Delphi Automotive Guarding/Cycle Initiate Methodology

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Delphi Guarding/Cycle Initiate Methodology Team

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Team Approach to Guarding/Cycle Initiate Methods

- **Discussion among team members resulted in the conclusion that there was not ONE solution that could be used for all applications**

- **Team felt that Guarding/Cycle Initiate methods should be tied into the Risk Assessment analysis as defined in the Delphi Design In Health and Safety Specification**

  - **All efforts should be made in the up front equipment mechanical design process to eliminate all hazards associated with the equipment**

  - **This would eliminate need for expensive and complicated guarding methods**

  - **Team felt that if the equipment was classified as a high risk machine, then safety must be given primary consideration and dictate the guarding/cycle initiate method used for the particular process**

- **Team felt the most appropriate approach was to develop a decision tree to assist the Manufacturing Engineer with the selection of the guarding/cycle initiate method for the particular equipment/process**

  - **Decision tree would step the ME through the thought process asking particular details about the equipment/process**

  - **Decision tree would list all feasible options available for a particular application with options listed in order of preference (e.g. least costly and least complicated)**

  - **Decision tree would include a Table describing the option including hardware required, Pro's and Con's of the option, and estimated cost for the controls and mechanical hardware required for implementation of the option.**
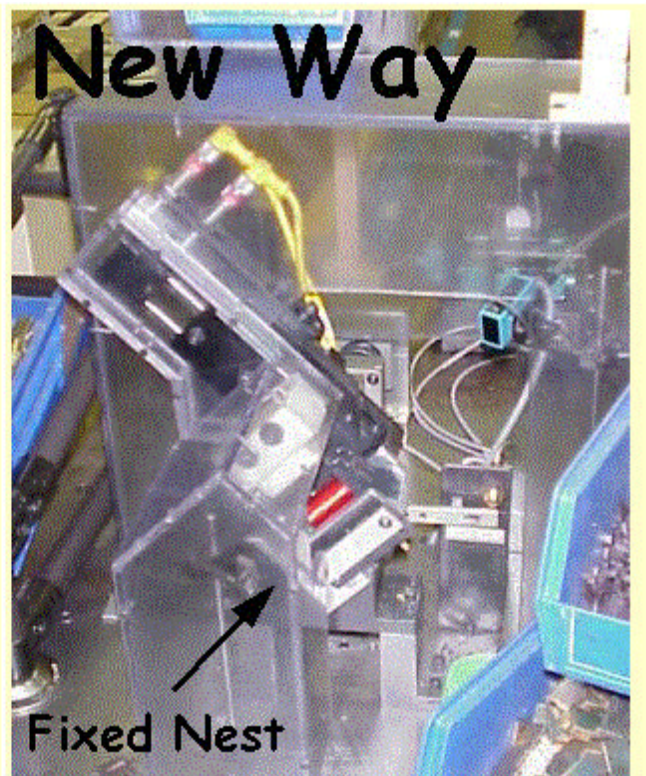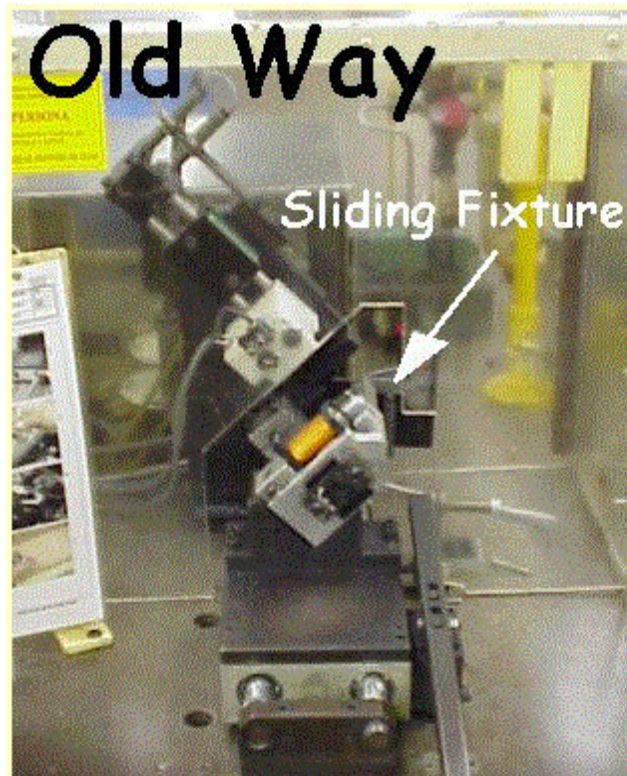
Equipment Guarding/Cycle Initiation Decision Tree

