Safety Inspection Checklist

Best Practice Guide To Injection Molding Machine Safety!

Written By:

John F. (Jack) Podojil
CHCM, CHMM, REP, REA, ASA, CUSA, CPEA, CHS-III
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Forward

The issue of machine safeguarding is very confusing. Often, people in my opinion, do not guard machines by using the right guard for their operations. In my 35 years in the safety & health field and guarding machinery, I have watched countless employers try and protect their employees from danger by listening to a sales person tell them to guard the machine with photo-electric (light curtains) or two hand controls. These guarding devices are just that safeguarding devices.

The true meaning of a machine guard is one where you can not reach over, under, around or through the guard to reach a hazardous area or point of operation on the machine. This guard must also protect the operator from the hazard of a part flying out of the machine. The hierarchy of guarding is not new. It has been written in every document that has ever been published on this subject.

To properly protect an employee from being injured by an injection molding machine, a risk analysis must be conducted. This means that the person conducting this analysis should take into consideration all of the hazardous operations of the machine and the potential for part or machine failure and employee misconduct.

This guide / checklist book is written with my hope that it will help people select the right guard and guarding device. This document provides “Best Practice” guidance and was written by using the best practices used in industry today.

I would like to thank the many people who have contributed to the writing of this guide by allowing me to use some of their work. I would like to thank my past employers the State of Arizona (ADOSH), Federal OSHA for the opportunity to inspect the many types of machines that are found in manufacturing environments. I would like to thank NIOSH, and other writers for allowing me to use some of their work in preparing this document.

Most of all, this guide / checklist book is written in hope that engineers, safety, health and environmental professionals, students, maintenance personnel and operators have an opportunity to obtain the necessary information that is found in this guide book to make their machine guarding programs better.

In my teaching of students, I have always told them to remember this statement “Everything that you want to know about a subject is written in a book somewhere” This was told to me by my mentor “Gordon Jones” and today I find myself still researching the many documents that can be found on the internet and in books.
One particular place that offers the best information on machine safety can be found in the **interpretation section** of the OSHA website. Here you will find the many answers to the many questions that are asked by people searching to protect their operators and maintenance personnel from harm.

It is my hope as you read this guide / checklist document that you learn from it and most of all use the information contained in this guide to protect people from harm.

Note: This checklist is not all inclusive of the hazards that can be found on injection molding machines. There are many manufacturers of these machines and each has the own inherent hazards. The owners / operators manual must be read, used and the information contained in these manuals must be followed when conducting the inspection.
Molding Machine Process and Modes

Injection molding machines are manufactured in two styles: vertical and horizontal. Although major differences exist in the construction and usage of these types of machines, the safety requirements are similar.

An injection molding machine is constructed in two pieces: (1) an injection unit and (2) a clamp unit. Both of these units are integral in the overall molding process. This process involves the melting of pelletized plastic in a plasticizing chamber (located in the injection unit) by a reciprocating screw. After melting, the reciprocating screw forces the "melt" into the mold under extreme pressures (generally in the 10,000 to 20,000 psi range). While the molten plastic hardens in the mold, forming the requisite product, the screw rotates in a reverse direction, melting more plastic and preparing for the next "shot." The reciprocating screw is actuated by hydraulic or electric means.

Another common activity involving the injection unit is a "purge." To purge the injection unit, the operator moves the injection unit away from the mold and then causes the injection unit to extrude plastic onto the bed of the machine. Plastic degrades if heated for an extended time, thus purging becomes necessary.

During the injection cycle, the two halves of the mold must be clamped together tightly to withstand the high injection pressures. The amount of clamp force required varies depending on the size of the part, but this pressure ranges from 50 tons to 3000 tons and above. After the injection cycle has completed, and the plastic resolidified, then the clamp unit opens the two halves of the mold and ejects the products. The clamp unit is actuated either by a hydraulic cylinder that generates the forces or a "knuckle" approach for mechanical advantage.

An injection molding machine operates in three different modes. The first, full automatic, allows the machine to manufacture product with no human intervention. It simply melts plastic, shoots it into the mold and then ejects the product. During ejection, the product either falls onto a conveyor or chute, or the products are removed by robotic arms (typically for very cosmetic type products). This mode is generally used for production.

The second mode, semi-automatic, is used during the start up of the machine or for product that demands human intervention. In this mode, the machine operates automatically for one full cycle and then stops. The human must open the operator safety gate and then close it to actuate the next cycle. Insert molding, where a metal insert is placed into the mold prior to injection, is a case where human interaction is necessary. Another use of "semi" is for products that do not eject automatically.
The final mode, manual, is used exclusively for machine set up. In this mode, the machine takes no action without human involvement. The clamp will not close, injection unit not function nor will the ejection mechanism activate without the set up person instructing the machine to do so via a control panel. The purging procedure, detailed above, is a common use of manual mode.

As can be obviously seen, there are many opportunities for injuries to occur, as there are many energy sources involved in working with this type of machine.

**Slips, Trips and Falls**

Slips, trips and falls occur in many ways within injection molding companies. The most common slip transpires because of plastic pellets on the floor. Plastic is transported to molders as pellets contained in bags, boxes, truck load or rail car. In truck load and rail car quantities, the pellets are stored in large, grain-style silos. The plastic enters the plant via pipes directly connected to the molding machines, thus preventing most spills. But, for companies that use bags or boxes, spills are common. With these pellets on the floor, it is nearly impossible to prevent slips. Fortunately, most of these slips are minor.

Falls can be much more dangerous. Prior to entering the injection unit of the molding machine, the pellets are stored in large hoppers attached to the top side of the injection unit. A vacuum system moves the plastic from box or silo to the hopper. This vacuum system contains a piece of equipment (the loader) that sits on top of the hopper. It is often necessary to construct platforms for personnel to attend to these loaders. These platforms require ladders and can be as high as 20 feet in the air. Falls transpire when a person attempts to maneuver the loader while either on the ladder or the platform.

Slips, trips and falls are extremely difficult to prevent. To prevent slips and trips, a capable housekeeping system should be enforced. The policy should allow for sweeping of the area surrounding the molding machines frequently. This will avoid many slips be keeping the plastic pellets off of the floor. If possible, the company should also receive the pellets into a silo and pipe them into the hoppers of the machines. This helps to avert the possibility of pellets ending up on the floor.

Falls can be avoided. To eliminate the need to climb to an excessive height to clean up the vacuum system, a company can install a system that is not mounted on the machine. Modern material handling techniques allow for the hoppers to be mounted in the floor of the plant, thus making the heavy loaders available at waist level. On the machine itself is a simple, small hopper that contains only about 1 pound of material. This mini-hopper is much lower to the ground, again averting the necessity of climbing a ladder.
To sidestep the falls associated with machine mounted robots, a company should provide a safe aerial basket. The aerial basket would then be maneuvered over the machine, near the robot and allow the maintenance, or setup, person to perform operations on the robot.

**Auxiliary Equipment**

The auxiliary equipment around an injection molding machine contains several hazards. The first piece of necessary auxiliary equipment is the mold itself. A mold consists of a minimum of approximately 1000 pounds of steel and assorted other metals. This chunk of metal must be positioned in the molding machine. Positioning the mold involves lifting it up and over the framework of the machine. This is done either by overhead cranes or by fork trucks with chains. Either of these methods have some inherent dangers of their own. Should the mold be mishandled, it can lead to crushed and/or severed limbs.

Molds also present a burn danger. To pragmatically mold product, the mold itself is often heated to a maximum of about 180\(^\circ\) F. For efficient changeovers of the machine, the mold is pre-heated to the molding temperature. During the handling of the mold, the mold setter must be careful to not come in contact with the heated surfaces.

Scrap grinders present dismemberment perils to operators and setup personnel. The rotating blades contained in these machines can either directly amputate a body part, or it can trap loose clothing or jewelry. Since grinders granulate material, it is possible for some of it to fly into the eye of a person operating the grinder.

Machine mounted robots contain the second most prevalent source of hazards in injection molding companies. The major concerns with machine mounted robots are: (1) trapping, (2) falls and (3) electrocution.

**Accidents & Fatalities**

The National Institute for Occupational Safety and Health (NIOSH), OSHA and other agencies investigates accidents that occur in the workplace. The reports are listed and put into a program file called “FACE” The purpose of the FACE program is to identify and rank factors that influence the risk of fatal injuries for selected employees. Here are a few of the types of accidents that have occurred on these types of machines:
**Case # 1:** On November 12, 1986, a "set-up" man was electrocuted when he simultaneously contacted an injection molding machine which was grounded and a grinding machine with a ground fault.

**Background/Overview of Employer's Safety Program:**

The victim was an injection mold "set-up" man for a plastics manufacturing company. The company manufactures plastic components (i.e., plastic lawnmower wheels) for other companies. There are no safety meetings and no designated safety officer. While there is a written safety manual, it appears to be used infrequently. All training is "on the job."

