OPTIMIZING PERFORMANCE OF TMR MIXERS

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Outline

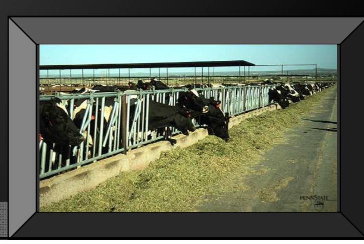
- Introduction
- Variation **Among** Batches
- Variation **Within** Batches
- Experimenting on the farm
  - How
  - Example analysis
- Summary

Goals of TMR Delivery

- Consistent blend in the feed bunk
  - over time
  - across location
  - despite feedstuff changes
- Proper particle size
- Low labor & equipment cost
- Long equipment life & low energy use

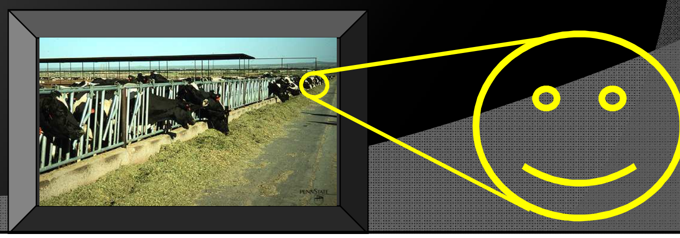
<u>Open</u> Loop Control

Describe the animals → Characterize the feeds → Balance the ration → Deliver the ration



Closed Loop Control

Describe the animals → Characterize the feeds → Balance the ration → Deliver the ration → Monitor the ration



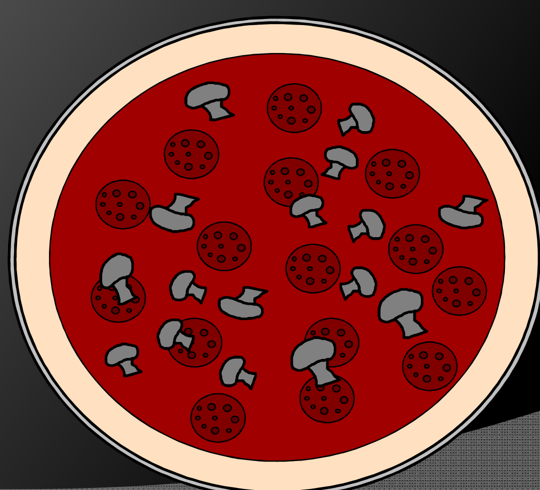
Grammar of Acronyms

- TMR
- MTR
- MPR
- PMTR
- TMTR

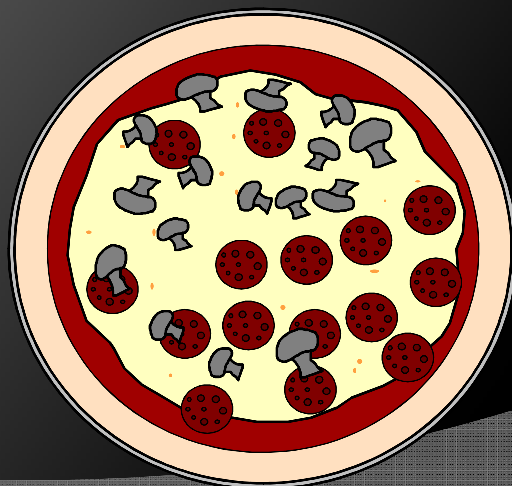
Grammar of Acronyms

- TMR — Total Mixed Ration
- MTR — Mixed Total Ration
- MPR — Mixed Partial Ration
- PMTR — Partially Mixed Total Ration
- TMTR — Totally Mixed Total Ration