Conduct Risk Assessment for Equipment as defined in Delphi Design In Health and Safety Specification

Have all opportunities been exhausted to mechanically design out the hazard or reduce the hazard to an R1 or R2 risk level? (Review Examples as listed under **Option 1** in associated Table in this document)

No

Yes

Is Operator loading directly to the point of operation?

No → Can part transfer device (e.g. shuttle) be manually pushed into point of operation?

Yes

Yes **No**

Is Hazard at Point of Operation Considered High Risk for severe injury (e.g. R3A, R3B,R4) based on risk assessment?

Use most cost effective method of simple guarding & cycle initiate based on process and reference examples listed under **Option 1** in associated Table in this document

Can operator be safely protected from hazards at point of operation by hard guarding through which the part transfer device passes?

No **Yes** *(At this point, Safety is of primary concern & dictates type of guarding/cycle initiate method)*

No **Yes**

Intricate Guarding not required. Use most cost effective method of simple guarding & cycle initiate based on process and reference examples listed under **Option 1** in associated Table in this document

Does Process Have Potential for Ejection of material toward the Operator?

Implement **Option 2** "Fixed Hard Guarding or Flapper Gate w/ E-stop switch implemented in conjunction w/ a Whisker Switch for cycle initiate"

per Delphi Application Guideline for Safety Circuits

No **Yes**

Does the process allow for all hazardous motions to be immediately returned to home in a safe manner if cycle initiation device/guarding is interrupted during hazardous portion of machine cycle? (e.g. No Quick Stopping Required)

Yes **No**

1. Implement **Option 3** "Two Hand Control Circuit" **or**
2. Implement **Option 4** "Manual Close Door" or " Gravity Drop Door "**or**
3. Implement **Option 5** "Vertical (raise from bottom) or Horizontal Powered Door" **or**
4. Implement **Option 6** "Safety Light Curtain w/ spring return valves"

per Delphi Application Guideline for Safety Circuits

1. Implement **Option 4** "Manual Close Door" or "Gravity Drop Door" **or**
2. Implement **Option 5** "Vertical (raise from bottom) or Horizontal Powered Door" **or**
3. Implement **Option 7** "Safety Light Curtain W/ Mechanical Rod Brakes for all Hazardous Motions"

per Delphi Application Guideline for Safety Circuits

1. Implement **Option 4** "Manual Close Door" or "Gravity Drop Door" **or**
2. Implement **Option 5** "Vertical (raise from bottom) or Horizontal Powered Door"

