Safety and Environment

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Preventing Unsafe Acts

Safety experts agree: the vast majority of industrial accidents are caused by **unsafe acts**, not unsafe conditions. Therefore, while equipment condition, guards, and safety features are still extremely important, the safety program must always focus on the individual worker --- insuring that each worker is well trained, alert, and focused on always working in a safe manner.

Keeping workers alert to safety and properly motivated is a constant challenge for management. One solution is to hold regular meetings for reviewing safety rules and/or recent accidents and near misses. Meet with all workers on a crew-by-crew basis, even if only for 5 or 10 minutes at the beginning of the shift. Promotions, contests, and other "gimmicks" may work if they can keep the workers alert to avoiding unsafe acts.

Training for new workers and regular re-training are also important --- few newly-hired workers arrive at the plant gate with any understanding of industrial safety. Each new worker must be put through a period of formal safety training, with performance evaluated just as for any other part of the job. Then a periodic review of the training is needed to maintain awareness.

HUMAN BEHAVIOUR

How accidents happen…any one can be traced back to these few causes…

- ***I don't know….***
- ***I don't care….***
- ***I am not trained….***
- ***I know but ignore….***
- ***I get accustomed….***
- ***I grow into bad habits….***

Comment by Hans Bohde, EEC Conference, 2002

Accident Reporting, Investigation, and Follow-up

Every injury or near-miss accident in the plant must be reported and investigated, no matter how small. Only by following up on small incidents is it possible to reduce or eliminate the major ones.

H.W. Heinrich in 1931 proposed that injuries occur in a distribution resembling a pyramid; for every major injury (top) there will be 29 minor-to-serious injuries (middle) and 300 near-misses (on the bottom). Managers often make the mistake of trying to eliminate only the top of the pyramid without working on the base. While that approach may seem cost effective, in fact it is a waste of time and money. It is only possible to shrink the top of the pyramid by reducing the base.

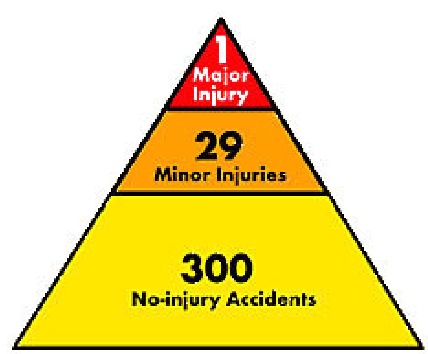

Figure D-1: H.W. Heinrich's Injury Frequency Pyramid

So, it is important for every minor injury or near-miss be reported and investigated, and for action to be taken to prevent recurrence. When minor and medium-severity accidents and injuries are minimized, the major ones will also decrease. And, the investigations and follow-up actions will eventually result in an effective on-going safety program.

Common Hazards in the Extrusion Plant[1]

The most common hazards in the extrusion plant are well known. Following is a brief review, with recommendations for minimizing their impact on plant operations.

Extrusion Tooling

The following rules for safe operation of extrusion tools were offered by Bill Mason and Mel Molitor[2]:

- Never extrude using cold or room temperature tools.
- Never look into the exit end of a die when applying extrusion load.
- Never use improperly supported dies, backers, and bolsters.
- Always use safety devices and shields.
- Caution - Many extrusion dies and support tools are subjected to stresses at or near the yield strength of the steel, allowing for little or no safety factor. Always adhere to rigid safety practices.
- Never use a bad eye bolt for lifting a die, and always make sure the eye bolt is screwed in at least 4 or 5 full turns.
- Beware of fire when applying lubricants (wax or grease) to hot dies and tooling.

Tooling breakage has caused many serious injuries due to flying shrapnel. Dies generally are under their highest stress during breakout of the extrusion. There are many occurrences of die fractures ejecting steel shrapnel down the runout table.

Misalignment of the tool stem and the billet container has resulted in slivers of steel from the nose flying out of the press toward operating personnel. Tool stems are designed primarily for axial loading and misalignment of the stem and billet container can generate bending stresses along with the axial stresses that can cause catastrophic failure. Total fractures of tool stems have occurred due to major misalignment problems. **Figures D-2** and **D-3** are examples of such a fracture on a direct stem.

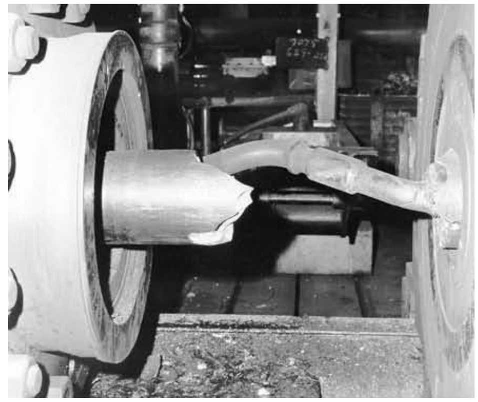

Figure D-2: Shattered Press Stem

Figure D-3: Pieces of shattered press stem.

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[1] This section reports on work presented by Alan Bartelt of Alcoa at Aluminum Extruders Council Press Maintenance Workshop, Chicago, April 4, 2002, and from similar materials from the following paper:
Bartelt, Alan, "Extrusion Hazards and Risk Reduction," *Proceedings of 8th International Aluminum Extrusion Technology Seminar*, (2004).

[2] Mason, Bill, and Molitor, Mel, Session on Die Correction at 1989 Die Workshop, Aluminum Extruders Council, October 1989, Chicago.

Tooling Safety Procedures

Tooling components are the most highly stressed items in the extrusion press system. Obviously, it is important to design and maintain these items for personnel safety and customer needs. The following are some things to help maintain the tooling in safe working order and to reduce the risk of personal injury.

