American National Standard

for Plastics Machinery – Robots Used with Horizontal and Vertical Injection Molding Machines – Safety Requirements for the Integration, Care, and Use

ANSI/SPI B151.27-2003

Approved American National Standard

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ANSI/SPI B151.27-2003
Revision of
ANSI/SPI B151.27-1994

American National Standard
for Plastics Machinery –

Robots Used with Horizontal and Vertical Injection Molding Machines – Safety Requirements for the Integration, Care, and Use

Sponsor

The Society of the Plastics Industry

Approved September 29, 2003

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Foreword (This foreword is not part of American National Standard ANSI/SPI B151.27-2003.)

This standard is a revision of *American National Standard for Plastics Machinery - Robots Used with Horizontal Injection Molding Machines - Safety Requirements for the Integration, Care, and Use,* ANSI/SPI B151.27-1994.

The project on Safety Requirements for the Integration, Care and Use of Robots Used with Horizontal and Vertical Injection Molding Machines was initiated under the auspices of the Auxiliary Section of the Society of the Plastics Industry (SPI) Machinery Division and the Safety Committee of the SPI Molders Division.

Both divisions have long been concerned with operator safety on plastics processing machinery and auxiliary equipment. Accordingly, each section of the Machinery Division has established a standards committee charged with the task of establishing safety standards.

A standard addressing the integration, care, and use of robots used with horizontal and vertical clamp injection molding machines is complicated by the variety and sizes of machines and robots manufactured and in use and by virtually infinite combinations of parts being produced, production methods used, and operating conditions existing in industry today.

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

To accomplish this objective, the committee decided to approach the problem of integration safety from two different directions:

- eliminate, by design criteria, recognized hazards, and establish standard approaches to design so that robot integration from competitive manufacturers will have similar operational characteristics;

- safeguard the point of operation to protect the operator from recognized hazards.

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

Suggestions for improvement of this standard will be welcome. They should be sent to the Society of the Plastics Industry, 1801 K Street, NW, Suite 600, 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 horizontal injection molding machines, 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.

Alcona Associates
Packaging Machinery Manufacturers Institute
Robotic Industries Association
Rubber Manufacturers
Textron
Society of the Plastics Industry
  Machinery Manufacturers Division
  Molders Division
  Mold Makers Division

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The Robotics Section, Standards Development Committee of the Machinery Divsion, The Society of the Plastics Industry, Inc., which was responsible for this standard, had the following members:

J. Healy, Chairman
The Conair Group

G. Atkinson
(Husky Injection Molding Systems)
G. Hamilton
(AEC/Sterling)
C. Irick
(EPCO Machinery LLC)
H. Luttman
(Engel Canada)
M. Lyons
(Automated Assemblies Corporation)
L. Mills
(Van Dorn Demag Corporation)
B. Monteith
(Milacron, Inc.)
J. Rexford
(HPM Corporation)

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Explanation of Standard Format

American National Standard ANSI/SPI B151.27-2003 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 and is printed in bold type.

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.

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.

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American National Standard
for Plastics Machinery –

Robots Used with Horizontal and Vertical Injection Molding Machines – Safety Requirements for the Integration, Care, and Use

STANDARD REQUIREMENTS

EXPLANATORY INFORMATION

(Not part of *American National Standard for Plastics Machinery – Robots Used with Horizontal and Vertical Injection Molding Machines – Safety Requirements for the Integration, Care, and Use,* ANSI/SPI B151.27-2003)

1 Scope, Purpose, and Application

1.1 *Scope*

The requirements of this standard shall apply to all robots used on or in conjunction with horizontal and vertical IMM(s).

1.2 *Purpose*

The purpose of this standard is to establish recommended safe practices and procedures for the integration, care, and use of robots entering the *mold area* of horizontal and vertical IMM(s). Procedures for automatic mold changers and other ancillary equipment are not included in this standard.

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1.3 *Application - All Robot Installations*

Recognizing the impossibility of updating systems and changing operation methods allied with existing systems immediately after approval date of this standard, an 18-month period has been provided to employers for updating all robot systems used with IMM(s), following the approval date of this standard. New installations of robots with injection molding machines shall be in compliance with this standard within one year from the approval date of this standard.