per Delphi Application Guideline for Safety Circuits

Op #	Option Description	Additional Requirements	Pro and Cons	Controls Cost	Hardware Costs	Machine Time (VA time not included)	Operator Time
		NOTE:	*All option 1 examples have been designed with all hazards eliminated or reduced to Risk Assessment Levels R1 or R2 through effectively removing all pinch points by allowing the part to be the guard, limiting cylinder stroke length so there is no pinch point without the part being in place, or designing so that a finger and the part cannot both fit under the moving part of the equipment.*				
1A	**Load directly to point of operation**, Part presence switch **(PSDI)** initiates cycle **(Great Idea #113)**	Properly designed fixed guarding to eliminate pinch points, part present sensor	(+) Loading to point of operation eliminates non value added (NVA) machine motions (+) PSDI eliminates need for operator reach and cycle initiate motions. (1.2 seconds of operator time) (+) Operator cannot get hands into work area (-) Requires additional hard guarding to make sure all pinch points eliminated which may not be possible in all applications	< $500	$0	Load/unload x sec Initiate Cycle 0 sec	Load/unload x sec Initiate Cycle 0 sec
1B	**Load part just above the point of operation** and let gravity index the part into the pinch point **(Great idea #151 & #153)**	External switch for cycle initiate	(+) Gravity drop tooling eliminates operator loading into pinch points (+) Gravity drop tooling may allow for parts to be loaded while machine is cycling eliminating machine wait time for operator loading of parts. (+) Part acts as a guard eliminating pinch points when loaded in fixture (-) External cycle initiate device required adding operator reach and cycle initiate motions. (1.2 seconds of operator time)	< $500	< $500.00	Load/unload 0 sec Initiate Cycle 1.2 sec	Load/unload x sec Initiate Cycle 0.6 - 1.2sec* *Can be done when walking
1C	**Load to fixture, manual pull head over part**, switch on slide initiates cycle, head spring returns upon release **(Great idea #34)**	Properly designed tooling with appropriate fixed hard guarding, keyed interlock switch for cycle initiation	(+) Allows for direct loading to point of operation w/ no hazards (+) Fixed guarding travels with manual head to protect the pinch points (+) Auto release feature removes non value added content from operator (-) Machine time and operator time added for slide motion (1.2 seconds)	< $500	Slide with spring and detent $2,500	Load/unload 0 sec Initiate Cycle By Pulling Head 1.2 sec	Load/unload 0 sec Initiate Cycle By Pulling Head 1.2 sec
1D	**Load to nest, manually push nest** into point of operation w/**guarding** travelling with nest and **sliding up via a ramp.** **(Great Idea 103)**	Keyed interlock switch for cycle initittation	(+) Requires no powered motion on shuttle eliminating need for motion control. (+) Guard moves out of the way for clear loading, but protects pinch points during cycle of machine (+) Keyed interlock switch starts cycle w/ no external cycle initiate device required (-) Requires operator to manually advance shuttle to start cycle and retract shuttle after machine cycle complete (1.2 seconds).	< $500	Slide $2,500 Ramp/Roller < $500	Load/unload x sec Initiate Cycle By Pushing Nest 1.2 sec	Load/unload x sec Initiate Cycle By Pushing 1.2 sec + .6 sec to pull hand back

Op #	Option Description	Additional Requirements	Pro and Cons	Controls Cost	Hardware Costs	Machine Time (VA time not included)	Operator Time
1E	**Load to nest, manually push nest** into point of operation w/**guarding** travelling with nest and **sliding up via a ramp.** **Nest retracts automatically** after cycle complete	Properly designed movable nest with moving guarding, keyed interlock switch for cycle inititation, valve for auto retract of nest	(+) Guard moves out of the way for clear loading, but protects pinch points during cycle of machine (+) Keyed interlock switch starts cycle w/ no external cycle initiate device required (+) Saves (0.6 seconds) of operator cycle time from option 1D since nest automatically retracts at cycle complete. (-) Requires powered motion to auto retract nest when cycle complete	$800.00	Slide $2,500 Ramp/Roller < $500	Load/unload x sec Initiate Cycle By Pushing Nest 1.2 sec	Load/unload x sec Initiate Cycle By Pushing 1.2 sec
2	**Load to part transfer device,** initiate whisker switch and have transfer device **index through fixed guarding** or with use of **flapper gate**	E-stop switch that does not present pinch point during forward and return stroke of part transfer device, cycle initiate switch, valve for shuttle	(+) Fixed guarding protecting point of operation eliminates need for added door or light screen for operator protection from point of op (+) Part transfer device prevents operator from placing hands directly into point of operation, but adds cost mechanically (-) Part transfer will add machine cycle time for advance and retract motion (0.5 to 2.0 seconds) (-) External cycle initiate device required adding operator reach and cycle initiate motions. (1.2 seconds of operator time which may be done in parallel with walking to next process).	$500	Dial $7,500 or Powered Slide $1,500 Flapper Door < $500	Load/unload x sec + index for slide 0 sec + index for dial Initiate Cycle 0 sec	Load/unload x sec Initiate Cycle 0.6 to 1.2 sec* *Can be done when walking
3	**Load directly to point of operation,** initiate cycle via **two hand anti tie down circuit**	Safety relay, Low Force actuation devices, two single solenoid valves in series	(+) Forces operator clear of hazards during hazardous potion of cycle (+) Eliminates need for light screen $ or extra motions of door (-) External cycle initiate device required adding operator reach and cycle initiate motions. (1.2 seconds of operator time) (-) Additional cycle time required for operator to remain at machine until pinch point eliminated (1.0 to 2.0 seconds) (-) Cannot be used if potential for ejection of material exists (-) Two hand cycle initiate may disrupt operator flow	$1,000	$0	Load/unload x sec Initiate Cycle 1.2 sec	Load/unload x sec Initiate Cycle 1.2 sec Wait 1-2 sec for hazard to be gone

