Proceedings for the annual

I-29 Moo University Winter Workshop Series

Barn Benchmarks for Success

January 14-18, 2019

Table of Contents

Program Agenda

Agenda will be repeated at each location

9:30 a.m. – Registration & Refreshments | visit sponsors

10:00 a.m. – **Ventilation Benchmarks for Lactating Cows**
Kevin Janni – University of Minnesota

10:30 a.m. – **Roundtable discussion;** Led by I-29 Moo University faculty
Impacts on the cows & employees

11:00 a.m. **Bedding & Stall Benchmarks**
Kim Clark, University of Nebraska-Lincoln

11:30 a.m. – **Roundtable discussion;** Led by I-29 Moo University faculty
Impacts on the cows & employees

12:00 p.m. – **Lunch & Midwest Dairy / Dairy Association Updates (Select Locations) | Sponsor Updates**

1:15 p.m. – **Barn & Pen Design Benchmarks**
Jim Salfer, University of Minnesota

1:45 p.m. – **Roundtable discussion;** Led by I-29 Moo University faculty
Impacts on the cows & employees

2:15 p.m. – **Hot Wash & Wrap-up**

2:30 p.m. – SDDP annual meeting (Brookings, SD only)

Workshop Locations

January 14 – Perham, MN; The Cactus – 43521 Fort Thunder Road
In partnership with Minnesota Milk's Dairy Management Workshops and Midwest Dairy's District 3 & 4 meetings.

January 15 – Brookings, SD; Swiftel Center – 824 32nd Ave.
In partnership with Midwest Dairy South Dakota District Meetings and South Dakota Dairy Producers Annual Meeting

January 16 – Pipestone, MN; Pipestone Systems—1801 Forman Drive
In partnership with Minnesota Milk's Dairy Management Workshops and Midwest Dairy's District 18 meetings.
**Facilities sponsored by Pipestone Veterinary Services*

January 17 – **Orange City, IA; Sioux County Extension Office**—400 Central Ave. NW

January 18 – **Wayne, NE; Wayne State College, Student Center Niobrara Room**—E 14th St.

I-29 Moo University Faculty Members

Iowa State University

Jennifer Bentley

Extension Dairy Specialist
Phone: 563-382-2949; Email: jbentley@iastate.edu

Jennifer Bentley is a Dairy Field Specialist for ISU Extension and Outreach in NE Iowa. Her base office is in Decorah, Iowa and she currently works and develops educational programming with producers in 10 surrounding counties. Jennifer grew up on a dairy farm in North Central Iowa, where the 3rd and 4th generation family is operating the dairy farm today. She earned her Bachelor of Science Degree in Dairy Science and Masters of Agriculture Degree both from Iowa State University. She works closely with dairy producers, providing them with information regarding facility design, calf management, and overall dairy herd management. She enjoys educating the public about modern dairy practices and plays an integral role in telling the Iowa Dairy Story, a program to educate consumers about the importance of the dairy industry in Iowa. Jennifer is married and has 2 children Owen (12) and Addison (10).

Fred Hall

Northwest Iowa Extension Dairy Specialist
Phone: 712-737-4230; Email: fredhall@iastate.edu

Hall joined Iowa State University Extension in January 2017 as the dairy specialist for Northwest Iowa. He served as the Chickasaw County Extension Director for Iowa State University Extension from 2005 to July of 2009. Hall was the county lead on the Iowa Emergency Management Agency agricultural disaster team and served on the Iowa Extension Dairy Team. Hall is married to Sharon Lee and has two sons. Conor is a graduate of Iowa State University, served in the U.S. Marine Corps and is currently in law school at the University of Iowa. Cameron is a graduate of Iowa State University in Global Resource Systems and is currently the manager of the Poultry Research Center at Iowa State University. The family lives south of Orange City and are active Milking Shorthorn breeders and beekeepers.

Leo Timms

Extension Dairy Specialist
Phone: 515-294-4522; Email: ltimms@iastate.edu

Leo Timms is a Morrill Professor of Animal Science / Veterinary Diagnostics and Production Animal Medicine and Extension Dairy Specialist at Iowa State University. Leo was reared in NE PA and worked on his brother-in- laws 40 cow dairy. Leo received his BS degrees in Animal Science and Agricultural Engineering from Cornell University in 1978. Following 3 years as a herdsman on a 400-cow dairy in western NY, he returned to school and received a M.S. in 1982 and a Ph.D. in 1984 in Dairy Science from the University of Wisconsin-Madison. He joined the Animal Science faculty at Iowa State in 1984. He has fostered many extension educational opportunities, many jointly with agri-business, and has conducted over 7000 individual farm troubleshooting visits and consultations. Leo co-developed the Dairy Production Medicine rotation at the College of Veterinary Medicine in 1984 and has also developed courses in lactation biology, dairy troubleshooting, and distance education classes in nutrition, facilities, and biosecurity. Leo's research has focused on mastitis prevention and therapy, milk quality, reproductive management tools, accuracy of milk component measurements, dairy housing, comfort and welfare, and using dairy records. Leo is married (37 years) and has 4 children Rob (35), Sam (33), Sadie (22) and Josh (19)

South Dakota State University

Heidi Carroll

Extension Livestock Stewardship Field Specialist & State BQA Coordinator
Phone: 605-688-6623; Email: Heidi.carroll@sdstate.edu

After working in various aspects of the livestock industries across South Dakota and even Beijing, China, Heidi has promoted responsible animal care and safe food products. She has a Masters Degree in animal science with an emphasis in ruminant nutrition. She handles a wide variety of topics concerning animal well-being and perceptions of livestock care practices
Expertise: Low-stress livestock handling and behavior; Quality assurance trainer for BQA, BQAT, PQA, TQA, and SSQA; Consumer perceptions of livestock husbandry practices

Tracey Erickson

Extension Dairy Field Specialist
Phone: 605-882-5140; Email: tracey.erickson@sdstate.edu

After developing a passion for dairy while growing up on a diversified dairy, livestock and crops farm in eastern South Dakota, Tracey continues to be involved with farming today with her husband and in-laws. With a double major in Dairy Production and Manufacturing, as well as a Masters in Human Resource Management, most of her career has been spent serving dairy producers and the agricultural community through SDSU Extension focusing on Human Resource Management and Safety Protocols, Quality Assurance Programs and Dairy / Livestock development and profitability.
Expertise: Dairy production, Human Resource Management, Farm Safety Training Programs, Dairy & Livestock Nutrition, and Quality Assurance Trainer.

Maristela Rovai

Assistant Professor/Extension Dairy Specialist
Phone: 605-688-5488; Email: maristela.rovai@sdstate.edu

Dr. Rovai is a Veterinarian from Brazil with a MSc & PhD degree in Veterinary with emphasis in Animal Science (UAB-Spain). She had postdoc positions in USA (UW-Madison and E. (Kika) de la Garza American Institute for Goat Research-Langston University) and Europe (TUM in Germany and UAB-Spain) working in animal science with emphasis in mammary gland physiology and ruminant management. Dr. Rovai's research activity has involved studies on the area of milk ability in dairy ruminants (goat, sheep, camels and cows), with a strong focus on milking technology, milk quality improvement, mastitis impact on technological properties of milk and cheese. Dr. Rovai has published more than 45 scientific and extension papers and has mentored graduate students in pursuing either their Master or PhD degree in Animal Science.

Currently, she is an Assistant Professor / Extension Dairy Specialist at the Department of Dairy and Food Science at the South Dakota State University in Brookings, SD. Dr. Rovai's main responsibilities are to develop Extension programs for improvement of milk quality and assist dairy producers and industry personnel on workforce development and best production practices. She is also coordinating a program called "Semillas" – the Spanish word for seeds - designed to help Latino youth of dairy workers within the region to embrace their heritage and gain a sense of community while understanding the Dairy Industry. Dr. Rovai has the ability to assist dairy producers on developing farm protocols, educational trainings, which include hands on and assisting with farm employee meetings.

Expertise: Lactation Physiology and Milk Quality; Employee Educational Training; Speaks fluent Spanish, English and Portuguese.

University of Minnesota

Jim Salfer

Extension Educator-Dairy
Phone: 320-203-6093; Email: salfe001@umn.edu

Jim Salfer is a Regional Extension Educator – with University of Minnesota Extension. Jim has served in his present position for 22 years. Before that he managed a feed department, was a dairy nutritionist, a district sales manager for an AI company and managed a dairy farm. Jim has been involved on farm research projects studying robotic milking systems and automatic calf feeders. The focus of his education program has been to help farmers and other industry professionals understand the major factors driving dairy farm profitability and develop management strategies to improve profitability.

Emily Wilmes

Extension Educator-Livestock
Phone: 320-255-6169 ext. 3; Email: krek0033@umn.edu

Emily grew up on her family's dairy farm near Le Sueur, Minnesota. She works for University of Minnesota Extension as an Extension Educator in Stearns, Benton, and Morrison counties. Her programming focuses on dairy, beef, and farm business topics, and her favorite topics to work with are milk quality/mastitis management and farm safety & health. She has a BS in Animal Science and a Masters in Agricultural Education from the University of Minnesota.

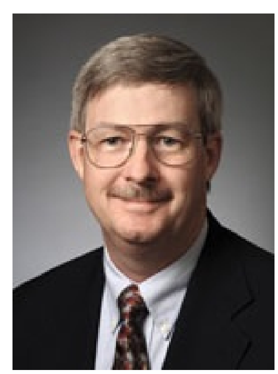
University of Nebraska

Kim Clark

Dairy Extension Educator
Phone: 402-472-6065; Email: kimclark@unl.edu

Kim Clark is a dairy extension educator at the University of Nebraska-Lincoln (UNL) in the Animal Science Department since 2015. Clark earned both her B.S. degree in Animal Science and her M.Ag. Degree in Animal Science and Agricultural Economics with a minor in Agriculture Leadership from the University of Nebraska-Lincoln. Since 2016, Clark has served as chair/co-chair for I-29 Moo University, a five-state dairy extension consortium. Additionally, she also serves as the coordinator for the Nebraska Dairy Ambassador Program. Clark's expertise includes calf care and animal welfare. She is PAACO certified is a National Dairy FARM auditor.

Robert Tigner



Agricultural Systems Economist Educator
Phone: 308-696-6734; Email: Robert.tigner@unl.edu

Tigner was born and raised on a small dairy farm near Fort Dodge Iowa. Tigner joined the US Navy in 1975 and served on active duty and reserve duty for 14 years. He operated a dairy farm near Fennimore WI before starting an Extension career. Tigner earned a Bachelor of Science degree from Iowa State University's Animal Science department majoring in Dairy Science. His Master of Science degree is from the University of Wisconsin-Platteville in Agricultural Industries. Tigner is currently the Area Agricultural Systems Economics Educator. Tigner's educational specialty includes crop marketing, computer decision aids, computer accounting, farm women's financial and risk management education, crop cost and farmland leasing, farm transition and succession, employee management and farm bills as they are passed.

