OPTIMIZING PERFORMANCE OF TMR MIXERS

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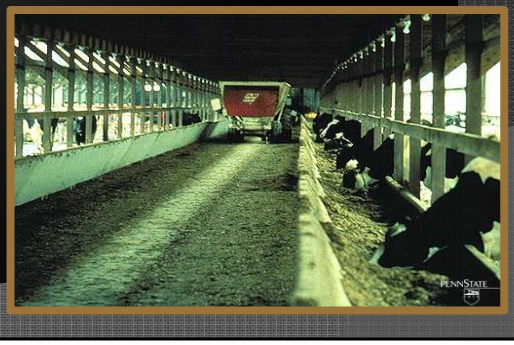
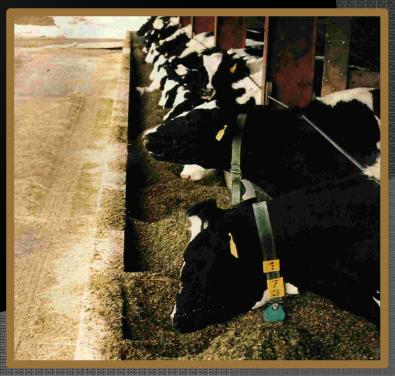
Outline

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



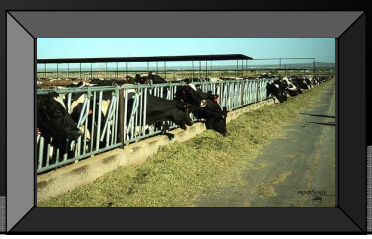
Goals of TMR Delivery

- 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

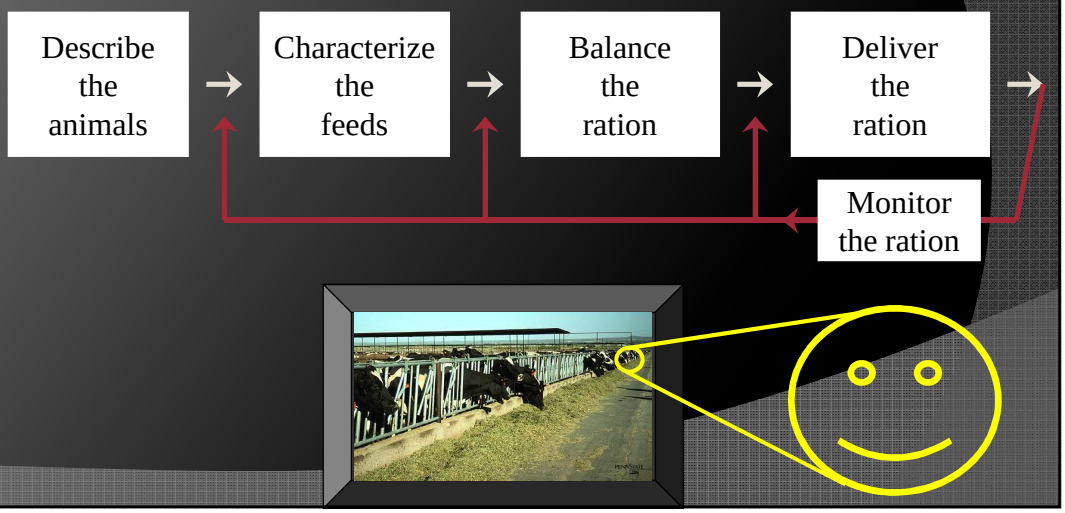


Open Loop Control

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



Closed Loop Control



Grammar of Acronyms

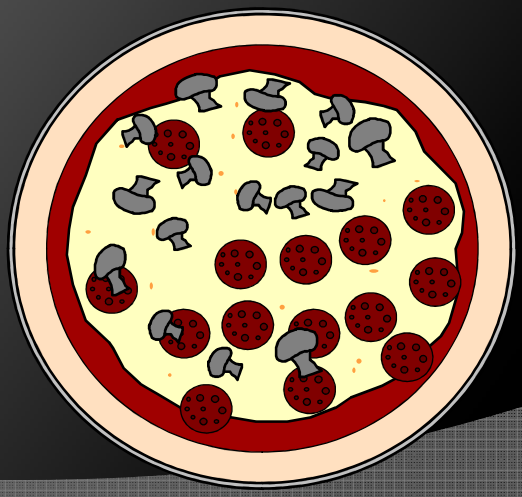
- TMR
- MTR
- MPR
- PMTR
- TMTR

Grammar of Acronyms

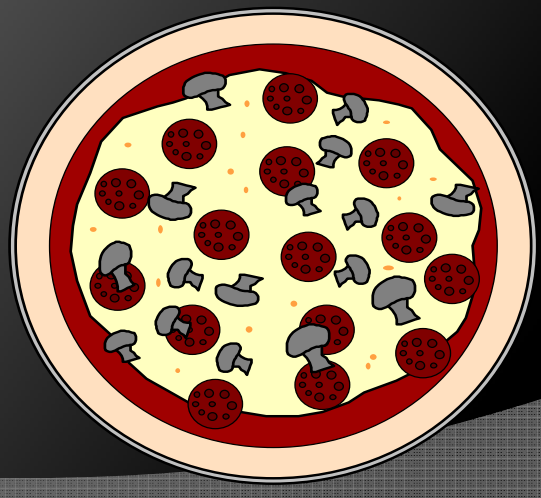
- TMR Total Mixed Ration
- MTR Mixed Total Ration
- MPR Mixed Partial Ration
- PMTR Partially Mixed Total Ration
- TMTR Totally Mixed Total Ration

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)

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

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

