Postharvest Storage

Paths to Efficiency, Quality and Profit

Practical Produce Safety Workshop

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CULTIVATING HEALTHY COMMUNITIES

Outline

- Postharvest Basics
- Quality Factors
- 4 Crop Case Studies
- Systems & Efficiency

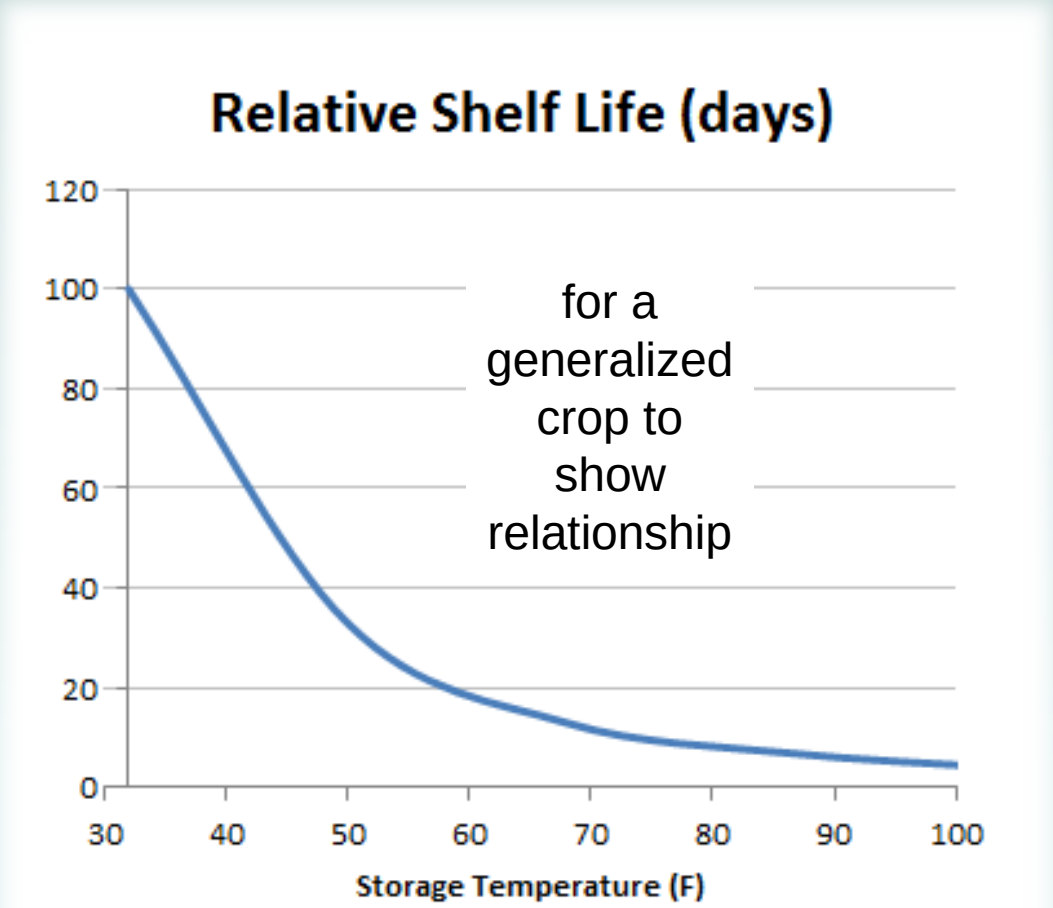



You Grew It... Now what?

- By the time you harvest, most costs are sunk.
- Lasting quality depends on good storage.
- Profitability is directly related to waste.

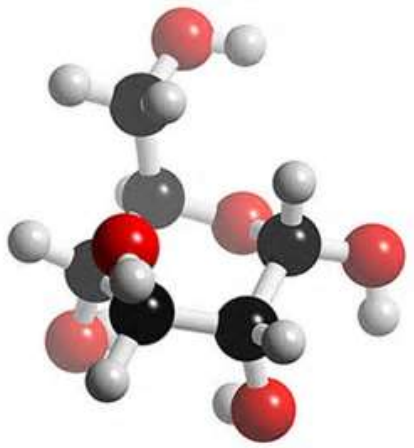
Postharvest Basics

- Metabolism continues after harvest (respiration).
- …and it is highly dependent on temperature.



