Use of RFID for managing large chemical Inventories

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Chemical, Sample and Asset Management Tools Symposium

Presentation built on the work of: Jeff Sickau, Virginia Hopkins, Mikayla Deardorff, Marcus Mentzer, and many more!!

ORNL is managed by UT-Battelle
for the US Department of Energy

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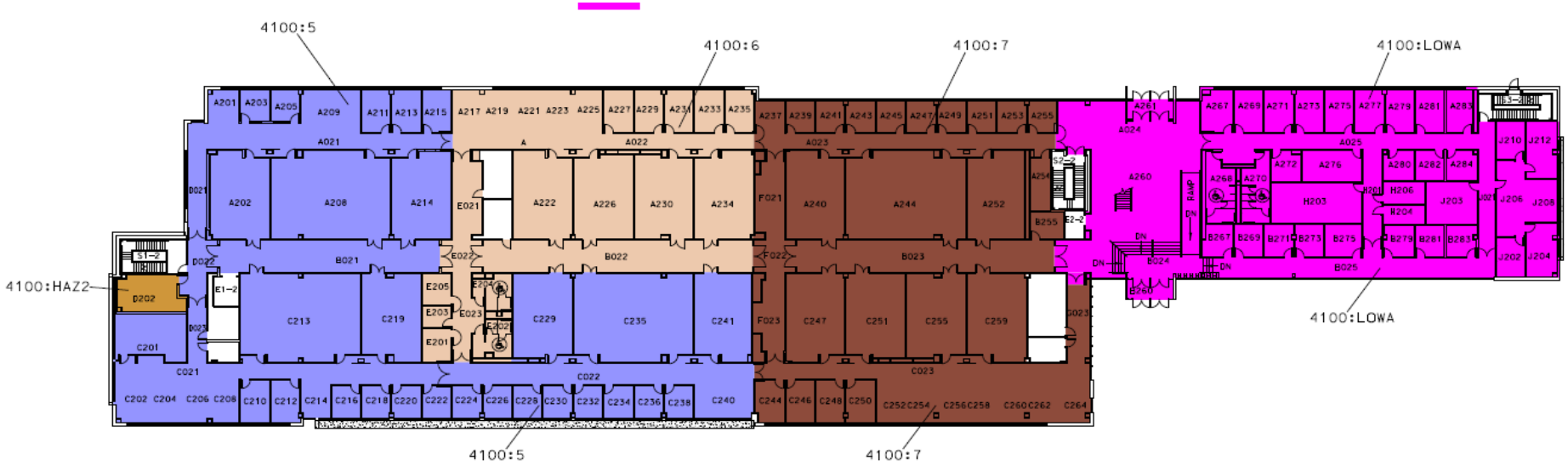
- **Background- The scale of the chemical inventories at ORNL**
- **Discussion of Tools and Methodologies**
- **Implementation of the RFID program and Lessons learned**
- **What's next**

Background Info

- Chemical Division
  - 24,000 items (approx 25% of total campus inventory) in ~100 areas
- Hierarchy
  - Fire Protection Limits based on building design and zone (Hazardous Materials Control Areas)
  - Chemicals Stored in Labs and storage rooms (control areas)



