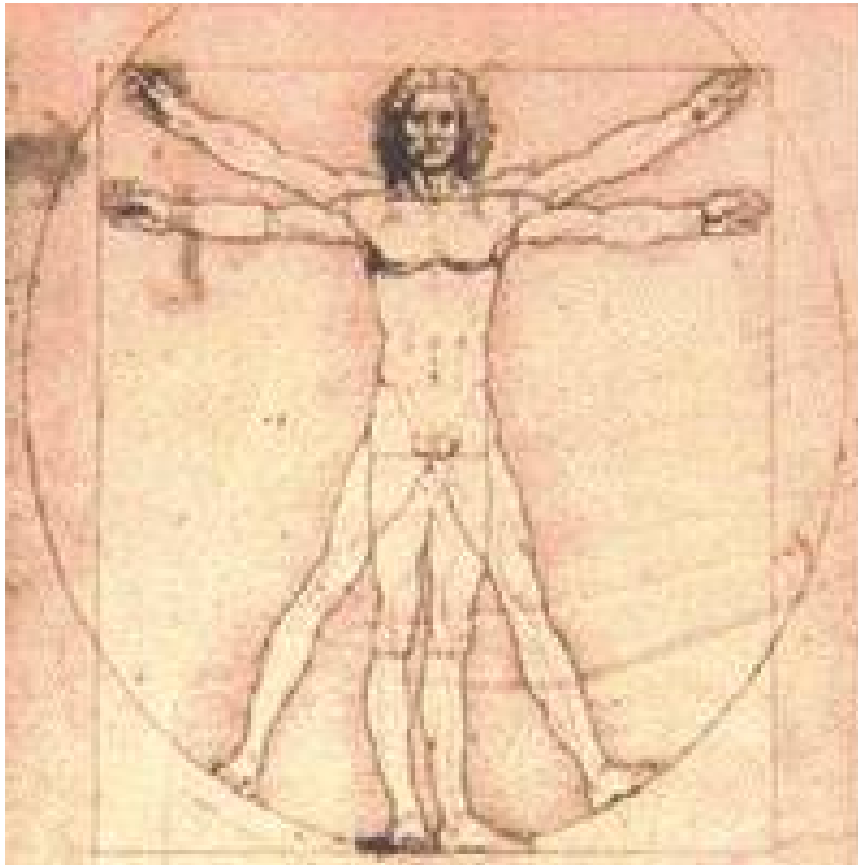



Human Error & Error Proofing



John Montague



Human Error


- 
- To err is human.
 - To prevent is process.