What happens in storage?

- Metabolism & Respiration
  - Sugar and Oxygen
    → Carbon Dioxide and Water Vapor and Heat
  - $C_6H_{12}O_6 + 6\ O_2$
    → $6\ CO_2 + 6\ H_2O$ + Heat
  - Reduces weight and generally sweetness
  - Controlled by temperature



Glucose ($C_6H_{12}O_6$)

What happens in storage?

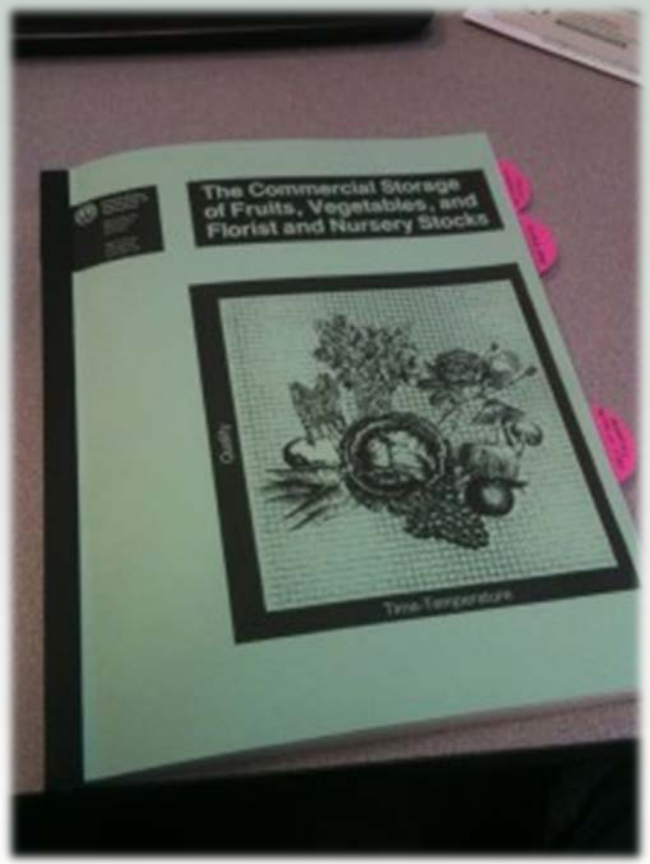
- Chilling / Freeze Injury
  - Tissue damage
  - Variable over body of plant
  - Min temp not same as freezing temp
- Desiccation / Drying Damage
  - Cool or cold air
  - Heat from respiration
  - Moisture (H_2O) available at surface of produce
  - Need humidity (H_2O) in air, "RH" or relative humidity

What happens in storage?

- Ethylene
  - C_2H_4
  - Produced in stored produce (at various rates)
    - plant hormone
    - physiologically active at very low concentrations
      - (0.1 to 10ppm)
  - Stored produce is variably sensitive to Ethylene
    - Bittering effect
    - Premature decay

And each crop is different

- Recommended storage conditions
  - Temperature
  - Relative humidity
- Ethylene production rate
- Ethylene sensitivity
- Chilling/Freezing Injury
- Variety differences



USDA Handbook 66 – "The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks"
http://www.ba.ars.usda.gov/hb66

4 Crops – Case Studies




Crop	Units	Carrot	Onion	Potato	Cabbage
Storage Density	lb/ft^3	22	20	42	17
Temp	°F	32 – 34	32	40	32
RH	%	98 – 100	65 – 70	99 – 100	98 – 100
Duration	Months	7 – 9	6 – 9	Up to 12	3 – 6
Resp. rate at temp	$\frac{\text{mg } CO_2}{\text{kg - hr}}$	10-20	3 (cured)	6 – 18 (cured)	4 – 6
	$\frac{\text{BTU}}{\text{ton-hr}}$	138	28	110	46
Ethylene Prod. Rate	$\frac{\text{uL}}{\text{kg-hr}}$	< 0.1	< 0.1	< 0.1	< 0.1
Ethylene Sensitivity	$\frac{\text{uL}}{\text{L}}$	High ~ 0.2	Low > 1500-2000	Low	High ~ 1.0

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Zoned Storage

- Zoned by temperature and relative humidity
- Also consider ethylene production and sensitivity
- Low cost – vapor barrier walls
- Higher cost – dedicated structures
- Could also be useful to have a zone dedicated to precooling / removal of field heat.