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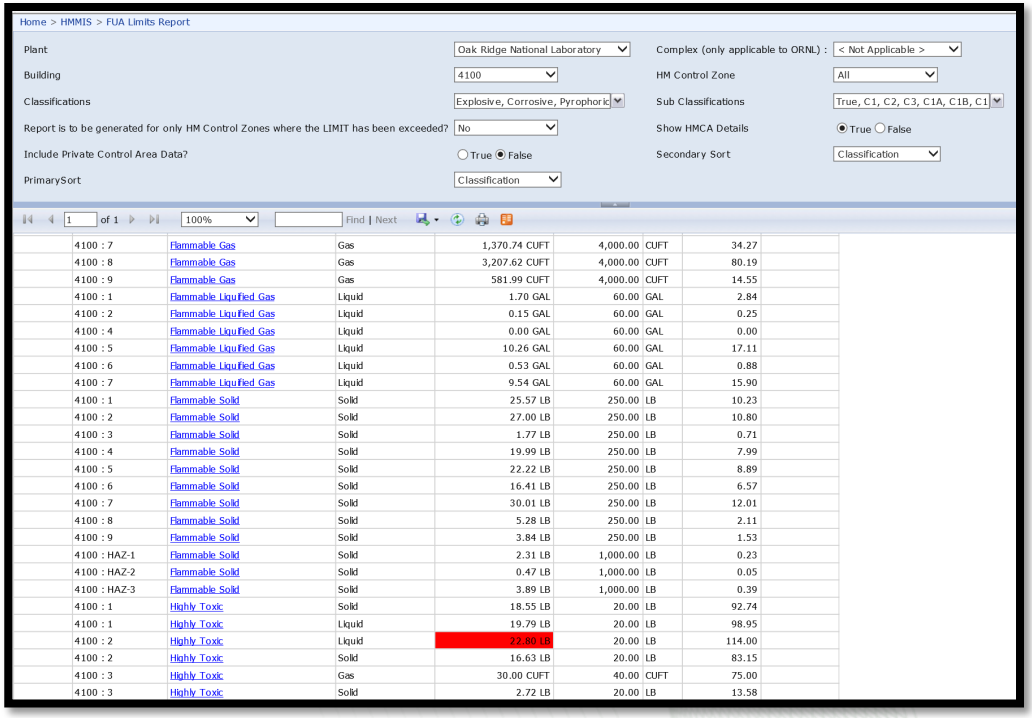
Hazardous Materials Management Information System (HMMIS)

- Integrated with Fire Protection Technical requirements (Maximum Allowable Quantities)
  - Exceedance Reports
- Highly searchable (location, common name, category, CAS, …)
- Repository for SDS collection
- Integrated with Purchasing
  - Forces consideration of items deemed surplus
  - Compares new item requests to existing inventory



4100 : 7	Flammable Gas	Gas	1,370.74 CUFT	4,000.00	CUFT	34.27
4100 : 8	Flammable Gas	Gas	3,207.62 CUFT	4,000.00	CUFT	80.19
4100 : 9	Flammable Gas	Gas	581.99 CUFT	4,000.00	CUFT	14.55
4100 : 1	Flammable Liquified Gas	Liquid	1.70 GAL	60.00	GAL	2.84
4100 : 2	Flammable Liquified Gas	Liquid	0.15 GAL	60.00	GAL	0.25
4100 : 4	Flammable Liquified Gas	Liquid	0.00 GAL	60.00	GAL	0.00
4100 : 5	Flammable Liquified Gas	Liquid	10.26 GAL	60.00	GAL	17.11
4100 : 6	Flammable Liquified Gas	Liquid	0.53 GAL	60.00	GAL	0.88
4100 : 7	Flammable Liquified Gas	Liquid	9.54 GAL	60.00	GAL	15.90
4100 : 1	Flammable Solid	Solid	25.57 LB	250.00	LB	10.23
4100 : 2	Flammable Solid	Solid	27.00 LB	250.00	LB	10.80
4100 : 3	Flammable Solid	Solid	1.77 LB	250.00	LB	0.71
4100 : 4	Flammable Solid	Solid	19.99 LB	250.00	LB	7.99
4100 : 5	Flammable Solid	Solid	22.22 LB	250.00	LB	8.89
4100 : 6	Flammable Solid	Solid	16.41 LB	250.00	LB	6.57
4100 : 7	Flammable Solid	Solid	30.01 LB	250.00	LB	12.01
4100 : 8	Flammable Solid	Solid	5.28 LB	250.00	LB	2.11
4100 : 9	Flammable Solid	Solid	3.84 LB	250.00	LB	1.53
4100 : HAZ-1	Flammable Solid	Solid	2.31 LB	1,000.00	LB	0.23
4100 : HAZ-2	Flammable Solid	Solid	0.47 LB	1,000.00	LB	0.05
4100 : HAZ-3	Flammable Solid	Solid	3.89 LB	1,000.00	LB	0.39
4100 : 1	Highly Toxic	Solid	18.55 LB	20.00	LB	92.74
4100 : 1	Highly Toxic	Liquid	19.79 LB	20.00	LB	98.95
4100 : 2	Highly Toxic	Liquid	22.80 LB	20.00	LB	114.00
4100 : 2	Highly Toxic	Solid	16.63 LB	20.00	LB	83.15
4100 : 3	Highly Toxic	Gas	30.00 CUFT	40.00	CUFT	75.00
4100 : 3	Highly Toxic	Solid	2.72 LB	20.00	LB	13.58

