Lab Workstation Automation:
A Phased Approach to Sample Container Labeling

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"You have to walk before you can run." You've heard it in other contexts, but is it true in laboratory automation? Our experience indicates that it is. We've also learned that trying to automate everything at once is a prescription for disaster. Like the human progression from crawling to walking to running, labs that choose to automate do it most successfully in a logical sequence of steps, or phases, each one building on the foundation of the last.

Some Assumptions

In order to deal helpfully with this topic, we're going to assume several things:

- Your lab handles multiple (dozens to thousands) of sample containers on a regular basis, perhaps daily;
- Each sample container must be uniquely identified, and if additional samples are created from the original, those must be uniquely identified as well;
- Sample containers are tubes, vials, plates, slides, or some other type of lab container designed to hold and protect a chemical, reagent, body fluid, or other specimen for short-term processing and perhaps long-term storage.

We're also going to assume that laboratory productivity is one of your goals. Whether you're seeking increased throughput, fewer errors, quicker turnaround, or overall cost savings, you have elected to pursue automation as a way—perhaps the primary way—to meet those objectives.

Finally, we're assuming you will need measurable results to justify the investment. Even in public sector and not-for-profit labs, the need to improve operationally in a way that translates to the service you provide—or the quality and speed of the results you deliver—is always present. So we assume that there's a need both to improve the lab, and to "*prove* the improvement."

Sample ID Workstation Automation—A Very Good Place to Start

In order for labs to be efficient, samples must be identified in a common way as early in the process as possible. Sample intake or sample generation is often the first place—and always the best place—automation is deployed. Downstream automation becomes illogical at best and impossible at worst if sample identification isn't standardized. Automating the sample ID workstation at the beginning of the process is the single biggest step any lab can take in its automation efforts.

Our focus in this paper will be the automation of sample identification; that is our area of expertise and, as just mentioned, it is a critical and necessary step leading to a broad range of

other automation. While we will be using products available from our own suite, in most cases other sources may offer comparable solutions.

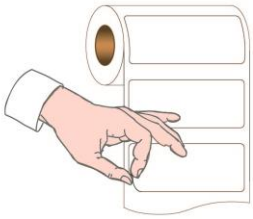
►*Manual application of sample ID labels*
The status quo at many labs is manual application of labels. There is nothing inherently wrong with that approach—many facilities have been using this tried-and-true method for years, and will continue to profitably do so. If your lab is currently doing manual label application, and all or some of the following are true of your situation, it might make sense to continue hand-labeling:

- Sample volume is very low and not expected to increase;
- Downstream scanning of manually-placed labels typically proceeds without problems or delays;
- Lab personnel involved in hand-labeling could not be better employed elsewhere in the lab performing other tasks;
- Overall productivity is sufficient to handle demand without compromising quality.

If hand-labeling continues to make sense, here are a couple of suggestions regarding the labels themselves:

1. Pre-printed sequentially-numbered labels might be the most cost-effective approach for manual labeling. Sequential numbers provide a "license plate" that uniquely identifies that specific sample and enables the details of its identity to be accessed via the database.
2. Label sets, or several like-numbered labels die-cut into a single group, can be provided to accommodate the need to identify different containers with the same number, or even identical numbers with varying prefixes or suffixes. "Piggyback" adhesives can also be utilized to make it possible for some labels to be transported on the original container for use later in the process.
3. Regardless of whether the labels are pre-printed or printed on-demand/on-site, providing a die-cut label with waste removed might aid in easy removal from the release liner. As you can see from the graphic, the margin around the label makes it easy for the person to grip the edge of the label and remove it without attempting to lift an edge that is nestled against the adjacent label.

►*Apply-only devices for pre-printed labels*
As mentioned above, pre-printed labels are often the most cost-effective identification method available in today's lab. Labels can be custom-engineered to survive the environment in which they're used, and sequence integrity—the prevention of duplicate numbers—can be guaranteed if labels are purchased from a vendor offering that feature.



Fortunately, using pre-printed labels doesn't preclude the use of automatic application. There are devices specifically designed to rapidly "capture, peel, and place" a pre-printed label to a flat surface with a placement accuracy of ± 0.35mm. One such device is pictured below; its price is around $21,000 (US).

There are several reasons labs adopt print-and-apply systems:

- Need for increased throughput without adding staff;
- Liability for repetitive stress injuries associated with manual labeling;
- New projects are delayed or shelved because of staff shortages;
- Label placement errors are reducing downstream throughput;
- Client perception of reliability of results is compromised by haphazard label placement.

►*Semi-automatic application of sample ID labels*

Perhaps some of the criteria listed above for manual application do not apply to your situation—your sample volume is growing, you occasionally have problems with manually-placed labels, there are other tasks those scientists or technicians could be engaged in more productively than applying labels, and/or you'd like to increase overall lab productivity to accommodate new clients, new projects, or new technologies.