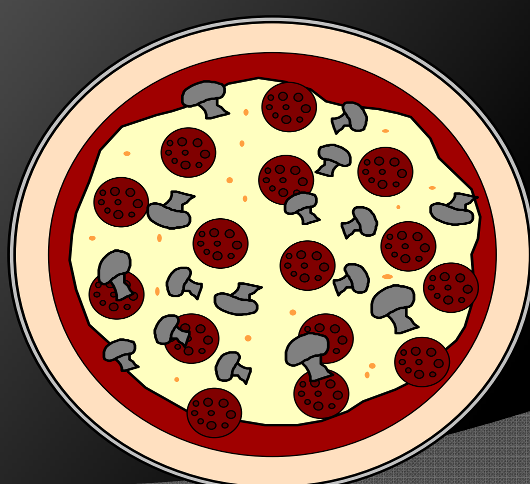
MPR



PMTR



TMTR



Acronym conclusion

Uniformity AMONG Batches

- In a ration with 5 ingredients, there are 15 reasons for the ration NDF, CP, NE_L, or other characteristic to be different than the target!
  - DM content (%)
  - Nutrient concentration (% of DM)
  - Amount in the mix (lb as is)

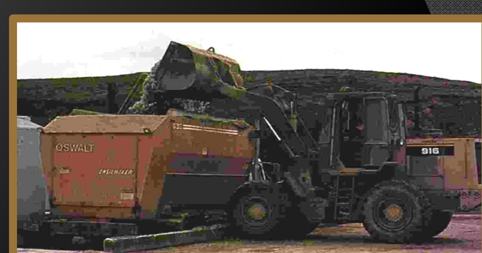
$$NDF_{ration,\%} = \frac{\sum_{feeds} AMT_{lb} \times DM_{fraction}}{\sum_{feeds} AMT_{lb} \times DM_{fraction}}$$

Uniformity AMONG Batches

- **Monitor**
  - ingredient nutrient concentrations
  - ingredient DM concentrations
  - particle size reduction
- **Control**
  - amounts in the ration
  - mixing protocol (fill order & mixing time)

Variation AMONG Batches

- EXAMPLE 1
  - Ration with:
    - haycrop silage
    - corn silage
    - grain premix
  - Haycrop silage moisture goes up (a 5 to 10 percentage point swing over a week time span is certainly possible)

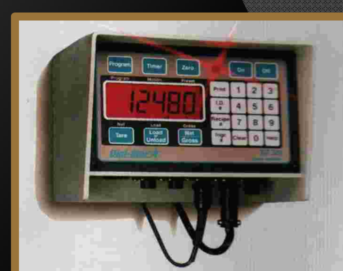


Variation AMONG Batches

- EXAMPLE 1 (haycrop moisture increases)
  - Consequences if no corrective action is taken
    - less haycrop DM in ration
    - lower protein in the ration
    - higher energy concentration in the ration
    - likely reduced effective fiber in the ration
    - more grain consumption than planned
  - **Corrective action:** adjust amounts in the ration

Variation AMONG Batches

- EXAMPLE 2
  - Ration with:
    - haycrop silage
    - corn silage
    - grain premix
  - Corn silage amount swings widely from batch to batch



Variation AMONG Batches

- EXAMPLE 2 (corn silage amount varies)
  - Consequences if no corrective action is taken
    - inconsistent energy concentration in the ration
    - inconsistent protein concentration in the ration
    - inconsistent effective fiber in the ration
    - intake is inconsistent and likely decreases
  - **Corrective action:** meter in more consistently or vary other ingredients proportionally

Variation AMONG Batches

- EXAMPLE 3

Fill order #1	Fill order #2
haycrop silage	grain premix
corn silage	corn silage
grain premix	haycrop silage

Mixer (which is designed to do some particle size reduction) is run during filling

Variation AMONG Batches

- EXAMPLE 3 (varied fill order)
  - Consequences if no corrective action is taken
    - inconsistent particle size distribution in the ration
    - inconsistent effective fiber in the ration
  - **Corrective action:** Implement a consistent mixing protocol

Uniformity WITHIN Batches

- Mixer capacity
  - select for minimum batch size
  - select for maximum batch size
- Mixer management
  - fill order
  - mixing time
  - particle size reduction

Mixer Sizing

Don't overlook the obvious

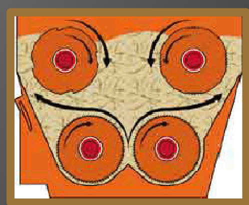
- Size for maximum batch size
- Size for minimum batch size
- Maybe not all groups get the same number of batches per day
- Most mixers don't work well when "full" (likely 70% full -- the fine print is always most important!)

