

# Chemical Labeling: 2D barcodes vs Combo 2D/RFID tags

## Overview of Pros and Cons

The choice between 2D barcodes, RFID tags, and Combo 2D/RFID Tags entails significant implications for efficiency, safety, and adaptability. Users of these technologies must evaluate short- and long-term labor and resource costs for tagging containers, annual inventory reconciliation, risk from physical contact with chemical containers, scalability as inventories grow, and the potential to integrate future technologies.

RSS user feedback was compiled for this document to share pros and cons of 2D barcodes versus Combo 2D/RFID tags and different scanning methodologies. There are two components to understand: which **scanner technology** to use, either barcode or RFID, and which **labels** to use with those scanners. In the past, RSS offered 2D barcode stickers/labels which can *only* be read with barcode scanners. There are RFID-only labels (which RSS does NOT offer) that can *only* be used with RFID scanners. Finally, there are Combo 2D/RFID tags (currently offered by RSS) which can be read by *both* RFID and barcode scanners.

## RFID Method

There are significant differences between managing chemical inventories using RFID vs. barcode scanners. While either type of sticker/tag offers inventory tagging solutions, RFID's radio wave technology allows faster data capture with less physical handling and line-of-sight requirements. This can dramatically reduce scanning time and labor costs, particularly for medium to large inventories with little turnover. A disadvantage of RFID scanning is that other products with RFID tags can potentially be read in the process. These erroneous data points need to be checked for during reconciliation. RFID scanning can also require some data manipulation/formatting to import into RSS Chemicals. This can largely be attributed to the current constraints of the RSS Chemicals Reconciliation tool, rather than the RFID scan methodology itself. RSS is actively enhancing this functionality to address user concerns and is developing guidance to streamline data import. Most importantly, prior to purchasing any RFID scanner, organizations should ensure that it supports the easy transfer of standard data files (.csv, .xls, etc.) via Bluetooth, USB cable or USB drive. RFID scanners with proprietary software required to read files may require more effort to use with RSS Chemicals.

## Barcode Method

For smaller inventories and reduced labor for data import, using only a 2D barcode scanner may be more cost effective. Although scanning each barcode individually takes more time, the scanned data may require less manipulation. 2D scanning is also more effective than RFID scanning for sublocation verification. During the reconciliation process in RSS Chemicals, the

system will inform users as to which barcodes match, which are missing, and which are new. This functions for both inventory level and sublocation level scans using either 2D or RFID scanning. 2D scanning requires the user to handle every container, which adds to risk of chemical exposure. Either type of RSS label, 2D or Combo 2D/RFID can be used by 2D barcode readers. RFID-only labels, which campuses may purchase independently, will not support 2D scanning.

## Combo 2D/RFID Method

Combo 2D/RFID tags are the most versatile and are recommended by RSS. Combo tags allow the organization to take advantage of both technologies (RFID scanning and 2D barcode scanning) based on the situation. Combo tags also include a unique alpha-numeric identifier if users need to simply type in an inventory number into a computer or mobile device. Many UC locations use Combo 2D/RFID tags with both types of scanners (2D barcode and RFID). Both scanning options are outlined below and are compatible with Combo tags. 2D-only barcode stickers allow for 2D Barcode scanning (last column), but not RFID scanning.

Additional features of the combo tags include solvent resistance, printing on both sides of the flag tag, and a partial human readable section that can be left behind on the container when the tag is ripped off.

## Comparison Table

Labels and Scanning Technologies		
	Combo 2D/RFID tags	2D barcodes
<b>Initial Equipment Cost</b>	Combo 2D/RFID Tag: \$0.125-0.25/each <sup>1</sup> ( <i>RFID labels + 2D Barcodes</i> )  RFID-only tags <sup>2</sup> : not provided  RFID Scanners: \$1,200-4,000/each	2D-only Labels <sup>3</sup> : \$0.08-0.10/each  Barcode Scanners: \$65-1,011/each

<sup>1</sup> UC Subsidized Cost of Combo 2D/RFID Tags – subject to changes in shipping, tariffs, etc...

