American National Standard for Plastics Machinery

Requirements for the Manufacture, Care, and Use of Extrusion Machinery

August 12, 2008

Draft 7.1

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Foreword

(This Foreword is not part of American National Standard ANSI/SPI B151.7)

This standard is a revision of American National Standard Requirements for the Manufacture, Care, and Use of Plastic Extrusion Machines, ANSI B151.7-1996. The standard was revised because:

(1) Some paragraphs required modification for clarity and intent.
(2) Additional explanatory material and illustrations were added.
(4) Additional definitions were required.
(5) Some paragraphs required modification and some paragraphs were added to conform more closely to change in technology

The project on requirements for the manufacture, care, and use of extrusion machines was initiated under the auspices of the Extrusion Section of the Machinery Division of the Society of the Plastics Industry, Inc (SPI).

SPI has long been concerned with operator safety on plastics processing equipment. Accordingly, the organization has established a standards development committee charged with the task of establishing necessary standards.

A standard treating the manufacture, care, and use of extrusion machines is complicated by the wide variety and sizes of machines manufactured and in use, and by the virtually infinite combinations of parts being produced, the production methods used, and the operating conditions existing in industry today.

The primary objective of this standard is to minimize hazards to personnel associated with machine activity by establishing requirements for the manufacture, care, and use of these machines.

To accomplish this objective, the committee decided to approach the problem of machine safety as follows;
The committee developed a list of hazards typical of Extrusion Machines and listed these in section 6 of this standard. For each hazard identified within the scope of the standard, the committee assessed the potential severity of injury related to the hazard, the frequency of exposure to the hazard, and possible avoidance. This process involved discussion among the committee, and resulted in the recommended preventive control measure included in sections 7 through 10 inclusive and additional Annex reference material. Compliance with this standard is considered to adequately control hazards identified in section 6. Other hazards not listed in section 6 that can occur with Extrusion Machines may require additional preventive controls not included in this standard.

To assist in the interpretation of these requirements, responsibilities have been assigned to the manufacturer, the remanufacturer, the modifier, and the employer.

Recognizing the impossibility of immediate updating of design and manufacturing methods, Sections 7 and 10 shall become effective one year after the approval date of this standard.

Suggestions for improvement of this standard will be welcome. They should be sent to the Society of the Plastics Industry, Inc, 1667 K Street, NW, Washington, DC 20006

Consensus for this standard was achieved by use of the Canvass Method.

The following organizations recognized as having an interest in the standardization of extrusion were contacted prior to the approval of this standard. Inclusion in this list does not necessarily imply that the organization concurred with the submittal of the proposed standard to ANSI.

******Will be added after balloting and public review of finalized document*******

The Extrusion Safety and Standards Development Committee of the Machinery Division, and the Safety Committee of the Molders Division of The Society of the Plastics Industry, Inc, which was responsible for this standard, had the following members:

John Rexford	HPM a Taylor's Company-Chairman
Brad Eisenbarth	American Maplan Corp.
John Radovich	Davis-Standard, LLC
Jim Pilavdzic	Husky Injection Molding Systems
Ed Chorey	Milacron – Plastics Technologies Group, Inc.
Dennis Meckler	Bosch Rexroth
Mike Mithchell	Welex Incorporated
Tom Scheck	Eurotherm Inc.
Abdul Wahab	Coperion

Secretariat to the Committee: W. Bishop - Executive Director, Machinery Division of the Society of the Plastics Industry

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Explanation of Standard Format

American National Standard ANSI/SPI B151.7 - 2008 uses a two-column format to provide both specific requirements and supporting information.

The left column, designated "Standard Requirements," is confined solely to these requirements.

The right column, designated "Explanatory Information," contains only information that is intended to clarify the standard. This column is not a part of the standard. Where supplementary illustrations are required, they are designated as "figures."

Operating rules (safe practices) are not included in either column unless they are of such a nature as to be vital safety requirements, equal in weight to other requirements, or guides to assist in compliance with the standard. The Annex includes common procedures practiced on plastics machinery. This is considered “Explanatory Information” and is supplementary to the standard.

1 Scope, Purpose, Application and Installation	
1.1 Scope The requirements of this standard shall apply to extrusion machines that are used in the plastics industry. Safety requirements of ancillary equipment used with extrusion machines are not covered by this standard.	
1.2 Purpose The purpose of this standard is to identify and address known hazards to personnel working on, or adjacent to, an extrusion machine.	
1.3 Application	**E1.3 Application** Inquiries with respect to the application of, or substantive requirements of this standard should be addressed to the Society of the Plastics Industry, Inc, 1667 K Street, NW, Washington, DC 20006.
1.3.1 New or Remanufactured Extruders The requirements of this standard pertaining to manufacture shall apply to all new or remanufactured extrusion machines installed in the United States of America. Date of manufacture (month and year) shall be affixed permanently and legibly to the machine along with the name of the manufacturer or remanufacturer. Compliance shall be achieved within one year of the approval date of this standard.	**E1.3.1 New or Remanufactured Extruders** Date of manufacture is understood to be the date the extruder was complete and available for delivery to the employer.
1.3.2 Existing Installations The employer is responsible for bringing existing machines into compliance with the requirements of this standard within one year of the approval of this standard.	
1.3.3 All Installations An employer shall not operate a machine or permit it to be operated unless it is in compliance with this standard. The use shall be in accordance with Section 9 of this standard and shall be effective on the approval date of this standard.	

2 Referenced American National Standards This standard is to be used with the following American National Standards. ANSI Z535.3-2006, Criteria for Safety Symbols ANSI Z535.4-2006, Product Safety Signs and Labels ANSI Z535.6-2006, Product Safety Information in Product Manuals, Instructions, and Other Collateral Materials ANSI/NFPA 79 -2007, Electrical Standard for Industrial Machinery ANSI Z97.1-2004, Safety Glazing Materials Used in Buildings – Safety Performance Specifications and Methods of Test	**E2 Related Standards and Publications** AN-137- Recommended Guideline for Safety Signs for Plastic Machinery and Related Equipment ANSI/ASSE Z244.1-2003- Control of Hazardous Energy- Lockout/Tagout and Alternative Methods AN-150 Arc Flash Hazards
3 Definitions	
3.1 Alarm. An indication that a failure or misadjustment of a device has occurred.	
3.2 Barrel. The cylinder portion of the extruder within which the material is processed.	
3.3 Emergency Stop Device. A mechanism that, when actuated, stops all machine movement associated with the specific machine	**E3.3 Emergency Stop Device.** This mechanism may include but is not limited to a trip rod, cord, button, electronic device, etc.
3.4 Employer. Any person who contracts, hires, or is responsible for the personnel associated with the Installation, set-up, operation and maintenance of extruders.	
3.5 Extruder or Extrusion Machine. A machine which plasticizes and conveys solid and/or liquid material by means of one or more screws rotating within a barrel and discharges it continuously.	**E.3.5 Extruder or Extrusion Machine.** See Figures 1 and 2 for typical extrusion machines.
3.6 Guard. A physical barrier that prevents access to areas where known hazards exist.	
3.6.1 Guard, Fixed. A guard that is fixed in place and requires a tool for moving or removal.	
3.6.2 Guard, Movable. A guard which may be moved or removed without the use of tools. A movable guard requires an interlock(s).	
3.7 Hazard. A source of possible injury or damage to health.	
3.8 Instructions. Documentation for the installation, operation, care, maintenance, and safe use of the extruder.	**E3.8 Instructions**. See ANSI Z535.6 – 2006, Product Safety Information in Product Manuals, Instructions, and Other Collateral Materials.
3.9 Interlock. An arrangement whereby the operation of one control or mechanism allows or prevents the operation of another.	
3.10 Lockout. The placement of a lockout device on an energy isolating device, in accordance with an established procedure, ensuring that the energy isolating device and the equipment being controlled cannot be operated until the lockout device is removed.	