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2 Normative References

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

ANSI Z535.3-1998, *Criteria for safe symbols*

ANSI Z535.4-1998, *Product safety sign and labels*

ANSI/NFPA 79-1997, *Electrical standard for industrial machinery*

ANSI/SPI B151.1-1997, *Plastics machinery – Horizontal injection molding machines – Safety requirements for the manufacture, care, and use*

ANSI/SPI B151.29-2001, *Safety requirements for the manufacture, care and use of vertical clamp injection molding machines.*

SPI AN-116, *SPI Electrical interface for robot/injection molding machine*

E2 *Bibliography*

AN-133-SPI *Recommended Guideline – Robot Mounting Pattern*

AN-134-SPI *Recommended Guideline for Technical Manuals Supplied With Plastics Machinery and Related Equipment*

AN-137-SPI *Recommended Guideline for Safety Signs for Plastic Machinery and Related Equipment*
AN-141-SPI *Harmonized International Safety Warning Signs for Injection Molding Machines.*

ANSI/RIA R15.06-1999 *Industrial robots and robot systems – Safety requirements*

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3 Definitions

3.1 *Actuator*

a) A power mechanism used to effect motion;

b) A cylinder or motor that converts electrical, hydraulic, or pneumatic energy to effect motion.

3.2 *Automatic Mode*

The state in which automatic operation can be initiated.

3.3 *Automatic Operation*

The time during which the robot or IMM is performing unattended programmed tasks.

3.4 *Barrier*

A physical means of separating persons from hazard.

3.5 *Control Device*

Any piece of control hardware providing a means for human intervention in the control of a robot or robot system.

E3.5 *Control Device*

Examples of a control device include, but are not limited to:

- Emergency stop button
- a start button
- a selector button
- a relay
- a solenoid valve
- a sensor

3.6 *Control Program*

The inherent set of control instructions that define the capabilities, actions, and responses of the robot system.

3.7 *Controlled Continuous Operation*

The time during which the robot or IMM is performing programmed tasks at a slow speed through attended program execution.

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3.8 *Cores*

Stationary and movable mold half parts that shape a portion the interior of a hollow part.

3.9 *Drive Power*

The energy source or sources for actuators that produce motion.

3.10 *Ejector*

Any and all provisions for the release of the finished product from the mold.

E3.10 *Ejector*

The term, *ejector*, is intended to include all provisions for the release of the finished product from the mold. This includes ejector pins, ejector rings, IMM ejector plates, cores and their associated actuators, unscrewing devices, stack mold racks, mold sprue break device, mold seeps and drawbar or drawchain mechanisms, blowoff mechanisms, Air poppets, or other devices as understood in accepted molding terminology. The ejectors may be actuated by the motion of the machine clamp or by hydraulic, electric, or pneumatic circuitry, or any combination of cicuitries, integral with, or independent of, the machine circuits.

3.11 *Emergency Stop*

A hardwired circuit that overrides all other controls, removes drive power from the actuators, and causes all moving parts to stop.

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3.12 *Employer*

A company, a business, or a person who uses robots or robot systems and who contracts, hires, or is responsible for the personnel associated with the robot or system operation.

3.13 *End Effector*

An accessory device or tool specifically designed for attachment to the robot wrist or tool-mounting plate to enable the robot to perform its intended task.

E3.13 *End Effector* (also referred to as end of arm tooling)

Examples may include mechanical gripper(s), vacuum cup(s), etc.

3.14 *Energy Source*

Any electrical, mechanical, hydraulic, pneumatic, chemical, thermal, potential, kinetic, or other sources of power/movement.

3.15 *Fixed Guard*

A fixed barrier that requires the use of tools to remove it.

3.16 *Function Testing*

That procedure in which interference signals, controls, and interlocks are tested to assure proper and intended operation.

3.17 *Gate*

An interlocked moveable barrier.

3.18 *Guard*

See *barrier*.

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3.19 *Hazard*

A potential source of harm.

3.20 *Hazardous Motion*

Any motion that may cause injury to person(s).