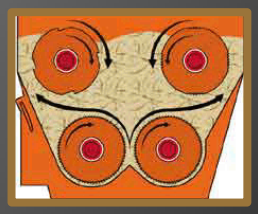
- Size for maximum batch size
- Size for minimum batch size
- Maybe not all groups get the same number of batches per day
- Most mixers don't work well when "full" (likely 70% full -- the fine print is always most important!)

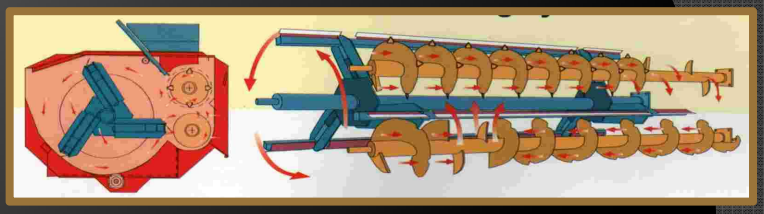
Mixer Management

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

Sample Mixing Protocol

- 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

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

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		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

Errors in print

T test results of comparing meal portio	
p=	0.494

Example Analysis # 3 …**Comparison**

	alternative mixing		baseline procedu
Among batch analysis of the CVs	procedure		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" …

Mixer Manual Excerpts

What follows is some good information from actual operators manuals and mixer manufacturer websites.

