Using Equilibrium Moisture Content in Managing Grains

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Using Equilibrium Moisture Content in Managing Grains

Monday Feb 27, 2023; 4:30-5:30 PM

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AGI Digitial

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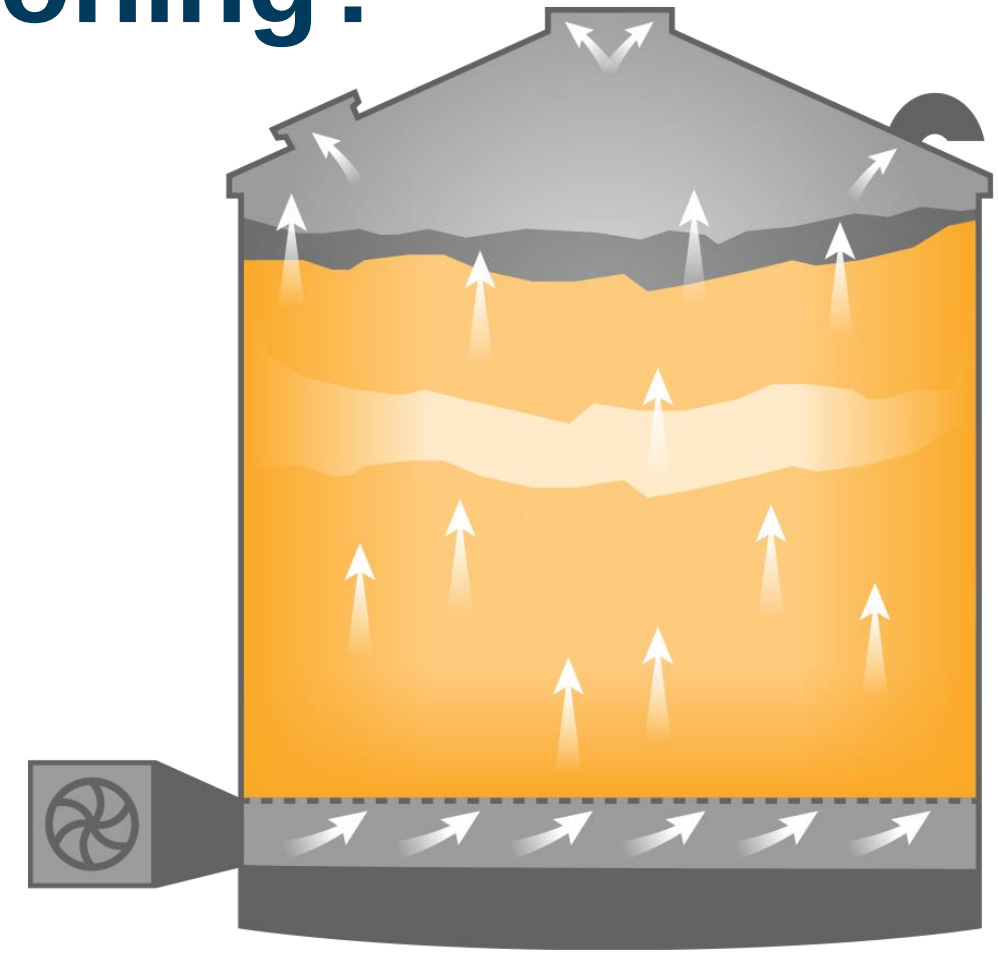
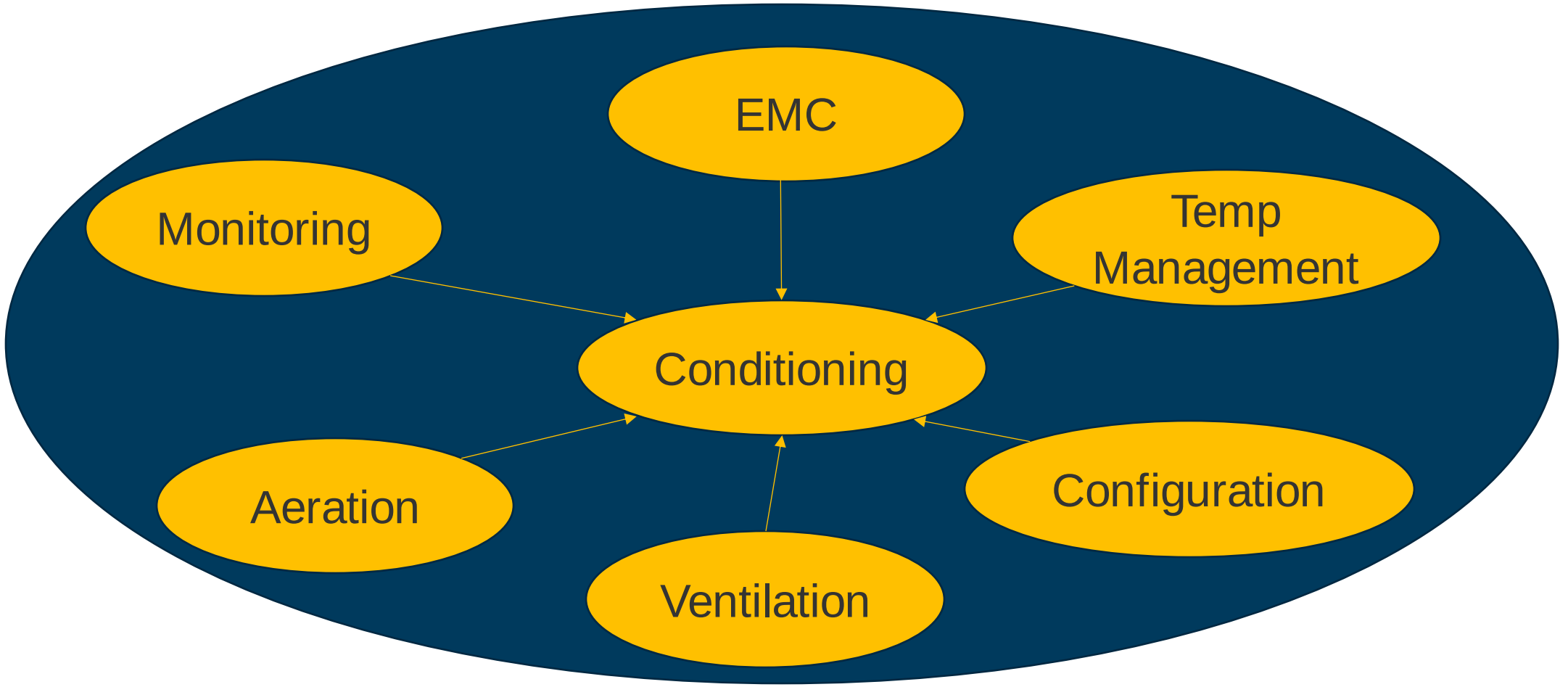
What is Grain Conditioning?

- Moisture conditioning
  - Removing of moisture
  - Adding of moisture
- Temperature conditioning
  - Cooling
  - Rewarming



Essentials for Good Conditioning



Moisture Content (Wet Basis)

$$MC(wet\ basis), \% = \frac{Weight\ of\ Moisture\ (W_m)}{Weight\ of\ Moisture(W_m) + Weight\ of\ DM(W_d)} \text{ x } 100$$

$$MC(wet\ basis), \% = \frac{Weight\ of\ Moisture(W_m)}{Weight\ of\ Grain(W_g)} \text{ x } 100$$

Most commonly used moisture content in industry

Moisture content measurement by moisture meter like Dickey-John GAC

Moisture Content (Wet Basis)

Example:

Weight of moisture is 3 g, Weight of dry matter is 12 g.
Calculate % MC wb?

$$\mathrm{MC(wet\ basis)} = \frac{3 * 100}{[12 + 3]} = 20.0\%$$

Moisture Content Determination

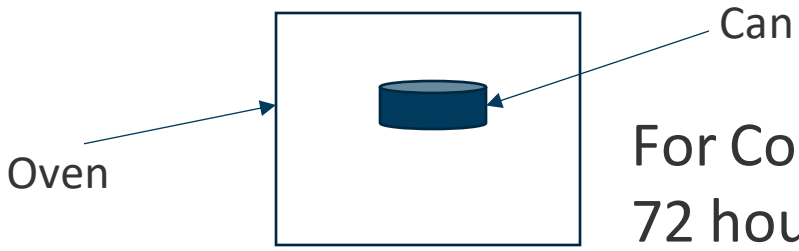
1. Oven drying
2. Electronic devices (moisture meters)
3. NIR-Near Infrared Spectroscopy

Oven Drying

The known weight of grain placed in an oven drier for a prescribed time and temperature based on research. After this time, grain assumed to be having no moisture, only dry matter.