Human Error



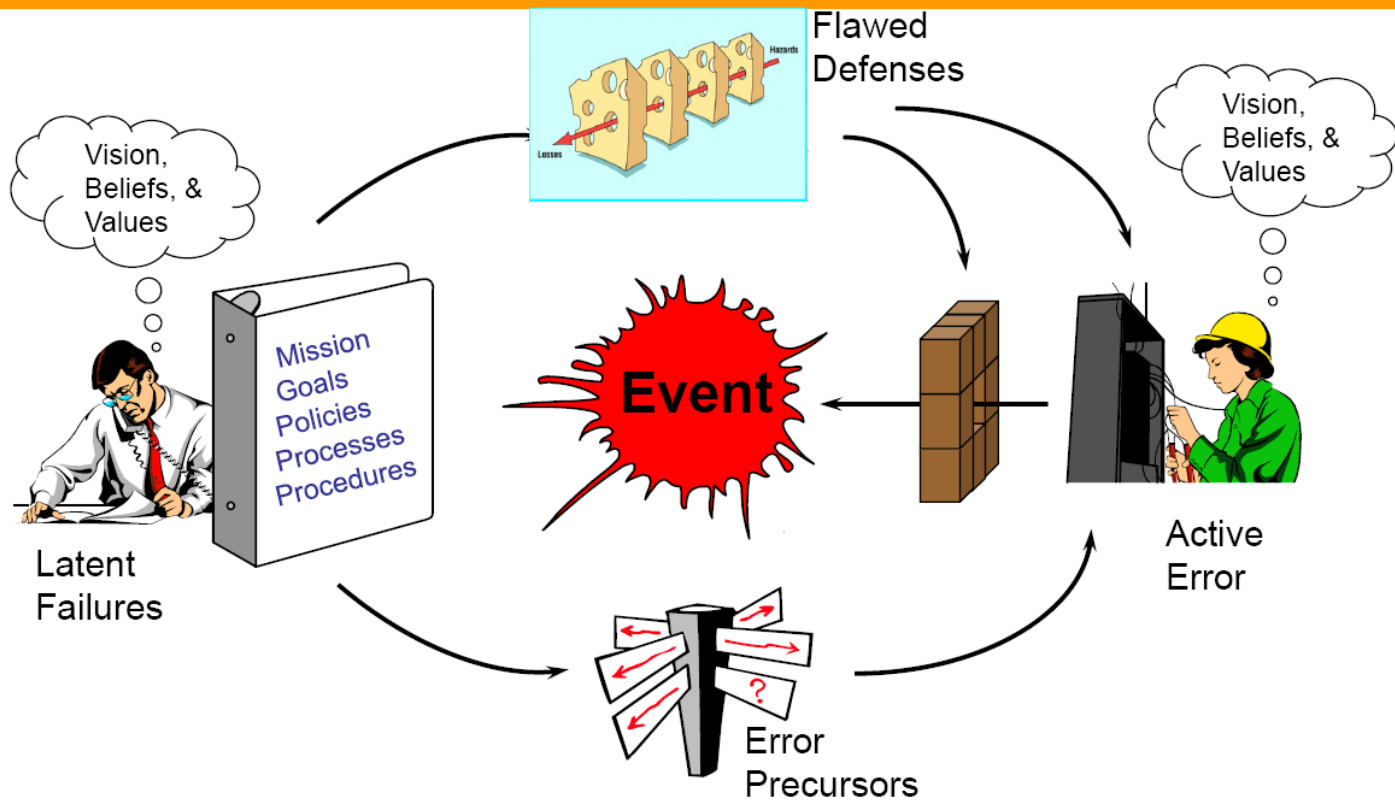


Human Error



Where do errors come from and how do they occur?

Human Error



Human Error

Types of human errors

Active Errors



Latent Errors






Human Error



Types of Human Mistakes

- 1. Forgetfulness**
 - 2. Misunderstanding**
 - 3. Wrong Identification**
 - 4. Lack of knowledge & experience**
 - 5. Willful (ignoring rules or standard procedure)**
 - 6. Lack of attention – sloppiness**
 - 7. Boredom – Lack of engagement**
 - 8. Lack of standard work process or poorly written**
- 



Human Error



- 9. Distracted by surprise event**
- 10. Intentional (sabotage)**
- 11. Poor verbal communication & listening**
- 12. Doing many things at once**
- 13. Sleepy or fatigued**
- 14. Proceeding when uncertainty exists**
- 15. Low probability paradox – believing nothing can go wrong, proceeding is risk free**
- 16. Failure to verify results**
- 17. In a hurry**



Human Error



1. Humans are fallible

- Under normal conditions, humans make an average of **5-7** errors per hour
- Under stressful/emergency/unusual conditions, humans make an average of **11-15** errors per hour

Human Error

- **The brain has limited attention resources**

- We can concentrate on, at most, **2-3** things simultaneously



- **The brain has a limited working memory**

- Most people can reliably remember **3-4** items at a time (**5-7** upper limit)



Human Error

2. Error is Predictable

Error (Provoking Factors) Precursors

- Team Beliefs
- Poor Communication
- Memory Lapses
- Errors in Habit
- Mistaken Assumptions
- Inexperience

- Shift Turnover
- Time Pressure
- Hazard Awareness
- Documentation
- Unsuitable Tools
- Etc.



Human Error

- 
- How to find error sources.