**Synopsis of Events:**

The victim, a co-worker, and a supervisor were working to "set-up" an injection molding machine. The plastic parts being manufactured were defective and the victim opened a door to the molding machine to remove and examine one of the plastic parts. As he closed the door with his left hand, he supported himself with his right hand by holding the metal handle of the nearby portable grinding machine, which was used in recycling scrap plastic. An energized wire to a safety interlock (a switch designed to stop the grinder when the top cover was opened) apparently was contacting the metal case of the switch, electrically energizing the switch and the metal case of the grinder at 270 volts. The victim's body provided a path to ground from the energized grinder to the grounded injection molding machine. Due to involuntary muscular contraction ("can't let go" phenomenon), the victim could not let go of either handle. His co-worker noticed that "something was wrong" and grabbed the victim from behind. He received an electrical shock, but was not injured. The supervisor then went to the electrical panel (a few feet away) and de-energized both machines.

The victim collapsed and an attempt at cardiopulmonary resuscitation (CPR) was made by co-workers. The plant is located in a rural setting and the emergency medical service (EMS) did not arrive for approximately 16 minutes. Ambulance personnel stated that no one was performing CPR when they arrived, no one at the scene was certified in CPR, and apparently only mouth-to-mouth efforts (without chest compressions) had been attempted. The victim was blue in color, had no pulse or respiratory effort, and had a "flat" (no electrical activity) electrocardiogram. It was felt that the victim was beyond help at this point and no further resuscitation efforts were made.
Cause of Death:

The medical examiner found no burns on the victim's body. He ruled the cause of death to be "accidental electrocution," since the victim had no history of heart disease and a co-worker who tried to aid him was "shocked." No autopsy was performed.

Recommendations/Discussion:

Recommendation #1: All electrical systems should be inspected periodically by qualified electricians and undergo routine preventive maintenance as prescribed by the equipment manufacturer.

Discussion: The plant engineer stated that the plug of the grinder was loose in the receptacle and that there was evidence of "arching" on the back of the receptacle. The receptacles were ceramic and had been in service for many years. Apparently, a continuous path to ground was not provided for the grinder, in accordance with Section 250-51 of the 1987 edition of the National Electrical Code (due to poor mechanical contact at the receptacle). Receptacles should be routinely tested with a receptacle tension tester to ensure that good mechanical contact is made; the resistance to ground of all grounded equipment should be verified periodically. Electricians were brought in from outside the plant to locate and repair the electrical problem after the accident occurred. Qualified electricians should also provide routine preventive maintenance for all electrical equipment.

Recommendation #2: Safety should be a design consideration in all electrical installations.

Discussion: The safety interlock, a design modification, was electrically energized at 270 volts. This voltage is greater than necessary; using a transformer to step down the voltage to the safety interlock would provide for a safer installation. Electrical equipment design modifications should only be done by qualified personnel.

Recommendation #3: The handles of all metal enclosures housing electrical equipment should be non-conductive (insulated).

Discussion: After the accident, the company installed insulation on the metal handles of some electrical equipment. Non-conductive (insulated) handles are not currently required by the National Electrical Code; however, many low voltage electrocutions occur when the victim "can't let go" after grasping an energized metal handle.
While non-conductive (insulated) handles should not be considered a substitute for effective grounding, it would increase the overall safety of the equipment. This recommendation will be submitted to the National Electrical Code Committee for consideration.

**Recommendation #4: The company should develop a planned response to emergencies.**

**Discussion:** The plant personnel who attempted CPR apparently did not have current certification. Provision should be made to ensure that all work shifts have qualified individuals with current CPR certification available. Employers in rural areas may want to discuss the feasibility of obtaining an automatic defibrillator with their plant physician or medical consultant. Prolonged EMS response times to rural locations (greater than eight to ten minutes) make successful resuscitation of a cardiac arrest victim unlikely.

**Case # 2 SUMMARY**

A 33-year old supervisor (decedent) died when his head was crushed between a hydraulic cylinder and a panel of a plastics injection molding machine. The decedent was setting-up the machine for a run and was in the process of tightening a bolt. While tightening the bolt the decedent positioned his head so that it was between the hydraulic cylinder and a panel of the machine. During this time the machine cycled and his head was caught. The employer had no written instructions for the set-up procedure. The employer also did not have an Injury and Illness Prevention Program (IIPP) or any written safety or training information. The CA/FACE investigator determined that, in order to prevent future occurrences, employers should:

- ensure employees do not place body parts in the pinch point of machines
- develop a written procedure which covers the manner in which machine set-up should be performed and ensure that it is understood and followed
- establish and implement a written company safety program.

**INTRODUCTION**

On January 8, 1998, at 2:03 p.m., a 33-year old male supervisor was fatally injured when his head was crushed between a hydraulic cylinder and panel of a plastics injection molding machine. He was setting-up the machine for a run
when the machine cycled and caught his head. He died the following day at 2:40 p.m.

The CA/FACE investigator learned of this incident from a district office of the Division of Occupational Safety and Health (Cal/OSHA) on January 12, 1998. On January 13, 1998, the CA/FACE investigator traveled to the manufacturing facility where he met with the president of the company, his business partner, an Assistant Safety Engineer from the local Cal/OSHA district office, and an investigator from the Los Angeles office of the Bureau of Investigations. The CA/FACE investigator interviewed the president, his business partner, a safety professional who is a friend of the president, an employee who works as a stock handler (through an interpreter), and a machine operator, and photographed the machinery involved.

The employer, a custom plastics injection molding company, operated a small manufacturing facility which contained 11 injection molding machines of varying sizes. The company had been in business for 4 years and 5 months at the time of the incident. The president had worked in the industry for a total of 27 years. The company had 13 employees with 9 working on site at the time of the incident. The decedent had been working for the company for 2 months as a supervisor. He had worked elsewhere in the industry for 17 years prior to his employment with this company. Company safety responsibilities were not defined and the company had no Injury and Illness Prevention Program (IIPP). The decedent was trained on-the-job, but no documentation was available. The company did not have specific written procedures for the task being performed. The employer stated that the decedent was familiar with the type of machinery involved in this incident through experience and on-the-job training. He also stated that the decedent had performed the type of setup involved in this incident many times.

During on-the-job training at the company, employees were instructed and supervised until it was determined by the company that they were ready to undertake a task on their own, such as operating a certain injection molding machine.

INVESTIGATION

The scene of the incident is a custom plastics injection molding plant containing 11 injection molding machines. The machine involved has a 110-ton hydraulic ram and was only ten months old. The job the decedent was performing was setting-up the machine to make a plastic part, which looked like a pipe, for a client who uses the part in an osmosis process.
The employer keeps the molds (dies) stored at his facility until the client requests more parts. It takes about 8 hours to set-up the machine to make a run. The moveable and stationary molds had already been installed earlier in the day.

Also installed earlier in the day at the top and bottom of the molds were hydraulic mold cylinders which functioned to eject the core of the pipe being made. The jobs that remained were final adjustments and installation of the hydraulic hoses.

This injection molding machine has three safety devices which prevent the operation of the machine under certain circumstances. The machine has two doors which are used to access the area in which the molds are installed and the molded parts. During this incident the rear door was closed, but the front door open. In this situation, all three safety devices would function.

The first safety device is a solenoid-operated switch that dumps off the hydraulic pressure when the front door is opened. Although hydraulic pressure would not immediately reach zero, the ram would slow to a stop if it was cycling. The second safety device is an electrical interlock. When the front door is opened, this interlock shuts off power to the machine, including the hydraulic pump. The third device is a gravity drop bar which falls into one of many notches on another metal bar. This bar is hinged and rides on the top of the notched bar until it reaches a notch. When it falls into a notch, the machine is blocked from operation. Each depression is 2 1/2 inches from the other. The machine could, therefore, move a maximum of 2 1/2 inches if the other interlocks failed.

During the investigation, the machine could not be operated so it fully closed because it could ruin the very expensive dies. However, in testing the machine, the interlocks worked as designed under observation by the CA/FACE investigator. This was also the outcome when the machine was tested shortly after the incident according to the witnesses that were present at that time. The machine operator stated that the company had never had a previous problem with this machine.

According to the stock handler, who was helping the decedent set up the machine, this particular machine had not been operated for three weeks. A customer had called in to request that the company make a run of the parts. The decedent was performing the set-up on the machine using this customer's molds (dies) which the employer stores on shelves in their facility. The molds were installed at approximately 1:30 p.m. but lacked final adjustment. The decedent was in the process of finishing the installation of the mold cylinder from underneath the machine just below the area of the moveable mold.
The stock handler brought the hydraulic lines to the machine and then left while the decedent continued to install the mold cylinder. When the stock handler came back, the decedent asked him if he knew how to set up the hydraulic lines. He said he did. Although he preferred to speak Spanish, the stock handler could communicate in English.

The stock handler left to obtain some tools and wrenches. When he returned the decedent asked if the machine had to be turned off. The stock handler replied that it did and the decedent turned it off at the operator’s panel. It is unclear whether the emergency stop or the hydraulic pump shutoff were turned off. The emergency stop would turn off the pump and the electrical power.

The decedent was nearly finished installing the mold cylinder. He needed to tighten a bolt. He had his head positioned between the mold cylinder and the panel wall which is located just beneath the stationary mold. During an initial interview with a Cal/OSHA investigator, the stock-handler said he handed the decedent a wrench between the molds through the open front door. At a subsequent interview with the CA/FACE investigator, he stated he simply laid the wrench on a tool tray beneath the injection machine which would have been beyond the reach of the decedent. The stock handler turned away and heard a noise from the decedent. When he looked back, the decedent's head was caught between the mold cylinder and the panel wall.