3.11 Maintenance Personnel. Individuals who by virtue of their training and skills are qualified to inspect, maintain, and repair extrusion machines.	
3.12 Manufacturer. Any person whose business is the manufacture of equipment covered in this standard for installation in the United States of America.	
3.13 Maximum permissible barrel temperature. The temperature limit which the barrel temperature shall not be allowed to exceed to prevent failure of the barrel and/or attached components.	**E.3.13 Maximum permissible barrel temperature.** This limit may be less than or equal to the barrel maximum design temperature.
3.14 Modification. For the purpose of this standard, any change to a product that affects the safety of personnel is considered a modification.	**E3.14 Modification.** Modification is intended to include adding, deleting, converting or altering the original product. This could affect such areas as control systems, ladders, enclosures, guards, etc., Anything that has been added, moved or removed, converted, or altered which effects the interface between the extruder and the personnel constitutes modification.
3.15 Modifier. Any person who performs a modification to an extruder.	
3.16 Normal production. The utilization of the extruder to perform its intended production function.	
3.17 Operator. An individual who has been trained and authorized by the employer to perform production work on the extruder.	
3.18 Plastic. Any material processed by the extruder.	
3.19 Presence Sensing Device. A device which is capable of detecting an intrusion into a specified area.	
3.20 Purging. The clearing of material from the barrel to the atmosphere.	
3.21 Rebuild. Restoring a portion of the extruder to its original purpose, capacity, or function including compliance with Section 7 and 10 of this standard.	**E3.21 Rebuild.** Some change in original design may be required to comply with Section 7 and 10 of this standard.
3.22 Remanufacture. A substantial restoration of the extruder.	**E3.22 Remanufacture.** Remanufacture typically consists of the following: 1.) Complete dismantling of the extruder. 2.) Cleaning and carefully inspecting all parts. 3.) Reworking worn parts to as new condition or replacing with new parts. 4.) Reconditioning barrels, screws, etc., to meet applicable standards and guidelines. 5.) Completely reconditioning or replacing power system components to meet applicable standards and guidelines. 6.) Thoroughly inspecting all electrical and control systems and replacing component/systems as required. 7.) Removing modifications which are not in conformance with Sections 7 and 10 of this standard and informing the employer of the removal.
3.23 Remanufacturer. Any person whose business is the redesign and/or remanufacture of extruders for installation in the United States of America.	
3.24 Repair. The restoration of a portion of the extruder to original function using original design by replacement or reworking of worn or damaged parts.	**E3.24 Repair**. Repair may include such items as replacement or re-work of the barrel, screw, heater bands, motors, seals,

3.25 Safety Signs. A visual alerting sign, label, decal, placard, or other marking that advises the observer of the nature and degree of the potential hazard(s) that can cause injury or death and the required actions to avoid the hazard.	**E3.25 Safety Signs**. See AN-137 Safety Signs.
3.26 Servicing and/or maintenance. Workplace activities such as constructing, installing, setting up, adjusting, inspecting, modifying, and maintaining and/or servicing equipment. These activities include lubrication, cleaning or unjamming of machines or equipment and making adjustments where the employee may be exposed to the unexpected energization or startup of the equipment or release of hazardous energy.	
3.27 Set up. Any work performed to prepare the machine to perform its normal production.	
3.28 Setup Personnel. Individuals who are trained and authorized by the employer to prepare the machine and ancillary equipment for production.	
3.29 Shall. The word "shall" is to be understood as denoting a mandatory requirement.	
3.30 Should. The word "should" is to be understood as denoting a recommendation.	
3.31 Tagout. The placement of a tagout device on an energy isolating device, in accordance with an established procedure, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.	
3.32 Vapors. Gas or steam formed by processing plastic.	
3.33 Vent Cover A barrier covering the vent port opening.	
3.34 Vent Port. An opening provided in the barrel to permit vapors to exit from the plastic material during processing.	

4 Care—Responsibility for	
4.1 Instructions	
4.1.1 Manufacturer It shall be the responsibility of the manufacturer to furnish instructions with the extruder.	**E4.1.1 Manufacturer.** See ANSI Z535.6 – 2006, Product Safety Information in Product Manuals, Instructions, and Other Collateral Materials.
4.1.2 Modifier It shall be the responsibility of any person modifying an extruder to furnish instructions specific to the modification.	**E4.1.2 Modifier.** See ANSI Z535.6 – 2006, Product Safety Information in Product Manuals, Instructions, and Other Collateral Materials.
4.1.3 Remanufacturer It shall be the responsibility of any person remanufacturing an extruder to furnish instructions with the remanufactured extruder.	**E4.1.3 Remanufacturer.** See ANSI Z535.6 – 2006, Product Safety Information in Product Manuals, Instructions, and Other Collateral Materials.
4.2 Training of Maintenance and/or Setup	

Personnel It shall be the responsibility of the employer to ensure the original and continuing competence of personnel caring for, setting up, inspecting, and maintaining extruders.	
4.3 Inspection and Maintenance It shall be the responsibility of the employer to establish and follow a program of periodic and regular inspections of extruders to ensure that they are in safe operating condition and proper adjustment. At the minimum, the employer shall follow the inspection and maintenance instructions provided by the manufacturer.	
5 Manufacture, Remanufacture, Repair, Modification, and Rebuild	
5.1 Responsibility	
5.1.1 Manufacture The manufacture of new extruders shall be in accordance with Sections 7 and 10 of this standard.	
5.1.2 Remanufacture The remanufacture of an extruder shall be in conformance with Sections 7 and 10 of this standard. Remanufacture shall not reduce the level of safety existing on the extruder at the time of manufacture.	
5.1.3 Modification The modification made to existing extruders shall be in accordance with section 7 and 10 of this standard that apply to the modification. Any modification shall not reduce the level of safety existing on the extruder at the time of manufacture or remanufacture.	**E5.1.3 Modification** For the purpose of this standard, bringing an extruder into conformance with the requirements of Section 7 is considered a modification.
5.1.4 Repair Repair shall not reduce the level of safety of the extruder.	**E5.1.4 Repair** The intent of this section is to ensure that repairs are done properly with equivalent or better components.
5.1.5 Rebuild Rebuild of any portion of an existing extruder shall be in accordance with Section 7 and Section 10 of this standard. Rebuild shall not reduce the level of safety of the extruder.	

