cover of a Non-HP cartridge also separated**



Non-HP 51604: Printhead & Body Separation

■ **None of the HP cartridges showed *any* of these defects**

*Spencer*LAB'S test demonstrated that over this period, HP cartridges did not suffer any print quality degradation, did not suffer any significant ink loss or leakage, had no corrosion, and stayed intact. However, the Non-HP cartridges suffered quite significantly in all of these areas, highlighting the reliability risk.

*Spencer*LAB testing has shown that HP provides quality packaging of TIJ 1.0 cartridges that is essential to assure no significant ink loss, ink leakage, contact corrosion – and significantly decreased probability of dead-on-arrival TIJ 1.0 cartridges.

Elite Suppliers, Environmental and Social Stewardship

HP is committed to compliance with world-wide regulations, consumer safety, and the environment. HP requires its suppliers to be accountable, both to HP and to society. Highlights:

All HP TIJ 1.0 major suppliers are ISO 9001 compliant. This quality management standard helps organizations achieve internationally recognized performance. HP engages such suppliers for their commitment to the control and improvement of product quality and elimination of costs caused by poor quality. This enables high quality cartridge production.

HP suppliers are required to comply with RoHS (Restriction of Hazardous Substances), and HP is committed to the EU RoHS 2 and China RoHS Phase II, which restrict potentially hazardous substances to limit environmental, health, and safety risks. HP supports the REACH (EU standard of Regulation, Evaluation, Authorisation and Restriction of Chemicals) objective of improving the protection of human health and the environment.

HP expects all suppliers to operate in a socially and environmentally responsible manner, including:

- Ensure their operations and products supplied to HP comply with all national and other applicable laws and regulations
- Understand and reduce environmental impacts of their operations and products supplied to HP, minimize use of hazardous materials; promote energy and resource efficiency, reuse and recycle, and reduce emissions to air, water, and soil
- Ensure that parts and products supplied to HP are DRC (Democratic Republic of the Congo) conflict-free
- Integrate environmental, occupational health and safety, human rights and labor policies, and ethics into their business practices

Additionally, HP's Planet Partners program enables convenient, and proper, recycling of HP cartridges and other electronics. Since 1997 HP has taken back over 300 million ink and toner cartridges. HP engineers have learned how to reuse the plastics through a closed-loop recycling system, a cleaner process than shredding. HP has made over 500 million cartridges using this closed-loop process.

Lower Price ≠ Lower Real Cost

This detailed assessment has convinced us of one conclusion: There are significant unseen costs in these Non-HP C6602 and 51604 TIJ 1.0 cartridges. The astonishingly high probability that these Non-HP cartridges will fail after storage within their shelf life means untold invisible cost. These Non-HP cartridges may work for a while, but not stand up to the demands a professional institution places on them.

Worrying about whether or not mission-critical operations are going to be disrupted by a print cartridge problem is probably not where you want to spend time and energy.

HP takes the worry out of buying ink for use in your printing hardware investment. HP is devoted to the quality and reliability of the TIJ 1.0 product line with on-going investments; keeping the product up-to-date with redesigns, updated materials, elite supplier resourcing, best-in-class manufacturing and rigorous testing practices. HP users are assured they are receiving a quality product – tested and warranted.

Like the procurement executive at a major U.S. bank noted: he couldn't remember a single quality issue with an original HP cartridge over 5 years in the job and hundreds of thousands of cartridges used by their thousands of banks.

Because bank employees are at the front lines, they are the ones that will deal with any issues created by an inferior facsimile of the HP cartridge – throwing them away when they prematurely stop printing, leaking into printing equipment and causing expensive service calls and down systems, customer inconvenience and unhappiness. All these "hidden costs" disguise the true cost of the cartridge.

Original HP inkjet cartridges offer high value. Be wary of cheap versions, only to pay a premium on the back-end when they fail to deliver as promised.

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September 2012

*Spencer*LAB DIGITAL COLOR LABORATORY

Serving the industry since 1989, Spencer & Associates Publishing, Ltd. earned a premier reputation for its expertise in evaluating key performance metrics of digital printing and imaging systems. The firm provides leadership in quantitative and qualitative comparisons – consultation and evaluation services, benchmark test software/hardware, and focus group management. Increasingly, Spencer & Associates is engaged to find solutions to new, complex printing and imaging challenges.

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