Dry Matter Weight

$$MC\ (\%wb) = \frac{(Initial\ Grain\ Weight - Final\ Grain\ Weight)}{Initial\ Grain\ Weight} x100$$



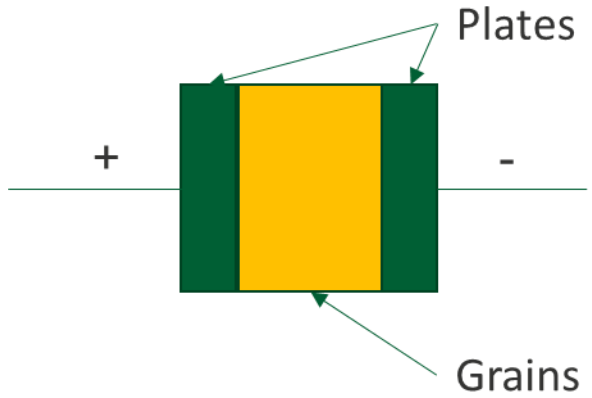
For Corn, take 15g in a can and keep it 103°C for 72 hours

Moisture Meters

Measure an electrical property, such as capacitance, related to the dielectric constant of a test cell filled with grain.

Most commonly used USDA-GIPSA approved moisture meters are:

- Dickey-John GAC 2500 UGMA
- Perten Moisture meter AM5200-A
  UGMA-Unified Grain Moisture Algorithms



Perten AM 5200-A

Dickey-John GAC 2500 UGMA

NIR (Near InfraRed) Spectroscopy

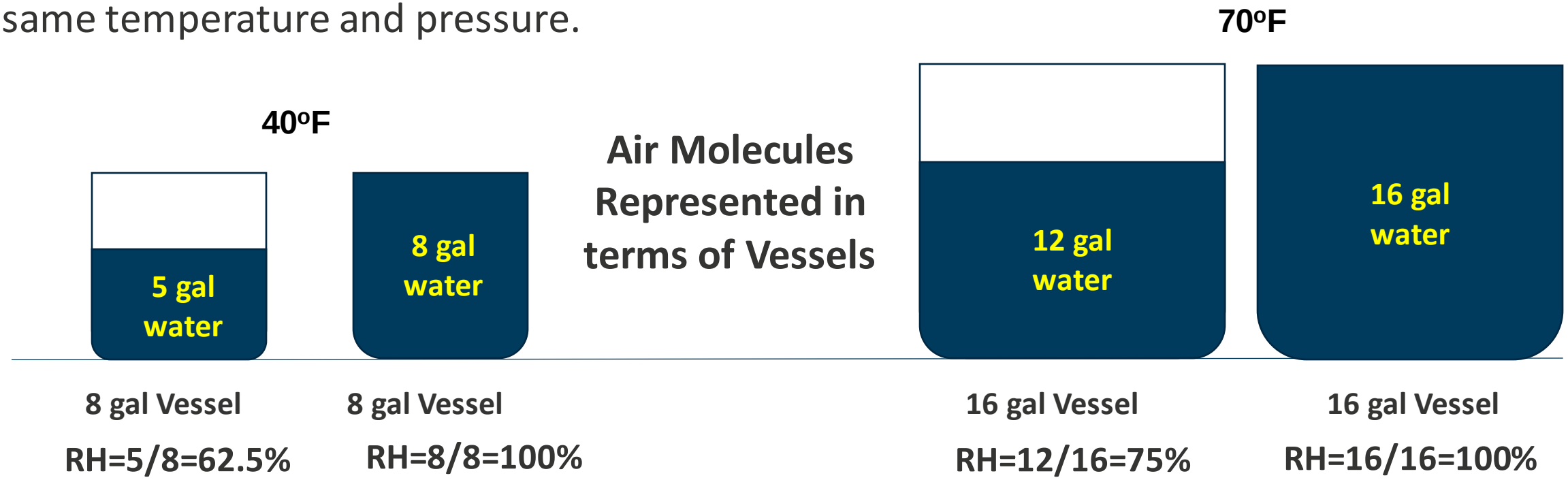
- NIR is a non-destructive method of moisture measure.
- This instrument is used to measure NIR spectra in the short wavelength region from 700 nm (nano meter=10^{-9} Scale) to 1100 nm in transmittance mode for moisture content.
- Principle: The specific organic molecules absorb specific wavelengths of near infrared light energy.
- This method is also used to measure oil and protein content in the grain sample.

FOSS Infratec 1241

Perten Inframatic 8800

Relative Humidity (RH)

It is the ratio of water vapor pressure of air and saturated water vapor pressure of air at the same temperature and pressure.



$$\mathrm{RH} = \frac{\text{water vapor pressure x } 100}{\text{Saturated water vapor pressure}}$$

Equilibrium Moisture Content (EMC)

- All grains equilibrate to a moisture content at fixed surrounding temperature and relative humidity – known as EMC.
- At EMC, there is no moisture intake or drying that will happen.

EMC is defined as:
Vapor Pressure (RH) Inside the Grain =
Vapor Pressure (RH) Surrounding Outside

It is a characteristic of grain

Safe Storage Moisture Content

Questions to Participants:

- Who told you corn 15% moisture content (MC) and soybean 13% MC are the safe storage moistures?
- How safe storage moisture content is determined?
- What is the basis for fixing safe storage moisture content limit?

Safe Storage MC: Remove/Add Moisture

Drying (Removing):

