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SAFETY BRIEF

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The Principle of Uniform Safety*

by Ralph L. Barnett†

I. Abstract

THE GENERIC WIFE–

"Are you insane? If you invite Abacrombi Phafufnik to the wedding, you must invite all other third cousins or you'll offend them."

This expression of the Principle of Uniformity is generalized and focused on safety issues. Product designs which do not treat dangers uniformly, often cause human errors which arise from inductive inference and generalization of experience.

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II. THE PROBLEM OF INDUCTION

A. Inference

Inference is the act of deriving knowledge by reasoning which involves either deduction or induction. Inferences based on deduction are always correct. On the other hand, inferences based on induction, however logical, may not be true. This is the problem of induction; indeed, it is the central issue addressed by the Principle of Uniform Safety.

It is impossible to overstate the role of personal vigilance in the prevention of accidents. Compromising personal vigilance with false knowledge obtained through induction simply cannot be tolerated. To focus properly on inductive reasoning, we begin with a brief account of deduction for contrast and completeness.

B. Deduction

> *"All dogs are mortal. Sherman* is a dog, therefore Sherman is mortal."*

This example of deduction illustrates the general characteristic of reasoning from a general truth to a particular instance of the truth. In the more general sense, deduction is any process of reasoning by which one draws conclusions from principles or information already known. A valid deductive argument is one where the truth of its premises guarantees the truth of its conclusion; in some sense the conclusion is already contained in the premises. Consider the following:

Mathematical Example

A is smaller than B. [A < B]
B is smaller than C. [B < C]
Therefore A is smaller than C.
[A < B < C ∴ A < C]

An identical deductive inference is provided by a set of logical Chinese boxes called a sorites; "whom he did predestinate, them he also called; and whom he called, them he also justified; and whom he justified, them he also glorified."[1]

Three Men Facing A Wall

Three blindfolded men stand in a queue facing a wall. Each wears a hat taken from a bin containing three tan hats and two black ones. Given this information, the blindfolds are removed allowing the men only to see forward. When asked what color hat he is wearing, the man farthest from the wall declares, "I do not know which color hat I am wearing." The second man from the wall hears the reply, sees the man in the hat in front of him and replies in the same way. The man closest to the wall who cannot see any hats, but has heard the two replies states, "I know what color hat I am wearing." Which color hat is he wearing and how did he determine its color?

The solution by deductive reasoning begins with the subconclusion that the man farthest from the wall does not see two black hats or he would know he was wearing tan. The middle man knows that man farthest from the wall sees either two tan hats or a black and a tan hat. If the middle man saw a black hat, he would know his was tan; therefore, he must see a tan hat to remain ignorant. This allows the man closest to the wall to conclude that his hat is tan.[2]

Zeno's Paradox:
Achilles and the Tortoise

To illustrate how easily one can be led astray, we have included one of the motion paradoxes of the Greek philosopher, Zeno of Elea (born c. 490 BC). To prove that motion does not exist, he used the technique called *Reductio Ad Absurdum*;** a statement is established as true because its falsity leads to an absurdity: If there is motion, then Achilles (the faster) can never overtake the tortoise in a race where the tortoise is given a head start. When Achilles reaches where the tortoise started, the tortoise will have advanced. When Achilles gets there, the tortoise will have moved a little farther because it is always in motion as assumed. This process continues indefinitely, but the tortoise maintains his lead, albeit an ever-decreasing one.

In spite of being the faster, Achilles never overtakes the tortoise. Since this conclusion is absurd, the statement that "motion