The stock handler ran to get help and brought another employee, who had also helped to set-up the machine, to the incident site. The other employee called to the office manager to telephone 911. Meanwhile, the owner of the business next door heard about the accident and ran over to help. He noted the decedent with his head caught between the cylinder and the panel wall. He tried to pull the cylinder back, but it would not budge. The second employee of the employer turned the power on for the machine from the main disconnect located on the south side of the machine and went back to turn on the machine at the operator's panel. When the front door was closed, the ram moved back and decedent fell free.

The paramedics were dispatched at 2:04 p.m. and arrived at 2:08 p.m. They found the decedent with agonal respirations and treated him on site. The paramedics arranged for an air ambulance that arrived at 2:12 p.m. and rushed the decedent to a local hospital where he died the following day at 2:40 p.m.

**CAUSE OF DEATH**

The death certificate stated the cause of death to be a crush injury to the head.
RECOMMENDATIONS/DISCUSSION

During this investigation, inconsistencies arose in the information collected; e.g. the cylinder moved even though the power was off and all three interlocks functioned correctly during testing. All attempts at resolving these inconsistencies were unsuccessful. Therefore, only some of the factors contributing to the victim's death could definitely be determined. These factors form the basis for the following recommendations.

Recommendation #1: Employers should ensure employees do not place body parts in the pinch point of machines.

Discussion: The employee placed his head in an obvious pinch point, often called a nip point. A pinch point in this case is the area in which a body part can be caught between a stationary and moving part. Although the machine, according to all witnesses, was turned off with interlocks functioning, it is still inappropriate to place a body part in a pinch point. Machines can fail and body parts can be caught in pinch points. In this case, the decedent could have been in several different positions to perform his job without placing his head in danger. Since there are many pinch points in this type of machine the employer should not allow employees to place body part in those areas. Tools are available that can perform the job without requiring employees to place body parts in pinch points. Extension tools are often made of deformable metal or light wood which would limit or prevent employee injury while protecting the equipment.

Recommendation #2: Employers should develop a written procedure which covers the manner in which machine set-up should be performed and ensure that it is understood and followed.

Discussion: The employer failed to provide written instructions describing machine set-up or energy control procedures to employees. Such instructions would normally contain safety precautions such as not placing body parts in pinch points. The pinch points of machines would be detailed so the employee would understand exactly which parts of the machine could pinch or catch a body part. An energy control procedure would be appropriate for the plastic injection molding machine since it has several sources of hazardous energy including electrical and hydraulic. The procedure would detail the scope, purpose, authorization, rules, and techniques used to control potentially hazardous energy. Included should be the procedural steps for the placement, removal, and transfer of lockout and tagout devices and the responsibility for them. If necessary, a procedural check-off and signoff sheet could be developed as long as any changes to the machine are immediately reflected in the check-off sheet. If such instructions and procedure were provided, and followed, this fatality may not have happened.
**Recommendation #3: Employers should establish and implement a written company safety program.**

Discussion: The employer had no written Injury and Illness Prevention Program as required. Safety responsibilities and precautions were not defined. Although it was stated that training was provided on the job, no documentation could be provided. It was also stated that the employee, although only working for the company for 2 months, was familiar with the type of machine involved in the incident. However, if safety is not made a priority through a formal safety program which covers the hazards of the job, safety is often ignored or the hazards go unrecognized.

**Case # 3 SUMMARY**

A 38-year-old male supervisor (the victim) at a plastics molding company died when his head was crushed between moving parts of an injection molding machine. The incident occurred at one of three plants operated by the company, whose central office was in another state. The plant maintenance and repair person quit the company about a month before the incident, and a replacement had not been hired. About two weeks before the incident, a machine guard had been removed from the molding machine in preparation for a visit from a maintenance worker from another company plant. At the time of the incident, the victim (shift supervisor) and a co-worker were examining the machine to determine the location of a hydraulic fluid leak.

The molding machine was operating while the victim and co-worker peered into it so they could see the location of the leaks with the hydraulic hoses under pressure. The victim was bending forward into the back of the machine, with his head positioned next to a fixed metal bracket. The machine cycled automatically, causing a metal tie bar to move back and pinch his head against the bracket with about 500 pounds of pressure. The co-worker heard a sound, looked in the direction where the victim had been working, and saw the victim's head pinned in the machine. The co-worker called for help, the machine was turned off, and the victim was released. EMS workers arrived within four minutes, and transported the victim to the hospital where he was pronounced dead.

To prevent future fatalities of this type, the FACE investigator recommends employers should:

- **maintain guards in place over machine pinch points when machines are operating**
• develop and enforce specific lockout and tagout procedures for injection molding machines.

INTRODUCTION

On January 26, 1999, a 38-year-old male shift supervisor died when his head was pinned between a moving tie rod and a fixed metal bracket on a plastics injection molding machine. The Wisconsin FACE field investigator was notified by the OSHA Area Office on January 28, 1999. On February 16, 1999, the field investigator conducted an on-site visit, accompanying an OSHA inspector. The investigator obtained the death certificate and the medical examiner's report.

The company in this case was in the business of manufacturing plastic beverage service items used by taverns and eating establishments. While the company has been in business for over 18 years, it has had at least five owners in that time. The current owners assumed management of the company about 14 months before the incident. Corporate offices were located in another state, and machine maintenance and repair services were being provided by employees of a plant in that state until the local plant could recruit a maintenance worker. Thirteen employees were employed by the company at the site at the time of the incident. The plant ran three shifts a day, five days a week.

The victim worked for the company for a total of sixteen years; for the first thirteen years, he worked with molding machine setup and operation. About three years ago, he became first shift supervisor. He was characterized by co-workers as a worker who would perform work outside of his assigned duties to keep production on target. At this company, workers received classroom and on-the-job training for safety aspects of their assigned jobs. There was no comprehensive safety program to address hazards in the workplace, and the lockout/tagout program lacked specific procedures to cover all of the machines in the plant.

INVESTIGATION

The plant was arranged with four injection molding machines in one large room. Not all of the machines were usable on the day of the incident, due to breakdown and maintenance problems. An experienced maintenance worker quit the company several weeks before the incident, and the company had not found a replacement for him. On-site employees attempted to maintain production levels by choosing work orders that could be accomplished by the functional machines, and by performing temporary or minor repairs themselves. Complex repair needs were set aside until a maintenance person from another plant could arrive to assist the local plant. The company had a lockout/tagout (LOTO) policy and procedure, but it was not specific for each machine.
The horizontal injection molding machine involved in the incident was manufactured in 1972, and had been used at this plant since the early 1980's. It had not been overhauled since being installed at this plant, but had undergone repairs as breakdowns occurred. The machine was used to run production jobs from contracts developed by the main office. It required setup by a skilled worker when the jobs changed, but a maintenance person was required whenever complex repairs were needed. About two weeks before the incident, the victim assisted the setup worker in removing guards from the back of the machine. This was done to prepare for an anticipated visit from the substitute maintenance person.

The platens on the machine were too worn to be adjusted for jobs needing precise mold fits, so the operations manager from the corporate office directed the plant manager to run the machine with molds for a job that required less tolerance on the platens. When running this job, the machine cycled automatically every 18 seconds. The guards were left off while plant workers awaited the maintenance person.

On the day of the incident, plant employees saw evidence of hydraulic fluid leaking from the machine during operation, and brought this to the attention of the setup worker and the supervisor. They went to the machine to view the problem while the machine was running. If the machine was shut down while running a job (when the hot thermoplastic material was in the line) about 30 minutes of purge time was needed before production could be resumed. The setup worker was positioned at the back of the machine on the operator's side, while the victim was on the other side trying to see the location of the fluid leak.

The victim apparently bent forward, looked into the machine then said he found the leak. Immediately after hearing that statement, the co-worker heard the machine cycle to its recoil phase. This phase brought the tie bar back to within three inches of the metal bracket where the victim's head was positioned. The setup worker heard a sound, then saw the victim's head pinned in the machine. The co-worker called for help, the machine was turned off, and the victim was released. EMS workers arrived within four minutes, and transported the victim to the hospital where he was pronounced dead. EMS responders were on the scene within four minutes. The victim was transported to the hospital, where he was pronounced dead.
CAUSE OF DEATH

The medical examiner's report listed the cause of death as traumatic head injury.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Employers should maintain guards in place over machine pinch points when machines are operating.

Discussion: Machine guards are necessary where pinch points are creating by moving machinery parts. Guards had been removed and not replaced on the machine several weeks prior to the incident, while the company waited for an off-site maintenance worker. In the interim, the company ran the machine for jobs that could be performed without repairs. The incident would have been prevented if the guards were in place while the machine was running.

Recommendation #2: Employers should develop and enforce specific lockout and tagout procedures for injection molding machines.

Discussion: The company’s LOTO policy was not specific for each molding machine, and was not applied to all situations where hazardous energy could be unexpectedly released. At the time of the incident, the victim was performing inspection activities that were out of his role of shift supervisor because qualified maintenance help was not available. If the company had developed and enforced a LOTO policy that specified the lockout procedure for inspection of hydraulic leaks, the incident might have been prevented.

There are many more of these tragic stories. They can be found on the internet by typing in injection molding fatalities or by typing in the word Face Reports. What can we learn from these accidents above? We have learned that with proper maintenance and operation of the machine and with proper training in the machines owners / operators manual that these accidents could have been prevented.