6 Hazards and Areas of Danger

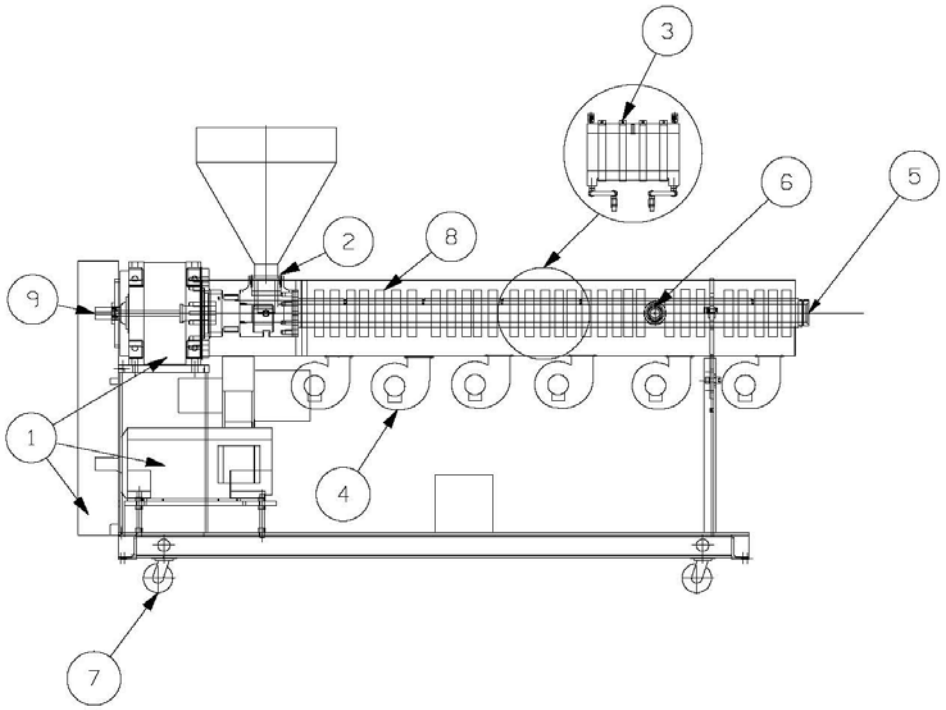

FIGURE 1
Typical representation of a single screw extruder and specific areas of hazard.

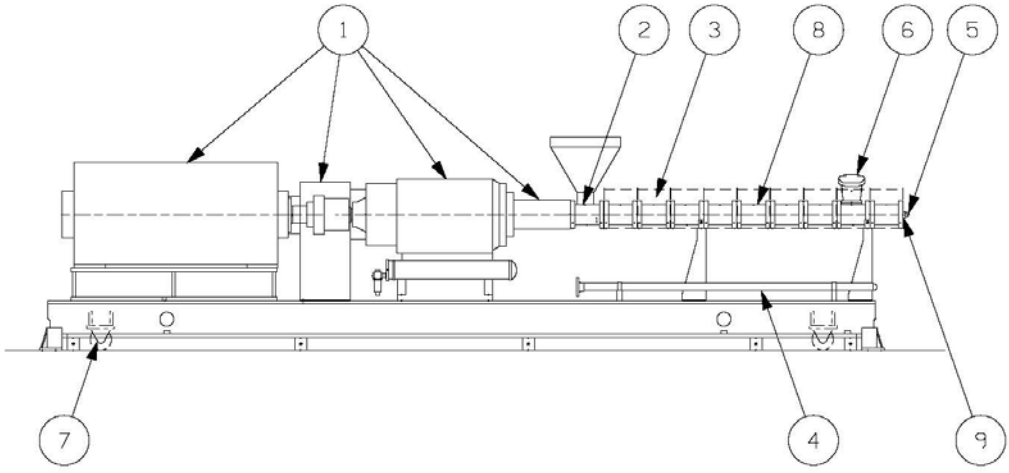

FIGURE 2
Typical representation of a twin screw compounding extruder and specific areas of hazard.

6.1 Specific machine areas where hazards exist Refer to Figures 1 and 2 1 Drive and power transmission 2 Feed opening 3 Barrel heaters 4 Barrel cooling system 5 Extruder discharge 6 Vent port 7 Wheels and machine movement 8 Barrel 9 Screw heating/cooling system	
6.1.1 Drive and power transmission	**E6.1.1 Drive and power transmission** See Figures 1 and 2 area 1
6.1.1.1 Mechanical hazards Crushing, shearing, and/or entanglement hazards caused by movement of: • Motor shaft(s). • Couplings. • Belts and sheaves. • Gears. • Reducer shaft(s). • Screw(s).	
6.1.1.2 Thermal Hazards Burns due to operating temperature of: • Motor. • Reducer.	
6.1.2 Feed Opening	**E6.1.2 Feed Opening** See Figures 1 and 2 area 2
6.1.2.1 Mechanical Hazards Crushing, shearing, impact and/or entanglement hazards caused by: • Motion between screw(s) and barrel. • Motion between screws. • Movement of material shut-off device. • Expulsion of material.	
6.1.2.2 Thermal Hazards Burns due to operating temperature of: • Plastics. • Feed opening area.	
6.1.3 Barrel heaters	**E6.1.3 Barrel heaters** See Figures 1 and 2 area 3.
6.1.3.1 Thermal hazards Burns due to operating temperature of heating systems.	
6.1.4 Barrel cooling system	**E6.1.4 Barrel cooling system**

	See Figures 1 and 2 area 4.
6.1.4.1 Mechanical hazards Shearing, impact, and/or entanglement hazards due to movement of: • Fan blades. • Motor shafts. • Failed hose(s) and/or hose coupling.	
6.1.4.2 Thermal hazards Burns due to contact with: • Overheated coolant. • Motor. • System components.	
6.1.5 Extruder Discharge	**E6.1.5 Extruder Discharge** See Figures 1 and 2 area 5.
6.1.5.1 Mechanical hazards. Impact, shearing, and/or entanglement hazards due to: • Movement of the screw(s). • Expulsion of material. • Expulsion of mechanical equipment.	
6.1.5.2 Thermal hazards Burns due to contact with: • Plastic material. • Screw(s) and barrel.	
6.1.6 Vent Port	**E6.1.6 Vent Port** See Figures 1 and 2 area 6.
6.1.6.1 Mechanical hazards Impact, shearing, crushing, and/or entanglement hazards due to: • Movement between screw(s) and barrel. • Movement of screw(s). • Expulsion of material. • Expulsion of vent stack system components.	
6.1.6.2 Thermal hazards Burns due to contact with: • Plastic material and vapors. • Screw(s) and barrel. • Vent stack.	
6.1.7 Wheels and machine movement	**E6.1.7 Wheels and machine movement** See Figures 1 and 2 area 7.
6.1.7.1 Mechanical hazards Crushing, shearing, and/or entanglement hazards due to movement of: • Wheels. • Extruder.	
6.1.8 Barrel	**E6.1.8 Barrel** See Figures 1 and 2 area 8.
6.1.8.1 Mechanical Hazards Impact hazard due to overpressurization.	

6.1.8.2 Thermal Hazards Burns due to contact with the barrel.	
6.1.9 Screw heating/cooling systems	**E6.1.9 Screw heating/cooling systems** See Figures 1 and 2 area 9.
6.1.9.1 Mechanical Hazards Impact hazard due to failure of hoses and/or hose coupling.	
6.1.9.2 Thermal Hazards Burn hazard due to contact with: • Heating systems. • Overheated coolant.	
6.2 Other Hazards	
6.2.1 Electrical Hazards Electric shock or burns due to contact with live conductive parts and/or arc flash.	
6.2.2 Vapors and Gases Certain processing conditions and/or plastics can cause hazardous fumes or vapors.	