Human Error




**“Say... What’s a mountain goat
doing way up here in a cloud
bank?”**



Human Error



The 6 Principles of Human Performance:

- Humans are fallible
 - Error is predictable
 - Organizations influence behavior
 - Behaviors are reinforced by the organization
 - Events are avoidable
 - To drift is human
- 



Human Error

Error-prevention Tools


- **Self-checking**
- **Peer-checking**
- **Concurrent verification**
- **Independent verification**
- **Three-way communication & Phonetic Alphabet**
- **Stop and Collaborate**
- **Situational awareness**



Human Error



Error-prevention Tools

- **Place-keeping (marking steps)**
 - **Briefings (Pre, Post, & Job Site Tool Box Huddle)**
 - **Problem-solving**
 - **Procedure use & adherence**
 - **Questioning attitude**
 - **Devils Advocate**
- 

Human Error

Task Demands	Individual Capabilities
<ul style="list-style-type: none"> Time pressure (In a hurry) 	<ul style="list-style-type: none"> Unfamiliarity w/ task / First time
<ul style="list-style-type: none"> High Workload (high memory requirements) 	<ul style="list-style-type: none"> Lack of knowledge (mental model)
<ul style="list-style-type: none"> Simultaneous, multiple tasks 	<ul style="list-style-type: none"> New technique not used before
<ul style="list-style-type: none"> Repetitive actions / Monotony 	<ul style="list-style-type: none"> Imprecise communication habits
<ul style="list-style-type: none"> Irrecoverable acts 	<ul style="list-style-type: none"> Lack of proficiency / Inexperience
<ul style="list-style-type: none"> Interpretation requirements 	<ul style="list-style-type: none"> Indistinct problem-solving skills
<ul style="list-style-type: none"> Unclear goals, roles, & responsibilities 	<ul style="list-style-type: none"> "Unsafe" attitude for critical tasks
<ul style="list-style-type: none"> Lack of or unclear standards 	<ul style="list-style-type: none"> Illness / Fatigue
Work Environment	Human Nature
<ul style="list-style-type: none"> Distractions / Interruptions 	<ul style="list-style-type: none"> Stress
<ul style="list-style-type: none"> Changes / Departures from routine 	<ul style="list-style-type: none"> Habit patterns
<ul style="list-style-type: none"> Confusing displays or controls 	<ul style="list-style-type: none"> Assumptions
<ul style="list-style-type: none"> Workarounds / Out of service instruments 	<ul style="list-style-type: none"> Complacency / Overconfidence
<ul style="list-style-type: none"> Hidden system response 	<ul style="list-style-type: none"> Mind-set
<ul style="list-style-type: none"> Unexpected equipment conditions 	<ul style="list-style-type: none"> Inaccurate risk perception
<ul style="list-style-type: none"> Lack of alternative indication 	<ul style="list-style-type: none"> Mental shortcuts (biases)
<ul style="list-style-type: none"> Personality conflicts 	<ul style="list-style-type: none"> Limited short-term memory



Human Error

What is error proofing?


Mistake proofing, or its Japanese equivalent poka-yoke (pronounced PO-ka yo-KAY), is the use of any automatic device or method that either makes it impossible for an error to occur or makes the error immediately obvious once it has occurred.



Human Error



When to Use Error Proofing

- **When a process step has been identified where human error can cause mistakes or defects to occur, especially in processes that rely on the worker's attention, skill or experience.**
 - **In a service process, where the customer can make an error which affects the output.**
 - **At a hand-off step in a process, when output or (for service processes) the customer is transferred to another worker.**
 - **When a minor error early in the process causes major problems later in the process.**
 - **When the consequences of an error are expensive or dangerous.**
- 



Human Error



Error-Proofing Procedure

1. Obtain or create a flowchart of the process. Review each step, thinking about where and when human errors are likely to occur.
2. For each potential error, work back through the process to find its source.
3. For each error, think of potential ways to make it impossible for the error to occur. Consider:
 - !Elimination—eliminating the step that causes the error.
 - !Replacement—replacing the step with an error-proof one.
 - !Facilitation—making the correct action far easier than the error.