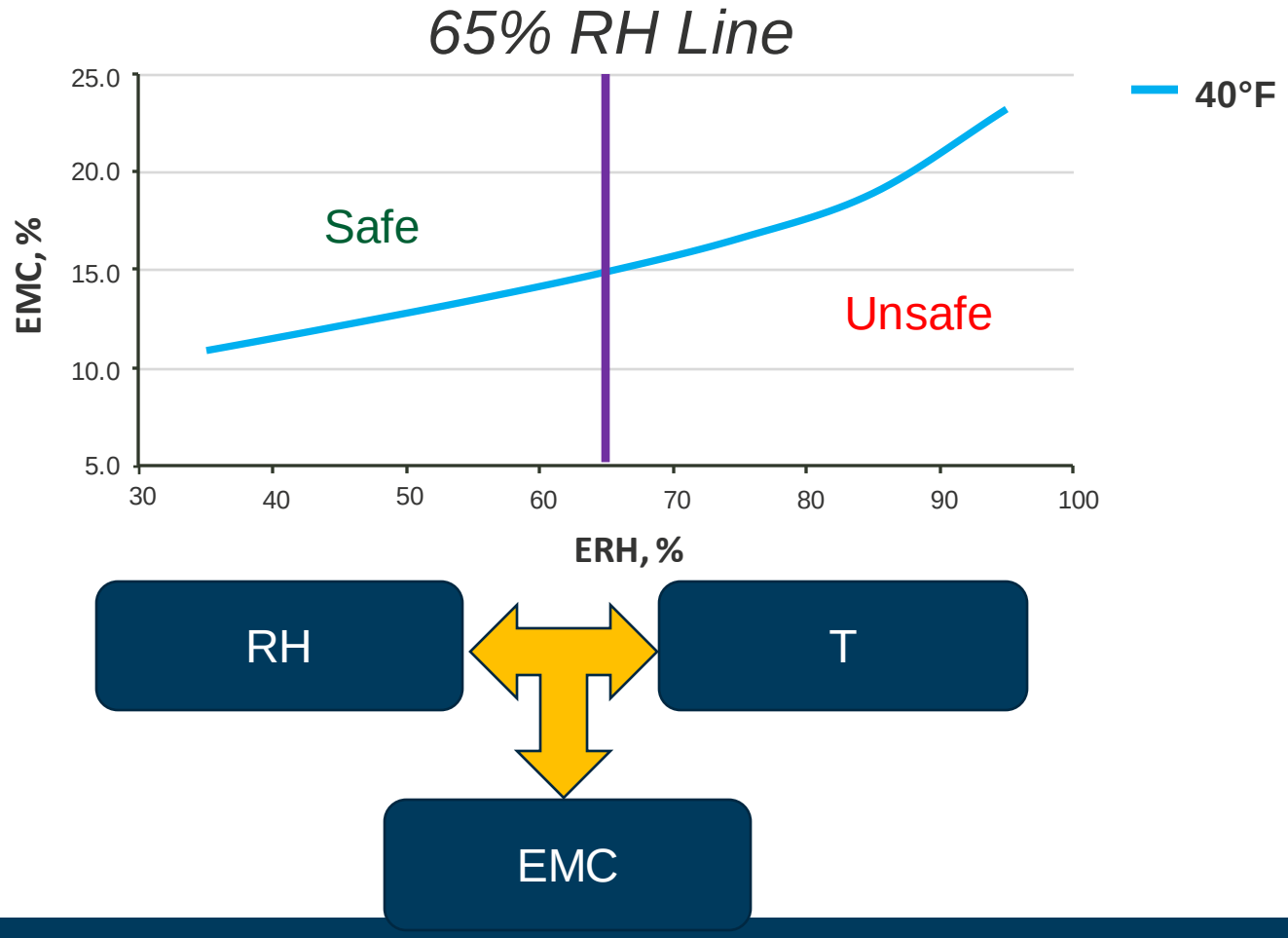
Grain Type	Safe Storage at 40°F	
	MC,%	RH,%
Corn	15.0	65
Soybean	13.0	65
Wheat	13.5	65

Hydration(Adding):

Grain Type	Storage Condition at 40°F	
	MC,%	RH,%
Corn	15.0	70
Soybean	13.0	70
Wheat	13.5	70

Grain Type	Safe Storage at 40°F	
	MC,%	RH,%
Corn	14.0	65
Soybean	12.0	65
Wheat	12.5	65

Why is EMC Important?

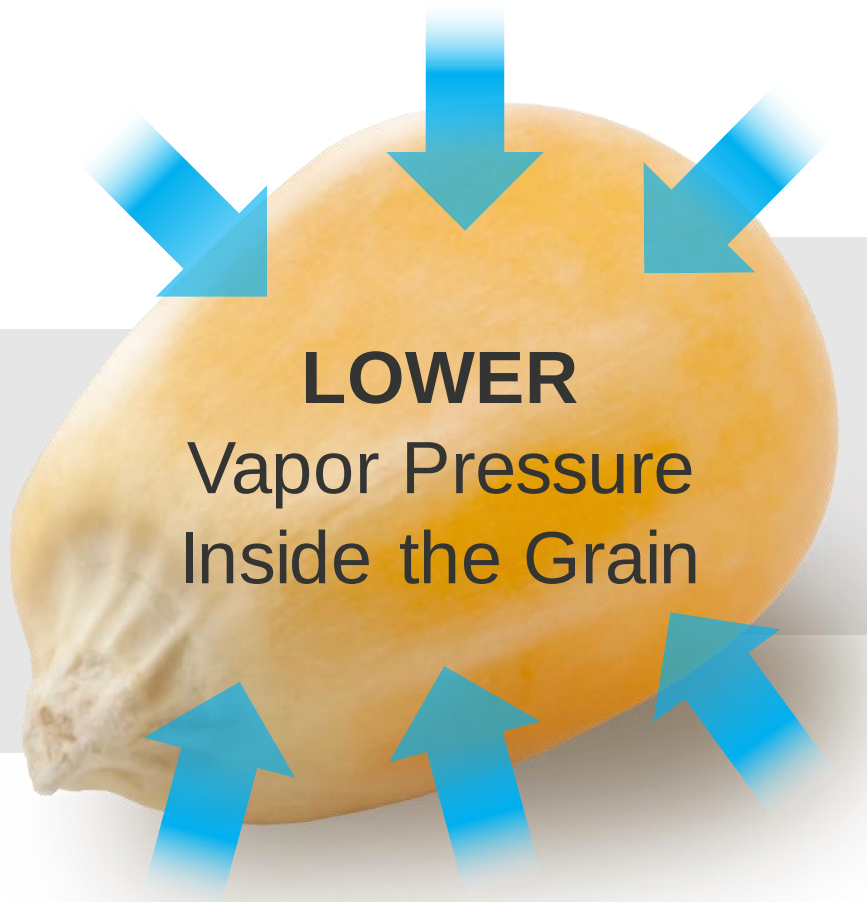


EMC: Dry Condition

Lower Vapor Pressure in the Surrounding Environment

Moisture Loss to Outside to Maintain Equilibrium

EMC: Wet Condition



Higher Vapor Pressure in the Surrounding Environment

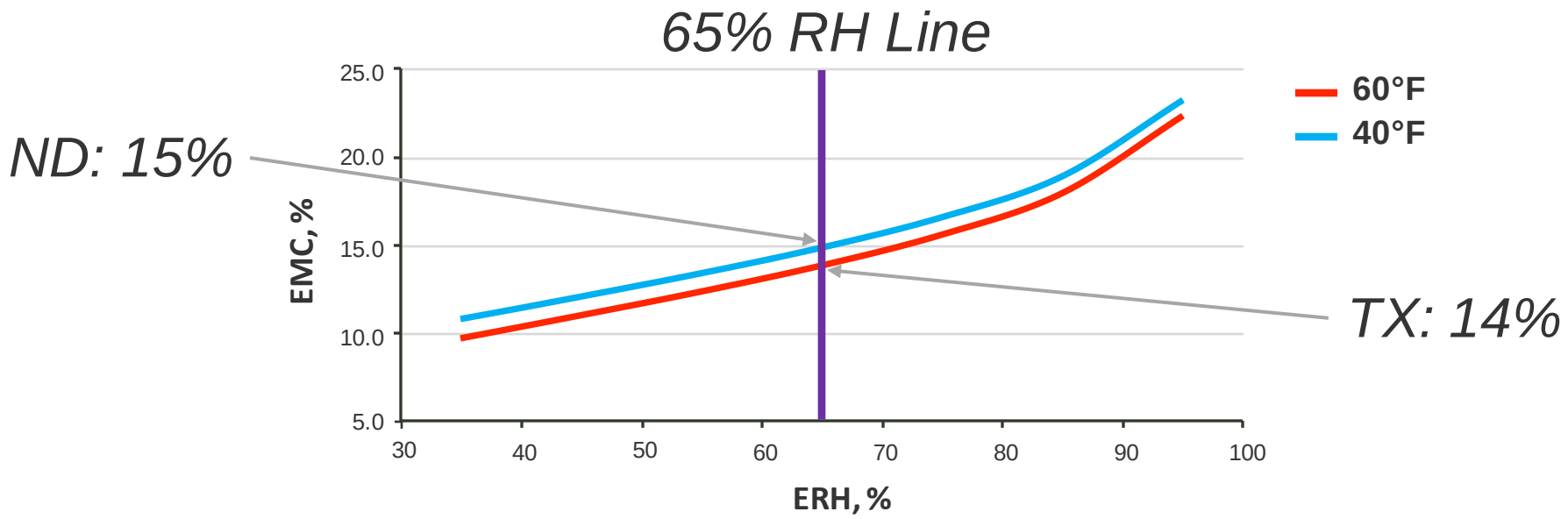
Moisture Gain into the Grain to Maintain Equilibrium

Factors Affecting EMC

- Temperature
- Relative Humidity
- Grain Type
- Grain Variety/Hybrids
- Grain Maturity and History
- Composition of Material (oil, protein, starch)

EMC Variations: Effect of Temperature

- Temperature increases, EMC decreases at a constant RH.