7 Safety Requirements and/or methods	
7.1 General Guarding Reach over safety distances shall be in accordance with table 3 of Figure 3 unless otherwise specified. Reach through opening shall be in accordance with table 4 of Figure 4. Safety measure(s) shall be provided where hazards exist. Movable guards shall be interlocked to stop hazardous motion exposed by moving or removing the guard. Fixed guards shall require fasteners to attach guard in place and tools to install or to remove the fasteners.	**E7.1 General Guarding** Examples of some types of fasteners that should not be used are: • slotted head screws • wing nuts • magnets • latches and hasps • hooks and eyes.

Table 3 - Safety Distance, Reach Over Protective Structure																			
Height of Danger Zone (a)		Height of fixed barrier or protective structure (b)																	
mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
		1000	39.37	1200	47.24	1400	55.12	1600	62.99	1800	70.87	2000	78.74	2200	86.61	2400	94.49	2500	98.43
		Horizontal distance to danger zone (c)																	
2500	98.43	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
2400	94.49	100	3.94	100	3.94	100	3.94	100	3.94	100	3.94	100	3.94	100	3.94	100	3.94	----	----
2200	86.61	600	23.62	600	23.62	500	19.69	500	19.69	400	15.75	350	13.78	250	9.84	----	----	----	----
2000	78.74	1100	43.31	900	35.43	700	27.56	600	23.62	500	19.69	350	13.78	----	----	----	----	----	----
1800	70.87	1100	43.31	1000	39.37	900	35.43	900	35.43	600	23.62	----	----	----	----	----	----	----	----
1600	62.99	1300	51.18	1000	39.37	900	35.43	900	35.43	500	19.69	----	----	----	----	----	----	----	----
1400	55.12	1300	51.18	1000	39.37	900	35.43	800	31.50	100	3.94	----	----	----	----	----	----	----	----
1200	47.24	1400	55.12	1000	39.37	900	35.43	500	19.69	----	----	----	----	----	----	----	----	----	----
1000	39.37	1400	55.12	1000	39.37	900	35.43	300	11.81	----	----	----	----	----	----	----	----	----	----
800	31.50	1300	51.18	900	35.43	600	23.62	----	----	----	----	----	----	----	----	----	----	----	----
600	23.62	1200	47.24	500	19.69	----	----	----	----	----	----	----	----	----	----	----	----	----	----
400	15.75	1200	47.24	300	11.81	----	----	----	----	----	----	----	----	----	----	----	----	----	----
200	7.87	1100	43.31	200	7.87	----	----	----	----	----	----	----	----	----	----	----	----	----	----
0	0.00	1100	43.31	200	7.87	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Barriers less than 1000mm (39 inches) in height are not included because they do not sufficiently restrict movement of the body. There shall be no interpolation of the values of this table. Consequently, when the known values of tables a, b, or c are between two values, the values to be used are those which provide the higher level of safety.

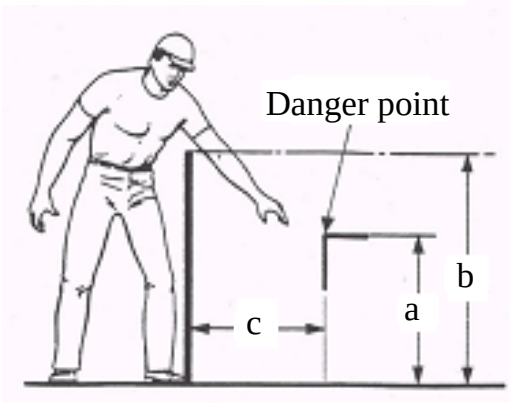

Figure 3 – Reach over protective structure

Table 4- Safety distance, Reach through opening

The following table gives the safety distance for regular openings. The dimensions of opening "**e**" correspond to the side of a square opening, the diameter of a round opening and the narrowest dimension of a slot opening. For opening > 120 mm (4.724 inch) table 3 shall be used.

Opening "e"		**Safety Distance "Sr"**					
		Slot		**Square**		**Round**	
(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)
e ≤ 4	e ≤ 0.157	≥ 2	≥ 0.079	≥ 2	≥ .079	≥ 2	≥ .079
4 < e ≤ 6	0.157 < e ≤ 0.236	≥ 10	≥ 0.394	≥ 5	≥ .197	≥ 5	≥ .197
6 < e ≤ 8	0.236 < e ≤ 0.315	≥ 20	≥ 0.787	≥ 15	≥ .591	≥ 5	≥ .197
8 < e ≤ 10	0.315 < e ≤ 0.394	≥ 80	≥ 3.150	≥ 25	≥ .984	≥ 20	≥ .787
10 < e ≤ 12	0.394 < e ≤ 0.472	≥ 100	≥ 3.937	≥ 80	≥ 3.150	≥ 80	≥ 3.150
12 < e ≤ 20	0.472 < e ≤ 0.787	≥ 120	≥ 4.724	≥ 120	≥ 4.724	≥ 120	≥ 4.724
20 < e ≤ 30	0.787 < e ≤ 1.181	≥ 850 (1)	≥ 33.465 (1)	≥ 120	≥ 4.724	≥ 120	≥ 4.724
30 < e ≤ 40	1.181 < e ≤ 1.575	≥ 850	≥ 33.465	≥ 200	≥ 7.874	≥ 120	≥ 4.724
40 < e ≤ 120	1.575 < e ≤ 4.724	≥ 850	≥ 33.465	≥ 850	≥ 33.465	≥ 850	≥ 33.465

(1) If the length of the slot opening is ≤ 65 mm (2.56 inch) the thumb will act as stop and the safety distance can be reduced to 200 mm (7.87 inch).

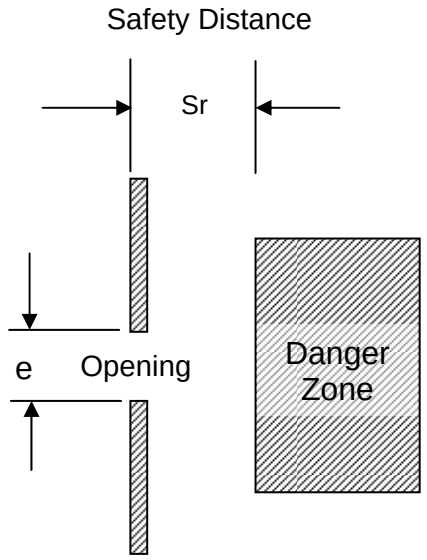

Figure 4- Safety through opening

7.2 General safety requirements	
7.2.1 Window When a window is used in a gate or guard to provide visibility, the window material shall be polycarbonate or tempered glass and meet the requirements of ANSI Z97.1.	
7.2.2 Thermal Hazards Guard or warning tag against hot surfaces above 175°F (80°C) shall be provided.	**E7.2.2 Thermal Hazards** See clause 7.3.3.1 for barrel cover requirements.
7.2.3 Electrical Requirements Extrusion machines shall be in accordance with the requirements of ANSI/NFPA 79.	
7.2.3.1 Safety Circuit Performance For Type II interlocks, safety shall be maintained in the case of a single fault. The safety circuit shall be designed, constructed and applied such that any single component failure shall lead to the shutdown of the system in a safe state and prevent the subsequent automatic operation until that component failure has been corrected. Safety circuits shall be hardware or a software/firmware based controller. When safety related software and firmware based controllers are used in place of hardware based components, they shall be listed for such use. In either case the monitoring shall: (a) Generate a stop motion signal if a fault is detected. (b) Provide a warning if the hazard remains after cessation of motion. (c) Maintain a safe state until the fault is cleared. (d) Detect the single fault at time of failure. If this is not practical, the failure shall be detected at the next demand upon the safety function, and If a software/firmware controller is not listed for use in safety related control functions, then each position switch shall be connected to its own input module, or if a common input module is used, the inverse signals of both position switches shall be inputted and any fault in the input circuits shall be automatically recognized.	**E7.2.3.1 Safety Circuit Performance** See 7.3 For example, if relays controlled by the position switch(es) are used for the purpose of contact multiplying, monitoring of these relays is necessary.
7.2.3.2 Machine Grounding The machine and all exposed, noncurrent-carrying conductive parts, material, and equipment likely to be	