Standards

As mentioned in the previous sections on hazard control, there are three standards that directly apply to injection molding machines. These standards are:

1. ANSI/SPi B151.1: Safety Requirements for the Construction, Care, and Use of Horizontal Injection Molding Machines, Revised 1990.

3. Recommended Guideline for the Safety Requirements for the Manufacture, Care and Use of Multiple Station Vertically C Molding Machines. 1996.

All of these standards are comprehensive in nature. They cover the molding machines and all auxiliary equipment, except for robots. Standard (1) & (2) are very similar in nature. There are no discernible differences between the two. The third standard is different in that it adds some clauses related to having multiple stations.

OSHA & The Plastic Industry

SPI and the Occupational Safety and Health Administration (OSHA) have entered into an alliance to promote a safe and healthy work environment in plastics facilities. The Alliance will assist in providing employers with information and guidance that will help them protect employees, specifically in identifying and eliminating hazards likely to result in amputations, emphasizing machine guarding and lockout/tagout, and reducing and preventing exposure to ergonomic hazards. The goals of the Alliance include:

Training and Education:

- Jointly developing and delivering training addressing machine safety, to be delivered in conferences, meetings, OSHA Training Institute (OTI) Ed Centers, and through distance learning.

Outreach and Communication:

- Jointly developing and disseminating information through print and electronic media, including electronic assistance tools and links from OSHA's and SPI's Web sites.
- Speaking, exhibiting, or appearing at SPI conferences, including Plastics USA 2004, local meetings, or other industry events.
- Promoting and encouraging SPI members' participation in OSHA's cooperative programs such as compliance assistance, the Voluntary Protection Programs (VPP), and Consultation and its Safety and Health Achievement Recognition Program (SHARP).
- Working with other Alliance participants on projects on ergonomics that are addressed and developed through the Alliance Program.
Accomplishments:

The first year of the SPI/OSHA Alliance brought national recognition of the plastics industry's focus on improving workplace safety. On May 16, 2003, OSHA unveiled a web page developed as a product of the Alliance, noting that more than 1.5 million workers in the U.S. plastics industry stand to benefit from the new web page, **OSHA Assistance for the Plastics Industry**. This web page provides links to:

- safety and health information about the plastics industry;
- standards that apply to plastics processing;
- information about hazards and solutions;
- focused links to all tools developed under the Alliance.

Products of the Alliance:

**Machine Guarding eTool for Plastics Machinery**. eTools are stand-alone, interactive, Web-based training tools on occupational safety and health topics. They are highly illustrated and utilize graphical menus. Because amputation is one of the more severe and crippling types of injuries in the occupational workplace, and often results in permanent disability, this eTool focuses on recognizing and controlling common amputation hazards associated with the operation and use of injection molding machines. This interactive eTool addresses the guidelines and safety measures for use in horizontal injection molding, and includes a detailed, interactive safety tour, potential hazards and solutions, lockout/tagout procedures and additional safety measures that can be taken to help reduce or prevent injuries resulting from inadequate machine guarding on complex plastics processing machines.

**Injection Molding Machine Safety Training Course**. The Alliance Team produced a Machine Safety for Injection Molding Machines training course that was presented at NPE 2003. The presenters, Jim Washam, OSHA, and Wayne Wilson, United Southern Industries, Inc., brought recognized technical expertise from both the Agency and the Industry, and demonstrated the excellent working relationship that has developed between OSHA and the plastics industry.
This train-the-trainer course:

- describes types of injuries seen in the injection molding industry;
- discusses the possible causes of these injuries; and
- describes the ways that employees can protect themselves.

Plans are underway to make the Machine Safety for Injection Molding Machines training available through the 36 OSHA Education Centers. As part of the OSHA curriculum, the course will reach a wide audience including the general public and OSHA agency personnel.

The **Machine Safety for Injection Molding Machines Training Course** consists of two power point modules, and can be downloaded, as a zip file, from

These courses on Machine Guarding and Lockout/Tagout were created by a dedicated team consisting of experts from OSHA and industry. The courses are train-the-trainer courses that not only consolidate the critical information you need on machine guarding and lockout/tagout, but also prepare you to train your employees at your worksite.

Please remember that these courses address machine guarding and lockout/tagout safety issues relating to plastics machinery operations. They do not cover everything you need to know about plant safety. Machine safety programs are only part of the effective safety and health management system at your plant. You may want to consider using OSHA’s [Safety and Health Management eTool](https://www.osha.gov/dsg/etools), with what you learn in these courses to develop, refine or improve your company’s goals for addressing safety and health in your workplace.
Sample of an Injection Molding Machine Set-up

All injection molding machines must have written set-up and die setting procedures for their machinery. As you have read in the above sections of this guide book, many serious accidents occur during this phase of set-up or die changing. We thank the Hwamda Corporation for allowing us to use the information that was found in their owners / operators manual to help the reader understand that should the operator follow this type of information serious accidents can be prevented.

The words that look different in this next section of the document come from the machines owner / operators setup manual. These words illustrate the information that can be found on the operators control button and illustrated panel and screen.

The operation of the injection molding press involves:

- Mold Installation
- Machine Startup
- Temperature Specification
- Mold Setup
- Specifying Injection Conditions
- Ejector Setup
- Building a Shot
- Producing Parts
- Machine Shutdown

The most important requirement is to operate the machine safely. If you have any questions or doubts about machine operation, do not proceed with using the machine. Seek help and answers to your questions.

The Hwamda injection molding press is a multi-user machine. All users are expected to shut down the press using the REQUIRED SHUT DOWN PROCEDURE detailed here. The next user will then find the press in proper working condition and will be able to bring it on-stream with minimum difficulty and annoyance. You must leave the press in its SHUT DOWN MODE. If you find the press in other than shutdown mode contact your supervisor who will identify the last user.
Molding Press State in SHUT DOWN MODE

<table>
<thead>
<tr>
<th>Component</th>
<th>State/Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hopper</td>
<td>Empty and valve control slider fully in</td>
</tr>
<tr>
<td>Barrel</td>
<td>Empty</td>
</tr>
<tr>
<td></td>
<td>Completely devoid of polymer melt and resin</td>
</tr>
<tr>
<td>Sled</td>
<td>Completely retracted</td>
</tr>
<tr>
<td></td>
<td>Sled/screw assembly at extreme right</td>
</tr>
<tr>
<td>Screw</td>
<td>Completely retracted</td>
</tr>
<tr>
<td></td>
<td>Screw at extreme right in the barrel</td>
</tr>
<tr>
<td>Hydraulic pump</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td>Handle rotated counter-clockwise to shut power off</td>
</tr>
<tr>
<td>Machine power</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td>Button 29 on Operator Station Assembly pushed in</td>
</tr>
<tr>
<td></td>
<td>Yellow handle on valve for blue hose on rear wall</td>
</tr>
<tr>
<td>Main power</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td>Electrical box on rear wall</td>
</tr>
</tbody>
</table>

Shut Down Procedure

To leave the press with the barrel empty, and the sled and screw in the fully retracted condition, the first thing to do is to PURGE the barrel. Purge the barrel by carrying out the following steps.

Purging the Press

At the end of making parts:

1. Close off the hopper by pushing the pellet flow control slider fully in. This prevents flow of polymer pellets from the hopper into the barrel during purging.

2. Select Mode Button 13 on the Operator Station Assembly (OSA) Panel - MANUAL mode button - punch the button; verify that CYCLE = MANUAL is displayed on the LCD screen. (Button 16 toggles MANUAL/MLDSET)

3. Select Mode Button 10 on the OSA Panel - SLED button - punch the button; verify that CYCLE = MANUAL and FUNCTION = SLED is displayed on the LCD screen.

4. Close the door.
5. Select Mode Button 5 on the OSA panel - RIGHT ARROW BUTTON - and push and hold the RIGHT ARROW button until the sled moves all the way back to its extreme right position. The end point of motion can be recognized by the change in pitch of the hydraulic motor.

6. Select Mode Button 11 on the OSA panel - INJection button - and punch the button; verify that CYCLE = MANUAL and FUNCTION = INJ is displayed on the screen.

7. Select Mode Button 4 on the OSA panel - LEFT ARROW button - and push and hold the LEFT ARROW button until the INJection screw moves all the way forward, i.e., extreme left position. The end point of motion can be recognized by the change in pitch of the hydraulic motor.

Purged polymer melt is hot and sticky -- do not touch or handle the purged material until it is completely cool. Be safe.

Moving the injection screw forward in the barrel pushes out the melt in front of the screw. At this position, the melt between the flights of the screw is still inside the barrel. To purge this residual melt, the screw has to be rotated to extrude out the residual melt.

Note: Extrude will not function unless the screw is at the extreme left position of its travel.

To extrude the melt

1. Select Mode Button 12 on the OSA panel - Extruder button - and punch the button; verify that CYCLE = MANUAL and FUNCTION = INJ is displayed. Note that FUNCTION = INJ will change to FUNCTION = EXT only as long as Button 12 is held in.

2. Push and hold the EXTruder button 12 until the barrel is completely purged. The end point of purging can be recognized from the pressure reading displayed on the LCD, menu 11, screen. The pressure will decrease to about 100 psi and will stay close to it when the barrel is completely purged.