I-29 Moo University Winter Workshop Speakers

Kevin Janni is a professor and Extension engineer in the Department of Bioproducts and Biosystems Engineering at the University of Minnesota. He joined the department faculty in 1980. He works closely with both the Dairy and Poultry Extension teams. He has written extensively on ventilation, air quality, heat stress, odors, biofilters and biosecurity associated with animal agriculture. He teaches an air quality and pollution control engineering course.

Kim Clark is a Dairy Extension Educator at the University of Nebraska-Lincoln. She joined Extension in 2015 and rebuilt the Nebraska dairy extension program. Clark works closely with dairy producers in Nebraska and across the Midwest. Her focus is on calf health and nutrition and animal welfare. Kim is a Dairy FARM evaluator and PAACO Dairy Stewardship certified. She and her husband, Jason, reside in Seward along with their two children, Olivia and Liam.

Jim Salfer is a Regional Extension Educator – with University of Minnesota Extension. Jim has served in his present position for 22 years. Before that he managed a feed department, was a dairy nutritionist, a district sales manager for an AI company and managed a dairy farm. Jim has been involved on farm research projects studying robotic milking systems and automatic calf feeders.
The focus of his education program has been to help farmers and other industry professionals understand the major factors driving dairy farm profitability and develop management strategies to improve profitability.

Thank You I-29 Moo University Gold Sponsors

AGROPUR

NOVAMEAL
BYPASS PROTEIN

AUTOMATED DAIRY SPECIALISTS, LLC
WWW.AUTOMATEDDAIRYSPECIALISTS.COM
CLEARWATER, NEBRASKA 402-485-2655
AUTHORIZED BouMatic DEALER

Sealpro
SILAGE BARRIER FILMS
BY CONNOR AGRISCIENCE

Thank You I-29 Moo University Silver Sponsors

Phibro
ANIMAL HEALTH CORPORATION TM

ARM & HAMMER
THE STANDARD OF PURITY TM

CENTRAL PLAINS
DAIRY FOUNDATION

COTTONSEED, LLC
"Cottonseed To Cows"

SOY BEST® "L"
with Rumen-Protected Lysine

Elanco TM

AGRI-KING®
KEY TO PROFIT
Technology Driven Nutrition

MULTIMIN® 90

Thank You I-29 Moo University Bronze Sponsors

Stray Voltage Consulting

Nebraska State Dairy Association

SDDP South Dakota Dairy Producers

isda Iowa State Dairy Association

Franken Custom Cutting

WIDA Western Iowa Dairy Alliance

Alforex Seeds

Minnesota Milk Producers Association

DCC Waterbeds iso Dual Chamber Cow Waterbeds

POET nutrition

AminoPlus Ag Processing Inc

Gorter's Clay & Dairy Equipment Of Minnesota, Inc.

ZINPRO Performance Minerals®

AATC American Agco Trading Company Specializing in Agricultural Commodities

Kroese & Kroese P.C. Certified Public Accountants

Phileo Lesaffre Animal Care

ProAg Engineering, Inc.

AWS Automated Waste Systems LLC

Trans Ova genetics

QLF Quality Liquid Feeds

Calf-Star Calf Feeding Solutions Custom made for your farming needs! a division of Abts Equipment LLC

I-29 Moo University

I-29 Moo University 2019 Winter Workshop Series

BENCHMARKS FOR SUCCESS

- **BENCHMARKS ARE A SCALE OR REFERENCE BY WHICH YOU CAN EVALUATE PERFORMANCE OR CONDITIONS**
  - Think about benchmarks that you want to consider.
  - Will these benchmarks provide you with indicators to achieve performance goals?
  - Will these benchmarks measure how well you and your employees are doing?

- **BENCHMARKS HELP YOU WITH CONTINUOUS QUALITY IMPROVEMENT**
  - Write down your benchmark targets / goals
  - Monitor what you are doing
  - Assess how well you are doing,
  - If meeting goals, pat yourself on your back, Congratulations!
  - If not meeting goal, investigate ways to do better. Find the bottleneck. Make changes and monitor impact of change.
  - Review goals and go through process again

- **TODAY'S TOPICS:**
  1) Ventilation, 2) Bedding and Stalls, 3) Barn and Pen Design

  What is your biggest concern or question about these three topics? (Write it down and make sure that you bring it up in one of the discussion sections or visit with one of us about it before you leave today. If don't have a big issue or question, that is okay too.)

  - What is your biggest ventilation issue, question or concern?

  - What is your biggest bedding and stall issue question or concern?

  - What is your biggest barn and pen design issue, question or concern?

Ventilation Benchmarks for Lactating Dairy Cows

Kevin Janni, Ph.D.
Bioproducts and Biosystems Engineering
University of Minnesota
kjanni@umn.edu

Benchmarks

- Point of reference by which you evaluate performance
- Can be goal or target
- Need to be quantifiable and measurable

Specific
Measurable
Attainable
Realistic
Timely

Today's Topics

- Ventilation
- Bedding and Stalls
- Barn and Pen Design

What are your biggest concerns or questions?

What are acceptable?

- Barn temperatures
  - In cold weather
  - In hot weather
- Relative humidity levels
- Temperature-Humidity-Index (THI) levels
- Air velocities
- Ammonia levels

Dairy Comfort Zone Temperatures

Thermal neutral zone

- Lactating cows 5ºF to 77ºF
- Calves (birth – 1 month) 50ºF to 77ºF
- Calves (> 1 month) 32ºF to 73ºF

- Upper Midwest temperatures commonly range from below -20ºF to over 100ºF

Heat stress lactating cows

- Temperature-Humidity-Index (THI)
  - Stress threshold THI = 68 - 72
  - Mild-moderate stress threshold THI = 72 - 80
  - Moderate-severe stress threshold THI = 80 - 90

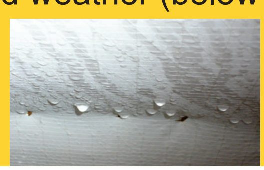
Air	Dew-point temperature (F)										
Temp (F)	35	40	45	50	55	60	65	70	75	80	85
65	62.4	62.7	63.0	63.4	63.8	64.4	65.0				
70	65.2	65.6	66.1	66.6	67.3	68.1	69.0	70.0			
75	67.8	68.3	68.9	69.5	70.3	71.2	72.3	73.5	75.0		
80	70.3	70.8	71.4	72.1	73.0	74.0	75.2	76.6	78.2	80.0	
85	72.6	73.2	73.8	74.6	75.5	76.5	77.8	79.2	80.9	82.8	85.0
90	74.9	75.5	76.1	76.9	77.8	78.9	80.1	81.5	83.2	85.2	87.4
95	77.1	77.7	78.3	79.1	80.0	81.0	82.3	83.7	85.4	87.3	89.5
100	79.3	79.9	80.5	81.2	82.1	83.1	84.3	85.7	87.4	89.2	91.4
105	81.5	82.0	82.6	83.3	84.2	85.2	86.3	87.7	89.2	91.0	93.1
110	83.6	84.1	84.7	85.4	86.2	87.1	88.3	89.5	91.0	92.8	94.8

Air velocity benchmarks

- Sixty feet per minute (60 fpm) – not drafty
- Tunnel ventilation and Cross-ventilated barns Target velocity – 528 ft/min (6 mph) (MWPS-7)
- Inlet air velocity – 800 to 1000 ft/min

Relative humidity/Dew-point temp

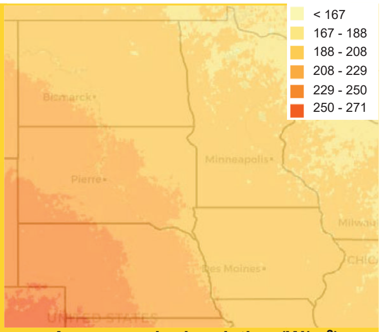
- Target 50% to 80% relative humidity
- Avoid condensation on walls and ceiling except during very cold weather (below 0ºF)
- No dripping ceiling



University of Minnesota
Driven to Discover℠

Average solar load

- Peak is 317 Btu/hr ft^2 (1000 W/m^2)
- Building roof blocks solar load
- Typically feel 10 to 15ºF cooler in shade than in full sun because reduced solar load



Average solar insolation (W/m^2)

https://maps.nrel.gov/nsrdb-viewer/
www.azsunblock.com/temperature-difference-between-shade-and-full-sun/

Indoor Air Quality – animal areas

- Toxic gases
  - Ammonia (NH_3)
  - Hydrogen sulfide (H_2S)
- Particulate matter
- Molds and other biological particles

Toxic gases can accumulate to life threatening levels in confined spaces with manure!

U.S. gas exposure limits

	Ammonia (NH_3) [ppm]	Hydrogen sulfide (H_2S) [ppm]
OSHA Regulated Permissible Exposure Limit (PEL)		
Time weighted average (TWA)	50	20
Short term exposure limit (ST)		50 [10-min]
NIOSH Recommended Exposure Limit (REL)		
Time weighted average (TWA)	25	
Short term exposure limit (ST)	35	10 [10-min]
Immediately dangerous to life or health (IDLH)	300	100

https://www.cdc.gov/niosh/npg/npgd0028.html https://www.cdc.gov/niosh/npg/npgd0337.html

Dairy barn gas concentrations

- NH_4 concentrations ranged from ≈ 0.3 to 32 ppm
- H_2S concentrations ranged from ≈ 0.002 to 0.05 ppm

		NH_4 [ppm]	H_2S [ppm]
Compost barn (1)	6 barns, 4 seasons, MN, SD	3.9	0.013
Naturally ventilated (1)	6 barns, 4 seasons, MN, SD	3.3	0.017
Cross-ventilated (1)	6 barns, 4 seasons, MN, SD	5.2	0.032
Naturally ventilated (2)	1 barn, Fall, MN	1.0	0.004 to 0.026
Naturally ventilated (3)	2 barns, 3 months, OH	0.3 to 3.0	0.002 to 0.031
Robot barn – NV summer, Fans winter (4)	1 barn, 3 seasons, Canada	1 to 32	0.005 to 0.028

1. Lobeck et al. 2012; 2. Zhu et al., 2000; 3. Zhao et al., 2007; 4. Huang and Guo, 2017

Why ventilate in cold weather?

- Provide fresh air
- Remove moisture to manage relative humidity and condensation
- Remove gases (NH_3, H_2S) to manage gas concentrations

University of Minnesota
Driven to Discover℠

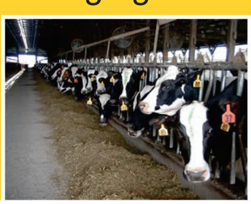
Consequences bad ventilation

- Cold drafts
- High humidity
- Damp wet conditions
- Condensation on cold surfaces
- Dripping ceilings
- Stained wood & mold growth
- Poor air quality

University of Minnesota
Driven to Discover℠

Why ventilate in hot weather?

- Remove animal and solar heat
- Help animals manage heat stress
- Remove gases (NH_3, H_2S) to manage gas concentrations
- Provide fresh air



University of Minnesota
Driven to Discover℠

Consequences of heat stress

- Reduced
  - Dry matter intake
  - Milk production
  - Pregnancy rate
  - Calf birth weights
  - Milk production of heifers

Nothing Good!

