ASAE D384.2 MAR2005 (R2014)
Manure Production and Characteristics

American Society of Agricultural and Biological Engineers

STANDARD

ASABE is a professional and technical organization, of members worldwide, who are dedicated to advancement of engineering applicable to agricultural, food, and biological systems. ASABE Standards are consensus documents developed and adopted by the American Society of Agricultural and Biological Engineers to meet standardization needs within the scope of the Society; principally agricultural field equipment, farmstead equipment, structures, soil and water resource management, turf and landscape equipment, forest engineering, food and process engineering, electric power applications, plant and animal environment, and waste management.

NOTE: ASABE Standards, Engineering Practices, and Data are informational and advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. The ASABE assumes no responsibility for results attributable to the application of ASABE Standards, Engineering Practices, and Data. Conformity does not ensure compliance with applicable ordinances, laws and regulations. Prospective users are responsible for protecting themselves against liability for infringement of patents.

ASABE Standards, Engineering Practices, and Data initially approved prior to the society name change in July of 2005 are designated as "ASAE", regardless of the revision approval date. Newly developed Standards, Engineering Practices and Data approved after July of 2005 are designated as "ASABE".

Standards designated as "ANSI" are American National Standards as are all ISO adoptions published by ASABE. Adoption as an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria for approval have been met by ASABE.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

CAUTION NOTICE: ASABE and ANSI standards may be revised or withdrawn at any time. Additionally, procedures of ASABE require that action be taken periodically to reaffirm, revise, or withdraw each standard.

Copyright American Society of Agricultural and Biological Engineers. All rights reserved.

ASABE, 2950 Niles Road, St. Joseph, MI 49085-9659, USA, phone 269-429-0300, fax 269-429-3852, hq@asabe.org

Documents
Document Sharing Hub

Copyright American Society of Agricultural and Biological Engineers
Provided by IHS Markit under license with ASABE
No reproduction or networking permitted without license from IHS
Full document details: ASABE D384.2 2014

Licensee=/, User=,
Not for Resale,

Manure Production and Characteristics

Developed by the Engineering Practices Subcommittee of the ASAE Agricultural Sanitation and Waste Management Committee; approved by the Structures and Environment Division Standards Committee; adopted by ASAE December 1976; reconfirmed December 1981, December 1982, December 1983, December 1984, December 1985, December 1986, December 1987; revised June 1988; revised editorially and reaffirmed December 1993; revised editorially March 1995; reaffirmed December 1998, December 1999, December 2001, February 2003; revised March 2005 by joint committee of ASAE and Federation of Animal Science Societies members; reaffirmed January 2010, December 2014.

Keywords: Livestock, Manure, Waste

1.0 Purpose

1.1 This standard provides three types of information for estimating characteristics of livestock and poultry manure:

- Typical characteristics for manure "as-excreted" by livestock and poultry based on typical diets and animal performance levels in 2002 (Section 3);
- Equations for estimating manure excretion characteristics based on animal performance and dietary feed and nutrient intake specific to an individual situation (Sections 4 through 9);
- Typical characteristics for manure "as-removed" from manure storage or animal housing (Section 10).

1.2 Typical or average estimates of manure excreted become obsolete due to changes in animal genetics, performance potential, feeding program strategies, and available feeds. To minimize future concerns, a set of equations for predicting nutrient excretion (primarily nitrogen and phosphorus), dry matter, and, depending upon species, other potential characteristics have been assembled for beef, dairy, swine, horses and poultry. The Equation Estimates sections (Sections 4 through 9) allow an estimate of manure characteristics that is relevant to a wide range of dietary options and animal performance levels commonly observed in commercial production.

1.3 It is more appropriate to use the equations in Sections 4 through 9for the following situations:

- When comprehensive nutrient management plans are being developed specific to an individual animal feeding operation (AFO);
- When farm specific data is available for an AFO's feeding program and animal performance;
- When feed intake, feed nutrient concentration, feed digestibility, or animal performance varies from the assumptions used to estimate the typical values in Table 1.
- When Table 1 has not been updated to address industry trends.

1.4 It may be more appropriate to use the typical values found in Table 1 for the following situations:

- When planning estimates are being made on a scale larger than a single farm (e.g. county or regional estimate of nutrient excretion)
- When a rough approximation is needed for farm planning;
- When farm-specific information of animal performance and feed intake is not available.

Documents Document Sharing Hub
Copyright American Society of Agricultural and Biological Engineers
Provided by IHS Markit under license with ASABE
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ASABE D384.2 2014

2.0 Caution

2.1 Section 3. Typical As-Excreted Manure Production and Characteristics. The user of these data should recognize that the reported typical values may become obsolete with time due to changes in animal genetics, feeding programs, alternative feeding technologies, and available feeds. In addition, users should also recognize that under current conditions, excretion of nutrients and other related characteristics will vary for individual situations from the currently listed values due to variations in animal feed nutrient intake, animal performance, and individual farm management. Sections 4–9 provide an alternative, and often more accurate, methodology for estimating nutrient excretion for individual production systems.

2.2 Sections 4 – 9. Equations for As-Excreted Manure Characteristics Estimates for Individual Species. These sections demonstrate the impact of dietary changes on nutrient excretion. However, this is not intended to be used as a ration-balancing tool, nor is this the appropriate tool for estimating the nutrient needs of the animal. Nutrient needs are best defined in the National Research Council's publication series or by using University recommendations. Both sources of information can provide estimates that reflect biological inefficiencies and digestibility limitations.

2.3 In using Sections 4 – 9 to evaluate the impact of alternative rations, it is important to recognize that these equations accurately estimate excretion only when animals are fed diets that meet or exceed the animal's minimum nutrient requirements. Estimates of excretion based on dietary options that do not meet an animal's minimum needs will not be accurate. Sections 4–9 are to be used following ration development by an animal nutrition professional.

2.4 New research data on excretion will be of value for confirming or improving the accuracy of the equations estimating excreting. The authors of this standard are very interested in comparing new research data with these equations. Authors can be contacted through the ASAE Standards staff.

2.5 Section 10. Typical As-Removed Manure Production and Characteristics. Many physical, chemical, and biological processes can alter manure characteristics from its original as-excreted form. The as-removed manure production and characteristics values reported in this table allow for common modifications to excreted manure (Section 3) resulting from water addition or removal, bedding addition, and/or treatment processes. These values represent typical values based on available data sources (see end of Section 10). These estimates may be helpful for individual farm long-term planning prior to any samples being available and for planning estimates addressing regional issues. Whenever possible, site-specific samples or other more localized estimates should be used in lieu of national tabular estimates. **This table should not be used to develop individual year nutrient management plans for defining field specific application rates, unless absolutely no site-specific manure analysis data are available.** However, where site-specific data are unavailable, this table may provide initial estimates for planning purposes until those site specific values are available.

3.0 Typical As-Excreted Manure Production and Characteristics

3.1 Two approaches were used for estimating typical characteristics summarized in Table 1.

1) Manure characteristics listed in **BOLD** are estimated for dietary intake and animal performance levels common for livestock and poultry management in 2003 using the equations listed in Sections 4 through 9. Beef, poultry and swine excretion characteristics are based on a calculation of dietary nutrient intake minus animal nutrient retention using dietary and performance measurements typical for the industry at the time these data were published. Nutrient retention estimates followed common industry methodologies used for recommending feeding programs. Dry matter excretion is estimated to be a function of dry matter intake minus dry matter digestibility (see equations in Sections 4 and 9).

   For estimating dairy and equine manure characteristics, existing research data and regression analysis were used to identify relationship between feeding programs, animal performance, and excretion.

   Total nitrogen, total phosphorus, and dry matter excretion were estimated by these methods for all species. Available research data or models allowed additional excretion estimates for some species. All data in Table 1 based upon animal dietary intake and performance measure is illustrated in **BOLD** with supporting assumptions for dietary intake and performance assumptions and references listed in Sections 4 through 9.

Documents
Document Sharing Hub
Copyright American Society of Agricultural and Biological Engineers
Provided by IHS Markit under license with ASABE
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ASABE D384.2 2014

2) Where dietary intake and animal performance level based excretion estimates could not be made, a review of current references including the USDA Agricultural Waste Management Field Handbook, previous ASAE D384 standard, and Manure Characteristics (MWPS-18, Section 1). Those values in Table 1 that are not bold are based upon these references.

3.2 Caution

3.2.1 Manure and nutrient production characteristics for meat producing animals are reported on a unit mass excreted per finished animal. Manure excretion by meat producing animals varies with stage of growth. This format was selected to minimize misuse of a daily average values to represent an entire production phase. Sizing of treatment systems based upon instantaneous loading rates should use the equations in Sections 4 through 9 with appropriate feeding program and performance inputs typical of the later stages of growth. Manure excretion rates for other animals are more constant and thus reported on a daily basis.

3.2.2 In addition, facilities for meat producing animals are rarely in full production 365 days per year due to uneven growth rates of animals, time required for facility cleaning after a group, and availability of animals for restocking a facility. Planning based on number of finished animals provides a more realistic planning estimate for annual manure volume and nutrient production.

3.2.3 It should also be noted that Table 1 estimates and predictive equations in Sections 4 through 9 provide an as-excreted estimate of manure production, excluding any additions of waste feed or dilution water, biochemical degradation of solids, or volatilization of nitrogen and carbon. Manure characteristics after storage and/or treatment of manures are better estimated by site-specific manure samples or, when farm specific information is not available, by the typical as-removed values listed in Section 10.

3.3 References

3.3.1 Fulhage, C. D., 2003. Proposed Revision to ASAE D384.1 for Representative Values of "As-Excreted" Manure Production. Proceedings of the International Symposium for Animal, Agricultural, and Food Processing Wastes IX. ASAE. St. Joseph, MI. 269-276.

Table 1 – Section 3 – Estimated typical manure (urine and feces combined) characteristics as excreted[1] by: Table 1.a – Meat-producing livestock and poultry. Diet based numbers are in BOLD. See footnotes 2 and 3 for source of non-bold values.

Animal Type and Production Grouping	Total Solids[3]	Volatile Solids[3]	COD[3, 4]	BOD[3, 4]	N	P	K	Ca	Total Manure[5]		Moisture[6]	Assumed Finishing Time Period (days)
	kg/ finished animal (f.a.)								kg/ f.a.	liter/ f.a.	% w.b.	
Beef: Finishing cattle	**360**	**290**	300	67	**25**	**3.3**	17.1	**7.7**	4,500	4,500	92	153
Poultry: Broiler	**1.3**	0.95	1.05	0.30	**0.053**	**0.016**	**0.031**		4.9	4.9	74	48
Poultry: Turkey, males	**9.2**	7.4	8.5	2.4	**0.55**	**0.16**	0.26		36	36	74	133
Poultry: Turkey, females	**4.4**	3.5	4.0	1.1	**0.26**	**0.074**	0.11		17	17	74	105
Poultry: Duck	**1.7**	1.0	1.4	0.28	**0.062**	**0.022**	0.031		6.5	6.5	74	39
Swine: Nursery pig,12.5 kg	4.8	4.0	4.4	1.5	**0.41**	**0.068**	0.16		48	48	90	36
Swine: Grow-finish, 70 kg	**56**	45	47	17	**4.7**	**0.76**	2.0		560	560	90	120
	lb/ finished animal (f.a.)									ft^3/ f.a.	% w.b.	
Beef: Finishing cattle	**780**	**640**	670	150	**55**	**7.3**	38	**17**	9,800	160	92	153
Poultry: Broiler	**2.8**	2.1	2.3	0.66	**0.12**	**0.035**	**0.068**		11	0.17	74	48
Poultry: Turkey, males	**20**	16	19	5.2	**1.2**	**0.36**	0.57		78	1.3	74	133
Poultry: Turkey, females	**9.8**	7.8	8.8	2.4	**0.57**	**0.16**	0.25		38	0.61	74	105
Poultry: Duck	**3.7**	2.2	3.0	0.61	**0.14**	**0.048**	0.068		14	0.23	74	39
Swine: Nursery pig, 27.5 lb	10	8.7	9.7	3.4	**0.91**	**0.15**	0.35		87	1.4	90	36
Swine: Grow-finish, 154 lb	**120**	99	104	38	**10**	**1.7**	4.4		1200	20	90	120

Documents Document Sharing Hub
Copyright American Society of Agricultural and Biological Engineers
Provided by IHS Markit under license with ASABE
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ASABE D384.2 2014

Table 1.b – Section 3 — All other livestock and poultry. Diet based numbers are in BOLD. See footnotes 2 and 3 for source of non-bold values.

Animal Type and Production Grouping	Total Solids[3]	Volatile Solids[3]	COD[3, 4]	BOD[3, 4]	N	P	K	Ca	Mg	Total Manure[5]		Moisture[6]
	kg/ day-animal (d-a)									kg/ (d-a)	liter/ d-a.	% w.b.
Beef: Cow (confinement) [7,10]	**6.6**	**5.9**	6.2	1.4	**0.19**	**0.044**	0.14	**0.089**		-	-	88
Beef: Growing calf (confinement)	**2.7**	**2.3**	2.3	0.52	**0.13**	**0.025**	0.085	**0.040**		22	22	88
Dairy: Lactating cow	**8.9**	7.5	8.1	1.30	**0.45**	**0.078**	**0.103**			68	68	87
Dairy: Dry cow	**4.9**	4.2	4.4	0.626	**0.23**	0.03	0.148			38	3	87
Dairy: Milk fed calves					0.0079							
Dairy: Calf, 150 kg	1.4				0.063					8.5	8.5	83
Dairy: Heifer, 440 kg	3.7	3.2	3.4	0.54	**0.12**	**0.020**				22	22	83
Dairy: Veal, 118 kg	0.12				0.015	0.0045	0.0199			3.5	3.5	96
Horse: Sedentary, 500 kg [8]	**3.8**	3.0		0.48	**0.089**	**0.013**	**0.027**	**0.023**	**0.009**	25	25	85
Horse: Intense exercise, 500 kg[8]	**3.9**	3.1		0.49	**0.15**	**0.033**	**0.095**	**0.069**	**0.018**	26	26	85
Layer	**0.022**	0.016	0.018	0.0050	**0.0016**	**0.00048**	0.00058	**0.0022**		0.088	0.088	75
Swine: Gestating sow, 200 kg	0.50	0.45	0.47	0.17	**0.032**	**0.009**	0.022			5.0	5.0	90
Swine: Lactating sow, [9] 192 kg	1.2	1.0	1.1	0.38	**0.085**	**0.025**	.053			12	12	90
Swine: Boar, 200 kg	0.38	0.34	0.27	0.13	0.028	0.0097	.0176			3.8	3.8	90
	lb/ day-animal (d-a)									lb/ d-a.	ft^3/ d-a.	% w.b.
Beef: Cow (confinement) [7, 10]	**15**	**13**	14	3.0	**0.42**	**0.097**	0.30	**0.20**		-	-	88
Beef: Growing calf (confinement)	**6.0**	**5.0**	5.2	1.1	**0.29**	**0.055**	0.19	**0.088**		50	0.81	88
Dairy: Lactating cow	**20**	17	18	2.9	**0.99**	**0.17**	**0.23**			150	2.4	87
Dairy: Dry cow	**11**	9.2	9.7	1.4	**0.50**	**0.066**	0.33			83	1.3	87
Dairy: Milk fed calves					0.017							
Dairy: Calf, 330lb	3.2				0.14					19	0.30	83
Dairy: Heifer, 970 lb	8.2	7.1	7.5	1.2	**0.26**	**0.044**				48	0.78	83
Dairy: Veal, 260 lb	0.27				0.033	0.0099	0.044			7.8	0.12	96
Horse: Sedentary, 1,100 lb [8]	**8.4**	6.6		1.1	**0.20**	**0.029**	**0.060**	**0.051**	**0.020**	56	0.90	85
Horse: Intense exercise , 1,100 lb [8]	**8.6**	6.8		1.1	**0.34**	**0.073**	**0.21**	**0.15**	**0.040**	57	0.92	85
Layer	**0.049**	0.036	0.039	0.011	**0.0035**	**0.0011**	0.0013	0.0048		0.19	0.0031	75
Swine: Gestating sow, 440 lb	1.1	0.99	1.0	0.37	**0.071**	**0.020**	0.048			11	0.18	90
Swine: Lactating sow,[9] 423 lb	2.5	2.3	2.4	0.84	**0.19**	**0.055**	0.12			25	0.41	90
Swine: Boar, 440 lb	0.84	0.75	0.60	0.29	0.061	0.021	0.039			8.4	0.13	90

(continued)

Copyright American Society of Agricultural and Biological Engineers
Licensee=/, User=,
Not for Resale,
Copyright American Society of Agricultural and Biological Engineers
Provided by IHS Markit under license with ASABE
No reproduction or networking permitted without license from IHS
Full document details: ASABE D384.2 2014
AVA Documents Document Sharing Hub

Copyright American Society of Agricultural and Biological Engineers
Provided by IHS Markit under license with ASABE
No reproduction or networking permitted without license from IHS
Full document details: ASABE D384.2 2014

Table 1.b – Section 3 (continued)

[1] Prior to any changes due to dilution water addition, drying, volatilization or other physical, chemical or biological processes.

[2] Non-bold table numbers indicate that predictive equations were not available from Sections 4 – 9 for estimating this characteristic. These numbers are average values taken from MWPS-18 Section 1, NRCS Agricultural Waste Management Field Handbook, and the previous version ASAE D384.1 or calculated based upon procedures used in footnote 3.

[3] Total Solids (TS) is estimated for most animal groups by equations in Sections 4 – 9. For beef cattle, volatile solids is also based upon equations. For all other species, volatile solids are calculated from TS and literature values of the ratio of VS to TS. Similarly, BOD and COD values are calculated using VS and the literature values of the ratio of BOD and COD to VS. Literature values are taken from MWPS-18 Section 1, NRCS Agricultural Waste Management Field Handbook, and the previous version ASAE D384.1.

[4] BOD: biochemical oxygen demand, 5-day, COD: chemical oxygen demand.

[5] Total manure is calculated from Total Solids and manure moisture content.

[6] As-excreted manure moisture contents range from 75 to 90 percent. At these moisture levels as-excreted manure has a density nearly equal to that of water, and a specific gravity of 1.0 was assumed in calculation of manure volume.

[7] Solids estimates (TS, VS, COD, and BOD) do not include solids in urine.

[8] These values apply to horses 18 months of age or older that are not pregnant or lactating. The representative number applies to 500 kg horses and the range represents horses from 400 to 600 kg. ‘‘Sedentary’’ would apply to horses not receiving any imposed exercise. Dietary inputs are based on minimum nutrient requirements specified in “Nutrient Requirements of Horses” (NRC, 1989). “Intense” represents horses used for competitive activities such as racing. Dietary inputs are based on a survey of race horse feeding practices (Gallagher et al, 1992) and typical feed compositions (forage = 50% alfalfa, 50% timothy; concentrate = 30% oats, 70% mixed performance horse concentrate).

[9] Bold values include contribution of nursing pigs.

[10] Beef cows’ values are representative of animals during non-lactating period and first six months of gestation.

Licensee=/, User=,
Not for Resale,
AVA Documents
Document Sharing Hub

4.0 Equations for As-Excreted Manure Characteristics Estimates for Beef

4.1 Fundamental Model

Nutrient Excretion = Feed Nutrient Intake – Nutrient Retention

*Dry Matter Excretion = Feed Dry Matter Intake × (1 – Dry Matter Digestibility)**

* Same relationship for organic matter or volatile solids excretion.

4.2 See 2.0 Caution

See Table 2, Definitions of variables — as excreted — beef.

Table 2 – Section 4 – Definition of variables — as excreted — beef

Variable	Description	Units
Animal Performance Characteristics Input		
BW_F	Live body weight at finish of feeding period (market weight) [2]	kg
BW_I	Live body weight at start of feeding period (purchase weight) [2]	kg
BW_{AVG}	Average live body weight for feeding period [2]	kg
SRW [3]	Standard reference weight for expected final body fat	478 kg for Choice (28% marbling) 462 kg for Select (26.8% marbling)
Feed Program Characteristics Inputs		
DMI	Dry matter intake	g dry feed/day
DMD	Dry matter digestibility of total ration	% of DMI
OMD	Organic matter digestibility of total ration	% of OMI
ASH	Ash concentration of total ration	% of DMI
C_{cp}	Concentration of crude protein of total ration	g of protein/g of dry feed
C_P	Concentration of phosphorus of total ration	g of phosphorus/g of dry feed
DOF	Days on feed for individual ration	days
x	Ration number	
n	Total number of rations fed	
Excretion Outputs		
N_{E-T}	Total nitrogen excretion per finished animal	g of nitrogen/finished animal
P_{E-T}	Total phosphorus excretion per finished animal	g of phosphorus/finished animal
Ca_{E-T}	Total calcium excretion per finished animal	g of calcium/finished animal
DM_E	Dry matter excretion per animal per day	g of dry matter/day/animal
DM_{E-T}	Total dry matter excretion per finished animal	g of dry matter/finished animal
OM_E	Organic matter (or volatile solids) excretion per animal per day	g of organic matter/day/animal
OM_{E-T}	Total organic matter (or volatile solids) excretion per finished animal	g of organic matter/finished animal

[1] Data specific to individual herd performance or feed analysis should be used when data is available. If situation specific information is not available, a default value from the Assumptions Table for Typical Manure Characteristics at the conclusion of this section may be the next best alternative.
[2] For beef cow/calf pairs (including pregnancy), assume $BW_F – BW_I$ equals weaning weight of calves. For beef cows on maintenance diet, assume the $BW_F – BW_I$ equals 0.
[3] If SRW is unknown, recommend using 478 kg as standard reference weight.

4.3 Equations for Estimating Excretions

Equations from the 1996 NRC Nutrient Requirements of Beef Cattle for retained protein and energy equations provide the basis for estimating nitrogen retention. Supplemental information referenced by this publication provides background information on validation of this approach for estimating retained nitrogen.

Documents
Document Sharing Hub
Copyright American Society of Agricultural and Biological Engineers
Provided by IHS Markit under license with ASABE
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ASABE D384.2 2014

Retained phosphorus is generally recognized as 3.9 g of retained P per 100 g of retained protein. Retained calcium is generally recognized as 7.1 g per 100 g of retained protein. Therefore, P and Ca retention are calculated as a function of retained protein. Both assumptions originate from the 1996 NRC Nutrient Requirements of Beef Cattle. Additional supporting information is cited by this publication.

4.3.1 *Dry matter excretion equations for calves and finishers:* [1]

$$DM_E = [DMI * (1 - DMD/100)] + 20.3 * (0.06 * BW_{AVG}) \quad (1)$$

$$DM_{E-T} = \sum_{x=1}^{n} DMI_x * DOF_x * (1 - DMD_x/100) + \sum_{x=1}^{n} DOF_x * 20.3 * (0.06 * BW_{AVG}) \quad (2)$$

4.3.2 *Organic matter (or volatile solids) excretion equations:*

$$OM_E = [DMI * (1 - ASH/100)] * (1 - OMD/100) + 17 * (0.06 * BW_{AVG}) \quad (3)$$

$$\begin{aligned} OM_{E-T} = & \sum_{x=1}^{n} [DMI_x * DOF_X * (1 - ASH_x/100)] * (1 - OMD_x/100) \\ & + \sum_{x=1}^{n} DOF_X * 17 * (0.06 * BW_{AVG}) \end{aligned} \quad (4)$$

4.3.3 *Nitrogen excretion equation:*

$$\begin{aligned} N_{E-T} = & \sum_{x=1}^{n} (DMI_x * C_{cp-x} * DOF_x * /6.25) - [41.2 * (BW_F - BW_I)] \\ & + \left[0.243 * DOF_{Tt} * [(BW_F + BW_I)/2]^{0.75} * (SRW/(BW_F * 0.96))^{0.75} * [(BW_F - BW_I)/DOF_T]^{1.097}\right] \end{aligned} \quad (5)$$

4.3.4 *Phosphorus excretion equation:*

$$\begin{aligned} P_{E-T} = & \sum_{x=1}^{n} (DMI_x * C_{P-x} * DOF_x) - [10.0 * (BW_F - BW_I)] \\ & + \left\{5.92 * 10^{-2} * DOF_T * [(BW_F + BW_I)/2]^{0.75} * (SRW/BW_F * 0.96)^{0.75} * [(BW_F - BW_I)/DOF_T]^{1.097}\right\} \end{aligned} \quad (6)$$

4.3.5 *Calcium excretion equation:*

$$\begin{aligned} Ca_{E-T} = & \sum_{x=1}^{n} (DMI_x * C_{Ca-x} * DOF_x) - [18.33 * (BW_F - BW_I)] \\ & + 0.445 * \left\{0.243 * DOF_T * [(BW_F + BW_I)/2]^{0.75} * (SRW/(BW_F * 0.96))^{0.75} * [(BW_F - BW_I)/DOF_T]^{1.097}\right\} \end{aligned} \quad (7)$$

4.4 Manure Characteristics Based Upon Typical Performance and Diets — See Tables 3a and 3b.

Table 3a – Section 4 – Estimated manure (urine and feces combined) characteristics as excreted based upon equations and assumptions in Table 3b

Animal Type and Production Grouping	Total solids	Volatile Solids	Nitrogen	Phosphorus	Calcium	Total Manure[1]
Finishing cattle	kg/finished animal					
	360	290	25	3.3	7.7	3,400
	lb/finished animal					
	780	640	55	7.3	17	7,400

[1] Total manure is calculated from total solids and assumed moisture of 92%.

[1] Estimates dry matter for 1) feces based upon indigestibility of feed and for 2) urine based upon regression equation from 300 observations of urine excretion by beef cattle finishers ranging in weight from 100 to 620 kg and urine solids content of 6%.

Documents Document Sharing Hub
Copyright American Society of Agricultural and Biological Engineers
Provided by IHS Markit under license with ASABE
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ASABE D384.2 2014

Table 3b – Section 4 – Dietary and performance assumptions

Animal Type and Production Grouping	Live Weight (kg)		Average Daily Gain (kg/da)	Days on Feed	Feed Conversion (kg of feed per kg of gain)	Dietary Assumptions						
	In	Out				DMI (% of avg. body weight)	DMD	OMD	Crude Protein (g/day)	P (g/day)	Ca (g/day)	Ash
Finishing cattle	338	554	1.42	153	6.3	2.0%	80%	83%	1200	28	62	4%
Range: Only feed conversion efficiency and dietary nutrient content or digestibility were varied to determine range for N, P, and Ca.					5.8–6.8		70–85%	75–88%	1100–1300	22–45	53–80	

4.5 References

4.5.1 Anrique, R. G., M. L. Thonney, and H. J. Ayala. 1990. Dietary energy losses of cattle influenced by body type, size, sex, and intake. Anim. Prod. 50:467-474.

4.5.2 Danner, M. L., D. G. Fox, and J. R. Black. 1980. Effect of feeding system on performance and carcass characteristics of yearling steers, steer calves and heifer calves. J. Anim. Sci. 50:394-404.

4.5.3 Ellenberger, H. G., J. A. Newlander, and C. H. Jones. 1950. Composition of the bodies of dairy cattle. Vt. Agric. Exp. Sta. Bull. 558.

4.5.4 Erickson, G. E., B. Auvermann, R. Eigenberg, L.W. Greene, T. Klopfenstein, R. Koelsch. 2003. Proposed Beef Cattle Manure Excretion and Characteristics Standard for ASAE. Proceedings of the International Symposium for Animal, Agricultural, and Food Processing Wastes IX. ASAE. St. Joseph, MI. 269-276.

4.5.5 Fortin, A., S. Simpfendorfer, J. T. Reid, H. J. Ayala, R. Anrique, and A. F. Kertz. 1980. Effect of level of energy intake and influence of breed and sex on the chemical composition of cattle. J. Anim. Sci. 51:604-614.

4.5.6 Garrett, W. N. 1980. Energy utilization by growing cattle as determined in 72 comparative slaughter experiments. Energy Metab. Proc. Symp. 26:3-7.

4.5.7 Harpster, H. W. 1978. Energy requirements of cows and the effect of sex, selection, frame size, and energy level on performance of calves of four genetic types. Ph.D. dissertation. Michigan State University, East Lansing, MI.

4.5.8 Lomas, L. W., D. G. Fox, and J. R. Black. 1982. Ammonia treatment of corn silage. I. Feedlot performance of growing and finishing cattle. J. Anim. Sci. 55:909-923.

4.5.9 NRC. 1996 (2000 update). Nutrient Requirements for Beef Cattle. Seventh Revised Edition. National Academy Press. 242 pages.

4.5.10 Tylutki, T. P., D. G. Fox, and R. G. Anrique. 1994. Predicting net energy and protein requirements for growth of implanted and nonimplanted heifers and steers and nonimplanted bulls varying in body size. J. Anim. Sci. 72:1806-1813.

4.5.11 Woody, H. D., D. G. Fox, and J. R. Black. 1983. Effect of diet grain content on performance of growing and finishing cattle. J. Anim. Sci. 57:717-728.

5.0 Equations for As-Excreted Manure Characteristics Estimates for Dairy Cattle

5.1 Fundamental Model

5.1.1 The estimates for manure and nutrient excretion were derived from the combination of multiple data sets from Washington State University, University of California–Davis, The Ohio State University, and Pennsylvania State University. The data sets contain records from Holstein cattle and include a wide variety of animal ages, ranging from calves to multiparous lactating cows.

Documents Document Sharing Hub

Copyright American Society of Agricultural and Biological Engineers
Provided by IHS Markit under license with ASABE
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ASABE D384.2 2014

5.1.2 The data for the calves and heifers were divided according to animal body weight and includes four groups, milk fed calves, weaned calves weighing less than 204 kg, heifers weighing between 274 to 613 kg, and veal calves. Excretion estimates for veal calves were adapted from Sutton et al., 1989. Additional classifications of animals include non-lactating and lactating cows.

5.1.3 Lactating cow excretion estimates were derived from regression equations developed using lactating Holstein cows regardless of body weight or milk production. The data set for lactating cows was evaluated to compare the amount of metabolizable protein (MP) required to the MP supplied to the cow using the 2001 Dairy NRC Model. Only cows fed less than 112% of MP requirements were included in the data set. The average values reported for lactating cows were determined using the regression equation for a cow producing 40 kg of milk. The regression equations were developed using PROC MIXED of SAS, with study included as a random variable (St-Pierre, 2001).

5.2 See 2.0 Caution

See Table 4, Definitions of variables — as excreted — dairy cattle

Table 4 – Section 5 – Definition of variables — as excreted — dairy cattle

Variable	Description	Units
Animal Performance Characteristics Inputs		
Milk	Milk production	kg of milk/animal/day
MF	Milk fat	g/g milk/day
MTP	Milk true protein	g/g milk/day
DIM	Days in milk	days
DP	Dry period length	days
BW	Average live body weight	kg
Feed Program Characteristics Inputs		
DMI	Dry matter intake	kg dry feed/animal/day
DMD	Dry matter digestibility of total ration	% of DMI
OMD	Organic matter digestibility of total ration	% of OM intake
ASH	Ash concentration of total ration	% of DMI
C_{cp}	Concentration of crude protein of total ration	g crude protein/g dry feed
C_P	Concentration of phosphorus of total ration	g phosphorus/g dry feed
C_K	Concentration of potassium of total ration	g potassium/g dry feed
Excretion Outputs		
M_E	Total manure excretion per animal per day	kg/animal/day
N_E	Total nitrogen excretion per animal per day	g/animal/day
P_E	Total phosphorus excretion per animal per day	g/animal/day
K_E	Total potassium excretion per animal per day	g/animal/day
DM_E	Dry matter (solids) excretion per animal per day	kg/animal/day
OM_E	Organic matter (or volatile solids) excretion per animal per day	kg/animal/day
U_E	Urine excretion per animal per day	liters/animal/day

Documents Document Sharing Hub
Copyright American Society of Agricultural and Biological Engineers
Provided by IHS Markit under license with ASABE
No reproduction or networking permitted without license from IHS
Licensee=/, User=,
Not for Resale,
Full document details: ASABE D384.2 2014