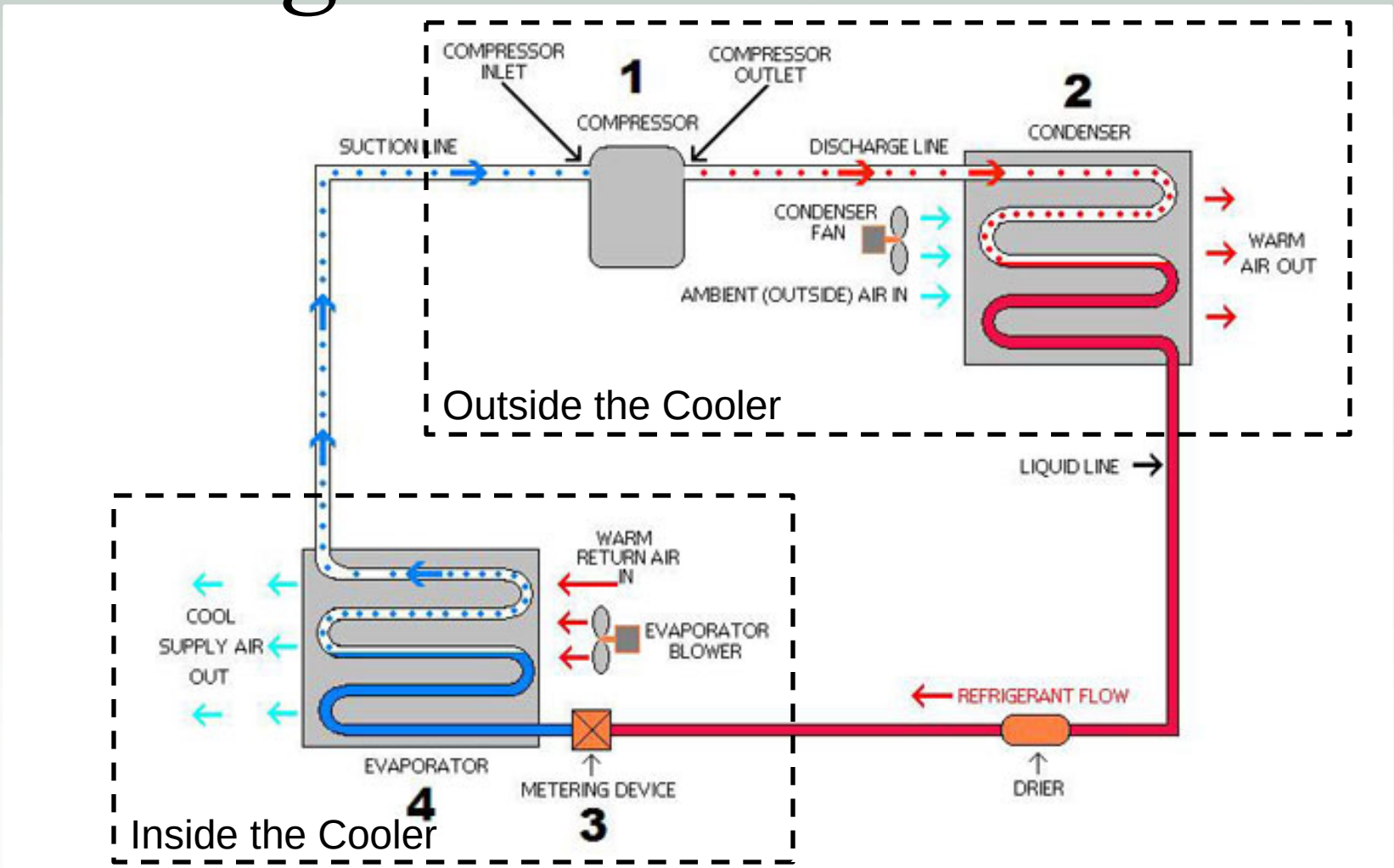
Removing Heat

- Root Cellar
  - Essentially a cool sink with high humidity
- Cooler
  - Mechanical refrigeration to “pump” heat out