Op #	Option Description	Additional Requirements	Pro and Cons	Controls Cost	Hardware Costs	Machine Time (VA time not included)	Operator Time
4A	**Manually Close Door** and Also **Manually Open Door** when cycle complete. *NOTE: Requirement to manually opening door makes this a low probability option*	Door, Keyed interlock Door Switch, Safety Relay *NOTE: cycle initiated when door closed switch is actuated.*	(+) Provides barrier protection between operator and point of Op (+) Door allows operator to be closer to point of operation (+) Manual Open/Close Door saves on fluid power circuitry (+) Manually closing door will auto start cycle w/no external initiate device required (-) Manual closing of door required adding operator reach and cycle initiate motions. (1.2 seconds of operator time). (-) Manually opening door adds to cycle time since operator needs to be at machine to open door prior to loading next part. (1- 2 secs) (-) Disruption in cell flow as operator needs to open door. (-) Doors must be added to preventive maintenance list for machine (-) Vertical door requires counterbalance system to keep door up	$1,500	Manual Door $1,000	Load/unload x sec Initiate Cycle By Closing Door 1.2 sec Machine Wait 1.2 sec for door opening motion	Load/unload x sec Initiate Cycle By Closing Door 1.2 sec Other Operator 1.2 sec for opening door
4B	**Manually Close Door. Door opens automatically** when cycle complete. *NOTE: cycle initiated when door closed switch actuated.*	Door, Keyed interlock Door Switch, Safety Relay, valve for door	(+) Provides barrier protection between operator and point of op (+) Door allows operator to be closer to point of operation (+) Auto opening door saves cycle time when compared to option 4A since operator does not have to open door prior to loading next part. (1 to 2 sec) (+) Manually closing door will auto start cycle w/no external initiate device required (-) Manual closing of door required adding operator reach and cycle initiate motions. (1.2 seconds of operator time). (-) Doors must be added to preventive maintenance list for machine (-) Vertical door requires counterbalance system to keep door up	$1,800	Manual Door $1,000 Cylinder to Open $250	Load/unload x sec Initiate Cycle By Closing Door 1.2 sec Machine Wait 1-2 sec for door opening motion	Load/unload x sec Initiate Cycle By Closing Door 1.2 sec
4C.	**Gravity drop door** with **whisker switch** for initiate. **(Great Idea #037)**	Door, Keyed interlock Door switch, safety relay, whisker switch, valve for door	(+) Door provides barrier protection between operator and point of operation (+) Door allows operator to be closer to point of operation (+) Whisker switch provides positive action from operator to initiate cycle (-) External cycle initiate device required adding operator reach and cycle initiate motions. (-) Door motion adds 1.0 to 2.0 seconds to equipment cycle time (-) Recommended for equipment less than 30 inches in width (-) Doors must be added to preventive maintenance list for machine	$2,000	Door $1,000 Cylinder $250	Load/unload x sec Initiate Cycle 1.2 sec Machine Wait 1-2 sec for door to open 1-2 sec for door to close	Load/unload x sec Initiate Cycle 0.6 - 1.2 sec* *Can be done when walking