Tool Stems:

- Maintain good press alignment by regular uniform clearance checks between the stem and billet container.
- Always preheat stems prior to using. Stems are constructed from hot working steels and are more brittle when cool.
- Perform visual checks for any buildup of aluminum on the stem surface. This is usually an indication of nose (dummy block) damage or misalignment.
- Remove stems at least every 6 months and have them cleaned, visually inspected and penetrant inspected.
- Clean stems with caustic, flap wheels, scraping, and or wire brushing. Grinding with a hard wheel can generate stress risers.
- Inspect the main crosshead pressure plate for flatness within 0.003 inch.
- Check stem nose and bell for flatness within 0.003 inch.
- Check straightness of stem along length to be within 0.010" total indicator reading.
- Repair nose or bell if localized indentations are greater than 0.010 inch deep and cover more than 5% of the surface area.
- Check the stem hardness to insure its strength is within the manufacturer's specification.
- Weld repairs to stems should generally not be performed unless special technical practices are provided and followed.
- A tool service history file should be maintained on each stem.

Dies and Backers:

- Dies and backer blocks require special design consideration for stresses and deflections and should be done by personnel technically qualified for such.
- Dies should be cleaned with caustic and penetrant checked after each use. Dies should also be checked for permanent deflection set to determine if they have been over stressed.
- Dies may be welded if performed with a specified procedure and qualified personnel.

Heat

The temperatures at which aluminum is extruded are very hazardous to human contact, but the outward appearance of the metal gives no warning when it is hot. Certain steel parts of the press and tooling also present similar high temperature hazards, particularly tooling just removed from the press. Any exposed personnel, especially visitors to the press area, must be properly instructed in avoiding hot materials; and procedures should be instituted to help avoid accidental contact.

Temperatures in the press environment may also cause a variety of heat related physical and mental conditions[3].

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[3] Bartelt, Alan, Ibid.

Fire[4]

The potential for fire around extrusion presses exists since most presses use mineral oil hydraulic systems at relatively high pressures. These hydraulic fluids are extremely flammable if atomized by a leak in a pipe, hose or fitting. Since the extrusion process is a thermal process, there are many sources of ignition. Several deaths have been associated with fires on extrusion presses.

Hydraulic oil leaks are the major cause of fires on extrusion presses. The following have been shown to reduce the risk of leaks.

- All connecting fittings should have o-ring seals with back up rings if possible.
- All fittings and flange connection fasteners should be torqued to the manufacturer's specifications.
- Manifolds should be used to minimize connections.
- The use of hoses should be minimized unless needed for flexibility.
- High pressure hoses should have safety sleeves installed over them to provide an extra barrier to spray leaks.
- Consider using nonflammable fluids for billet loaders which do not require high pressures.
- All piping systems should have proper supports to minimize vibration from dynamic pressure fluctuations.
- The use of proportional control valves can significantly reduce shock loading that could cause leaks.

Fire protection measures around the press vary according to the company and the laws and regulations of the locality. A few companies use non-flammable hydraulic fluids such as ethylene glycol or phosphate esters; however, these require particular materials of construction, especially elastomer seals, so that they are not easily retrofitted in presses using petroleum oils. Some authorities require automatic sprinklers for fire suppression, with heads located both above and below the hydraulic tank. Addition of fusible-wire systems allows automatic alarms to signal any fire event and stop the hydraulic pumps.

Hot work safety is primarily related to maintenance when welding, burn cutting, heating and grinding generates a source of heat for igniting oil or other flammable materials that may be present around a press facility. One method of reducing the risk of a fire associated with such work is the use of a **HOT WORK PERMIT** by personnel performing the work. Such a permit is typically completed by the supervisor of the personnel performing the work and reviewed with those persons. A permit should identify the person doing the work, the location of the work area, conditions of the work area, what work is being done, when the work is being done, and also help in determining safety hazards associated with the job. It should help identify what can be done to reduce the risks associated with the work. Communication with the plant security group about the job prior to beginning the work can also improve response to a fire if one should occur.

Lifting

Extrusion tooling, fixed dummy blocks, and similar heavy press components must be handled, often with difficult and awkward lifting positions, thus creating a constant risk of lifting injuries. Every employee must be given specific training in correct lifting procedures, and also provided with appropriate back support belts. Each lifting operation should also be the subject of ergonomic studies, to eliminate or minimize lifting requirements, and to provide correct lifting devices. Heavy lifting should be done with the legs instead of the back, and twisting should be avoided while lifting.

[4] Ibid.

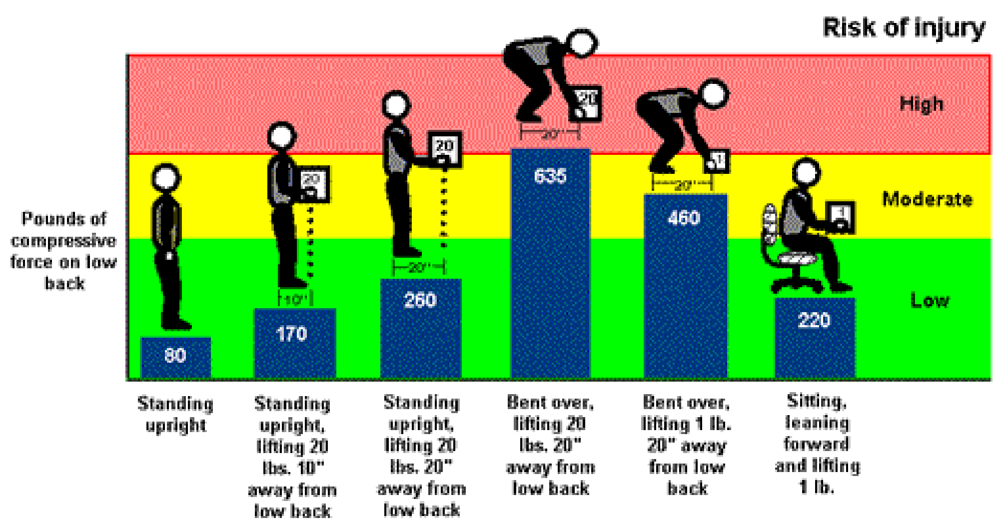
Safe Lifting Techniques[5]

As part of the goal of accident prevention, we want to provide education to everyone on safe lifting techniques in order to prevent back injuries. Please note the information and diagram below which outline the basic rules for proper lifting.