Human Error

4. If you cannot make it impossible for the error to occur, think of ways to detect the error and minimize its effects. Consider inspection method, setting function and regulatory function.
5. Choose the best mistake-proofing method or device for each error. Test it, then implement it.



Human Error



Six Error-proofing Principles or Methods

1. **Elimination:** This method eliminates the possibility of error by redesigning the product or process so that the task or part is no longer necessary.

Example: product simplification or part consolidation that avoids a part defect or assembly error in the first place.

2. **Replacement:** To improve reliability, simply substitute an unpredictable process with a more reliable process.

Examples: Use of robotics or automation that prevents a manual assembly error; automatic dispensers or applicators to insure the correct amount of a material such as an adhesive is applied.

3. **Prevention:** Design engineers should design the product or process so that it is impossible to make a mistake at all.

Examples: Part features that only allow assembly the correct way; unique connectors to avoid misconnecting wire harnesses or cables; part symmetry that avoids incorrect insertion.



Human Error



Six Error-proofing Principles or Methods

4. **Facilitation:** Utilizing specific methods and grouping steps will make the assembly process easier to perform.

Examples: Visual controls that include color-coding, marking or labeling of parts; a staging bin that provides a visual control that all parts were assembled; locating features on parts.

5. **Detection:** Errors are detected before they move to the next processing step so that the user can quickly correct the problem.

Examples: Sensors in the production process to identify when parts are incorrectly assembled.

6. **Mitigation:** The principle of attempting to decrease the effects of errors.

Examples: Fuses to prevent overloading circuits resulting from shorts; products designed with low-cost, simple rework procedures when an error is discovered.



Human Error

- 
- Tools of the trade.



Human Error




1. Has this activity been previously performed?
2. What are the critical steps or phases of this activity?
3. How can we make a mistake at a *critical step*?
4. What could go wrong with the facility, the environment, the equipment, or personnel?
5. What barriers or defenses are needed or are in place?



Human Error



Techniques for error proofing


- Task Preview
 - Encourage a Questioning Attitude
 - Stop When Unsure
 - Self-checking
 - Procedure use and adherence
 - Three-way communication
 - Phonetic alphabet
- 



Human Error



Techniques for error proofing.

- Technical solutions and procedure/process based
 - Identify potential for error and assess risk
 - Develop reliable processes
 - Adopt and promote best practices
 - Provide complete information
 - Evaluate personnel competence and qualifications needed
 - Providing adequate training
 - Examine all risk influencing factors
- 

Human Error

TABLE 1 Internal Performance Shaping Factors

Training/skill	Emotional state
Practice/experience	Gender
Knowledge of required performance standards	Physical condition/health
Stress: mental or bodily tension	Influences of family and other outside persons or agencies
Intelligence	Group identifications
Motivation/work attitude	Culture
Personality	

Source: A.D. Swain and H.E. Guttman, *Handbook of Human Reliability Analysis With Emphasis on Nuclear Power Plant Applications* (Washington, DC: U.S. Nuclear Regulatory Commission, 1985).

Human Error

TABLE 2 External Performance Shaping Factors

Situational characteristics	Task, equipment and procedural characteristics
Architectural features	Procedures: written or not written
Environment: temperature, humidity, air quality, lighting, noise, vibration or general cleanliness	Written or oral communications
Work hours/work breaks	Cautions and warnings
Shift rotation	Work methods/practices
Availability/adequacy of special equipment, tools or supplies	Dynamic vs. step-by-step activities
Staffing levels	Team structure and communication
Organizational structure: authority, responsibility or communication channels	Perceptual requirements
Actions by supervisors, co-workers or accreditation and regulatory personnel	Physical requirements: speed and strength
Facility policies	Anticipatory requirements
	Interpretation/decision making
	Complexity: information load
	Long- and short-term memory load
	Calculational requirements
	Feedback: knowledge of results
	Hardware interface factors: design of control equipment, test equipment, process equipment, job aids or tools
	Control-display relationships
	Task criticality
	Frequency/repetitiveness

Source: A.D. Swain and H.E. Guttman, *Handbook of Human Reliability Analysis With Emphasis on Nuclear Power Plant Applications* (Washington, DC: U.S. Nuclear Regulatory Commission, 1985).