- Increased
  - Respiration rate
  - Panting
  - Body temperature
  - Sweating
  - Time standing
  - Days open
  - Mortalities

St-Pierre et al., 2003; Tao and Dahl, 2012; Tao et al., 2013

University of Minnesota
Driven to Discover℠

Who is most sensitive?

- **High producing cows** are more sensitive to heat stress than low producing cows
- **High producing cows** begin to experience heat stress at lower THI levels
- Genetics may be used to select for cows less sensitive to heat stress

West., 2003

How much hot weather?

Sioux Falls, SD 2018 Data

	Hours			
	THI Ranges			Monthly Total
Month	68 – 72	72 – 80	80 – 90	(% hours)
May	95	112	7	29
June	175	205	31	57
July	214	276	33	70
August	243	247	5	66
September	147	113	5	37

www.wunderground.com/history/daily/us/sd/sioux-falls/KFSD

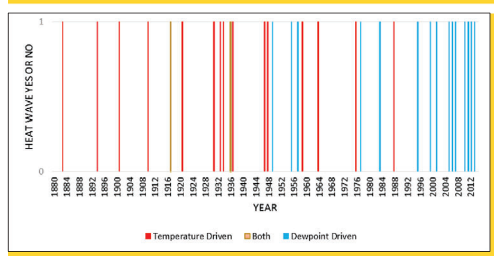
How much hot weather?

Detroit Lakes, MN 2018 Data

	Hours			
	THI Ranges			Monthly Total
Month	68 – 72	72 – 80	80 – 90	(% hours)
June	196	88	0	38
July	223	139	5	49
August	175	109	0	38

www.wunderground.com/history/daily/us/mn/detroit-lakes/KDTL

Historical heat wave frequency in MN

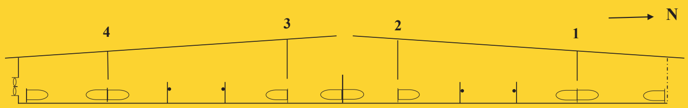


- More frequent heat events since 2000
- More recent heat events are dew-point driven

Changes in frequency and drivers of heat waves in MN. (Seeley, 2015)

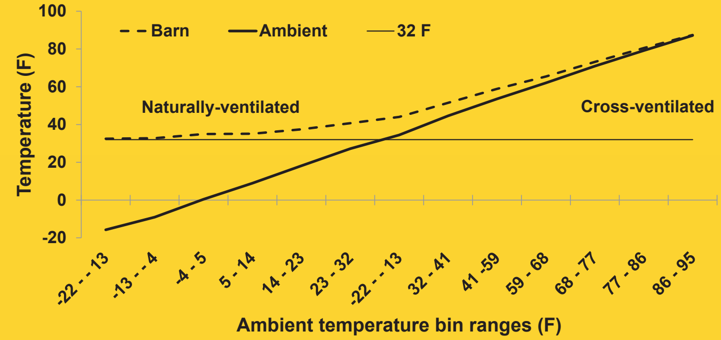
Barn description

- Ten row barn
- NV cold and mild weather CV hot weather
- Four baffles when cross-ventilated
- 52 belt-driven 5 ft fans in south sidewall
- Baffled ridge opening
- Curtains above fans and north sidewall
- Sprinklers along two feed mangers on timer
- 228 ft wide, 370 ft long, 14 ft sidewalls



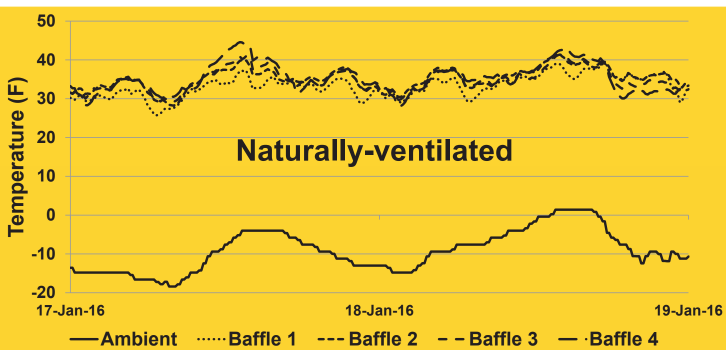
UNIVERSITY OF MINNESOTA
Driven to Discover

Average Barn Temperatures



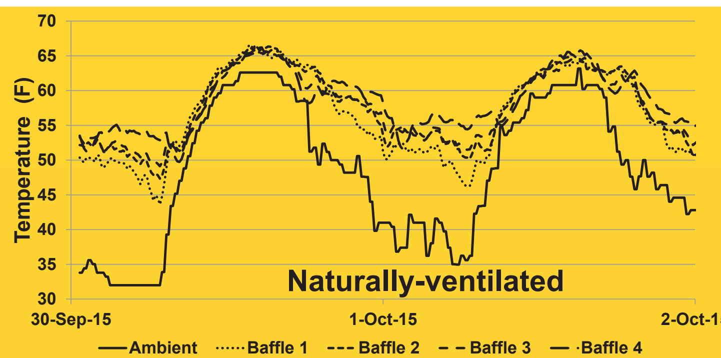
UNIVERSITY OF MINNESOTA
Driven to Discover

Temperatures, cold weather



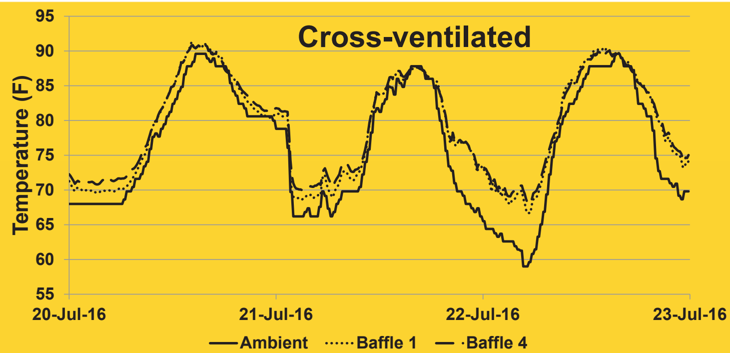
UNIVERSITY OF MINNESOTA
Driven to Discover

Temperatures, mild weather



UNIVERSITY OF MINNESOTA
Driven to Discover

Temperatures, Hot weather



University of Minnesota
Driven to Discover℠

Thermoregulation model

Heat loads

- Metabolic heat
  - Maintenance
  - Milk production
  - Embryo growth
- THI
- Solar heat or non-insulated building

Heat losses

- Respiration
- Sweating
- Convection to air
  - Air velocity & temperature
- Radiation to surfaces

University of Minnesota
Driven to Discover℠

Heat Stress Levels & Indicators

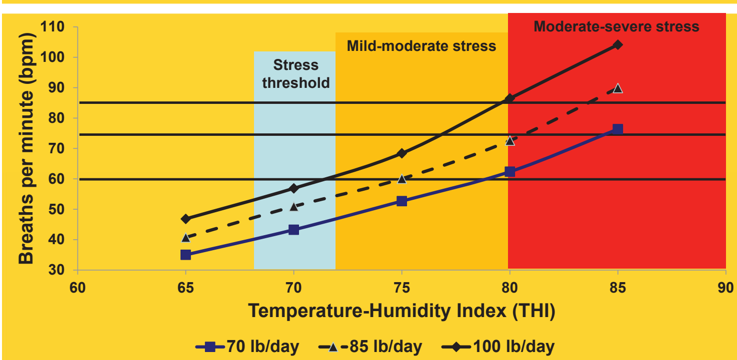
- Temperature-humidity index
- Respiration rate
- Body temperature

Heat stress level	THI	Respiration rate[1] (bpm)	Rectal temperature[2] (F)
None	< 68	21 to 43	100.4 to 101.5
Threshold	68 - 71	> 60	> 102.3
Mild-moderate	72 - 79	> 75	> 103.0
Moderate-severe	80 - 89	> 85	> 103.5
Severe	90 - 99	120 - 140	> 105.8

1 Renaudeau et al. (2012); 2 Thompson et al., (2011)

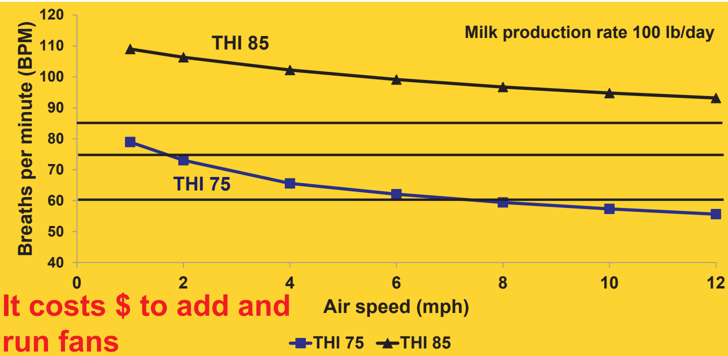
University of Minnesota
Driven to Discover℠

Respiration rate vs THI



University of Minnesota
Driven to Discover℠

Respiration rate vs THI & air velocity



It costs $ to add and run fans

Solar load and air velocity

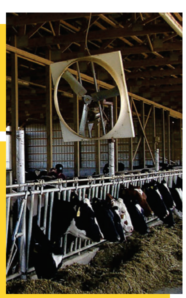
Milk production	85 lb / day		100 lb/day	
Air velocity	No solar	Solar	No solar	Solar
mph	Respiration Rates (bpm)			
3	57.9	83.5	69.3	97.7
6	53.2	72.1	62.1	85.5
12	48.1	61.7	55.7	69.9

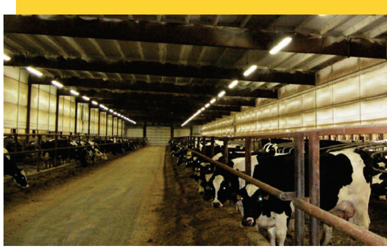
THI = 75; Solar load = 500 W/m^2

UNIVERSITY OF MINNESOTA
Driven to Discover℠

What to do?

- Different ventilating systems
  - Natural
  - Tunnel
  - Cross
- Mixing fans
- Sprinklers
- Baffles





Mixing fans

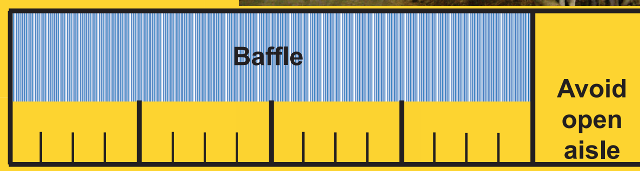
- Increase air velocity at cow level

UNIVERSITY OF MINNESOTA
Driven to Discover℠

Sprinklers

- Evaporative cooling
  - Reduced effect at high dew-point temperatures

Baffles



Options to reduce heat stress

- Provide shade
- High speed mixing fans
- Cool air with misters and cooling pads
- Sprinklers for evaporative cooling wet cows
- Increase air velocity
- Air conditioning

Monitoring

- Respiration rates
- Milk production
  - Identify typical daily variation
  - Monitor milk production variation
  - Identify weather conditions that lead to reduced milk production beyond normal variation
- What is the cost of lost milk production?