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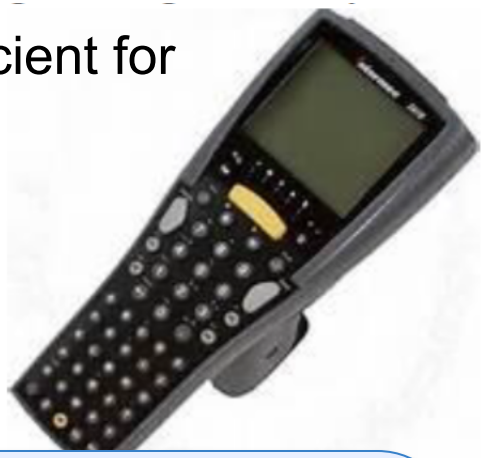
Why and How

Maintain Inventories to :

- Stay under chemical loading limits for facility (Fire Protection)
- Know where our chemicals are located; Inventory sufficient for work (Mission Execution)



By:

- Conducting 100% Annual inventory
- Capture Adds/Consumes/Moves of chemicals

Pre 2000: Excel Spreadsheets, track by name
~2000: Web Based Inventory System (HMMiS)
- Track by unique identifier (YEARMODALOITEM)
- Label with optical/text barcode

2010: Transition to RFID/optical/text barcode
- Rolling System Conversion- all new chemicals come with RFID tag
- Comprehensive local conversion – lab by lab conversion of existing tags

About RFID

- **Radio-frequency identification** (**RFID**) uses electromagnetic fields to automatically identify and track tags attached to objects.
  - The tags contain electronically stored information.
  - Passive tags collect energy from a nearby RFID reader's interrogating radio waves.
  - Active tags have a local power source such as a battery and may operate at hundreds of meters from the RFID reader.
  - The tag need not be within the line of sight of the reader, so it may be embedded in the tracked object.

Source: https://en.wikipedia.org/wiki/Radio-frequency_identification

Tags

- Optical Tags: Barcode correlates to unique identifiers
  - Identifier associated with information in Database
- RFID: The tags contain electronically stored information on multiple channels.
  - Unique Identifier of tag can be associated with database
  - Tags can be “written” on to store additional information

Scanner Technology

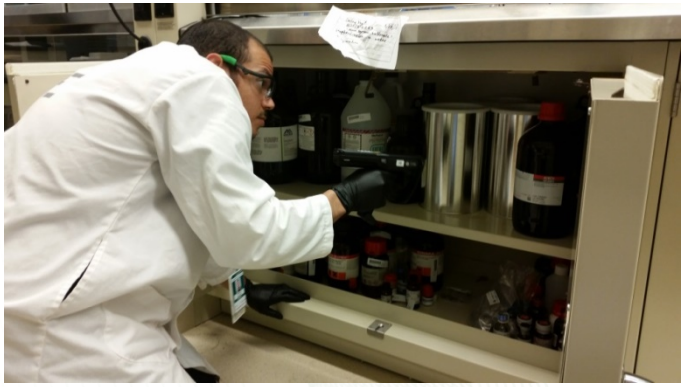
- Factors to consider
  - Cost
  - Back end system
  - Antenna Power and directionality
  - Ease of Use
- Generation-1 Scanner (linear)
  - Best locator functionalities
  - Limited battery; communications issues
- Generation-2 Scanner (conical)
  - Less dependent on label orientation
  - Integrated system
- Both Scanners allow manual entry (keypad) and optical scanning