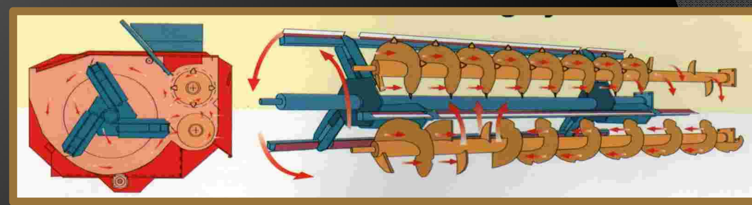
Mixer Management

General principles

- Mix long enough (assure uniformity)
- Don't mix too long (avoid excessive wear, particle size reduction, energy & labor)
- Control particle size reduction
- Understand the material flow in the mixer

Material Flow is a Big Deal





Mixer Management

<u>Sample Mixing Protocol</u>

- Mixer off during loading
- Small quantity and liquid ingredients loaded in first
- Haycrop silage loaded last
- Mix 3-5 minutes after filling is complete
- Unload quickly, mixer off except when unloading

Monitoring your TMR

- DM content
  - microwave, Koster tester, vortex dryer, or drying oven
- Particle size distribution
  - Penn State separator or lab analysis
- Nutrient concentrations
  - Lab analysis
- Tracers in the ration

Experimenting on the Farm

Rules for on-farm experimenting:

- Replicate, replicate, replicate
- Change one thing at a time
- Be consistent and document what you are doing
- Use appropriate (likely simple) statistics
- Ask for advice when you should

Be looking for variability *among* and *within* batches.

Experimenting on the Farm

1. Exploring mix uniformity by varying mixing protocol

- change fill order
- change mixing time (count revolutions instead of time)
- try not running the mixer during filling & transport (or run it slowly)

corn | **hay** | **silage 1** | **silage 2** | **premix**

Experimenting on the Farm

1. Uniformity … (how to measure)

- Add a tracer such as whole shelled corn, cotton seeds, corn cobs, mini carrots, or other safe, physically identifiable objects. Look for variation along the bunk.
- Take samples from the bunk for lab analysis



Experimenting on the Farm

2. Exploring particle size reduction

- “mix” a single forage (vary time and monitor particle size reduction)
- hand mix a mini-ration as a comparison
- compute weighted average particle size distribution from ingredients used

Experimenting on the Farm

2. Particle size ... (how to measure)

- Penn State separator
- Laboratory analysis

Note: To a degree, particle size analysis of samples within a batch (along the feed bunk) can be useful for identifying within batch variation.

Example Analysis #1

- 15 lb of whole shelled corn was added for each ton of TMR which otherwise did not contain whole kernels
- 2 lb samples were pulled along the feed bunk
- Kernel counts per 2 lb sample is reported.

Example Analysis #1

Sample number	Kernel count
1	15
2	13
3	10
4	12
5	14

collected at different times during unloading or varied places along the feedbunk

Average	12.8
Std. Deviation	1.9
CV	15.0
90% confidence range	1.41
90% confidence, %	11.1

Example Analysis #2

- Five similar replicate batches
  - Same mixer
  - Same ingredients from the same structures
  - Same fill order
  - Same mixer operation and procedure
- 2 lb samples pulled from bunk
- Hay was a significant part of the ration
- % long particles (top sieve of PSU separator) reported

What should be evaluated?

- % long material
- CV of % long material
- Confidence interval of CV of % long material

It's time to think about the CV of CVs

Example Analysis # 2 … **Within**

Sample number	Batch #1 % long mass	Batch #2 % long mass	Batch #3 % long mass	Batch #4 % long mass	Batch #5 % long mass
1	8.2	10.0	9.4	12.0	5.5
2	7.0	9.5	7.8	7.0	7.2
3	5.5	6.0	7.6	8.1	3.4
4	9.2	7.4	10.7	10.3	3.8
5	8.0	8.0	8.5	8.0	8.0

collected at different times during unloading or varied places along the feedbunk