3. Operating the EXTruder will tend to move the INJection screw to the right leaving some melt in front of the screw. To eject the small amount of melt remaining in front of the screw Select Mode Button 11 on the OSA panel - INJection button - and push the button; verify that CYCLE = MANUAL and FUNCTION = INJ is displayed on the screen.
4. Select Mode Button 4 on the OSA panel - LEFT ARROW button - and push and hold the LEFT ARROW button until the injection screw moves forward and completely empties the barrel.

5. This one extrude-injection cycle may leave a small amount of material in the barrel, so cycle through it once more.

6. After the barrel is empty select Button 11 and Mode Button 5 - RIGHT ARROW button - and push and hold the RIGHT ARROW button until the injection screw moves all the way back to its extreme right position, i.e., the fully retracted position inside the barrel. The end point of motion can be recognized by a change in pitch of the hydraulic motor.

**Machine Shut Down**

1. Once the barrel is empty, turn the hydraulic pump OFF by pushing Button 29 (Push in the red button) on the OSA panel.

2. Turn the electrical power to the machine OFF by throwing the MACHINE POWER Handle on the electrical panel which is on the lower right front of the machine.

3. Turn the main electrical power to the press OFF at the Electrical box on the wall behind the machine.

4. Approximately 10 minutes later, turn the water to the press OFF. The water supply valve is on the wall behind the machine, the press is supplied with water through the blue hose.

5. Empty the Hopper and dispose of the resin pellets.

   DO NOT place pettets in open, unlabeled bags or containers. If you have made arrangements to leave material in the hopper, LABEL the resin (Vendor and Vendor product number) and leave a copy of the Material Safety Data Sheet attached to the hopper.

6. EVERY PRESS USER IS RESPONSIBLE FOR DISPOSAL OF ALL MATERIAL THAT IS NOT USED, FOR PUTTING AWAY REFERENCE MANUALS, FOR CLEANING THE MACHINE AND WORK AREA AND FOR MAINTAINING THE PRESS.
**Press Start-Up**

1. **Verify that the machine is in the SHUT DOWN MODE. The Plastic injection molding machine state should be:**

<table>
<thead>
<tr>
<th>Component</th>
<th>State/Status</th>
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</thead>
<tbody>
<tr>
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<td>Off</td>
</tr>
<tr>
<td>Hydraulic pump</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>Main power Off</td>
</tr>
<tr>
<td></td>
<td>Button 29 on Operator Station Assembly Off</td>
</tr>
<tr>
<td></td>
<td>Yellow handle on valve for blue hose on rear wall</td>
</tr>
</tbody>
</table>

2. **Turn the water to the press ON - the water supply is the blue marked water line mounted on the wall behind the press.**

3. **Turn the main electrical power to the press ON at the main electrical supply box on the wall behind the press.**

4. **Turn the electrical power to the machine ON by throwing the switch located on the lower right front of the machine.**

5. **The LCD screen of the Operator Station Assembly (OSA) panel will POWER UP; Diagnostics will be run, the microprocessor will initialize and run to verify that all systems are working. When all electronic tests have been passed, MENU 1 will appear on the OSA screen.**

   **The menu number is displayed in the upper left corner of the screen.**

**Press Setup**

A very useful feature of the machine is the FAULTS menu, Menu 43. Calling menus and reading them is explained below.
The point here is that if during machine operation problems are encountered, (particularly no response to commands), looking at the FAULTS menu is often useful for identification of the problem.

The major concerns here are the MACHINE SETUP SECTION (Menu 10 and associated Menus) and the PROCESS INFORMATION (Menu 30 and associated menus).

**Entering Machine and Process Parameter Values**

Plastic injection molding machine and process parameters have to be specified before the press can be used to produce parts. Many of the parameters are related to the machine itself, e.g., die height which is explained below. Other parameters are for the specific process to be run, e.g., melt temperature and injection velocity. The process parameter values have to be determined from process models and material properties.

The facilities for setting up and operating the press are presented in a number of Menus. When the press is powered up and after the diagnostic tests are successfully completed, Menu 1 is displayed on the OSA screen. This menu lists general facilities which can be used to control the machine and gather information. The Menu number is shown at the top left corner of the screen. The Machine Mode is shown on the second line of the menu and on startup it is

\[ CYCLE = (NO CYC) \quad FUNCTION = (blank) \]

Note the soft keys/buttons (those which assume different functions) which are the first row of buttons on the OSA immediately below the display screen. This row of buttons is referred to as "row 2" on the OSA Figure. These buttons lead directly to often-used setup facilities and the alarm status screen. The first of these soft buttons, which is blank on startup, will change during machine use. The important change of function of this soft button is when it functions as SWTCH and is used to switch or toggle between choices when the machine is being setup and used.

There are four kinds of machine and process parameters displayed in menus.

1. Current values are shown on the screen as light numbers or letters on a dark background, i.e., they are read only.

2. Black alpha-numeric'son a white background show the set points specified for the parameter value. These are values that can be changed or set.
3. When the cursor is moved to a 'set-able' parameter the displayed value will blink and the value can be changed. If only two states are available (e.g. heater ON or OFF) toggle the value by pushing the SWTCH soft key. The switch button, Button 2.1 comes up as SWTCH when this is the relevant choice. If a numerical value is needed for the parameter, it is entered using the numeric keypad and then pushing the ENTER key, Button 27 at the lower right corner of the keypad.

4. Some parameter values cannot be specified. The value is displayed and moving the cursor to it will not cause the display to blink.

To change menus, either enter the Menu number using the numeric keypad on the OSA and then push the ENTER key, Button 27, or, step through the menus by pushing the NEXT MENU key, Button 17. The second procedure (stepping through the menus) is recommended since there is no chance of altering the machine parameters. That is, when entering menu numbers it is possible to push the wrong keys and instead of changing menus a machine parameter may be changed.

**Machine Setup**

Menu 10 is a list of menus which are useful for machine setup; enter 10 using the numeric keypad on the OSA and press ENTER, Button 27. Notice that:

- the first soft key (Button 2.1, the first button in the first row of keys or the '2 row') is MAIN which when pushed will return the system to Menu 1
- this soft key will change to switch, SWTCH, in instances of setting the machine when toggling between values is required.
- some of the commonly used menus are available by pushing the soft keys in the '2 row', e.g., pushing the TeMPeRature button will bring up Menu 15 which is the temperature setup menu.
- Alternately, page through the menus using the NEXT MENU key, Button 17.

**Bring up Menu 11.**

This page displays some of the important machine and process parameters. The top section of the display shows temperature values. The barrel and nozzle temperatures are a logical choice for starting the machine setup procedure since other parameters can be set while the temperatures are coming up to the
specified levels. Remember that readings are shown by light numbers on a dark background.

Set Barrel and Nozzle Temperatures - Menu 15

1. Select SOFT BUTTON 2.6 (in the top row of buttons immediately below the screen it is the 6th of 7 counting from the left) which is labeled TMP for temperature and push it. The display will show the Temperature setup screen which is Menu 15.

2. Use the UP ARROW, Button 25, or the DOWN ARROW, Button 26, to select the right, middle, left barrel heat zones and set the desired temperature in each zone. The Blinking quantity can be set. To change a value move the cursor to it, use the numeric keys to set the value and ENTER the value by pushing Button 27. The appropriate temperatures should be available from a quantitative process design effort.

   Typically the middle zone temperature is set 10 - 20 degrees F below the temperatures set for the right and left zones.

3. Set the nozzle temperature using the same set of buttons and procedure. Typically the nozzle temperature should be set at 10 - 20F below the temperature for the left heater zone.

4. The Alarm Band adjustment range is 1% - 20%.

5. Hydraulic oil and feed throat temperature are shown but these are not controllable. This and other menus show some machine conditions.

Go to Menu 27 to see machine status and to make sure the heaters are ON. Again, notice that if the cursor is moved to a parameter with two states, say the Barrel Heats parameter which can be OFF or ON, the soft key which was MAIN changes to SWTCH and is used to toggle the selected parameter.

It will take 20 - 30 minutes for the barrel and nozzle temperatures to reach the set temperatures.

Material Supply

Now a shot must be built. The barrel, though hot is empty, and the press is set for mold filling.
The machine and mold setup procedure requires that the screw position be close to the position needed for the specified shot size, so make certain that the shot size is realistic for the part to be made and that the following procedure is followed.

1. Turn on the Hydraulic Power if it is not already on.

2. To build a shot, fill the hopper with about 2 kg of dry resin pellets (about 2 liters). Open the slider at the bottom of the hopper so that the resin can flow into the extruder barrel.

3. Set the shot size. This is a linear distance of screw motion during mold filling. The shot volume is related to this distance and the screw diameter. It is best to start with short shots and to build toward the final shot size. (The shot size for the tensile test dog bone mold is about .6 in., for the spiral flow mold the shot size will vary depending on the test to be run).

4. Move the screw to its fully forward position by choosing Button 11 for screw linear motion and then using the left arrow button, Button 4, to move the screw.

5. Rotate the screw to move resin down the barrel, Button 12. Melt should be extruded out of the nozzle. Typically the initial material extruded will have visible bubbles and these will become smaller and the melt will look smoother as more material is extruded.

6. Move the screw back past the shot size and run a cycle of the machine. Since the extrude run part of the cycle is not implemented yet, this initial shot will be a short shot. The barrel should be fully packed after this first shot. The next cycle of the machine will give a full shot which may still be a shot if the shot size set is less than that necessary to fill the mold.