According to …
www.kuhnnorthamerica.com

TMR Mixer Analysis for Proper Mixer Choice

Dairy—Milking, Dry Cow, and Heifer Rations

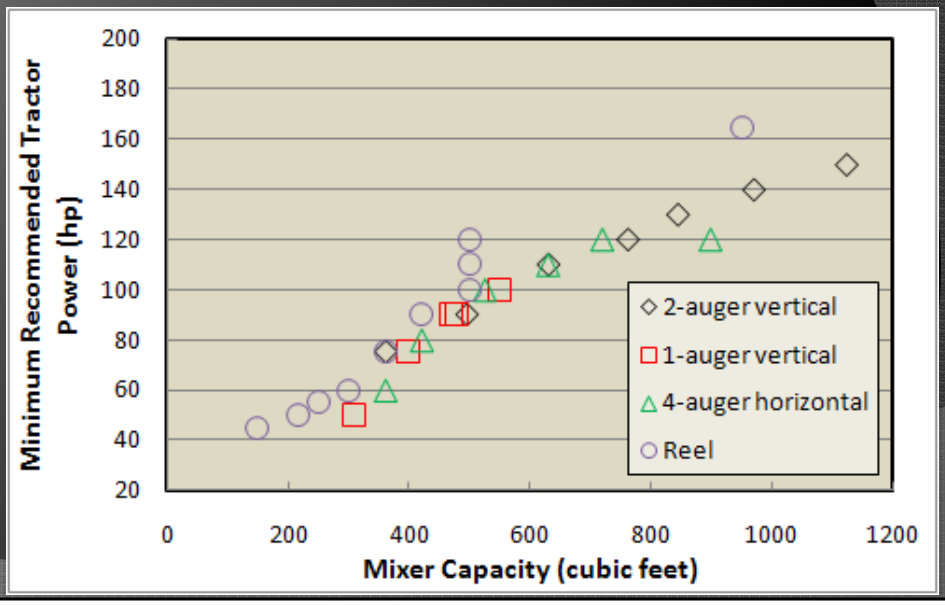
Mixers	Complete Rations					Ration Ingredients		
Mixer Type & Model	All haylage, corn silage, concentrates	Up to 20% dry hay*, haylage, corn silage, concentrate	20-50% dry hay*, haylage, corn silage, concentrate	Over 50% dry hay*, haylage, corn silage, concentrate	Balage, haylage, corn silage, concentrates	Pre-mixing of concentrates	Round bales (unprocessed)	Square bales (unprocessed)
4-Auger	☺	☺	☺	☺	⊘	☺	⊘	☺
Reel	★	★	⊘	⊘	⊘	★	⊘	☺
Vertical	☺	☺	★	★	★	☺	★	★

★ Best ☺ Good ⊘ Not Recommended

***Dry hay is good-quality alfalfa hay, both small or large square bales**

This chart is a general guideline only. Individual rations vary for every operation and will affect your mixer choice.

Mixer Power Suggestions



Mixer Maintenance … applicable to all brands & types

- Frequent cleaning
- Keep proper belt tension
- Keep proper chain tension
- Grease appropriately
- Check oil levels (always use the correct oil)
- Operate PTO shaft at proper angle
- Use correct shear pins
- Maintain scales (protect wires, calibrate)
- Sharpen knives and maintain proper clearances between cutting elements
- Keep proper tire pressure

Mixer Manual Excerpts … general

Do not operate your feed mixer until you have read this Owner's Manual, the Truck Owner's Manual, and understand the danger associated with its operation.

Overloading will seriously affect machine performance and life, and will invalidate your warranty.

Remove all twine, wire and/or wrapping and load bale in mixer.

SAE 10

SAE 30

Gear Lube (EP 90 weight)

Light Weight Oil

Do not use heavy / high viscosity oil

READ THE FOLLOWING BEFORE WELDING ON THIS MIXER/FEEDER

When welding on your mixer/feeder, do not allow the current to flow through the ball bearings or the roller chains. Ground directly to the item being welded.

Always disconnect the scale instrumentation from the weigh bars or load cells and the power source. Be sure the current does not pass through weigh bars or load cells or scale indicator. The alternator should always be disconnected if the mixer/feeder is not disconnected from the towing vehicle.

Daily

Cleaning: Clean all old feed from around body to prevent damage to paint and corrosion.
VFC door: Before using the machine, check that the door opens and shuts fully and operates smoothly.
Wheel Nuts: Check torque settings
Oiler : Check the oil level and replenish with SAE 10 oil as required.

Manual Excerpts … Keenan

Load Order	Feed Ingredients	Paddle RPM	Tractor Engine Speed RPM
1st	Water, liquid feeds	All at 6-8 RPM	1400-1600 RPM
2nd	Straw		
3rd	Minerals, Protein meals, Pulps, Cereal grains		
4th	Grass silage		
5th	Maize silage, cereal Silage.		

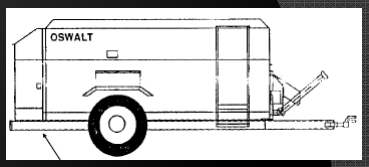
As a general rule engine speed during loading should be as low as possible without the risk of stalling the tractor. See guidelines on loading and mixing procedures.