Monitoring

- Barn temperatures (dry-bulb, dew-point)
- Air velocities
- Heat stress
- Uniform conditions

https://kestrelmeters.com/products/kestrel-drop
https://kestrelmeters.com/products/kestrel-3000-wind-meter
https://kestrelmeters.com/products/kestrel-5400-heat-stress-tracker
https://www.onsetcomp.com/products/data-loggers/u23-001

Maintenance

- Fans
  - Dirty fans can have 40% to 80% airflow
- Fan louvers
  - Dirty and rusty louvers reduce fan airflow
- Sprinklers and misting systems
  - Make sure all nozzles work properly
  - Fix leaks

University of Minnesota
Driven to Discover℠

What will you do?

- Set benchmarks
- Measure performance
- Assess consequences, costs and benefits of taking action
- Take action
- Repeat measurement and assessment

Specific
Measurable
Attainable
Realistic
Timely

University of Minnesota
Driven to Discover℠

References

Huang, D. and Guo, H. (2017) Diurnal and seasonal variations of odor and gas emissions from a naturally ventilated free-stall dairy barn on the Canadian prairies, *Journal of the Air & Waste Management Association* 67:10, 1092-1105.

Lobeck, K.M., Endres, M.I., Janni, K.A., Godden, S.M., Fetrow, J. (2012) Environmental characteristics of low profile cross-ventilated, naturally ventilated, and compost bedded pack dairy barns. *Applied Engineering in Agriculture* 28(1):117-128.

MWPS-7, Dairy Freestall Housing and Equipment. (2013) 8th ed. Ames, IA: MidWest Plan Service

Renaudeau, D., Collin, A., Yahav, S., de Basilio, V., Gourdine, J.L., Collier, R.J. (2012) Adaptation to hot climate and strategies to alleviate heat stress in livestock production. *Animal Consortium* 6(5),707-728.

Seeley, M. (2015) Minnesota Weather Almanac. 2nd Ed. St. Paul, MN: Minnesota Historical Society Press.

St-Pierre, N.R., Cobanov, B., Schnitkey, G. (2003) Economic losses from heat stress by US livestock industries. *J. Dairy Sci.* 86, E52-E77.

Tao, S., Monteiro, A.P.A., Thompson, I.M., Hayen, M.J., Dahl, G. E. (2012) Effect of late-gestation maternal heat stress on growth and immune function of dairy calves. *J. Dairy Sci*. 95, 7128-7136

Tao, S., Dahl, G.E. (2013) Heat stress effects during late gestation on dry cows and their calves. *J. Dairy Sci.* 96, 4079-4093.

Thompson, V. A., Fadel, J. G., Sainz, R. D. (2011) Meta-analysis to predict sweating and respiration rates for bos indicus, bos taurus, and their crossbreds. Journal of Animal Science, 89(12), 3973-3982.

West, J.W. (2003) Effects of heat-stress on production in dairy cattle. *J. Dairy Sci*. 86, 2131–2144.

Zhao, L. Y., Brugger, M. F., Manuzon, R. B., Arnold, G., Imerman, E. (2007) Variations in air quality of new Ohio dairy facilities with natural ventilation systems. *Applied Engineering in Agriculture* 23(3): 339-346.

Zhu, J., Jacobson, L. D., Schmidt, D., Nicolai, R. 2000. Daily variations in odor and gas emissions from animal facilities. *Applied Engineering in Agriculture* 16(2): 153-158.

University of Minnesota
Driven to Discover℠

Ventilation Benchmarks Worksheet

Think about how you manage ventilation of your dairy barn.

- Please write down answers or notes for a dairy barn you manage that houses lactating cows.
- You may give single numbers, ranges of numbers or descriptive terms
- This is for your use only.

TARGET OR DESIRED BARN CONDITIONS IN COLD WEATHER

1. Do you try to manage temperatures in your lactating dairy barn in cold weather? Yes / No
    - **If yes**, what do you adjust to manage barn temperatures?
2. What temperature do you desire to have in your barn during very cold weather, when the **outside temperatures** are…
    a) below 0ºF ? ______________________
    b) around 32ºF? _____________________
3. Do you try to manage relative humidity or moisture conditions in your barn in the winter?
    - Yes / No
4. What relative humidity or moisture conditions do you try to maintain in the barn in **cold weather**?
5. Do you try to manage air velocity in your barn in the winter? Yes / No
    - **If yes**, what air velocity conditions do you try to maintain in the barn in the winter?
6. Can you manage to get uniform conditions throughout your barn in **cold weather**?
    - Yes / No / Don't know

TARGET OR DESIRED BARN CONDITIONS IN HOT WEATHER

1. Do you try to manage temperatures in your lactating dairy barn in hot weather? Yes / No
    - **If yes**, what do you adjust to manage temperatures? List all things that can be adjusted.
2. What temperature do you desire to have in your barn during hot weather, when the **outside temperatures** are…
    a) around 70ºF ? _______________
    b) above 90ºF ?________________
3. Do you try to manage relative humidity or moisture conditions in your barn in the summer?
    - Yes / No
4. What relative humidity or moisture conditions do you try to maintain in the barn in **warm weather**?
5. Do you try to manage the **temperature humidity index (THI) in summer**?
    - Yes / No
    - **If yes**, what do you do as THI levels increase?
6. Do you try to manage **air velocity** past the cows in your barn in the **summer**?
    - Yes / No
    - **If yes**, what air velocity conditions do you try to maintain in the barn in the summer?
7. Can you manage to get uniform conditions throughout your barn in **hot weather**?
    - Yes / No / Don't know

I-29 Moo University 2019 Winter Workshop Series

ROUNDTABLE DISCUSSION

BENCHMARKS ARE A SCALE OR REFERENCE BY WHICH YOU CAN EVALUATE PERFORMANCE OR CONDITIONS

1. What am I doing right on my farm?

2. Where can I make improvements?

3. How is this impacting my health and my employees health?

4. How is this impacting my cows' health and comfort?

5. What changes can I or should I make in the **near future**?

6. What changes can I or should I make in the **long-term**?

Additional Notes:

Stall and Bedding Benchmarks

How would you define cow comfort?
Cow comfort and welfare is often measured by lying time, the way cows enter the stalls, duration of stall movement; cows show preference for lying on softer materials. Dairy cows spend 12 to 14 hours a day lying down. Ensuring they have adequate space and comfort for lying leads to healthier, cleaner cows producing higher quality milk.

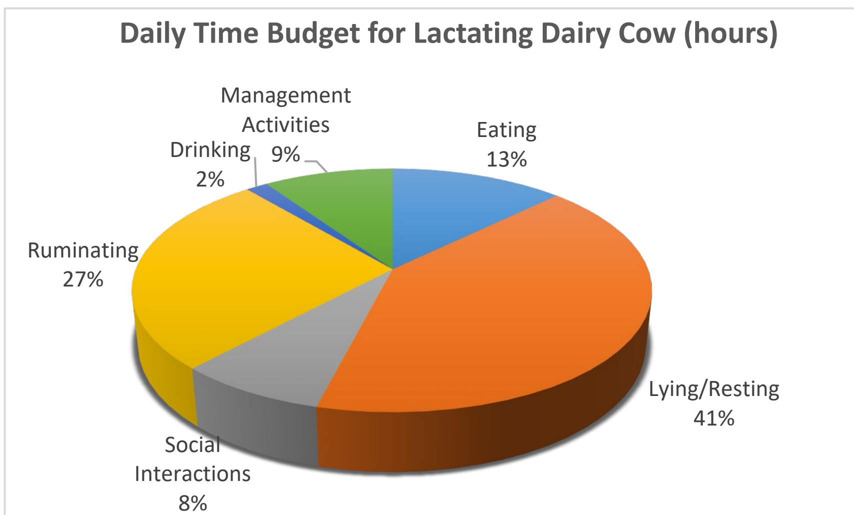
To ensure optimal cow comfort, ask yourself these questions:

- Are cows and stalls clean and dry?
- Do cows easily and readily use the stalls?
- Are there injuries, punctures, abrasions, swelling of hocks, legs, hips, etc.?
- Do cows have to push, bang and or bump against stall components to recline, rise or change positions?
- Do cows have traction to easily recline and rise?

The cow is the final inspector, if cows are not using stalls, are dirty or show signs of injury, change is necessary.

Your goal should be to provide clean, dry bedding, which improves comfort and lying times while controlling both bacterial counts and udder health and not interrupting natural movements of rising and lying behaviors.

Your management goal should be to provide facilities that reduce or eliminate injuries and swelling to hocks, necks, legs and hips of cows in the herd, while making the most efficient use of farm labor by reducing the amount of time required to clean manure from the stall and replace bedding.



Features of cow comfort include:

- A stock density of greater than 120% leads to a competition of resources and reduced lying times, lameness, reduced rumination and milk yield. There is no benefit to under stocking freestall pens.
- Free movement without being jostled and shoved by other cows
- Minimizing regrouping and moves between groups
- Easy, continuous access to fresh feed and water
- Clean, dry well-bedded resting area
- Plenty of space in freestalls or on a bedded pack to recline and rise
- Enough freestalls or bedded pack space to always have a place to lie down. Again, an excessive stock density leads to competition of resources including stalls for lying. Overstock results in an increased number of cows standing idly in the alley waiting for stalls. When resting or lying time is

lost, it may take cows up to 40 hours to recoup the lost resting time. More than likely, if cows are competing for space in stalls, they are competing for space at the feedbunk.
- Confident, slip-free flooring
- Plenty of fresh, dry air
- Dry, draft-free conditions in the winter
- Shady, breezy locations during hot weather

Signs of comfort issues:
- Hock lesions – may be the result of small stalls and space restrictions or short chains in tie-stalls
- Abrasions on the back of the neck - often times caused by the height or location of the neck rail
- Broken tails – these are signs of poor animal handling
- Lameness – causes include overgrown claws, poor stall cushioning, short stalls
- Dirty cows – not directly a cow comfort issue but dirty cows are linked to higher somatic cell counts (milk quality issue)

Benchmark considerations to address cow comfort:
- Monitor how frequently cows are lying in a stall
- Measure how long cows lie in stalls
- How many lame cows are in each pen? How severe is the lameness?
- Do cows stand in the stall versus lie down?
- Do cows stand two feet in the stall and two feet in the alley?
- How dirty are the cows?
- Monitor the dirtiness and wetness of the stalls
- Is your bulk tank somatic cell count too high?
- See the Benchmarks worksheet for additional consideration

Stalls

Freestalls should provide a place for cows to:
- lie down comfortably and rest up to 14 hours per day
- promote cow and udder cleanliness
- allow for more efficient rumination
- prevent injuries.

A comfortable stall encourages resting and accommodates reasonable rates of heat loss. Freestall dimensions for a group of dairy cows depends on the size of the cows and the tolerance of the farmer or labor for tending manure contaminated stalls. Freestalls should be sized to provide the largest 25% of cows in a group with a comfortable place to rest. The largest cow in the herd should be able to enter the stall, lie down, rest comfortably and easily get to her feet and exit the free stall. However, adjustments to stall sizes may need to be made if the group consists of greater than 50% of first lactation heifers in a mixed-age pen.