7. To minimize wasted material, when shot building is complete, the barrel should be full with the screw at a position slightly behind the shot size that is to be used.

**Mold Set-Up** - Die Height and Clamp Tonnage - **Menu 12**

Mold height must be set and at the same time safe machine (clamping force) tonnage is also set.
The setting of these quantities and the operation of the machine require hydraulic pressure. Hydraulic fluid temperature is shown on the Temperature screen which can be displayed by pushing the SOFT BUTTON 2.6 which is label TMP on the OSA panel or by bring up Menu 15. Recommended operating temperature for the hydraulic fluid is between 90F and 130F. It oil temperature rises to above 130F during machine use, the press will shut itself down.

The Hwamda injection molding press is a microprocessor-controlled unit capable of automated mold setup and real-time monitoring of the molding process. Part of the real-time monitoring includes continuously tracking the position of the moving platen with respect to the stationary platen using a linear position transducer. Move to Menu 12 and the display in the lower right corner of the screen shows the transducer reading. The position of the moving platen can be reset periodically (every N machine cycles, N about 25) to compensate for tie rod expansion, machine/mold compliance, etc.

Every time the press is turned off, the linear position transducer MUST be reset to establish an origin for the machine movements specified.

Therefore, Mold and Clamp setup is a MANDATORY requirement every time the press is turned on.

The press uses a toggle linkage to hold the mold halves together during melt injection. The toggle position and the hydraulic pressure clamping the mold closed are also set during mold setup. This is referred to as adjusting the "press tonnage". Automated mold setup includes this step of the machine setup procedure.

Again, the OPEN MOLD GRAPHIC that is displayed at the lower right corner of some menu screens indicates platten position - but is not a direct measure of platten position. The numerical value displayed is the position of the piston in the hydraulic cylinder which drives the moving platten. Since the platten is driven through a toggle mechanism, there is a relation between the piston position and the platten position but the piston position displayed is not the platten position.

NOTE: We've had only one recurring problem in setting up the mold. The toggle mechanism must be in a correct range of position for the tonnage to automatically set itself. If it is not, in the part of the following procedure where the machine should cycle a few times and set the tonnage the machine will continue to cycle. This problem seems to occur when molds and the MUD set (Master Unit Die which the mold halves are mounted to) are changed and the die/mold height changes greatly. The toggle is then out of its effective working range. The fix is to move the left end of the toggle mechanism to a useful position - find someone who knows how to do this.
**Mold Setup Procedure:**

1. Set up the mold and ejector system,

2. Install and bolt the mold set in place; slide the safety door shut,

3. If it is not on, turn the hydraulic power ON with Button 28 (green) on the OSA panel.

4. Display Menu 12 by entering 12 using the number key pad and the Enter Button, button 27.
   The first page of menu 12 will display the title 'Clamp Set Up', machine state and numerical values close to the following:

   
   \[
   \begin{align*}
   \text{CYCLE} &= \text{ NO CYC} \\
   \text{FUNCTION} &= \text{(blank)} \\
   \text{Mold closing speed parameters} &= \text{Mold protection parameters} \\
   \text{Open Limit} &= 6.00 \\
   \text{Mold Touch} &= 0.32
   \end{align*}
   \]

5. The Mold Touch value (0.32 in this example) is set by the machine after the auto tonnage setting.

6. Mold retraction (mold operating speed parameters)

7. and the current position of the moving platen (about 6.00) is indicated in an OPEN MOLD GRAPHIC at the lower right corner of the screen.

8. Use Button 13, the OPEN PALM, to set the machine in **MANUAL** mode.
   On the screen the display will show

   \[
   \begin{align*}
   \text{CYCLE} &= \text{ MANUAL} \\
   \text{FUNCTION} &= \text{(blank)}
   \end{align*}
   \]

9. Toggle to **MOLDSET** cycle by using Button 16. On the screen the display will show

   \[
   \begin{align*}
   \text{CYCLE} &= \text{ MLDSET} \\
   \text{FUNCTION} &= \text{(blank)}
   \end{align*}
   \]

10. Select **FUNCTION** Die Height (DIH) with Button 6. The screen display will show

   \[
   \begin{align*}
   \text{CYCLE} &= \text{ MLDSET} \\
   \text{FUNCTION} &= \text{ DIH}
   \end{align*}
   \]
11. Use the LEFT ARROW, Button 4, and retract the moving platen (move it to the left) about 1/4 to 1/2 inch.

If the mold set has not been changed since last press use, retract about 1/8 inch.

If a new mold set has been bolted in to the press, retract to the extreme left position. See the Note above about a problem which may occur below in setting tonnage.

Observe the OPEN MOLD GRAPHIC at the lower right corner of the screen. It should show the position measure (numeric value) of approximately 6.00.

If the ejection cycle was not completed in the last operating cycle of the previous run, the next operations cannot be executed - the press will not respond. There is a Note below that describes where in the setup procedure this problem may be seen.

12. Select FUNCTION CLamP by pushing Button 7. The display will show

\[ \text{CYCLE= MLDSET FUNCTION= CLP} \]

13. Use the RIGHT ARROW, Button 5, and bring the moving platen to the right until it just touches the stationary platen - to do this push and hold the RIGHT ARROW button.

Platen touching and contact are recognized by change in pitch of the hydraulic motor.

NOTE: If the ejection cycle was not completed in the last operating cycle of the previous run, the following steps cannot be executed - the press will not respond.

If the moving platen stops within about 1/8 inch from the stationary platen, automated mold setting will correct for this during mold setup. There is no absolute need to force the mold halves to touch. However, if the mold halves are brought to contact the automated mold setting is easier and quicker since the machine has to make fewer adjustments.

Observe the OPEN MOLD GRAPHIC at the lower right corner of the screen. The linear position transducer will reset and indicate a position measure of about zero.
During automated mold setting, this number will be corrected to a value dependent on the tonnage (in this example, to close to 0.31) as the origin of the linear position transducer is set.

If this condition is encountered, select FUNCTION EJecT with Button 9, push the LEFT ARROW button, Button 4, and retract the EJecTion cylinder. Some machine conditions may stop operation of the press, e.g., the purge cover may be up. Menus 43 and 44, the FAULTS and ALARMS, often show what is the problem.

14. Once the mold halves are in contact, or very close to it, stay in FUNCTION mode CLamP with the screen showing

\[
\text{CYCLE}= \text{MLDSET FUNCTION}= \text{CLP}
\]

15. Push and hold the LEFT ARROW, Button 4, to retract the moving platen to its normal (left) position.

16. Go to page 2 of the current menu (Menu 12) by pushing the PAGE DOWN button, Button 19. Switch ADJUST TONNAGE to ON by moving the cursor to OFF, pushing the soft key SWTCH, which is what Button 2.1 is now, and then moving the cursor back to the top of the menu.

17. Set the value for the required tonnage by moving the cursor, using the number pad and then the ENTER button, Button 27.

18. Return to the first page of Menu 12 (page up is Button 18) and set the press in cycle MANUAL by toggling Button 16. The screen display will be

\[
\text{CYCLE}= \text{MANUAL FUNCTION}= \text{CLP}
\]

19. NOTE: Other that setting tonnage, the only other recurrent problem we've had in machine operation is in the next few steps. The machine needs close to a full shot or it will not run, and so the screw position must be close to the shot size. This characteristic of the press is not documented. If the screw is not retracted far enough from the mold section, it may not be possible to enter the MANUAL mode below. If the machine will not respond to this command below, AND ALL OTHER POSSIBILITIES HAVE BEEN CHECKED, try moving the screw back slightly, linear motion not rotation. The situation can be checked - shot size is shown and set in Menu 17 and screw position shown in Menu 11.
20. Again, this kind of action should not be necessary and resorted to only as a last alternative. Check shot size, check screw position when screw is fully retracted, go to Manual Mode, move screw back so that shot size and screw position are roughly equal, go back to Single Cycle Mode.

21. Open the sliding door past the safety limit switch.

22. Set the press in cycle **SINGLE** with Button 14. The screen display will show

   \[ \text{CYCLE} = \text{SINGLE FUNCTION} = (\text{blank}) \]

23. Close the sliding door completely.

   The moving platen will advance toward the stationary platen, the red light on top of the press will turn ON. The moving platen will approach/contact the stationary platen and the automatic mold setting process will begin.

   Observe the OPEN MOLD GRAPHIC at the lower right corner of the screen. The position value will decrease to zero and increase to approximately 6.00 when the moving platen retracts and stops.

24. Once the forward-return cycle is complete,
   The sliding door should remain shut - there is no need to cycle the door.
   set the press in CYCLE mode **CONTinuous** by pressing Button 15. The screen display should show

   \[ \text{CYCLE} = \text{CONT FUNCTION} = (\text{blank}) \]

25. The microprocessor will now take over. The press will automatically cycle several times (3 to 10 cycles) while completing the mold height/tonnage setup.

   When it is completed, the red light on top of the machine will go OFF. The display should show

   \[ \text{CYCLE} = \text{NO CYC FUNCTION} = (\text{blank}) \]

   The OPEN MOLD GRAPHIC should show a position value of about 0.31 when the moving platen touches the stationary platen.
Mold height and tonnage setting is now complete.