Quick lifting tips:

- Before lifting, make sure your path is dry and clear of objects that could cause a fall.
- Bend your knees and keep your back straight. (Lift with your legs, not your back.)
- Bring the load close to your body.
- Lift in a slow, even motion.
- Don't twist your body. If you must turn, move your feet.
- Keep your back straight when putting down the load.

The weight of the objects you lift is an important factor in determining your risk of injury, and you will want to be especially careful when lifting heavy items such as storage boxes full of files and cases of copy paper. However, weight is not the only thing that determines your risk of injury. The following chart notes the effect that posture can have when combined with lifting different size loads:



More on lifting techniques:

1. **Keep the load close:** Holding a 20 pound object with your hands 20 inches from the body creates more compressive force on your low back than holding it 10 inches away. This is because the muscles in your back have to work harder to counterbalance the weight when it is further from the body. **As the compressive force on your low back increases, so does the risk of muscle strains, ligament sprains and damage to disks in the spine.**

2. **Avoid lifting from the floor:** Lifting from the floor can greatly increase your risk of injury for two reasons. First, it is difficult to bring objects close to your body when picking them up from the floor, especially large objects where your knees can get in the way. Second, your low back must now support the weight of your upper body as you lean forward, in addition to supporting the weight of the item you are lifting. Lifting the same 20 pounds from the floor more than doubles the amount of force on your low back when compared with lifting it from waist height. Even a one pound object lifted from the floor increases your risk of injury if you use a bent over posture.

3. **Plan ahead:** Decide how you will lift, carry, and place the item before you pick it up. Test the weight of the load by moving or tipping it before you pick it up. Figure out if you can break the load down by placing the contents of a large container into a number of smaller ones before moving them.

[5] From Gonzaga University – Environmental Health and Safety, www.Gonzaga.edu

Mechanical Press Equipment

Moving parts of the press and related equipment --- especially automatic components of newer handling systems --- require special precautions to prevent injuries:

- Observe lock-out/tag-out rules when working on any moving or powered equipment.
- Never step into the extrusion press without following the lock-out/tag-out procedures. For example, when removing a fallen or wedged billet, or checking a limit switch or loader problem, it is possible to accidentally actuate a switch or to release energy stored in the hydraulic system, etc.
- Watch for people who are inexperienced, inattentive, or visitors to the press area, to prevent them from contacting moving equipment.
- Watch for anyone standing in the way of a puller, hot saw or shear, stretcher headstock, cold saw, stacker, etc.
- Never try to un-jam metal from the puller unless the lock-out/tag-out procedures have been followed and the press operator notified.
- Keep hands free of stretcher jaws and puller teeth or jaws.
- Moving equipment should be provided with guards, light curtains, and/or safety switches to prevent operation when people are present. All safety devices must be properly maintained, in place and operating.

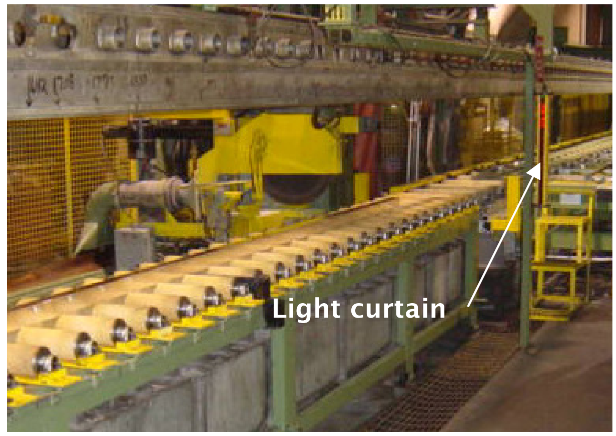


Figure D-4: Light curtain in lead-out table area

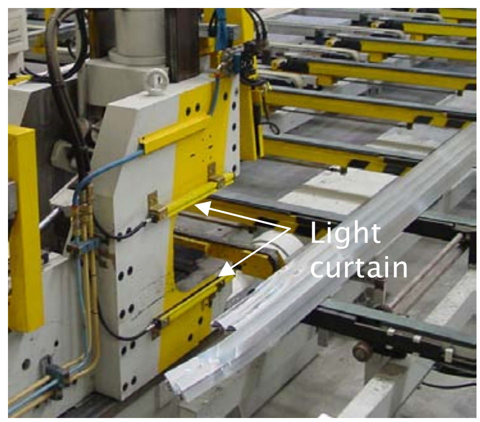


Figure D-5: Light curtain on stretcher jaws

Material Handling

Many plants report that their highest frequency of injuries occurs from moving profiles, tooling, etc., through the plant. Some specific examples of hazards and recommended safety rules:

Overhead Cranes:

- Crane operators should receive mandatory training on a regular basis and be certified as to their operating skills.
- Loads are often dropped due to sudden starts and stops, or due to the load hitting something; operator care and skill are essential to avoiding these problems.
- Never stand under or near a load suspended from a crane, even if it is an empty rack or load lifter device; operators must never allow this to occur.
- Immediately move out of the way if a load is coming toward you.