3.21 *IMM*

An injection molding machine.

E3.21 *IMM*

An injection molding machine includes HIMM – horizontal IMM, and VCIMM – vertical clamp IMM.

3.22 *Instructions*

Documentation that describes the operation, care, and safe use of the system.

3.23 *Interlock*

An arrangement whereby the operation of one control or mechanism brings about, or prevents, the operation of another.

3.24 *Limiting Device*

A device that restricts the maximum space by stopping or causing to stop all robot motion and is independent of the control program and the task programs.

3.25 *Manual Mode*

A control selection in which movement of any component is permitted only while the button or switch for the elected movement is manually maintained in an actuated position.

3.26 *Maintenance*

The act of keeping the system in proper operating condition.

3.27 *Manufacturer*

A person(s) whose business is the manufacture of new equipment.

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3.28 *Maximum Envelope (Space)*

The volume of space encompassing the maximum designed movements of all robot parts including the end-of-arm tooling, workpiece and attachments.

3.29 *Mold Area*

That zone between the platens of the IMM.

3.30 *Operating Space*

That portion of the restricted space that is actually used by the robot while performing its programmed motions.

3.31 *Operator*

The person designated to start, monitor, and stop the intended productive operation of a system.

3.32 *Operator's Gate*

A moveable barrier arranged to guard the operator side of the mold area of the IMM.

3.33 *Pendant*

Any portable control device, including teach pendants, that permits the control of a system.

3.34 *Perimeter Guarded Area*

The area that includes the restricted space of the robot.

3.35 *Perimeter Guard*

A barrier or presence sensing device arrangement that encloses and prevents access to the restricted space from the working surfaces.

3.36 *Platen*

The stationary or moving member of any IMM to which the mold is fastened.

E3.32 *Operator's Gate*

The operator's gate may be open and closed with each machine cycle.

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3.37 *Presence-Sensing Device*

A device designed, constructed and installed to create a sensing field or area to detect intrusion or presence within such field or area by personnel, robots, or other objects.

3.38 *Program*

a) (*n*) A sequence of instructions to be executed by the computer or robot controller to control a robot/robot system;
b) (*v*) To furnish (a computer) with a code of instructions;
c) (*v*) to teach a robot system a specific set of movements and instructions to accomplish a task.

3.39 *Rear Guard*

A barrier arranged to guard the rear mold area.

3.40 *Remanufacturer*

Any person whose business is the redesign or reconstruction of equipment.

3.41 *Restricted Space*

That portion of the maximum space to which a robot is restricted by limiting devices. The maximum distance that the robot, and *end effector*, and work piece can travel after the limiting device is actuated defines the boundaries of the restricted space of the robot.

3.42 *Robot*

A multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks.

E3.42 *Robot*

The term *robot*, is meant to include reprogrammable manipulators including sprue pickers. This term does not include automatic mold changers or conveyor.

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3.43 *Robot System*

The integration and use of a robot in conjunction with the operation of an IMM.

3.44 *Safeguard*

A barrier guard, device, or safety procedure designed for the protection of personnel.

3.45 *Safety Sign*

A visual alerting device in the form of a sign, label, decal, placard, or other marking that advises the observer of the nature and degree of the hazard(s) that can cause injury or death.

3.46 *Sensor*

A device that responds to physical stimuli (such as heat, light, sound, pressure, magnetism, motion, etc.) and transmits the resulting signal or data to provide a measurement or to operate a control.

3.47 *Service*

The inspection, maintenance, set-up, or adjustment of the robot, the IMM, or the system.

3.48 *Shall*

The word s*hall* is to be understood as denoting a mandatory requirement.

3.49 *Should*

The word s*hould* is to be understood as denoting a recommendation.

3.50 *Semi-Automatic or Single Cycle*

A selectable mode of operation of the HIMM or VCIMM that allows it to perform one complete cycle and then stop.

3.51 *Slow Speed Control*

A mode of robot motion control where the speed is limited to 10 in/sec (≤250 mm/sec) to allow persons sufficient time to either withdraw from the hazardous motion or stop the robot.