Op #	Option Description	Additional Requirements	Pro and Cons	Controls Cost	Hardware Costs	Machine Time (VA time not included)	Operator Time
4D	**Gravity drop door** with **beam array as PSDI** cycle initiate and additional sensors for part detection	Door, keyed interlock Door switch, safety relay, beam array, valve for door	(+) Provides barrier protection between operator and point of oper. (+) Door allows operator to be closer to point of operation (+) Machine will automatically cycle when operator clears PSDI unit saving operator reach and cycle initiate motions (1.2 seconds). (+) PSDI is good solution for constraint, quick cycle (1) man dedicated mach. (+) PSDI is good solution for processes where operator has no hand free to actuate external cycle initiate device (-) PSDI requires potentially multiple switches to sense parts (-) Door motion adds 1.0 to 2.0 seconds to equipment cycle time (-) Recommended for equipment less than 30 inches in width (-) Doors must be added to preventive maintenance list for machine	$2,500-$3,000	Door $1,000 Cylinder $250	Load/unload x sec Initiate Cycle 0 sec Machine Wait 1-2 sec for door to open 1-2 sec for door to close	Load/unload x sec Initiate Cycle 0 sec
5A	**Fully powered**, Vertical (Raise from Bottom) or Horizontal **Door** with **Whisker switch** for cycle initiation	Door, Keyed interlock Door switch, safety relay, whisker switch, valve for door	(+) Provides barrier protection between operator and point of oper. (+) Door allows operator to be closer to point of operation (+) Door Switch provides positive action from operator to initiate cycle (+) Normally, door is down and out of way providing clear access (+) Can be installed in applications where equipment width greater than 30 in. (-) External cycle initiate device required adding operator reach and cycle initiate motions. (-) Door motion adds 1.0 to 2.0 seconds to equipment cycle time (-) Need to verify that vertical powered door does create hazard in upward motion or install electrical bumper strip on door (-) Doors must be added to preventive maintenance list for machine (-) May require installation of electrical bumper strip on horiz. door	$2,000	Door $1,000 - $2,000 Cylinder $250	Load/unload x sec Initiate Cycle 1.2 sec Machine Wait 1-2 sec for door to open 1-2 sec for door to close	Load/unload x sec Initiate Cycle 0.6 - 1.2 sec* *Can be done when walking
5B	**Fully powered,** Vertical (Raise from Bottom) or Horizontal **Door** with **beam array as PSDI** cycle initiate and additional sensors for part detection	Door, Keyed interlock Door switch, safety relay, beam array, valve for door	(+) Provides barrier protection between operator and point of oper. (+) Door allows operator to be closer to point of operation (+) PSDI requires no positive action from oper. to initiate cycle (+) Normally, door is down and out of way providing clear access (+) Good solution in applications where equipment width greater than 30 in. (+) Machine will automatically cycle when operator clears PSDI unit saving operator reach and cycle initiate motions (1.2 seconds). (+) PSDI is good solution for constraint, quick cycle (1) man dedicated mach **(continued on next page)**	$2,500-$3,000	Door $1,000 - $2,000	Load/unload x sec Initiate Cycle 0 sec Machine Wait 1-2 sec for door to open 1-2 sec for door to close	Load/unload x sec Initiate Cycle 0 sec