- Stop the crane immediately if someone fails to move out of the way.
- Because profiles in a rack may tend to shift or may be loaded off-center, lift every load slowly and carefully to check that the load is stable in the rack and will not tip and slide out, and that the load does not swing to one side when it clears the floor.
- All personnel should stand a good distance clear when profile racks are lifted in case the load shifts.
- Make sure that the “grabber” for picking up racks is correctly latched or connected to the rack before lifting.
- Use care when hooking the crane hook into a load: do not put fingers into the hook, and be sure that the hook is fully engaged and latched

*Keeping Overhead Cranes Safe**

The pre-shift inspection: OSHA (Occupational Safety and Health Administration) CFR 1910.179 mandates a crane inspection before every shift. It involves a full operational check so that the function of the crane is observed and documented. The OSHA mandate does not specify what the inspection will include; a good starting point for a checklist is either the “Crane Operator’s Manual,” Published by the CMAA (Crane Manufacturers Association of America), or the CMAA’s Specification 78, containing standards and guidelines for servicing overhead and traveling cranes.

The CMAA’s 11-point list of items to be inspected daily includes existing lock-outs/tag-outs, controls, brakes, hooks and hook latches, the wire rope and reeving, limit switches, oil leaks, unusual noises, and the presence of legible warning and safety labels. The results of the inspection are to be documented, with deficiencies precisely detailed.

The OSHA regulation also directs that a crane must be taken out of service until all faults are repaired. Management support for this rule is required to prevent “working around” the deficiencies in order to make production.

A key issue in the daily inspection: make sure the actual crane movements correspond to the indicators on the controls. For example, should the controls be accidentally connected out of phase after repairs, limit switches would be defeated and disaster could occur.

Common sense advice:

- Avoid using limit switches or bumpers to stop crane movements; these are for emergency use only.
- Take up slack slowly, until the load just clears the floor. Only then should the operator make a continuous lift. Don’t jerk or snatch the load.
- Draw a sling tight in stages. Do not make a continuous lift with a slack sling.
- Be aware of how much weight the crane is lifting. Do not assume that every load will be within the rated capacity of the crane.
- Stand clear of the load. Most pendant cranes have the controls on a separate festoon track, which moves the operator away from the load. No such [safety] exists with a radio-controlled crane, and it’s easy to wander into harm’s way.
- When traversing a load, know how much clearance is available around obstructions. And never, ever, traverse a load over someone’s head.
- When testing the brakes in the pre-shift inspection, be sure the block doesn’t drift after the direction buttons are released. And test the bridge and trolley brakes as well as the drum brakes.
- In addition to listening for trouble, operators should use their noses. Smell is an excellent indicator of impending motor burnout or brake failure.

*Excerpted from “Keeping Overhead Cranes Safe,”, *Modern Metals*,
J. Nieland Pennington, Executive Editor. December 2003, pages 28-30.

Fork Lifts:

- In the USA, drivers must receive mandatory training on a regular basis and be certified as to their operating skills.
- All workers and also visitors must be alert to fork lift traffic at all times, and particularly in vehicle aisles and near blind doorways.
- Drivers must be alert to avoid workers or visitors who may wander into the vehicle's path.
- Never allow a suspended load to pass over or near another person.

Hand Injuries. Often the most frequent injuries in extrusion plants are to the hands. Following are some of the hazards to be avoided:

- Handling heavy, awkward tooling, especially when the proper lifting equipment is not used.
- Burns from hot tooling, also butts and profiles.
- Getting fingers caught in stretcher jaws and puller teeth or jaws.
- Putting the hand near a moving saw blade, even if it is just coasting.
- New saw blades --- they are especially sharp.
- Fingers caught between the extrusions and the saw stop or between the cut profiles and the rest of the extrusion.
- Cuts from handling the cut ends of extrusions --- also extremely sharp.
- Cuts from the sharp edges on the ends on pre-cut billets.
- Fingers smashed when handling billets.
- Fingers caught in crane hooks when hooking billet or profile racks or tooling.

While gloves may prevent many hand injuries, in other cases they may increase the hazard, for example when working near moving machinery. Some plants prohibit the wearing of rings or watches for the same reason.

A Check List of Additional Safety Hazards Associated with Various Extrusion Plant Equipment

Extrusion Presses

- ❑ automatic machine movements
- ❑ hot machine parts
- ❑ tooling failure
- ❑ broken hydraulic lines
- ❑ relief valves incorrectly set
- ❑ heavy lifting (billets, tooling, press parts)
- ❑ loading tooling into the press (hoisting dangers, heat)

Billet/Log Feed Conveyors

- ❑ automatic machine movements
- ❑ hands caught between billets or logs
- ❑ billets or logs dropped
- ❑ sharp ends on pre-cut billets and logs

Billet/Log Heaters - Gas Fired

- ❑ heat --- burn hazards from hot surfaces or hot air discharge
- ❑ combustion safety (discussed in more detail below, page 15-10)
- ❑ billets or logs dropped
- ❑ hands caught between billets or logs
- ❑ automatic movement of doors, thermocouples, and other mechanical parts
- ❑ system overheating due to failure of temperature controls
- ❑ fire hazards if combustible hydraulic fluids are used nearby

Billet/Log Heaters - Induction

- ❑ heat --- burn hazards from hot surfaces
- ❑ billets thrown out by induction forces
- ❑ billets or logs dropped
- ❑ hands caught between billets or logs
- ❑ automatic movement of doors, thermocouples, and other mechanical parts
- ❑ system overheating due to failure of temperature controls or cooling water
- ❑ electrical power system hazards

Log Shears

- ❑ automatic machine movements --- log feed, shearing, and billet transfer
- ❑ hands caught between billets or logs
- ❑ billets or logs dropped
- ❑ sharp ends on logs
- ❑ heat --- burn hazards from hot surfaces
- ❑ billets or logs dropped
- ❑ hands caught between billets or logs
- ❑ fire hazards from combustible hydraulic fluids

