AUBURN UNIVERSITY

BIOSYSTEMS ENGINEERING

BSEN 4310 - Senior Design

Project Title: Automated Feed Bin Gate System

Client: Cumberland

Group Members: Richard Colley III, Brock Daughtry, Holly Haber

Spring 2016

Table of Contents

Content **Page**

February 15, 2016

Cumberland Inc, GSI

To whom it may concern:

We were excited to work on this project that focuses on automating the opening and closing of commercial poultry feed bin gates. This report focuses on our design alternatives for the mounting of a system of linear actuators on two tandem feed bins, as well as their associated costs and feasibility. Considerations for a three bin set-up are also included.

A design utilizing one linear actuator per gate was selected, and two alternative mounting methods were evaluated. These linear actuators, in combination with proximity sensors on each bin adapted from those currently used with Cumberland's Flow Hammer, will tie into the current climate control system used in large commercial poultry houses through a set of relays. Both current concerns about weather durability and user safety of the mounting options, as well as feasibility of design, are included in the enclosed report. In order to determine the feasibility of our design alternatives, a number of factors were assessed. These include a force analysis of the necessary strength needed to open the gates, along with ease of installation, which were crucial in determination of the final recommendation. Cost estimates of materials necessary to implement both designs are also included in the packet.

From the assessment criteria described above, it Design Alternative 2 is recommended. This in-line actuator system design is an additional unit mounted in-line with the slide gate between the plastic transition piece below the boot and the feed auger connections. This low cost alternative ($861.34) would allow existing bins to be retrofitted by acting as an add on, so no change in the design of Cumberland's products would be required. Additionally, having the linear actuator and motor completely housed in sheet metal ensures both weather durability and user safety.

Feel free to call us at 555-555-5555 with any questions you may have about the report.

Sincerely,

Richard Colley III *Richard Colley III*

Brock Daughtry *Brock Daughtry*

and Holly Haber *Holly Haber*

Enclosure: Engineering Report

Introduction

Cumberland is a member of the GSI Group of companies and is a major producer of commercial poultry production equipment, including feeding systems and storage. Large commercial broiler farms utilize multiple automated systems to reduce labor costs (Rhodes et. al, 2011) including mechanized feeding systems to deliver both granular and pelleted feed to the birds. Broilers are kept in houses equipped with sophisticated climate control systems and automated feeding systems supplied by large external dual feed bins. One flaw in the current poultry production system is that opening these feed bins requires manual operation. If the opening can be automated, farms could save both time and money. In a typical operation, the first bin of the storage system feeds the auger conveyance system until empty, then additional bins are manually opened. Farmers are paid based on a bird weight to feed amount delivered ratio, so any amount of time broilers spend without feed results in a decrease of farm profit due to a reduction in broiler weight. So, if the second bin is not immediately opened these poultry operations will be losing money. Cumberland's request to automate this process will ensure that the birds do not go without feed. The main objectives of this project are to detect when the first of the tandem tanks is empty and initiate the start of a safe, cost-effective, weather-durable mechanism that will automate movement of the slide gates. The amount of moving parts must be minimized in our design, and the motor system must be able to resist a high air particulate count, even though it will be shielded per Stetson's et al. (1989) recommendations. Also, a sensor control algorithm will be incorporated into the current climate control system. This interface will collaborate with the control system (similar to the Cumberland Pro Vision Environmental Controller) and initiate a decision matrix tailored to the farmer's preferences. This decision matrix will determine the sequence of bin openings, and also the settings for filling the bins. A proximity sensor used because of the simplicity and accuracy of the electric field it uses, consists only of an oscillator and either one or two capacitor plates (Texiera et. al, 20YY). The following analysis will reveal the calculated methodology behind the final design of the automated feed bin gate system.

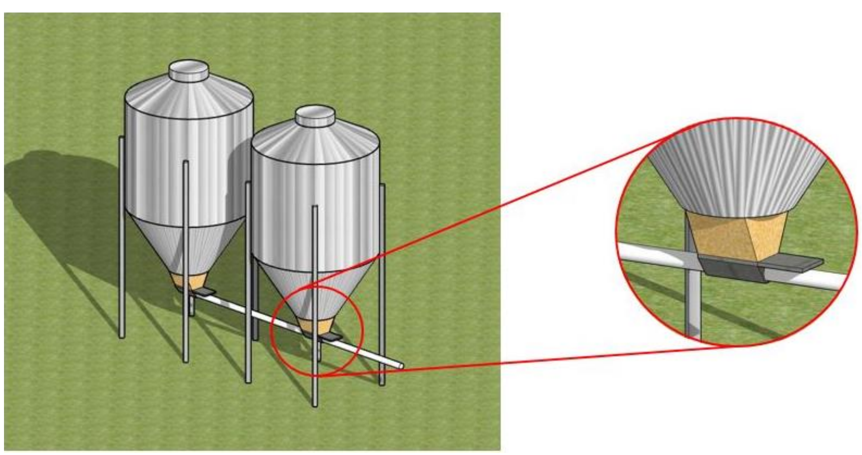


Figure 1: Boot and slide gate of tandem poultry feed bins

Design objectives:

1.) Mechanical: Design a cost-effective, weather durable mechanism to be implemented in a mass production chicken facility's feed storage system that will automatically close the slide gate of one bulk feed bin (for 6'-15' diameter models) while simultaneously opening the gate of the adjacent bin when the first feed bin empties of fine grained and pelleted chicken feed.

2.) "Smart" (electrical): Create an interface with the current climate control system (similar to Cumberland Pro Vision Environmental Controller) in the poultry house, that will initiate the start of the mechanism (described in objective 1) when the first feed bin is emptied, while also alerting the controller when both feed bins are empty.

Standards

Please refer to Appendix C for full description of standards listed below.

ASABE Shielding Standards
- S318.17 JUN2009: Safety for Agricultural Field Equipment
- S493.1 JUL2003 (R2012): Guarding for Agricultural Equipment
- S354.5 JAN2006 (R2011): Safety for Farmstead Equipment

ASABE Feed Bin Standards
- S337.1 FEB1987 (R2012): Agricultural Pallet Bins
- D274.1 JAN1992 (R2012): Flow of Grain and Seeds through Orifices
- EP433 DEC1988 (R2011): Loads exerted by Free-Flowing Grain on Bins

Prior Arts

Cumberland Inc. currently manufactures a product called a Flow Hammer (Figure 2) that mounts to the collar portion of a poultry feed bin using either a 16 inch or 22 inch mounting bracket, depending on bin size. The Flow Hammer, in combination with a proximity sensor, monitors flow of feed through the boot of the bin to ensure that bridging of feed does not occur inside of the bin. These mounts were considered in a preliminary design for our project that was later ruled out; however, the proximity sensor remains incorporated into our two design alternatives. A full description of this adaptation can be seen in the Development of Project section later in the report.

Figure 2: Cumberland Inc. Flow Hammer and proximity sensor mounted to feed bin collar (Cumberland)

Upon further literature review, a product called a Vortex Model Salina Roller Gate Valve was found (Appendix B). This particular model Vortex valve is a linear actuated housing and mount for the feed bin slide gate made from stainless state made by Vortex. As a reference for the potential cost associated with a similar final design, a request for quote was solicited by our team. In order for this company to manufacture this product to meet the dimensions and specifications needed for our particular application, they quoted a price of $11,841.12. Using this currently manufactured product as a platform, one of our final design alternatives utilized the rectangular housing of the linear actuator component of this design and built upon it. In our alternative (Alternative 2), this rectangular housing extends 37 inches in length and encases both the linear actuator and its motor. A full description of this design alternative can be seen in the Development of Project section later in the report as well.

Development of Project

Initially, designs were considered that utilized a mechanism spanning between the tandem bins, like a hinged arm for example. However, these ideas were ruled out because of the variability among distances between bins. There is no uniform distance that tandem feed bins are spaced apart from one another. Therefore, a rigid system could not be produced with inconsistencies in these distances. From this, it was instead decided that a system of linear actuators would be utilized in order to automate the movement of the slide gates; one per gate. From this, the following design was formulated that made use of a linear actuated single bin system mounted from previous Cumberland feed bin mounts. This system features the adaptation of a currently produced mount manufactured by Cumberland, Inc. which is used to attach their Flow Hammer product to poultry feed bins (Figure 4). This is the bigger of two Flow Hammer mounts produced by Cumberland and is able to hold more weight, which is needed to support the linear actuator specified. Because this mount is currently in production, adapting it to meet our objectives lowers the overall cost. A graphic of this design (Figure 3) shows this mount attached to four legs that hold the linear actuator parallel with the gate. These are made more rigid through the use of small diagonal support beams extending from the top of one leg to the bottom of the leg parallel to it on either side. The mount connects to the collar portion of the feed bin while the bottom end of the legs hold the linear actuator parallel to the slide gate. This design was later ruled out because of the high price associated with fabrication of such a large external structure, and replaced with the two more cost-effective alternatives included in this report.

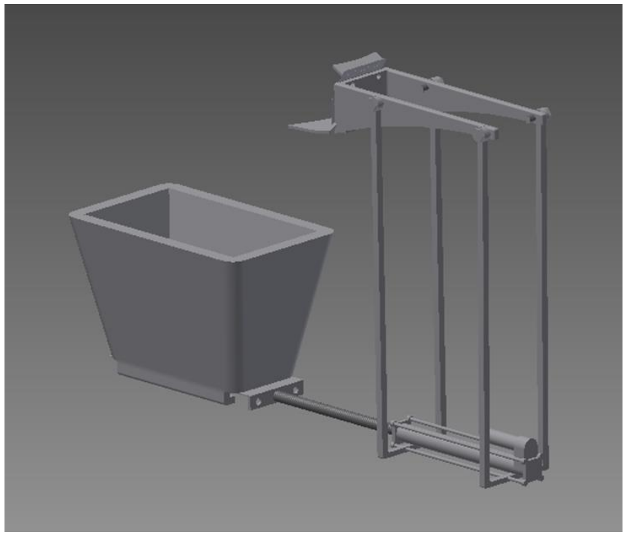


Figure 3: Linear actuated single bin system mounted from previous Cumberland mount

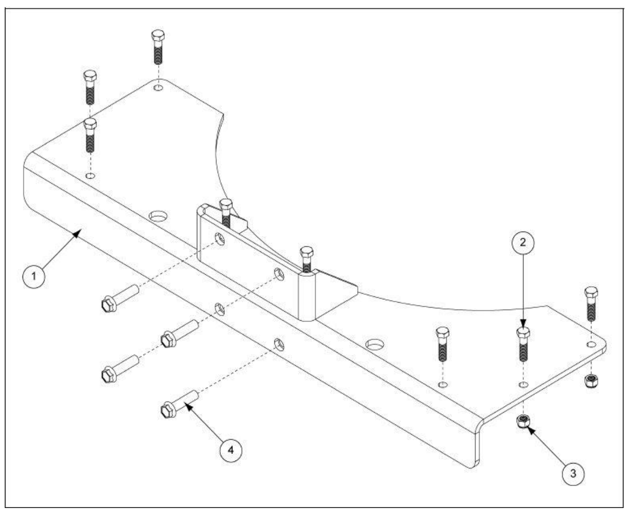


Figure 4: Existing Cumberland Inc. mounting bracket (Flow Hammer, 2016)

Design Alternatives

General design considerations

For both alternatives, it is proposed that a linear actuator be mounted to each of the side-by-side bins (Appendix D). The track linear actuator included in the cost estimate has a 900 lb capacity and a 10 inch stroke length. Using a track linear actuator over a traditional one helps to save about 10 inches in length. In order to mount these actuators, two design alternatives were developed, Design Alternative 1 and Design Alternative 2. Additionally, both alternatives make use of the Flow Hammer proximity sensor discussed previously that is currently produced by Cumberland Inc.

A force analysis was conducted and can be seen in Appendix A. This component of the design process ensures that sufficient force is supplied by the designed system to open and close the slide gates. From the analysis utilizing the equation below, it was determined that the force needed is 145 lb. This is well below the possible 900 lb force output the linear actuator we have specified can produce.

$$P_{vf} = \frac{\rho g A}{k\mu c}\left[1 - e^{\left(\frac{-\mu k C}{A} * h\right)}\right] \quad \text{.......Equation 1}$$

Where: ρ is bulk density (lb/ft^3)
g is the gravitational constant (32.2 ft/sec)
A is the cross-sectional area of the bin (ft^2)
μ is the wall friction coefficient fo the bin (unit-less)
c is the circumference (ft)
h is the vertical height between the bin apex and the transition (ft)

$$P_f = \mu \, P_{vf} \quad \text{.......Equation 2}$$

Where: $\mu = 0.5$ is the coefficient of static friction of pelleted feed and side of the bin (Bahnasawy & Mostafa, 2011)
P_{vf} is the vertical force on the slide gate (lbs)

Design Alternate 1: Side Mounted Linear Actuator System

The first design alternative will adapt the black plastic transition piece that currently sits below the plastic boot (Figure 5). This part of the feed bin will be altered in order to mount the linear actuator onto the side of it (Figure 6). Orientating the linear actuator so that the moving portion extends away from the bin, in reverse, allows it and its housing to be incorporated into the new plastic transition piece. The linear actuator and its motor will be completely enclosed in a rectangular housing in order to shield the actuator for safety, as well as provide stability for moving parts of the system. Because the linear actuator will extend parallel to the slide gate, an attachment is needed to connect the end of the actuator with the end of the slide gate. This connector piece will be perpendicular to the linear actuator and attach to both side of the curved portion of the gate. Connecting to the entire end of the slide gate will ensure that the force on the gate when being pulled and pushed is spread evenly. An additional support brace connected to the side of the gate nearest the side mount will help to lessen the impact the movement force has on that side of the plastic transition piece. There is no need for an external support frame in this alternative, lowering the manufacturing cost of this design ($853.66) as well as allowing for ample spacing under the bin.

Figure 5: Location of transition piece to be adapted in Alternative 1

Figure 6: Alternative 1- side mounted linear actuator system

Design Alternate 2: In-line Linear Actuator System

The second design alternative incorporates a transition unit that will be used to hold the linear actuator in line with the slide gate. This unit will sit between the transition piece described in Design Alternative 1 and the bottom portion of the bin that connects to the feed auger lines. The linear actuator will be oriented so that it closes the gate as it extends and opens the gate as it retracts (Figure 7). This in-line housing makes use of c-joints around the frame of the transition piece (section 1 in Figure 7) to not impede the flow of feed into the auger and then a fully enclosed rectangular housing (section 2 in Figure 7) where the system extends out past the bin in order to both support the linear actuator system as well as provide safety. Linear actuator placement directly perpendicular to the slide gate allows it to be attached to the center of the end of the gate using a pin, ensuring the force exerted on the gate is evenly distributed. The unit will be made from aluminum bare 0.032 inch thick sheet metal and bent into the needed shape, keeping the cost of manufacturing as low as possible. Aluminum, specifically, has been chosen because it is resistant to corrosion and easy has a high formability. The total estimated cost of this alternative is $861.34, which exceeds the cost of Alternative 1 by $7.68.

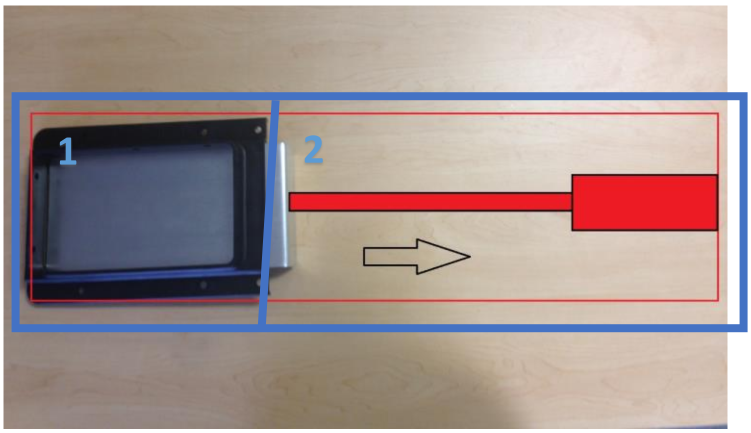


Figure 7: Alternative 2- In-line linear actuator system

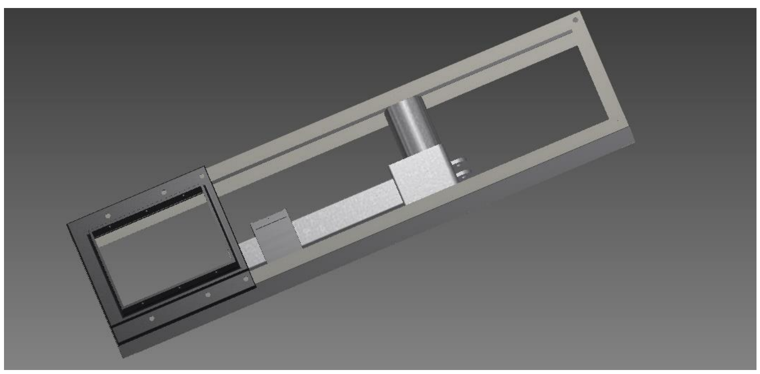


Figure 8: Alternative 2- In-line linear actuator system drawing

Cost Analysis

Table 1: General manufacturing cost estimate for two bin system Alternative 1

Unit/Operation	Cost Per Unit (U.S. Dollars)	Number of Units	Total Cost (U.S. Dollars) for Unit/Operation
Linear actuator	199/actuator	2	398.00

sheet metal (aluminum bare sheet, 0.032" thickness)	3.84/(12"x 12" sheet)	2	7.68
bolts/nuts/washers	0.10/unit	30	3.00
sheet metal shearing	0.02/cut	25	0.50
sheet metal bends	0.05/bend	10	0.50
drilled hole (smaller than 1" diameter)	0.35/hole	10	3.50
Weld	0.06/cm (0.15/inch)	10 in	1.50
Labor	45.00/hr	1	45.00
Wiring kit	29.99	2	59.98
Proximity sensor	167	2	334.00
Total Cost of Alternative			853.66

Source: Auburn University Quarter Scale Tractor Team (Appendix E)

Table 2: General manufacturing cost estimate for two bin system Alternative 2

Unit/Operation	Cost Per Unit (U.S. Dollars)	Number of Units	Total Cost (U.S. Dollars) for Unit/Operation
Linear actuator	199/actuator	2	398.00
sheet metal (aluminum bare sheet, 0.032" thickness)	3.84/(12"x 12" sheet)	4	15.36
bolts/nuts/washers	0.10/unit	30	3.00
sheet metal shearing	0.02/cut	25	0.50
sheet metal bends	0.05/bend	10	0.50
drilled hole (smaller than 1" diameter)	0.35/hole	10	3.50
Weld	0.06/cm (0.15/inch)	10 in	1.50
Labor	45.00/hr	1	45.00
Wiring kit	29.99	2	59.98
Proximity sensor	167	2	334.00
Total Cost of Alternative			861.34

Source: Auburn University Quarter Scale Tractor Team (Appendix E)

Design Recommendation

Based on the analyses included above, Design Alternative 2 is recommended. This system reduces the stress forces on the slide gate because it is mounted in-line with the gate which is preferred over the side-mount in Alternative 1. This alternative is able to be cheaply manufactured, for $467.36, out of aluminum sheet metal and would be easily aligned by the operator. This design alternative differs from the other by less than $10; however, less maintenance is anticipated with this system which helps save cost over time. Additionally, this in-line linear actuator system, would allow existing bins to be retrofitted by acting as an add on. No change in the design of parts currently produced by Cumberland Inc. would need to be made with this alternative, suggesting a greater ease of implementation over the first alternative. Having to remove the system from the bin set-up in order to perform maintenance on it may be a concern associated with this design alternative. However, because the bin is suspended by a series of legs, removing the system would only require a disassembly of the portion below the boot portion of the feed bin; leaving the bin and boot intact.

Proposed Remaining Timeline

For the remaining duration of our project design process, a timeline of dates has been created (Table 2). This table briefly describes proposed dates for completion of the remaining tasks to be completed by our design group as well as additional comments that provide additional information about the tasks.

Table 2: Proposed timeline for remaining design project tasks

Date to Have Task Completed By	Task to Be Completed	Additional Comments
March 1, 2016	Complete AutoCAD drawings of two alternative designs	N/A
	Finalize written logic statements for use with relays	After these logic statements are finished being written, the design team will work with Dr. McDonald in order to program relays that will control the “smart components” of our design.
	Update ePortfolio for submittal	The team has created an ePortfolio dedicated specifically for this project using the platform Wix. This site will need to be updated

		prior to this date before draft submittal.
March 11, 2016	Perform force analysis on system to determine necessary force to open and close gate	We will collaborate with Dr. Fasina to perform a force analysis on the system because the force gauge was not strong enough to measure the force necessary during the site visit.
	Safety Housing	Per ASABE standard S493.1 JUL2003 (R2012): Guarding for Agricultural Equipment, the mechanical system must be shielded to ensure safety.
	Select a linear actuator based on needed specifications	N/A
March 25, 2016	Build/Test Prototypes of design alternative	After purchasing the specified linear actuator, our design team will build a prototype of our final design to mount onto the collar and boot provided by our client. Movement will be controlled by a relay switch with this prototype, but in actual implementation would be powered by the climate control system and make use of conduit wiring.
	Programmed logic codes for relays	For automation, a system of relays will be needed for communication with the current climate control system.
	Final cost-analysis	N/A

References

"Flow Hammer | Cumberland Poultry." *Flow Hammer | Cumberland Poultry*. N.p., n.d. Web. 18 Feb. 2016. <http://www.cumberlandpoultry.com/products/storage-and-delivery/flow-hammer.html>.

"Flow HAMMER: Options." *Flow HAMMER Options*. N.p., n.d. Web. 18 Feb. 2016. <http://www.automatedproduction.com/en/apflowhammeroption.php>.

Bahnasawy, A., & Mostafa, H. M. (2011, October). Some Engineering Properties of Different Feed Pellets. *PROCESS ENGINEERING*, *28*(4), 947-960.

Rhodes, J., J., Nottingham, J. R., & Musser, W. (2011). Broiler Production Management for Potential and Existing Growers. University of Maryland Poultry Extension, 7. Retrieved February 5, 2016.

Stetson, L. E., G. R. Bodman, J. L. Schinstock. 1989. Electrical Wiring Methods and Materials for Agricultural Buildings. Applied Engineering in Agriculture. 5(1): 2-9.

Texiera, T., Dublon, G., & Savvides, A. 20yy. A Survey of Human-Sensing: Methods for Detecting Presence, Count, Location, Track, and Identity. ACM Computing Surveys, *5*(1), 12. Retrieved February 4, 2016.

Appendices

Appendix A: Force analysis Calculations

Appendix B: Vortex Specifications

Appendix C: Full Standards

Appendix D: Linear Actuator Specifications

Appendix E: Auburn University Quarter-Scale Tractor Team Pricing Sheet

Feed Bin Slide Gate Force Calculation

$$P_v = \frac{\rho g A}{K \mu C}\left[1 - \exp\left(-\frac{\mu K C}{A}\cdot h\right)\right] \qquad (1)$$

(Jassen Equation)

→ Using 15 ft diameter bins, filled to top w/ slide gate closed

$\rho_{feed} = 40\ lb/ft^3$

$g = 32.2\ ft/s^2$

$D = 15\ ft$

$\mu = \tan(\alpha) = \tan(60°) = 1.73$

$C = \pi(15\ ft) = 47.1\ ft$

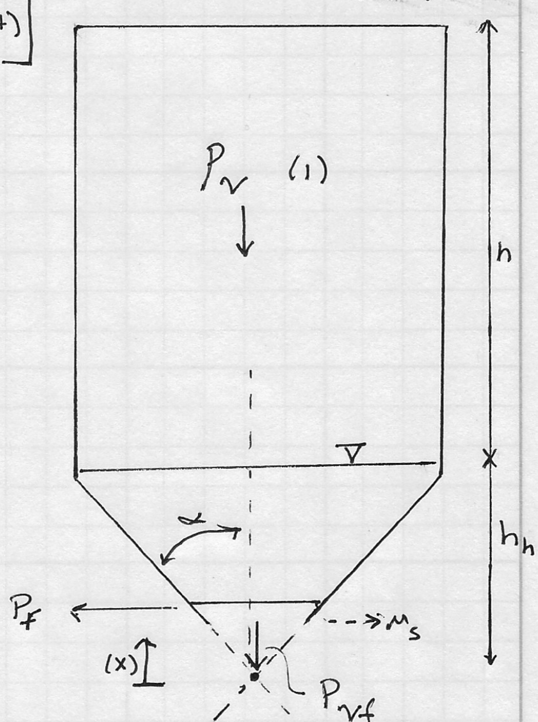
$A = \frac{\pi}{4}(15\ ft)^2 = ~~147~~ = 176.71\ ft^2$

$K = 0.4$ (assumption)

$$P_v = \frac{(40\ lb/ft^3)(176.71\ ft^2)(32.2\ ft/s^2)}{(0.4)(1.73)(47.1\ ft)}\left[1 - \exp\frac{-(1.73)(0.4)(47.1\ ft)}{(176.71\ ft^2}(18.5\ ft)\right]$$

$$= (6983.1\ lbs)[0.967]/32.2\ ft/s^2$$

$$P_v = 210\ lbs$$



$$P_{vf} = P_v\left(\frac{x}{h_n}\right)^n + \frac{\gamma h_n}{n-1}\left[\left(\frac{x}{h_n}\right) - \left(\frac{x}{h_n}\right)^n\right] \qquad (2)$$

$n = 2 a \mu_n \cot(\alpha)$

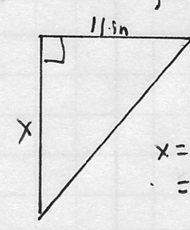
$= 2(0.8)(\mu = 0.5)(\cot(60°))$

$= 0.46$

$h_n = 15\ ft$

$x = 1.83\ ft$

$$P_{vf} = (210\ lbs)\left(\frac{1.83\ ft}{15\ ft}\right)^{0.46} + \frac{(40\ lb/ft^3)(32.2\ ft/s^2)(15\ ft)}{(0.46-1)}\left[\left(\frac{1.83}{15}\right) - \left(\frac{1.83}{15}\right)^{0.46}\right]$$



$x = 22\ in$
$= 1.83\ ft$

$$P_{vf} = \frac{9{,}308\ lbs}{32.2\ ft/s^2}$$

$$P_{vf} = 289\ lbs$$

$$P_f = \mu_s(P_{vf}) \qquad (3)$$

$\mu_s = 0.5$ (per Bahnasawy, 2011)

$= 0.5(289\ lbs)$

$$\boxed{P_f = 145\ lbs \text{ on slide}}$$

Salina Vortex® Corporation
1725 Vortex Avenue   Salina, Kansas   67401-1768   USA
Telephone: 785.825.7177   Fax: 785.825.7194
Email: vortex@vortexvalves.com
Web: www.vortexvalves.com

Attention: **TREY COLLEY**

AUBURN UNIVERSITY
500 WEBSTER ROAD

AUBURN, AL 36832

Email: rtc0009@tigermail.auburn.edu
Phone: 205-213-8519
Fax:

Quote Date: 1/25/16

Quote #: EA00080066

Reference:

Thank you for the opportunity to quote our products. Vortex Valves takes pride in delivering quality products modified specifically for your application requirements. The data below was used to determine the correct product and required modifications. Please contact us immediately if any of the specifications are incorrect as this may affect the equipment performance, price, and lead time.

APPLICATION DATA

- Material Handled: **CHICKEN FEED**
- Temperature Rating: **< 180° F**
- Material is conveyed by: **GRAVITY ONLY**
- Aeration used? NO
- Material Sticky? **NO** • Material Abrasive? **NO**
- Valve Placement: **OUTDOORS**
- Controls Package Voltage: **115V, 1PH, 60Hz**
- Washdown Area? **NO**
- Material Contact: **304 STAINLESS STEEL**
- Material Particle Size:
- Purpose of valve: **STOP MATERIAL FLOW**
- Material Weight: **550-650** Lbs./Ft^3

Note: If information above is missing relevant data please contact us immediately.

Regards,

Dominick Tatum
Inside Sales Engineer

Quantum® Series
Titan Series
Loading Solutions

*Visit our website at **www.vortexvalves.com***

Quotation

Salina Vortex® Corporation
1725 Vortex Avenue Salina, Kansas 67401-1768 USA
Telephone: 785.825.7177 Fax: 785.825.7194
Email: vortex@vortexvalves.com

Quote #: **EA00080066**

Attn: TREY COLLEY
AUBURN UNIVERSITY
500 WEBSTER ROAD
AUBURN, AL 36832
Email:rtc0009@tigermail.auburn.edu
Phone:205-213-8519
Fax:

Material:	CHICKEN FEED
Conveyed By:	GRAVITY ONLY
Temperature:	< 180° F
Reference:	
Type:	D

Customer	Terms	Quote Date	Expiration Date	Territory	Customer Currency
14053	TO BE DETERMINED	1/25/2016	4/24/2016	66D	USD

SV Line	Quantity	Item	Unit Price	Extended Price
1	**2**	**REC06X12V1-E80066**	**5,920.56**	**11,841.12**

Vortex Model No. REC06X12V1-E80066, 06" x 12" Salina Roller Gate Valve. Valve Body is 6061-T6 aluminum with a 304 stainless steel blade and seal retainers. Material contact is 304 stainless steel and polymer. Milled access slots in side frame allows removal and replacement of bonnet seals while the gate valve remains in service. Valve body is modified to accept proximity switches (plugged if indication switches are not utilized).
• Electric linear actuator.
• Valve is rated for 180˚F(82˚C) maximum continuous service. PET side seals and upper and lower bonnet seals are live loaded and silicone rubber backed. Valve also includes cam-adjustable slide rollers and PET roller spacers. End seal and bonnet blade guides are UHMW-PE.
- (E80066) - RECTANGULAR ROLLER GATE.

Shipment: Approximately 7-8 WEEKS (after receipt of order and/or approval drawings.)

Total Amount: **11,841.12**

Delivery: Exworks, Salina, Kansas
Drawings: (3) sets are provided (if requested). Each additional set is $10

Please reference quotation number EA00080066 when ordering or inquiring

Quote Submitted By: Dominick Tatum
Inside Sales Engineer

Vortex Representative: ADAMS BROTHERS, INC
1600 NORTHSIDE DRIVE, N.W.
SUITE 200
ATLANTA,GA 30318

404-351-4889

Salina Vortex® Corporation -- STANDARD TERMS AND CONDITIONS OF SALE

The following terms and conditions of sale apply to all quotations and proposals made by **Salina Vortex Corp.** (referred to herein as "SVC") and to all orders accepted by **SVC** and shall constitute the final terms and conditions of the agreement between the Buyer and **SVC. Further, all quotations and proposals for SVC Products are based upon data and specifications supplied to SVC by Buyer, and that Buyer understands that the price, performance, and/or safety of SVC's Products may be affected if any such data or specifications are incorrect or incomplete.** The terms and conditions of sale as stated herein cannot be changed, modified, or amended by the Buyer unless **SVC** and the Buyer agree in a specific writing to change, modify, or amend the terms that is signed and dated by **SVC** and the Buyer. Unless changed, modified or amended in a specific writing signed and dated by both parties, this agreement is understood to be the complete and exclusive agreement between the parties, superseding all prior agreements, oral or written, and all other communications between the parties relating to the subject matter of this sale. **If the Buyer is anything other than an End-User of SVC products, then the Buyer shall have a duty to provide a copy of these Standard Terms and Conditions of Sale to such End-User.**

1. **PRICES AND FREIGHT TERMS**: All prices and service charges, unless otherwise provided, are net exworks **SVC**'s plant and are subject to change without notice to conform to **SVC**'s published price list in effect at the time of shipment. Delivery shall be deemed to occur and risk of loss shall pass to Buyer upon delivery to the carrier. Pricing for the goods does not include freight, delivery or handling charges unless so stated on the face of the purchase order. All sales are FOB shipping point. **SVC** reserves the right to make partial shipments and will render invoices accordingly.

2. **PAYMENT TERMS:** Terms are subject to the approval of **SVC**'s Credit Department prior to shipment, and the Buyer agrees with respect to its obligation for payment, that: (1) If in **SVC**'s judgment Buyer's financial condition or other conditions do not justify shipment on normal credit terms, **SVC** may require full or partial payment in advance; (2) after the products are shipped, it will pay to **SVC** the amount of the invoice in accordance with the terms of payment stated thereon, with interest at the rate of 1.5 percent per month on any late payment; (3) after the invoice is issued, if in **SVC**'s judgment Buyer's financial condition in any way becomes impaired or jeopardized, the invoice shall become immediately due and payable; and (4) except where expressly prohibited by law, Buyer will, in event of default, pay **SVC**'s cost of collecting any amount due under these terms and conditions including court costs and reasonable attorneys' fees. In addition to the purchase price, the Buyer agrees to pay the amount of any sales, use, occupation, excise or similar tax applicable to the transaction.

3. **CANCELLATION:** In the event of cancellation by the Buyer, or a change initiated by the Buyer that results in a partial cancellation or delay in delivery, of an order for products that are to be specifically constructed or adapted for the Buyer's use, the Buyer agrees that it shall confirm such cancellation or change in writing and shall reimburse **SVC** for all actual costs and damages incurred, including but not limited to, engineering, fabrication expenses, restocking fees, order price for all products or services that have been completed in accordance with this order and not previously paid for, the actual cost of work-in-progress, and raw materials incurred by **SVC** in complying with such cancellation or change.

4. **CHANGE ORDERS:** The Buyer may request changes to be made in the design or construction of the product being specifically constructed or adapted for the Buyer's use, which request shall be subject to SVC's acceptance in its discretion. If SVC accepts such request, it shall provide to Buyer an adjustment in the purchase price, which adjustment shall include any revisions to shipping dates and the estimated date of completion of the project. Upon Buyer's acceptance of the adjustment(s) and revision(s), SVC shall proceed with completion of the project in accordance with the revised plans. SVC reserves the right to substitute like components of equal quality with those called for in the specifications or plans.

5. **PLANS AND SPECIFICATIONS:** Specifications, plans, blueprints, or similar SVC proprietary products received with the finished goods purchased by Buyer are, and shall remain, property of SVC. They shall not be reproduced, transmitted, or otherwise disclosed to any person not connected with Buyer's organization, nor delivered to a competitor of SVC.

6. **FORCE MAJEURE: SVC** shall not be liable for loss, damage, delay, or failure of delivery resulting from fire, embargo, strikes, riot or civil commotion, differences with workmen, inability to obtain materials, casualties, delays in transportation, or any other causes of a similar or dissimilar nature to those named, all of which are beyond **SVC**'s reasonable control, nor shall SVC be liable for consequential damages, including without limitation, lost profits that may result from any delay whatsoever.

7. **SAFETY DEVICES: SVC's recommended safety devices should be a part of the products sold herein and Buyer should purchase these recommended safety devices as a part of its purchase of SVC's products. If Buyer fails to purchase SVC's recommended safety devices, such failure shall be at Buyer's risk.** If Buyer specifically rejects SVC's recommended safety devices, then in consideration of SVC's agreement to ship and deliver the products with out such recommended safety devices, Buyer agrees to indemnify **SVC** and hold it harmless from any claim, demand, or cause of action asserted against **SVC** by any person, and any losses and expenses, including attorneys' fees, incurred by **SVC** by reason of same, which relates, directly or indirectly, to the lack of SVC's recommended safety devices. In the event any special safety device is provided by **SVC**, **SVC** shall only warrant that the design and installation of such safety devise shall be of a type that is generally recognized in the industry. Buyer agrees that exceptions taken by local inspectors, not consistent with generally accepted industry interpretation and practice, will **not** be considered a failure on the part of **SVC** to fulfill its obligations.

8. **LIMITED WARRANTY, DISCLAIMER & LIMITATION OF REMEDIES**: **SVC** warrants to the original Buyer only that all products or parts sold by **SVC** shall be free of defects in materials and workmanship for a period of one (1) year from the date of shipment, when used according to **SVC**'s recommended usages. If Buyer discovers within this period a defect in material or workmanship, it must notify **SVC** in writing. In no event shall such written notification be received by **SVC** later than thirteen (13) months from the date of delivery and any action or suit for breach of warranty must be commenced within fifteen (15) months following delivery of the goods.

    A. **The Buyer's exclusive remedy and SVC's entire liability in contract, tort, or otherwise is strictly limited to repair, refund of purchase price paid for, or replacement in kind of any nonconforming items, provided those products are returned to SVC prepaid. SVC reserves the right to decide which of these exclusive remedies shall be exercised.**
    B. **This warranty shall be considered void if such products are misused, improperly installed, inappropriately stored, operated beyond rated limitations, damaged, neglected, altered/ changed/ repaired/ or modified in any way by anyone other than personnel authorized by SVC**
    C. **An "Instruction and Operating Manual" (referred to herein as "IOM") will be made available to Buyer. Buyer assumes responsibility to read and understand the IOM prior to installation and operation of the products.**
    D. **Should material leakage occur, SVC shall have no liability due to such leakage, and Buyer agrees to indemnify SVC for any consequential injuries or damages that occur therefrom.**
    E. **SVC does not warrant any products not manufactured by SVC**
    F. **THE WARRANTY EXPRESSED ABOVE IS IN LIEU OF AND EXCLUSIVE OF ALL OTHER WARRANTIES. THERE ARE NO IMPLIED WARRANTIES OF MERCHANTIABILITY OR FITNESS FOR A PARTICULAR PURPOSE. THOSE WARRANTIES ARE SPECIFICALLY DISCLAIMED AND EXCLUDED. IN NO EVENT, BE IT BREACH OF WARRANTY OR OTHER CAUSE FROM PERFORMANCE OR NONPERFORMANCE, SHALL SVC BE LIABLE FOR ANY INCIDENTAL, SPECIAL, OR CONSEQUENTIAL DAMAGES INCURRED, OR DAMAGES OCCURRING FROM ANY NEGLIGENCE OF THE BUYER, ITS EMPLOYEES, OR AGENTS.**

9. **REMEDIES AND INDEMNIFICATION**: The Buyer agrees that, except where such limitations, exclusions, and indemnities are specifically prohibited by applicable law, Buyer's exclusive remedy and the limit of liability of **SVC** for any losses or damages resulting from defective goods or from any other cause shall be for the purchase price of the particular delivery with respect to which losses or damages are claimed, plus any transportation charges actually paid by Buyer. To the extent that any such claim exceeds the afore-stated limit of liability, Buyer agrees to indemnify and hold harmless **SVC**, its officers, agents, and employees from and against any and all liabilities, damages, losses, costs, attorney fees, and expenses, for injury or death of an officer, agent, employee or customer of Buyer arising out of or in connection with the use of products and services to be provided under this agreement. Except as otherwise stated in this paragraph, Buyer further agrees to release and waive any liability of any claim against **SVC**, its officers, agents, and employees, for loss of or damages to property, including loss of use arising directly or indirectly out of or in connection with its performance under this Agreement.

10. **INDEMNITY AND HOLD HARMLESS FROM VIOLATION OF OSHA DUTIES AND STANDARDS INCLUDING LOCKOUT/TAGOUT PROCEDURES:** Buyer is required by law to follow the requirements and duties imposed by the Occupational Safety and Health Administration ("OSHA"), including but not limited to LOCKOUT/TAG OUT procedures set forth at 29 C.F.R. 2910.147, as may be amended from time to time. Buyer hereby and, by reason of its installation and use of equipment manufactured or supplied by **SVC** and its suppliers, which claims arise at times when OSHA mandated LOCKOUT/TAG OUT procedures or other OSHA standards applicable to Buyer are not followed. This indemnity includes all attorney fees incurred by **SVC** and it's suppliers in the defense or any claims arising when OSHA standards and/or LOCKOUT/TAG OUT procedures are not being followed.

11. **RETURNED GOODS**: All sales are final. Thus, products shall not be returned without the written permission and shipping instructions from **SVC** Products that are returned for reasons other than being defective shall be shipped exworks destination and the Buyer shall pay the following expenses: a 25 percent restocking fee and all expenses that may be necessary to restore the products to salable condition. Only products of current design and in salable condition shall be considered for return.

12. **SECURITY INTEREST:** The Buyer grants and **SVC** retains a purchase money security interest in the products purchased hereunder until the net purchase price is fully paid and all other obligations of the Buyer are satisfied, and Buyer authorizes SVC to take such steps as SVC deems reasonably necessary to perfect its security interest in such products. If Buyer is in default of its payment obligation to SVC, in addition to any other remedies available, SVC shall have the right and the Buyer shall permit SVC, or its designated agent, to enter the premises where the SVC product(s) is installed and repossess the product as to which full payment has not been received.

13. **MISCELLANEOUS:** The Buyer shall make any claims for shortage or error in filling its order within five (5) days after receipt of shipment. **SVC** does not guarantee any product to meet local, municipal, state, or national laws or regulations. Any lenience granted to the Buyer shall not constitute a waiver of any of **SVC**'s rights hereunder. Should any part, term, or provision of this agreement be declared illegal or in conflict with any law, rule, or regulation, the validity of the remaining portion, terms, or provisions shall not be affected thereby. The terms and conditions contained herein constitute the entire agreement of the parties relating to this transaction. The captions at the beginning of sections are used for convenience only and are not to be considered in attempting to construe any part of this agreement. This agreement, and all disputes between the parties, shall be governed and interpreted in accordance with the laws of the state of Kansas, and the jurisdiction and venue for any action between the parties shall be solely and exclusively in Saline County, Kansas.

EAGLE® LINEAR ACTUATORS

FEATURES

- Non-rotating drive rod
- Non-backdriving
- All metal gearing
- Compact with electromechanical repeatability
- Simple to mount; easy to wire
- Comparable cost to pneumatic or hydraulic systems
- Equivalent in size to hydraulic or pneumatic cylinders
- Operating range -40°F to +150°F

Temperature Range

Ambient: -40°F to +150°F

Motor Data

115V, 1Ph, 2.6A*
230V, 3Ph, .52A*
460V, 3Ph, .26A*
575V, 3Ph, .22A*
CSA approval
Class B Insulation
NEMA "D" design

* Full load current (Amps).

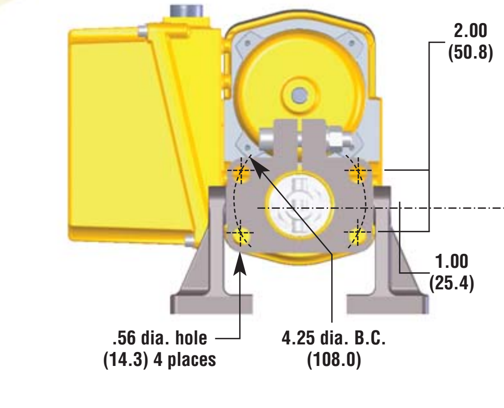
STANDARD EQUIPMENT

- Thermal switch in motor winding
- Two independently adjustable, gear driven position limit switches with all metal gearing
- Nickel-plated drive rod
- Clevis and pin on drive rod end
- Weatherproof and/or Dust-Ignition proof (Class II, Division 1 & 2, Groups E, F and G) enclosure
- Anti-friction bearings on all drive components
- All metal gearing
- Cast aluminum construction
- Clevis mount on the motor end
- Permanently lubricated for maintenance-free operation
- Heavy duty industrial motor; 115 VAC, 60 Hz, single phase, TENV, permanent split capacitor, high starting torque, low inertia

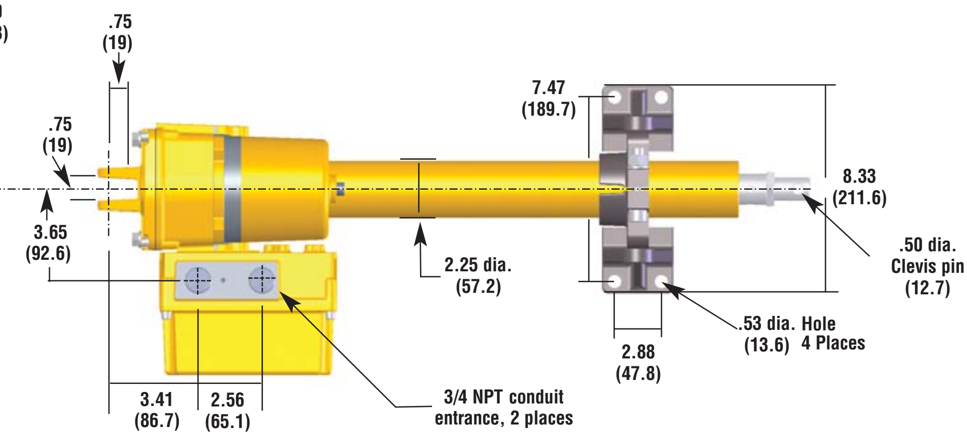
OPTIONAL EQUIPMENT

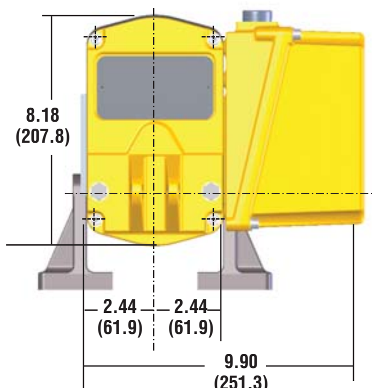
- 230 VAC, 460 VAC and 575 VAC, 60 Hz, 3 Phase Motor
- Potentiometer (all metal gear driven)
- Integral position process control board for modulating applications (various communication protocols are available)
- 4-20mA Position Transmitter
- Adjustable trunnion mount and trunnion brackets
- Adjustable face/flange mount
- Manual override

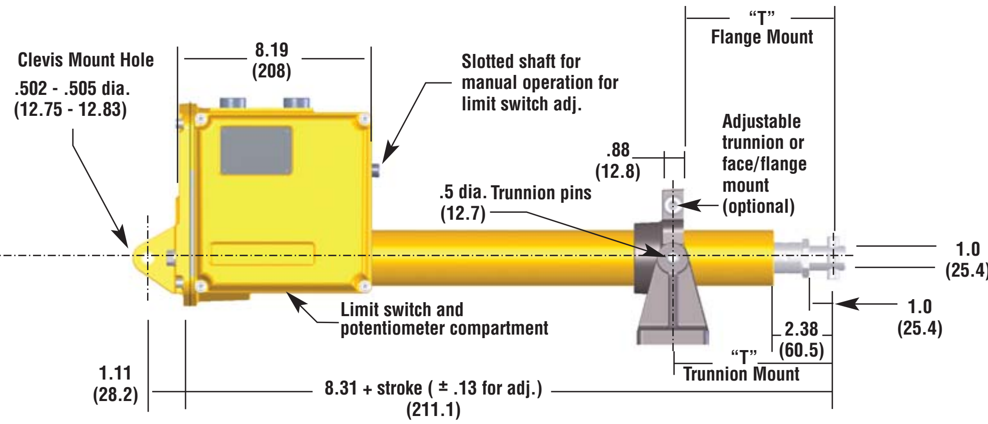
DIMENSIONS

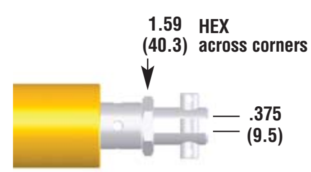


Adjustable Face/Flange Mount (optional)
(Viewed facing Drive Rod end of Actuator)









NOTES

1. Unbracketed dimensions are in inches
2. Bracketed dimensions () are in millimeters
3. Dimensions shown with actuator fully retracted

EAGLE ELECTRICAL CYLINDER PERFORMANCE

3100 Series				
Velocity (in./sec.)	Breakaway Force (lbs)	Running Force (lbs. at 5% duty)	Weight Range (lbs.)	Stroke (in.)
0.2	2000	1000	35-75	6, 12 18, 24 30 & 36
0.4	1500	750		
0.8	750	340		
2.0	500	200		

ADJUSTABLE TRUNNION OR FACE/FLANGE

"T" Adjustable Dimension		
Stroke	Inches	Millimeters
6	2.38 - 2.88	(60.45 - 73.15)
12	2.38 - 8.00	(60.45 - 203.20)
18	2.38 - 14.00	(60.45 - 355.60)
24	5.38 - 20.00	(136.65 - 508.00)
30	11.38 - 26.00	(289.05 - 660.40)
36	17.38 - 32.00	(441.45 - 812.80)

Industrial Products Group
Dresser, Inc.
16240 Port Northwest Dr.
Houston, TX 77041-2645
Ph: 832.590.2306 Fax: 713.849.2879
Toll Free Phone: 800.945.9898 Email: andco@dresser.com

www.dresser.com

ASAE D274.1 JAN1992 (R2012)
Flow of Grain and Seeds Through Orifices

American Society of Agricultural and Biological Engineers

STANDARD

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

ASAE D274.1 JAN1992 (R2012)

Flow of Grain and Seeds Through Orifices

Approved by the ASAE Committee on Technical Data; adopted by ASAE 1948; revised 1954, 1962; reconfirmed by the ASAE Electric Power and Processing Division Technical Committee December 1968, December 1973, December 1978, December 1983, December 1988, December 1989, December 1990; revised by the ASAE Grain and Feed Processing Storage Committee; approved by the ASAE Food and Process Engineering Institute Standards Committee January 1992; reaffirmed December 1996; revised editorially February 2000; reaffirmed December 2001, February 2003; revised editorially March 2003; reaffirmed February 2008, December 2012.

Keywords: Bins, Flow, Grain, Seeds.

1 Purpose and Scope

1.1 This Standard gives equations and graphs that can be used to estimate the flow rate of specific grains and oilseeds through horizontal and vertical orifices for mass flow situations (Ref: Chang et al., 1984, 1988, 1990a). They can be applied to flow from bins and hoppers during emptying and are appropriate for specific ranges of moisture content.

2 Terms and Definitions

2.1 hydraulic diameter: The hydraulic diameter of an orifice is 4 times the orifice area divided by the orifice perimeter.

2.2 aspect ratio: The aspect ratio of a rectangular orifice is the ratio of the length of the longer sides to the length of the shorter sides. For an orifice of a given area, the aspect ratio affects the hydraulic diameter of the orifice.

2.3 horizontal and vertical orifices: A horizontal orifice is parallel to the ground. An example is the orifice in the flat surface of a bin floor. A vertical orifice is perpendicular to the ground. An example is an orifice in the vertical wall of a bin.

2.4 large and small orifices: A small orifice is one that has a hydraulic diameter less than 15 times the minor diameter of the grain or seed. Orifices with hydraulic diameters ≥ 15 times the minor diameter of the grain or seed are large orifices.

3 Equations and Graphs

3.1 Equation for prediction of flow rate. For mass flow situations, the rate of flow of grain and oilseeds through a horizontal or vertical orifice can be predicted by the following equation:

$$Q = C_0 A D^n$$

where

Q = volume flow rate, m^3/h

A = area of the orifice, cm^2

D = hydraulic diameter of the orifice, cm

C_0 = coefficient from Table 1 (n varying, horizontal orifices), Table 2 (n varying, vertical orifices), or Table 3 (n = 0.7, horizontal and vertical orifices), $m^3/cm^{(n+2)}h$

n = exponent with a value between 0.5 and 1.0 (see Tables 1, 2, and 3)

3.1.1 Range of application and accuracy. This equation has been validated for square and circular orifices in both horizontal and vertical orientations. Ranges of orifices tested are shown in the tables. Use outside this range is not recommended. In the case of rectangular orifices, the equation has been validated only for horizontal orifices with aspect ratios form 1.33 to 2.67. However, results of a recent study (Ref: Chang et al., 1990b) suggest that the equations can be used for vertical rectangular orifices. Chang and coworkers also examined the effect of orientation of the rectangular orifice (long dimension vertical or horizontal). The best accuracy can be obtained using the values of n and C_0 shown in Table 1 for horizontal orifices and in Table 2 for vertical orifices. A simplified form of the equation is obtained by setting n = 0.7 for all grains. For this simplification, the equation is usually accurate with ± 6% for large orifices and ± 12% for small orifices. For a given orifice size, the flow rate is directly proportional to the value of C_0. Therefore, greater flows will be achieved for grains with larger values of C_0. The best choices for values of C_0 when n = 0.7, based on experimental results, are given in Table 3.

NOTE: The simplication, n = 0.7, gives the greatest error for cases where n varies substantially from 0.7 (see Tables 1 and 2). Extreme caution should be used for these cases.

3.1.2 Effects of grain depth. Flow was independent of grain depth in the experimental studies used to develop the equations and graphs in this Standard. These depths were typically 1 to 2 m (3.3 to 6.6 ft). Although no studies on the effect of grain depth have been published, there is a general consensus that grain depth has very little effect on flow rate for depths greater than the 1 to 2 m (3.3 to 6.6 ft) used in the experimental studies cited by this Standard. For depths less than 1 m (3.3 ft), flow can be affected by depth.

3.1.3 Effects of moisture content. Increased moisture content reduces the mass flow rate for corn and wheat but increases the mass flow rate for sorghum. However, when flow rate is stated on a volume basis (as given by the equation), much of the difference is accounted for by the change in bulk density with moisture.

3.1.4 Effect of orifice location. An orifice in the floor of a bin adjacent to a smooth vertical wall will discharge approximately 15% more grain than an orifice in the center of the bin floor.

3.2 Graphical data. For convenience in making rapid estimates in flow rates, the equation of paragraph 3.1 is plotted in Fig. 1 (horizontal orifices) and Fig. 2 (vertical orifices) for various grains at typical storage moisture contents. In Fig. 2, the curves for soybeans and sorghum were nearly identical and are shown as one curve. These graphs were generated using coefficients from Tables 1 and 2. Each graph has axes for diameters and flow rates in both SI (cm and m^3/h) and English (in. and ft^3/h) units.

3.3 Additional data. Experimental data on flow through orifices are available for other grains and granular materials and for flow through smaller orifices. Data are given by Gregory and Fedler, 1987, and Moysey et al., 1988.

Table 1 – Coefficients and exponents for equation predicting flow of grains and seeds through horizontal orifices

Grain	Moisture Content, % w.b.	Orifice Hydraulic Diameter Tested, cm	C_0	n	Reference No.
Corn	12-15	13-25	0.028	0.82	1
	19-22	13-25	0.047	0.65	1
Wheat	13-15	10-25	0.050	0.69	2
Sorghum	11-14	10-25	0.092	0.46	2
	16-18	10-25	0.078	0.53	2
Canola (rapeseed)	6-12	7-20	0.055	0.70	5
Flaxseed	4-13	7-20	0.042	0.70	5

Table 2 – Coefficients and exponents for equation predicting flow of grains and seeds through vertical orifices

Grain	Moisture Content, % w.b.	Orifice Hydraulic Diameter Tested, cm	C_0	n	Reference No.
Corn	13-16	13-25	0.016	0.79	3
	20-22	13-25	0.018	0.70	3
Wheat	10-15	10-25	0.038	0.54	3
Sorghum	12-18	10-25	0.024	0.63	3
Soybeans	12	10-30	0.018	0.73	3

Table 3 – Equation coefficients for predicting flow of grain through horizontal and vertical orifices assuming n = 0.7

Grain	Moisture Content, % w.b.	Orifice Hydraulic Diameter Tested, cm	Value of C_2		Reference No.
			Horizontal Orifice	Vertical Orifice	
Corn	13-15	13-25	0.040	0.020	1, 3
	20-22	13-25	0.040	0.018	1, 3
Wheat	13-15	10-25	0.050	0.021	2, 3
Soybeans	12	10-30	—	0.019	3
Sorghum	11-14	10-25	0.043	—	2
	16-18	10-25	0.046	—	2
	12-18	10-25	—	0.018	3
Canola	6-12	7-20	0.055	—	5
	7-9	7-20	—	0.025	5
Flaxseed	4-13	7-20	0.042	—	5
	7-9	7-20	—	0.021	5

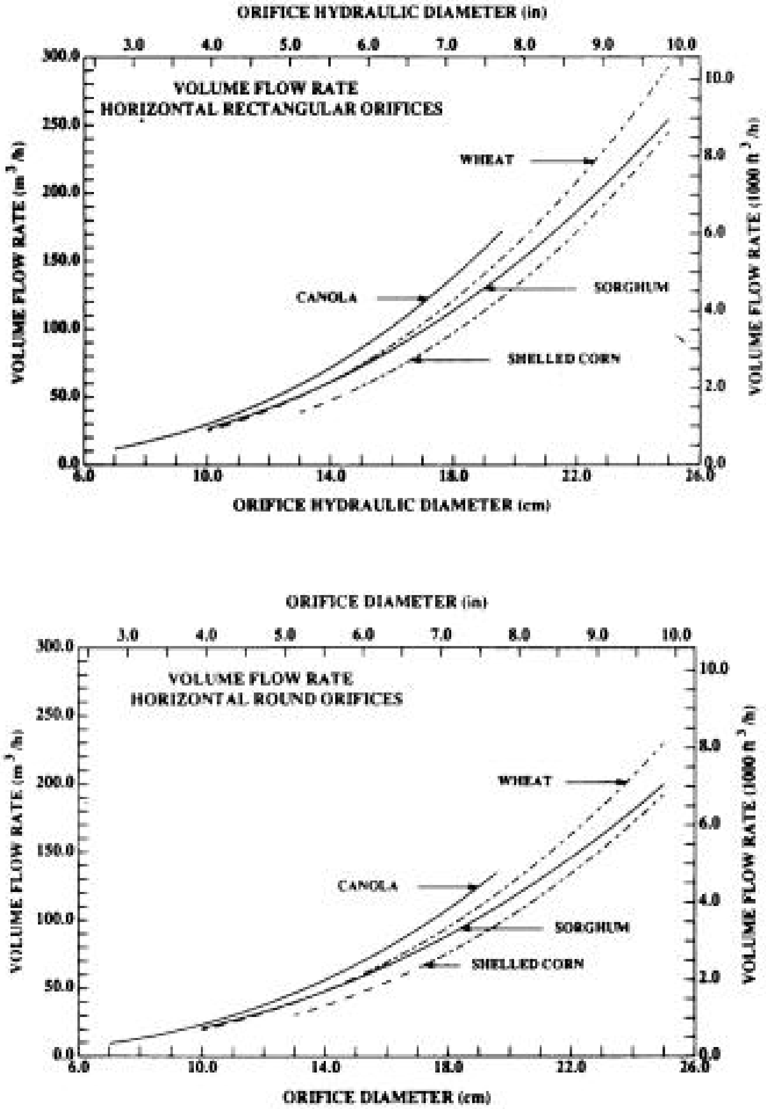
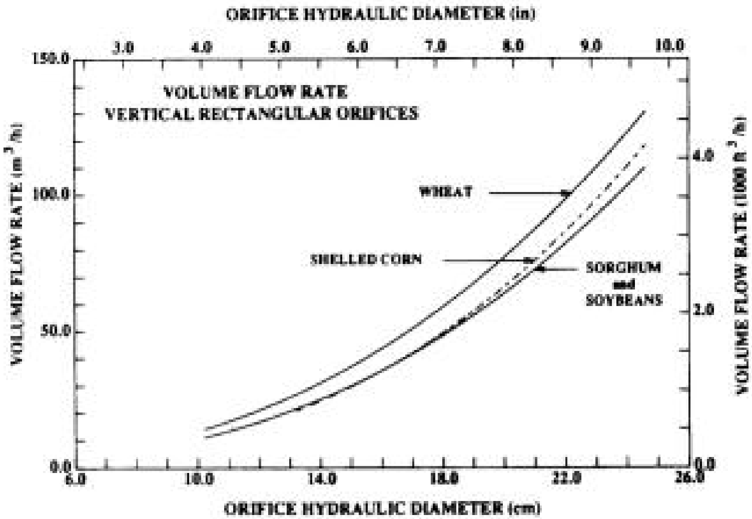


Figure 1 – Flow rates of grains through horizontal rectangular and round orifices



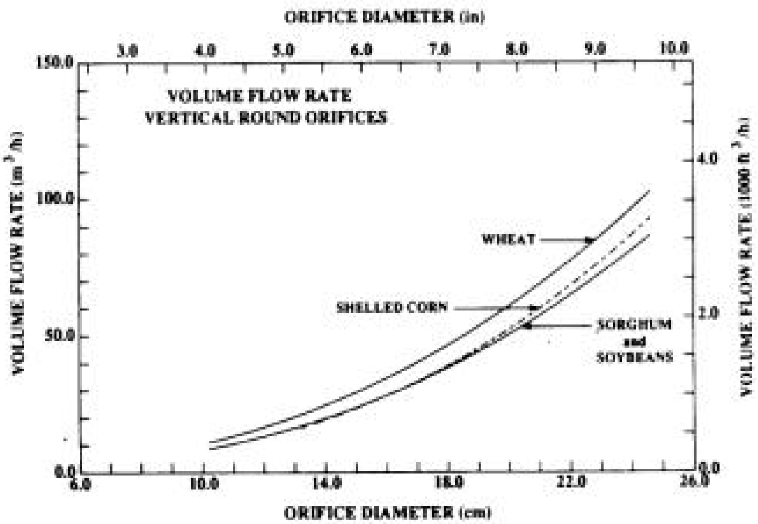


Figure 2 – Flow rates of grains through vertical rectangular and round orifices

References

1. Chang, C. S., H. H. Converse and F. S. Lai. 1984. Flow rate of corn through orifices as affected by moisture content. Transactions of the ASAE 27(5): 1586-1589.
2. Chang C. S., and H. H. Converse. 1988. Flow rates of wheat and sorghum through horizontal orifices. Transactions of the ASAE 31(1): 300-304.
3. Chang C. S., H. H. Converse and J. L. Steele. 1990a. Flow rate of grain through vertical orifices. Transactions of the ASAE 32(2): 601-606.
4. Chang C. S., H. H. Converse and J. L. Steele. 1990b. Flow rates of grain through various shapes of vertical and horizontal orifices. ASAE Paper No. 90-6584. American Society of Agricultural Engineers, St. Joseph, MI 49085.
5. Fast, A., and E. B. Moysey. 1988. Flow of grain through orifices in bin walls and floors. ASAE Paper NCR 88-061. American Society of Agricultural Engineers, St. Joseph, MI 49085.
6. Gregory, J. M. and C. B. Fedler. 1987. Equation describing granular flow through circular orifices. Transactions of the ASAE 30(2): 529-532.
7. Moysey, E. B., E. W. Lambert and Zhijie Wang. 1988. Flow rates of grain and oilseeds through sharp-edged orifices. Transactions of the ASAE 32(1): 226-231.

ANSI/ASAE S354.5 JAN2006 (R2011)
Safety for Farmstead Equipment

American Society of
Agricultural and Biological Engineers

STANDARD

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

Revision approved February 2006; reaffirmed February 2011 as an American National Standard

Safety for Farmstead Equipment

Proposed by the Farmstead Equipment Association of the Farm and Industrial Equipment Institute; approved by the ASAE Electric Power and Processing Division Standards Committee; adopted by ASAE as a Recommendation June 1972; revised and reclassified as a Standard April 1975; reconfirmed December 1979, December 1980, December 1981, December 1982; revised December 1983; reaffirmed by the ASAE Farm Materials Handling Committee and approved by the Food and Process Engineering Institute Standards Committee December 1988; revised April 1990; revised editorially and reaffirmed December 1994; reaffirmed December 1995; revised December 1998, January 2006; approved as an American National Standard February 2006; editorial revision February 2009; reafirmed by ASABE January 2011; reaffirmed by ANSI February 2011.

Keywords: Bale chopper, Barn cleaners, Equipment, Farmstead, Guarding, Manure auger elevator, Mills, Mixers, Safety, Safety signs, Shielding, Silo unloaders

1 Purpose and scope

1.1 The purpose of this Standard is to provide a reasonable degree of personal safety for operators and other persons during normal operation and servicing of farmstead equipment.

1.2 This Standard applies to powered farmstead equipment as defined in paragraph 3.1. This Standard does not apply to agricultural field equipment nor to self-propelled mobile equipment such as motor vehicles, all terrain vehicles, and skid-steer loaders. In addition, it does not apply to farmstead equipment covered by other ASABE safety standards unless it is specifically referenced by these standards.

1.3 In addition to the design and configuration of equipment, hazard control and accident prevention are dependent upon the awareness, concern, prudence, and proper training of personnel involved in the installation, operation, transport, maintenance, and storage of equipment or in the use and maintenance of facilities.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Standards organizations maintain registers of currently valid standards.

ANSI/ASAE S318.15 DEC02, *Safety for Agricultural Equipment*
ANSI/ASAE S493.1 JUL03, *Guarding for Agricultural Equipment*
ANSI/NFPA 70, *National Electric Code*
ASAE EP363.1 FEB03, *Technical Publications for Agricultural Equipment*
ASAE S390.3 JUN03, *Definitions and Classifications of Agricultural Equipment*
ASAE S441.1 FEB1999, *Safety Signs*
ASAE S466.1 FEB04, *Nomenclature/Terminology for Livestock Manure Handling Equipment*
ASAE EP470 FEB03, *Manure Storage Safety*
ASAE S207.12 FEB04, *Operating Requirements for Tractors and Power Take-off Driven Implements*

3 Definitions

3.1 Farmstead Equipment: Equipment; other than agricultural field equipment, used in agricultural operations for the production of food and fiber (examples include livestock feeding systems, livestock watering and waste handling systems, crop dryers, milling systems, material handling equipment, etc.).

3.2 For other definitions see ASAE S390, ASAE S466, ASAE S493 and ANSI/ASAE S318

4 Electrical specifications

4.1 Electric controllers shall contain a positive, lockable electrical disconnect to prevent unintended application of electrical power to the equipment. An appropriate safety sign shall be affixed in close proximity to the controller and components of the controlled equipment that may require routine maintenance, instructing the operator to disconnect and lock out power before performing service or maintenance on the equipment.

4.2 For motors equipped with a manual reset type of overload protector, there shall be an appropriate safety sign, constructed per the requirements of clause 9, located near the reset. The sign shall instruct the operator to lock out power before resetting the overload.

4.3 Electric motors with automatic reset–type overload protection are allowable only in equipment applications where the motor is inaccessible and extreme difficulty would be encountered in the manual reset of the overload. In addition to the requirements of clause 9 of this Standard, safety signs shall be affixed in close proximity to the motor and driven equipment (if located remotely), informing the operator and others of the potential for sudden, unanticipated start-up, and the measure(s) that should be taken to avoid potential hazards.

5 Guarding

5.1 All power driven rotating drive shafts, and implement input drivelines, shall conform to ANSI/ASAE S207 and S318.

5.2 Guarding requirements. Refer to ANSI/ASAE S493.

6 Service Access

6.1 Access shall be provided to equipment components requiring daily or routine maintenance, adjustment, lubrication, or inspection procedures. This access shall be so designed that these procedures can be readily carried out.

6.2 Access doors that must be opened for routine or daily service, inspection or cleaning shall:

6.2.1 Be easy to open and close.

6.2.2 Remain attached; for example, by means of a hinge, slide, linkage, tether, or other suitable means.

6.2.3 Include a convenient and effective means to keep them closed.

6.2.4 An interlock shall be provided if opening the access door exposes hazardous moving mechanisms.

7 Operator's instructions

7.1 Written operator's instructions in accordance with ASAE EP363 shall be supplied with the equipment.

7.2 Where applicable, safety instructions shall include the proper use of positive lockable electrical disconnects for electric controllers.

7.3 Operator's instructions shall include a statement that all wiring shall

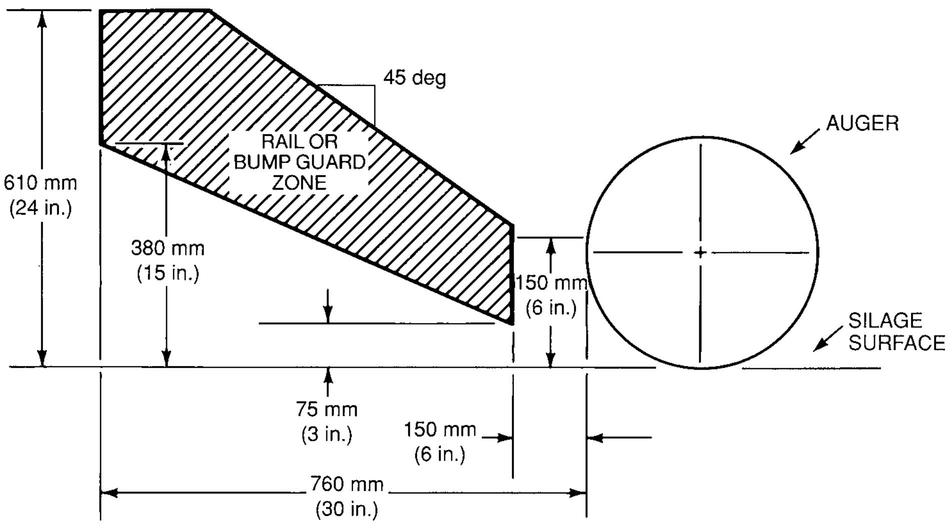


Figure 1 – Gathering mechanism barrier zone

be installed in compliance with the latest edition of ANSI/NFPA 70 as a minimum requirement and shall also be in compliance with all local, state, and national electrical codes.

8 Installation instructions

8.1 Installation instructions, where applicable, shall be prepared in accordance with ASAE EP363. In addition, if applicable, they shall include any or all of the following specific information:

8.1.1 Require that equipment be installed in compliance with the latest edition of ANSI/NFPA 70 as a minimum requirement, and in compliance with local wiring codes as applicable.

8.1.2 Require that electric circuits that are used to complete the system electrical wiring shall contain a positive, lockable electrical disconnect to prevent unintended application of electrical power to the equipment.

8.1.3 Require that the installation provide for convenient access for normal operation.

9 Safety signs

9.1 Safety signs shall be appropriately displayed when necessary to alert the operator and others of the risk of personal injury during normal operations and servicing.

9.1.1 Safety signs shall conform to the requirements of ASAE S441.

9.1.2 To distinguish from safety signs, instructional signs relating to equipment servicing and care should use signal words such as IMPORTANT or NOTICE, without the safety-alert symbol. The appearance of these signs should be different from safety signs.

10 Travel on Highways

10.1 Refer to ANSI/ASAE S318 for Travel on highways.

11 Product-specific safety requirements

11.1 All powered farmstead equipment shall meet the requirements of clauses 4 through 10 of this Standard. In addition, it shall meet any of the following subsections as applicable:

11.2 Top unloading silo unloaders

11.2.1 For purposes of this Standard, *top unloading silo unloader* is defined as a machine whose function is to unload ensiled material from the top surface within an upright tower silo. The machine consists of a mechanism operating on the top surface that loosens, collects, and discharges material into a vertical shaft or chute where it falls to the base of the silo.

11.2.2 A portable, manually operated control shall be provided for use in the silo at the location of the unloader. This control shall allow momentary application of electric power to assist in the testing of adjustments or repairs. The control shall lock out control functions from other locations and permit only momentary power application via momentary electrical contacts.

11.2.3 The sweep arm material gathering mechanism shall be provided with a barrier that is generally parallel to and extending the fullest practical length of the gathering mechanism, located as shown in figure 1. This barrier shall conform to the requirements of ANSI/ASAE S493.

11.2.4 Suspension system

11.2.4.1 For the purposes of this clause, the following definitions apply:

11.2.4.1.1 Suspension system: A system that suspends and hoists top unloading silo unloaders. It consists of a supporting framework, located at the top of the silo, wire rope that connects the unloader within the silo to a take-up winch located on the silo exterior via the supporting framework, and the winch itself.

11.2.4.1.2 Maximum working load: The weight of the largest (heaviest) model equipped with all options and the largest recommended electric motor.

11.2.4.1.3 Wire rope breaking strength: The minimum static tensile breaking strength, measured in N (lbf).

11.2.4.1.4 Wire rope duty cycle: One 180-deg wrap-over suspension system sheave, one 360-deg wrap-around-the-system winch drum, followed by unwrapping the cable through the reverse cycle (see figure 2).

11.2.4.1.5 Factor of safety: Wire rope breaking strength divided by maximum working load.

11.2.4.2 Wire rope winch

11.2.4.2.1 The winch drum shall have a minimum diameter of seven times the wire rope diameter.

11.2.4.2.2 The winch mechanism shall be a design such that the suspended load will not move unless an input force or torque is applied to the winch.

11.2.4.3 Wire rope sheaves used in the suspension system shall have a minimum root diameter seven times the wire rope diameter.

11.2.4.4 Wire rope

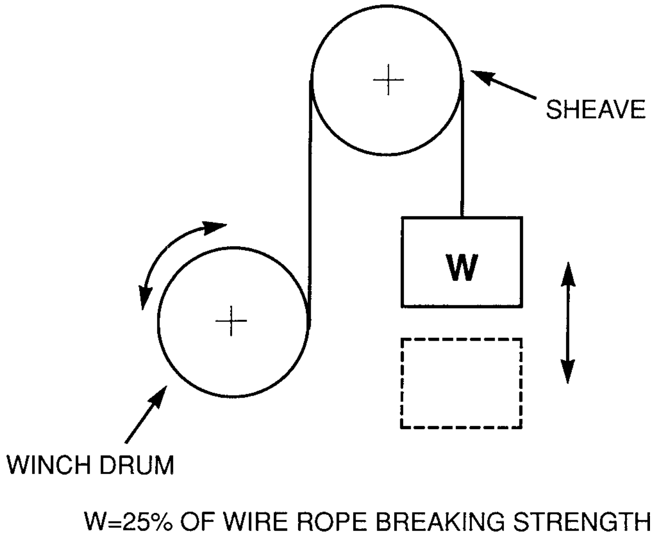


Figure 2 – Configuration for testing of wire rope duty cycle

11.2.4.4.1 Wire rope used with top unloading silo unloader suspension systems shall be constructed of corrosion-resistant materials.

11.2.4.4.2 The wire rope shall have a minimum design factor of safety of 4.0.

11.2.4.4.3 A test sample length of wire rope selected must pass the following verification test:

11.2.4.4.3.1 Cycle per the above-defined duty cycle while under a load equal to 25% of the wire rope breaking strength.

11.2.4.4.3.2 After 80 complete cycles, wire rope shall exhibit a minimum breaking strength of 200% of maximum working load.

11.2.5 In addition to the requirements of clause 9, safety signs shall be affixed at the following locations:

11.2.5.1 On the portable electrical control informing the operator of the hazard associated with remote start-up of the equipment, and of the need to place the control in the "locked out" position.

11.2.5.2 On the unloader gathering mechanism, informing the operator of the hazard of contact with the mechanism and the recommended safe operating practices that should be followed to prevent the occurrence.

11.3 Bottom-unloading silo unloaders

11.3.1 For purposes of this Standard *bottom-unloading silo unloader* is defined as a machine whose function is to unload ensiled material from the underside of that material stored within an upright tower silo. The mechanism consists of a gathering means that loosens, collects and discharges ensiled material from the interior of the silo to the exterior.

11.3.2 Safety signs. In addition to the requirements of clause 9, a safety sign(s) shall be placed in close proximity to the bottom access of the structure in which the unloader is installed, informing of the following hazards contained within: moving machinery, hazardous atmosphere, automatic start-up, insufficient oxygen, and falling ensilage.

11.4 Chain barn (gutter) cleaner—narrow gutter type

11.4.1 For purposes of this Standard, the following definitions apply:

11.4.1.1 barn (gutter) cleaner: A powered mechanical device that incorporates a continuous loop of chain with attached spaced paddles. The chain is driven by an electric motor and speed reducer, which moves the chain and paddles in a gutter circling the barn floor area, for the purpose of removing animal waste and bedding.

11.4.1.2 reverse curve (return corner): A curved shoe assembly attached to the gutter wall that allows the returning chain to make an inside bend by holding the chain toward the wall of an inwardly curved gutter and allowing the paddles to sweep under the curved shoe.

11.4.1.3 return gutter: That portion of the barn gutter in which the chain moves after it has rounded the drive unit and before it becomes the gutter area containing waste and bedding.

11.4.1.4 elevator: A component of a barn (gutter) cleaner which may or may not be required, but when used, serves to incline the gutter in order to elevate the waste and bedding for further handling.

11.4.2 In addition to the requirements of clause 9, the reverse curve or return corner entry nip point shall be guarded by a deflector or equivalent means that will minimize the potential of inadvertent entry during operation.

11.4.3 In addition to the requirements of clause 9, the installation instructions shall direct the installer of the equipment to ensure that covers are installed to shield the following areas:

11.4.3.1 The return gutter, from the base of the elevator (or power unit on systems without an elevator) to and including the reverse curve or return corner.

11.4.3.2 Gutter areas that must be frequently traversed by human, livestock, or equipment traffic.

11.5 Barn cleaners—wide alley type ("alley scraper")

11.5.1 For the purpose of this Standard, *wide alley barn cleaner (alley scraper)* is defined as a powered mechanical device that incorporates a continuous loop of chain, cable or other flexible tensile member, with one or more scraper blades attached. The scraper blade(s) span the width of barn alleys and move solid or semi-solid manure to one or both ends of the barn and into other receptacles. The tensile member is driven by an electric motor and speed reducer with reversing controls to provide reciprocating motion to the scraper blade(s).

11.5.2 Safety signs. In addition to the requirements of clause 9, for those cleaners that operate automatically on a preset time interval, safety signs shall be affixed in close proximity to the control panel, the power transmission component, and other places where sudden starting of the machine could cause a safety hazard. These signs shall inform the operator and others of the potential for sudden, unanticipated startup and the measure(s) that should be taken to avoid potential hazards.

11.6 Roughage (large diameter) auger equipment

11.6.1 In addition to the requirements of clause 5, guards shall be provided for the following areas:

11.6.1.1 Covers shall extend the fullest practical length of the auger with the exception of the feed intake areas.

11.6.1.2 The ends of the auger tube/trough shall be guarded.

11.6.1.3 Augers installed below a floor or working surface shall be shielded with a covering of sufficient strength to withstand the load of the anticipated traffic over that floor area. The covering shall be installed in such a manner that it cannot become dislodged by floor traffic but can be removed for service.

11.6.1.4 Intake areas shall be provided with hoppers or other means to direct feed flow into the auger. The hopper or other means shall fit securely on the auger tube, U-trough, or sideboard, guarding the auger from outside access other than the intake area itself.

11.6.2 A safety sign(s) informing of the hazard of a rotating auger and instructing in the recommended preventative actions to avoid the hazard shall be affixed in the proximity of the intake areas.

11.7 Chain conveying/feeding equipment. In addition to the requirements of clause 5, the drive and idler chain sprockets of a conveying chain shall be guarded at their nip points. A safety sign, warning of the hazard of the nip point and instructing in the recommended preventative actions required to avoid the hazard, shall be affixed in the proximity of the nip point.

11.8 Feed mixing equipment ("TMR" mixers)

11.8.1 Open top mixers

11.8.1.1 For purposes of this standard, *open top mixer* is defined as a powered feed mixing device consisting of a mixing chamber that is open on the top, and with length: width: height proportions roughly 1.5:1:1. The mixing chamber has either a triangular or U-shaped cross section. The mixing elements may consist of but are not limited to, rotating augers, or a combination large-diameter rotor and augers, or a combination external helix "ribbon" and auger. Discharge may be from the bottom of the mixing chamber, incorporating a discharge conveyor, or from the side via a discharge chute. A discharge conveyor, if so equipped, may be either belt, chain & flite/slat or multiple auger design. The mixer may be truck mounted, trailer mounted, or in a stationary configuration. Power may be supplied via electric or hydraulic motor or tractor PTO.

11.8.1.2 Access to the open top of the mixing chamber of stationary configured mixers shall be guarded to prevent inadvertent entry. This guard shall remain functional under the forces that could be applied by a 123-kg (270-lb) person leaning on or falling against it in normal operation or servicing of equipment, and shall have a maximum width of aperture of 300 mm (11.8 in.). The width of aperture may be varied, without compromising minimum strength to allow introduction of larger size commodities such as hay bales and long-stem haylage.

11.8.1.3. Safety signs informing of the hazard of mixing element entanglement shall be affixed in close proximity to potential access routes into the mixing chamber. These signs shall be designed to meet requirements of ASAE S441.

11.8.2 Closed drum (tumble) mixers

11.8.2.1 For purposes of this standard, a closed drum (tumble) mixer is defined as a feed-mixing device consisting of a cylindrical drum that rotates horizontally or at an incline to horizontal. Feed materials are loaded into the mixer through one end, and mixing is provided through the tumbling action of the drum and by paddles located on the interior of the drum. Feed is discharged through the loading end. A central auger may deliver feed to this discharge point, and may also provide end-to-end mixing. The mixers are typically employed in a stationary configuration, but may be mounted in a truck or trailer configuration. Power may be supplied via electric or hydraulic motor, or tractor PTO.

11.8.2.2 The exterior of the rotating mixing drum shall be free of protrusions or have these protrusions suitably guarded per the requirements of ASAE S493.

11.8.2.3 The following nip points shall be considered, and in all cases an appropriate safety sign, warning of the specific hazard, shall be affixed in close proximity as a minimum requirement.

11.8.2.3.1 If the drum drive mechanism provides rotation by driving on the drum exterior, any areas of potential entanglement and/or nip points shall be appropriately guarded.

11.8.2.3.2 If the minimum closure point between the rotating drum and any frame/support location is less than 100 mm (3.9 in.), and the distance decreases with drum rotation, this location shall be appropriately guarded.

11.8.2.3.3 The mixing drum support system (non-driven) roller shall have the drum-roller contact nip point appropriately guarded.

11.9 Traveling self-unloading feed dispenser

11.9.1 Remote controlled traveling self-unloading feed dispenser.

11.9.1.1 For purposes of this Standard, *traveling, self-unloading feed dispenser* is defined as a self-propelled machine designed to travel along a predetermined path. The dispenser is electrically powered, reversible, and equipped with controls to dispense specified amounts of feed at multiple locations.

11.9.1.2 In addition to the requirements of clause 5 of this Standard, traveling, self-unloading feed dispensers shall be equipped with stop controls located at both ends facing the direction of travel. The control shall be red and prominently located such that it can be readily actuated with one motion of the control.

11.9.1.3 A safety sign shall be affixed to all accessible sides of the dispenser, informing of the hazard of automatic startup of the dispenser and instructing in the recommended preventative actions to avoid the hazard.

11.9.2 Operator driven traveling self-unloading feed dispenser

11.9.2.1 For the purposes of this Standard, *operator driven, traveling, self-unloading feed dispenser* is defined as a self-propelled machine designed to be operator driven to transport feed ration(s), to distribute feed ration(s) into a manger or the like and/or to dispense feed ration(s) at specific location(s).

11.9.2.2 In addition to the requirements of clause 5 of this Standard, operator-driven, self-propelled feed dispensers equipped with a riding platform for the operator shall have guarding behind the operator for protection while feed dispenser travels in direction of operator station.

11.9.2.3 Operator driven, self-propelled feed dispensers designed for the operator to walk on the surface ahead of or behind the feed dispenser shall be equipped with a manual control requiring the operator to initiate and sustain travel in either direction, and upon operator release of the control travel shall cease.

11.9.2.4 Operator driven, self-propelled feed dispensers powered by an internal combustion engine shall have the engine equipped with flame and spark arresters appropriate for the environment of usage.

11.10 Roller mills

11.10.1 For purposes of this Standard, *roller mill* is defined as a feed-processing machine designed to crush feed grains by passing them between closely spaced grooved rolls appropriate to obtain desired particle size. Roller mills may be stationary or portable, and may include input and output conveyors.

11.10.2 Guarding for intake area in roller mill rolls

11.10.2.1 Free-flowing materials (shelled corn, small grains, etc)

11.10.2.1.1 Grating-type guard(s). Openings in grating-type guard(s) shall have their largest dimension no greater than 120 mm (4.75 in.). The area that includes such openings shall be no larger than 6450 mm^2 (10 $in.^2$) and the grating no closer than 65 mm (2.5 in.) to the nip point of the exposed rolls or the hopper agitator, if so equipped.

11.10.2.1.2 Baffle-style guard(s). Slotted openings in baffle-style guard(s) shall be no wider than 40 mm (1.5 in.) or closer than 90 mm (3.5 in.) to the nip point of the exposed rolls or the hopper agitator, if so equipped.

11.10.2.2 Non–free-flowing materials (ear corn, corn-cob mix, corn silage, etc). Guarding described in clause 11.10.2.1 shall remain attached but be capable of exposing the minimum area possible for processing these materials. This minimum area shall be guarded to the maximum extent that is practical and reasonable, while allowing the rated capacity of the mill with the most non–free-flowing materials intended to be processed.

11.10.3 Guarding for roller mill intake conveyors

11.10.3.1 Free-flowing materials (shelled corn, small grains, etc). Auger intake guarding shall be in compliance with the requirements of ASAE S361.

11.10.3.2 Non–free-flowing materials (ear corn, corn-cob mix, corn silage, etc). Auger intake guarding described in clause 11.10.3.1 shall remain attached but be capable of exposing the minimum area possible for conveying these materials. This minimum area shall be guarded to the maximum extent that is practical and reasonable, allowing the most non–free-flowing materials intended to be conveyed by the auger to flow into it.

11.10.4 Safety signs. In addition to the requirements of clause 9, safety signs shall be placed in close proximity to the roller mill intake and the auger conveyor inlet areas, informing the operator and others of the hazards of entanglement in the rolls or auger and of the appropriate preventative measures that should be taken to avoid the hazard.

11.11 Bale/bedding chopper

11.11.1 For the purpose of this Standard, *bale/bedding chopper* is defined as a portable powered mechanical device used to convert dense baled material, such as straw, hay, corn stalks, paper, etc, into a loose, relatively finely chopped consistency; and to distribute the chopped material to desired locations or other receptacles.

11.11.2 Bale choppers powered by internal combustion engines shall have the engine equipped with flame and spark arresters appropriate for the environment of usage.

11.11.3 Electric motor–powered units shall comply with the latest edition of ANSI/NFPA 70 and applicable local electric codes.

11.11.4 Safety signs. In addition to the requirements of clause 9 of this Standard, the following safety signs shall be used to inform the operator and others of the hazards present and the appropriate preventative measure(s) that should be taken to avoid the hazard.

11.11.4.1 Safety sign(s) shall be appropriately placed to identify the cutting knife hazard in the bale chamber.

11.11.4.2 Safety sign(s) shall be appropriately placed to warn of the potential of flying foreign objects being discharged.

11.12 Manure auger elevator

11.12.1 For the purpose of this Standard, *manure auger elevator* is defined as a machine used to convey and elevate livestock waste and bedding by the rotation of screw type flighting in relation to a trough-shaped or tubular enclosure.

11.12.2 A manure auger elevator consists of, but is not limited to, an intake area, a conveying section, and a discharge end with the auger drive mechanism.

11.12.3 In addition to the requirements of clause 5, manure auger elevators shall conform to the following guarding requirements:

11.12.3.1 Intake areas shall be provided with hoppers or other means to direct material flow into the auger, thereby minimizing operator exposure to the auger by limiting outside access.

11.12.3.2 Instructions shall be provided to installers of the manure auger elevators directing them to provide protective barriers meeting the requirements of clause 5 against inadvertent entry into the intake areas.

11.12.3.3 Conveying section lengths shall enclose the auger completely within a tube or covered U-trough.

11.12.3.4 Discharge ends shall be guarded to the fullest extent possible without restricting material flow or other intended function of the machine.

11.12.4 In addition to the requirements of clause 9 of this Standard, a safety sign shall be placed in close proximity to the intake and the discharge of the auger, informing of the hazard of a rotating auger and instructing in the recommended preventative actions necessary to avoid the hazard.

11.13 Manure transfer pumps

11.13.1 For the purpose of this Standard, *manure transfer pump* is defined as a machine used to agitate and/or transfer liquid or semi-solid manure.

11.13.2 In addition to the requirements of clause 9, a safety decal shall be affixed to the pump or in close proximity and visible. The decal shall indicate that the presence of manure gases may exist and (if applicable) are strongest during agitation.

11.13.3 In addition to the operator instructions specified in clause 7, the operator's manual should provide instruction on the availability of ASAE EP470.

ANSI/ASAE S493.1 JUL2003 (R2012)
Guarding for Agricultural Equipment

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.

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

ANSI/ASAE S493.1 JUL2003 (R2012)
Revision approved July 2003; reaffirmed March 2013 as an American National Standard

Guarding for Agricultural Equipment

Proposed to ASAE by the Farm and Industrial Equipment Institute; developed and approved by the ASAE Agricultural Safety Committee and by the ASAE Power and Machinery Division Standards Committee; adopted by ASAE April 1988; approved as an American National Standard July 1989; reaffirmed by ASAE December 1992; reaffirmed by ANSI July 1993; reaffirmed by ASAE December 1997; reaffirmed by ANSI November 1998; reaffirmed by ASAE February 2003; revised July 2003; approved by ANSI July 2003; reaffirmed by ASABE and ANSI February 2008; reaffirmed by ASABE December 2012; reaffirmed by ANSI March 2013.

Keywords: Guarding, Safety, Shielding

1 Purpose and Scope

1.1 This Standard provides general guidelines for guarding for agricultural equipment so as to provide a reasonable degree of personal safety for operators and other persons during the normal operation and servicing of such equipment.

1.2 This Standard applies to agricultural equipment as identified in ASAE Standard S390.

2 Normative References

The following standards contain provisions that, through reference in this text, constitute provisions of the Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Standards organizations maintain registers of currently valid standards.

2.1 ASAE S390.3 JUN01, Definitions of Agricultural Field Equipment

2.2 ASAE S441.3 FEB99, Safety Signs

3 Definitions

3.1 **guard:** A protective device designed and fitted to reasonably minimize the possibility of inadvertent contact with machinery hazards, as well as to restrict access to other hazardous areas. There are four types of guards, each consistent with the requirements of safety distance as defined in paragraph 3.4 below:

3.1.1 **shield or cover:** Protective devices designed and fitted so that alone or with other parts of the machine, they prevent the hazard/hazardous area being reached from the side or sides covered. (see figure 1)

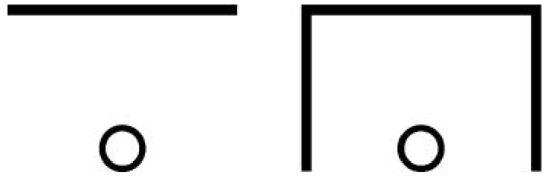


Figure 1 – Shield and cover

3.1.2 casing: Protective device designed and fitted so that, alone or with other parts of the machine, it prevents contact with the hazard/hazardous area from all sides. (see figure 2)

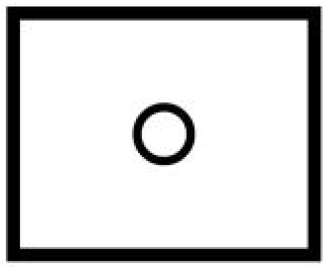


Figure 2 – Casing

3.1.3 enclosure: Protective device which by means of a rail, fence, frame or the like ensures the safety distance on all sides necessary so the hazard/hazardous area cannot be reached inadvertently.

3.1.4 barrier: Protective device such as a rail, fence, frame, or the like designed and fitted so that, alone or with other parts of the machine, it prevents the hazard/hazardous area from being reached inadvertently.

3.2 inadvertent contact: Contact between a person and a hazard resulting from the person's unplanned actions when operating or servicing the equipment.

3.3 hot surface: A surface which reaches operating temperatures in excess of 130 °C and which could involve injury by inadvertent contact.

3.4 safety distance: Minimum distance between a hazard/hazardous area and a guard required to reasonably minimize the possibility of inadvertent contact with the hazard/hazardous area. This distance is typically reach around a barrier or reach through an opening in a guard.

3.5 safety distance guarding: A means of providing guarding where the possibility of inadvertent contact with the hazard is reasonably minimized by the combination of the guard configuration (including openings) and the safety distance between the guard and the hazard/hazardous area.

3.6 machinery hazard: Machinery parts which can cause injury upon direct contact or by entanglement of personal apparel. This includes, but is not limited to, pinch points, nip points, and projections on rotating parts.

3.7 guarding by location: A hazard is guarded by location when it is guarded by other parts or components of the machine that are not themselves guards, or when the hazard is beyond the safety distance.

3.8 nip-point: A type of pinch point characteristic of components such as meshing gears and the run-on point where a belt, chain or cable contacts a sheave, sprocket or idler.

3.9 ground-driven components: Components which are powered by the forward or rearward motion of equipment traveling over the ground.

3.10 normal operation and service: Use of the machine for the purposes and in the manner intended by the manufacturer by an operator familiar with the machine characteristics and complying with the conditions of operation, service and safe practices as specified by the manufacturer in the operator's manual and by signs on the machine.

4 Guarding Requirements

4.1 Components which must be exposed for proper function, drainage or cleaning shall be guarded to the maximum extent that is practicable and reasonable as permitted by the intended operation or use.

4.2 Where paragraph 4.1 does not apply and where hazard elimination through design is not technically feasible and functionally practicable, machinery hazards shall be guarded by location, or with guard(s), or by safety distance guarding as described in Section 6 Safety Distance Guarding. Examples of such hazards are:

4.2.1 Moving traction elements in relation to the operator's station.

4.2.2 Revolving engine components.

4.2.3 Nip-points.

4.2.4 Outside faces of pulleys, sheaves, sprockets and gears.

4.2.5 Revolving shafts, universal joints, and other revolving parts with projections such as exposed bolts, keys, pins or set screws. Revolving shafts excluded are:

4.2.5.1 Smooth shafts revolving at less than 10 rpm.

4.2.5.2 Smooth shaft ends protruding less than one half the outside diameter of the shaft.

4.2.6 Surfaces which create shearing or pinching hazards.

4.2.7 Ground-driven components, if operating personnel are required to be in the area while the drives are in motion.

4.2.7.1 Those components which perform the same function as ground-driven components but which, for the purposes of test, diagnostics or calibration of the machinery, can be placed in motion while the machinery is stationary are excluded from the guarding requirements of paragraph 4.2 provided that: when in the test, diagnostic or calibration mode the Figure 4 fastest components rotate at speeds no greater than 20 rpm, and which come to a complete stop after no longer than 3 seconds after start of the motion, or the components can only be placed in motion through activation of a hold-to-operate control that requires continuous activation by an operator in order to maintain the motion.

4.2.8 Hot surfaces.

4.3 Guarding, where required, shall reasonably minimize inadvertent contact with machinery hazards during normal mounting, starting, operating, and dismounting of the equipment. Hot surfaces which can be inadvertently contacted by the operator during normal operation of the machine shall be guarded or insulated. This includes hot surfaces which are near steps, handrails, handholds, working areas and integral machine parts used for access to and egress from the normal operator's station and which may be inadvertently touched.

4.4 Machines with access doors or guards which can be opened or removed to expose machine elements which continue to rotate or move after the power is disengaged shall have, in the immediate area, a readily visible evidence of rotation, or an audible indication of rotation, or a suitable safety sign.

4.5 Safety sign(s) conforming to the requirements of ASAE S441, and/or operating instructions shall be provided stating that guards must be kept in place, and/or that the machine should not be operated with guards removed.

5 Guard Construction

5.1 Guards shall be sufficiently strong. Unless it is clearly inappropriate, they shall, without cracking, tearing or permanently deflecting, withstand a perpendicular static load of 1 200 N.

5.2 Parts designed as platforms and steps which are also guards shall comply with appropriate strength requirements for platforms and steps.

5.3 Where a guard is intended by the manufacturer to be used as a step it shall withstand a load of 1 200 N.

5.4 Guards shall be rigidly fixed, have no sharp edges, be weather resistant and retain their strength under extremes of temperature, taking into account the intended use.

5.5 Guards shall be designed in such a way that normal operation and service of the machine can be readily carried out.

5.6 Guards shall normally be attached to the machine such that they cannot be removed without the use of a tool. They may be openable, in which case they should remain attached to the machine in some way, for example by means of a tether, hinge, slide, linkage or other suitable means, and should be provided with a convenient means to keep them closed.

5.7 Guards may be formed of a welded or rigid mesh or grille. The size of the opening permitted depends on the distance between the guard and the hazard/hazardous area given in Section 6. The design of the guard shall be such that it is not possible to distort the mesh or the grille during normal operation and use in such a way that the opening size and distance relationship exceeds the limits given in Section 6.

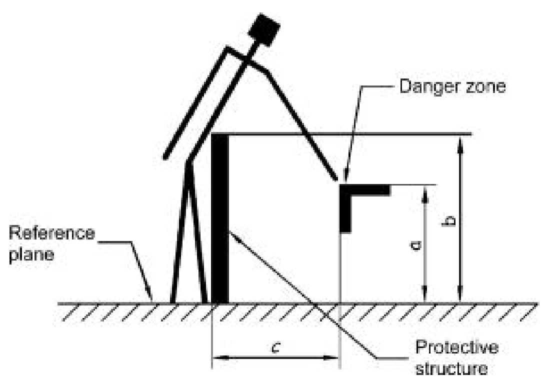


Figure 3

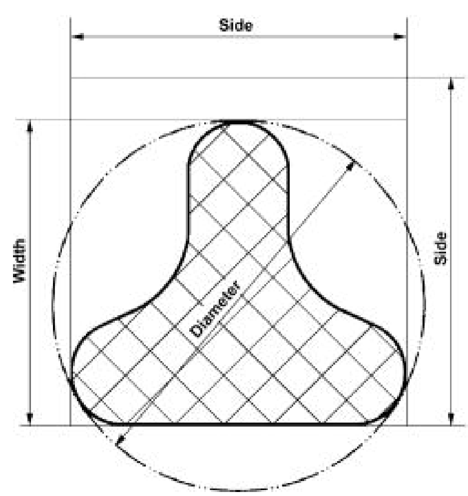


Figure 4

6 Safety Distance Guarding

6.1 Where guarding is required (see Section 4 Guarding requirements), the general principle of safety distance guarding is acceptable provided the applicable criteria in the remaining clauses of this section are met.

6.2 Safety distance from hazard/hazardous area. The safety distance is based on measurements from the location which a person can occupy to operate, maintain or inspect the hazard/hazardous area.

6.2.1 Safety distance for upward reach is 2 500 mm for persons standing upright.

6.2.2 Reach-over barriers

6.2.2.1 Barriers shall be 1 000 mm in height, minimum.

6.2.2.2 The safety distance for sideward or downward reach-over barriers of 1 000 mm or greater height depends on:

- the distance from the ground level to the hazard
- the height of the barrier
- the horizontal distance between the hazard and the barrier.

Figure 3 and Table 1 shall be applied. The dimension *c* is a minimum.

Table 1

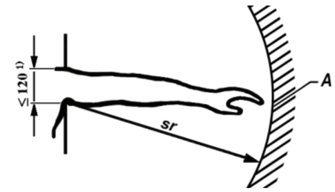
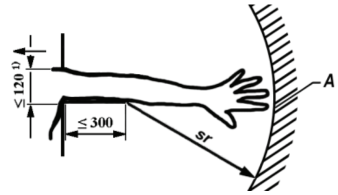
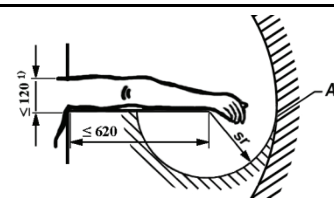
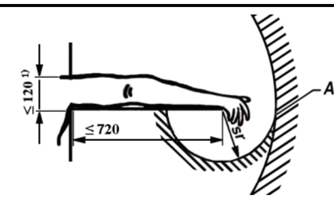
Dimensions in millimeters

Height of danger zone, *a*	Height of protective structure, *b* [1]								
	1 000	1 200	1 400	1 600	1 800	2 000	2 200	2 400	2 500
	Horizontal distance to danger zone, *c*								
2 500 [2]	–	–	–	–	–	–	–	–	–
2 400	100	100	100	100	100	100	100	100	–
2 200	600	600	500	500	400	350	250	–	–
2 000	1 100	900	700	600	500	350	–	–	–
1 800	1 100	1000	900	900	600	–	–	–	–
1 600	1 300	1000	900	900	500	–	–	–	–
1 400	1 300	1000	900	800	100	–	–	–	–
1 200	1 400	1000	900	500	–	–	–	–	–
1 000	1 400	1000	900	300	–	–	–	–	–
800	1 300	900	600	–	–	–	–	–	–
600	1 200	500	–	–	–	–	–	–	–
400	1 200	300	–	–	–	–	–	–	–
200	1 100	200	–	–	–	–	–	–	–
0	1 100	200	–	–	–	–	–	–	–

6.2.3 Round reach. Table 2 shows the extent of reach around guards which can be attained, taking into account the aperture and the distance from other obstructions. Potential hazards shall be beyond these limits if they are not independently guarded.

Table 2

Dimensions in millimeters

Limitation of movement	Safety distance, sr	Illustration
Limitation of movement only at shoulder and armpit	≥850	
Arm supported up to elbow	≥550	
Arm supported up to wrist	≥230	
Arm and hand supported up to knuckle joint	≥130	

A is the range of movement of the arm

1) This is either the diameter of a round opening, or the side of a square opening, or the width of a slot opening.

6.2.4 Inside reach through guards. The safety distances depend on the shape of the openings. The openings shall not exceed the size appropriate to the distance of the guard from the potential hazard (see Table 3).

6.2.4.1 Irregular openings. In the case of irregular openings, the following steps shall be carried out.

a) Determine first

— the diameter of the smallest round opening, and

— the side of the smallest square opening, and

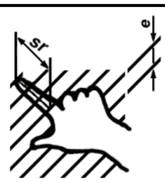
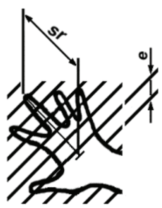
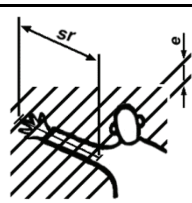
— the width of the narrowest slot opening into which the irregular opening can be completely inserted (see Figure 4).

b) Select the corresponding three safety distances according to Table 3.

c) The shortest safety distance of the three values selected in b) may be used.

Table 3

Dimensions in millimeters

Part of Body	Illustration	Opening	Safety distance, sr		
			Slot	Square	Round
Finger tip		e≤4 4<e<6	≥2 >10	≥2 >5	≥2 >5
Finger up to knuckle joint Or hand	 	6<e≤8 8<e≤10 10<e≤12 12<e≤20 20<e≤30	≥20 ≥80 ≥100 ≥120 ≥850	≥15 ≥25 ≥80 ≥120 ≥120	≥5 ≥20 ≥80 ≥120 ≥120
Arm up to junction with shoulder		30<e≤40 40<e≤120	≥850 ≥850	≥200 ≥850	≥120 ≥850

1) If the length of the slot opening is ≤65 mm, the thumb will act as a stop and the safety distance can be reduced to 200 mm.

ANSI/ASAE S318.17 JUN2009
Safety for Agricultural Field Equipment

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.

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

ANSI/ASAE S318.17 JUN2009

Revision approved June 2009 as an American National Standard

Safety for Agricultural Field Equipment

Supersedes ASAE R275, Improving Safety on Farm Implements, adopted June 1964; R280, Improving Safety on Farm Tractors, adopted December 1964; and S297T, Enclosure-Type Shielding of Forward Universal Joint and Coupling Means of Agricultural Implement Power Drive Lines, adopted June 1966. Proposed by the Engineering Policy Committee of the Farm and Industrial Equipment Institute; adopted by ASAE as a Recommendation December 1968; revised December 1969; revised and reclassified as an American National Standard April 1973; revised December 1973, March 1977, March 1978; reconfirmed December 1982; revised March 1984, March 1985, March 1987, April 1988; revision approved by ANSI June 1989; revised editorially April 1991; reaffirmed by ASAE December 1992; reaffirmed by ANSI July 1993; revised March 1995, March 1997, February 1998; revision approved by ANSI November 1998; reaffirmed by ASAE December 1998; revised May 1999; revision approved by ANSI September 1999; revised December 2002; revision approved by ANSI December 2002, revised editorially November 2005; revised June 2006; revision approved by ANSI June 2006; revised June 2009; revision approved by ANSI June 2009.

Keywords: Braking, Controls, Definitions, Fire Protection, Guarding, Manuals, Power take-off, ROPS, Safety, Safety signs, Shielding, Transport.

1 Scope

1.1 This Standard is a guide to provide a reasonable degree of personal safety for operators and other persons during the normal operation and servicing of agricultural field equipment.

1.2 This Standard does not apply to skid steer loaders, permanently installed grain dryers, and agricultural equipment covered by other safety standards, such as but not limited to permanently installed farmstead equipment, portable grain augers, and storage structures, except where specifically referenced by other standards.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies unless noted. For undated references, the latest approved edition of the referenced document (including any amendments) applies.

ANSI/ASAE S279, *Lighting and Marking of Agricultural Equipment on Highways*

ANSI/ASAE S338, *Field Equipment for Agriculture-Safety Chain for Towed Equipment*

ASAE S365, *Braking System Test Procedures and Braking Performance Criteria for Agricultural Field Equipment*

ASAE S390, *Definitions and Classifications of Agricultural Equipment*

ASAE S441, *Safety Signs*

ANSI/ASAE S478, *Roll-Over Protective Structures (ROPS) for Compact Utility Tractors*

ANSI/ASABE S604, *Safety for Power Take-off (PTO), Implement Input Driveline (IID), Implement Input Connection (IIC), and Auxiliary Power Take-off (aux. PTO) for Agricultural Field Equipment*

SAE J674, *Safety Glazing Materials—Motor Vehicles and Motor Vehicle Equipment*

SAE J1194, *Rollover Protective Structures (ROPS) for Wheeled Agricultural Tractors*

SAE J2194, *Roll-Over Protective Structures (ROPS) for Wheeled Agricultural Tractors*.

ANSI Z26.1-1990, Safety Code for Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways

ISO 4254-1, Agricultural machinery—Safety—Part 1: General Requirements

ISO 4254-5 Agricultural machinery—Safety—Part 5: Power driven soil working equipment

ISO 4254-6 Agricultural machinery—Safety—Part 6: Sprayers and liquid fertilizer distributors

ISO 4254-7 Agricultural machinery—Safety—Part 7: Combine harvesters, forage harvesters and cotton harvestors

ISO/DIS 4254-8.2, August 19, 2008, Agricultural machinery—Safety—Part 8: Solid fertilizer distributors. Once approved ISO 4254-8 shall be used in place of referenced ISO/DIS document.

ISO 4254-9 Agricultural machinery—Safety—Part 9: Equipment for sowing, planting and distributing fertilizers

ISO/DIS 4254-10.3, February 28, 2008, Agricultural machinery—Safety—Part 10: Rotary tedders and rakes. Once approved ISO 4254-10 shall be used in place of referenced ISO/DIS document.

ISO/DIS 4254-11, December 20, 2007, Agricultural machinery—Safety—Part 11: Pick-up balers. Once approved ISO 4254-11 shall be used in place of referenced ISO/DIS document.

ISO/DIS 4254-12, December 20, 2007, Agricultural machinery—Safety—Part 12: Rotary mowers and flail mowers. Once approved ISO 4254-12 shall be used in place of referenced ISO/DIS document.

ISO 26322-1, Tractors for agriculture and forestry—Safety—Part 1—Standards tractors.

ISO/DIS 26322-2, August 8, 2008, Tractors for agriculture and forestry—Safety—Part 2: Narrow-track and small tractors.

3 Definitions

3.1 agricultural field equipment and other terms: (see ASAE S390).

4 General Requirements

4.1 Tractors shall comply with the requirements of the applicable parts of ISO 26322 unless otherwise specified.

4.2 Other agricultural equipment shall comply with the requirements of the applicable parts of ISO 4254 unless otherwise specified.

4.3 Tractors with PTO shafts and implements with associated drivelines shall comply with the requirements of ANSI/ASABE S604.

4.4 Operator manuals for tractors and implements with PTO drives shall include a suitable warning against the use of adaptors to defeat the purpose of the different geometrical designs.

NOTE: Operator Presence Systems requirements need not be applied to self-propelled machines with crop gathering mechanisms where the initial contact between the crop and the mechanism(s) has one or more of these characteristics:

–Tends to expel the crop;

–Does not constitute a pinch or nip point;

–Motion of crop-gathering mechanism does not occur without tractive motion of the machine.

5 Operating station

5.1 A suitable station shall be provided for each person required for the operation of the equipment.

5.2 Operator platforms shall have slip-resistant surfaces.

5.3 Glazing material, such as glass or plastic used in operator enclosures, shall meet the requirements of SAE J674, except that

5.3.1 Windshields may conform to tempered safety glass, item 2 of ANSI Z26.1;

5.3.2 Windshields may include zone toughened glass conforming to ECE Regulation Number 43;

5.3.3 Curved and flat glazing material larger than 1.4 m^2 (15.1 ft^2) for windshields and for side and rear windows of self-propelled machines may deviate from 7.3.1 requirements in that, when broken, what appears to be the 10 largest particles shall weigh no more than the equivalent weight of 64.5 cm^2 (10 $in.^2$) of the sample.

5.4 All sharp edges and corners at the operator's station shall be appropriately treated to minimize potential hazard to the operator.

6 Access and egress

6.1 If the operator is required to stand while operating then the machine shall have a platform that is level when the machine is on a level surface, have a non-slip surface and, if appropriate, a provision for drainage.

7 Tractor roll-over protection system

7.1 Tractor roll-over protective structure (ROPS) meeting the requirements of ANSI/ASAE S478, SAE J1194, or SAE J2194 may be used in lieu of the ROPS requirements of the SAE 26322-1.

8 Travel on highways

8.1 Lighting and marking for agricultural field equipment shall conform to ANSI/ASAE S279 whenever such equipment is intended to operate or travel on public roads or highways.

8.1.1 The operator's manual for the unit shall instruct the operator to turn on flashing warning lights whenever traveling on a highway, except where such use is prohibited by law.

8.2 Agricultural tractors and self-propelled machines with operator enclosures (cabs) shall have at least one rear-view mirror to permit the operator to see the highway behind the machine.

8.3 Hitch pins and other hitching devices shall be provided with a retainer to prevent unintentional unhitching.

8.4 Components that are retracted to decrease the width for highway transport shall have means to positively secure those components during highway transport. One or more types of locking systems may be used. Examples of locking systems are hydraulic cylinder locks and folding over-center.

8.5 Provisions shall be made for the use of auxiliary attaching systems per ANSI/ASAE S338 on towing machines and on equipment where expected uses include towing on highways by single point attachment.

8.6 For towed or semi-mounted implements, instructions in the operator's manual and sign(s) on the machine shall specify a maximum transport speed.

9 Braking

9.1 Braking systems and information shall be provided in accordance with ASAE S365.

10 Parking

10.1 All towed equipment with a tongue imposing a vertical downward force at the hitch point of more than 250 N (56.2 lbf) at a height of 400 mm (15.75 in.) when on level ground and any condition of loading shall be equipped with a means for attaching to the propelling machine without manual lifting.

11 Safety signs

11.1 Safety signs meeting the requirements of ASAE S441 may be used.

ANSI/ASAE EP545 MAR1995 (R2015)
Loads Exerted by Free-Flowing Grain on Shallow Storage Structures

American Society of Agricultural and Biological Engineers

STANDARD

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

ANSI/ASAE EP545 MAR1995 (R2015)

Approved February 1996; reaffirmed January 2015 as an American National Standard

Loads Exerted by Free-Flowing Grain on Shallow Storage Structures

Developed by the ASAE Loads Due to Bulk Grains, Fertilizers and Silage Subcommittee of the Structures Group; approved by the Structures and Environment Division Standards Committee; adopted by ASAE March 1995; approved as an American National Standard February 1996; reaffirmed by ASAE December 1999; reaffirmed by ANSI June 2000; reaffirmed by ASAE February 2005; reaffirmed by ANSI March 2005; revised editorially March 2005; reaffirmed by ASABE January 2010; reaffirmed by ANSI February 2010; reaffirmed by ASABE January 2015; reaffirmed by ANSI January 2015.

Keywords: Grain, Loads, Pressure, Structures

1 Purpose

1.1 This Engineering Practice presents methods of estimating the grain pressures within shallow storage structures used to store free-flowing, agricultural whole grains.

2 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this Engineering Practice. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Engineering Practice are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Standards organizations maintain registers of currently valid standards.

ANSI/ASAE D241.4 FEB93, *Density, Specific Gravity, and Mass-Moisture Relationships of Grain for Storage*

3 Terminology

3.1 Terms used in this Engineering Practice are defined as follows:

3.1.1 shallow storage structure: Grain storage with a square or rectangular floor plan used to store grain where the width of the building is greater than 2 times the height of the grain at the wall.

4 Nomenclature

k is ratio of lateral to vertical pressure, dimensionless;

z is equivalent grain depth at a discrete point, m (ft);

G is gravity acceleration constant, 9.8×10^{-3} kN/kg (1.0 lbf/lb);

H is total equivalent grain height, used to calculate resultant shear vertical and lateral forces acting on the wall, and floor pressure at the base of the wall, m (ft);

$L(z)$ is lateral pressure at equivalent grain depth z, kPa (lbf/ft^2);

P_H is resultant lateral force acting on the wall, kN/m (lbf/ft);

P_S is resultant shear force acting on the wall, kN/m (lbf/ft);

$V(z)$ is vertical pressure at equivalent grain depth z, kPa (lbf/ft^2);

W is bulk density of stored grain, kg/m^3 (lb/ft^3);

Y is height of grain on the wall, m (ft);

α is factor used to calculate total equivalent grain height, dimensionless (equation 2 and Table 1);

β is angle of repose of the grain, deg;

μ is coefficient of friction of grain on structural surfaces, dimensionless;

Φ is internal angle of friction for grain, deg.

Table 1 – Coefficient, *α*, to determine the total equivalent grain height, H, for storages with sloping backfill

Internal Angle of Friction, *Φ*, deg	Angle of Repose, *β*, deg							
	16	**18**	**20**	**22**	**24**	**26**	**28**	**30**
24	1.15	1.17	1.19	1.22	1.25	-	-	-
26	1.16	1.19	1.22	1.25	1.28	1.31	-	-
28	1.18	1.21	1.24	1.27	1.31	1.35	1.39	-
30	1.20	1.23	1.27	1.30	1.35	1.39	1.44	1.50

5 General Design Information

5.1 Total equivalent grain height. For conditions in which the top grain surface is not horizontal (sloping backfill condition), use the total equivalent grain height, *H* (see Figure 1). The total equivalent grain height can be determined by multiplying the actual grain depth at the wall by the appropriate coefficient, *α*, from Table 1 or by using equation 2.

$$H = Y\alpha \tag{1}$$

$$H = Y + Y\left[\frac{\sin\phi\sin\beta}{\cos(\phi+\beta)}\right] \tag{2}$$

5.2 Equivalent depth of grain. The equivalent depth of grain, *z*, is shown in Figure 1.

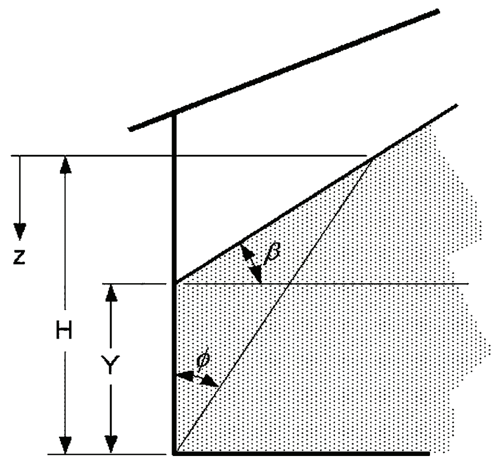


Figure 1 – Flat storage geometry

5.3 Bulk density. For design purposes a bulk density of 834 kg/m^3 (52 lb/ft^3) is recommended. This corresponds with the bulk density of wheat modified by a packing factor. For pressures imposed by grains other than wheat, use bulk densities determined by the Winchester Bushel Test (USDA, 1980) or those listed in ANSI/ASAE D241, increased by packing factor of 1.08.

5.4 Ratio of lateral to vertical pressure. The ratio of lateral to vertical pressure, k, is assumed to be 0.5.

5.5 Internal angle of friction. Suggested values of the internal angle of friction are given in Table 2.

Table 2 – Internal angle of friction for selected grains

Grain	Internal Angle of Friction, Φ, deg
Corn	27
Wheat	27
Soybeans	29

5.6 Angle of repose. For free-flowing grains with a narrow range of particle sizes, the angle of repose can be assumed to be equal to the angle of internal friction.

5.7 Coefficient of friction between grain and wall material. Use values of the static coefficient of friction as given in Table 3.

Table 3 – Static coefficient of friction for selected grains on various wall surfaces

Grain	Steel	Concrete	Corrugated Steel	Plywood
Corn	0.25	0.35	0.50	0.44
Wheat	0.25	0.35	0.50	0.50
Soybeans	0.25	0.35	0.50	0.38

5.8 Static pressures and dynamic pressures on walls and floors. (See Figure 1 and Figure 2)

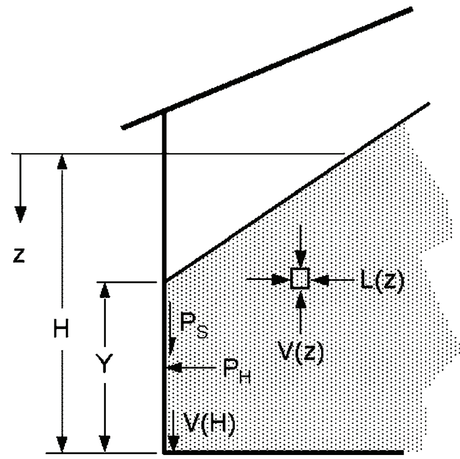


Figure 2 – Stresses on the structure and within the grain

5.8.1 Static vertical pressures. At a discrete point, *z*, the static vertical pressures, *V*(*z*), as estimated by a modified Coulomb's equation are

$$V(z) = WGz \tag{3}$$

5.8.2 Static lateral pressures. To estimate the static lateral wall pressures, *L*(*z*), at a discrete point

$$L(z) = kV(z) \tag{4}$$

5.8.3 Vertical pressures on floor. The floor pressure next to the wall, *V*(*H*) is estimated by

$$V(H) = WGH \tag{5}$$

5.9 Resultant lateral and shear forces on the walls

5.9.1 Resultant lateral force. The resultant lateral force per unit length of wall, P_H, is estimated by

$$P_H = \frac{L(H)H}{2} \tag{6}$$

5.9.2 Resultant shear force. The resultant shear force per unit length of wall, P_S, is estimated by

$$P_S = \mu P_H \tag{7}$$

5.9.3 Dynamic pressures. Dynamic pressures are not considered to act on shallow storage structures; therefore, the pressures during loading and unloading are considered to be equal to static pressures.

5.10 Special load considerations. Increased loads are caused by unbalanced loading conditions, by moisture or hygroscopic pressures, and by vibration induced pressures. No reliable methods exist to predict the magnitudes of increased loads caused by these factors. Factors of safety shall be increased if the possibility of these loading conditions exists.

6 Design Example

The following example is provided to illustrate the design concepts presented in this Engineering Practice:

Initial design conditions:

— stored material, wheat;

— wall height, 4 m (13.12 ft);

— wall material, smooth galvanized steel.

Step 1. Determine material properties:

— from 5.3, Bulk density equals 834 kg/m^3 (52 lbf/ft^3);

— from Table 2, Internal angle of friction equals 27 deg;

— from Table 3, Coefficient of friction equals 0.25.

Step 2. Calculate total equivalent grain height:

— read, α from Table 1 (equation 2) assuming the angle of repose equals the internal angle of friction. Interpolating between the values for 26 deg and 28 deg, gives a value of 1.35 for α.

— calculate total equivalent grain height using equation 2:

$$H = Y\alpha = 4 \times 1.35 = 5.4 \text{ m}$$

Step 3. Calculate static pressures:

— calculate static vertical pressure using equation 3:

$$V(z) = WGz = 834 \times 9.8 \times 10^{-3} \times z = 8.2\ z \text{ kPa}$$

— calculate lateral pressures using equation 4:

$$L(z) = kV(z) = 0.5 \times 8.2z = 4.1\ z \text{ kPa}$$

— calculate vertical pressure on the floor using equation 5:

$$V(H) = WGH = 834 \times 9.8 \times 10^{-3} \times 5.4 = 44.1 \text{ kPa}$$

Step 4. Calculate resultant wall forces:

— calculate resultant lateral force using equation 6:

$$P_H = L(H)\ H/2 = 4.1 \times H \times H/2 = 4.1 \times 5.4 \times 5.4/2 = 59.8 \text{ kN/m}$$

— calculate the resultant shear force using equation 7:

$$P_S = \mu P_H = 0.25 \times 59.8 = 14.9 \text{ kN/m}$$

Annex A
(informative)
Commentary

A.1 Pressures. Pressures are estimated using a modified Coulomb approach. Vertical pressures are assumed to be geostatic and vary linearly with respect to the height of material at any given point. Lateral pressures are estimated based on the assumption that the wall supports a wedge of material. The wedge is bounded by the wall and the plane defined by the angle of internal friction (see Figure 1). The basic assumptions of this technique are

— the stored material is isotropic and homogeneous and possesses internal friction;

— failure occurs along a plane surface;

— the material surface is planar;

— friction forces occur along the failure plane;

— the failure wedge is a rigid body;

— wall friction exists between the stored material and the wall;

— it is assumed that the wall is infinitely long such that a unit length can be considered;

— the stored material is semi-infinite such that no interaction occurs between opposite walls.

A.2 Total equivalent grain height. For a sloping backfill condition, an equivalent grain depth, *H*, must be calculated. The equivalent grain depth, *H*, is based on lateral earth pressure theory for a vertical wall as assumed by Coulomb (Bowles, 1977). The equivalent grain depth, *H*, can be calculated using

$$H = Y + Y\left[\frac{\sin\phi\sin\beta}{\cos(\phi + b)}\right] \tag{2}$$

A.3 Equivalent depth of grain. To estimate grain pressures at discrete points the equivalent depth of grain, *z*, as shown in Figure 1 must be used. This takes into account the effects of a sloping backfill condition.

A.4 Bulk density. If a bin is used to store a variety of grains over its lifetime, it is recommended that it be designed for the storage of wheat. For wheat a bulk density of 834 kg/m^3 (52 lb/ft^3) is recommended. Values of bulk density for other grains are given in ANSI/ASAE D241. These values are based on standard tests and should be multiplied by a factor of 1.08 to account for the effects of compaction in a structure. Bulk density values determined by the Winchester Bushel Test (USDA, 1980) can be used in lieu of the values listed in ANSI/ASAE D241.

A.5 Ratio of lateral to vertical pressure. The ratio of lateral to vertical pressure is assumed to be a constant value of 0.5 for all loading conditions and grains.

A.6 Internal angle of friction. The internal angle of friction has an effect on the total equivalent depth of grain, *H*, and the pressures estimated to occur within the structure. Values shown in Table 2 are average values of those normally found in the literature for free-flowing grains. The range of values found in the literature varies from 25 deg to 30 deg. Internal angles of friction for some oilseeds such as flaxseed and vetch may fall outside of this range.

A.7 Angle of repose. For a sloping backfill condition the grain is assumed to stack at the angle of repose. The angle of repose has an effect on the total equivalent depth of grain, *H*, and the pressures estimated to occur within the structure. Gaylord and Gaylord (1984) and Bowles (1977) suggest that for free-flowing grains the internal angle of friction and the angle of repose are approximately equal. Kalman et al., (1993) have indicated that the angle of repose is influenced by the floor surface on which the material is being stacked. Pierce and Bodman (1987) conducted a field study in which piling angles of corn and milo were measured in round piles and flat storage buildings. Average piling angles of 23 and 29 deg were measured for corn and milo, respectively. Pierce and Bodman indicated that moisture content of the grain did not appear to influence the piling angle of repose. Their values are approximately 4 deg smaller than those normally shown in the literature. Other sources in the literature indicate a moisture content effect on angle of repose. If the structure is filled by some mechanical technique which affects the stacking angle of the material, then the angle at which the grain is assumed to stack in the building should be used in design.

A.8 Coefficient of friction between grain and wall material. The static coefficient of friction is used because in flat storage, the grain is stationary along the walls until the last stages of unloading. The coefficients of friction listed in Table 3 are in the range of those given by Brubaker and Pos (1965) and others listed in Moshenin (1986).

A.9 Static vertical pressures. Pressures are estimated using a modified Coulomb approach. The vertical pressures, $V(z)$, are influenced only by the material directly above a discrete point. The lateral wall pressures, $L(z)$, are influenced by the failure wedge supported by the wall. To calculate pressures at a discrete point, the equivalent grain depth, z, must be used.

A.10 Resultant lateral and shear forces on the walls. The resultant forces are expressed as loads per unit length of wall.

A.11 Special load considerations

A.11.1 Unbalanced loading conditions. Unbalanced loading conditions can occur within the structure if material is not uniformly stacked against all walls in the structure. This can result in additional moments.

A.11.2 Moisture or hygroscopic pressures. Moisture content increases of 4% or more during storage may cause an increase in lateral pressures over static conditions. Dale and Robinson (1954) observed pressures that increased to several times over the static load conditions.

A.11.3 Vibration induced pressures. Additional pressures within shallow grain storage structures located adjacent to railroads and highways have been attributed to vibration. However, there are insufficient data available to predict the magnitude or significance of vibration induced pressures.

Annex B
(informative)
Bibliography

The following documents are cited as reference sources used in development of this Engineering Practice.

Bowles, J. E. *Foundation Analysis and Design*. McGraw-Hill Book Company, New York, NY; 1977.

Brubaker, J. E., and J. Pos. *Determining static coefficient of grain on surfaces*. Transactions of the ASAE 8:53-55; 1965.

Dale, A. C., and R. N. Robinson. *Pressures in deep storage structures*. Agricultural Engineering 35(8):570-573; 1954.

Gaylord, E. H., and C. N. Gaylord. *Design of Steel Bins for Storage of Bulk Solids*. Prentice-Hall, Inc., Englewood Cliffs, NJ; 1984.

Kalman, H., D. Goder, M. Rivkin, and G. Ben-Dor. *The effect of the particle-surface friction coefficient on the angle of repose*. Bulk Solids Handling 13(1):123-128; 1993.

Moshenin, N. N. *Physical Properties of Plant and Animal Materials,* 2nd Ed. Gordon and Breach Science Publishers, New York, NY; 1986.

Pierce, R. O., and G. R. Bodman. *Piling angles of corn and milo*. ASAE Paper 87-4058, ASAE, St. Joseph, MI; 1987.

USDA. *Grain Inspection Manual*. United States Federal Grain Inspection Service, Washington, DC; 1980.

ASAE S361.3 APR1990 (R2011)
Safety for Portable Agricultural Auger Conveying Equipment

American Society of
Agricultural and Biological Engineers

S
T
A
N
D
A
R
D

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

Safety for Portable Agricultural Auger Conveying Equipment

Proposed by the Auger Safety Committee of Farm and Industrial Equipment Institute; approved by ASAE Power and Machinery Division Standards Committee; adopted by ASAE as a Tentative Standard February 1973; reconfirmed December 1973; revised February 1975; reconfirmed December 1975, December 1976, December 1977, December 1978, December 1979, December 1981, December 1982; revised December 1983; reconfirmed December 1984; reconfirmed and reclassified as a full Standard December 1985; revised April 1990; reaffirmed December 1994, December 1999, February 2005; periodic review extension for one year approved April 2009; reaffirmed January 2011.

Keywords: Auger, Conveying, Guarding, Safety, Safety signs

1 Purpose

1.1 The purpose of this Standard is to provide for a reasonable degree of personal safety for operators and other persons during normal operation of auger conveying equipment used to convey agricultural materials on farms.

1.2 In addition to the design and configuration of equipment, hazard control and accident prevention are dependent upon the awareness, concern, and prudence of personnel involved in the operation, transport, maintenance and storage of equipment or in the use and maintenance of facilities.

2 Scope

2.1 This Standard covers only portable farm augers and their related accessories designed primarily for conveying agricultural materials on farms. For definitions see ASAE Standard S374, Terminology and Specification Definitions for Agricultural Auger Conveying Equipment.

2.2 American National Standards ANSI/ASME B15.1, Safety Standard for Mechanical Power Transmission Apparatus, and ANSI/ASME B20.1, Safety Standard for Conveyors and Related Equipment, do not apply to agricultural auger conveying equipment.

3 Electrical specifications

3.1 Conductors, connectors and grounding. The path to ground from motors, controls and electrical enclosures shall be continuous; shall have ample carrying capacity to conduct safely any currents liable to be imposed on it; and shall have impedance sufficiently low to limit the potential aboveground and to facilitate operation of control and over-current devices in the circuit. Where separable connectors are used, the grounding conductor shall be the first to make contact and the last to break contact. Motor disconnect switches and conductor cables shall comply with ANSI/NFPA Standard 70, National Electrical Code, and any local codes which apply.

3.1.1 Flexible cords and cables may be used. Ratings of separable connectors and conductors shall be at least as great as motor-running current rating for motor leads, and at least as great as control current rating for control leads. Separable connectors shall be constructed and installed to guard against inadvertent contact with live parts.

3.2 Electrical controls and wiring

3.2.1 Motors operating at less than 30 volts. Controls shall be conveniently located and so arranged that the motor(s) will start only by button or lever actuation by the operator. Overload protection shall be of the "manual reset" type. Controls shall automatically go to the OFF mode in case of circuit interruption.

3.2.2 Motors operating at more than 100 volts. Controls shall be conveniently located and so arranged that the motor(s) will start only by button or lever actuation by the operator, except in automatic systems. Overload protection shall be the "manual reset" type. Motor starting devices shall be so arranged that controls will automatically go to the OFF mode in case of power interruption, conductor fault, low voltage, or circuit interruption. Overload reset and motor-starting control station should be so located that the operator can see that all personnel are clear of the equipment.

3.3 Electric motors

3.3.1 Motor rating. Motors should be selected for each auger unit with no less than the minimum mechanical power rating as recommended by the equipment manufacturer.

3.3.2 Motor enclosure. Motors should be enclosed to exclude entry of moisture, dirt and foreign objects but allow air fan cooling. Enclosures must suit the environment where the motor will be used. Special enclosures should be used in hazardous or explosive atmospheres, such as enclosed bins with grain dust suspended in the air.

4 General specifications

4.1 Shields and guards for drive components

4.1.1 Belts, pulleys, chains, and sprockets. All shields and guards for belts, pulleys, chains, and sprockets shall conform to American National Standard ANSI/ASAE S493, Guarding for Agricultural Equipment.

4.1.2 Implement input driveline, IID. Implement input drivelines shall conform to ANSI/ASAE Standard S493, Guarding for Agricultural Equipment, and/or ANSI/ASAE Standard S318, Safety for Agricultural Equipment.

4.1.3 Drive shaft. All power driven rotating drive shafts shall be guarded in accordance with ANSI/ASAE Standard S493, Guarding for Agricultural Equipment.

4.2 Shields and guards for functional components. Functional components, which must be exposed for proper function, shall be shielded to the maximum extent permitted by the intended function of the component(s). In addition, the following specific requirements shall be met.

4.2.1 Hopper flighting guard. The exposed flighting shall be guarded.

4.2.1.1 Grating type guard(s). Openings in grating type guard(s) shall have their largest dimension no greater than 121 mm (4.75 in.). The area that includes such openings shall be no larger than 6450 mm^2 (10 $in.^2$) or closer than 64 mm (2.5 in.) to the flighting.

4.2.1.2 Baffle style guard(s). Slotted openings in baffle style guard(s) shall be no wider than 38 mm (1.5 in.) or closer than 89 mm (3.5 in.) to the exposed flighting.

4.2.2 Intake

4.2.2.1 The intake shall be guarded or otherwise designed to provide a deterrent from accidental contact with the rotating flighting. The guard shall cover the top 180 deg of the inlet area and extend a minimum of 64 mm (2.5 in.) above and below the exposed flighting. Openings in the guard, for the free flow of material, shall have their largest dimension no larger than 121 mm (4.75 in.). The area of each opening shall be no larger than 6450 mm^2 (10 $in.^2$). The guard shall be no closer to the

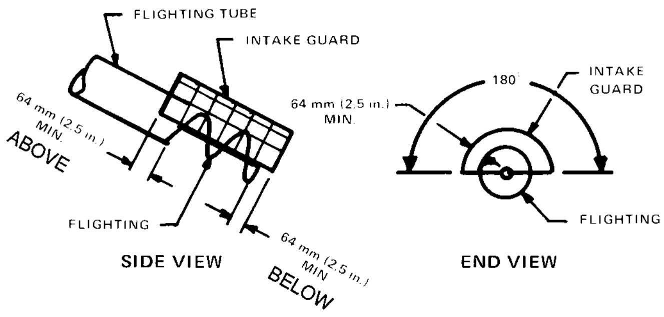


Figure 1 – Intake guard

rotating flighting than 64 mm (2.5 in.) and be of sufficient strength to support a 123 kg (270 lb) person without permanent deformation (see Fig. 1).

4.2.2.2 A safety sign(s) shall be provided to inform of rotating flighting hazard and to warn against modification or removal of the guard.

4.2.3 Drag auger shielding. Drag augers should have the handle end and the top half shielded by a guard. Openings in such guards shall have their largest dimension no greater than 121 mm (4.75 in.). The guard openings shall be located no closer to the rotating flighting than 64 mm (2.5 in.). The area of each opening shall be no larger than 6450 mm^2 (10 $in.^2$).

4.3 Lateral stability. The wheel tread width shall be of sufficient span that, with the auger in the lower transport position, static side tipping will not occur on slopes below the angle of 20 deg.

4.4 Tube restraint. To avoid inadvertent separation, a positive restraint shall be provided between the auger tube and the undercarriage lifting arm. Stops that restrict the maximum raised angle and the minimum lowered angle shall be provided.

4.5 Winch

4.5.1 Winch drum. The diameter of the winch drum center shall be no less than 10 times the wire rope diameter.

4.5.2 Hand winch. The hand winch shall be provided with a control which will hold the auger at any angle of inclination and respond only to handle actuation. It shall not be necessary to disengage such control to lower the auger. The force required on the handle to raise or lower the auger manually shall not exceed 222 N (50 lbf).

4.5.3 Electric winch. Controls shall be conveniently located and so arranged that the winch will operate only during switch or lever actuation by the operator. The actuating switch or lever shall automatically return to the OFF mode when the operator releases the actuating switch or lever. Overload protection shall be provided.

4.6 Wire rope (cable). Wire rope shall be rust resistant and selected for the design load and service intended. Wire ropes and their anchors used for lifting the auger tube into the raised operating position shall be designed with a safety factor, working load compared to breaking strength, of no less than 5. Wire ropes and their respective anchors used as structural supports for the auger tube shall be designed with a safety factor, working load compared to breaking strength, of no less than 3. All wire rope fastening devices shall be in accordance with wire rope manufacturer's recommendations.

4.7 Pulleys. The wire rope lifting pulleys shall be grooved to fit the wire rope with which they are used. Their pitch diameter shall be no less than 10 times the wire rope diameter. A factor of safety of no less than 5 shall be used when comparing working load to breaking strength of the pulleys and pulley anchors.

4.8 Hydraulics

4.8.1 Hydraulic lifting systems shall include a means to control the rate of descent of the auger or arrest the descent of the auger in the event of sudden hydraulic pressure release.

4.8.2 A safety sign(s) shall be provided to inform of possible escaping high pressure hydraulic fluid from connectors and pinhole leaks and the hazards therein.

5 Overhead power lines

5.1 A safety sign(s) shall be provided, to inform of possible overhead powerline contact or near contact, on portable farm augers which exceed 4.3 m (14 ft) in height during any mode of operation, transport, or preparation for transport.

6 Upending

6.1 A safety sign(s) shall be provided to inform of possible upending during operation, transport, or preparation for transport.

7 Safety signs

7.1 Safety signs shall be appropriately displayed when necessary to alert the operator and others of the risk of personal injury during normal operations and servicing.

7.2 Safety signs shall conform to requirements of ASAE Standard S441, Safety Signs.

7.3 To distinguish from safety signs, any instructional signs relating to equipment servicing and care should use signal words such as IMPORTANT or NOTICE, without the safety-alert symbols. The appearance of these signs should be different from safety signs.

7.4 Typical "safety" sign information for portable augers is as follows:

1. Read and understand the operator's manual before operating.
2. Keep all safety shields and devices in place.
3. Make certain everyone is clear before operating or moving the machine.
4. Keep hands, feet and clothing away from moving parts.
5. Shut off power to adjust, service or clean.
6. Support discharge end or anchor intake end to prevent upending.
7. Disconnect power before resetting motor overload.
8. Empty auger before moving to prevent upending.
9. Lower auger to transport position for transporting.
10. Make certain electric motors are grounded.

Cited Standards:

ANSI/ASAE S318, Safety for Agricultural Equipment
ANSI/ASAE S493, Guarding for Agricultural Equipment
ANSI/ASME B15.1, Safety Standard for Mechanical Power Transmission Apparatus
ANSI/ASME B20.1, Safety Standard for Conveyors and Related Equipment
ANSI/NFPA 70, National Electrical Code
ASAE S374, Terminology and Specification Definitions for Agricultural Auger Conveying Equipment
ASAE S441, Safety Signs

ASAE S374 MAR1975 (R2011)
Terminology and Specification Definitions for Agricultural Auger Conveying Equipment

American Society of
Agricultural and Biological Engineers

STANDARD

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

Terminology and Specification Definitions for Agricultural Auger Conveying Equipment

Proposed for the Auger and Elevator Manufacturers Council of the Farm and Industrial Equipment Institute; approved by the ASAE Power and Machinery Division Standards Committee; adopted by ASAE March 1975; reconfirmed December 1979, December 1984, December 1989; revised editorially September 1990; reconfirmed December 1990; reaffirmed December 1995, January 2001, February 2006; January 2011.

Keywords: Auger, Conveying, Definitions

1 Purpose and scope

1.1 The purpose of this Standard is to provide uniform terminology, performance specifications and dimensional specifications for portable farm augers and their related accessories designed primarily for conveying agricultural materials on farms.

2 Performance specifications

2.1 Capacity. The capacity of units shall be expressed in bushels per hour (one bushel = 1.244 cubic feet) or liters per hour.

2.2 Power. The power requirements shall be expressed in horsepower or watts.

3 Dimensional specifications (See Fig. 1)

3.1 Auger length: The length of the tube assembly including any intake but not including any intake hopper or head drive components (dimension A).

3.2 Intake length: The length of the visible flighting with the control gate (if unit is so equipped) in the full open position (dimension B).

3.3 Transport angle: The angle included between the auger tube and the ground when the unit is in the lowest recommended transport position and with hitch on the ground (dimension C).

3.4 Maximum operating angle: The angle included between the auger tube and the ground when the unit is in the highest recommended operating position, and with the hitch on the ground (dimension D).

3.5 Auger size: The outside diameter of the auger tube (dimension E).

3.6 Reach at maximum height: The horizontal distance from the foremost part of the undercarriage to the center of the discharge end when the unit is at the maximum recommended operating angle with hitch on ground (dimension F).

3.7 Maximum lift height: The vertical distance from the ground to the lowest point of the discharge (excluding down spout attachments) when the unit is raised to the maximum recommended operating angle and with the hitch on the ground (dimension G).

3.8 Transport height: The vertical distance from the ground to the uppermost portion with the unit in the lowest transport position and with the hitch on the ground (dimension H).

3.9 Eave clearance: The vertical distance from the ground to the foremost component of the undercarriage when the unit is at the maximum raised height (dimension J).

3.10 Discharge length: The total length of conveying from the outer end of the exposed flighting assembly at the intake to the centerline of the discharge (dimension K).

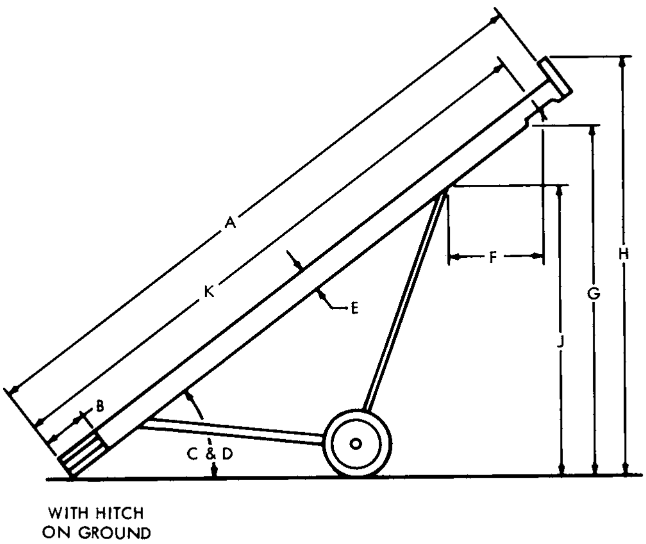


Figure 1 – Typical portable auger

4 Terminology

4.1 Types of machines

4.1.1 Auger: A conveyor with screw type flighting in a tubular shaped enclosure with auxiliary accessories, to be usable in conveying recommended materials by rotating the flighting in relation to the enclosure.

4.1.2 Distributing auger: An auger capable of discharging material to one or more locations.

4.1.3 Feeding auger: An auger which releases conveyed material essentially uniformly along a substantial portion of its length.

4.1.4 Portable auger: An auger whose accessories include a suitable support system which provides mobility.

4.1.5 Stationary auger (fixed): An auger essentially permanently installed on a particular site without mobility capability.

4.1.6 Tube auger: An auger in which the enclosure is essentially a cylinder.

4.1.7 Utility auger: A mobile auger which is not equipped with an auxiliary transport support.

4.2 Types of final drives

4.2.1 Center drive: When final drive location is between the intake and discharge.

4.2.2 Final drive: Where torque is applied to the auger flighting assembly.

4.2.3 Intake or bottom drive: When final drive location is at the intake end.

4.2.4 Top or head drive: When final drive location is at the discharge end.

4.3 General terminology

4.3.1 Automatically controlled: Operated by the action of its mechanism being initiated by some impersonal influence, such as being controlled by low-level and high-level indicators.

4.3.2 Axle: Portion of undercarriage support to which wheels are attached.

4.3.3 Connecting stub shaft: Connector between two flighting assemblies.

4.3.4 Discharge: The area where conveyed material is discharged from the machine.

4.3.5 Drive shaft: Shaft that transmits power between the power source and the final drive.

4.3.6 Drive-shaft bearing support: Drive-shaft bearing holder.

4.3.7 Enclosed: Moving parts are so guarded that physical contact is precluded as long as the guard remains in place. This does not prohibit use of access areas for inspection or lubrication as long as the access is otherwise inaccessible by use of substantial covers designed for removal and replacement.

4.3.8 Flighting: Helicoid screw.

4.3.9 Flighting assembly: Flighting shaft with flighting attached.

4.3.10 Flighting shaft: Shaft on which flighting is mounted.

4.3.11 Guarded: Shielded fenced, or otherwise protected by means of suitable deterrent, or by nature of location so as to remove foreseeable risk of personal injury from accidental contact or approach.

4.3.12 Guarded by location: Moving parts are so protected by their location with reference to frame, foundation, or structure as to remove the foreseeable risk of accidental contact by persons or objects.

4.3.13 Guarding not possible: Wherever conditions prevail which if guarded would render the auger unusable.

4.3.14 Head stub shaft: Connector between flighting assembly and head drive or head bearing.

4.3.15 Hitch: Device for connecting to a towing vehicle.

4.3.16 Installer: Management in effective control of putting equipment in place and in operating condition.

4.3.17 Intake: The area where material to be conveyed enters the machine.

4.3.18 Intake guard: Safety device for exposed intake flighting assembly.

4.3.19 Intake stub shaft: Connector between intake flight assembly and intake drive or bearing.

4.3.20 Lift arm: Undercarriage support member located nearest discharge end.

4.3.21 Lower arm: Undercarriage support member located nearest to the intake end.

4.3.22 Manager: The management in effective control of the operation after installation.

4.3.23 Moving parts: Parts which have motion during operation of the machine.

4.3.24 Nip point (pinch point): That point at which a machine element moving in line or rotating meets another element in such a manner that it is possible to nip, pinch, squeeze, or entrap objects coming into contact with one or both of the members.

4.3.25 Operator: Designated agent(s) of the owner or manager.

4.3.26 Safety device: Mechanism or an arrangement for the specific purpose of improving the degree of personal safety for the operator and others involved during the normal operation and servicing of a portable farm auger.

4.3.27 Shield: Device used to enclose or guard to reduce the possibility of accidental contact with portions of a machine which, if contacted, could cause personal injury.

4.3.28 Track: Guide for lift arm for undercarriage support.

4.3.29 Trough: Flighting assembly housing which is open at the top and essentially "U" shaped in cross section.

4.3.30 Truss: Structural supporting framework.

4.3.31 Truss anchors: End attaching point for truss.

4.3.32 Truss rod or cable: Tie between truss anchors and truss support.

4.3.33 Truss support: Stand off brace for truss.

4.3.34 Tube: Flighting assembly housing which is essentially round in cross section.

4.3.35 Undercarriage: Assembly that supports auger and provides mobility.

4.3.36 Winch: Drum type lifting device to achieve desired angle of elevation.

4.3.37 Winch cable: Wire rope used for raising and lowering the auger.

4.4 Accessories or auxiliary equipment:

4.4.1 Control gate: Device to adjust the intake areas for capacity control.

4.4.2 Discharge spout: Means for guiding released material from the discharge in a desired direction to a desired receptacle.

4.4.3 Drag auger: A device with a screw type flighting in contact with material, pivotally attached to the auger intake to draw material toward the intake when rotated. Rotating power is through the pivotal attachment.

4.4.4 Drag auger handle: Portion of drag auger assembly used to control position of drag auger.

4.4.5 Gravity hopper: Device for receiving and directing material into the rotating flighting without power driven components.

4.4.6 Hopper: Device for receiving and directing material into the rotating flighting.

4.4.7 Powered hopper: A device for receiving material to be conveyed at a point near the auger rotating flighting and for conveying the material to the rotating auger flighting. Method of conveying is usually by rotating flighting in the hopper, but is not confined to this conveying method.

4.4.8 Swing away hopper: Powered hopper which swings to one or both sides to clear a driving lane through the normal operating position.

4.4.9 Tilting hopper: Powered hopper which raises to approximately vertical to clear a driving lane through the normal operating position.

ASAE S337.1 FEB1987 (R2012)
Agricultural Pallet Bins

STANDARD

American Society of Agricultural and Biological Engineers

ASAE S337.1 FEB1987 (R2012)

Agricultural Pallet Bins

Developed by the ASAE Farm Materials Handling Committee; approved by the ASAE Electric Power and Processing Division Standards Committee; adopted by ASAE December 1969; reconfirmed December 1974; revised editorially and reconfirmed December 1975; reconfirmed December 1980; revised by the ASAE Transportation, Handling, and Warehousing of Agricultural Products Committee; approved by the ASAE Food and Process Engineering Institute Standards Committee February 1987; revised editorially February 1989; reaffirmed December 1991, December 1992, December 1995, January 2001, February 2003, February 2008; revised editorially February 2008; reaffirmed December 2012.

Keywords: Bins, Pallet, Test

1 Purpose and Scope

1.1 The purpose of this Standard is to provide uniform design and performance specifications for agricultural pallet bins (also known as, bulk bins, bin boxes, bulk crates, totes, field boxes and pallet boxes). This Standard is intended to help suppliers and users specify pallet bins that will facilitate handling, interchanging, storing, and transporting.

1.2 The scope of this Standard encompasses outside dimensions, capacity, materials, design features, performance tests, and specifications of pallet bins.

1.3 This Standard covers the general description of pallet bins for use in the agricultural industry. Additional recommendations may be required for specific applications. Detailed pallet bin design specifications are not included in order to permit alternate design concepts.

1.4 These guidelines are arranged in a manner that allows selection of those paragraphs applicable to specific cases. The purchaser or other user specifies applicable paragraphs and requirements. This Standard also functions as a checklist of characteristics that a user may wish to consider when purchasing pallet bins.

1.5 Terminology of construction is the same as defined in American National Standard MH 1.1.2, Pallet Bins and Terminology. Sizes specified in ANSI Standard MH 1.2.2, Pallet Sizes, are used when appropriate.

2 Dimensions

2.1 Only overall outside dimensions are specified for length, width, and height. These dimensions shall not be exceeded by bulge or deflection from bin loading or by overfill.

2.2 One square cross section bin and one rectangular cross section bin are specified that give a projected area (footprint) with the dimensions shown. Two overall heights are specified. A separate stacking height may also be specified to give the distance measured from the base plane to the plane where the next pallet bin could rest.

2.2.1 The square bin shall be 120 ±1 cm × 120 ±1 cm (47.25 ±0.39 in. × 47.25 ±0.39 in.).

2.2.2 The rectangular bin shall be 120 ±1 cm × 100 ±1 cm (47.25 ±0.39 in. × 39.37 ±0.39 in.).

2.2.3 The overall height shall be 72 ±1 cm (28.35 ±0.39 in.) or 133 ±1 cm (52.36 ±0.39 in.).

2.3 Fork clearances shall be a minimum of 8.9 cm (3.5 in.) in opening height and a minimum of 22.90 cm (9.0 in.) in opening width, and shall be on 45.7 to 61.0 cm (18 to 24 in.) center spacings.

3 Capacity

3.1 Since overall outside dimensions are specified, inside dimensions (and thus volume capacity) will vary with construction materials, bin design and inside depth.

3.2 Where volume capacity is required for measuring contents, quality control, piece work payments or other reasons, calibration marks shall be placed inside the bin.

3.3 To facilitate stacking and airflow for refrigerating and degreening, the bins should be loaded to provide a minimum of 5 cm (2 in.) of headspace. A mark (painted, stamped, etc.) shall be placed 5 cm (2 in.) below the top edge to provide a guide for loading.

4 Materials

4.1 Pallet bins may be constructed from any materials that have been shown to be suitable for the intended application. Common materials include wood, plastic, metal and fibreboard. The materials selected shall comply with the paragraphs in this section when they are specified.

4.2 Food safety. Materials in contact with the product shall be approved by the U.S. Food and Drug Administration and/or the U.S. Department of Agriculture. Preservatives and other special treatment chemicals also must be approved.

4.3 Temperature range. The material shall withstand exposure to specified minimum and maximum temperatures without appreciable loss in strength or change in other characteristics.

4.4 Radiation. The material shall pass specified performance tests after specified exposure to sunlight (ultra-violet radiation).

4.5 Moisture. The material shall pass specified performance tests after specified exposures to high humidity or free moisture, e.g., hydrocooling.

4.6 Cleaning/sanitizing. The material shall be capable of being cleaned and/or sanitized by hot water, steam, chemical applications or other specified methods.

4.7 General requirements. Pallet bins shall be constructed from new materials that are free of harmful imperfections such as knots, bark, blow holes or other undesirable characteristics.

5 Design Features

5.1 The following paragraphs describe bin characteristics which may be specified for specific applications.

5.1.1 Food safety. Design features shall be incorporated that prevent accumulations of mildew, bacteria and fungi. Surfaces in contact with food shall be free of rust, cracks, small radii, porosity and other conditions that prevent adequate cleaning and sanitation.

5.1.2 Handling safety. Pallet bin safety shall be enhanced by using designs that are without sharp edges, are resistant to splintering, are free of protruding parts and have other features that minimize the chance of injury.

5.2 General design features. The following design characteristics shall be specified when applicable.

5.2.1 Collapsible or knock down (KD). The design shall enable the pallet bin to be changed from a set-up configuration to a geometrically reduced configuration after use to promote efficient use of space while in storage or on back haul routes.

5.2.2 Expendable. The pallet bin shall have a five expectancy of one trip.

5.2.3 Reusable/returnable. The pallet bin shall have a life expectancy of more than one trip.

5.2.4 Lidded. The pallet bin shall have an uppermost surface capable of being closed by a lid.

5.2.5 Modular. The pallet bin shall be formed from smaller pallet bins which, when fit together, form a unit load equal in size to the base dimension of the parent pallet.

5.2.6 Nestable. The design shall enable one pallet bin to interpenetrate another of the same geometric form to reduce storage space when empty.

5.2.7 Strap guides. The design shall incorporate guides that prevent the inappropriate movement of the load during transport by forklift.

5.2.8 Top lift cleats. A provision for top cleats shall be provided to permit a loaded pallet bin to be lifted and/or dumped using its top rim.

5.3 Handling features. The following handling features shall be specified when applicable.

5.3.1 Forklift compatibility. Pallet bins shall be compatible with commonly used forklift, pallet trucks and other conveyances or lifting devices common to the agricultural industry. Handling by fork can be of the two-way or four-way entry style.

5.3.2 Stackability. Pallet bins shall be designed for safety in stacking during handling, transit, and storage.

5.3.3 Systems compatibility. Pallet bins shall be designed to be compatible with generally accepted conveyor systems, rack storage systems and other mechanical handling devices.

5.3.4 Runners. A bottom deck board shall be provided to enclose the fork entry opening and shall be designed into a given pallet bin base as a permanent structure. Runner design shall allow the load to be handled on powered or nonpowered conveyor systems.

5.4 Ventilation and hydrocooling. The pallet bin design shall have sufficient openings in its bottom, and sides if needed, to provide uniform cooling or warming of product in the bin and to permit timely drainage of water during hydrocooling. The location, size and quantity of openings shall be user specified; however, a minimum of 5% open area in the bin bottom is recommended.

5.5 Product protection. To minimize damage to the contents, the pallet bin shall have a smooth inside surface free of protrusions. Ventilation shots or holes shall have a 13 mm (0.5 in.) minimum radius or chamfer on their edges.

5.6 Labeling and identification. Provision shall be made on the pallet bin for identification of the product within the container, and where possible, the container itself shall be identified by using color codes, branding, bar codes, card slots or other suitable methods.

6 Performance Tests

6.1 General. The purpose of performance and handling tests is to simulate (in an accelerated manner) the ordinary use that a pallet bin may be subjected to over its expected life. Performance criteria should be specified by the users and designed to meet their particular requirements. If only the pallet base is to be tested, the American National Standard ANSI/ASME MH1.4.1M, Procedures for Testing Pallets, may be used.

6.1.1 To assure confidence in test results, at least three pallet bins shall be subjected to each type of test. Also, if the test prescribes a loaded bin, the product for which the bin is intended shall be used as the test load.

6.1.2 One or more of the performance test procedures presented in this section may be specified for measuring expected performance against selected criteria.

6.2 Stacking test. The ability of the bins to endure expected stacking weights shall be determined by a stacking test. The test load may be determined by the following equation:

$$L = W \times n \times F$$

where

L = total load bottom pallet bins must withstand, N (lbf)

W = gross weight of loaded pallet bin, N (lbf)

n = expected number of overhead bins

F = safety compensating factor (1.5 is suggested)

The test bin shall be loaded with the same type bin or by a hydraulic compression tester. After the specified load has been applied, the container shall be examined for failure. The load requirement shall consider the effects of overload, time in storage and alignment.

6.3 Racking test. Measurement of the stiffness of a bin in the horizontal plane indicates resistance to racking. Holes shall be drilled in each top corner and a 0.64 cm (0.25 in.) diameter steel threaded rod with a dynamometer at the center shall be placed diagonally across the bin. Nuts shall be tightened on the rod from outside the bin until a force of 667 N (150 lbf) is recorded on the dynamometer. The distance from corner to corner is measured before any pull is exerted and again at the above specified force. The rods shall then be removed, placed across the other diagonal, and the same measurements repeated. The average change in the two diagonal measurements shall not exceed 7.0 cm (2.75 in.).

6.4 Rollover test. Racking resistance may also be tested by a rollover to simulate positioning of the empty bins in the field. Each test bin shall be subjected to a side-to-end rollover test on a strip of concrete pavement. The bin is tipped up on its side and pivoted up on one corner to just past the point of balance, and then shall be permitted to fall freely to the concrete. This procedure shall be repeated until 16 falls are completed or 4 revolutions of the bin. The difference in the racking measurements before and after the rollover test shall not exceed 10%.

6.5 Sag test. A sag test simulates the stress of placing full bins on uneven ground. For this test, a loaded bin shall be placed on a 10 × 10 cm (4 × 4 in.) timber so that the bin is oriented diagonally across the length of the timber. The sag of the unsupported corners in relation to the plane of the supporting timber shall be measured. The bin then is rotated 90 deg so that the other two corners are unsupported and the sag readings obtained. The sag shall not exceed 1.5 cm (0.6 in.).

6.6 Vibration test. The stress of vibration caused by truck or rail transport over rough roads shall be evaluated with a vibration test. For this test, a loaded bin shall be placed on a mechanically operated platform and vibrated at a frequency of 6 to 9 Hz for 30 min at peak acceleration of 4.90 m/s^2 (16.1 ft/s^2), 1/2 the acceleration of gravity. The vibration shall be stopped at 10 min intervals and bulge measurements taken on the sides and ends. Bulge shall not exceed 0.75 cm (0.30 in.). ASTM Standard D4169, Practice for Performance Testing of Shipping Containers and Systems, may be referred to for more detailed information on vibration testing.

6.7 Impact test. An impact test with a loaded bin shall be used to evaluate the resistance of the bin to severe lateral impacts. This test may be conducted using a pendulum or rolling incline device to horizontally impact the bin against solid steel or concrete bumpers at a velocity of 2 m/s (7 ft/s). The area of contact with the bumper shall be about 10 cm (4 in.) across the bottom of the bin. Four impacts are required, one on each side and end of the container. The side and ends will tend to rack out of square, and the resistance to this stress shall be determined by measuring the diagonals of the side or end impacted and calculating the change in dimensions due to impact. Change shall not exceed 0.5 cm (0.2 in.). ASTM Standard D4169, Practice for Performance Testing of Shipping Containers and Systems, may be referred to for more detailed information on impact testing.

6.8 Cornerwise-drop test. Resistance to dynamic racking stresses shall be evaluated by dropping a loaded bin on its corner. This is probably the most abusive test of the series and shall be conducted last. This test also is the most inclusive and shall be the single test to run if resources are not available to conduct the other tests in the series. This test shall be conducted by placing the loaded bin with one edge on a 15 cm (6 in.) high timber. One of the supported corners shall be blocked up with another 15 cm (6 in.) high block. The corner diagonally opposite the highest corner shall be lifted and set upon a block 15 cm (6 in.) high. This block then shall be jerked away allowing the unsupported side of the container to fall freely striking a steel plate embedded in a large mass of concrete. After the first fall, the bin shall be rotated 90 deg and the adjacent corner dropped in a similar manner. The other two corners shall be tested by the same procedure. The tests shall be repeated from heights of 30.5 cm (12 in.), 45.7 cm (18 in.), and 61 cm (24 in.). After a total of 16 cornerwise drops, 4 additional edgewise drops shall be made. These consist of 61 cm (24 in.) falls of one bottom edge while the other bottom edge is supported on just the 15 cm (6 in.) high timber. Evidence of deterioration or failure shall be recorded after each of the cornerwise and edgewise drops. Measurements shall also be taken on the amount of sag in the unsupported corners. Sag shall not exceed 9.0 cm (3.5 in.).

6.9 Top lift cleats. Pallet bins designed for handling with top lift cleats shall be tested by repeating a handling cycle that consists of filling, lifting and dumping. The bins tested shall be free of failure after 300 handling cycles.

6.10 Base deflection. Pallet bins loaded with 680 kg (1500 lb) of product shall not deflect more than 2.5 cm (1.0 in.) when lifted from a flat surface.

7 Specifications

7.1 Bin specification. Purchasers and other users shall give specifications of pallet bins by identifying applicable paragraphs from Section 2 Dimensions, Section 3 Capacity, Section 4 Materials, Section 5 Design Features, through Section 6 Performance Tests. The specifications in paragraphs 7.1 through 7.6 shall be designated when applicable.

7.2 Application. State the intended application of the pallet bin including products, environments, storage durations, stacking heights, etc.

7.3 Dimensions. The first dimension stated shall be the length, the second shall be the width, and the third shall be the height. Any additional dimensions shall be clearly identified and shall be compatible with ANSI Standard MH 1.2.2, Pallet Sizes.

7.4 Capacity. State the internal volume required and the maximum mass to be contained. Provide details on any calibration or maximum level indicators.

7.5 Materials. State any requirements for food safety, temperature range, radiation levels, moisture cycles, cleaning and sanitizing, or other special needs.

7.6 Design. State design requirements such as strength, service life, smoothness, stackability, ventilation, pallet entry, design features for food safety or bin safety, etc. Construction details may also be specified.

7.7 Testing. State any requirements for evidence that the pallet bins provided are capable of performing satisfactorily when evaluated according to specified test procedures.

References

Heebink, T. B. 1961. An evaluation of eleven bin-pallet designs. USDA. Forest Products Lab., Madison, WI. Report No. 2216.

Maley, W. A. 1967. Systems for bulk handling of food crops. ASAE Paper No. 67-429. ASAE, St. Joseph, MI 49085.

National Safe Transit Association. 1973. Pre-shipment test procedures. Chicago, IL.

O'Brien, M. 1960. Designs for bulk fruit bins. California Agricultural Experiment Station, University of California, Davis. Circular 490.

Wardowski, W. F., and W. Grierson. 1978. Pallet boxes for Florida citrus. Florida Cooperative Extension Service, University of Florida, Gainesville. Circular 443.

Cited Standards

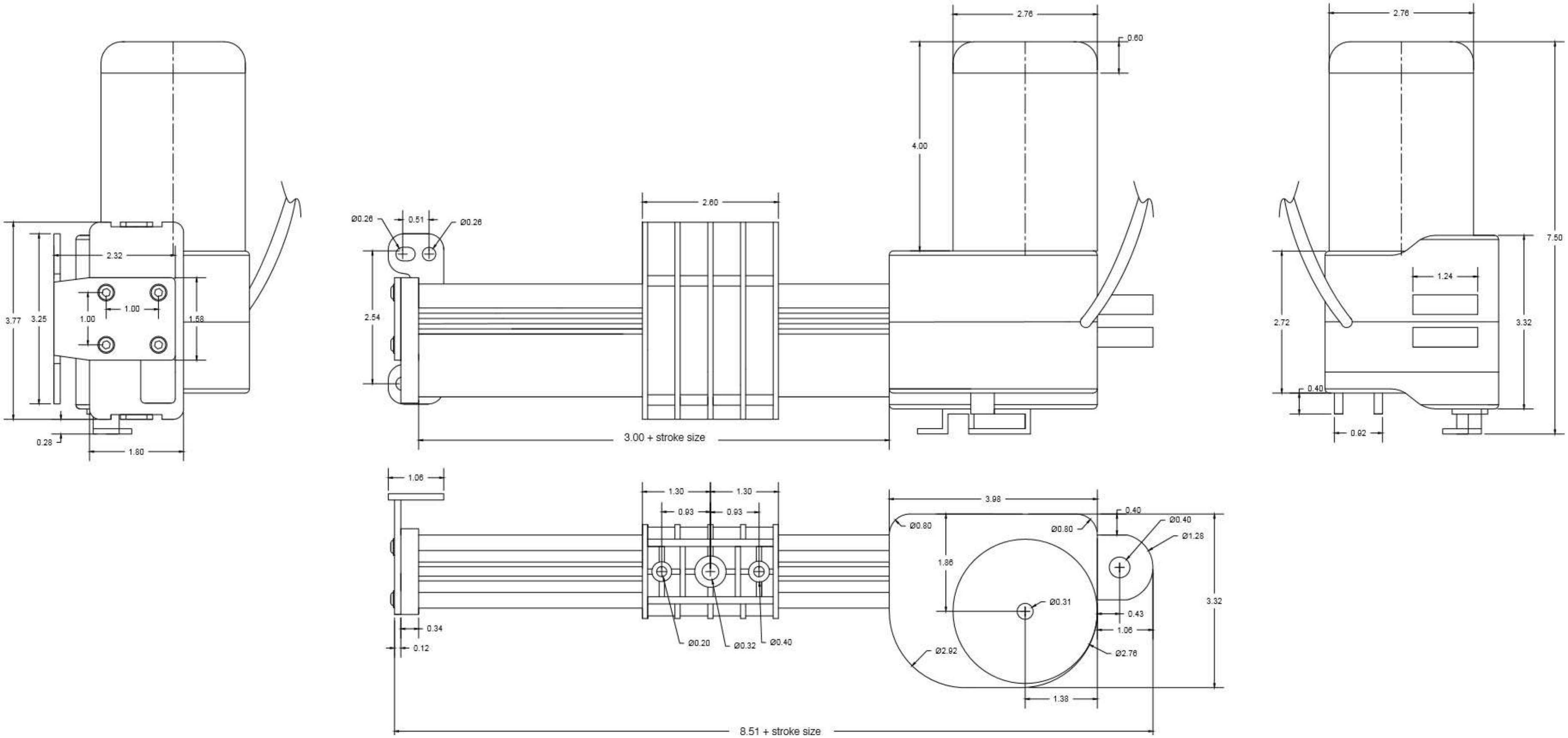
ANSI/ASME MH1.4.1M, Procedures for Testing Pallets

ANSI MH1.1.2, Pallet Bins and Terminology

ANSI MH1.2.2, Pallet Sizes

ASTM D4169, Practice for Performance Testing of Shipping Containers and Systems

DIMENSIONS IN INCHES



4.1.3.3 Operation Cost Table

Operations Cost Table	
Operation	Cost (in U.S. Dollars)
CNC Machining	70.00/hr
Weld	0.06/cm (0.15/inch)
Saw cut	0.15/cm (0.38/inch)
Tube Bends	0.75/bend
Pre-welding preparation for tube ends	0.75/end
Drilled hole smaller than 1" dia., any depth	0.35/hole
Drilled hole larger than 1" dia.	0.35/inch greater than 1" per hole
Tapped Hole	0.35/hole
Sheet metal shearing	0.20/cut
Sheet metal bends (under 3/8 inch thickness)	0.05/bend
Plate bends (material over 3/8 inch thickness)	0.10/bend
Sheet metal punching	0.20/hole
Plasma cutting/ Lazer cutting	0.10 /inch
Fiberglass	$9.00/sq ft
*Powder coating	$55.00/hr
Chromeplating/anodizing/phosphate coating	$2.00/foot
**Painting	$50.00/hr
Assembly of nut,bolt, and washer	0.10/per
Component assembly (Time)	35.00/hr
Labor (machine set-up, load, unload)	45.00/hr
Miscellaneous operations	Obtain quote on 3000 pieces
* Does not include painting.	