YELLOW DENT CORN

EMC Variations: Effect of Temperature

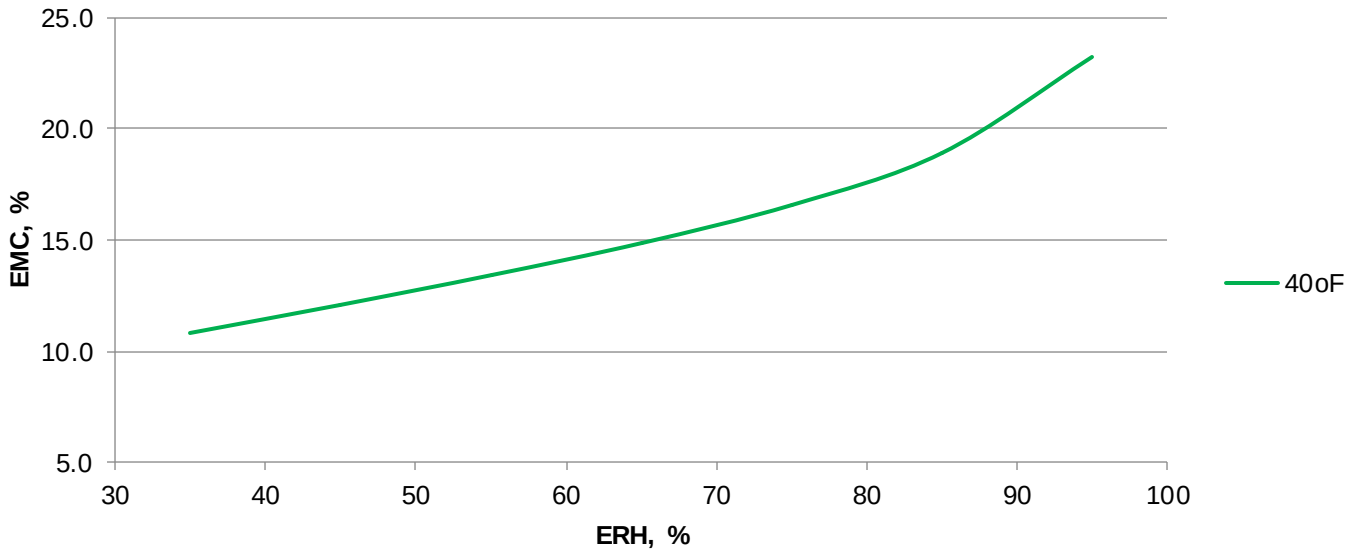
- EMC Characteristics Table for Corn Hybrid-B

Grain Temperature (°F)	Relative Humidity, %						
	35	45	55	65	75	85	95
100	9.4	10.6	11.8	13.1	14.7	16.8	20.8
90	9.7	10.8	12.0	13.3	14.9	17.0	21.0
80	10.0	11.1	12.3	13.6	15.2	17.3	21.2
70	10.3	11.4	12.6	13.9	15.4	17.5	21.4
60	10.6	11.7	12.9	14.2	15.7	17.8	21.7
50	10.9	12.1	13.2	14.5	16.0	18.1	22.0
40	11.3	12.4	13.6	14.9	16.4	18.4	22.2
30	11.7	12.8	14.0	15.2	16.7	18.8	22.6