Billet Conveyors

- ❑ automatic machine movements
- ❑ hands caught between billets or logs

- ❏ billets or logs dropped
- ❏ sharp ends on pre-cut billets and logs
- ❏ heat --- burn hazards from hot surfaces or hot air discharge
- ❏ billets or logs dropped
- ❏ hands caught between billets and other objects

Billet Lubrication

- ❏ flammable lubricants
- ❏ combustion hazards (with flame-type lubricator)

Lead-out Tables

- ❏ hot profiles
- ❏ tooling failure --- flying particles
- ❏ heavy lifting (cannisters)

Hot Saws or Hot Shears

- ❏ saw or shear blade
- ❏ moving machine parts --- saw or shear (travel and actuation), mini-slat, puller
- ❏ flying saw chips

Air Quenches

- ❏ air-blown particles (eye hazards)
- ❏ suction at the fan inlet(s)
- ❏ fan shafts, belt drives, or couplings

Water Quenches

- ❏ possible hot water or steam

Pullers

- ❏ very fast puller movements, automatically controlled
- ❏ possible failure of braking (linear motor type pullers)
- ❏ danger to hands from puller jaws

Slat Conveyors

- ❏ moving chains and slats
- ❏ automatic start and stop
- ❏ hot profiles

Lift-Over and Transfer Devices

- ❏ moving mechanical parts with automatic actuation
- ❏ hot profiles
- ❏ walking on table to reach profiles or to deal with equipment problems --- most table surfaces are slick with carbon or lubricants.
- ❏ pinch points at walking beams

Walking Beams

- ❏ moving mechanical parts with automatic actuation
- ❏ hot profiles
- ❏ walking on table to reach profiles or to deal with equipment problems --- most table surfaces are slick with carbon or lubricants.
- ❏ pinch points at walking beams

Belt Systems

- ❏ moving mechanical parts with automatic actuation

- ❏ pinch points at belt pulleys and take-ups
- ❏ hot profiles
- ❏ walking on table to reach profiles or to deal with equipment problems --- footing may be inadequate unless a walkway is installed; even so, no handrails and possible automatic re-start of belts.

Stretchers

- ❏ risk of hands caught or crushed in jaws
- ❏ head- and tailstock movement, often automatically controlled
- ❏ profiles breaking or slipping out of jaws while under tension
- ❏ interference with, or caught in, telescoping belts or profile support devices
- ❏ walking on table to reach profiles or to deal with equipment problems --- footing may be inadequate unless a walkway is installed; even so, no handrails and possible automatic re-start of belts.

Saw Feed Conveyors

- ❏ moving rollers and/or belt drives, with automatic actuation
- ❏ automatic raise-lower action (some saw feed conveyors)
- ❏ pinch points at walking beams or pulleys and take-ups of feed belts

Saws

- ❏ putting the hand near a moving saw blade, even if it is just coasting
- ❏ handling new saw blades --- they are especially sharp.
- ❏ fingers caught between the extrusions and the saw stop or between the cut profiles and the rest of the extrusion
- ❏ cut ends of extrusions --- also extremely sharp
- ❏ sawing pipe or other rounded extrusions --- these may kick out, so they must be held firmly in place.
- ❏ placing a new blade in service (if blade should be installed backward, teeth may break off and be thrown out)
- ❏ moving machine parts --- saw blade actuator, and conveyors
- ❏ flying saw chips
- ❏ saw noise
- ❏ lifting of profiles
- ❏ scrap and other tripping hazards in saw area

Length Gauges

- ❏ moving mechanical parts with automatic actuation
- ❏ pinch points at belt gauge stop and chain or rack and pinion drives
- ❏ cut ends of extrusions --- extremely sharp.

Off-Load Conveyors

- ❏ moving mechanical parts --- pinch points on belt pulleys and take-ups, also lifting mechanisms.

Profile Stackers

- ❏ moving mechanical parts with automatic actuation
- ❏ dropped loads (gantry-type stackers)

Age Oven

- ❏ combustion safety hazards
- ❏ worker trapped in oven (never enter an oven without a safety watch)

- ❑ load shifting or falling over in the oven
- ❑ walking on floor-type rollers or conveyors

Die Ovens

- ❑ hot surfaces and hot tooling
- ❑ hot air escape when the door is opened
- ❑ hoisting hazards

Personal Protective Equipment

Requirements for protective equipment vary from plant to plant and from country to country. Following are typical practices seen in a variety of extrusion plants:

Eye Protection: every plant now requires wearing of safety lenses with side shields.

Hearing Protection: all plants require hearing protection (suitable ear plugs or ear-muffs), for workers in the press area. Occupational safety rules generally require monitoring of noise levels and routine testing of worker hearing, in order to monitor potential hearing loss due to high noise levels in the press area.

Safety Shoes: almost all plants require workers to wear shoes with steel safety toes, and some also require shoes with metatarsal shields, to protect the instep area from dropped objects.

Safety Hats: most plants require that maintenance workers and visitors wear hard hats in all areas, but relatively few press workers are required to wear head protection continuously.

Gloves: workers normally only use gloves for specific tasks, such as handling of hot metal or tooling. As noted above, in some cases gloves may increase the risk of injury, particularly around moving equipment.

Back-Support Belt: these belts are used increasingly in all areas of industry as part of efforts to reduce back injuries from lifting heavy objects.

Face Shields: used when grinding or working around caustic.

Some plants also require ***FR7 or FR 9 Fire retardant Clothing*** for mechanics or electricians performing medium voltage or hot work or welding.