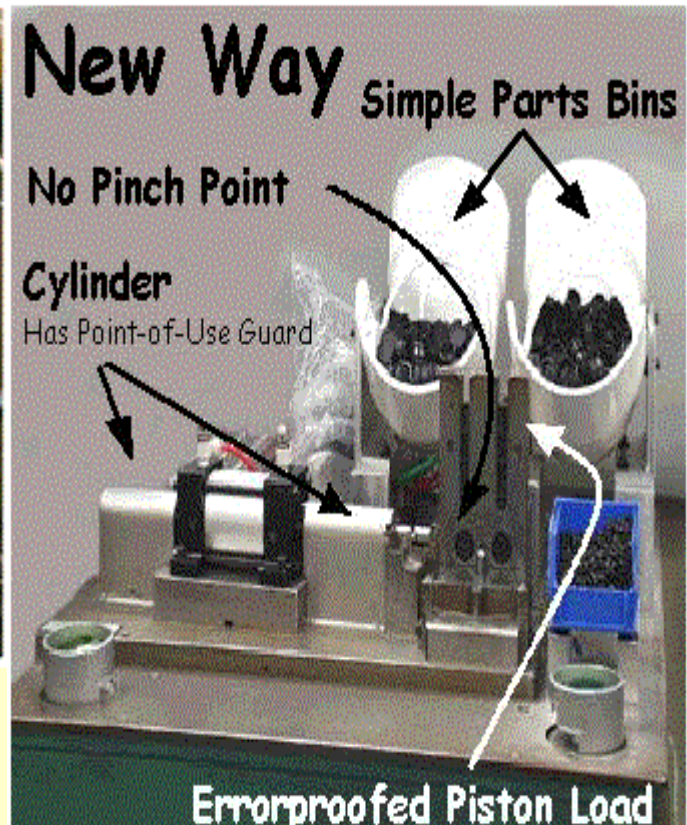| Op #	Option Description	Additional Requirements	Pro and Cons	Controls Cost	Hardware Costs	Machine Time (VA time not included)	Operator Time
5B (cont'd)	**Fully powered,** Vertical (Raise from Bottom) or Horizontal **Door** with **beam array as PSDI** cycle initiate and additional sensors for part detection	Door, Keyed interlock Door switch, safety relay, beam array, valve for door	**(continued from previous page)** (+) PSDI is good solution for processes where operator has no hand free to actuate external cycle initiate device (-) PSDI requires potentially multiple switches to sense parts (-) Door motion adds 1.0 to 2.0 seconds to equipment cycle time (-) Need to verify that Vertical door does not create hazard in upward motion or install electrical bumper strip on door (-) Doors must be added to preventive maintenance list for machine (-) May require installation of electrical bumper strip on horiz. door				
6	**Light Curtain** with **single solenoid spring return valve**s and **whisker switch** for cycle initiation	Light Curtain, Safety Relay, two single solenoid valves in series, whisker switch cycle initiation device	(+) Provides for potentially more open machine (+) No moving parts for guarding (+) Light curtain good application when operator required to enter machine multiple times during single cycle of machine (-) Very Costly to implement (additional 2500.00 for light curtain) (-) Requires operator to be farther away from point of operation than doors adding to operator reach time to load/unload parts (1.2 sec) (-) External cycle initiate device required adding operator reach and cycle initiate motions. (-) Can inhibit part presentation (-) Can interrupt operator work path in the cell	$3,500	$0	Load/unload x sec + 1.2 sec per part for added reach Initiate Cycle 1.2 sec	Load/unload x sec +1.2 sec per part for added reach Initiate Cycle 0.6 - 1.2sec* *Can be done when walking
7	**Light Curtain w/ Mechanical Rod Brakes** for hazardous motions loading to point of operation and quick stopping required with **whisker switch** for cycle initiation	Safety Relay, Mechanical Rod Brakes (2-3 motions typical), Additional valving for rod brakes.	(+) No Moving Parts for guarding (+) Potentially more open machine (+) Light curtain good application when operator required to enter machine multiple times during single cycle of machine (-) Extremely more expensive to implement (-) Requires operator to be farther away from point of operation than doors adding to operator reach time to load/unload parts (1.2 sec) (-) External cycle initiate device required adding operator reach and cycle initiate motions. (-) Very technical solution for quick stopping complicating equip. (-) Can inhibit part presentation and increase operator reach (-) Can interrupt operator work path in the cell	$6,000	$0	Load/unload x sec + 1.2 sec per part for added reach Initiate Cycle 1.2 sec	Load/unload x sec +1.2 sec per part for added reach Initiate Cycle 0.6 - 1.2sec* *Can be done when walking

Old Way

Sliding Fixture

New Way

Fixed Nest

Great Idea #113 (Load directly to fixed nest w/hard guarding for protection)

Pistons (bowl fed)