Advantages of Automated Methods
RFID

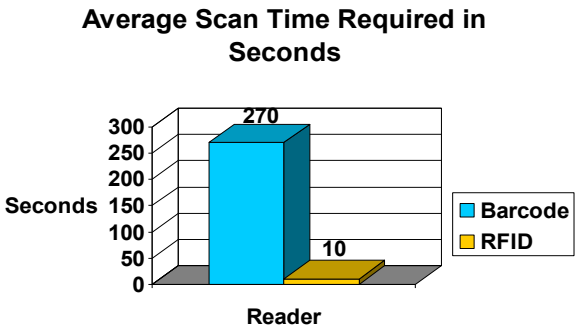
- Time savings for grouped containers
- Reduction in incidental contact with chemicals
- Reduced likelihood of spills from container handling
- Reduced injury potential from accessing containers
- RFID tags appear to be more durable than bar code labels
- Line of sight reading is not necessary
- Larger data capacity
- Readable through glass cabinets

Disadvantages of Automated Methods
RFID

- Signal Attenuation
  - Signal can reflect off metal cabinets
  - Level of liquid in bottle can affect signal attenuation
  - Tag placed on metal can may attenuate signal
- Signal strength can lead to read overlap in a multiple control area location.
- Large labels may not fit on small bottles
  - Convert to smaller labels
  - Truncate or fold labels
  - Utilize “Tent” Labels
- Label printing overlap
  - Next generation printers resolve this issue with isolation



Flammable Cabinet

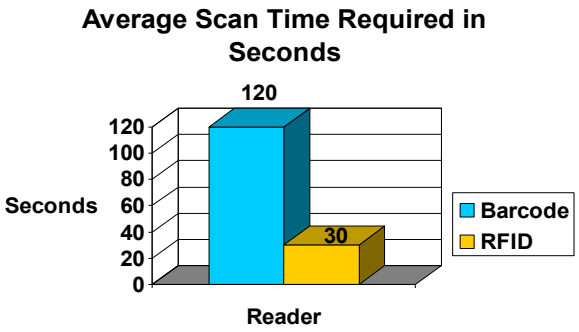


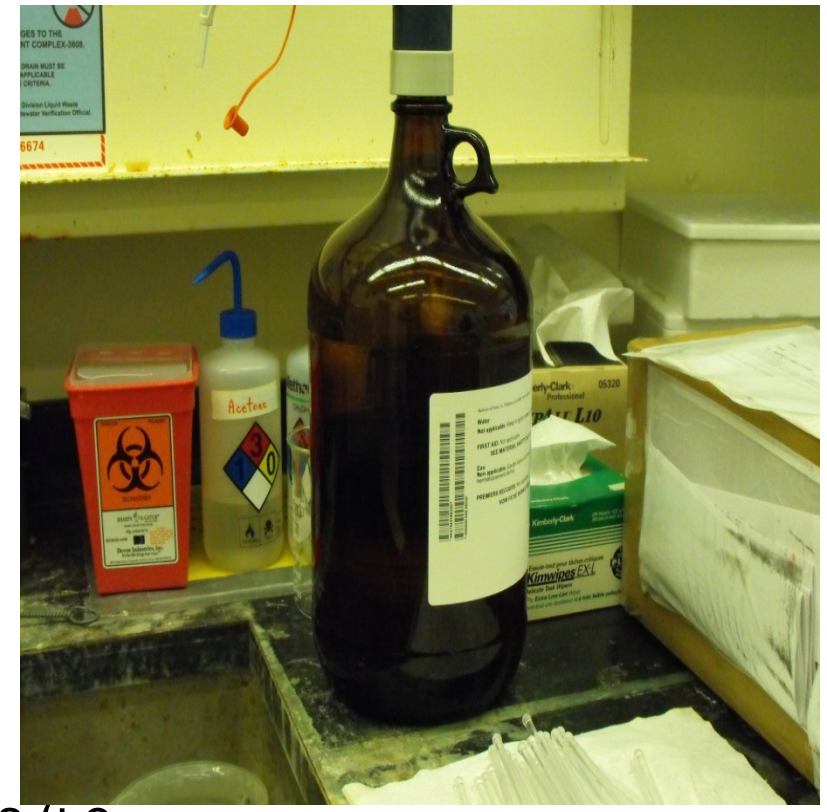
Conditions of area scanned:

- Cabinet doors open
- Multiple shelves
- Multiple items per shelf
- Various container sizes and placement

RFID was 100% accurate at a distance of 2 ft. from containers.

Open Shelving and Counters



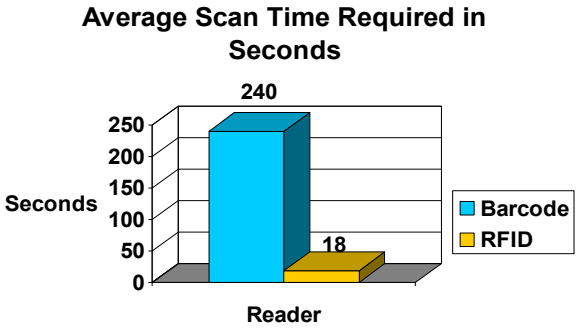


Condition of area scanned:

- Multiple shelves
- Various container types and sizes
- Multiple shelf locations
- Items placed in secondary containers (i.e. plastic baggies and beakers)

RFID was 60% accurate at a distance of 4 ft. from containers and 100% accurate at a distance of 3 ft.

Typical Laboratory Storage



Condition of area scanned:

- Countertop placement
- Items located behind glass doors (i.e. hoods and cabinets)
- Wooden containers
- Items located behind obstructions (i.e. boxes, lab items, etc.)
- Desiccators

RFID was 100% accurate at varied distances from containers while moving about lab.

Most Effective Scanning Method

- Move reader horizontally
- Place RFID tag near top of the container
- Tag facing outward
- Move scanner at a pace proportionate to container density.

Efficiency of Process

Method: Manual	Time (min)	% error	Cost for labor	Read rate
Trial 1:	140	0	$35.00	62 s
Trial 2:	78	0	$19.50	35 s
Average:	109	0	$27.25	48 s

Method: Barcode	Time (min)	% error	Cost for labor	Read rate
Trial 1:	17	0	$4.25	7.5 s
Trial 2:	15	0	$3.75	6.6 s
Average:	16	0	$4.00	7.0 s

Method: 1st RFID	Time (min)	% error	Cost for labor	Read rate
Trial 1:	8	15 (19/135)	$2.00	3.5 s
Trial 2:	9	12 (16/135)	$2.25	4.0 s
Average:	8.5	14.5	$2.13	3.75 s

Productivity Gains

Item	RFID	Barcode
Read Rate	30 tags/second	1 barcode / 6 seconds
Time per area reconciled	1-2 hours	8-10 hours
Time to annually reconcile ~1,300 storage areas at ORNL	1,300 – 2,600 hours	10,400 – 13,000 hours
Example cost assuming $15/man-hour (intern)	$19,500 - $39,000	$156,000 - $195,000
Potential Annual Labor Time Savings	9,100 – 10,400 hours	N/A
Annual Labor Cost Savings	$136,500 – $186,400	N/A