What the Well-Dressed Extruder is Wearing Today
Safety Glasses with Side Shields (required in all plants)
Hard Hat (required in some plants)
Hearing protection (required in all plants)
Reflective vest for visibility (required in some plants)
Back support belt (required for lifting)
Hot-work gloves (required for some tasks)
Safety Shoes
Steel toes (required in all plants)
Metatarsal guards (required in some plants)

Lock-Out Tag-Out Procedures

A clear, rigidly enforced lock-out/tag-out procedure must be in effect throughout any plant. Lockable switchgear is more positive, although some plants use a tag-our procedure effectively if there are sufficient controls against removing tags without proper approval.

Machines can be powered by:

- Electricity
- Fuel gas
- Compressed air
- Coiled springs
- Raised loads
- Steam
- Pressurized liquids

Tragic accidents have occurred involving billet loaders where the hydraulic pressure was not properly released before working on the loader! Always be sure the pressure is deactivated before working on any billet loader.

Some machines may be powered from multiple sources. And any single source by itself may present a danger, even if the others are turned off.

A written procedure should be provided for lock-out/tag-out of each type of machine!

Elements of a Lock-Out/Tag-Out Program:

Figure D-7: Typical Lock-out Tag-out devices

1. Identify what energy sources will be locked out
2. Can locks be used? Locks should be applied whenever possible.
3. Determine the sequence to follow.
4. Multiple maintenance personnel: be sure each person applies their own lock or tag to all lock-out points.
5. Be sure that all stored energy is safely released.
6. Try all sources and switches to confirm that all energy sources have been deactivated.
7. Before removing locks or tags be sure that:
   - All safety guards are back in place
   - Work is complete and tools have been put away
   - Workers are positioned safely for start-up
   - Controls are positioned correctly for start-up and the machine is ready for operation

8 Only the person who applied the lock or tag may remove it. In case there are multiple lockout points and maintenance people, team leaders should remove their locks last.

9 Follow the approved sequence in unlocking and un-tagging the lockout points and returning the machine to service.

Six Lock Tips:

- One lock – one key.
- Identify locks with numbers or colors.
- Use multiple lockout devices if needed.
- Never give your assigned lock or key to someone else.
- Always use a tag-out with your lock.
- If a lock can't be applied, contact your supervisor.

For additional suggestions on proper procedures, refer to OSHA rules for *Control of Hazardous Energy Sources (Lock-out/Tag-out)*, and "A Lock-Out/Tag Out Procedure that Works."[6]

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[6] Wirtz, Rodney, "A Lock Out/Tag Out Procedure that Works," *Proceedings of 4th International Aluminum Extrusion Technology Seminar,* Vol. II, (1988), p. 421-422.

Maintenance Safety

Safety responsibilities of the maintenance department extend beyond maintaining safe conditions for maintenance workers, for example:

Maintaining Safety Devices. Maintenance workers must be trained in the proper use and maintenance of such safety equipment as:

- electrical or PLC interlocks
- combustion safety logic and devices
- device guards
- light curtains

Maintenance must have a primary responsibility in insuring that guards are in place and safety switches and interlocks are working properly. They should be motivated with a personal interest in safety so that unsafe conditions will be corrected or reported immediately and proper remedial steps may be taken. Someone may put jumpers around safety relays or defeat purge timers or flame safeties, as a quick fix to a problem; but the result could be major injury and/or equipment destruction.

Electrical Safety. Only properly qualified personnel should be permitted to work on electrical equipment.

Servicing energized industrial control equipment can be hazardous. Severe injury or death can result from electrical shock, burn, or unintended actuation of controlled equipment. Recommended practice is to disconnect and lock-out control equipment from power sources, and release stored energy, if present. Refer to *National Fire Protection Association Standard No. NFPA70E, Part II* and (as applicable*) OSHA rules for Control of Hazardous Energy Sources (Lock-out/Tag-out)* and *OSHA Electrical Safety Related Work Practices* for safety related work practices, including procedural requirements for lock-out-tag-out; and appropriate work practices, personnel qualifications and training requirements where it is not feasible to de-energize and lock-out or tag-out electric circuits and equipment before working on or near exposed circuit parts.

Industrial control equipment should be inspected periodically. Inspection intervals should be based on environmental and operating conditions and adjusted as indicated by experience. An initial inspection within 3 to 4 months after installation is suggested. See National Electrical Manufacturers Association (NEMA) Standard No. ICS 1.3, *Preventive Maintenance of Industrial Control and Systems Equipment*, for general guidelines for setting up a periodic maintenance program. Some specific guidelines are listed below.

- Keep cabinet doors closed and locked to keep the interiors clean and to prevent unauthorized access.
- If inspection reveals that dust, dirt, moisture or other contamination has reached the control equipment, the cause must be eliminated. This could indicate an incorrectly selected or ineffective enclosure, unsealed enclosure openings (conduit or other) or incorrect operating procedures. Replace any improperly selected enclosure with one that is suitable for the actual environmental conditions -- refer to *NEMA Standard No. 250, Enclosures for Electrical Equipment* for enclosure type descriptions and test criteria. Replace any damaged or embrittled elastomer seals and repair or replace any other damaged or malfunctioning parts (e.g., hinges. fasteners, etc.).
- Dirty, wet or contaminated control devices must be replaced unless they can be cleaned effectively by vacuuming or wiping with a soft cloth. Compressed air is not recommended for cleaning because it may displace dirt, dust, or debris into other parts or equipment, or damage delicate parts.
- Guards and safety devices must be in place and working.

Combustion System Safety. "The objective of a combustion safety system is to stop the flow of fuel if the flame should happen to be extinguished. If the fuel flow is not stopped, the combustion chamber (or an entire building) may be filled with an explosive mixture of fuel and air.