SAFE **Mold begins to grow Above 65% RH** **UNSAFE**

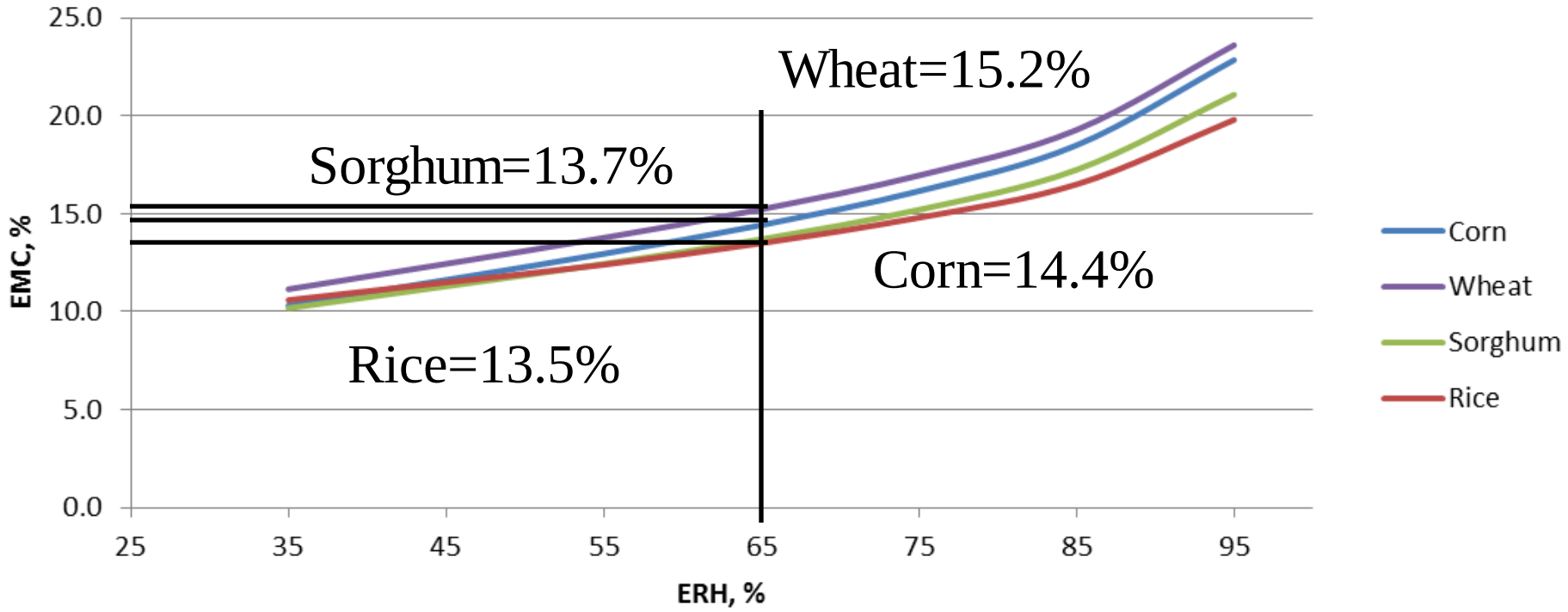
EMC Variations: Effect of RH

Relative Humidity increases as EMC increases at constant temperature



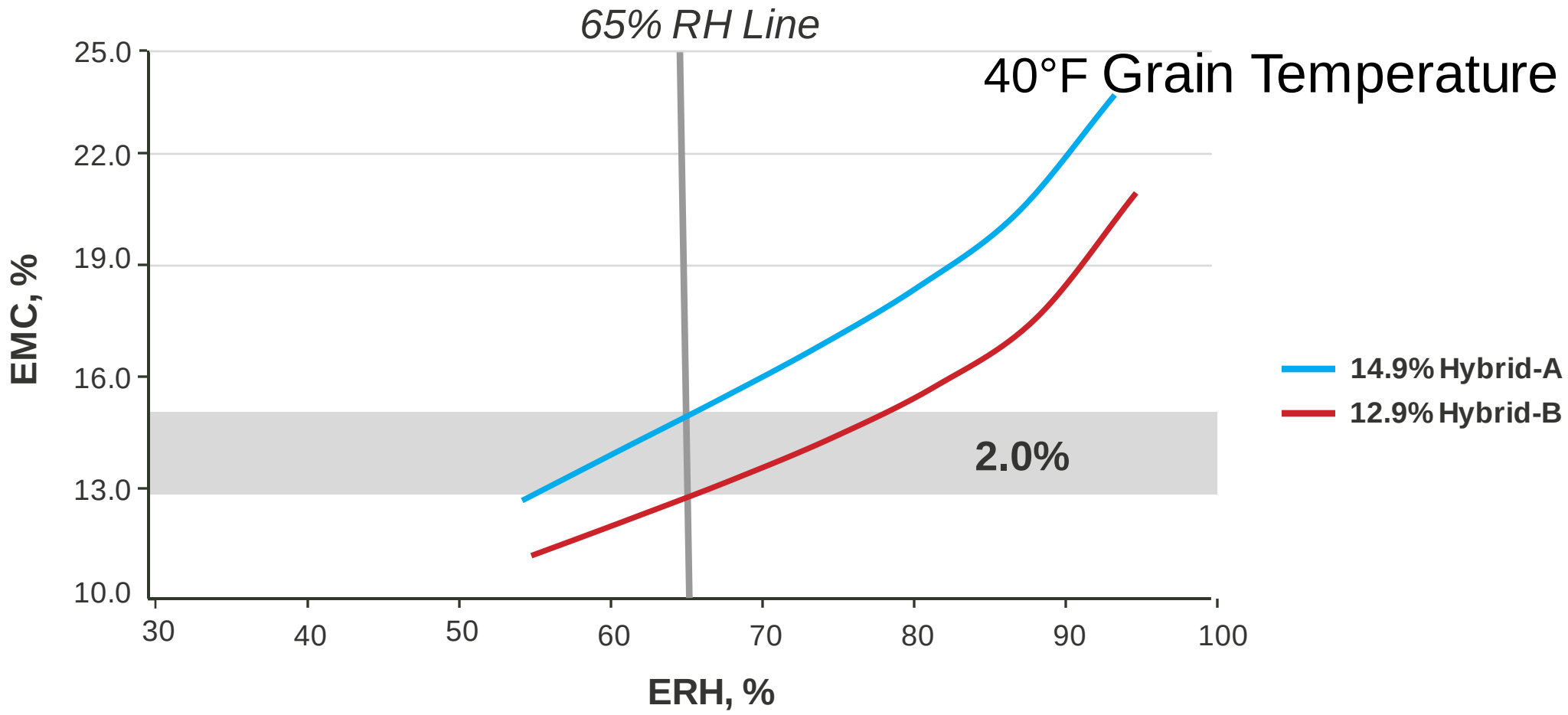
Yellow Dent Corn

EMC Variations: Grain Type



40°F Grain Temperature

EMC Variations: Corn Hybrids



EMC Variations: Corn Hybrids

Soybean Type	Relative Humidity, %						
	35	45	55	65	75	85	95
Hybrid-1	9.4	10.5	11.7	12.9	14.4	16.5	20.3
Hybrid-2	9.8	10.9	12.0	13.2	14.7	16.7	20.4
Hybrid-3	9.8	10.9	12.2	13.5	15.1	17.2	21.2
Hybrid-4	10.2	11.5	12.7	14.1	15.7	18.0	22.1
Hybrid-5	10.1	11.4	12.7	14.1	15.8	18.1	22.3
Hybrid-6	10.5	11.7	12.8	14.1	15.7	17.7	21.6
Hybrid-7	10.5	11.7	13.0	14.3	15.9	18.1	22.2
Hybrid-8	10.3	11.6	12.9	14.4	16.1	18.5	22.8
Hybrid-9	10.8	11.9	13.1	14.4	16.0	18.1	22.1
Hybrid-10	11.3	12.4	13.6	14.9	16.4	18.4	22.2

- At 40°F Grain Temperature
- Marketable Safe Storage Moisture Content is 15% for Corn

EMC Variations: Soybean Hybrids

Soybean Type	Relative Humidity, %						
	35	45	55	65	75	85	95
Hybrid-1	6.0	7.5	8.9	10.5	12.5	15.0	19.8
Hybrid-2	5.9	7.5	9.1	10.9	13.0	15.8	21.0
Hybrid-3	5.1	6.8	8.6	10.6	12.9	15.9	21.4
Hybrid-4	5.6	7.4	9.3	11.3	13.7	16.9	22.6
Hybrid-5	6.3	8.0	9.7	11.5	13.7	16.6	21.8
Hybrid-6	6.4	7.8	9.3	10.9	12.8	15.4	20.2
Hybrid-7	6.2	8.1	10.0	12.1	14.5	17.7	23.5
Hybrid-8	7.7	9.4	11.0	12.8	14.9	17.7	22.9
Hybrid-9	5.3	7.2	9.2	11.3	13.8	17.1	23.1

- At 40°F Grain Temperature
- Marketable Safe Storage Moisture Content is 13% for Soybeans

EMC Variations: Corn Hybrid-A

- Yellow Dent Corn– Desorption

Grain Temperature (°F)	Relative Humidity, %						
	35	45	55	65	75	85	95
100	7.6	8.8	10.1	11.5	13.2	15.5	19.8
90	7.8	9.0	10.3	11.7	13.4	15.7	20.0
80	8.0	9.2	10.5	11.9	13.6	15.9	20.1
70	8.2	9.5	10.8	12.2	13.8	16.1	20.3
60	8.5	9.7	11.0	12.4	14.0	16.3	20.5
50	8.7	10.0	11.2	12.6	14.3	16.5	20.7
40	9.0	10.2	11.5	12.9	14.5	16.7	20.9
30	9.3	10.5	11.7	13.1	14.8	17.0	21.1