3.52 *Start-Up*

Routine application of power to the system.

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3.53 *System Integrator*

That party that is responsible for assuring the design and assembly of the robot, the IMM, and other equipment into a system conforming with the requirements of this standard.

3.54 *Task Program*

The set of instructions that define the specific intended tasks of robots and robot systems to make them reprogrammable and multifunctional. This program may be originated and modified by the robot user.

3.55 *Teach (Programming)*

Programming performed by:

a) Manually leading the robot end-effector;

b) Manually leading a mechanical simulating device;

c) Using a teach pendant to move the robot through the desired actions;

d) Using the IMM control to move the robot through the desired actions.

3.56 *Teach Mode*

The control state that allows the generation, storage and playback of positional data points while under slow speed control.

3.57 *Teacher*

A person who provides the robot with a specific set of instructions to perform a task.

3.58 *Working Surface*

These surfaces include, but are not limited to, the floor and permanently installed platforms and catwalks intended for operating or servicing the system.

E3.53 *System Integrator*

The *system integrator* may be the supplier or the manufacturer of the IMM or of the robot, the remanufacturer of the IMM or of the robot, an independent contractor, or the employer.

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4 Responsibilities

4.1 *Employer*

The employer of the integrated *robot system(*s) has the overall responsibility for the system, and shall ensure that the system, as used, is in compliance with this standard.

4.2 *System Integrator*

The *system integrator* shall ensure that the system complies with clauses 5, 7, 8, and 9 of this standard. The *system integrator* has the responsibility of ensuring that any modifications made to the IMM shall conform to ANSI/SPI B151.1-1997 (HIMM) or ANSI/SPI B151.29-2001 (VCIMM) except where modified by this standard. In general, when a *gate* or *guard* is removed or modified to accommodate a robot, alternate interlocked perimeter guarding shall be incorporated.

The employer shall be the *system integrator* unless another party contractually accepts responsibility as the *system integrator*.

5 System Installation, Test, and Start-Up

The employer of the integrated *robot system* has the overall responsibility for the system and shall ensure that the system is installed, tested, and started-up in accordance with this clause.

5.1 *Installation*

The system shall be installed in accordance with the specifications of the manufacturer(s) of all system equipment, applicable codes, guidelines, and standards.

5.1.1 *Robot Mounting*

Uncrating, rigging, and lifting shall be in accordance with instructions of the robot manufacturer. The robot shall be mounted in accordance with the robot manufacturer's instructions and specifications, such as bolt patterns, levelness, etc.

E5.1.1 *Robot Mounting*

Refer to SPI AN 133.

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5.1.2 *System Power Requirements*

All sources of power provided shall meet the specifications of the manufacturer(s) of all system equipment and applicable codes.

E5.1.2 *System Power Requirements*

Sources of power may include, but are not limited to, electrical, pneumatic, hydraulic, vacuum, or mechanical.

5.1.3 *System Grounding Requirements*

Electrical grounds shall be provided in accordance with the specifications of the manufacturer(s) of all system equipment and applicable codes.

5.1.4 *Power Disconnect*

The system shall have one or more means to disconnect all power to all system equipment. This/these means shall be located outside the *restricted space* and shall have lockout capability. Disconnection or loss of power at any time, shall not result in a hazard.

5.1.5 *Control Device Location*

***Control devices*, indicators, and displays requiring access during *automatic operation* shall be accessible and be outside the *perimeter guarded area*.**

E5.1.5 *Control Device Location*

It is the intent of this standard that a person using/monitoring the controls be outside the *perimeter guarded area*.

5.1.6 *Electrical Interface*

The robot shall be interfaced with the *IMM* in accordance with the SPI Robot/Injection Molding Machine Electrical Interface, SPI AN-116 or equivalent. Any deviation shall not reduce the level of safety in the system.

5.1.7 *Associated Equipment Shutdown*

The system shall be installed so that the shutdown of associated equipment shall not result in a hazard.

5.1.8 *Restricted Space*

***Restricted space* shall be conspicuously identified.**

5.1.9 *Emergency Stop*

The system shall have an *emergency stop* circuit in accordance with 7.2.3.