**Mold Platen Motion - Menu 12**

The motion of the moving platen during the molding cycle is set using Menu 12.

The top part of the Menu 12 display shows the specified mold closing motions.

- **CLS SPEED 1** is how fast the moving platen approaches the fixed platen.

- **SLOWDOWN** indicates the distance from the minimum mold height at which the moving platen slows down to the mold closing speed which is set at the factory.

- **MOLD PROTECT** pressure is used to close the mold in the Slowdown region. It is set so that if there is an obstruction between the platens, the machine will stop platen motion and hold its position for the amount of time specified and then will drop out of the automatic cycle mode.

The lower part of the display shows

- **the position of the moving platen at which the mold halves first touch, MOLD TOUCH**

- **the maximum distance that the clamp can open, OPEN LIMIT.** This is not the actual clamp opening but a measure of the clamping mechanism position.

- **the speeds during various parts of the mold opening motion**

**BREAKAWAY** - moving platen speed at start of clamp opening sequence.

**OPEN FAST** - distance at which speed changes from Breakaway to speed for main part of mold opening until SLOWDOWN position is reached where the factory set slowdown speed is imposed.

The Clamp Position is displayed in the OPEN MOLD GRAPHIC at the lower right corner of the display.
There is a second page to Menu 12 which provides the possibility of the machine automatically checking die height to provide the set clamp tonnage. It can be reached by pushing the PAGE DOWN button, Button 19.

In general:

- the Initial Tonnage will be set
- the Adjust Tonnage switch will be OFF since if it is on, the machine will adjunct tonnage on the very next cycle which is not normally useful since the mold height has just been set during machine setup
- Auto Check of mold height is useful and sets the number of cycles between adjustments of clamp tonnage during operation.
- Tonnage Auto Check ON

**Ejector Mechanism Setup - Menu 13**

ForWarD SPEED, ForWarD LIMIT and DWELL are the ejector mechanism forward speed, maximum distance of motion and how long the ejector mechanism remains at the forward position before retracting.

RETtract LIMIT and RETract SPEED specify the ejector mechanism speed and home position after the forward motion.

Some machines have both hydraulic and pneumatic ejectors. If the Hydraulic Eject switch is ON in Menu 27, (which it will be for this machine which does not have the pneumatic ejector option) the ejector must be fully backed out to the RET LIMIT position before the clamp will close for the next cycle. The EJECT STOP RET SINGLE on Menu 27 can be used to control the ejectors.

PULSE(S) sets the number of complete forward/reverse strokes of the ejection mechanism in each press cycle.

PULSE RETRACT is the distance the ejector mechanism retracts between pulses.

CLAMP and EJECTOR positions are shown on the OPEN MOLD GRAPHIC.

There are no general rules for ejector motions since successful ejection depends critically on the specific part shape and the part mechanical properties and temperature.
Process Timers - Menu 16

The allowable times (maximum times in some instances) for various parts of the molding cycle are set in the PROCESS TIMERS menu.

CYCLE ALARM LIMIT is the maximum time for one cycle and if exceeded an alarm will be generated.

CURRENT CYCLE TIME is the elapsed time since the current cycle started.

INJECT HIGH is the maximum length of time that the machine can stay in the Inject High state. The Inject High state is the part of the injection stroke under specified velocity control. The part of the injection stroke under pressure control is called the Injection Pack state.

PACK is the amount of time (absolute value of time, not a fraction of the cycle) allowed for the Injection Pack state.

HOLD is the (absolute) time allotted to the Injection Hold machine state.

COOLING specifies how long (absolute time value) the part is allowed to cool before the clamp opens.

EXTRUDER DELAY is the length of time between the end of Injection Hold and the start of the Extruder Run, a zero value is appropriate. Extruder Run is the part of the molding cycle in which the shot is made for the next injection.

OPEN DWELL is the time the clamp is open between opening at the end of one cycle and closing for the start of the next cycle. This Open Dwell time is used in both Single Cycle and Continuous Cycle operation.

In SINGLE CYCLE operation the machine door must be opened and closed before a new cycle will begin.

Injection Velocity Profile - Menu 17

The top part of this menu is used for setting the cushion.

CUSHION is the amount of material left in front of the screw in the barrel at the end of the injection stroke. As is Shot Size, this process parameter is a distance corresponding to a particular volume of material.
ADAPTIVE SHOT SIZE is a facility which automatically adjusts Shot Size and Transfer Position to maintain the Cushion set point. The Transfer (XFER) position is where injection screw forward speed control (the Injection High mode) changes to pressure control, the PACK mode. The Adaptive Shot Size feature is only useful if only good parts are being produced, i.e., truly steady state operation has been achieved.

% ERROR CORRECTION is the % of the error (error = measured screw position (cushion set point) which is corrected during each cycle if ADAPTIVE SHOT SIZE is ON.

The bottom part of the menu is used to set parameters for the Injection High stroke. Injection High mode is the part of the injection stroke when the screw moves forward at specified velocities - velocities in 1 to 5 segments of the stroke can be specified.

SHOT SIZE is the distance (corresponding to material volume) the screw backs up during the Extruder Run part of the molding cycle. It is the distance away from the screw's fully extended position and so includes the cushion as well as the part volume and is set in Menu 19.

The number of the segments in the injection stroke is shown in the squares under SHOT SIZE. The number of segments is set in Menu 61, as NUMBER OF SEGMENTS TO PROFILE. The display shows the length of each segment of the Injection High stroke as the %age of the stroke remaining. For example, if segment 1 is 20% of the stoke length, a display of 80% is used to show the segment length as 80% of the stroke remaining.

Segment 1 is the set point for screw translation speed during segment 1 of the Injection High stroke. The screw moves forward at this speed until it reaches the position for the start of segment 2.

The other Segment set points (2 - 5 possible) specify the screw translation speed for other segments of the Injection High stroke.

XFER POS is the Transfer Position and specifies the location in the screw advance at which the injection sequence changes from velocity mode (Injection High state) to pressure mode (Injection Pack state). This position can be set based on one of

- screw position which is set in Menu 17
- hydraulic pressure in the last segment of the Injection High stroke and this is set at HYDraulic XFER pressure in Menu 18
- time
- cavity pressure which is not an option on the press. With this option Transfer of mode is based on an in-mold measurement of pressure

The actual values of Cushion, Transfer Position, Fill Time, Screw Position and Injection Pressure are shown along the bottom of the display screen.

**Injection Pressure Profile - Menu 18**

FILL PRS HI LIMIT sets the maximum injection pressure allowable during the Injection High stroke.

HYD XFER sets the hydraulic pressure at which the velocity to pressure (PACK) control change takes place, if Hydraulic Transfer is ON in Menu 27.

PACK sets the total length of time of the Injection Pack state which can be composed of 1 - 5 segments. If Injection Pack is composed of more than one segment, each is set to the same length of time equal to the time set divided by the number of segments.

Psi is used to set the pressure in each of the packing segments.

HOLD is the total length of time of the Injection Hold state. Total time is set and if more than one segment is specified, each segment length is set to an equal portion of the total time specified, as in PACK.

Psi is used to set the pressure for each segment of Injection hold.

The actual and set point hydraulic pressures are also show on the display.

**Extruder RPM & Back Pressure - Menu 19**

After an injection stroke another shot has to be built for the next press cycle. This is done during the Extruder Run machine state or mode during which

- before Extruder Run starts the injection screw can be pulled backward, away from the mold, by a distance set in DECompress BEFORE, a zero value is adequate.
the motor is rotated at a preset speed set in the rpm box

the screw rotates in the barrel

screw rotation causes feed material to move down the barrel.

melted material is augered down the barrel

the build up of material at the front of the barrel forces the screw backward

Back Pressure, specified in the psi box, is maintained in the injection cylinder resisting screw backward motion

the screw continues to rotate and move backward until the SHOT SIZE set point is reached

the screw stops rotating

the screw is moved backward a small distance to the Decompress After set point to remove pressure on material in the barrel

One to five segments of the Extruder Run can be specified.

Especially note that in specifying the segments of Extrude Run motions, the length of the segment completed is specified as a % - this is in contrast to the Injection stroke segments being specified as % of the stroke still to be completed.

The actual rotation speed, position and pressure are shown at the bottom of the screen.

**Machine Operation**

**Operate the machine only in the single cycle mode.**

- Begin with the door closed
- Open the door
- Push the SINGLE CYCLE key, 14
- Close the door
Problems That Have Occurred

Most of the problems that have occurred are related to not shutting the machine down fully or shutting it down incorrectly. Problems having to do with operating the machine does not occur very often if the operation of the machine - the nature and sequence of the machine actions - is understood.

As pointed out above, the starting place to look for solving problems is Menu 43, the faults menu.

The cover above the nozzle is easy to overlook, and if it is not down a safely interlock will not let the machine run.

Continuous cycling during tonnage setting usually indicates that the toggler mechanism is not in a useful position and the left, support location has to be reset.

Sometimes mold height setup and tonnage setting procedures cannot be done. The machine refuses to go into the MANUAL mode. Moving the screw back slightly seems to cure this problem. This is described in the Mold Set-Up procedure above. In general, the machine should be close to actual operating conditions during setup.

If there are air spaces in the machine barrel, not only will short shots result but the extrude run phase of machine operation in which the next shot is made, will not operate correctly. The symptom is that the screw (position shown on Menu 17) will not retract to past the shot size. Progressively shorter and shorter shots will be made. The cure for this problem is to re-make the shot ensuring that the first shot is made correctly.