"A pilot is not enough protection. It may go out or become inadequate to relight an extinguished main flame promptly; or a pilot may be unable to relight the main flame if the fuel/air ratio is too rich or too lean, if the feed rate is too fast or too slow, or if atomization is poor.

"The old idea that a *constant pilot* was helpful because it was always there to relight an extinguished flame has fallen into disrepute. Too many pilot flames have been unable to light a main flame when needed but have later served to ignite an explosive accumulation of fuel-air mixture. An *interrupted pilot* with its programmed trial-for-ignition period is the best way to avoid a pilot-ignited explosion. To prevent accumulation of unburned fuel in a combustion chamber, flame monitoring devices should be used to govern automatic fuel shutoff valves.

"**Automatic Fuel Shutoff Valves**. The prime requisites of any fuel shutoff valve are that it cannot be manually locked open, that it shut tightly, and that it be sensitive to any possible failure in the system. In addition it is desirable to have a manual shutoff arrangement, high mechanical advantage for easy opening, and an auxiliary switch.

"When the control circuit is interrupted the [valve's] electromagnet no longer holds the valve open and a strong spring snaps it shut so fuel flow is stopped quickly. When the trouble has been eliminated so that the circuit is again closed, the valve can be opened by the action of the hand lever. If, however, the trouble has not been satisfactorily corrected, the circuit remains open and the valve cannot be opened by moving the hand lever because the valve stem remains disengaged from the handle. This is termed *a manual reset fuel shutoff valve* as differentiated from an *automatic reset fuel shutoff valve* that automatically "resets" and reopens when power is restored. The manual reset type is used wherever the presence of an operator is required to assure a safe, low fire relighting of the burners….

"Any automatic fuel shutoff valve (manual reset or automatic reset) should close upon failure of:

1. combustion or atomizing air blower
2. any element of the input control system (such as temperature controllers)
3. air pressure at the burner
4. fuel pressure at the burner
5. current from the flame detector, or
6. current from other safety devices [such as door limit switches]….

"The fuel shutoff valve must be connected in series with all of these elements. Fuel [and] air pressure can be converted to an electrical signal by means of a bellows, Bourdon tube, or diaphragm operated switch…..

"Because a fuel shutoff valve effects the final action commanded by a trouble-detecting system, a leak or failure of such a valve could be extremely dangerous. For this reason, insuring authorities often insist on two fuel shutoff valves in series with the space between them vented outdoors (double block and vent valves), plus provision for a periodic leak test of the valves. All of the leak test methods consist of some sort of shutoff valve immediately downstream from the fuel shutoff valves with provision for detecting pressure build-up between the valves (as would occur if a fuel shutoff valve were leaking). The simplest form of leak test utilizes a petcock with a rubber hose, the open end of which is immersed in a beaker of water so that one can observe bubbles of fuel forming in the water if a leak exists. The most reliable leak check system is a programmed automatic check device such as a "Double Checker." It makes an automatic check after each closure of the fuel shutoff valve, using a pressure switch and alarm."[7]

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[7] From North American Combustion Handbook, 2nd Edition, North American Mfg. Co., Cleveland OH 44105 USA, page 296.

For the USA, rules for safe combustion systems are determined primarily by the National Fire Protection Administration (NFPA), and echoed in the rules of Factory Mutual (FM), Industrial Risk Insurers (IRI), and the US Occupational Safety and Health Administration (OSHA).

Emergency Plan

Every industrial plant should have a formal, written plan of emergency procedures --- what to do in case of a major disaster such as fire, tornado, flood, building collapse, etc. The plan should indicate escape routes and assembly areas so that employees may be accounted for. Responsibilities for dealing with every aspect of the emergency should be assigned. Copies of the plan should be given to every employee, reviewed in safety meetings, and posted, as well as provided to local fire and safety officials.

Other Sources of Safety Information

Additional information on safety programs is available from:

- Your insurance carrier
- Industrial Risk Insurers (IRI), Chicago, IL, USA
- Factory Mutual Engineering Corporation (FM): “Handbook of Industrial Loss Prevention,” 2nd Edition, McGraw-Hill Book Company, New York, NY, (1967).
- National Fire Protection Association (NFPA), Boston MA USA
- Industrial Heating Equipment Association (IHEA), Washington DC USA
- Occupational Safety and Health Administration (OSHA) (USA government)
- State or local fire and safety agencies

While some people may regard these agencies as their adversaries, who are to be avoided at all costs, in fact they may become valuable allies and a useful source of information. It is best to begin a cooperative relationship before troubles occur, so that their help can be counted on when it is needed.

Additional Safety References:

ANSI B11.17 Safety Requirements for Construction, Care and Use of Horizontal Hydraulic Extrusion Presses

ANSI B11-TR3 Risk Assessmant and Risk Reduction Technical Report

ANSI B11.19 Performance Criteria for the Safeguarding for Machine Tools

Copies available from AMT – The Association for Manufacturing Technology, 7901 Westpark Drive, McLean VA 22102 USA.

Faassen, J.R., and Teets, R.P., “Extrusion Press Safety,” *Proceedings of 3rd International Aluminum Extrusion Technology Seminar,* Vol. I, (1984), p. 405-406.

prEN 14656 Safety of machinery - Safety requirements for extrusion presses for steel and non-ferrous metals CEN/TC 322. It covers: - extrusion presses from the exit side of the heater through associated handling, cooling and quenching equipment including, e.g., the puller, the hot saw, the run-out table, the stretcher, the cold saw, cold saw table, etc.

Environment

The most pressing environmental issues faced by most extruders tend to arise in the billet foundry, painting plant, or anodizing line, for extruders who have these operations. However, these departments are beyond the scope of this manual, so here we will touch on several of the environmental concerns within the extrusion department.