energized shall be effectively grounded. Where electrical devices are mounted on metal mounting panels that are located within nonmetallic enclosures, the metal mounting panels shall be effectively grounded. The above items shall be interconnected to the equipment grounding (protective) conductor terminal.	
7.2.3.3 Stop Function Each Extrusion machine shall be equipped with a either Category 0 or Category 1 stop. Category 0 and Category 1 stops shall be operational regardless of operating modes. Stop function shall operate by de-energizing that relevant circuit and shall override related start functions. Where required, provisions to connect protective devices and interlocks shall be provided. Where applicable, the stop function shall signal the logic of the control system that such a condition exists. The reset of the stop function shall not initiate any hazardous conditions.	**E7.2.3.3 Stop Function** Category 0 is an uncontrolled stop by immediately removing power to the machine actuators. Category 1 is a controlled stop with power to the machine actuators available to achieve the stop then remove power when the stop is achieved.
7.2.3.4 Emergency Stop Emergency stop shall be initiated by a single human action. In addition to the requirements for stop functions, emergency stop shall have the following requirements: (1) It shall override all other functions and operations in all modes. (2) Power to the machine actuators, which causes a hazardous condition(s), shall be removed as quickly as possible without creating other hazards (e.g., by the provision of mechanical means of stopping requiring no external power, by reverse current braking for a Category 1 stop). (3) Reset of an emergency stop circuit shall not initiate a restart. (4) It shall function as either a Category 0 or a Category 1 stop. Where a Category 0 stop is used for the emergency stop function, it shall have only hardwired electromechanical components. Exception: Electronic logic (hardware or software) that meets NFPA 79 requirement can also be used. Where a Category 0 or a Category 1 stop is used for the emergency stop function, final removal of power to the machine actuators shall be ensured and shall be by means of electromechanical components. Where relays are used to accomplish a Category 0	**E7.2.3.4 Emergency Stop** The palm or mushroom head of the push button device must not be fitted with any kind of protective ring encompassing the head or cover over the head to prevent accidental activation.

emergency stop function, they shall be nonretentive relays. (5) Emergency stop pushbuttons shall be located at each operator control station or where motion can be initiated and at other locations where emergency stop is required. (6) Pushbutton-type devices for emergency stop shall be of the self-latching type and shall have positive (direct) opening operation. (7) Emergency stop switches shall not be flat switches or graphic representations based on software applications. (8) It shall not be possible to restore an emergency stop circuit until the emergency stop device has been manually reset. Where several emergency stop devices are provided in a circuit, it shall not be possible to restore that circuit until all emergency stop devices that have been operated have been reset. (9) Actuators of emergency stop devices shall be colored RED. The background immediately around pushbuttons and disconnect switch actuators used as emergency stop devices shall be colored YELLOW. The actuator of a pushbutton-operated device shall be of the palm or mushroom-head type. The RED/YELLOW color combination shall be reserved exclusively for emergency stop applications.	
7.2.3.5 Interlock Switches Where doors or guards have interlocked switches used in circuits with safety related functions, the interlocking devices shall have either positive (direct) opening operation, or provide similar reliability and prevent the operation of the equipment when the doors or guards are open (difficult to defeat or bypass). Exception: When two interlock switches are used together in a Type II interlock, one of the switches will not operate in a positive mode.	
7.2.3.6 Continuity of the Grounding Circuit One of the following methods shall be used to verify the continuity of the equipment grounding circuit: (1) Use an impedance measuring device, take into account any impedance in the measuring circuit. The measured impedance shall be 0.1 ohm or less. (2) Apply a current of at least 10 amperes, 50 Hz or 60 Hz, derived from a Safety Extra Low Voltage (SELV) source. The tests are to be made between the equipment grounding protective earthing (PE) terminal and relevant points that are part of the equipment grounding (protective bonding) circuit; the measured	

<table>
<tr>
<td>voltage between the equipment grounding protective earthing (PE) terminal and the points of test is not to exceed the values given in Table 5.

Table 5
<table>
<tr><th>Minimum Equipment Grounding (Protective Bonding) Conductor Cross-Sectional Area of the Branch Under Test (AWG)</th><th>Voltage Drop* (V)</th></tr>
<tr><td>18</td><td>3.3</td></tr>
<tr><td>16</td><td>2.6</td></tr>
<tr><td>14</td><td>1.9</td></tr>
<tr><td>10</td><td>1.4</td></tr>
<tr><td>> 8</td><td>1.0</td></tr>
</table>
*Values are given for a test current of 10 amperes</td>
<td></td>
</tr>
<tr>
<td>7.2.3.7 Electrical Disconnects

A lockable supply circuit disconnecting means shall be provided for each incoming supply circuit.</td>
<td></td>
</tr>
<tr>
<td>7.2.3.8 Short Circuit / Branch Circuit Protection

Supplementary overcurrent protective devices shall not be used as a substitute for branch-circuit overcurrent protective devices.</td>
<td></td>
</tr>
<tr>
<td>7.2.3.9 Arc Flash Hazard

A safety sign shall be provided adjacent to the disconnecting operating handle(s) where the disconnect(s) that is interlocked with the enclosure door does not de-energize all exposed live parts when the disconnect(s) in the open (off) position.</td>
<td>E7.2.3.9 Arc Flash Hazard

See AN-150 for Safety Sign requirements.</td>
</tr>
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<td></td>
<td></td>
</tr>
</table>

7.3 Additional safety requirements and/or methods in specific machine areas Safety circuit and its monitoring function described below shall comply with clause 7.2.3.1. A) Type I Interlock (Figure 5) An interlock consisting of one position sensor that is positively actuated when the guard opens and positively interrupts the energy supply to the device producing the hazardous motion. The single fault safety requirement stated in clause 7.2.3.1 does not apply to the position switch or the main shutoff device B) Type II Interlock (Figure 6) An interlock consisting of two position sensors that interrupt the energy supply to the device producing the hazardous motion when the guard opens. One position sensor shall be positively actuated and positively interrupt the energy supply to the device producing the hazardous motion when the guard opens. The second position sensor shall be released when the guard opens interrupting the energy supply to the device producing the hazardous motion. The guard position sensors are monitored to ensure that: • Each guard position sensor changes state each time the guard is opened or closed. • The state of each position sensor changes in predetermined sequence with respect of opening and closing the guard. • Each guard position sensor must be in predetermined state to permit the hazardous motion. Monitoring of the device shall be per clause 7.2.3.1	