Adding Heat

- For higher temperature crops
  - Electric, propane, biomass/pellet heaters

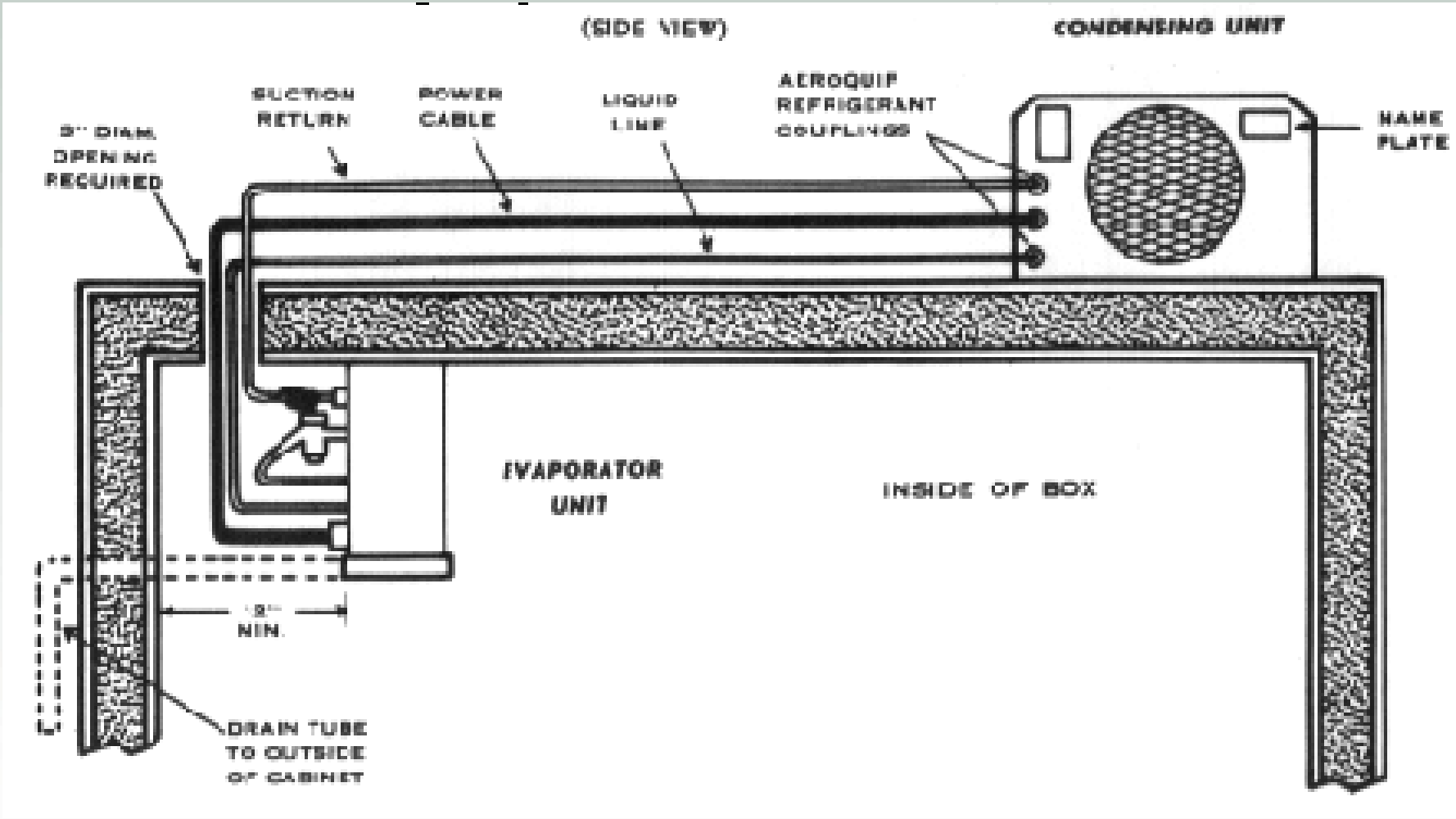
Refrigeration



Refrigeration

Evaporator Unit

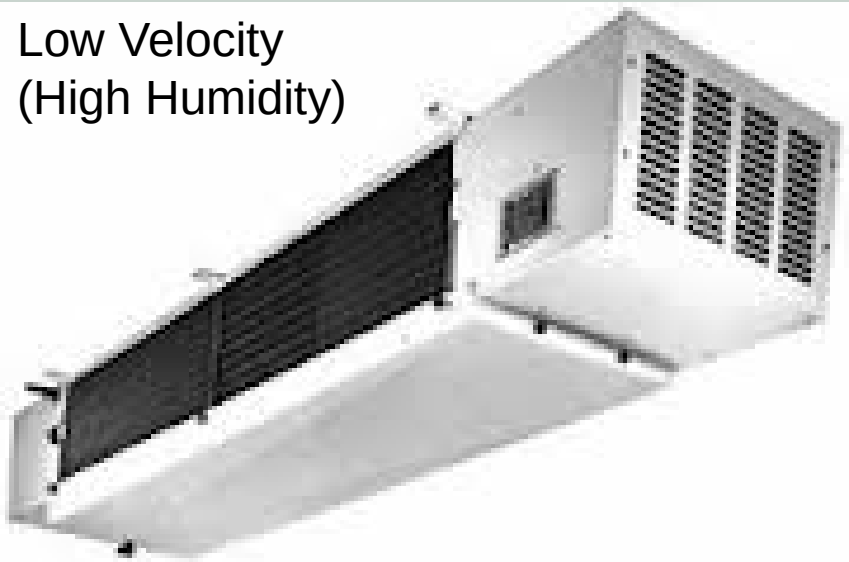
Compressor / Condenser Unit


(SIDE VIEW)
CONDENSING UNIT
SUCTION RETURN
POWER CABLE
LIQUID LINE
AEROQUIP REFRIGERANT COUPLINGS
NAME PLATE
3" DIAM. OPENING REQUIRED
EVAPORATOR UNIT
INSIDE OF BOX
2" MIN.
DRAIN TUBE TO OUTSIDE OF CABINET

Evaporator Options

Standard

Low Velocity
(High Humidity)



Plates

CoolBots™

- Adapt an air conditioner for use as a refrigeration system.
- Air conditioners are basically “packaged” refrigeration systems run at higher temperature.
- Build a “good box” first.

CoolBots™

- Pro's
  - Low initial cost
  - Easy to retrofit into existing spaces with basic construction
  - Potential efficiency benefit
- Con's
  - Slow to "pull down" temperature
  - Slow to recover from rises in temp
  - Can not freeze, only cools down to 35 °F

www.storeitcold.com – Has loads of info and is very clear.