Human Error

TABLE 3

Psychological and Physiological Stressors

Psychological stressors	Physiological stressors
Suddenness of onset	Long duration of stress
High task speed	Fatigue
Heavy task load	Pain or discomfort
High jeopardy risk	Hunger or thirst
Threats of failure or loss of job	Temperature extremes
Monotonous, degrading or meaningless work	Radiation
Long, uneventful vigilance periods	Exposure to diseases
Conflicting motives about job performance	Vibration
Negative reinforcement	Movement constriction
Sensory deprivation	Movement repetition
Distractions: noise, glare or movement	Lack of physical exercise
Inconsistent cueing	Disruption of circadian rhythm
Lack of rewards, recognition or benefits	

Source: A.D. Swain and H.E. Guttman, *Handbook of Human Reliability Analysis With Emphasis on Nuclear Power Plant Applications* (Washington, DC: U.S. Nuclear Regulatory Commission, 1985).

Human Error

TABLE 4 When To Use a Self-Checking Technique

1. Are you unsure about the intent of the steps or the task or performance standards?	6. Is this a routine or boring, but critical task?
2. Are you confused or do you sense something is not right?	7. Can you clearly see and identify the equipment you are working on?
3. Has the task been interrupted, causing you to begin the task again, or is it a departure from a well-established routine?	8. Do you have insufficient indication of system or component status?
4. Have you received verbal instructions on performing the task?	9. Have you had an unexpected encounter with a system, system interlock or system alarm?
5. Are you hurried or performing several tasks simultaneously?	10. Are you fatigued?

Human Error

Condoned behavior or willful violation?



Human Error Applications & Examples

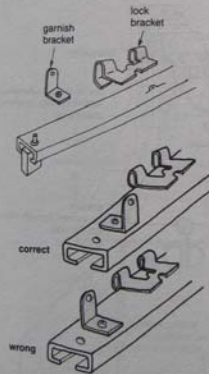
• Example 71

Process: Mounting brackets Prevent Error: Shutdown:
Problem: Brackets mounted in the wrong direction Detect Error: X Control: X
Solution: Detector to prevent further processing when brackets mounted backwards Alarm:
Key Improvement: Jig modified to detect defective parts

Description of Process: Brackets were spot-welded to bars.

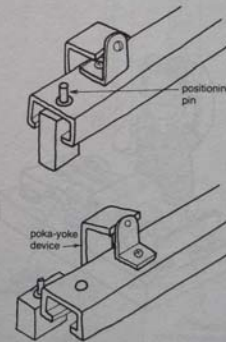
Before Improvement:

The brackets were sometimes attached to the bars backwards. If these pieces were not detected, they would be assembled, leading to defects that had to be reworked later.



After Improvement:

A poka-yoke angle iron was installed on the jig for the next process to detect bars with brackets mounted backwards by keeping them from seating on the jig.



Human Error

Applications & Examples

• Example 124

Process: Milling

Prevent Error: X

Shutdown: X

Problem: Workpieces fly off if they are not fastened down

Detect Error:

Control:

Solution: Detect when pieces are not fastened down

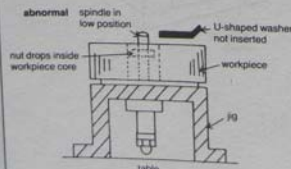
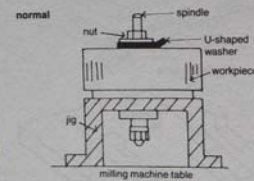
Alarm:

Key Improvement: Tool modified to protect operator from danger

Description of Process: Workpieces to be milled are set onto a spindle and fastened by inserting a U-shaped washer and turning a nut. The workpieces are then processed by the milling machine.