Each system operator station shall be provided with an accessible, unobstructed *emergency stop* device.

5.1.10 *Robot Power Loss*

Safeguards against hazards resulting from robot power loss shall be provided in accordance with 7.2.4.

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5.2 *Test and Start-Up Procedures*

This subclause defines the procedures that shall be followed during the test and *start-up* of systems after installation or relocation. It also applies to systems after changes in software or hardware and after *maintenance* or repairs that could affect their safe operation.

5.2.1 *Safeguarding*

Safeguarding shall be in place and operational prior to the *start-up* and testing procedure. During testing and *start-up*, no personnel shall be allowed in the *restricted space* of the system until safeguards and proper operation are verified.

5.2.2 *Installation/Relocation Test and Start-Up Procedures*

The *system integrator* is responsible for the test and *start-up* procedure that shall include but not necessarily be limited to the procedures outlined by the system equipment manufacturer(s) and the verification procedure outlined in 5.2.2.1 and 5.2.2.2.

5.2.2.1 Before applying power, clear the robot *restricted space* of personnel and obstructions and verify that the following have been installed in accordance with the system equipment manufacturer's specifications.

- **a) system safeguarding;**
- **b) mechanical mounting and stability of the robot;**
- **c) power source connections;**
- **d) *IMM*/robot interface connections;**
- **e) communications connections;**
- **f) peripheral equipment**
- **g) *limiting devices* for restricting the robot work space.**

5.2.2.2 After applying power, verify that:

- **a) each robot axis moves and is restricted as intended.**
- **b) *emergency stop* devices on the robot and *IMM* and associated equipment function;**
- **c) robot *drive power* disconnect functions;**

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d) *IMM*/robot interface functions;

e) interlocks function;

f) safeguards function;

g) system operates as intended;

h) slow speed of robot is in accordance with 6.1.3;

i) *automatic mode* functions as intended.

5.2.3 Test and start-up procedures after system modifications

A procedure for the restart of the system after modification of the hardware or program, repair, or *maintenance* of the system shall include all items listed in 5.2.2, relevant to the modifications made.

6 Training, Care, and Use

This clause specifies the requirements for training, care, and use including robot teaching, programming, and servicing. The employer using a system shall ensure that *safeguards* are provided, used, and maintained for each operation associated with the system.

6.1 *Robot Teaching*

6.1.1 The teacher shall be trained on the particular model of robot and shall be familiar with the recommended teaching procedures for the system. The teacher shall not teach the robot from a moving surface.

6.1.2 Before teaching a robot, the teacher shall visually check the robot and operational space to assure that conditions that may cause hazards do not exist. The teach controls of the robot shall be function tested to ensure proper operation. Any damages or hazards noted shall be corrected prior to commencing the *teach* program.

6.1.3 A record of all modifications to the program of the robot shall be maintained so that planned robot motions are known.

E6.1.3 This requirement allows the robot teacher to anticipate robot motion.

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6.1.4 *Robot Teaching*

Additional requirements while teaching within perimeter guarding

6.1.4.1 Before entering the *perimeter guarded area*, the teacher shall ensure that all necessary *safeguards* are in place and functioning, and that the slow speed of the robot (maximum 10in/s [250 mm/s]) is functional.

6.1.4.2 When the teach mode or program verification mode is selected, the following conditions shall be met:

a) The system shall be under the sole control of the teacher while the teacher is within the *perimeter guarded area*;

b) The robot shall not respond to any remote *interlocks* or signals that would cause motion;

c) Movement of equipment in the *perimeter guarded area* shall be under the sole control of the teacher if such movement is required and would present a hazard.

d) All robot and *IMM* system *emergency stops* shall remain functional.

e) The *gate* in the perimeter guard shall remain open anytime the teacher is inside the *perimeter guarded area*.

Only the teacher is allowed in the *perimeter guarded area* during *teach mode* or program verification mode.

6.1.4.3 The teacher shall be required to leave the *perimeter guarded area* prior to initiating *automatic mode* of the system.

6.2 *Servicing*

6.2.1 The employer shall ensure that personnel who service the system are trained and qualified in the procedures necessary to safely perform the required tasks.