CoolBot vs. Conventional

- 2009 NYSERDA Study
  http://storeitcold.com/coolbot%20Report%20May09.pdf
- 8'x10' storage room - Albany, NY conditions
- Cooled to 35 F
  - with evap fan controls
    - Conventional is 74 kWhr/yr more efficient ($10/yr)
  - without evap fan controls
    - CoolBot is 230 kWhr/yr more efficient ($30/yr)
- Coolbot cost $750 (net of cold room)
- Conventional cost $4,400 (net of cold room)

Adding Humidity

- Crops will add some humidity as they respire
- Moist slabs
- Moist burlap / cloth blankets
- Should be cleaned regularly
- Foggers / Nozzles

Removing Humidity

- Outside air exchange can be very effective
  - Small fan with ducting

Measure and Monitor

- "The measured variable improves."
- Temperature ***AND*** Relative Humidity
- Don't assume you have the conditions you want. **Measure**.
- **Low tech** – wall sensors, daily checks, log book
- **High tech** – remote monitoring, email alerts
- Calibration and certification

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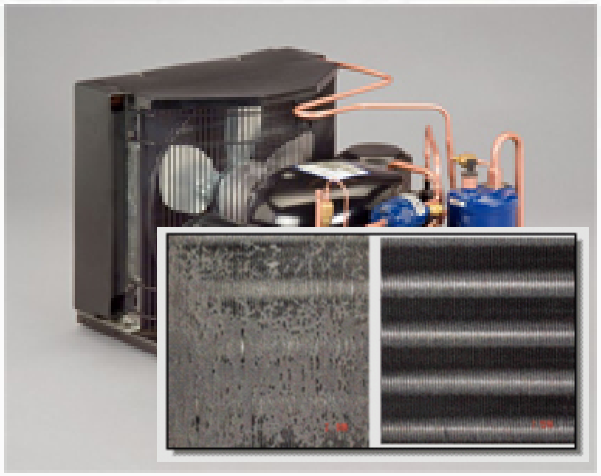
Scouting