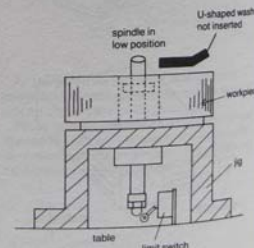
Before Improvement:

It was possible to operate the milling machine even if the U-shaped washer was not inserted to clamp down the workpiece. For quick changeover, the nut was smaller than the core of the workpiece and this resulted in a dangerous situation because the workpiece could fly off the spindle during processing.



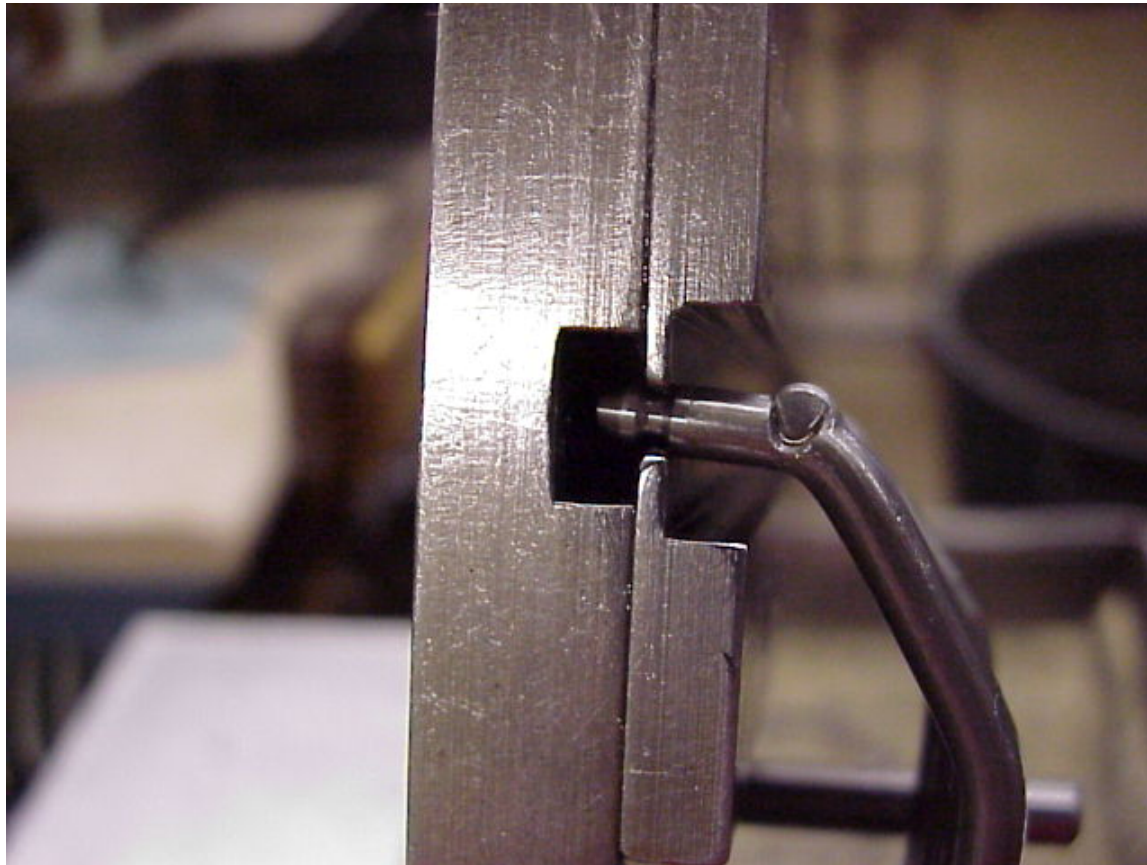
After Improvement:

If the workpiece is not clamped with the U-shaped washer, the nut and spindle drop down far below the normal operating position. A limit switch, interlocked with the milling machine power switch, was installed below the spindle to detect this condition. The milling machine can no longer be turned on if the U-shaped washer is not installed.