E6.1.4 *Robot Teaching*

It is the intent of this subclause to describe the safety requirements for the system while the teacher is within the *perimeter guarded area*.

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6.2.2 Personnel who service a system shall be safeguarded from injury due to unexpected or unintended motion. The most effective means of safeguarding is to shut the power off. A procedure shall be followed that includes lockout/tagout of all hazardous sources of power and releasing or blocking of potentially hazardous stored energy.

6.2.3 Prior to entering the *perimeter guarded area* while power to the robot or *IMM* is on, the following procedures shall be performed:

- **a) A visual inspection of the system shall be made to determine if conditions exist that are likely to result in potential hazards.**
- **b) If *pendant* controls are to be used, they shall be function tested prior to such use to assure their proper operation.**
- **c) If any damage or *hazard* is found, system power shall be turned off and required corrections shall be completed and retesting shall be performed before personnel enter the *perimeter guarded area* with the system power "ON".**

6.2.4 Personnel servicing the system within the *perimeter guarded area* when the system power is "ON", shall have total control of the system. This shall be achieved in the following manner:

- **a) The *robot system* shall be in *manual mode*;**
- **b) *Robot system* control shall be isolated within robot software programming from any remote signal that could initiate motion;**
- **c) Movement of other equipment in the system shall be under the control of the person in the *perimeter guarded area* if such movement is required and would present a hazard;**
- **d) All system *emergency stop* devices shall remain functional;**
- **e) The system shall be reset for *automatic operation* only after all personnel leave the *perimeter guarded area*;**
- **f) The *gate* in the perimeter guard shall remain open any time personnel are inside the *perimeter guarded area*.**

E6.2.2 When servicing is required with power on, refer to 6.2.3. and 6.2.4.

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6.2.5 The employer of a system shall establish a regular and periodic inspection and *maintenance* program to assure its continued safe operation. The employer shall be able to demonstrate that an effective service program is in place. The service program shall comply with the recommendations of the manufacturer(s) of the system. Hazards observed during inspection or daily operations shall be promptly corrected.

6.3 *Training*

6.3.1 The employer shall ensure that employees who program, teach, operate, or service the system are adequately trained and demonstrate competence to perform their jobs safely. Training shall include, but not be limited to:

- **a) a review of applicable safety procedures in this standard and the safety recommendations of the system manufacturers;**
- **b) a clear definition of assigned tasks;**
- **c) identification and explanation of all controls to be encountered in performing the assigned tasks. Specific safety precautions, procedures, and safeguarding devices that are particular to each system component shall also be integrated into every phase of training;**
- **d) a description of the hazards and consequences involved in the system**
- **e) the method for *function testing* the safeguarding devices;**
- **f) the method for safeguarding the operator, teacher, and service personnel.**

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7 Safeguarding Requirements and Methods

7.1 *Requirements*

When a robot is installed for use in conjunction with an *IMM*, hazards associated with the resulting integrated system shall be guarded in accordance with 7.2.

7.2 *Methods*

7.2.1 *Top or Bottom Entry Robot*

When a top or bottom entry robot is used with an *IMM*, interlocked barriers or interlocked perimeter guarding shall prevent personnel from reaching over, under, around, or through the guarding and into the *restricted space* of the robot. When the perimeter gate is opened, the motion of the robot shall be inhibited, except as required for robot teaching (6.1).

On those *IMM*s that incorporate a top guard, the top guard shall incorporate sufficient opening for the robot movement. This opening shall be protected by a *guard* or cover. If this *guard* or cover is fixed, requiring tools to remove it, interlocking is not necessary. When this *guard* or cover is removed to accommodate a top entry robot, perimeter guarding or other guarding shall prevent personnel from reaching over, under, around, or through the guarding and into the *restricted space* or into a hazardous area of the *IMM*.

When the robot is removed from the *IMM*, the employer shall ensure that the *gates* or *guard*s comply with ANSI/SPI B151.1-1997.

E7 *Safeguarding Requirements and Methods*

The purpose of this clause is to define the requirements and methods for safeguarding of personnel on work surfaces.