- Daily checks for spoilage, sprouting
- Have different people perform the task
- When pulling stored crops, check other bins
- Check for spoilage, sprouting
- Use all five senses
- “Scout” the mechanicals also

Cooler Audit

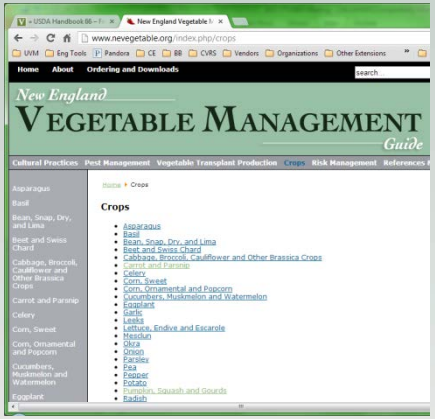
- Envelope (“The Box”)
  - All doors close tightly
  - All seals are sealing
  - Signs of degradation
  - Signs of mold
  - Air circulation inside
- Mechanicals (“The Chiller”)
  - Noise is energy
  - Condenser coil is clean and clear
  - Annual refrigeration tuning

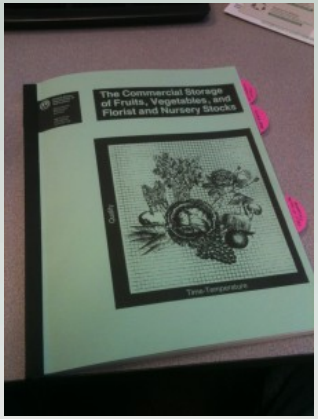


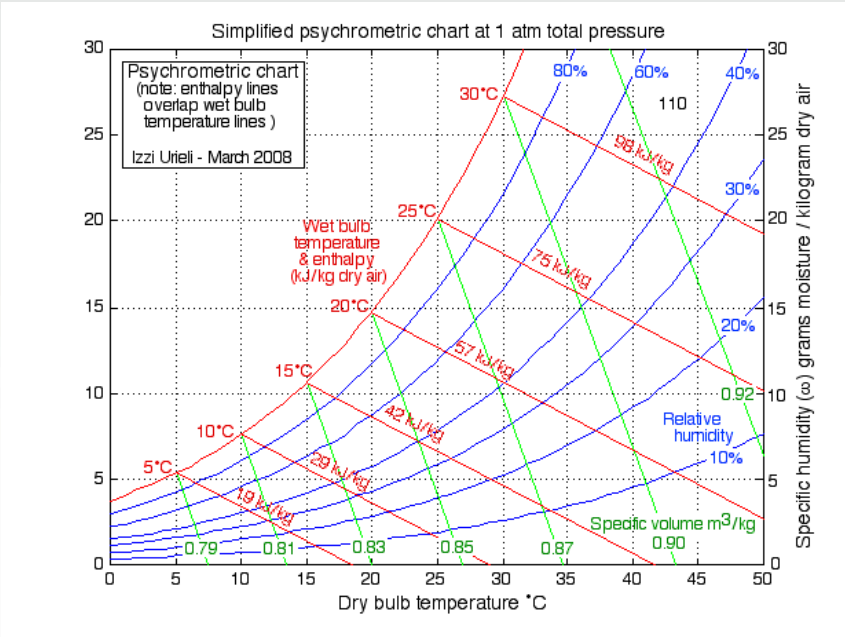
Technical References

- USDA HB 66
- NE Veg Guide
- UC Davis Post Harvest Website

  postharvest.ucdavis.edu
- Psychrometric Charts and Calculators







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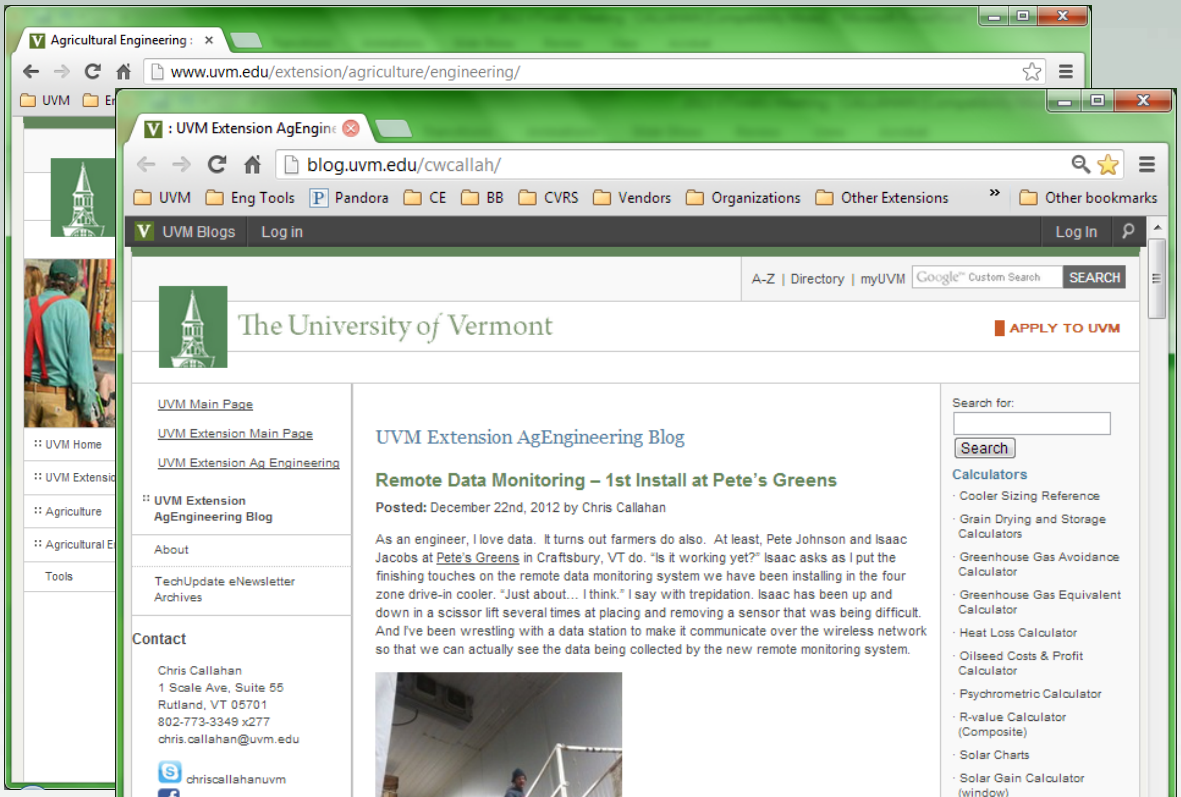

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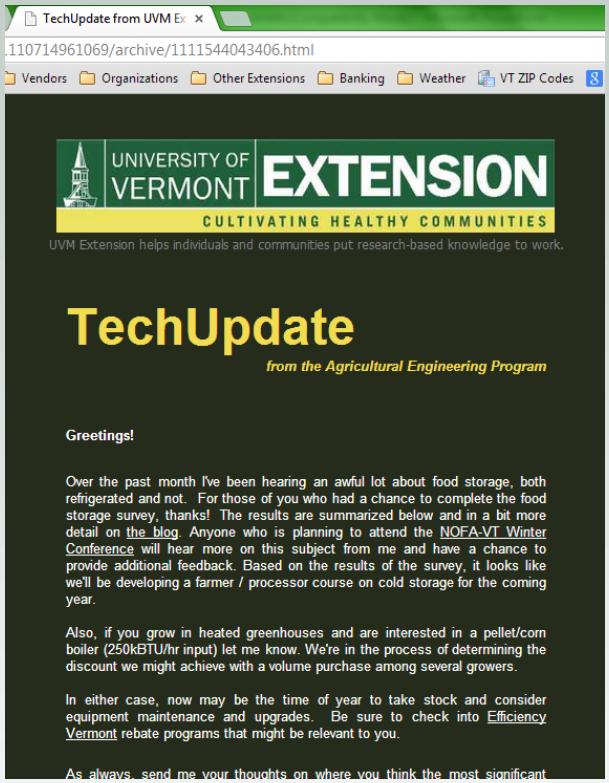

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