Oils - Hydraulic. Waste oils and greases in extrusion plant effluent streams are closely regulated in every jurisdiction, and so any oil-bearing streams must be captured and tightly controlled. All extrusion presses leak oil, but it is far more effective and economical to minimize leaks and spills than to capture and separate out the oil in a downstream location. In addition to visible leaks, Ultraviolet light (UVA) may be used to find leaks not otherwise visible. UVA lamps are available at most electrical-supply stores.

Recycling Hydraulic Oil. While most engineers, maintenance people, and equipment suppliers are reluctant to consider using recycled oil in an application so critical as an extrusion press, advancing technology may combine with environmental realities to make recycling necessary in the future. Consider the following information:

"In this day of tighter and tighter environmental regulations, a leaking hydraulic system can become very expensive. Not only do you have to purchase the oil, but now you may have to pay to dispose of it. Hydraulic oil is usually reclaimable. A system can be built or purchased for your own use, or a mobile unit can come and recycle the oil at your site. In either case, a lab is needed to analyze the condition of your oil to see if it is oxidized or if the additive package is intact.

"Many mobile recyclers can add the additive package, or a portion of it, to restore the oil's original properties. Also, viscosity modifiers are available.

"Mobile units are quite reasonable in cost. The latest quote at the time of this writing was for $1.35 per gallon on a press hydraulic oil that cost $2.25 per gallon to purchase. All reclaiming systems work on the same principle. The oil is first heated to 180°F to 200°F (80°C to 90°C) and the gross water is removed by settling or possibly with a centrifuge. Settling will remove down to about 5 to 10 percent water content. A centrifuge will get it down to 2 percent water content. After that, the oil is subjected to a vacuum to get the remaining water out. Most equipment manufacturers recommend no more than 500 parts per million of water. A vacuum can get down to about 250 parts per million. If the amount of water in the oil is very limited, say less than 0.5 percent, a water absorbing filter can be used but the cost of the filter must be watched as they can become very expensive for the amount of water removed. Gross dirt would be removed by the settling tank and the suction strainers for the pumps. Fine dirt can then be removed [by] filtering. Now that you have clean dry oil, the lab work must be done to insure that all of the additive package is present and the viscosity is correct."[8]

Oils - Saw and Billet Lubricants. Because of the development of new lubricant technologies for aluminum sawing and extrusion tooling, the oil and grease effluents from these sources may now be dramatically reduced. See **Chapter 8** for information on sawing, and **Chapter 3** for information on tooling lubricants.

Smoke. Flame-type billet lubricators, as well as other types of flammable lubricants, are being banned or limited in many jurisdictions due to their contribution to air pollution. Combustion-type log and billet heaters, especially oil-fired, must be maintained in top condition and firing on-ratio to minimize the discharge of hydrocarbons and particulates.

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[8] Ferryman, Roger L., "Proper handling of Hydraulic Oil in the Extrusion Press," *Proceedings of 5th International Aluminum Extrusion Technology Seminar,* Vol. II, (1992), p. 583-585.

Chips and Dust. Cyclone-type chip collectors typically have extremely high collection efficiency when fitted with cloth discharge bags. Most problems arise due to inadequate design of the capture hood and ductwork. See **Chapter 8** for references on saw chip capture systems.

Noise. The major sources of noise in the extrusion plant are press hydraulic systems and sawing of profiles. Hydraulic system noise may be abated at the source by locating the pumps and other components in an appropriate enclosure, or, where possible, in a concrete pit below floor level. Hydraulic noise is best addressed when a new press is installed or when major renovations are made to an older one. To minimize saw noise, older saws may be retrofitted with clamps and other devices[9]; however, the ultimate solution is replacement with a new saw of the under-table design.

Quench Water. Water used to quench profiles, either at the press or after solution heat treat furnaces, is subject to overall plant effluent limitations in most jurisdictions, and so must be considered in permit applications. Allowances for such elements as aluminum, zinc, chromium, and cyanide are calculated on the basis of pounds (or kg) of aluminum processed.

Die Cleaning Operations. Removal of aluminum from used dies often is a major source of effluent control problems. Caustic soda (NaOH) burn-out is effective in removing the aluminum but generates a waste stream which is restricted or not permitted at all in some jurisdictions; various proprietary commercial processes are available for treatment. A secondary problem is the generation of caustic fumes (actually aerosol mists) which must be collected at the source and scrubbed in order to avoid atmospheric corrosion within the plant and also discharge to the atmosphere.

In order to minimize the amount of aluminum which must be dissolved, various techniques are used to remove as much metal as possible before burn-out. Some try to strip out as much as possible with the butt shear before the die is removed from service; others remove metal by means of a chipping hammer. More recently, many extruders leave the aluminum in the die as long as it does not require modification or repair while out of service. The dies are stored with the aluminum intact, then reheated sufficiently for the aluminum to be extruded out with the first billet.

Other Atmospheric Pollutants and Surface Pitting. Extruders who produce highly finished products are well aware of the phenomenon of surface pitting. Bright-dipped profiles may display a mottled surface which, on microscopic examination, turns out to be tiny “pits” or cavities in the surface. Such surface pitting is usually found to be the result of tiny specks of particulate or liquid, usually but not always organic. While there is no general agreement as to the mechanism responsible, it is possible that the surface contaminant serves to create an anodic point on the surface, resulting in a form of galvanic corrosion. Episodes of pitting often occur after something has been spray painted within the plant, releasing airborne solvents and paint particles. Another common source is the aerosol mists of hydraulic oils, coming from faulty intake breathers, or from excessive use of lubricants on the press, tooling, or saws.

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[9] Stewart, John S., “Aluminum Extrusion Sawing Noise Reduction,” *Proceedings of 4th International Aluminum Extrusion Technology Seminar,* Vol. II, (1988), p. 423-427.