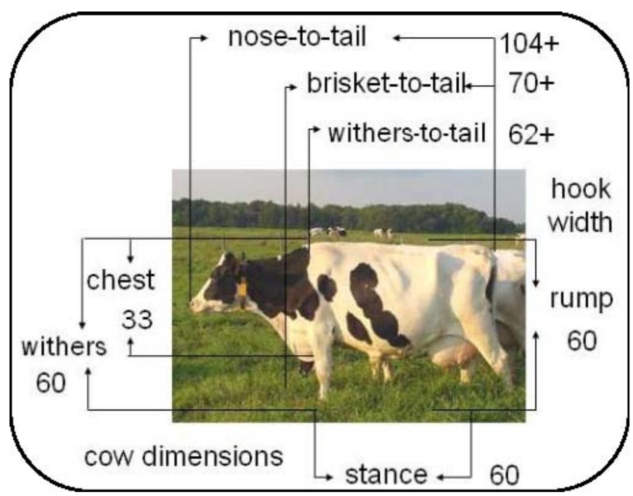


Figure 1: Several cow measurements taken on standing cows are useful for building freestalls. Other essential measurements are length and width of resting cows. Source: Dairy Cow Comfort - Freestall Dimensions, Ontario Ministry of Agriculture, Food &Rural Affairs.

Important items for consideration with freestall size:

- Cow size - age, breed, stage of lactation
- Open or closed front free stalls
- Base and bedding that provide a comfortable and confident surface for resting
- Lunge space for cow to extend as she reclines and rises
- Convenient maintenance that allows caretakers to keep cows clean, dry and comfortable

Important dimensions to consider when evaluating freestalls are: (See Table 1 for specific recommendations based on cow size.)

- Stall length
- Stall width
- Stall base slope
- Partition length
- Partition height and clearance under bottom rail
- Rear curb height
- Brisket locator placement and height above stall bed surface
- Neck rail placement and height above stall bed surface

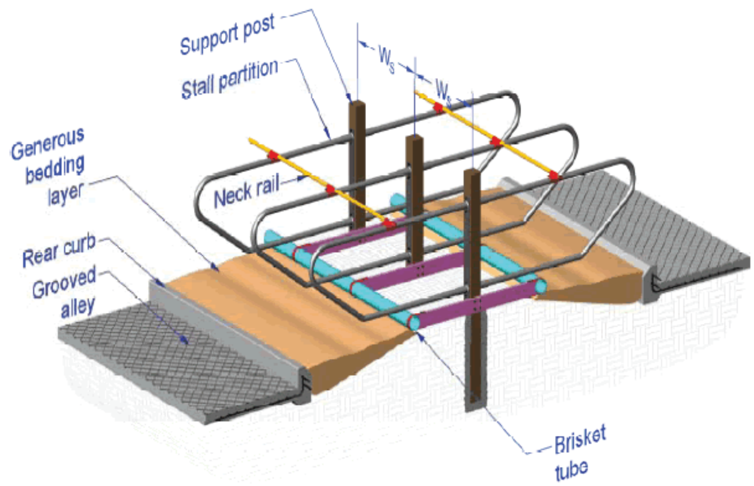


Figure 2: Head to head open front freestall. Source: Penn State Extension. Designing and Building Dairy Cattle Freestalls.

Free**stall length** should be about 8-12 feet. This stall length will provide adequate lunge space allowing for the cow to lunge forward and rise naturally. However, stall length needs vary based on cow age and size. Typical lunge space for a mature Holstein cow is 3 to 4 feet beyond the resting space. Shorter freestalls require an opening at the front of the stall to allow a cow to thrust her head through as she rises. As a cow begins to rise, she thrusts her body forward and head down as she rises, using her weight a momentum to raise her hind quarters, shifts her weight back to raise her front. She often puts her front foot out to help push up. If forward lunge space is not possible, modify the stall to allow the cow to lunge to the side through the partition. *Note: side lunge is not normal cow behavior and can reduce stall usage.* When fully raised, the cow should be able to stand with all four feet in the stall and her head under the neck rail completely. If cows are standing perched two feet in and two feet out of the stall or with their head above the neck rail, adjustments may be needed to the stall structure.

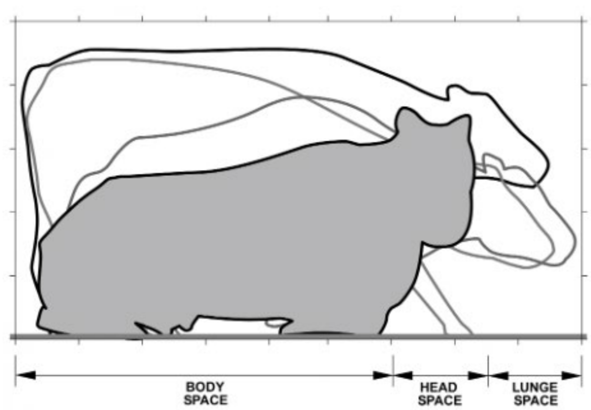


Figure 3: Space requirements for resting and rising dairy cow. Source: Penn State Extension. Designing and Building Dairy Cattle Freestalls.

Stall width should aim to prevent disturbances between neighboring cows and facilitate rising and lying. Stall width will vary from 42 inches for a 1,000 pound cow to 57 inches for a 2,000 pound cow. Excessively wide stalls allow smaller cows to lie at an angle that allows defecation in the stall.

Freestall partitions should guide the cow into the stall, help position the cow, and provide protection from cows in adjacent stalls. Lower divider rails should include a 5 inch space between the lower edge of the lower divider rail and the top of the brisket locator. This allows cows to work legs free if they should get stuck.

The **freestall curb** separates the stall area from manure in the cow alley. The curb should be high enough to prevent manure from entering the stall but low enough to allow cows to enter and exit the stall easily. Maximum recommended height is 8 inches. If mattresses or mats are used the maximum height from alley to stall is 7 inches.

The role of the **brisket board or locator** is to help position the cow as she lies down. The brisket locator should not interfere with the cow lunging or resting comfort. A brisket locator 4-6 inches high defines the available body space on the stall bed and discourages forward movement of resting cows. The top of the board should be no more than 4 inches above the top of the rear curb

The **neck rail** discourages cows from moving too far forward when entering the stall to provide adequate lunge space for rising and reclining. Properly positioned neck rails allow the largest cows to stand on the stall surface with all four legs and the top of her neck gently touching the neck rail. The neck rail is one of the most important pieces to position the cow properly. It encourages cows to step back as she rises to exit the stall. Many people position the neck rail too far back to make sure the stall stays clean; however, this decreases stall usage. Neck rails should be fixed, not free to move up and down.

Table 1. Adult Cow Freestall Dimensions

	Body Weight Estimate (lbs)					
Stall dimensions (inches)	1000	1200	1400	1600	1800	2000
Center-to-center stall divider placement (stall width)	42	45	48	50	54	57
Total stall length facing a wall	96	108	108	120	120	126
Outside curb to outside curb distance for head-to-head platform	180	192	192	204	204	216
Distance to rear curb to rear of brisket locator	64	66	68	70	72	75
Width of rear curb	6-8	6-8	6-8	6-8	6-8	6-8
Horizontal distance between rear edge of neck rail and rear edge of curb for mattress stalls	64	66	68	70	72	75
Horizontal distance between rear edge of neck rail and rear edge of curb for deep-bedded stalls	58	60	62	64	66	69
Distance from rear edge of divider loop to point of curb	9	9	9	9	9	9
Height of brisket locator above top of curb (loose bedded stall or mat/mattress surface)	3	3	4	4	4	4
Height of upper edge of bottom stall divider above top of curb (loose bedded stall or mat/mattress surface)	10	10	12	12	13	14
Interior diameter of the stall divider loop	30	33	33	36	36	36
Height of neck rail above top of curb (loose bedded stall or mat/mattress surface)	42	45	48	50	52	54
Obstruction height	5-35	5-35	5-35	5-35	5-35	5-35
Horizontal distance from brisket locator to loop angle	20-22	20-22	20-22	20-22	20-22	20-22
Rear curb height	8	8	8	8	8	8

Resource: Dairyland Initiative, University of Wisconsin-Madison. TheDairylandInitiative.vetmed.wisc.edu

Bent or broken stall components should be repaired and/or replaced before they become an obstacle to stall use, cow well-being or cause injury.

Diagonal Lying
Stalls will stay cleaner if we encourage cows to lie straight in the stall. For cows to lie straight we must provide cows with a space to have all four legs in the stall. Occasionally, cow may lie diagonally in stalls.

Diagonal lying may be caused by:

- Stalls being too short
- Stalls having forward lunge space obstructions such as a traverse stall divider mounting bars and deterrent bars which are between the stall surface and 38 inches above the surface
- Stalls having brisket locators higher than 4 inches above the stall surface
- Stalls having brisket locators placed too near the curb, restricting lying space
- Stalls are very wide for the size of cows in the barn or pen

Bedding

Bedding should provide thermal comfort, softness, and durability and have friction to allowing rising and lying down without slipping. The bedding surface should be soft and moldable from front to back. Bedding is one of the primary sources of exposure to environmental pathogens. Maximum bacterial growth occurs within 24 up to 48 hours of adding bedding material. Bedding options used on dairy farms depends on housing options and design, cost, bedding availability, cow comfort, ease of use, manure storage and disposal methods. Today's dairy farms use either organic or inorganic bedding. Information about each bedding option is found below.

Stalls and bedding should be checked 2-3 times daily, preferably while cows are being milked, to remove manure and wet material, and rearrange clean and dry bedding to provide a clean, dry uniform resting surface. Material type, stall bed type, group population, and season of the year determine the amount and frequency of bedding added.

Bedding quality
One measure of bedding quality is the concentration of environmental pathogens, which play a role in milk quality and are major causes of mastitis – clinical and subclinical. Environmental pathogen concentrations are impacted by the dry matter and pH of the bedding materials. As bedding dry matter increases, the concentration of environmental pathogens decreases and as the pH of the bedding material increases, environmental pathogen concentrations increase. Both of these factors impact the quality of bedding material. This is why stalls need to be cleaned while cows are milking each day – at least two times daily. We cannot forget that rain and moisture from the ground lead to elevated bacteria counts, also. There also tends to be a seasonality effect on the concentration of environmental pathogens in bedding material with summer having the highest concentration of pathogens likely due to temperature and humidity.

We can reduce teat contamination from environmental pathogens with good management practices. Teats become contaminated through contact with contaminated bedding and other environmental risks. The number of bacteria on the teat end has been positively correlated to the number of bacteria on bedding. Adequate amounts of dry bedding ensure minimal contamination of teat skin with bacteria.