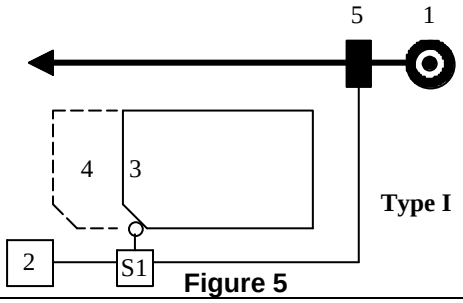
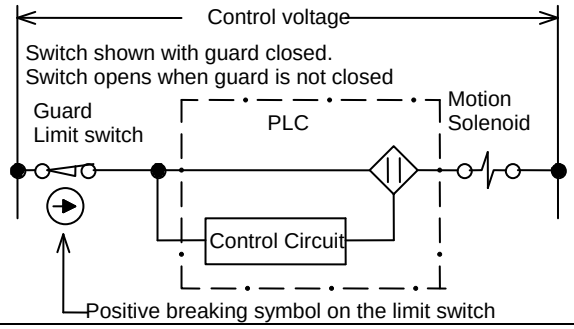


Figure 5

Example of Type I Guard



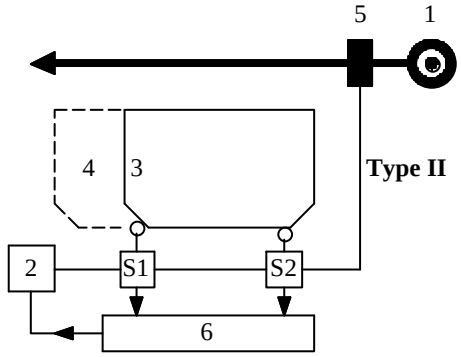
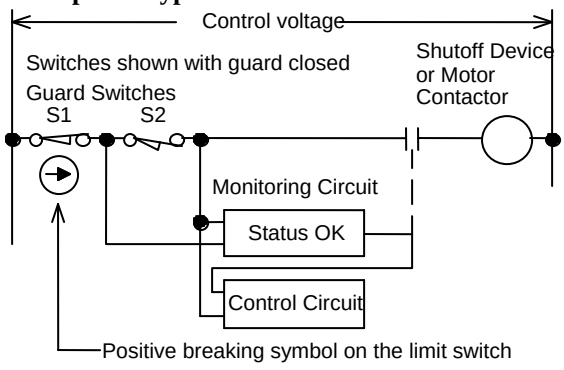


Figure 6

Example of Type II Guard



[1] power source	[2] control circuit
[3] guard closed	[4] guard open
[5] main shutoff device	[6] monitor circuit
[S1] limit switch 1	[S2] limit switch 2

The examples used are for illustration purpose only. Many methods and devices can be used to achieve the same degree of reliability and functionality.

7.3.1 Drive and power transmission Guards shall be provided over the drive and transmission areas. If these guards are moveable they shall be interlocked. The interlocks shall disconnect all power to the extruder. Guards shall meet the requirements of Section 7.1.	
7.3.2 Feed Openings All feed openings for plastic materials shall be guarded against insertion of hands and/or clothing. See Table 4 of Figure 4 for reach through opening and safety distance. Safety signs shall be used in this area.	**E7.3.2 Feed Openings** A fixed hopper can serve as a fixed guard for the feed throat opening to prevent insertion of hands. See Annex A3 for clearing blocked feed throat.
7.3.3 Barrel Heaters	
7.3.3.1 Barrel Covers A cover or barrier shall be provided to prevent inadvertent contact with high temperatures, except for those instances which cannot be covered for operational or process reasons. If the cover or the barrier surface temperature is above 175° F (80° C), safety signs shall be provided on or adjacent to barrel covers.	**E7.3.3.1 Barrel Covers** Insulating blankets may serve as the cover or barrier to prevent inadvertent contact with high temperature.
7.3.3.2 Electrical Connections to Heated Areas Electrical connections to heated areas shall be covered with a fixed nonconductive guard or a grounded metal barrier to prevent contact with live terminals.	
7.3.4 Barrel Cooling Systems	
7.3.4.1 Fan Blades All cooling fan openings shall be guarded against insertion of hands and/or clothing. See Table 4 of Figure 4 for reach through opening and safety distance. Safety signs shall be used in this area.	
7.3.4.2 Hoses The manufacturer shall instruct the employer in proper, regular hose inspection procedures.	**E7.3.4.2 Hoses** See section 9.9.
7.3.4.3 Motor Shaft and Coupling The motor shaft and coupling shall be guarded against insertion of hands and/or clothing. See Table 4 of Figure 4 for reach through opening and safety distance. Safety signs shall be used in this area.	
7.3.4.4 Barrel Cooling System Components	

A cover or barrier shall be provided to prevent inadvertent contact with high temperatures, except for those instances which cannot be covered for operational or process reasons. If component surface temperature is above 175° F (80° C), safety signs shall be provided on or adjacent to components.	
7.3.5 Extruder Discharge Mechanical and thermal hazards at the extruder discharge area are guarded by installed downstream equipment. If downstream equipment is removed or does not provide appropriate protection, additional guarding shall be installed. This is the sole responsibility of the employer. If component surface temperature is above 175° F (80° C), safety signs shall be provided on or adjacent to components.	**E7.3.5 Extruder Discharge** See Annex A4, A5, and A6. See section 9.4 for appropriate personal protective equipment.
7.3.6 Vent Port A cover shall be provided over the vent port to protect personnel from hot plastic and/or vapors which may be expelled.	**E7.3.6 Vent Port** See 9.7 for vapor hazards and 9.4 for personal protective equipment. See 9.6 for barrel vents ports. If a window is used as a cover, see 7.2.1.
7.3.7 Wheels and Machine Movement	
7.3.7.1 Vertical or Inclined Extruder Units In order to prevent unintentional gravity descent, the extruder shall be provided with a restraint device.	**E7.3.7.1 Vertical or Inclined Extruder Units** The means of preventing falling of the extruder or screw may include restraint devices such as a mechanical restraint, counter balance/weight pulley system or a friction device.
7.3.7.2 Power Driven Extruder Unit An extruder equipped for powered locomotion shall be provided with automatically operated alarm device(s) to warn prior to and during movement of the machine. There shall be a 3 second minimum delay during which an alarm is activated to warn the operator and others when the extruder is about to move. An alarm shall be activated during movement. After the 3 second delay, intermittent motion of the machine can continue without repeating the delay requirement. After stopping, motion of machine may be resumed within 12 seconds without the 3 second delay. Either a protective trip device shall be provided to stop machine motion if a person is detected in the path of	**E7.3.7.2 Power Driven Extruder Unit** Protective trip devices include but are not limited to:

the machine motion; or, a hold to run control device may be provided if it is located where there is a clear view of the path of the machine motion. Exposed crush points between the wheel and any contact surface shall be guarded.	• Trip bars or chords • Presence sensing devices
7.3.8 Barrel	
7.3.8.1 Temperature of barrel The temperature of the barrel shall be automatically monitored to ensure that the maximum permissible barrel temperature is not exceeded. The barrel manufacturer shall declare the maximum permissible temperature of the barrel. The energy supply to all barrel heating elements shall be automatically interrupted: • If the monitored barrel temperature exceeds the maximum permissible barrel temperature or • In case of a detected fault in the temperature control of one or more zones that, if ignored, could result in the maximum permissible barrel temperature being exceeded	**E7.3.8.1 Temperature of barrel** Reference section 9.8 for interrupted cycle. Faults may be detected by controller diagnostics or other monitoring elements. The intent of this standard is not to require redundant temperature controls and/or sensors. The machine should control and automatically monitor the temperature of the barrel. The maximum and/or minimum and/or deviation process set points should be alarmed. See 9.5 for set point.
7.3.8.2 Barrel over pressurization protection To prevent the over pressurization of the barrel, the extruder shall be provided with a pressure-relieving device or pressure-limiting device.	
7.3.9 Screw Heating/Cooling Systems A cover or barrier shall be provided to prevent inadvertent contact with high temperatures, except for those instances which cannot be covered for operational or process reasons. If component surface temperature is above 175° F (80° C), safety signs shall be provided on or adjacent to components. The manufacturer shall instruct the employer in proper, regular hose inspection procedures.	**E7.3.9 Screw Heating/Cooling Systems** See section 9.9.
7.4 Other Hazards	
7.4.1 Electrical Hazards See 7.2.3 for Electrical Safety Requirements	
7.4.2 Vapors or Gases A warning sign shall be provided in areas with possible exposure to vapors or gases.	**E7.4.2 Vapors or Gases** See 9.7 for ventilation

8 Existing Extrusion Machines An existing extrusion machine is any extrusion machine that is manufactured prior to the compliance date of this standard. Compliance date is one year after the publication date of this standard.	
8.1 Employer Responsibility The employer shall ensure that all extrusion machines are in conformance with Sections 7 and 10 of this standard.	
8.1.1 Reach Over and Safety Distances When guards are replaced or repaired they shall meet the requirements of Table 3 and 4.	
8.1.2 Temperature of Barrel When a barrel temperature control(ers) is being retrofitted or replaced, it shall be in compliance with section 7.3.8.1 of this standard.	
9 Use	
9.1 Instruction The employer shall train and instruct operators and maintenance personnel in the safe methods of work, as well as provide instruction on the safety devices provided, before they start work on any extruder covered by this standard. The employer shall ensure that correct work procedures are being followed. The employer shall make all instructions available to the operator and maintenance personnel.	**E9.1 Instruction** The employer should consider setting up a checklist to ensure operators and maintenance personnel are kept aware of procedures to follow in operating the machine safely. This checklist should be kept in the machine instruction manual and periodically (such as every 6 months), the employer should have operators and maintenance personnel check off the list.
9.2 Work Area Adequate lighting and clearance shall be provided around the machinery and equipment covered by this standard. Space for operation, maintenance, cleaning machines, handling material stock, and screw removal shall be provided.	
9.3 Ancillary Equipment It shall be the responsibility of the employer to ensure that use of ancillary equipment does not reduce the level of safety embodied in this standard.	

9.4 Personal Protective Equipment It shall be the responsibility of the employer to ensure that all personnel shall wear appropriate personal protective equipment for protection in areas where hazards exist.	
9.5 Temperature Set Point Users shall consult the material manufacturer for the material being processed and set the maximum temperature accordingly to prevent hazardous conditions.	
9.6 Vent Port Conversion Some vented barrels are designed only to operate with vent port open. Others may be designed to operate either in the open vent port mode or with a mechanical plug in the vent port. Always consult and follow the vented barrel manufacturer's instructions.	
9.7 Ventilation A means shall be provided by the employer to vent hazardous vapors away from the work area.	
9.8 Interrupted Operation If for any reason, the operation is interrupted for an extended period of time, it shall be the responsibility of the employer to assure that proper shut down procedures are followed.	**E9.8 Interrupted Operation** Proper shut down procedures are dependent upon the type of material being processed. Refer to the Material Safety Data Sheet from the material supplier or to the material supplier's recommendations.
9.9 Hose Inspection The employer shall evaluate factors such as the nature and severity of the application, past history and manufacturers information to establish the frequency of visual inspections and functional tests. Inspect all hoses for: • Leaks at hose fitting or in hose • Damaged, cut or abraded cover • Exposed reinforcement • Kinked, crushed, flattened or twisted hose • Hard, stiff heat cracked or charred hose • Blistered, soft, degraded or loose cover • Cracked, damaged or badly corroded fitting • Fitting slippage on hose • Other signs of significant deterioration If any of the above conditions exist, the hose assembly shall be replaced with a new assembly of equivalent quality and characteristics.	**E9.9 Hose Inspection** All hoses should be inspected monthly.
10 Safety Signs All signs shall conform to ANSI Z535.3-2006 and	**E10 Safety Signs** Existing signs need not be replaced unless they

ANSI Z535.4-2006 in color, format, size, and content.	are unreadable. See SPI AN-137 Recommended Guideline for Safety Signs for Plastic Machinery and Related Equipment.

ANNEX A (informative) - SPI RECOMMENDED PROCEDURES

A1- LOCKOUT/TAGOUT PROCEDURE

1. Read and understand this entire procedure before beginning.

WARNING: Failure to perform the Lockout/Tagout procedure before commencing with maintenance activities can lead to serious injury or death.

A “positive, lockable” means to remove all energy sources prior to maintenance must be provided. For each machine, it is the employer’s responsibility to provide a lockout/tagout procedure and training that is in compliance with all applicable national and local requirements. The following procedure is a general guide:

2. Turn off all motors.

3. Turn off and lock the electrical disconnect switch(s) and all other energy sources. Place a tag on the switch to indicate that work is being performed on the machine.

4. Verify that all auxiliary equipment with separate power sources has been turned off. Lock and tag each disconnect switch in the OFF position.

5. Verify that all electrical power has been disconnected from the machine and from any auxiliary equipment. If the machine or any piece of equipment is energized, locate the electrical circuit(s) supplying the power. Disconnect all power sources and lock and tag these power sources in the OFF position.

6. Verify that no sources of residual energy (accumulators, capacitors, suspended machine components, etc.) are present on any equipment. If necessary, manually discharge hydraulic, pneumatic, or steam pressure and capacitor voltage from charged components. Also, block all suspended or spring-loaded machine parts to prevent movement.

7. Perform required maintenance

8. When work is completed on the machine, visually inspect that all safety devices are in place.

9. Notify other affected employees that the locks and tags are being removed, and verify that all tools and personnel are clear of the machine.

10. When the machine is ready to resume operation, each individual shall remove their own lock(s) and tag(s).

If a personal lock or tag is left on an isolation point after all work has been completed, every attempt must be made by the supervisor responsible to contact the person or persons whose name appears on the tag.

a. Contact the individual who performed the lockout/tagout instructions. Ask this individual to remove the lock and/or tag. If the person cannot return to the site they may give verbal permission to remove the lock or tag along with any specific instructions that may be required to return the machine to a safe operating condition.

b. Verify the danger zone is clear of all personnel before attempting to remove the lock or tag.

c. If the person or persons cannot be contacted to remove the lock or tag, conduct a joint investigation involving the supervisor responsible for the area (or machine) and a competent technician who has a thorough understanding of the process and the machine:

i. Check all isolation points to make sure lines, wires, and/or systems are set to a safe position or condition.
ii. Verify the danger zone around the machine is clear of personnel.

iii. When both the supervisor and the technician agree that all systems are in order and there is no potential for injury, remove the lock and/or tag.