Sample Of Written Lockout & Tagout Procedures

The following simple lockout procedure is provided to assist employers in developing their procedures so they meet the requirements of this standard. When the energy isolating devices are not lockable, tagout may be used, provided the employer complies with the provisions of the standard which require additional training and more rigorous periodic inspections. When tagout is used and the energy isolating devices are lockable, the employer must provide full employee protection (see paragraph (c)(3)) and additional training and more rigorous periodic inspections are required. For more complex systems, more comprehensive procedures may need to be developed, documented, and utilized.
Lockout Procedure

Lockout Procedure for

(Name of Company for single procedure or identification of equipment if multiple procedures are used).

Purpose

This procedure establishes the minimum requirements for the lockout of energy isolating devices whenever maintenance or servicing is done on machines or equipment. It shall be used to ensure that the machine or equipment is stopped, isolated from all potentially hazardous energy sources and locked out before employees perform any servicing or maintenance where the unexpected energization or start-up of the machine or equipment or release of stored energy could cause injury.

Compliance With This Program

All employees are required to comply with the restrictions and limitations imposed upon them during the use of lockout. The authorized employees are required to perform the lockout in accordance with this procedure. All employees, upon observing a machine or piece of equipment which is locked out to perform servicing or maintenance shall not attempt to start, energize, or use that machine or equipment.

Type of compliance enforcement to be taken for violation of the above.

Sequence of Lockout

(1) Notify all affected employees that servicing or maintenance is required on a machine or equipment and that the machine or equipment must be shut down and locked out to perform the servicing or maintenance.

Name(s)/Job Title(s) of affected employees and how to notify.
(2) The authorized employee shall refer to the company procedure to identify the type and magnitude of the energy that the machine or equipment utilizes, shall understand the hazards of the energy, and shall know the methods to control the energy.

Type(s) and magnitude(s) of energy, its hazards and the methods to control the energy.

(3) If the machine or equipment is operating, shut it down by the normal stopping procedure (depress the stop button, open switch, close valve, etc.).

Type(s) and location(s) of machine or equipment operating controls.

(4) De-activate the energy isolating device(s) so that the machine or equipment is isolated from the energy source(s).

Type(s) and location(s) of energy isolating devices.

(5) Lock out the energy isolating device(s) with assigned individual lock(s).

(6) Stored or residual energy (such as that in capacitors, springs, elevated machine members, rotating flywheels, hydraulic systems, and air, gas, steam, or water pressure, etc.) must be dissipated or restrained by methods such as grounding, repositioning, blocking, bleeding down, etc.

Type(s) of stored energy - methods to dissipate or restrain.

(7) Ensure that the equipment is disconnected from the energy source(s) by first checking that no personnel are exposed, then verify the isolation of the equipment by operating the push button or other normal operating control(s) or by testing to make certain the equipment will not operate.

Caution: Return operating control(s) to neutral or "off" position after verifying the
isolation of the equipment.

Method of verifying the isolation of the equipment.

(8) The machine or equipment is now locked out.

"Restoring Equipment to Service." When the servicing or maintenance is completed and the machine or equipment is ready to return to normal operating condition, the following steps shall be taken.

(1) Check the machine or equipment and the immediate area around the machine to ensure that nonessential items have been removed and that the machine or equipment components are operationally intact.

(2) Check the work area to ensure that all employees have been safely positioned or removed from the area.

(3) Verify that the controls are in neutral.

(4) Remove the lockout devices and reenergize the machine or equipment. Note: The removal of some forms of blocking may require reenergization of the machine before safe removal.

(5) Notify affected employees that the servicing or maintenance is completed and the machine or equipment is ready for used.
In closing this portion of the guide, there is a lot of information that can be found and used to prevent an accident on these types of machines. Following the manufactures information that can be found in the owners / operators manual is the first step in preventing an accident. A second way of preventing an accident would be to develop a job safety and health analysis. A Third way to prevent accidents when conducting maintenance on the machine is to follow proper safety procedures including following OSHA 29 CFR 1910.147 LOCK-OUT, TAG- OUT and TRY-OUT procedures.

Read all of the information that can be found on the internet concerning accidents on these types of machine. Share this information with your operators and also with the person performing maintenance on these machines. Finally, here is information on one more accident that could have been prevented:

**SUMMARY:**

A 20-year-old female production worker at a plastic injection molding company died after coming in contact with 220 volt alternating current (ac) electricity.

At the time of the incident the employee was operating a plastic grinding machine. The separate on and off buttons were located inside a metal switch box on the front of the machine. The cover plate had been removed and not replaced for an undeterminable length of time. The victim reached to push the off button and missed allowing her finger to pass by the button and contact the 220 volt power source. The victim maintained contact with the power source until a co-worker de-energized the machinery. The MO FACE investigator concluded that, in order to prevent future similar occurrences, employers should:

- **ensure that all switch boxes have appropriate guarding in order to prevent contact with energized parts.**

- **develop, implement, and enforce a comprehensive safety program which includes worker training in recognizing and avoiding hazards, especially electrical hazards.**

- **train employees in Cardiopulmonary Resuscitation (CPR).**

**INTRODUCTION:**

On August 11, 1992, a 20-year-old production worker at a plastic injection molding company contacted 220 volts (ac) in an uncovered electrical box, housing the on and off buttons. The MO FACE investigator was notified of the fatality by the county coroner on August 12, 1992. The Occupational Safety and Health Administration was also notified and investigated the incident.
The MO FACE investigation was initiated on August 13, 1992 with an interview with the employer and tour of the incident site. Also interviewed was the county coroner. The MO FACE investigator obtained a copy of the coroner’s report, the emergency medical service run sheet, the police report, and the death certificate.

The company involved had been in operation for five years and six months. At the time of the incident 17 persons were employed, 12 of which had the same job title as the victim. The victim had been employed by the company for approximately five weeks.

The employer did not have a designated safety officer or written safety plan at the time of the incident. Employee training was accomplished on the job. The employer provided hearing and eye protection to the employee.

**INVESTIGATION:**

This plastic injection molding company manufactures small furniture fixtures, toy items, and plastic funnels. This operation runs three shifts, the victim was working a 2:55 pm to 11:10 pm shift. At the time of the incident, approximately 9:30 pm, there were 4 employees present. The victim and a co-worker were each operating a shaping/molding machine and a drying machine and shared the use of a waste plastic grinder. The victim was operating the Cumberland brand 8x10, serial #39006180, plastic grinding machine. This is a mobile piece of equipment which can be utilized throughout the facility. It is plugged in to a 220 volt ac outlet in the area where it is to be used. The production worker uses this grinder for preparing waste plastic for reuse into the injection molding process.

The victim was using this piece of equipment at the time of the incident. It was positioned in her usual work station and was not in contact with any other piece of equipment. It was insulated from the concrete floor by its rubber wheels. It was plugged into a 220 volt outlet located in the work area. The electrical connections were in good condition. The machinery is activated by the use of a separate on and off button. These buttons were mounted on a switch housed in a switch box mounted on the front of the machine. This switch box was much larger than the switch located inside it and allowed easy access to the energized parts inside. Apparently the victim went to activate the off button and missed.

Her fingers slid by the button and contacted the energized part of the switch. The victim was electrocuted by the 220 volt power source.

According to an interview with the co-worker, she normally works with her back to the victim and the grinder. She heard a noise coming from the victim, as if she was trying to speak. She turned to see the victim lying against the machine with her right hand inserted into the switch box housing the on/off buttons. Sparks
were being emitted around her hand. The co-worker immediately pulled the plug on the grinder and summoned help. The victim fell to the floor following the de-energization of the machinery.

The emergency medical service was summoned to the incident site. The plant employees had no CPR training and the victim was offered little assistance until the EMS arrived. Upon their arrival victim was found lying on her left side.

The victim had no pulse, no respiration and no blood pressure. CPR was initiated as well as Advanced Cardiac Life Support (ACLS). Attempts to resuscitate the victim were continued in route to the local hospital where she was pronounced dead shortly after arrival.

CAUSE OF DEATH

Cardiac arrest due to electrocution

RECOMMENDATIONS/DISCUSSION:

RECOMMENDATION #1: Employers should ensure that all electrical equipment have appropriate guarding in order to prevent contact with energized parts.

Discussion: Live parts of electrical equipment operating at 50 volts or more should be guarded against accidental contact by approved cabinets or other forms of approved enclosures. [29 CFR 1910.303(g)(2)(I)]

RECOMMENDATION #2: Employers should develop, implement, and enforce a comprehensive safety program which includes worker training in recognizing and avoiding hazards, especially electrical hazards.

Discussion: Employers should emphasize safety to their employees by developing, implementing, and enforcing a comprehensive safety program. The safety program should include, but not be limited to, training workers in recognition and avoidance of electrical hazards, emergency preparedness, and the proper selection and use of personal protection equipment.

RECOMMENDATION #3: Employees who work around electrical circuits, and electrical equipment should be trained in cardiopulmonary resuscitation (CPR).
Reference


Bean, Gary (Technimark Plant Manager). Personal Interview. 12 March 1998.


Looper, Glenn (Technimark Plant Manager). Personal Interview. 14 March 1998.