CAUTION — EQUIPMENT STARTS AUTOMATICALLY

CAUTION — DO NOT RUN MACHINE WITHOUT GUARDS

BeSafe

Feed tube for Vents

Body Sits Here

Light Curtains

BeSafe

Shuttle Motion

Old Way

New Way

No Pinch Point

Simple Parts Bins

Cylinder
Has Point-of-Use Guard

Errorproofed Piston Load

Parts Bins: see also GI #152
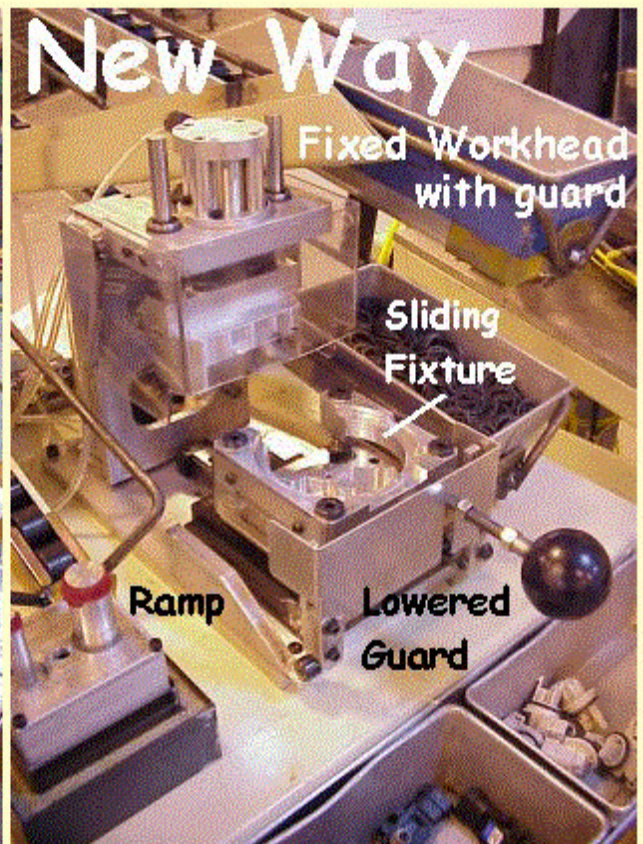No Pinch Point Load: see also GI #153