<sup>2</sup> RFID-only tags are not supported by RSS. Campuses may purchase them independently. Note: RSS Combo 2D/RFID tags are designed to be chemically resistant and are compatible with freezer storage

<sup>3</sup> 2D-only barcode stickers are not recommended by RSS. Special order requests shall be made to RSS by the campus EH&S director.

Labels and Scanning Technologies		
	Combo 2D/RFID tags	2D barcodes
<b>Initial Effort (adding new labels)</b>	Time consuming initial effort (personnel + new equipment) Time: 1-5 minutes per label	Time consuming initial effort (personnel + new equipment) Time: 1-5 minutes per label
<b>Reconciliation (scan existing inventory)</b>	More efficient, much faster. Can scan many containers within range rapidly. <b>Time estimate:</b> Minutes-Hours (see below based on inventory size)	Time consuming. Each container must be handled individually. <b>Time estimate:</b> Hours-days (see below based on inventory size)
<b>Accuracy</b>	RFID scan can miss containers if they are tightly packed or missing labels. Flag orientation is important for proper scanning and RFID flag tags should not be placed flat on a container or sublocation when using the RFID function.	Due to the need to scan each container individually, should be highly accurate (no missed containers). However, incorrect barcodes can be erroneously scanned (SKU, Lot#, Product #)
<b>Sublocations</b>	RFID scan will not be able to differentiate sublocations, so the reconciliation will not change the sublocations of any container entries. Individual room scans can help determine if containers have moved.	Can easily verify container sublocations and update sublocations for relocated containers using this method. For areas with significant relocation of items, 2D scanning may be more efficient.
<b>Importing Scanner Data into UC Chemicals</b>	May require editing and data manipulation to import into RSS Chemicals. RSS is developing tools and guidance to assist with this.	Straightforward

<b>Labels and Scanning Technologies</b>		
	Combo 2D/RFID tags	2D barcodes
<b>Deletion of Unscanned Containers</b>	RSS Chemicals currently does not allow batch deletion of unscanned containers. Instead, a report is generated that shows chemicals that were not captured in the scans. These need to be verified and manually deleted in RSS Chemicals. RSS is working on a batch delete function for RFID scans.	RSS Chemicals provides the option to batch delete unscanned containers.
<b>Small Containers</b>	RFID Combo tags can be too large/heavy for small containers. RFID labels can obscure the original label on small containers, though tags with clear “feet” minimize this. Pre-strung marking tags from Avery or manilla shipping tags with strings (to affix RFID tag to) have been recommended by some users.	2D barcodes can be placed flat on containers. 2D stickers may obscure the original label on small containers. Smaller size stickers may be available.
<b>Tags</b>	RFID tags function best when they are unobstructed and not clustered too densely.  Older tags can lose stickiness.	Older tags can lose stickiness.
<b>Freezer Spaces</b>	Containers need clean, dry surface prior to affixing tags. Tags can come off.	Containers need clean, dry surface prior to affixing tags. Tags can come off.
<b>Inventory Size: &lt;200 Containers</b>	RFID scanning (reconciliation) is efficient. Some users opt to not barcode static environments (custodial, maintenance)	2D scanning (reconciliation) is efficient. Some users opt to not barcode static

Labels and Scanning Technologies		
	Combo 2D/RFID tags	2D barcodes
		environments (custodial, maintenance)
<b>Inventory Size: 200-1000 Containers</b>	RFID scanning is faster. Time estimate: <45 minutes	2D scanning slow. Time estimate: 1-5 days
<b>Inventory Size: &gt;1000 Containers</b>	RFID scanning is much faster. Time estimate: <1-3 hours	2D scanning not recommended. Time estimate: 3-7 days

**Resources:**

RSS [video guide](#) to using RFID

UC Davis [ChemTag](#)

UCSF [Chemical Inventory](#)

## Additional Commentary on 2D vs. RFID Scanning

The Combo 2D/RFID labels have the greatest versatility, as they allow for both barcode and RFID scanning technologies. Many campus users employ a mix and match approach, using both types of reconciliation depending on the situation. Some instances where 2D scanning (using 2D or Combo tags) may be prioritized:

- Areas where many containers have moved to new sublocations
- On small containers where RFID tags are laid flat rather than with tag sticking out (this makes it difficult for RFID scanners to detect, therefore barcode scanning may be preferable)
- Areas where tracking sublocations is important
- When campuses provide “loaner” scanners, it is cheaper to use barcode scanners. Barcode scanners also tend to be less complicated and less prone to user error.