Desirable characteristics of bedding

Cow comfort: The cow spends most of its day laying down processing feed into milk.

a. Bedding must be comfortable to lie on
b. Bedding material should provide coolness in the summer and warmth in the winter. For example, straw provided added warmth in the winter and sand helps provide coolness in the summer.
c. Dry bedding is critical year round for cow comfort and to reduce pathogen growth. As bedding dry matter increases, bacterial populations have been shown to decrease.
d. Good footing prevents injury
e. Non-abrasive bedding promotes cow comfort and aides in injury reduction
f. Bedding should drain well to keep cows dry and limit pathogen growth
g. Bedding material should be easy to use. Bedding should readily available and easy for farm labor to access and add to keep stalls clean. Bedding needs to fit well with the housing option and design and the waste storage facilities and disposal methods used.

Bedding and bedding management contribute to cost effectiveness, cow comfort, udder health and milk quality.

Bedding management

Cow cleanliness is often linked to milk quality, specifically somatic cell count of individual cows and bulk somatic cell count. Studies have shown there is no difference in cleanliness scores of cows when comparing sand and foam mattresses as bedding options. Additionally, there is no correlation between cleanliness scores, freestall design, bedding characteristics, and overcrowding between various bedding options. As bedding dry matter decreases, counts of environmental bacteria typically increase. Bedding pH also plays a role in bacterial populations. As bedding pH increases, bacterial counts increase also.

Barn styles and bedding options

Barn style and bedding material used in stalls play an important role in cow comfort, health, management, and milk quality. Cow health includes severity of lameness, hock lesions, claw diseases and incidence of mastitis caused by environmental pathogens. The stall and bedding benchmark worksheet, which follows this document, will provide questions for consideration when assessing stall and bedding benchmarks. In an open barn style/bedded pack barn cow move around freely and lie down wherever they choose. Individual stalls such as tie stalls or freestalls allow cows may lie or stand within a specified stall or area.

Deep bedded free-stalls bedded with recycled manure solids are another type of bedding option which has been shown to exhibit a lower prevalence and severity of lameness compared to freestalls with mattresses. Additionally, hock lesions scores were lower for deep-bedded freestalls compared to mattresses in freestalls.

Organic Bedding:

Examples of organic bedding include straw, cornstalks, hay, saw dust, wood shavings, crop residue, shredded paper, paper, pulp residue, and composted or dried manure. Farm economy, bedding cost, labor cost, and hygiene have resulted in reduced use of organic bedding in stalls which may possibly reduce cow comfort. Because organic bedding rapidly supports bacterial growth, lime, which changes bedding pH, is commonly added to reduce bacterial growth.

Characteristics

- Because organic bedding tends to become contaminated and wetter more quickly, more frequent stall cleaning and bedding addition is needed. Farms using organic beddings tend to remove or replace bedding in the back of stalls more often than when using inorganic bedding.
- Many organic materials already contain pathogens which shorten the life of the bedding material. Because of this, it is recommended to allow organic materials to dry before using.
- As the particle size of organic bedding decreases, the population density of environmental pathogens increase. This is due to the smaller particle size which may cover teat ends leading to higher concentrations of bacteria of teat ends and higher instances of mastitis. It is recommended to use slightly larger particle size which supports slower pathogen growth. The downside of large particle size is that too large of particle size for some bedding materials is not comfortable for the cow.
  - Studies have shown that pathogen growth is the greatest the first 48 hours of placing new organic bedding in stalls. When the back 1/3 of the stall was cleaned at least once weekly, somatic cell counts of individual cows and the bulk tank decreased.

Inorganic bedding:
Examples of inorganic bedding include sand, crushed limestone and field lime.

Characteristics:
- Inorganic bedding is inert and does not support the pathogen growth. From the bacteriological standpoint, inorganic bedding is best to use.
- Lower bacteria counts in inorganic bedding are associated with reduced rates of new infections with environmental pathogens. It is important to note that frequent addition of new inorganic bedding material may supply nutrients to maintain pathogen concentrations rather than allowing pathogens to consume available nutrients and enter a death stage. Increased frequency of adding new bedding is correlated with increased SCC. Because of this, it is recommended to clean and clear the stalls of manure and wet bedding material at least two times daily, but not add new bedding material more than weekly.
- Higher rolling herd averages were noted on farms using inorganic bedding material compared to farms using organic and manure bedding.
- Lime may be used to reduce the bedding pH. If lime is used, a concentration too high can cause irritation to the skin of the udder and legs.

Organic bedding options

Compost bedding /bedded pack
Approximately 12-18 inches wood shavings or sawdust is initially spread on the floor of a bedded pack or compost barn. The bed-pack must be aerated two times daily during milking to a depth up of 8 to 10 inches; this incorporates oxygen for aerobic decomposition and to provide fresh surface without accumulated manure for cows to lie down on. Fresh, dry sawdust is added every two to five weeks depending on season, weather conditions and cow density. The pack can rise as much as 4 feet and is removed once or twice a year. When the bedded pack is cleaned out entirely, the soiled bedding is spread on fields according to farm manure management plans.

This system requires excellent pack and ventilation management for barns to perform well. Many bedded pack barns have fans to blow air downward onto the bedded pack to help dry the pack surface. When we see steam rising from the pack during aerating, moisture is escaping in large amounts.

Bedded pack barns, in general, have higher concentrations of environmental pathogens. To reduce the risk of mastitis in cows, farms need to maintain adequate bedding, ensure frequent grooming, provide excellent ventilation, avoid overcrowding, practice good parlor hygiene and corral grooming.

Pros:

- Manure is readily available and the cost is low.
- Despite the high bacterial count of the bedding material, udder health and milk quality were not compromised and SCC decreased overtime in a well-managed bedded pack barn. However, good parlor management is needed for this to occur.
- Herd turnover rates have been shown to decrease over time most likely due to reduced incidence of lameness and hock lesions. Bedded pack barns are very comfortable to cows and foot and leg health has been shown to be positive using this bedding system.
- Bedded pack barns allow cows the freedom of movement compared to freestalls and tie-stalls.
- There is a reduction in manure storage costs and needed space and a savings in labor and manure handling.
- Compost bedding shows lower incidence of first and second mastitis cases, lower SCC and higher milk yield when used during the dry period.

Cons:

- High ambient humidity and air temperatures are not conducive to effective use of dried manure solids or composted dairy waste as bedding material.
- Dried manure is an excellent medium for bacterial growth once moist; composting offers little benefit toward net reduction in teat end contamination of pathogens. Each 1% increase in the percent of cows with milk discarded was associated with a 0.14 increase in bulk milk somatic cell scores.
- The number of gram-negative bacteria in deep-bedded manure solids was greater compared to barns that contained a smaller amount of manure solids.

Mattresses

Mattress are mainly used in tie stalls or free stall barns. There is a waterproof exterior filled with a variety of materials such as rubber crumbs, foam and water. Mattresses are marketed as needing no bedding but research has shown that bedding makes the mattresses more attractive to cows and the Dairy Stewardship program requires bedding on mattresses. Cows prefer soft rubber mats to conventional, hard rubber mats or concrete when bedding is added over the top with at least one pound of straw over the top. With mattresses, it is recommended to bed daily rather than alternate-day bedding to control bacteria on mattresses since organic bedding is commonly used on top of mattresses.

Pros:

- Cows stalled on mattresses tend to be cleaner.
- Somatic cell count of cows is typically lower with mattresses.
- Cows prefer to stand on mattresses, especially lame cows - which indicates a cow's preference for cushioned surfaces.
- Mattresses bedded with lime have the lowest counts of environmental pathogens.

Cons:

- Cows on foam mattresses need more time to lie down and lying duration is shorter.
- Swollen and injured hock scores tend to be higher when compared to other bedding materials.

- Mattresses used as a stall base, decreased lying comfort and have been implicated as risk factors for lameness.

Paper

Paper is relatively inexpensive if close to paper mills. Chopped recycles newspaper may be used also and may be mixed with other bedding materials. Fineness of chop will influence bedding characteristics. Additionally, it is important to utilize recycled paper with minimal glossy and high ink residue. Chopped paper can be blown off stalls in naturally ventilated barns during windy conditions.

Sawdust or wood shavings

Pros:

- Cows have been observed to have more lying time with deep bedded sawdust.
- Lameness issues have been shown to decrease when using sawdust or wood shavings.
- Sawdust and wood shavings are high in absorbency.
- Ease of use is one of the primary reasons for use on many dairy farms.
- Adding lime to bedding to reduce pH may reduce pathogen growth; however, the effect of lime is short lived (24 hours) and lime should be added daily. It is recommended to add lime before bedding and mixing just prior to use is most effective to reduce pathogen counts.
- Sawdust and wood shavings can be broken down by microorganisms in the production facility.

Cons:

- Because they are organic, sawdust and wood shavings allow for rapid pathogen growth.
- Smaller particle size of sawdust has rapid growth of pathogens and higher bacteria counts. Small particle size of saw dust makes it more absorbent than wood shavings and quicker to break down

Straw and hay

Straw is often used for bedding because it is soft, provides thermal insulation, and composts well. Straw and hay are attractive bedding options when produced on the farm. A small particle size (3/4 inch screen) increases animal comfort and absorbency and shortens breakdown time of straw.

Pros:

- Lying duration is longer on straw compared to many other bedding options. Cows have been observed to lie down on concrete with large amounts of straw over the top than on lightly bedded soft rubber mattresses.
- Bacterial counts of straw have shown to be lower compared to sand and sawdust.
- Straw and hay can be grown on the farm.
- Cows prefer to lie on concrete stalls with lots of straw compared to soft rubber mat with a small amount of straw.

Cons:

- Cows lying on straw and hay are dirtier than cows lying on other bedding surfaces.
- Decreased cleanliness of cows is linked to higher incidences of mastitis.
- Hoof health is lower compared to cows housed on sand.
- Straw is often avoided due to difficulty of handling, cost, and compatibility with manure systems.

Inorganic bedding

Sand

Sand is economical, improves cow cleanliness and has advantages for leg and hoof health. It is an inert material that doesn't promote pathogen growth; however, when mixed with manure, pathogen growth may occur. Sand that is naturally occurring has rounded edges and is more comfortable for the cows. Particle size is important as sand too small in particle size will hold water well and large particle size is not comfortable for cows to lie on. Very fine sand provides less drainage because the fine sand fills voids between larger particles and allows pooling or pockets of moisture. A depth of 6 to 8 inches in a freestall is recommended for cow comfort, softness and molding.

Pros:

- Sand has shown to reduce prevalence of lameness in cows.
- Clean sand can be reused.
- Lying time of cows increases with sand.
- Environmental bacteria counts are lower with sand compared to organic bedding options.
- Cleanliness of cows, cow health with low environmental bacteria, reduced occurrences of hock lesions and claw diseases, and surface traction are the main reasons farmers choose to use sand.
- Sand acts as a cleaning agent to remove manure from legs, udder and flanks.
- Pathogen quantities increase and peak one day after placement of clean and recycled sand.

Cons:

- Disposal can be a challenge. Often sand does not work with manure systems. In a liquid manure handling facility the sand must be settled to the bottom and disposed of.
- Stalls may become compacted and sand will be difficult to separate from manure by passive or mechanical methods.
- Sand is difficult to use with slatted floors. It cannot be used with deep pit manure storage with slatted floors.
- When stalls with sand become concave, total lying time of cows decreases. Regular maintenance of stalls is needed to avoid this.
- When given a choice of bedding options between sand, straw and mattresses, sand is the least preferred option amongst cows. Some of this preference may be due to the bedding material introduced to dairy cows at a young age. However, sand is the most preferred bedding option on farms because of the reasons listed above.