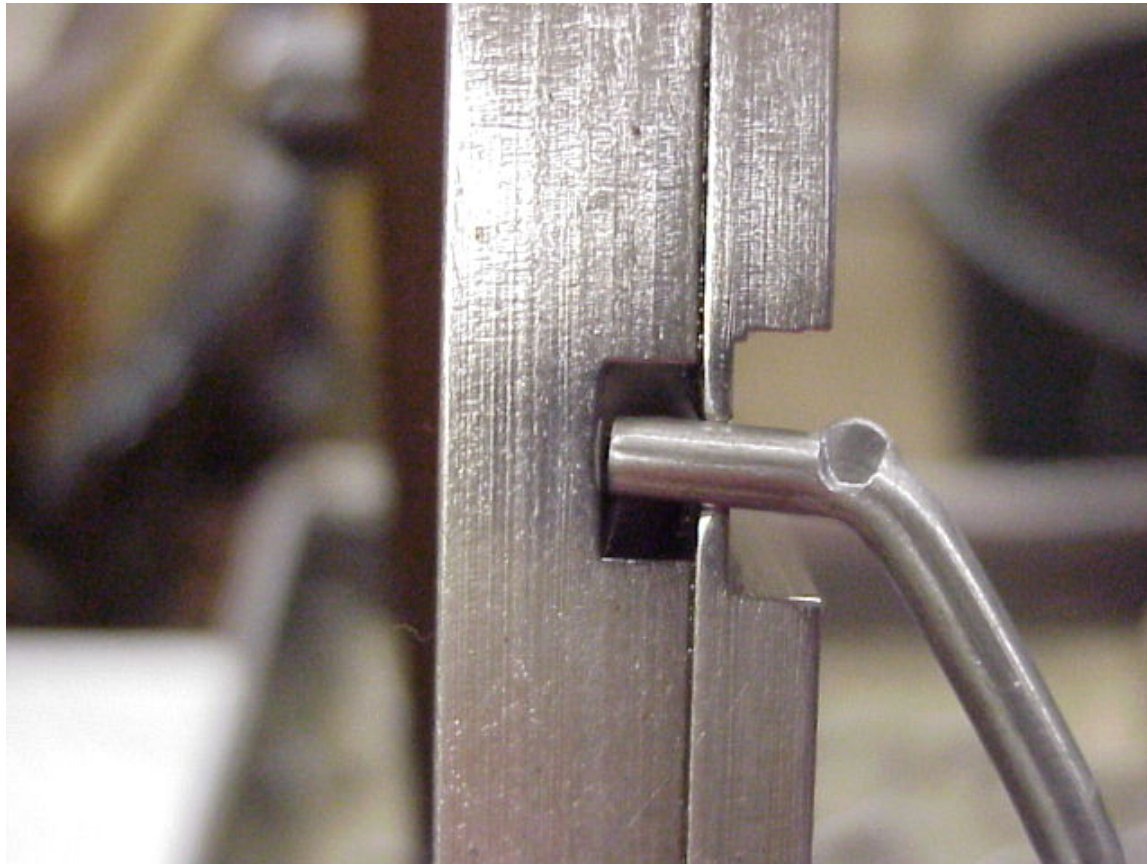
Human Error

Applications & Examples



Human Error

Applications & Examples



Human Error

Applications & Examples






Human Error



Some Common & Everyday examples.

- Automobile Lighting
 - Car Gas Caps
 - Lawn and Machine guards
 - Limit and Control Interruptions
 - Circuit breaker
 - Time Controls to Tune Off Appliances
 - Automobile Brake Interlock
 - Vehicle Brake Pad Warning
 - Automobile Low Fuel Warning
- 

Human Error

Applications & Examples



Human Error

Applications & Examples



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Human Error Applications & Examples



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Human Error

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