EVALUATING ALTERNATIVES & JUSTIFYING AUTOMATION EXPENSE

How should semi-automatic labeling devices be evaluated and justified? While a detailed financial analysis is beyond the scope of this paper, a common-sense approach would include several key variables:

1. Determine cost of current labeling method:
    a. Fully-loaded cost of staff member(s) manually labeling X percentage of their time dedicated to that task
    PLUS
    b. Identifiable cost(s) of fixing problems downstream caused by mislabeling or errant label placement (incorrect or missing data, rescans required, etc.)
2. Determine performance requirements of automation device
    a. Must it be capable of labeling both flat & cylindrical objects? (If yes, how critical is change-over time between the two?)
    b. Label size(s) required?
    c. Throughput required?
    d. Standalone operation or integrated with LIS?
3. Determine cost to operate automation device
    a. Purchase price PLUS
    b. Consumables (label stock/ribbon, print-heads)
4. THEN, calculate total value of estimated performance improvements
5. COMPARE cost of status quo to automation.

Regardless of the reason(s), the next logical step in workstation automation is the use of a semi-automatic device. For example, a print-and-apply applicator may offer some dramatic benefits without a significant capital investment. A thermal transfer printer fitted with an automation module that takes the label just printed and applies it automatically, when prompted by an operator-activated hand or foot switch, might provide several advantages:

- Throughput can be significantly increased over simple manual methods;
- Label placement can be precise and consistent, improving downstream scanning results;
- Information required on the label but not known until the time the label is needed can be provided by the printer operating in real-time;
- Repetitive stress injury claims, or just simple fatigue, can be reduced by a simple semi-automatic device.

Below are descriptions of two semi-automatic labeling devices with which we are familiar.

1. A+1000 printer-applicator. The A+1000 applicator is an 'all-purpose' device that works consistently in a wide variety of end-use environments. Built on a German-engineered CAB printer platform, it can print-and-apply labels to both flat and cylindrical surfaces with minimal changeover time. Resolution of the printer is up to 600 dots per inch (dpi), so symbol quality and text readability are outstanding.

   A long list of built-in interfaces (peripheral connection, PC/SPS interfaces, and network connections) eases integration; the device can also be run in stand-alone mode. And why CAB instead of a more well-known printer brand? The elegance and simplicity of their design make these printers more user-friendly, easier to load, and fewer moving parts to monitor. Typical price for the A+1000 (pictured below left configured for application of label to a cylindrical surface, and below right configured for flat surface application) is around $$13,000 - $27,000 (US).

2. TubePro PR100i. If you only label cylindrical objects in your lab, such as tubes and vials, the PR100i might be a good choice, especially if you're labeling vials of multiple sizes and shapes. Rollers, which are customized to accommodate a specific tube type, are easily changed over in only seconds, and no tools are required.

   The PR100i can handle tube and vial sizes from 6mm to 50mm outside diameter, plastic or glass, capped or uncapped; it can print label sizes from 6 mm x 6 mm to 100 mm x 100 mm, and place them within ± 0.2mm of the desired location. Both linear

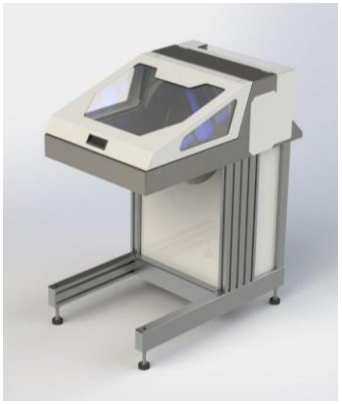
and 2-D symbols can be printed, and a trained operator can handle up to 900 tubes/hour with the PR100i. Typical price for the TubePro PR100i (pictured at right) is around $33,000 (US). Note the finger rest adjacent to the red activation button. This prevents the operator's hand from straying into the path of the piston during the label applying step.

►*Automatic application of sample ID labels*
High volume labs often require the labeling of hundreds, even thousands of tubes or vials on a regular basis. And even if your lab's volume is less than that, automation often pays for itself when labs consolidate their weekly sample ID needs into a single run. So labeling 1000 containers for the week via an automated device, for example, is much more efficient and cost-effective than manually labeling 200 per day. (One lab produces only 2000-3000 labeled containers per month, but was able to show a positive ROI for automatic application.)

Automation is now available that starts with bulk tubes being fed in one end, and perfectly labeled and racked tubes come out the other end. Justifying the added expense of more sophisticated automation is not as difficult as one might suppose. As a general rule, a lab that can improve its throughput by as little as 20% can save over $100,000 annually in labor costs. From that perspective, automating the sample ID workstation might show a return-on-investment in a short period of time.