Great Idea #151 (Keep-It-Simple Saves on Assembly Station)
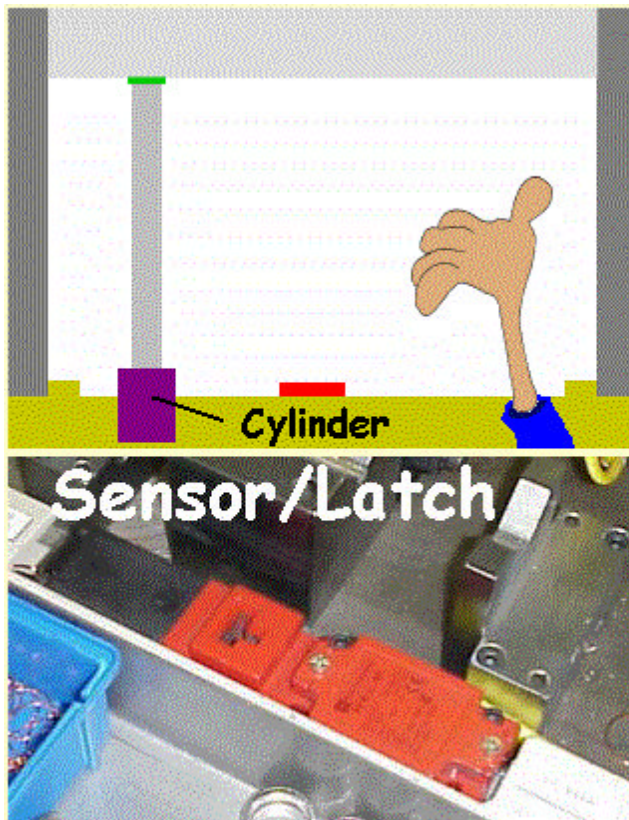
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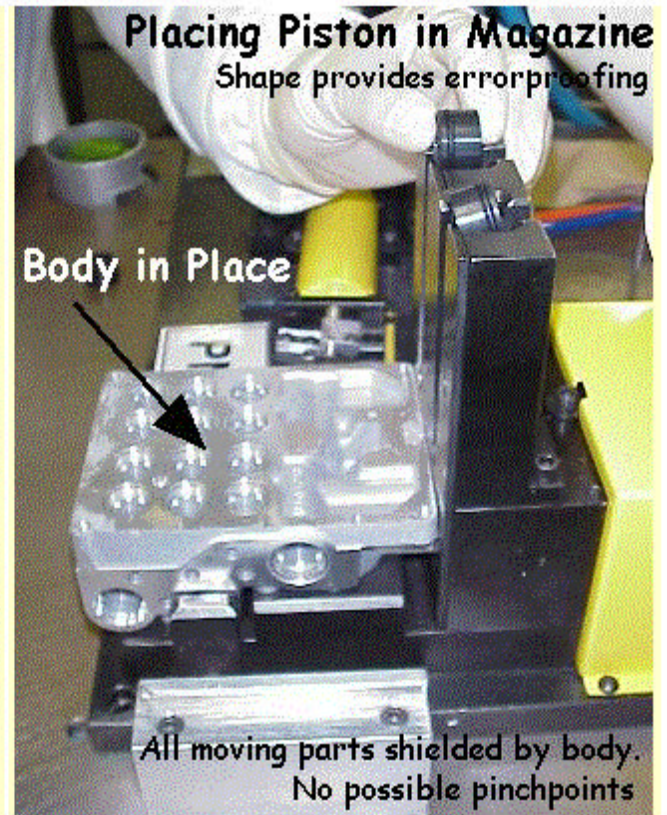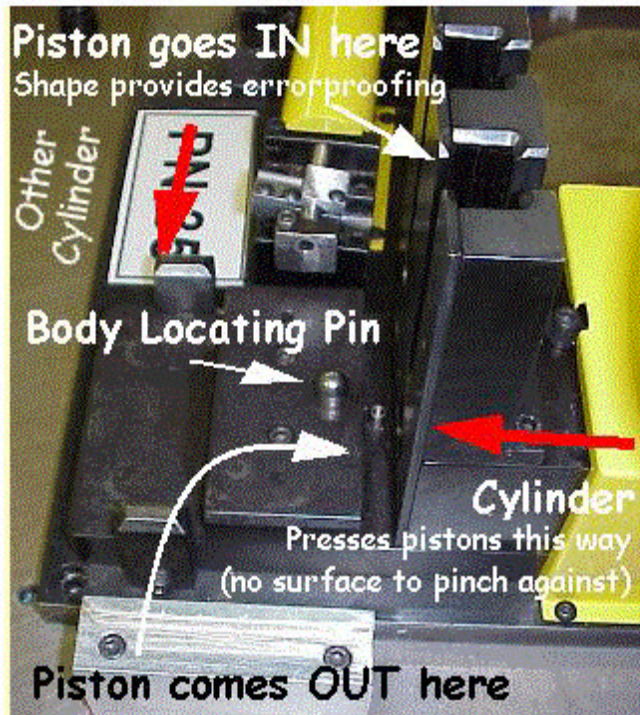
Great Idea #153 (Insert parts above nest and let gravity feed)
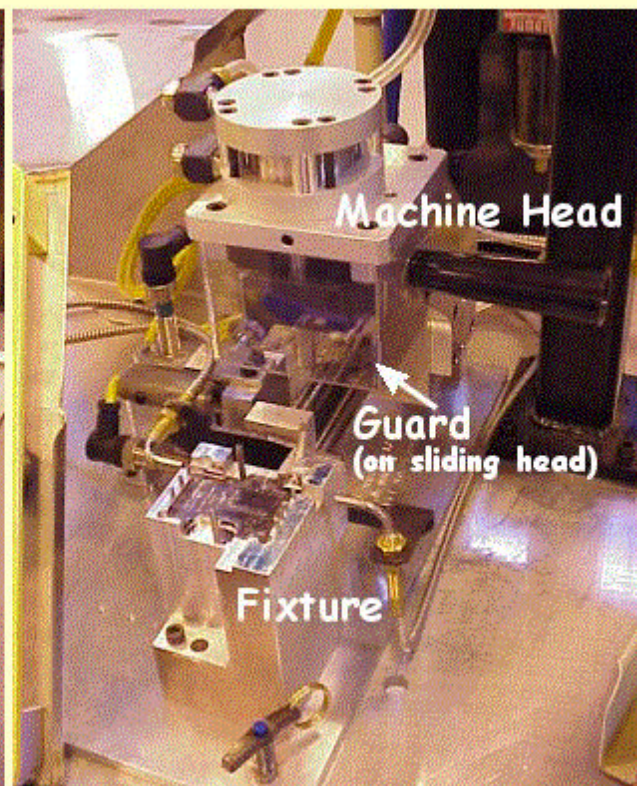
Great Idea #034 (Load fixture and manually pull head over fixture)

Great Idea #103 (Pivoting guard on manual shuttle)

Great Idea #037 (Gravity drop door w/whisker switch for cycle initiate)