System Setup Cost

Item	RFID	Barcode
Labels / Tags	$0.17 each	$0.02 each
Mobile Readers / Scanners	$3,000 each (dual purpose)	$1,450 each
Primary Printers for Production (2)	$3,150 each	$1,500 each
Secondary Printers for Satellite Locations (optional)	$987 each	$267 each
System Programming	$10,000	$8,000
System Start-up Cost (2 production printers)	- $6,300	- $3,000
- 3 satellite printers (optional)	- $2,961 - $1,700	- $801 - $200
- 10,000 labels	- $9,000	- $4,350
- 3 readers	- $10,000	- $8,000
- Programming	Total = $29,961	Total = $16,351

PNNL Deployment

- Conversion from barcode system to RFID
- Benchmarked ORNL
- Improved Conversion process; RFID data utilizatin

Expansion to Other Inventories
Sample Management

- Derivative of Inventory System mirrored for sample management
  - Rigorous sample registration process for potential beam line samples
  - Strategically deployed printers to facilitate immediate labeling
  - Sample management software include disposition and radiological activation components

Other Considerations

- Maintaining 100% inventory only possible if all add/ remove/transfer systems work 100%
  - If it did- is annual inventory required
  - Knowing it doesn't- is annual frequency sufficient?
- Who will conduct the inventory is important
  - Additional technology or personnel adds complexity, affects efficiency
- RFID process opens many opportunities
  - Process is only as good as the systems behind it
  - Factors such as where the data is stored and how it is transferred will affect process

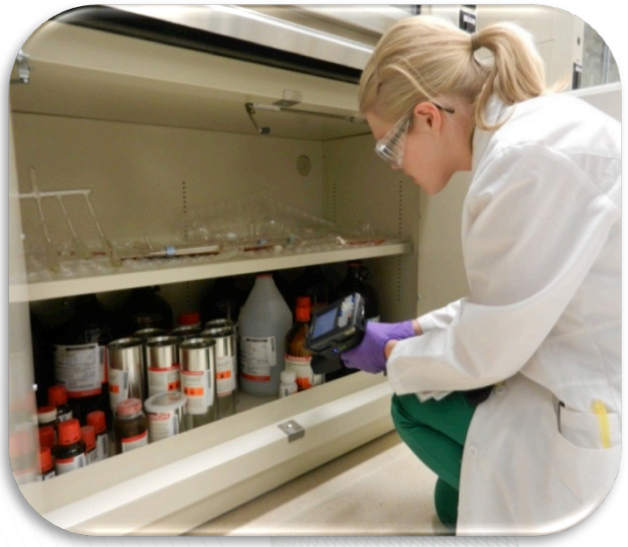
What's next (conceptual)

System focus

- Expand beyond chemicals (samples, assets)
- Improved Functionality (Find Me RADAR)
- Conversion station
- Static inventory methods
  - RFID portals
  - Inventory station

User focus

- Label improvements
- Accessibility with in lab devices (phone, ipads)



Summary

- Scanning technologies can improve inventory efficiency and safety
  - Method should depend on size and turnover of inventory
  - Multiple techniques can be utilized with well-designed labels
- There is no standard (yet?)- Selection of equipment and integration with back-end system requires careful planning to address local needs

https://youtu.be/D7fX3nqHhGI

Additional Information

- OpenWave Website (http://openwaverfid.com/)
- Swedberg, C. (2013). RFID Tracks Chemical Inventory at Oak Ridge National Laboratory. Retrieved on 06/03/2015 from http://www.rfidjournal.com/articles/pdf?10850
- Tseng, S., Kuo Yuan Hwa, , IFan Chang, , & Wenlung Li, (2009). An automatic RFID and wireless sensing system on GHS-bases hazardous chemicals management platform. *Informally published manuscript*, National Taipei University of Technology, Taipei, Taiwan. Retrieved on 06/05/2015 from http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=05402987