Stall and Bedding Benchmarks Worksheet

Think about how you manage stall and bedding design of your dairy barn.

- Please write down answers or notes for a dairy barn you manage that houses lactating cows.
- You may give single numbers, ranges of numbers or descriptive terms
- This is for your use only.

Stall Benchmarks

1. What is the average size of your cows in each pen?
2. What is the size of the stalls? Is this too small for the size of the cows? Too large?
3. How frequently do cows lie in stalls each day?
4. How long are the lying bouts?
5. How many cows stand in the stall with two feet in and two feet in the alley?
6. How long does it take cows to lie down in the stall?
7. How many cows shows signs of lameness? What is the severity of the lameness?
8. What changes can you make to your stalls today to improve cow comfort?

Bedding Benchmarks

1. Why are you using your current bedding material?
2. How often and frequently do cows lie down?
3. How long are the lying bouts?
4. How often are manure and contaminated bedding removed?
5. How frequently is new bedding material added?
6. Is mastitis an issue?
   Yes / No
   If yes, what is the source of bacteria? Are milking procedures being followed?
7. Is the bulk tank somatic cell count reaching your goals? Are individual cow somatic cell count reaching your goals?
   Yes / No If no, what is your target? What could be changed to reach your SCC goal?

I-29 Moo University 2019 Winter Workshop Series

ROUNDTABLE DISCUSSION

BENCHMARKS ARE A SCALE OR REFERENCE BY WHICH YOU CAN EVALUATE PERFORMANCE OR CONDITIONS

1. What am I doing right on my farm?

2. Where can I make improvements?

3. How is this impacting my health and my employees health?

4. How is this impacting my cows' health and comfort?

5. What changes can I or should I make in the **near future**?

6. What changes can I or should I make in the **long-term**?

Additional Notes:

UNIVERSITY OF MINNESOTA | EXTENSION

MAKING A DIFFERENCE IN MINNESOTA: ENVIRONMENT ✦ FOOD & AGRICULTURE ✦ COMMUNITIES ✦ FAMILIES ✦ YOUTH

Barn Design and Pen Design Benchmarks

Jim Salfer[1] & Tracey Erickson[2]

[1]University of Minnesota Extension, St. Cloud MN

[2]South Dakota State University Extension, Watertown SD

UNIVERSITY OF MINNESOTA Driven to Discover

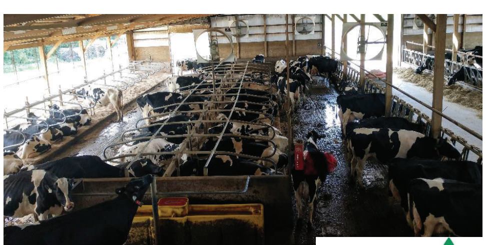
SDSU Extension

Well designed facilities should maximize cow well being and performance, be labor efficient and allow implementation of your desired management plan

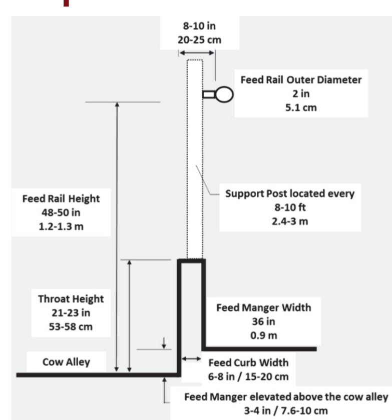
Facilities to improve cow health comfort and performance.

Areas to consider:

- Cow amenities
  - Stalls
  - Waterers
  - Feed bunk
  - Crossovers
- Flooring
- Foot bath
- Cow handling
- Minimize labor
- Holding area
- Manure removal
- Ventilation



Feed bunk design – post and rail



Dairyland Initiative, https://thedairylandinitiative.vetmed.wisc.edu

Feed Bunk design - headlocks

Cattle need to get used to headlocks

Photo: Dairyland Initiatives

Lactating cow bunk space

Milking cows

- Feed available 24/7 – 18 inch
- All animals eat at once – 26 to 30 inch

Transition cow guidelines

Pre-Fresh

- Bunk space – 30 inches/cow
- One stall per cows or 150 sq/ft per cow
- Minimize regrouping 2 to7 days before calving
- Quiet place to calve

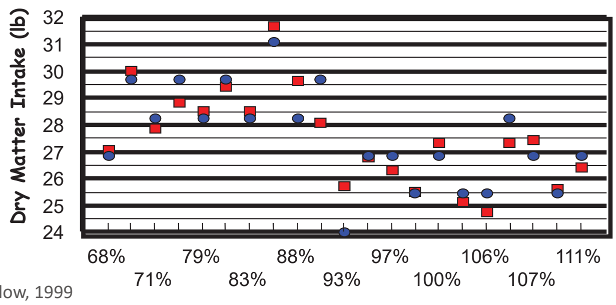
Post Fresh

- Bunk space – 30-36 inches/cow
- Loose housing or large deep bedded stalls
- One stall per cows or 150 sq/ft per cow

Dairyland Initiative, https://thedairylandinitiative.vetmed.wisc.edu

Feeding Space and DMI: Close-Up Cows

% stocking density as a % of headlocks - 130 headlocks in pen

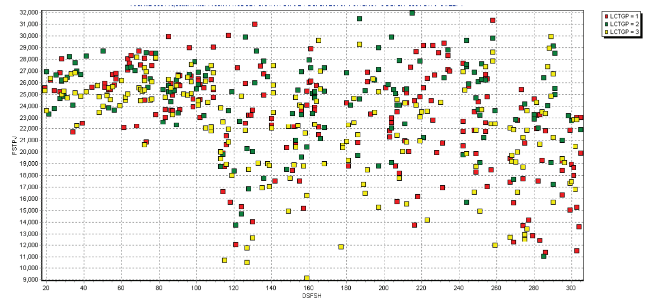


Buelow, 1999

University of Minnesota | Extension

SDSU Extension

Effect of Stocking Density on First Projection



Cook, 2007

University of Minnesota | Extension

SDSU Extension

Waterer requirements

Two per group/pen

3.5 inch (linear) perimeter per cow

6 to 8 inch deep water

Locate waterers on return from milking

Upper water edge depends on breed

- Mature Holsteins - 24 to 32 inches
- Mature Jersey – 21 to 29 inches

Water supply rate 6 to 8 gal per minute

University of Minnesota | Extension

SDSU Extension

Crossovers

Alley width

- Stall alleys – 10 to 12 ft wide
- Feed alleys – 12 to14 ft wide
- Feed and stall alleys 13 to15 ft wide

Crossovers

- Two crossovers per pen
- Every 25 stalls
- 14-16 ft wide

MWPS-7, Dairy Freestall Housing and Equipment, 8th Ed.
https://www-mwps.sws.iastate.edu/

University of Minnesota | Extension

SDSU Extension

Cow handling and managment

Short term interventions (hours)

- Breeding
- Vet checks
- Vaccinations

Longer term interventions (days)

- Lameness
- Illness

Return lane treatment chute

Photo David Kammel

Management rail

Headlocks

Transfer lanes

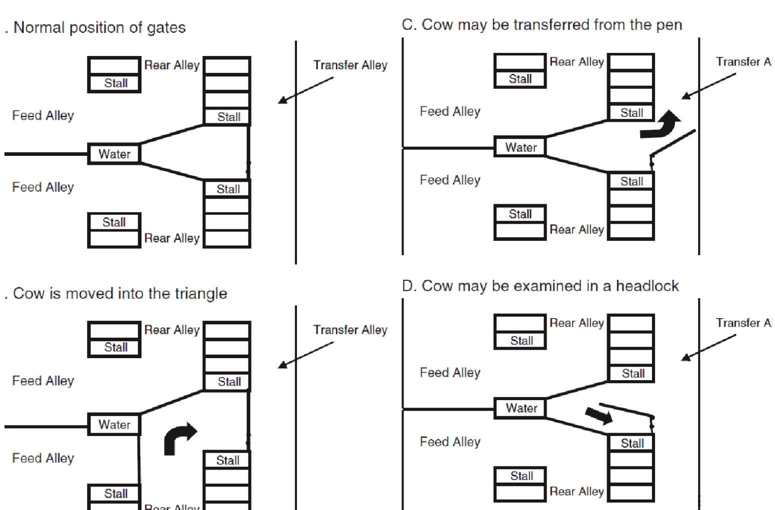
Costs of cow handling

Estimated costs for a 500-cow herd:

- Headlocks - $25.18/cow/year
- Palpation rail - $28.40/cow/year
- Sort gates - $32.83/cow/year

Palmer et al, 2000

Transfer alleys and triangle gates makes moving cows easy



Cook & Nordlund, Vet Clinc Food Anim, 2004

Flooring and footbath metrics to minimize lameness

Floor surface

- Grooving
- Rubber location

Footbath

- Design
- Location

Issues That Affect Cows.

Dairyland Initiative, https://thedairylandinitiative.vetmed.wisc.edu

University of Minnesota | Extension

SDSU Extension

Ideal groove

- 0.5-0.75 in deep
- 0.5-0.75 in wide
- 3.0-3.25 in on center
- Flat surface

https://thedairylandinitiative.vetmed.wisc.edu/home/housing-module/adult-cow-housing/flooring/

University of Minnesota | Extension

SDSU Extension

Rubber can help, but should not be a band aid

Areas to consider rubber:

- Holding area
- Parlor platforms
- Return lanes
- Minimum 30 in wide in long transfer lanes

University of Minnesota | Extension

SDSU Extension

Foot bath design

- Easy to clean
- Tapered sides – 20 to 24 inch at base
- Length – 10 to12 ft
- Close to mixing room
- No prebath required

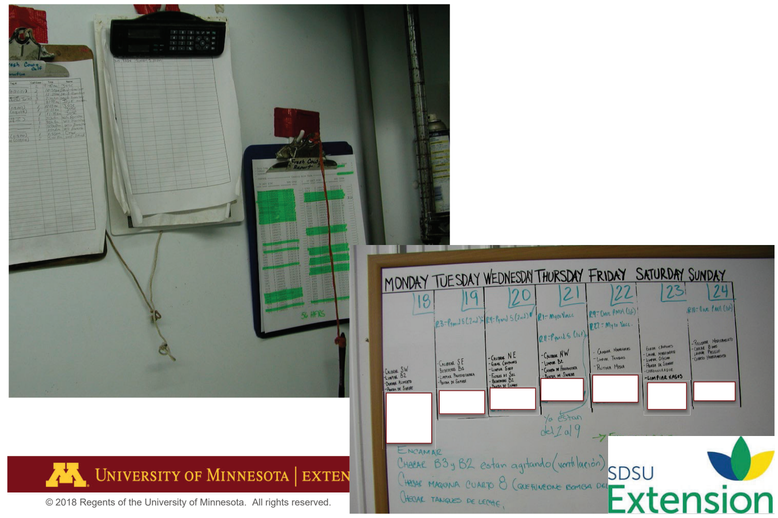
Dairyland Initiative, https://thedairylandinitiative.vetmed.wisc.edu