Manual excerpts … Oswalt

Normal mixing time after the last ingredient has been added.

Trailer 5 min. @540 RPM
Stationary 10 minutes

Total run time (filling, mixing, and discharging) should not exceed 15 minutes per batch for a trailer and 30 minutes for a stationary. Use of baled hay in the mix will increase the mix time for a trailer by 5 minutes and a stationary by 10 minutes.



FINE STEM GRASS HAY WITH LENGTHS OVER 16 INCHES **Are Not Recommended** because they tend to wrap around the augers unless they are extremely brittle.

The mixer is designed to mix complete rations including roughages which fall within the following length limits.

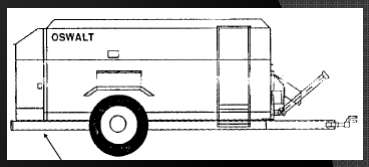
1. At least 75% of the material is 1-1/2 inches or shorter.
2. Less than 20% of the material exceeds 2-1/2 inches.
3. Maximum fiber length does not exceed 4 inches.

NOTE: Round bales should not be incorporated directly into the mixer without first being processed.

Manual excerpts … Oswalt

Oswalt mixers are designed to blend feed ingredients with "dry hay" to obtain a total mixed ration. Dry hay will have less than 20% moisture. A simple hand test on three stems of hay will tell you if the hay should be put into the mixer.

Reach into the core of the bale and remove 3 stems of hay. Try to bend and break these 3 stems when holding them between the thumb and forefinger of both hands. If they snap and break easily the mixer will process the hay fairly easily. If the hay is **NOT** very brittle and you have to twist, tug, pull, and pinch to break it apart, you have a "tough hay" condition. Weather and plant varieties, etc., can generate these conditions.

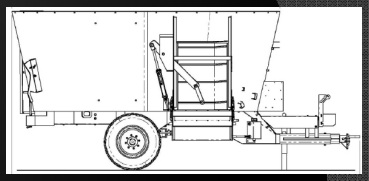


For a ration utilizing "dry hay" the ingredients can be all added at one time and then mixed. The ingredients should be added with the mixer stopped to avoid over processing. The ingredients should be added in the following order: all dry ingredients (corn, soybeans, cottonseed, etc.) then the hay, and the remaining materials last. When all ingredients have been added, the mixer can be started and mixing completed.

If adding all the materials at once causes mixing problems or if you have a "tough hay" condition, then add the ingredients using the following sequence. With the mixer stopped, add all dry ingredients. The introduction of the dry ingredients first helps the mixer break up the hay. Next turn on the mixer and add the hay. Hay should be broken apart and added at the drive end of the mixer. Allow the dry materials and hay to mix until the flakes of hay are broken up. Then add the remaining materials and complete the mixing. If this process causes over processing of the ingredients, shut off the mixer after mixing the hay and dry ingredients and restart and complete mixing after all remaining ingredients have been added.

Manual Excerpts … Rotomix

It is recommended that the mixer be operated while loading.



After adding the last ingredient, increase the PTO speed to 540 RPM and continue the mixing operation for about 3 to 4 minutes. The exact mixing time will be dependent on the size of the batch and difference in types of ingredients.

Add hay first.
Add balance of grain and/or commodities, keeping more fragile ingredients toward the end of the loading sequence as possible. For best results, add concentrates or other dry ingredients of small quantity as close to the middle of the loading sequence as possible
Load Silage, green chop and/or other high moisture products.
Load molasses, animal fat and/or other liquid supplements last.

Quality Control in TMR Delivery

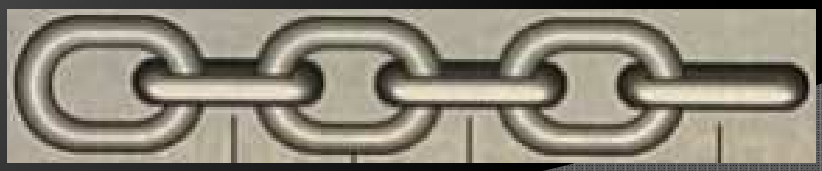
Where is the weakest link?

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

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