SAFE **Mold begins to grow Above 65% RH** **UNSAFE**

EMC Variations: Corn Hybrid-B

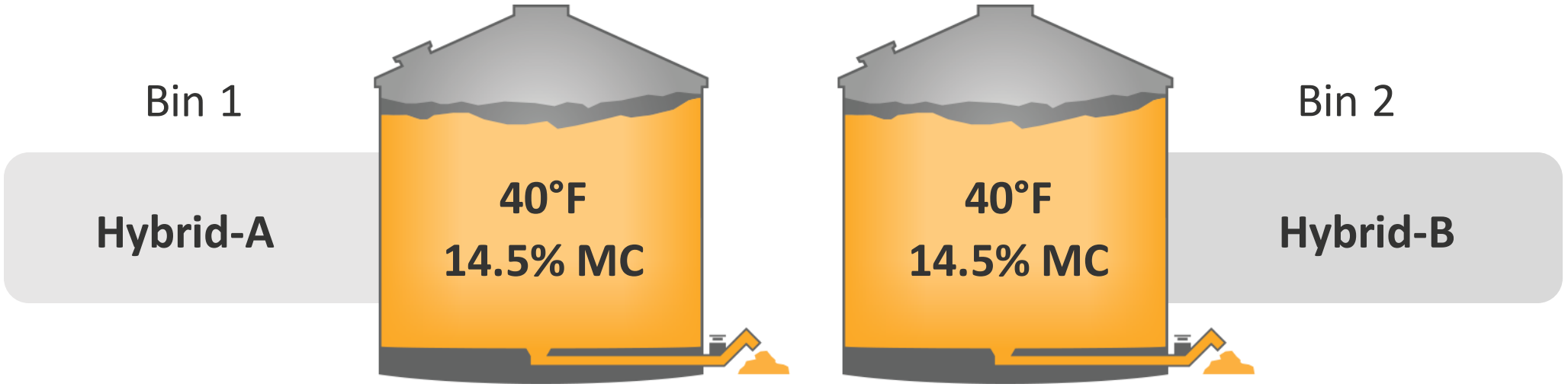
- Yellow Dent Corn– Desorption

Grain Temperature (°F)	Relative Humidity, %						
	35	45	55	65	75	85	95
100	9.4	10.6	11.8	13.1	14.7	16.8	20.8
90	9.7	10.8	12.0	13.3	14.9	17.0	21.0
80	10.0	11.1	12.3	13.6	15.2	17.3	21.2
70	10.3	11.4	12.6	13.9	15.4	17.5	21.4
60	10.6	11.7	12.9	14.2	15.7	17.8	21.7
50	10.9	12.1	13.2	14.5	16.0	18.1	22.0
40	11.3	12.4	13.6	14.9	16.4	18.4	22.2
30	11.7	12.8	14.0	15.2	16.7	18.8	22.6

SAFE **Mold begins to grow Above 65% RH** **UNSAFE**

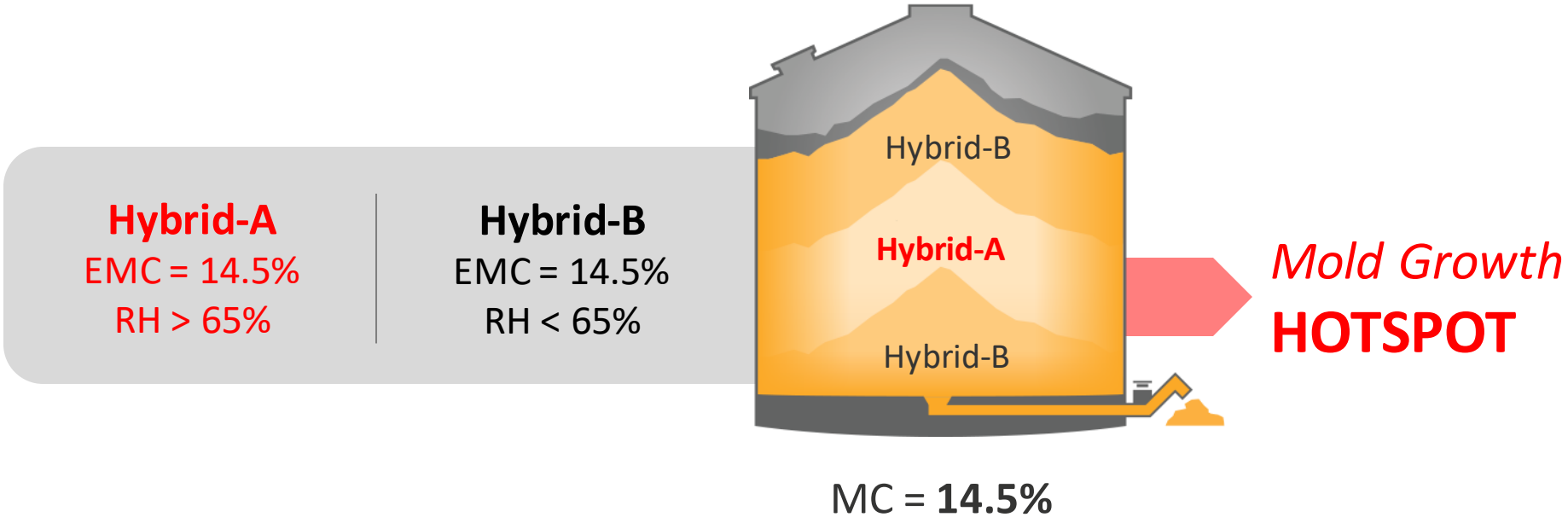
EMC Variations: Implications

- Which bin will have spoilage issues?



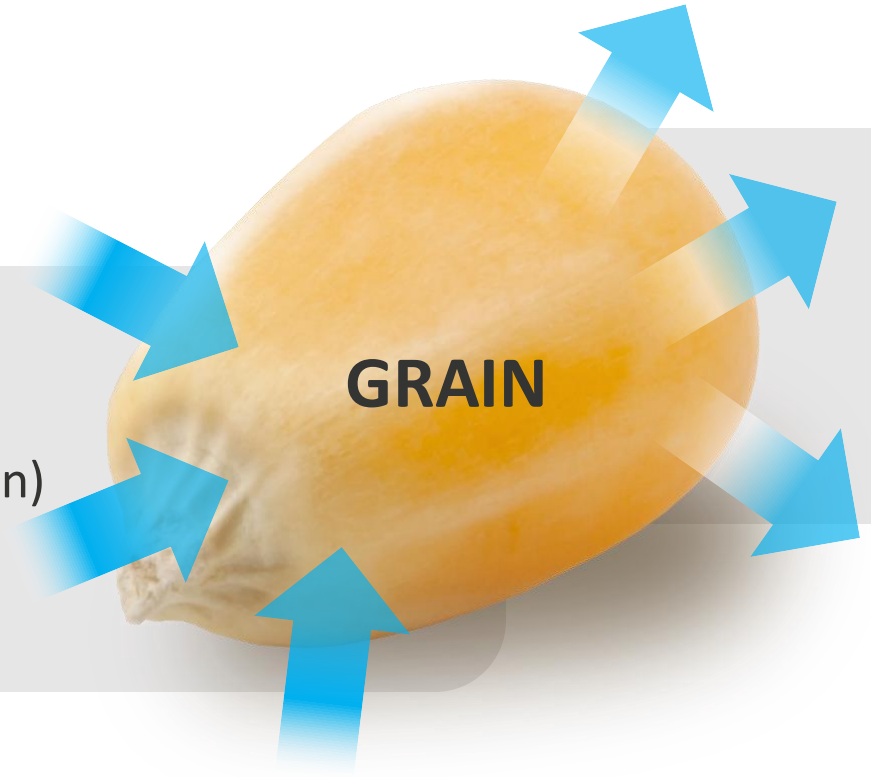
EMC Variations: Implications

- **Implications:** Loading in the same bin
- Mixing two different EMC hybrids of corn is **NOT** recommended