During reconciliation, the 2D scanning results are easily imported into UC Chemicals. RFID scanners can require data manipulation prior to uploading into UC Chemicals, though RSS is currently developing guidance to minimize this. Locating missing containers, containers that have moved to new sublocations, identifying containers without labels, and deleting containers no longer present in the space can add to the RFID processing time.

Situations where RFID scanning is most beneficial:

- Medium sized inventories (between 100 – 1,000 containers)
- Large inventories (over 1,000 containers)
- Inventories that do not utilize sublocations
- Static inventories
- Stockrooms/Receiving areas

### Gas Cylinders

Consider placing labels adjacent to the storage location rather than directly on cylinders. For commonly used gases, tags can be created for the maximum number of cylinders expected at any one time for each gas. Cylinder exchanges do not need to be tracked unless the maximum number increases. For example, if a storage area typically has 3-4 nitrogen cylinders and 1-2 oxygen cylinders, tags can be created for 4 nitrogen and 2 oxygen and placed nearby.

### High throughput, fairly static inventories (facilities, custodial, waste accumulation)

Consider placing labels adjacent to the storage location with maximum volume of expected chemicals. As long as the maximum volume does not increase, re-orders of chemicals do not need to be tagged/tracked. Some users opt out of using any labeling for static inventories.

### Compatibility with Future Technology

Combo 2D/RFID tag technology is scalable and allows for future efficiency initiatives such as automated tracking and closer integration with RSS software. Campuses that choose to purchase 2D or RFID-only tags may run into long-term problems where RSS software is not compatible with the scanner output. Users should purchase RFID scanners that allow for data export in standard file formats (i.e., .xls, .csv) rather than via proprietary software. In addition, RFID scanners that allow data transfer only via Bluetooth rather than via USB drive or cable can make data import into RSS Chemicals difficult.

### Cost of Switching

The largest cost for an institution in implementing a chemical inventory tracking system is the labor associated with the initial labeling or re-labeling when switching from 2D to RFID. For a large institution, the savings translate to millions of dollars. By adopting the Combo 2D/RFID tags up front, the institution will eliminate the duplicative cost associated with relabeling containers should they choose to switch to RFID in the future. They also reduce any risk associated with performing the relabeling task.

## Scanners: Information Collected from Campus Users

### 2D

Nadamoo 2D wireless barcode scanner	
<b>Cost</b>	\$65 (Amazon)
<b>Availability</b>	Yes
<b>Additional Hardware Required</b>	Laptop/desktop computer
<b>Compatibility</b>	Windows, MacOS, Linux
<b>Data File Format</b>	.xlsx
<b>Ease of Import into UC Chemicals</b>	No editing/processing required
<b>Notes</b>	Can be configured to ignore 1D barcodes

### RFID

	Alien ALR-H450	TSL 2128P	TSL 1128	Nordic scanners	Chainway C72 Bluetooth UHF RFID 2D Barcode Reader
<b>Cost</b>	\$250 (used market)	\$1,650 (device) + \$2,100 (additional hardware)	\$1,173		~\$950 from <a href="#">RFID4u</a>
<b>Availability</b>	No longer available from manufacturer, can purchase on eBay	Yes	Yes	Yes	Yes
<b>Additional Hardware Required</b>	None. Standalone device.	Handheld computer, docking station	Requires phone/mobile device		Charger. Optional software

	Alien ALR-H450	TSL 2128P	TSL 1128	Nordic scanners	Chainway C72 Bluetooth UHF RFID 2D Barcode Reader
<b>Compatibility</b>	Android	Android, iOS, Windows phone	Android, iOS, Windows phone		Android, iOS
<b>Data File Format</b>	.csv				.csv or .xls
<b>Ease of Import into UC Chemicals</b>	Easy, No editing/processing required.	Data manipulation required.  UCD has tutorial.	Easy, No editing/processing required.	Data manipulation required.	Easy, No editing/processing required.
<b>Notes</b>				Cannot search for specific tag.	