Within batch analysis					
Average	7.6	8.2	8.8	9.1	5.6
Std. Deviation	1.4	1.6	1.3	2.0	2.0
CV	18.5	19.8	14.5	22.3	36.3
90% confidence range	1.0	1.2	0.9	1.5	1.5
90% confidence, %	13.6	14.5	10.7	16.4	26.7
90% lower end	6.5	7.0	7.9	7.6	4.1
90% higher end	8.6	9.4	9.7	10.6	7.1

Example Analysis # 2 … **Among**

Within batch analysis					
Average	7.6	8.2	8.8	9.1	5.6
Std. Deviation	1.4	1.6	1.3	2.0	2.0
CV	18.5	19.8	14.5	22.3	36.3

Among batch analysis of the CVs	
Average batch CV	22.3
Std. deviation of batch CV	8.3
CV of batch CVs	37.4
90% confidence range of batch CVs	6.1
90% confidence of batch CVs, %	27.5

Example Analysis # 3 … Comparison

- Previous example

Sample number	Batch #1 % long mass	Batch #2 % long mass	Batch #3 % long mass	Batch #4 % long mass	Batch #5 % long mass
1	8.2	10.0	9.4	12.0	5.5
2	7.0	9.5	7.8	7.0	7.2
3	5.5	6.0	7.6	8.1	3.4
4	9.2	7.4	10.7	10.3	3.8
5	8.0	8.0	8.5	8.0	8.0

Note on sample number: collected at different times during unloading or varied places along the feedbunk

- Same mixer, new procedure

Sample number	% long mass	% long mass	% long mass	% long mass	% long mass
1	8.9	10.3	7.0	10.2	6.5
2	7.1	9.0	8.6	6.3	6.9
3	8.8	6.6	7.0	7.4	5.1
4	10.1	7.8	7.2	9.0	5.0
5	8.0	9.2	8.2	8.3	7.4

Note on sample number: collected at different times during unloading or varied places along the feedbunk

Example Analysis # 3 …Comparison

- Previous example

Within batch analysis					
Average	7.6	8.2	8.8	9.1	5.6
Std. Deviation	1.4	1.6	1.3	2.0	2.0
CV	18.5	19.8	14.5	22.3	36.3

- Same mixer, new procedure

Within batch analysis					
Average	8.6	8.6	7.6	8.2	6.2
Std. Deviation	1.1	1.4	0.7	1.5	1.1
CV	13.0	16.5	9.8	18.1	17.5

Example Analysis # 3 …**Comparison**

Analysis of 25 sampled meal portions			
Average of meal portions	7.8		7.8
Std. Deviation of meal portions	1.4		2.0
CV of meal portions	18.3		25.6

90% confidence range of meal portions	0.5	Errors in print	0.7
90% confidence of meal portions, %	6.0		8.4
90% low of meal portions	7.4		7.2
90% high of meal portions	8.3		8.5

T test results of comparing meal portio	
p=	0.494

Example Analysis # 3 …**Comparison**

Among batch analysis of the CVs	alternative mixing procedure		baseline procedu from example 2
Average batch CV	15.0		22.3
Std. deviation of batch CV	3.5		8.3
CV of batch CVs	23.2		37.4
90% confidence range of batch CVs	2.6		6.1
90% confidence of batch CVs, %	17.1		27.5

T test results of comparing CVs	
p=	0.055

About this example

- 25 samples, 5 each from 5 batches
- With this limited data, a very slight change in any one sample largely influences the analysis
- Batch CV averages 23.2 vs. 37.4 (p=0.055)
  With 5 samples from each of 10 batches (2x the work), p=.007
- Average of meals 7.8 in both cases
  CV of meals 18.3 vs. 25.6
- Even so, if procedure 2 “didn’t cost anything” …

Quality Control in TMR Delivery

Where is the weakest link?

Feed sampling
Dry matter content estimation
Mixer management
Lab nutrient analysis
Ration balancing
Bunk management

TMR Delivery ... the Bottom Line

Don’t have any weak links!

- Feed sampling
- Dry matter content estimation
- Mixer management
- Lab nutrient analysis
- Ration balancing
- Bunk management