11. If no other locks or tags remain on the machine, restart the machine using the startup procedures.

12. Before operating the machine, perform a full safety check. Personnel can be seriously injured if the machine is operated with non-functioning safety devices.

LOCKOUT/TAGOUT SERVICE PROVISION

Some service operations must be performed with the power on. The temporary removal of locks or tags from the machine is permitted **ONLY** under special testing or positioning conditions: for example, when power is needed to test or troubleshoot the machine, equipment, or components. Conduct machine startup and operation in accordance with the sequence of steps listed below:

1. Clear the machine or equipment of tools and materials.
2. Clear all employees from the machine or equipment area.
3. Remove only the lockout or tagout devices necessary to operate the machine or equipment for testing.
4. Power up the machine or equipment only as necessary to perform the operation or to proceed with testing or positioning.
5. After completing the procedure, de-energize all systems, isolate the machine or equipment from the energy source, and reapply the lockout or tagout devices removed in step 3.

A2- BLOCKED BARREL VENT

WARNING: **If steam and/or plastic vapor is not coming from the barrel vent, the barrel vent may be blocked. If this occurs, there will be trapped gas behind the blockage. Failure to follow the instructions in this section may result in serious personal injury.**

1. Read and understand the entire procedure before beginning.

2. Wear appropriate personal protective equipment such as long protective gloves, full body protective clothing and face shield.

3. Consult the Material Safety Data Sheet from the material supplier for any special material properties that might affect the procedure.

4. If the barrel vent is equipped with a heater band, check the temperature of the heater band. If the temperature is not correct, the heater band may need to be replaced. Use the following procedure when replacing the barrel vent heater band with the vent blocked.

    a. Completely purge the barrel as indicated in the purging instructions.
    b. Allow the barrel to cool to room temperature to protect against the possibility of being burned by hot plastic and/or hot gas, which could be expelled from the vent.
    c. Follow the lockout/tagout procedure.
    d. Repair or replace the heater band.
    e. Turn the main disconnect and barrel heaters on and allow the barrel to reach operating temperature.
    f. Check the barrel vent for flowing plastic or gas.

5. If the heater band is at the proper temperature but the vent still appears to be blocked, use the following procedure to clear the blockage.
    a. Follow Steps 4a through 4d above.
    b. Carefully remove the vent cover and clear the blockage from the vent.
    c. Re-install the vent cover.

6. If the blocked vent barrel problem persists, contact the vented barrel and screw supplier.

A3- CLEARING A BLOCKED FEED THROAT

WARNING: Hot plastic melt and/or gasses may be trapped just below the bridged material. Sudden release of hot plastic or gas can cause serious injury or death. Follow instructions below to avoid injury.

1. Read and understand this entire procedure before beginning.
2. Wear appropriate personal protective equipment such as long protective gloves, full body protective clothing and face shield.
3. Stop the flow of plastic pellets (or powder) into the feed throat.
4. Purge out the plasticizer completely to reduce the potential for trapped gasses and/or decomposed material splattering hot plastic**.**
5. Lockout/Tagout all power to the motor(s) and heaters.
6. Make certain that the feed throat cooling is operating. Check the temperature of the feed throat jacket. If overheated, do not remove (or swing away) the hopper until the barrel and feed throat temperature has reached less than 100 °F (37°C) in both the feed housing and barrel.
7. Hot plastic melt and/or gasses may be trapped just below the bridged material. Carefully remove the hopper. Use a vacuum to remove unmelted plastic. Never place your fingers or hand into this opening. Use tongs or other brass tools to remove material from this opening.
8. Using a brass rod or flat brass chisel and hammer, carefully break up the plastic bridge into chunks and vacuum the same away from the feed hole.
9. If these efforts fail, then refer to screw removal (Annex A6) and repeat step 8.

A4- SINGLE SCREW EXTRUDER SHUTDOWN AND CLEANING

WARNING: **While shutting down and cleaning an extruder, there is a danger of hot plastic and gas spraying from the exit end of the barrel. Make sure personnel are clear from the downstream end of the extruder. Wear protective equipment to guard against burns.**

Routine shutdown of an extruder at the end of a production run should be accomplished with the following procedure:

1. Read and understand the entire procedure before beginning.
2. Shut off the feed flow and run out the remaining material that is downstream of the shutoff.
3. As the load on the drive motor decreases,
    a. Stop the drive
    b. Shut off the screw cooling
4. When required and practical, remove the extruder downstream equipment so the end of the barrel and screw tip are exposed and run the screw at a low speed until material is no longer being discharged.

Note – If the screw and barrel rubbing contact creates a squealing noise, reduce the screw speed.

5. When material ceases to flow from the barrel, shut off the drive and let the screw come to a full stop.
6. After a short pause, start and run the extruder at a low speed to remove any remaining material. If, when the drive is shut off, the screw comes to an abrupt stop, material has not been completely removed from the barrel. Repeat this step as necessary until no further material exits the extruder barrel and the screw coasts to a stop.
7. Shut off barrel heat and lock-out equipment.

Note – Shutdown procedure may vary based on material being processed.

A5- SINGLE SCREW EXTRUDER PURGING

WARNING: **While purging an extruder, there is a danger of hot plastic and gas spraying from the exit end of the barrel. Make sure personnel are clear from the downstream end of the extruder. Wear protective equipment to guard against burns.**

PROCEDURE

For more thorough cleaning, after shutdown and cleaning, a purging procedure can be used:

1. Read and understand the entire procedure before beginning.
2. Wear appropriate personal protective equipment such as long protective gloves, full body protective clothing and face shield.
3. Introduce a pellet or granular form of material (preferably clear or white in color) that has a higher viscosity than the material previously being processed. For example, use fractional melt index (MI) polyethylene (PE). Pour a quantity of this material into the feed hopper while the screw is still turning slowly. As this stiffer material progresses down the screw and barrel, it will scrub the trailing edges of screw flights and other areas to remove and convey residual material. Alternately, use a commercially available purging material and follow the manufacturer's directions.

Note – For heat sensitive materials (such as RPVC), a commercially available highly filled heat stabilized PVC compound can be run through the extruder and tooling to clean residual heat sensitive RPVC from the equipment.

4. Continue feeding this purge material until the material exiting the barrel appears to be free of residual material previously being processed.
5. With no further addition of purge material, run the screw until no material exits the barrel.
6. Shut off barrel heat and lock-out equipment.

A6- SCREW REMOVAL AND CLEANING

WARNING: **While removing and cleaning an extruder screw, there is a danger of burns from contacting hot metal parts and hot plastic. There is a possibility of noxious fumes. Wear protective equipment to guard against burns.**

PROCEDURE

For more complete cleaning of the screw and barrel, such as before a color change, the screw can be quickly removed from the barrel and cleaned while the screw is still warm and the material is soft. This should be done with workers wearing appropriate PPE and with adequate ventilation. The screw can be cleaned with copper mesh pads, copper wire brushes or copper scrapers. Never use steel tools for this purpose as they may damage the screw surfaces. The barrel should also be cleaned with copper mesh pads or a barrel brush while still warm.