Two Types of EMC

Adsorption EMC Curve:
Rewetting (Moisture Gain) Characteristics

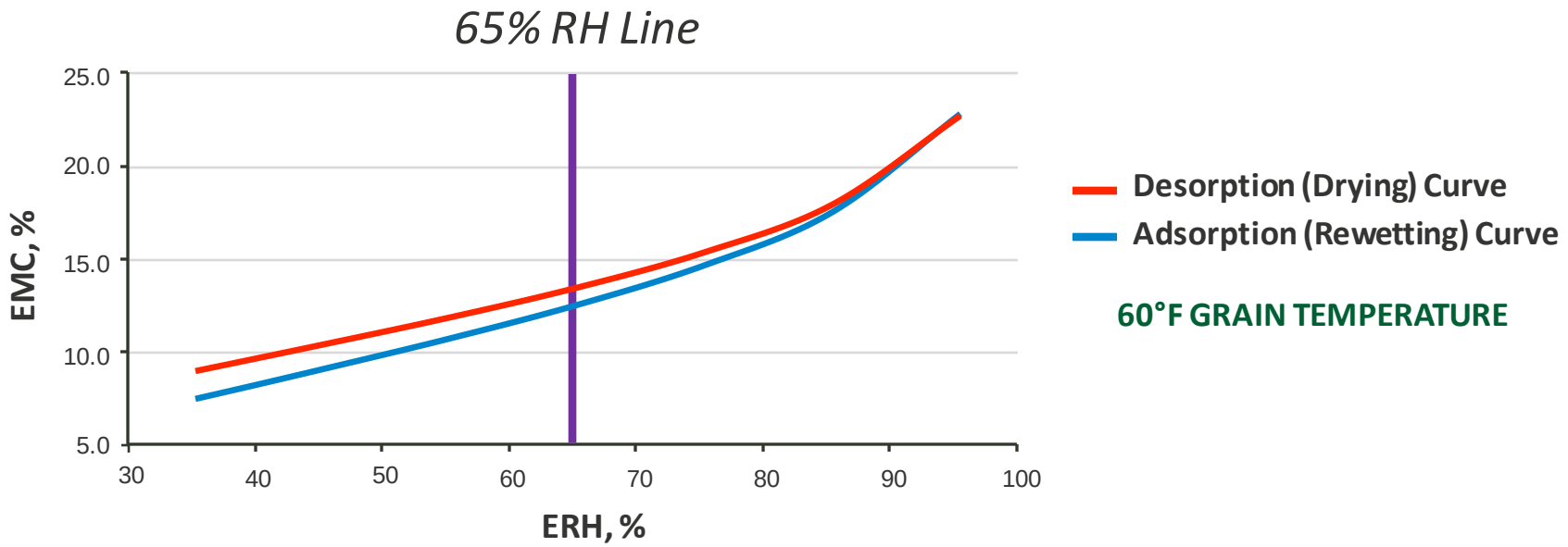


Desorption EMC Curve:
Drying (Moisture Removal) Characteristics

Desorption EMC values are usually higher than Adsorption EMC values

Hysteresis

- Desorption and Adsorption EMC values are distinct and that difference is called Hysteresis.



AGI Grain Lab

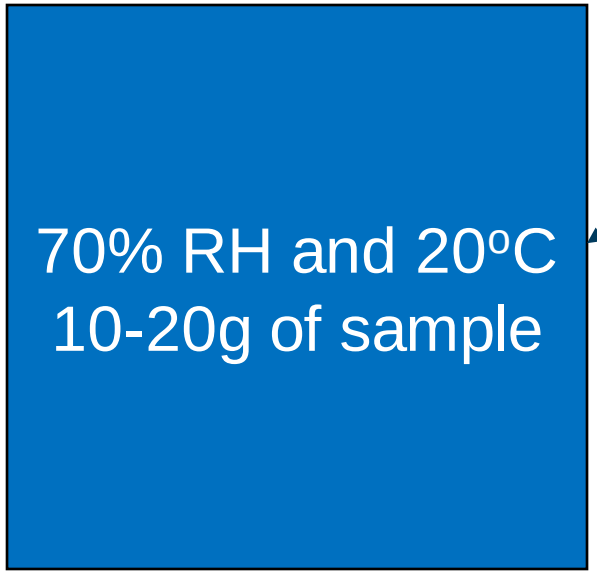
Determination of EMC Characteristics

- **STEP 1:** Request customer to send 5-7 gallons grain sample to the lab.
- **STEP 2:** Lab develops EMC Curve for the new sample.
- **STEP 3:** Upload the new EMC values into customer SureTrack FARM account to manage grains.

EMC Determination

Direct Method:

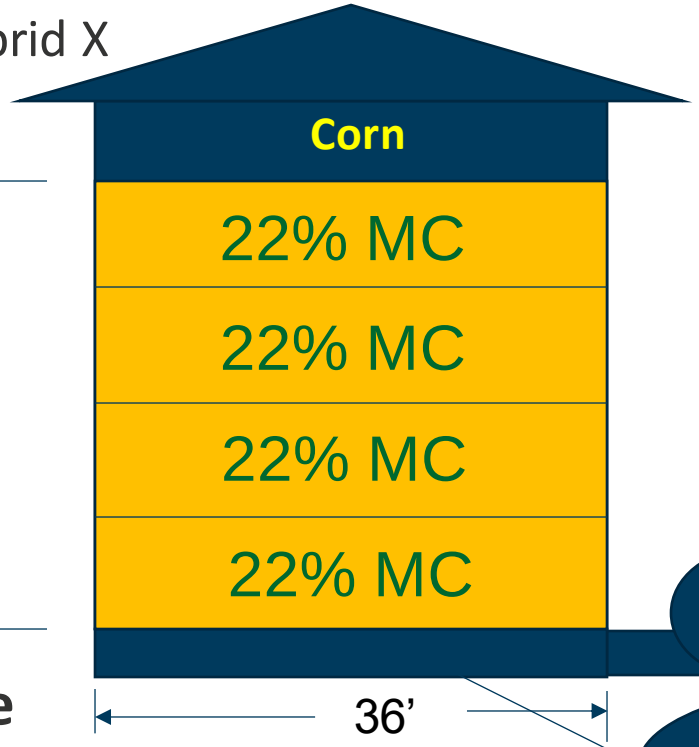
Set the RH and Temperature, wait for grain to equilibrate