E7.2.1 *Top or Bottom Entry Robot*

Guarding may be in the form of perimeter guarding with an interlocked gate or *fixed guarding* around the movement of the robot or similar guarding.

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7.2.2 *Side Entry Robot*

When a *gate* or *guard* of the *IMM* is left open, removed, or altered to accommodate a robot and its movements, alternate fixed guards, alternate interlocked *barriers*, or interlocked perimeter guarding shall be incorporated. The *interlocks* shall be redundant to ensure the equivalent level of safety that existed before installation of the robot to the *IMM*. The perimeter guarding or *barrier* shall prevent personnel from reaching over, under, around or through the perimeter guarding or *barrier* into the *restricted space* or into hazardous areas of the *IMM*.

If the *operator's gate* or *guard* of the existing *IMM* is not modified and is automatically opened and closed each cycle and the existing *interlocks* remain functional, interlocked *barriers* or interlocked perimeter guarding shall prevent personnel from reaching over, under, around, or through the guarding and into the *restricted space* of the robot. When the robot is removed from the *IMM*, the employer shall ensure that the *gate* or *guard* complies with ANSI/SPI B151.1-1997 (HIMM) or ANSI/SPI B151.29-2001 (VCIMM).

7.2.3 *Emergency Stop*

The system shall have a hardwired *emergency stop* circuit. The *emergency stop* circuit, when activated, shall override all other controls and cause the robot, *IMM*, and associated equipment within the *perimeter guarded area* that may present a *hazard* to stop all motion.

Pushbuttons that activate the *emergency stop* circuit shall be red, unguarded, palm or mushroom-head type. The *emergency stop* pushbuttons shall be of the type requiring manual resetting. Red palm or mushroom-head type pushbuttons shall not be used for any function except *emergency stop*.

Following an *emergency stop*, restarting the system shall require a deliberate action by the operator to follow a prescribed *start-up* procedure, which shall take place outside the *perimeter guarded area*.

E7.2.2 *Side Entry Robot*

It is the intent of this standard that the alternate interlocks be such that, when actuated, the motion of the robot and the motion of the *IMM* may be transferred to the perimeter gate.

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7.2.4 *Interruption of Power*

The robot and end-of-arm tooling shall be designed and constructed so that loss or change of mechanical, electric, hydraulic, pneumatic, or vacuum power shall not result in a hazard. If this is not feasible, then other methods of safeguarding shall be provided to protect against the hazards.

Following a power loss, restarting the robot shall require a deliberate action by the operator to follow a prescribed *start-up* procedure, which shall take place outside the *perimeter guarded area*.

7.2.5 *Interlocked Perimeter Guards*

Safety circuitry shall be designed, constructed and applied such that any single component failure in the safety circuit shall not prevent the stopping action of the robot.

The monitoring shall generate a stop signal if a fault is detected. A warning shall be provided if a *hazard* remains after cessation of motion.

Following detection of a fault, a safe state shall be maintained until the fault is cleared.

The single fault should be detected at a time of failure. If not practicable, the failure shall be detected at the next demand upon the safety function.

7.2.6 *Safety Signs*

***Safety signs* shall be provided in accordance with clause 8.**

7.2.7 *Catwalks and Platforms*

Catwalks and platforms that provide access to the *restricted space* of the robot shall have an interlocked *safeguard*. The *safeguard* shall inhibit motion of the robot, except as required for robot teaching (6.1). If the catwalk or platform provides access to hazardous areas of the *IMM*, then IMM motion shall be inhibited. Restarting motion shall require a deliberate action by the operator following a prescribed *start-up* procedure that shall take place outside the *perimeter guarded area*.

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8 Safety Signs

All new safety signs shall conform to the standards in the ANSI Z535 series.

E8 *Safety Signs*

The purpose of this clause is to define the requirements of the integrator for visual warnings for the integrated system.

9 Documentation

It shall be the responsibility of the *system integrator* to obtain and provide safety information on the integration of the molding machines with a robot.

E9 *Documentation*

See SPI AN-134

Robot Manufacturers should include reference to ANSI/SPI B151.27 in the equipment documentation.

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