Automation of this complexity is often assembled in a modular approach, with different modules designed to perform a specific task, then "pass on" the item to the next module for the next step in the process. We will outline below the operation of three modules that can accomplish fully automated tube/vial identification from raw, bulk-fed tubes through to labeled and racked tubes ready for use.

1. <u>Flex TVF (Tube and Vial Feeder).</u> The Flex TVF (pictured below) is the first module in the fully automated workstation. It is a gravity-fed hopper that accommodates hundreds of plastic or tempered glass containers. Vials of any outside diameter from 6 mm to 15 mm can be loaded into the hopper, and they can measure from 12 mm to 90 mm in length. Tubes and vials can be plastic or tempered glass, capped or uncapped.

   Depending on their size, several hundred vials can be handled at once in the hopper, and if the vials are small, up to 2000 can be loaded at once. This translates to about two hours of operation without human intervention. While all the vials must be of the same shape and size, there's no need to orient them in any way—the Flex TVF will do that. And if you have multiple sizes of items to

label, changeover is quick and does not require any tools.

One of the great advantages of the Flex TVF is its quiet operation. Compared to the noise created by a traditional vibratory bowl, the Flex TVF is whisper quiet, generating only around 65 decibels. Normal conversation, heard from three feet away, typically registers at 60 – 65 decibels, so you know the Flex TVF will never disturb the work environment in your lab.

After the tubes drop off the wheel, they fall onto a belt that carries them quickly to a device that ensures consistent positioning for the next module. A sensor detects which end of the vial is capped, and flips around those that do not match the desired position.

The correctly positioned vial is now on the belt, ready for further handling by your automation. In the next section, the operation of the actual print module is described, a more automated version of the TubePro PR100i mentioned above.

2. Flex TubePro PR100i. While the PR100i can operate standalone, as described above, it can also serve as a module within a totally automated workstation. It can accept correctly positioned tubes and vials from the Flex TVF and rapidly print and apply a label to each one, and subsequently pass those labeled tubes to the next automation module. When operating as part of an overall system, the PR100i prints a high-resolution label and wraps it around the vial which is nestled between the rollers customized to its shape and size. This ensures the label is placed in exactly the same position each and every time, cycle after cycle. A precision actuator feeds, prints, and places labels within a placement tolerance of ± 0.2 mm. And the printer itself, with a 600 dpi print-head, provides high resolution images which translate to scannable barcode symbols—either linear or 2-D—and virtually eliminates non-reads and mis-reads.

   After the vial is labeled, the second picker removes it from the roller set. These two picker devices operate in tandem to provide the maximum efficiency in loading and unloading the printer-applicator.

   It is at this point in the process where other automation can be added, such as robotics for placement of labeled tubes into racks, a common need in high-volume labs. That leads us to the final module in our workstation automation process, discussed below.

3. JAZZ Robotic Placement Cell. The JAZZ Cell is a configurable automation platform engineered to enhance the value of the tube/vial handling and labeling automation which precedes it in most process flows. The cell can be integrated with other material-handling automation such as tray handlers, indexers, and conveyors for a turn-key solution. Robotics can also be implemented in the form of standard SCARA and internally developed multi-axis robotic units. The JAZZ Cell incorporates PC-based controls and/or robotic integration using recognized hardware and software solutions that are supported worldwide.

►*Outsourcing sample identification*
The outsourcing of critical steps in a process is a common practice in business today. And over the last several years, it's a technique that is becoming increasingly popular in labs of all sizes and types. Many labs now prefer to receive pre-labeled labware that exactly matches their specifications, and is ready for use. Even the assembly of entire kits, including sample containers, forms, and other items can be outsourced.

As an example, our service offering in this area is called "Label Ease," and offers a wide variety of labels and containers, based on the needs of the individual lab:

- Any size or shape labware; plastic or glass
- Labeled exactly to specification
- Linear or two-dimensional symbols
- Materials/adhesives engineered to work in end-use environment
- Can permanently "fire" ceramic labels onto container for maximum durability
- In-house tare-weighing service
- In-house kitting service
- Client-supplied labware, or we procure it to specification

Conclusions

By now it should be clear that there is a wide range of approaches to workstation automation for sample ID. While cost and, therefore, return-on-investment will vary with each lab, it would be hard to envision a lab in which automating sample identification would offer no benefit. Even moving from manual application to semi-automatic offers enhancements beyond the cost of the device: reduced worker fatigue, consistent label placement, improved scanning results, and data accuracy are some examples.

As is true of any project, it is important to partner with trusted and experienced firms with a suite of products customizable to your needs. Workstation automation in the lab is not a one-size-fits-all situation, and your interests are not being served by those that would tell you otherwise.

While maintaining the status quo rarely leads to progress, moving from manual application to a fully automated workstation overnight is probably not wise either. Work with the right partner, "try before you buy," and walk before you run—following these simple rules will ensure a successful progression of automation in your lab.

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