University of Minnesota | Extension

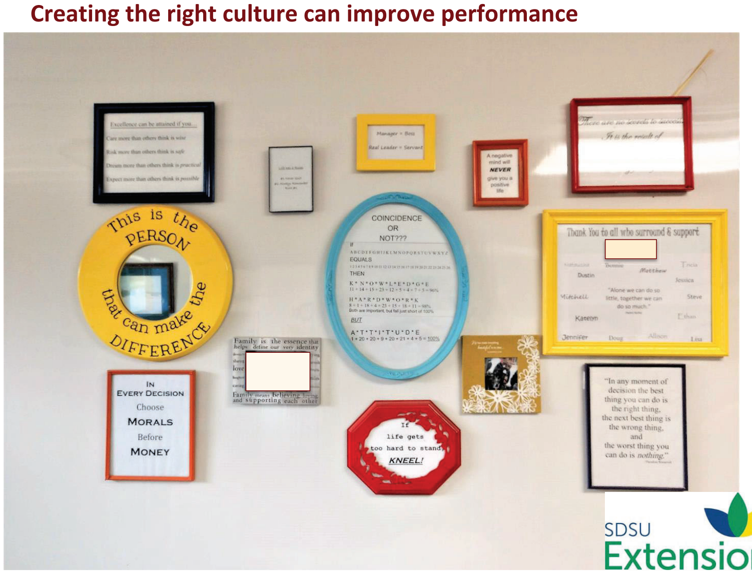
SDSU Extension

Equipment accessibility improves labor efficiency

Communication improves labor efficiency and performance

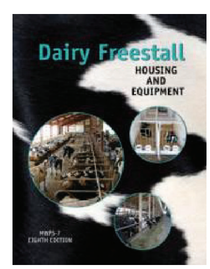


Creating the right culture can improve performance



Great reference to assist with your facility design and metrics

MWPS-7, Dairy Freestall Housing and Equipment, 8th Ed.
https://www-mwps.sws.iastate.edu/
$72.00 (print copy)
$51.50 (download copy)



Personnel Safety Passes and boot washes improve labor efficiency.

What to do now?

- Set benchmarks
- Measure performance
- Assess consequences, costs and benefits of taking action
- Take action
- Repeat measurement and assessment

Specific

Measurable

Attainable

Realistic

Timely

Jim Salfer
salfe001@umn.edu
Phone: (320) 203-6093

Tracey Erickson
tracey.erickson@sdstate.edu
Phone (605) 882-5140

I-29 Moo University 2019 Winter Workshop Series

BARN AND PEN DESIGN SELF ASSESSMENT

1) Feed bunk design

- Post and rail design
  a. Feed rail height is less than 48 inches, are bent and/or different heights across the bunk
  b. Not sure of height, but several cows have injured necks from reaching for feed
  c. Not sure of height, but a few cows have injured necks from reaching for feed
  d. All of the feed rail height is at recommended height for the group of animals (48-50 inches for mature cows) with the proper design.

- Headlock design
  a. Several headlocks are not working
  b. Animals cannot remove their head from the top and bottom of the headlock opening.
  c. Downer cows cannot be easily released from the headlocks.
  d. Individual cows cannot be locked and unlocked.
  e. Headlocks are the proper design, cows can remove their head from the top and bottom, downer cows are easily released and individual cows can be locked or unlocked.

- Feed bunk surface
  a. Eating surface is extremely rough and cannot be cleaned easily
  b. Eating surface is not real smooth, but can be cleaned
  c. Surface is smooth and easily cleaned

- Feed bunk space
  a. Lactating groups have less than 18 inches of bunk space/cow
  b. Lactating groups have greater than 18 inches of bunk space but less than 24 inches of bunk space/cow
  c. Lactating groups have greater than 24 inches of bunk space/cow.

- Transition cow feed bunk space
    a. Close up cows have less than 30 inches of bunk space and fresh cows have less than 36 inches of bunk space/cow.
    b. Close up cows have more than 30 inches of bunk space and fresh cows have less than 36 inches of bunk space/cow.
    c. Close up cows have more than 30 inches of bunk space and fresh cows have more than 36 inches of bunk space/cow.

2) Waterer design

- Waterers
    a. Only one watering space per lactating cow pen
    b. Two watering spaces per pen, waterers are often empty due to lack of water pressure
    c. Two watering spaces per lactating pen, less than 3 inches of linear space/cow
    d. Two watering spaces per lactating pen, more than 2 inches of linear space/cow
    e. Two watering spaces per lactating pen, more than 2 inches of linear space/cow and water is available in the return lanes while never running low on water.

3) Stocking density and alley design

- Stocking density
    a. Transition cows are stocked at more than one cow per stall or less than 120 ft^2 in loose housing and lactating cow stocking density is greater than 120%.
    b. Transition cows are stocked at 1 or fewer cows per stall or 150 ft^2 or more in loose housing and lactating cow stocking density is greater than 120%.
    c. Transition cows are stocked at 1 or fewer cows per stall or 150 ft^2 or more in loose housing and lactating cow stocking density is between 105-120%.
    d. Transition cows are stocked at 1 or fewer cows per stall or 150 ft^2 or more in loose housing and lactating cow stocking density is less than 105%.

- Lactating barn alley width
    a. Stall only alleys are less than 10 feet, and feed and stall alleys are less than 13 feet wide.
    b. Stall only alleys are between 10 and 12 feet wide and feed and stall alleys are 13 – 15 feet wide.
    c. Stall only alleys are 12 or more feet wide and feed and stall alleys are 15 or more feet wide.

- Alley crossovers
    a. One crossover per pen.
    b. Two crossovers per pen but less frequently than every 25 stalls (100 feet) and narrower than 14 feet with waterers.
    c. Two crossovers per pen at lease every 25 stalls (every 80- 100 feet) and 14 feet or wider with waterers.

4) Cow Handling

- Short term management intervention (breeding/shots/vet checks)
    a. Cow are managed in the freestalls and it often takes 2 or more people to deal with some cows.
    b. Cows are managed in double return lanes and/or palpation rails and are away from their pens for more than 1 hour during activities.
    c. Cows are managed in double return lanes and/or palpation rails and they are away from their pens for less than 1 hour longer during activities.
    d. Cows are managed in headlocks and are locked more than 2 hours per day during activities.
    e. Cows are managed in headlocks and are locked less than 2 hours per day during activities.

- Moving/sorting cows.
    a. Moving/sorting cows takes more than three people and often becomes a rodeo.
    b. Moving/sorting cows takes 2-3 people and is often frustrating.
    c. Moving/sorting cows is easy with 1 – 2 people, because of transfer lanes, gate triangles or other gating systems.
    d. Moving/sorting cows is easy with 1 – 2 people, because of transfer lanes, gate triangles or other gating systems along with special areas for hoof trimming and other treatments that do not disrupt normal daily activities.

5) Flooring and footbath management

- Alley flooring surface
    a. Flooring is very rough or too smooth resulting in injuries, cows slipping and/or downer cows due to floor surface.
    b. Flooring has grooves, but some cows slip and fall when normally moving cows.
    c. Flooring provides excellent footing so under normal activities, cows are sure footed and seldom slip or are injured due to slippery floors.

- High traffic/transfer lane flooring
    a. There is no rubber flooring anywhere in the barn.
    b. There is rubber flooring in the parlor, and other areas that cows make sharp turns.
    c. There is rubber flooring in parlor, where cows make sharp turns and in long transfer lanes.
    d. There is rubber flooring in parlor, where cows make sharp turns, in long transfer lanes and the holding area.

- Foot bath design and location
    a. Footbath is less than 10 feet long and it is not removed/bypassed or cleaned daily.
    b. Footbath is 12 feet long and is not removed/bypassed or cleaned daily.
    c. Footbath is 12 feet long and is removed/bypassed or cleaned daily.

6) Labor efficiency

- Equipment availability
    a. Equipment for regular activates such as brushes, feed push-up, processing calves and assist with cow care, chemicals and water to clean and prepare footbaths, and treatment product inventory are often not available or easily assessable and in working condition for workers.
    b. Equipment (see above) are sometimes not available and easily assessable and in working condition for workers.
    c. Equipment (see above) are usually available, easily assessable and in working condition for workers.
    d. Equipment (see above) is inventoried and is always available, easily assessable and in working condition for workers.
    e. Barn design makes it very easy for all employees to access equipment and minimize labor and steps to complete tasks such as filling footbaths, cleaning footbaths and waterers and other routine tasks.

- Employee labor flow
    a. There are limited or no personnel passes and workers need to open gates or climb over gates to accomplish their tasks.

b. There are personnel passes at ends of pens but workers need to walk out of their way or open gates to accomplish their tasks
c. There are strategically placed personnel passes throughout the barns that allow workers to accomplish their tasks efficiently.

- Boot wash and other personnel amenities
    a. There are limited boot wash stations when walking between clean and dirty areas, no designated break areas and limited locker room/bathroom areas for workers.
    b. There are well-located boot wash stations but limited break area and locker room/bathroom areas for workers.
    c. There are well-located boot wash stations, adequate break area, and locker room/bathroom areas for workers.

List the area(s) are likely to have the biggest improvement on profitability and worker efficiency over the next year.

- Develop a partial budget to determine the economic impact of these potential decisions

- Develop an action plan for improvement.

Action Plan Worksheet

University of Minnesota Extension

Dairy: ______________________________ **Date:** ____________

______________________________ **is our objective**

		Task (description)	Person Assigned	Date Due	Initial
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				
	☐				

Partial Budgeting Form
(Profitability Impacts)

UNIVERSITY OF MINNESOTA EXTENSION

Name of Decision Maker(s): ______________________________

Proposal Being Evaluated: ______________________________

Date: ____________

POSITIVE IMPACTS		COMPETING IMPACTS	
Increased Income		**Increased Costs**	
	$		$
		Opportunity costs:	
		Family time reservation value	
		Risk and management time	
		On the capital required by this	
		project, enter the:	
		Capital recovery charge	
		Repair cost	
		Other overhead and insurance	
Total Increased Income:	$ -	**Total Increased Costs:**	$ -
Reduced Costs		**Reduced Income**	
	$		$
Total Reduced Costs	$ -	**Total Reduced Income:**	$ -
Increased income + Reduced costs **= Total Positive Impacts:**	$ -	Increased costs + Reduced Income **= Total Competing Impacts:**	$ -
Pre-tax positive impacts - Competing impacts of the project =			$ -

I-29 Moo University 2019 Winter Workshop Series

ROUNDTABLE DISCUSSION

BENCHMARKS ARE A SCALE OR REFERENCE BY WHICH YOU CAN EVALUATE PERFORMANCE OR CONDITIONS

1. What am I doing right on my farm?

2. Where can I make improvements?

3. How is this impacting my health and my employees health?

4. How is this impacting my cows' health and comfort?

5. What changes can I or should I make in the **near future**?

6. What changes can I or should I make in the **long-term**?

Additional Notes: