American Journal of Mechanical Engineering, 2017, Vol. 5, No. 4, 128-137
Available online at http://pubs.sciepub.com/ajme/5/4/3

DOI:10.12691/ajme-5-4-3

Fixed Enclosure Guards and the Safety of Horizontal Screw Conveyors

Ralph L. Barnett*

Mechanical and Aerospace Engineering Triodyne Inc, 3054 N. Lake Terrace Glenview, IL
*Corresponding author: rbarnett@triodyne.com

Abstract One cannot overstate the value and ever growing importance of the screw conveyor and one cannot overemphasize the intrinsic danger associated with this classic monster. This danger can be controlled using fixed enclosure guards that are not only compatible with the function of screw conveyors but are anecdotally acknowledged to be the most desirable type of guard. Nevertheless, the speciality conveyor standards promulgate dangerous guarding systems with features two levels below the fixed barrier guard. This paper revisits the system of conveyor safety standards to rout out equivocal notions, expose shortcomings, and generally demonstrate that a foolish inconsistency is not the hobgoblin of small minds. Finally, this paper challenges the notion that a fixed enclosure guard is an elementary concept whose parameters are settled; e.g. a machine inside of a welded steel box. The definition of fixity and the duality of operation and maintenance are both explored.

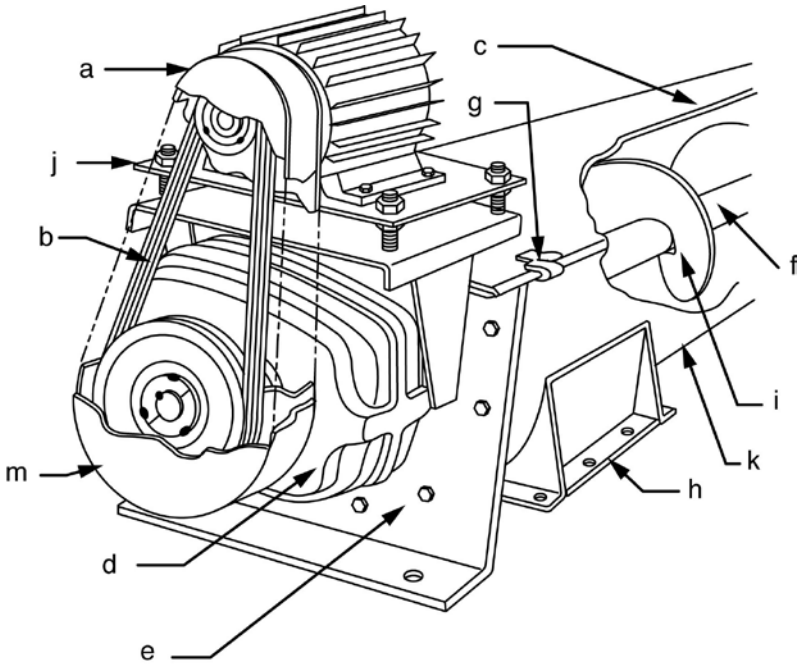

Figure 1. Typical Horizontal Screw Conveyor System [Taken from Figure 8.1, ANSI/CEMA 350-2009]

Keywords: *auger, CEMA, fixed guard, screw conveyor, standard*

Cite This Article: Ralph L. Barnett, "Fixed Enclosure Guards and the Safety of Horizontal Screw Conveyors." *American Journal of Applied Mathematics and Statistics*, vol. 5, no. 4 (2017): 128-137. doi: 10.12691/ajme-5-4-3.

1. Introduction

The screw conveyor was invented by Archimedes (287 to 212 B.C.) for removing water from the hold of a ship built for King Hiero of Syracuse [1]. It has a long history as a conveyor of bulk materials and a reputation as an uncompromising safety hazard with a benign appearance. For this reason, various standards have been developed that focus on the dangers associated with screw conveyors. This paper examines the viability of these standards.

Presently, available safety standards are classified [2] into three categories; A-type standards, B-type standards, and C-type standards.

A-Type Standards:

Definition: A-type standards specify basic concepts, terminology, and design principles applicable to all categories of machinery [2].

Examples:

1) ANSI B11.19-2010, American National Standards for Machines – Performance Criteria for Safeguarding [3].
2) BS 5304: 1988, British Standard Code of Practice for Safety of Machinery [4].

B-Type Standards:

Definition: B-type standards deal with specific aspects of machinery safety or specific types of safeguarding that can be used across a wide range of categories of machinery [2].

Examples:

1) JIS B 9702: 2000 (ISO 14121: 1999), Japanese Industrial Standard; Safety of Machinery – Principles of Risk Assessment [5].
2) JIS B 9714: 2006 (ISO 14118: 2000), Japanese Industrial Standard; Safety of Machinery – Prevention of unexpected start-up [6].
3) JIS B 9716: 2006 (ISO 14120: 2002), Japanese Industrial Standard; Safety of Machinery – Guards – General requirements for the design and construction of fixed and movable guards [7].
4) ISO 14119 (Second edition 2013-10-01), International Organization for Standardization; Safety of Machinery – Interlocking devices associated with guards – Principles for design and selection [8].

C-type Standards:

Definition: C-type standards provide specifications for a given category of machinery. The different types of machinery belonging to the category covered by a C-type standard have a similar intended use and present similar hazards. C-type standards may refer to A or B-type standards indicating which of the specifications of the A or B-type standard are applicable to the category of machinery concerned. When, for a given aspect of machinery safety, a C-type standard deviates from the specifications of an A or B-type standard, the specifications of the C-type standard take precedence over the specifications of the A or B-type standard [2].

Examples (Conveyor Standards):

1) ANSI/CEMA 350-2009, Conveyor Equipment Manufacturers Association (CEMA) – Screw Conveyors for Bulk Materials [9].
2) OSHA, Title 29→Subtitle B→ Chapter XVII part 1926 – Safety and Health Regulations for Construction, §1926.555 Conveyors, e-CFR data is current as of May 14, 2015 [10].
3) ASA B20.1-1957 (UDC 621.876 – 783), American Society of Mechanical Engineers – Safety Code for Conveyors, Cableways and Related Equipment. Note: OSHA refers to ANSI B20.1-1957, not the latest ASME B20.1-2012 standard (approved by ANSI) [11].
4) ASME B20.1-2012, American Society of Mechanical Engineers, An American National Standard – Safety Standard for Conveyors and Related Equipment [12].

The internal consistency of these standards will be challenged together with the premises behind their assertions. One of our approaches is to look beyond the ABC's of safety technology toward the judicial value system where the concept of "reasonable foreseeable use" dominates as a definitive criterion for safety evaluation. This concept requires a practicable design solution when a safety problem can be forecast to occur with reasonable frequency [13]. Traditionally, technologists have focused exclusively on the expected use of their products with the associated safety requirements that derive from their function. The judicial value system greatly expand this point of view to embrace all the uses of a product. These include the reasonably foreseeable misuses and extended uses of the works and processes of technology. It is startling to watch technologists bristle and squirm at the new and unanticipated uses that folks find for their original concepts.

As a final safety evaluation tool, this paper embraces the first canon of ethics of every engineering society; "Engineers shall hold paramount the safety, health, and welfare of the public in the performance of their professional duties." Note that welfare includes economic well-being.

2. Fixed Enclosure Guard

A. Operational Characteristics

The theoretical operation of a fixed enclosure guard is illustrated in Figure 2 where the protected hazard is represented by the triangular international safety symbol. The space giving rise to a contact hazard is surrounded by a safety boundary which must not be penetrated by a person's body; this is designated "Unsafe Zone." Between the Unsafe Zone and the inside of the enclosure guard is a space designated "Quasi-Safe Zone." There are no contact hazards in the Quasi-Safe Zone; however, there may be other hazards caused by missiles, heat, radiation, entrapment, and various non-mechanical threats. Outside of the enclosure guard the space is characterized as a "Safe Zone." With a properly designed enclosure guard, the Safe Zone provides a haven from mechanical contact hazards and missile hazards. In addition, injury is abated from noise, radiation, pressurized and poisonous fluids and gases, microbes, and perhaps rap music.

The design challenge of the enclosure guard arises from multiple functional demands to admit, contain, restrict, and release physical entities. Consider the following examples:

1. Admit Into Hazard Zone
   - Work pieces
   - Light
   - Tools
   - Debris (Vacuum Cleaners, Rakes)
   - Coolants
2. Contain Within Enclosure Guard
   - Shrapnel
   - Swarf
   - Welding (Ultraviolet, Infrared, Sparks)
3. Restrict Access to Hazard
   - Hair
   - Fingers
   - Torso
   - Debris
   - Clothing
4. Release From Quasi-Safe Zone
   - Fluids/Gases
   - Entangled Hair
   - Wedged Fingers

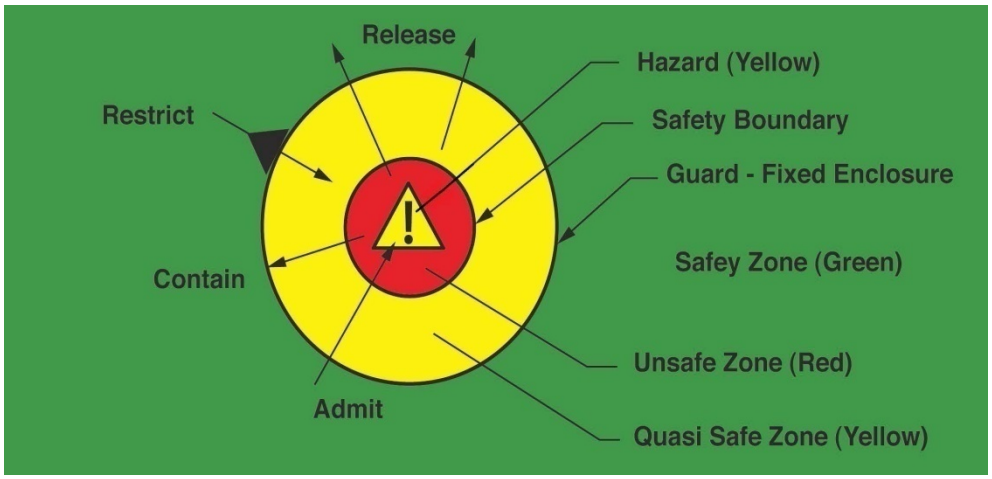

Figure 2. Operating Fixed Enclosure Guard

5. Release From Unsafe Zone
   - Finished Product
   - Scrap/Chips
   - Heated Air
   - Lubricants.

B. Fixity

What is the difference between an enclosure guard and a fixed enclosure guard? In the usual way, technologists have relied on consensus rather than research to answer this question. The resulting literature on fixed guards may be broken into five categories;

1. Unspecified Fixity
   - Great Britain, Factories Act of 1937. London, His Majesty's Stationary Office, 1937.

"…The Factories Act, 1937…places clear emphasis on the use of a fixed guard as the primary method of attaining secure fencing…When we refer here to a fixed guard, we mean a static fixed enclosure secured to the press so that there can be no access of the person to the danger area." p. 6.

2. Not Readily Removable by the Operator
   a. "Safety Requirements for Construction, Care, and Use of Lathes," ANSI B11.6-1975 New York: American National Standards Institute, 1975 [14].

5.9.1 Fixed Guards

Fixed guards used to satisfy the requirements of this standard shall do the following:

(3) Be securely attached to the lathe frame, component, or fixture, and utilize fasteners not readily removable by the operator p. 29.

   b. "American National Standard for Machine Tools—Single- and Multiple-Spindle Automatic Bar and Chucking Machines —Safety Requirements for Construction, Care and Use," ANSI B11.13-1992. New York, American National Standards Institute, approved June 2, 1992 [15].

"6.2.1 Fixed Guards

Fixed guards used to satisfy the requirements of this standard shall:

   c. Be securely attached to the machine, its components, or fixtures, and where possible, utilize fasteners not readily removable."

3. Secured Using Tools
   a. "Safeguarding of Machinery," BS 5304: 1975. London, British Standards Institution, 1975 [16].

"9. Fixed Guard

A fixed guard should be used whenever practicable. The guard should, by its design, prevent access to the dangerous parts of the machinery. It should be of robust construction, sufficient to withstand the stresses of the process and environmental conditions. It should be securely fixed in position when the machinery is in motion or is likely to be in motion, and it should not be possible to remove or open the guard at any time without the aid of a tool." p. 9.

   b. McNeil-Watson, D.B., "Some Advantages of Mechanical Guarding Systems," Sheet Metal Industries v. 54 (September 1977): pp.808-814 [17].

"When the Factories Act refers to 'Secure Fencing' it is instinctive to think of fixed guarding, and rightly so, because by every process of logical thinking, it is necessary to accept that the best solution to a dangerous mechanical situation is to enclose it with a structure which completely prevents human access. Unfortunately, life is not always that simple."

"Access may never be required to some parts, but in some places it will be necessary to remove the guards occasionally for maintenance, lubrication or adjustment, and in others every time the machine is set up for a different job, or even to clear a jam-up if mis-feeding occurs. So how fixed is fixed?"

"A school of thought, which is now gaining ground, advocates different treatment for these varying situations… but where guards frequently have to be moved during the normal course of events, then, in addition to normal fixing, involving the use of hand tools, some form of interlocking should be included, to ensure safety to the person requiring access." p. 808.

   c. "British Standard Code of Practice for Safety of Machinery," BS 5304: 1988. London, British Standards Institution, 1988 [4].

"Section six. Selection of safeguards…6.1 General…In selecting an appropriate safeguard for a particular type of machinery or danger area, it should be borne in mind that a fixed guard is simple, and should be used where access to the danger area is not required during operation of the machinery or for cleaning, setting or other activities."

"As the need for access arises and increases in frequency, the importance of safety procedures for removal of a fixed guard increases until the frequency is such that interlocking should be used. However, on some designs of self-propelled and trailed machines, it may not be reasonably practicable to fit interlocks at every guard. The requirements of safety procedures and/or interlocking will become more stringent as the level of risk increases…" p. 41.

Section 7.2 Types of guard 7.2.1 Fixed guard 7.2.1.1 General. Fixed guard is a guard which has no moving parts.

"The guard should, by its design, prevent access to the dangerous parts of the machinery. It should be of robust construction, sufficient to withstand the stresses of the process and environmental conditions."

"If the guard can be opened or removed, this should only be possible with the aid of a tool. Preferably the fastenings should be of the captive type. The guard should be securely fixed in position when the machinery is in motion or is likely to be in motion. Where guards have to be removed periodically, e.g., for such purposes as setting or cleaning, good design reduces the time required for their removal and replacement to a minimum. Ideally the removal of a single fixing with the appropriate tool should give the access required…" p. 43

d. "Safety of machinery—Guards—General requirements for the design and construction of fixed and movable guards," BS EN 953:1998. London: British Standards Institute, 1998 [18].

"3.2 fixed guard

Guard kept in place (i.e. closed):

--by means of fasteners (screws, nuts, etc.) making removal/opening impossible without using tools." p. 4.

e. Nicholas, Robert, "Keeping Guard," Safety and Health Practitioner, v. 18 n. 12 (December 2000): pp. 24-25 [19].

"Machinery safeguards and/or safety devices must not be considered as the first or only option for the prevention of exposure to machinery hazards. Physical safeguards can only be considered a viable alternative if attempts to eliminate hazards at the design stage have been deemed to be impracticable." p. 24.

"A fixed guard is one which is attached to the machine by simple fixing methods. The guard is not linked with the machine controls, motion of the machine or any hazardous situation created."

"Where a fixed guard is fitted it should not be capable of being casually displaced. Therefore the method of fixing is of vital importance to the integrity of the guard and the safety of the operator. BS EN 953: 1997 requires that fixed guards should be kept in place either permanently by welding, etc… or by means of fasteners (screws, nuts/bolts, etc) making removal/opening impossible without the use of tools." p. 24.

f. "British Standard Code of Practice for Safety of Machinery," PD 5304: 2000. London, British Standards Institution, 2000 [20].

"Section 7.2 Types of guard "

7.2.1 Fixed guard

"7.2.1.1 General. A fixed guard is a guard which is kept closed and in place.

"The guard should, by its design, prevent access to the hazardous parts of the machinery. It should be of robust construction, sufficient to withstand the stresses of the process and environmental conditions."

"If the guard is capable of being opened or removed, this should only be possible with the aid of a tool. Preferably the fastenings should be of the captive type. The guard should be securely fixed in position when the machinery is in motion or is likely to be in motion. Where guards have to be removed periodically, e.g., for such purposes as setting or cleaning, good design reduces the time required for their removal and replacement to a minimum. Ideally the removal of a single fixing with the appropriate tool should give the access required…"

g. "American National Standard for Machine Tools—Safety Requirements for Machining Centers and Automatic, Numerically Controlled Milling, Drilling and Boring Machines," ANSI B11.23-2002. New York, American National Standards Institute, approved June 14, 2002 [21].

"8.2.2 Fixed guards

A fixed guard shall be kept in place (i.e., closed) by either permanent means (e.g., welding), or by means of fasteners (e.g., screws, bolts), making removal/opening virtually impossible without the use of tools."

h. "American National Standard for Machine Tools Performance Criteria for Safeguarding," ANSI B11.19-2003 New York: American National Standard Institute, 2003 [22].

"7.2.6 The user shall ensure that barrier guards are installed, maintained, and operated so as to protect against:

(a) Unauthorized adjustment or circumvention;

E7.2.6 Guards installed in such a manner that tools are necessary for their adjustment or removal may satisfy this requirement. Training and supervision in the adjustment, maintenance, and operation of the safeguarding are necessary to ensure its proper operation." p. 14.

4. Secure With Special Tools (or Lock)

a. "Guarding of Machinery," CP 3004: 1964. London, The Council for Codes of Practice, British Standards Institution, 1964 23].

"a. Fixed guards. This type of guard should be provided in every practicable case since the Factories Act 1961 places clear emphasis on the use of a fixed guard as the primary method of attaining secure fencing."

"The guard should by the nature of its design and construction, prohibit access to the dangerous parts of machinery and should remain in position after installation."

"Where, for the purpose of production, e.g., to remove some obstruction, a fixed guard is removable without the use of special tools, it should incorporate a lock to ensure that it cannot be removed while the machine is in motion" p. 15.

b. "Principles of Guarding and Transmission Guards," Accident Prevention Manual for Industrial Operations, 6th ed. Chicago, National Safety Council, 1969, p. 658-689 [24].

"Fixed barrier guards Fixed barrier guards may be designed with a pivoting, sliding, or removable section to allow ready access to the die…" p. 704

"This type of [interlocked fixed barrier] guard should be secured to the press frame with fasteners which require a special tool, retained only by the foreman or the job setter, for removal." p. 706.

c. "American National Standard for Machines – Performance Criteria for Safeguarding," ANSI B11.19-2010, Leesburg, VA: B11 Standards, Inc [25].

"7.2.6 The user shall ensure that guards are installed, maintained, and operated so as to protect against:

- unauthorized adjustment or circumvention;

E7.2.6 Guards installed in such a manner that tools are necessary for their adjustment or removal may satisfy this requirement. Training and supervision in the adjustment, maintenance, and operation of the safeguarding are necessary to ensure its proper operation. Examples of some types of fasteners that should not be used are:

- slotted or Phillips head screws;
- wing nuts;
- magnets;
- latches and hasps;
- hooks and eyes.

The devices should be checked frequently for proper operation."

Comment A: Although no one has done it, a special tool can be defined as a tool not normally available to the community of personnel exposed to the fixed guard. The maintenance staff, of course, always has the means of removing a fixed guard.

Comment B: A guard lock key held by the maintenance staff is equivalent to a special tool.

Comment C: Instead of defining a special tool, ANSI B 11.19-2010 describes the devices that are not special; e.g. wing nuts and latches.

5. Permanent Fasteners

a. Nicholas, Robert, "Keeping Guard," Safety and Health

Practitioner, v. 18 n. 12 (December 2000): pp. 24-25. "… fixed guards should be kept in place…permanently by welding, etc…"

b. "American National Standard for Machine Tools—Safety Requirements for Machining Centers and Automatic, Numerically Controlled Milling, Drilling and Boring Machines," ANSI B11.23-2002. New York, American National Standards Institute, approved June 14, 2002.. "A fixed guard shall be kept in place (i.e. closed) by … permanent means (e.g. welding),…"

c. "American National Standard Safety Requirements for Transfer Machines," ANSI B11.24-2002 New York: American National Standards Institute, 2002 [26]

"8.2.2 Fixed guards.

A fixed guard shall be kept in place (i.e., closed) by either permanent means (e.g., welding), or my means of fasteners (e.g., screws, bolts), making removal/opening virtually impossible without the use of tools." p. 31

Triodyne, Inc. maintains a collection of sixty papers on fixed guards under the title "Fixed Versus Interlocked Guards." The associated annotated bibliography was the source for the 'Fixity Papers' cited in Section II-B. In spite of their diversity, the sixty papers all support one unifying theme; fixed enclosure guards should be used in preference to all other types.

3. Horizontal Screw Conveyor Safety

A. Description

Figure 1 illustrates one of the most commonly used horizontal screw conveyor systems with a self-contained screw conveyor drive consisting of a fully enclosed single or double reduction speed reducer (d) which drives a low speed shaft (f) through a special mounting trough end adapter (e). This reducer is driven by a V-belt drive.

(a) powered by an enclosed electric motor (a) mounted on a motor support bracket (j). The conveyor screw (i) is contained within a trough (k) that is covered with a cover guard (c) held in position with a fastener (g). A power transmission guard (m) covers the belt drive. Finally, a discharge spout (h) is shown on the bottom of the trough.

B. ANSI/CEMA 350-2009

The four C-Type standards identified in the introduction to this paper provided the most authoritative safety guidelines in the U.S. for designing horizontal screw conveyors. The viability and consistency of these standards is examined in this section which begins with the 160 page Screw Conveyor Book No. 350; ANSI/ CEMA 350-2009. This document has been developed and maintained by members of CEMA, the trade association of the Conveyor Equipment Manufacturers Association. Although there is no formal section entitled 'Scope,' the safety orientation of this book can be divined from the following excerpts:

- CEMA Organization Chart…shows a Safety Committee.
- Disclaimer: "The information provided in this document is advisory only. These recommendations are provided by CEMA in the interest of promoting safety in the work place."
- Chapter 5, Installation, Operation and Maintenance Safety

"Conveyor assemblies or components must be installed, maintained and operated in such a manner as to comply with the Occupational Safety and Health Act, all state and local regulations, and the American National Standard Institute safety code." (Note: Specific Standards are not identified)

- Chapter 4: Trough Covers

"The functions of trough covers are (1) where personnel are not protected by the inaccessible location of the moving parts of a conveyor, to protect personnel from serious injury resulting from contact with the rotating screw, and (2) to keep the conveyed material and dust within the conveyor housing and to exclude foreign materials.

1. COVERS AND GRATINGS. Use rugged gratings in all open loading areas and solid covers in other areas. Covers, guards and gratings at inlet points must be such that personnel cannot be injured by the screw.
2. LOCK-OUT AND TAG-OUT. A formalized lock-out or tag-out procedure must be followed when

a conveyor is stopped for maintenance or repairs and before conveyors or guards are removed. All safety devices, covers, and guards shall be replaced before starting equipment for operation.

3. GUARDS. For protection of the operator and other persons in the working area, purchaser should provide guards for all exposed equipment such as drives, gears, shafts, couplings, etc. In this publication, some guards and covers are shown removed to facilitate viewing of moving parts. Equipment must not be operated without guards and covers in place.

NOTE: DO NOT STEP OR WALK ON CONVEYOR COVERS OR GRATING OR POWER TRANSMISSION GUARDS."

- Standard Safety Labels

a. Penetration Scenario

b. Power Transmission Hazard

c. Contact Hazard

Figure 3. Typical Product Warning Labels (ANSI/CEMA 350-2009)

C. Fixed Enclosure Guard v. Enclosure Guard

There are numerous admonitions in the ANSI/CEMA standard not to operate screw conveyors without a solid cover or a grating in situ. The most important issue raised in this paper is that of fixity. It is unequivocal that the standard calls for enclosure guards; with proper fixity they become fixed enclosure guards.

1. Gravity Based Fixity

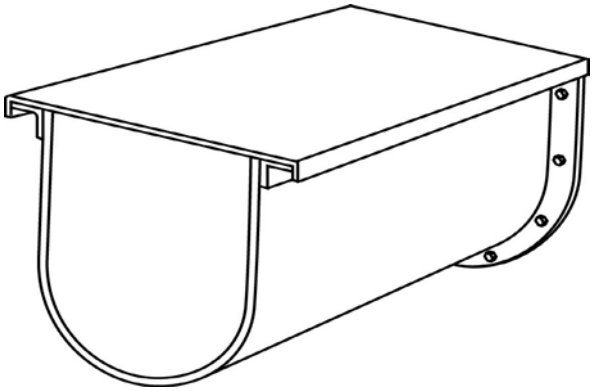

Figure 4a. Conventional Flanged Cover [ANSI/CEMA 350-1971, 2009 (After Figure 1.4)]

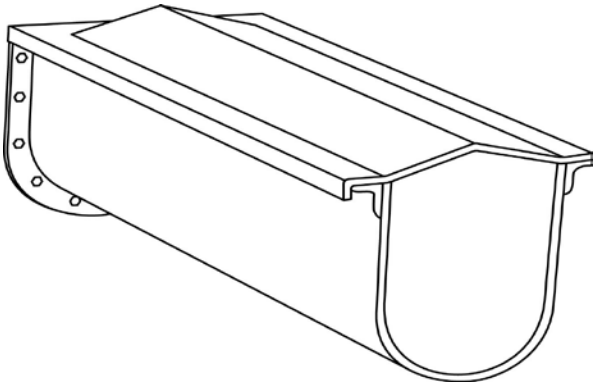

Figure 4b. Hip Roof Cover [ANSI/CEMA 350-1971, 2009 (After Figure 5.9D)]

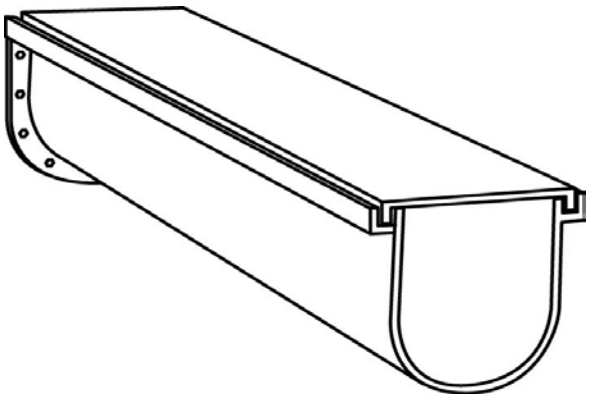

Figure 4c. Dust Seal Covers [ANSI/CEMA 350-1971, 2009 (After Figure 5.9B)

Comment A: The covers shown in Figure 4a, Figure 4b, Figure 4c are held in position by gravity alone. The covers were illustrated in the earliest (1971) and latest (2009) editions of ANSI/CEMA 350.

Comment B: ASME B20.1-2012, Safety Standard for Conveyors and Related Equipment, The American Society of Mechanical Engineers - this standard is silent

on the subject of fixity. The sections of the standard that apply to screw conveyors are provided in Reference A.

Comment C: OSHA.: Title 29 – Subtitle B – Chapter XVII – Part 1926 – Safety and Health Regulations For Construction; § 1926.555 Conveyors - there are only two references to screw conveyors in OSHA's Construction Regulations,

- (4) Screw conveyors shall be guarded to prevent employee contact with turning flights.
- Referenced by OSHA; ANSI B20.1 – 1972, "Safety Code for Conveyors, Cableways, and Related Equipment," The American Society of Mechanical Engineers, [27]

Section 21 Screw Conveyor

Troughs or boxes should be equipped with a cover. If it is not practical to cover the troughs or boxes, other guards shall be provided.

Observe that OSHA does not require guard fixity.

Comment D: The only three U.S. C-Type standards covering screw conveyors require only enclosure guards; they do not specify fixed enclosure guards.

Comment E: The principle of "reasonably foreseeable use" requires a fixed enclosure guard for screw conveyors not safeguarded by location or interlocking. This fixed guard protects personnel against reasonably foreseeable misuses such as the following:

- Walking or stepping on the covers or grating that is warned against in ANSI/CEMA 350.
- Failure to replace covers after maintenance.
- Accidentally displacing unsecured covers by bumping or leaning.
- Deliberate removal of covers for inspection, curiosity, disposal of spilled product, and for troubleshooting.
- Dislodging unsecured covers when conveyed material bulges up at the ends of the conveyor near a clogged discharge spout. This scenario is illustrated in Figure 8 - Photograph.

Comment F: Unsecured covers will not satisfy Type-A standards such as ANSI B11.19-2010, Performance Criteria for Safeguarding.

Comment G: Unsecured covers will not satisfy Type-B standards such as ISO 14120: 2002 (E); note, [28]

6.4.2 Where access is not required during use,

Fixed guards should be used on account of their simplicity and reliability.

2. Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO/TR 12100-1 and EN 1070 and the following apply. [29]

2.1. guard part of a machine specifically used to provide protection by means of a physical barrier

NOTE 1 Depending on its construction, a guard may be called casing, cover, screen, door, enclosing guard, etc.

NOTE 2 A guard may act:

- Alone, in which case it is only effective when it is closed;
- In conjunction with an interlocking device with or without guard locking, in which case protection is ensured whatever the position of the guard (see also 3.5).

NOTE 3 "Closed" means "kept in place" for a fixed guard.

[ISO/TR 12100-1:1992, 3.22]

2.2. fixed guard guard kept in place, that is closed, either permanently (by welding, etc.), or by means of fasteners (screws, nuts, etc.) making removal/opening impossible without using tools.

[ISO/TR 12100-1:1992, 3.22.1]

2.2.1 enclosing guard guard which prevents access to the danger zone from all sides.

3. Fasteners - No Tool Required

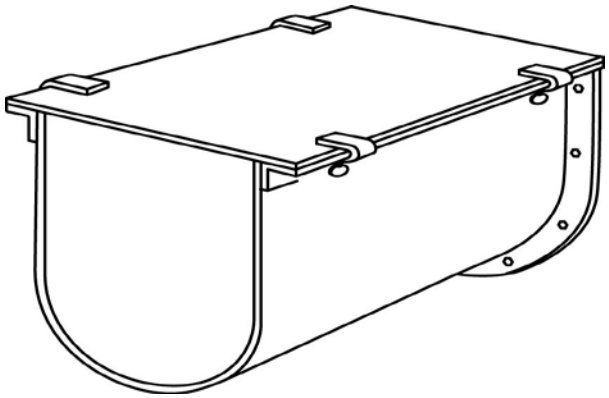

Figure 5a. Angle Flanged Type Trough With Plain Flat Cover Fastened with Thumb-Screw "C" Clamps [ANSI/CEMA 350-2009 (Figure 4. 16C)]

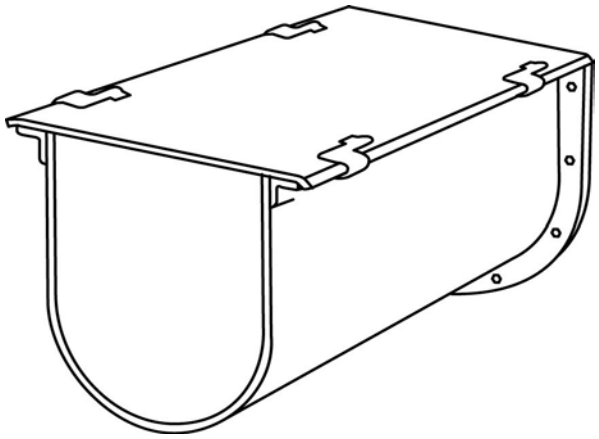

Figure 5b. Angle Flanged Type Trough With Semi-Flanged Cover Spring Clamped [ANSI/CEMA 350-2009 (Figure 4. 16D)]

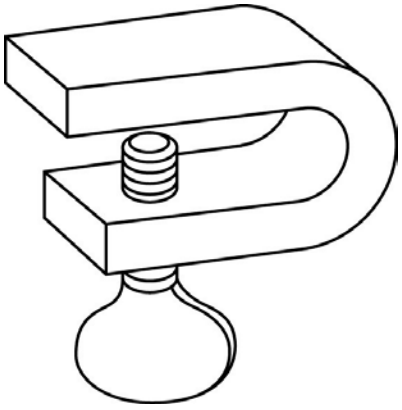

Figure 5c. Thumb-Screw Cover Clamp [ANSI/CEMA 350-2009 (Figure 4. 16E)]

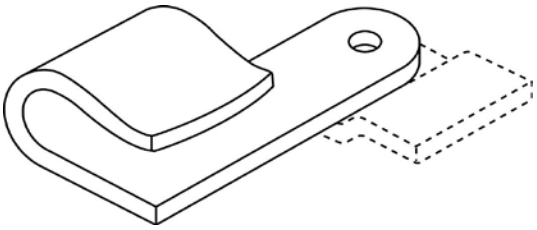

Figure 5d. Spring Cover Clamp Welding Bracket Optional

Comment A: The two covers illustrated in Figure 5a and Figure 5b are both taken from the 1971 and 2009 editions of ANSI/CEMA 350. Each is clamped into position using the fasteners shown in Figure 5c and Figure 5d which require no tools for their installation. In thirty- eight years no safety progress has been reflected in these standards.

Comment B: The two Type-C standards, ASME B20.1 or OSHA Construction regulations (Part 1926), place no prohibitions on the use of "tool free" fasteners. Furthermore, no fixity requirements are found in the OSHA regulations concerning Occupational Safety and Health Standards (Part: 1910). The specific machine regulations sometimes refer to ASME B20.1-1957.

Comment C: The previously cited Type-A and Type-B standards covering general safety principles and barrier guarding reject "tool free" fasteners.

Comment D: Recall that users are required to give preference to Type-C standards such as ANSI/ CEMA 350-2009. Consequently, conscientious designers often create old-fashioned dangerous screw conveyor systems.

Comment E: The thumb screw clamp shown in Figure 5c has four potential shortcomings that are not discussed in the CEMA Book 350,

- Lost Clamps…Because clamps are regularly removed to inspect, unjam, and maintain screw conveyors, it is not surprising that they occasionally disappear when there is no tethering. The spring clamp shown in Figure 5d can be secured below the trough flange by rivets with flat counter-sunk heads that lie flush with the top of trough flange.
- Tramp Metal…the clamps can fall into the trough.
- Relocation…the number and position of reinstalled clamps is often compromised by primitive communications. For example the OSHA regulations for Bakery Equipment §1910.263 addresses this problem;

(7) Screw Conveyors

(i)(ii) [Reserved]

(iii) The covers of all screw conveyors shall be made removable in convenient sections, held on with stationary clamps located at proper intervals keeping all covers dust-tight. Where drop or hinged bottom sections are provided this provision shall not apply.

- Permanent Distortion…Tightening the thumb screw with hand tools such as pliers, adjustable wrenches, or lock pliers is a reasonably foreseeable misuse that can yield the C-Clamp. Testing of a 2-inch cover clamp established an elastic limit compression force of approximately 500 lb; hand tightening produces 300 lb. All hand tools over 6-inches in length can develop clamping forces that exceed 500 lb.

4. Fasteners - Tool Required

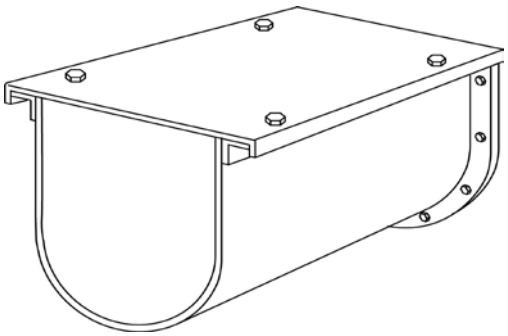

Figure 6. Angle Flanged Type Trough With Flanged and Bolted Cover [ANSI/CEMA 350-1971, 2009 (Figure 4.16A)]

The bolted cover depicted in Figure 6 requires a wrench to install or remove the fasteners. Because a tool is required to gain access to the auger, the cover is called a fixed enclosure guard.

All of the covers shown in Figure 4, Figure 5 can be converted to fixed enclosure guards by bolting or welding a grating inside of the troughs as illustrated in Figure 7. The dual system provides proper personnel protection with the grating whereas environmental protection is supplied by the unbolted covers. The grating allows the conveyor to be safely filled or inspected while the machine is running.

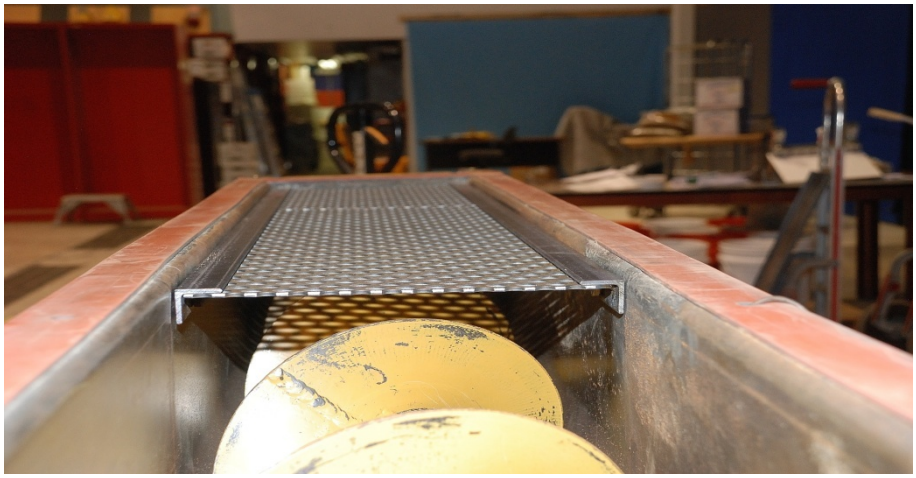

Figure 7. Fixed Grating Inside of Trough

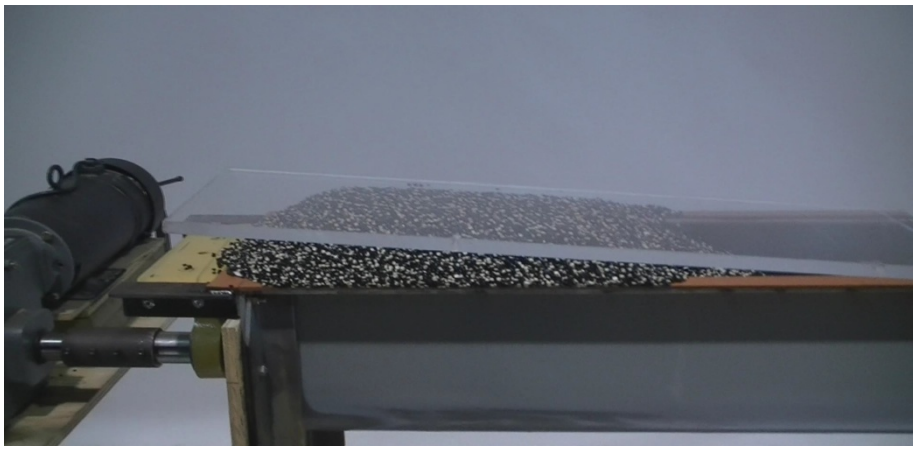

Figure 8. Material Driven to Dead End - Bulging Lifts Plastic Cover

5. Hinged Cover

The following description of the hinged cover shown in Figure 9 is taken from the ANSI/CEMA standard:

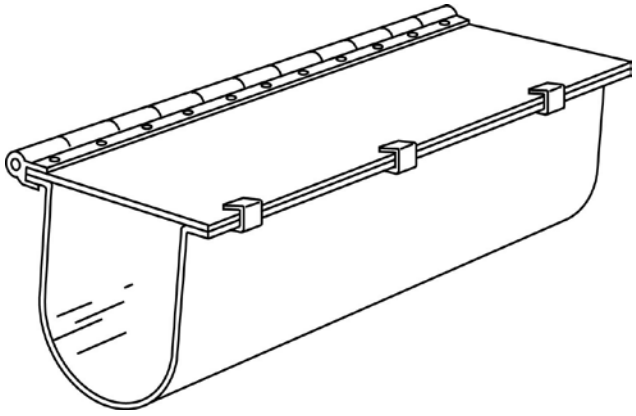

Figure 9. Hinged Cover [ANSI/CEMA 350-1971, 2009 (Figure 5.9C)]

Hinged Covers

"Hinged covers may be constructed from conventional flat covers or other special covers. They are equipped with a continuous (piano) type hinge along one edge. The other edge is bolted or clamped to the trough flange. Hinged covers are used in applications where it is not desirable to have a cover that must be completely removed such as high areas above walkways or work spaces where a detached cover might fall."

Comment A: When the fasteners are clamps that do not require a tool, the system is called an enclosure guard. The use of bolt fasteners provides a fixed enclosure guard.

Comment B: With an unfastened cover or a clamped cover the system can be converted to a fixed enclosure guard by the addition of a fixed grating for filling or inspecting the conveyor.

Comment C: The hinged cover is ideally suited to interlocking when the environment is compatible with the interlock system. The ANSI/CEMA 350 standards do not address interlocking. On the other hand, the Type-A standards readily endorse properly designed interlocked guards [e.g. ANSI B11.19-2010, 7.1.9].

Comment D: As shown in Figure 8, impeding the flow from a discharge chute may cause the product to bulge and lift an unsecured cover.

4. Observations

A. The most popular and extensive guide for designers of screw conveyors is the C-Type standard ANSI/CEMA 350-2009. This 160 page book does not require, support, or encourage the adoption of fixed enclosure guards. In the 38 years since the last publication of this standard, no change had been made in its position on guarding.

B. All of the A-Type and B-Type standards on general safety principles and the theory of guarding, both national and international, recognize that the fixed enclosure guard is the safest, simplest, and most reliable guarding system and should be used wherever possible. Without exception, the entire guarding literature supports this position.

C. OSHA does not require employers to use fixed enclosure guards around screw conveyors. This C-Type standard refers to the 43 year old conveyor standard, ASME 20.1.-1957.

D. The latest C-Type safety standard on conveyors, ASME B20.1-2012, requires enclosure guards on screw conveyors; but not fixed enclosure guards.

E. The principle of "reasonably foreseeable use" would reject enclosure guards for screw conveyors that are not fixed.

F. The notion of a fixed enclosure guard which appears straightforward at first blush, becomes very sophisticated when subsidiary requirements are imposed. These may include some of the following properties: benignity, reliability, transparency, cleanability, portability, degradation resistance, compactness, weight, stiffness, strength, cost, aerodynamics, aesthetics, fixity, and non- snagging.

References

[1] *"Screw Conveyors,"* Conveyor Equipment Manufacturers Association, 350-1971.

[2] *"Machinery Directive Harmonized Standards,"* Machine Building. net, July 2014.

[3] *"American National Standard – Performance Requirements for Safeguarding,"* ANSI B11.19-2010.

[4] *"Code of practice for safety of machinery,"* BS 5304: 1988.

[5] *"Japanese Industrial Standard; Safety of Machinery – Principles of Risk Assessment,"* JIS B 9702 2000.
[6] *"Japanese Industrial Standard; Safety of Machinery – Prevention of Unexpected Start-up,"* JIS B9714: 2006.
[7] *"Japanese Industrial Standard; Safety of Machinery – Guards – General Requirements for the Design and Construction of Fixed and Movable Guards,"* JIS B9716: 2006.
[8] *"International Standard Organization for Standardization; Safety of Machinery – Interlocking Devices Associated with Guards – Principles for Design and Selection,"* ISO 14119.
[9] *"Screw Conveyors for Bulk Materials,"* ANSI/CEMA 350-2009.
[10] *"Conveyors,"* OSHA 29 CFR 1926.555.
[11] *"American Society of Mechanical Engineers – Safety Code for Conveyors, Cableways and Related Equipment,"* ASA B20.1-1957.
[12] *"American Society of Mechanical Engineers- Safety Standard for Conveyors and Related Equipment,"* ASME B20.1-2012.
[13] Ralph L. Barnett, *"Reasonably Foreseeable Use,"* Triodyne Safety Brief, Vol. 14 No. 3, November, 1998.
[14] *"American National Standard for Machine Tools - Safety Requirements for Construction, Care, and Use of Lathes,"* ANSI B11.6-1975.
[15] *"American National Standard – Single –and Multiple-Spindle Automatic Bar and Chucking Machines – Safety Requirements for Construction, Care and Use,"* ANSI B11.13-1992.
[16] *"Code of Practice Safeguarding of Machinery,"* BS 5304:1975.
[17] D.B. McNeil-Watson, *"Some Advantages of Mechanical Guarding Systems,"* Sheet Metal Industries V. 54, 1977.
[18] *"Code of Practice for Safety of Machinery,"* BS EN 953: 1998.
[19] Nicholas, Robert, *"Keeping Guard,"* Safety and Health Practioner, V. 18, n. 12, Dec. 2000.
[20] *"British Safety Code for Safe Use of Machinery," PD 5304:2000.*
[21] *"American National Standard for Machine Tools – Safety Requirements for Machining Centers and Automatic, Numerically Controlled Milling, Drilling and Boring Machines,"* ANSI B11.23:2002.
[22] *"American National Standard for Machines – Performance Criteria for Safeguarding,"* ANSI B11.19-2003.
[23] *"Guarding of Machinery,"* CP 3004: 1964.
[24] *"Principles of Guarding and Transmission Guards,'* Accident Preventional Manual for Industrial Operations, 6th ed., National Safety Council, 1969.
[25] *"American National Standard for Machines – Performance Criteria for Safeguarding,"* ANSI B11.19-2010.
[26] *"American National Standard Safety Requirements for Transfer Machines,"* ANSI B11.24-2002.
[27] *"Safety Code for Conveyors, Cableways, and Related Equipment,"* ANSI B20.1-1972.
[28] *"Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards,"* ISO 14120:2002.
[29] *"Safety of machinery -- Basic concepts, general principles for design -- Part 1: Basic terminology, methodology,"* ISO/TR 12100-1:1992.