Time to equilibrate:
2-4 weeks

EMC Based Drying

Corn Hybrid Name: Hybrid X



Ambient
Temperature:70ºF
RH:95%

Ambient Air EMC: 21%

This air EMC is based on the grain stored in the bin

Airflow=1 cfm/bu

FAN ON

5” of SP=5ºF rise

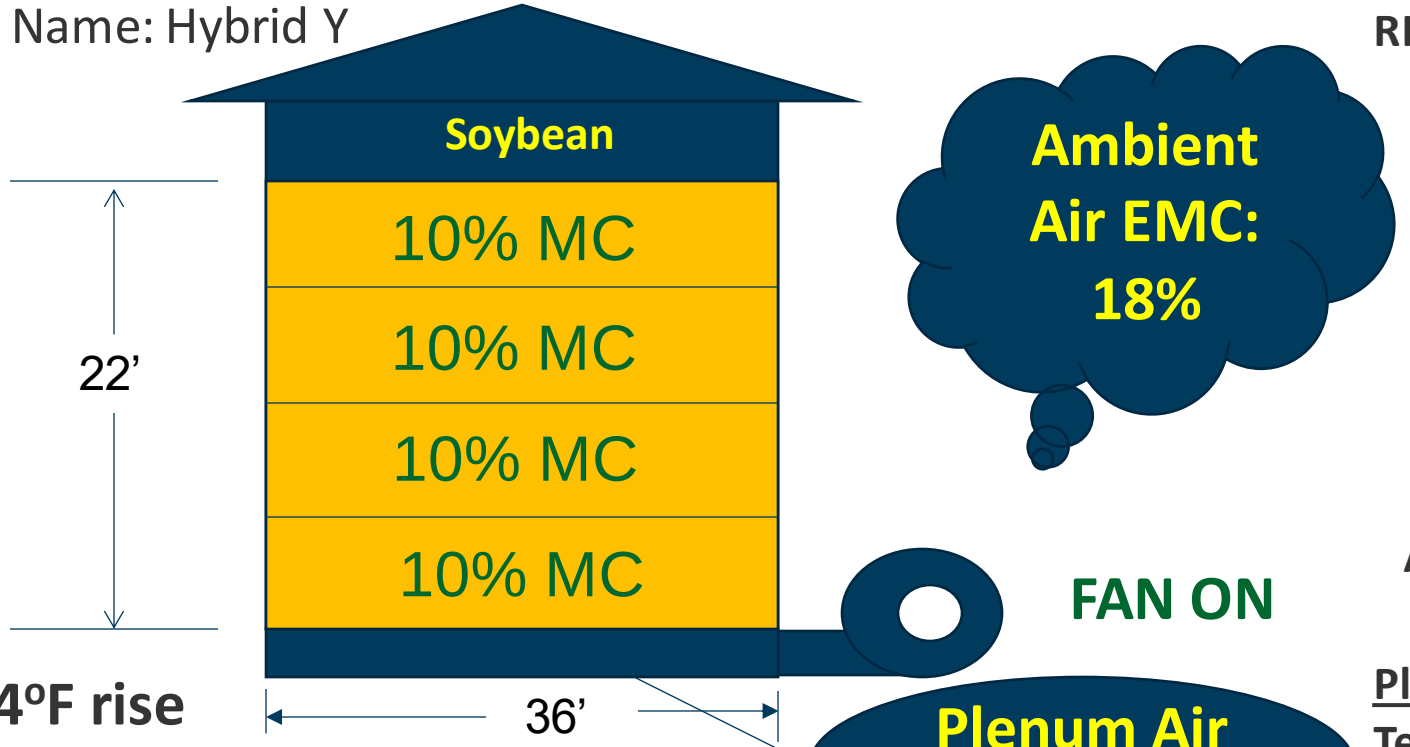
Plenum
Temperature:75ºF
RH:82%

Plenum Air EMC: 17%

Target Moisture Content=15%

EMC Based Hydration

Soybean Hybrid Name: Hybrid Y



Ambient
Temperature:60ºF
RH:85%

This air EMC is based on the grain stored in the bin

Airflow=1 cfm/bu

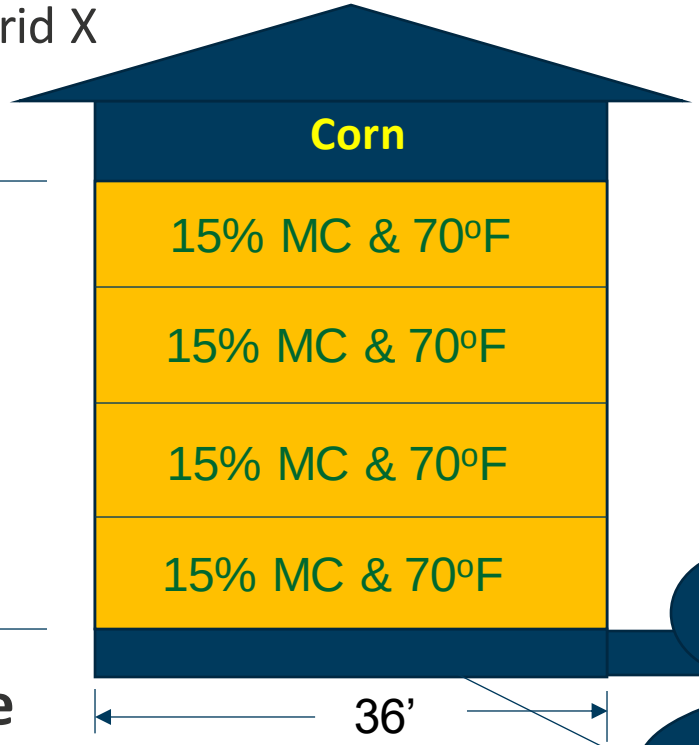
Plenum
Temperature:64ºF
RH:72%

4” of SP=4ºF rise

Target Moisture Content=15%

EMC Based Cooling

Corn Hybrid Name: Hybrid X



Ambient
Temperature:60ºF
RH:95%

Ambient Air EMC: 21%

This air EMC is based on the grain stored in the bin

Airflow=1 cfm/bu

FAN OFF

5” of SP=5ºF rise

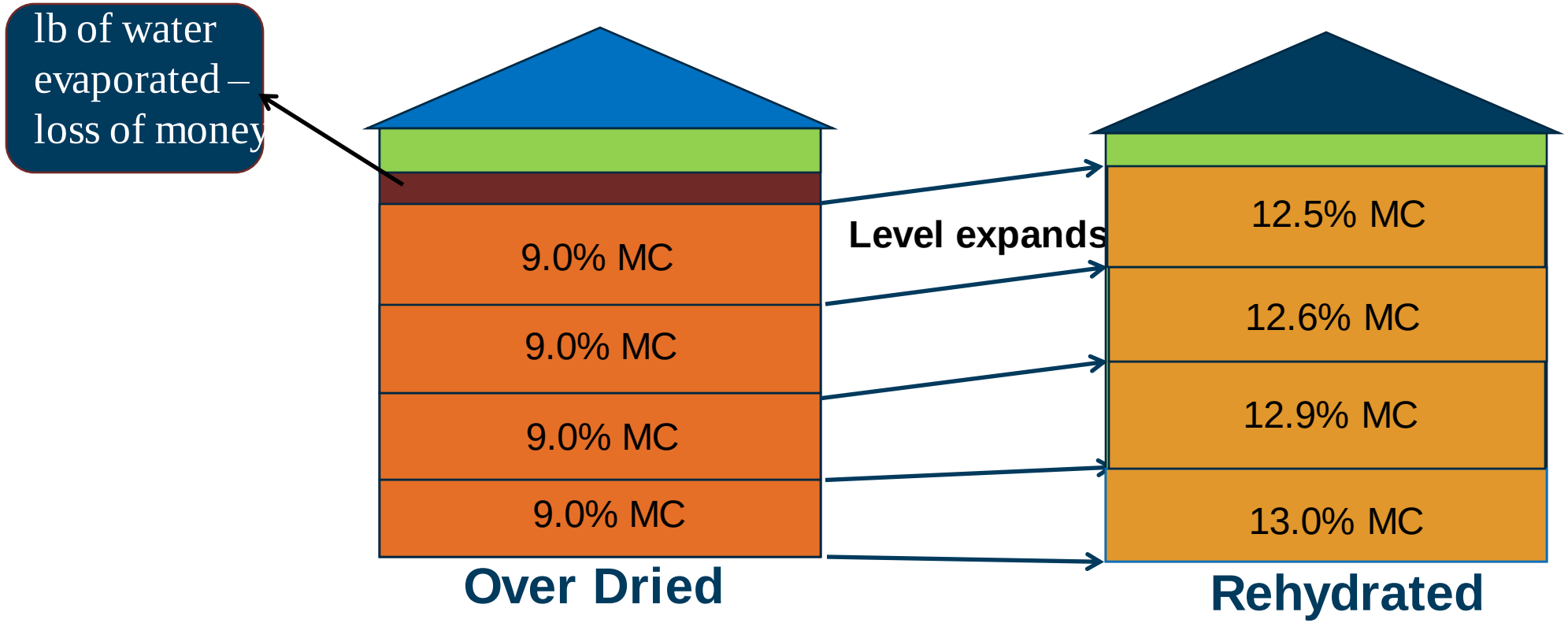
Plenum
Temperature:65ºF
RH:83%

Plenum Air EMC: 17%

Target Temperature =40ºF

Economical Benefit

Rehydration of Soybeans



Economical Benefit

Money Gained During Rehydration of Soybeans

Bin Size	lb of water rehydrated	Bushel of water	Money Gain
D36 H 7RW	52,747	879	**$13,185**
D42 H 8RW	60,532	1,024	**$15,360**
D48 H 9RW	79,062	1,337	**$20,055**

Calculated based on $15/bu of soybeans

Economical Benefit

Money Gained During Rehydration of Soybeans

Bin Size	Money Gain	Fan Run Energy Cost	Actual Money Gain
D36 H 7RW	$13,185	**$1,113**	**$12,072**
D42 H 8RW	$15,360	**$2,259**	**$13,101**
D48 H 9RW	$20,055	**$4,470**	**$15,585**

Calculated based on $15/bu of soybeans

Summary

- Safe storage moisture content of any grain type can be determined using the equilibrium moisture content (EMC) characteristics which helps in managing the hotspots (spoilage) in a bin

- Using EMC characteristics of grain, we can select ambient air for cooling, warming, drying and hydrating, an efficient method

- Using EMC based hydration and drying provide economic benefit to farmers and producers

Contact Information

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