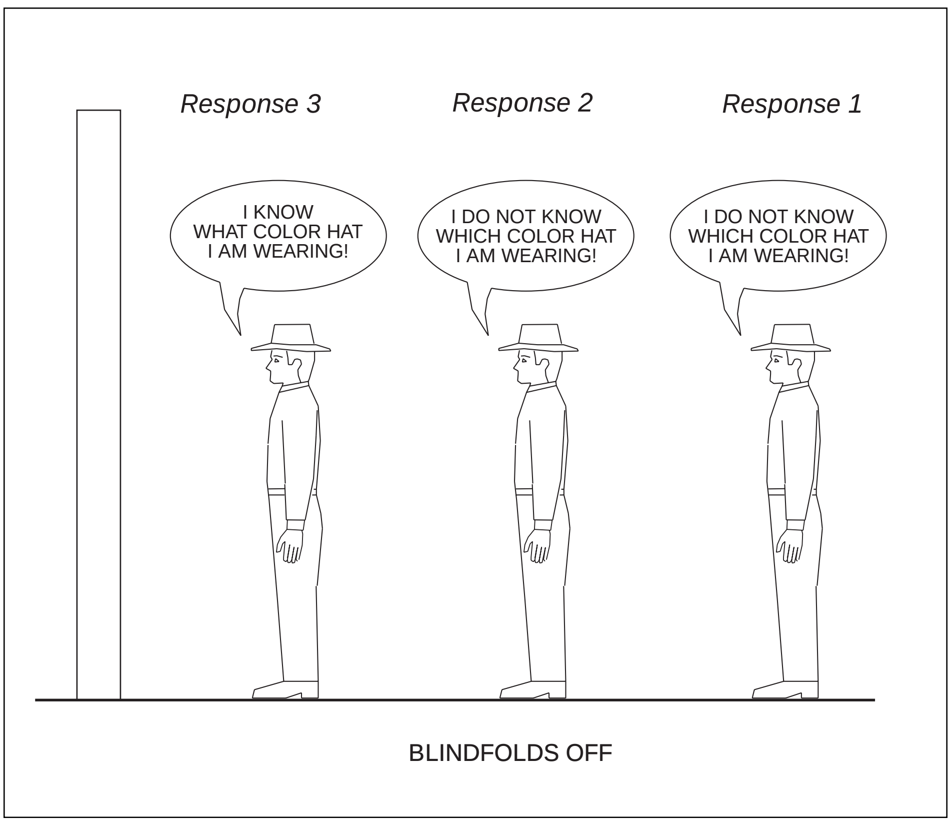


Figure 1. Three Men Facing A Wall

* Sherman Barnett is an Old English Mastiff

** "The *reductio ad absurdum* is God's favorite argument." –Holbrook Jackson exists" from which it is derived, is also absurd. This is how Zeno established that motion is impossible.

Achilles and the Tortoise provides an object lesson because the paradox arises from the improper method of formulating or expressing the problem. "This is itself interesting, indicating the extreme importance of finding appropriate mathematical and logical kinds of description, as well as appropriate conceptual models for describing or explaining the physical world and mind."[3]

C. Induction

While engineers and other applied scientists have a particular appreciation for the elegance of deducing specific truths from general truths and would like to think that this type of thinking is human nature, the fact is that most human information processing time is spent doing the opposite: deriving general truths from specific instances based on our experience, intuition and sometimes faith.

The method by which a general law is inferred from observed particular instances is called induction or inductive reasoning. It is a form of nondeductive inference in which the conclusion expresses something that goes beyond what is said in the premise; the conclusion does not follow with logical necessity from the premise. As an example, we can infer the general law that "All crows are black," based on observing a very large number of black crows and not seeing any other color. On the other hand, since all crows have not been observed, can we logically claim to have proved our inference?

Arguments based on induction do not appear to have the rigour or persuasiveness of deductions which are regarded as rationally grounded. Ultimately, however, the premises in deductive arguments rest on induction from observed cases. The only way around this dose of realism is to establish, if you can, general statements whose truth can be known *a priori*.

D. Generalization

Generalization is the internalization and application to everyday life of what has been inferred through inductive reasoning. Though learning and memory researchers differ about the exact ways that humans learn and retrieve information, most agree that, "much everyday behavior is done subconsciously. . . Subconscious thought matches patterns. . . finding the best possible match of one's past experience to the current one. . . A prototype event governs our responses to any other event that seems similar." Of course this generalizing of experience can lead to error, "mistakes might be made by mismatch; by taking the current situation and falsely matching it with something in the past."[4]

The following notions are helpful for understanding and relating to induction and generalization and for laying a foundation for "uniform safety."

Principle of the Uniformity of Nature

The principle is usually expressed as "the future will resemble the past" provided the circumstances for its happening are similar. Furthermore, it will always happen when the same circumstances recur. What justifies the assumption that nature always behaves in the same way under the same conditions? This remains an unanswered question; the uniformity of nature is simply accepted as a postulate, i.e., as a principle that is neither self evident nor provable, but nevertheless practically necessary and confirmed by all relevant experience. All science rests on this principle.

Most people assume the principle of the uniformity of nature in their relationship with the physical world. Certainly at the *man-machine* interface it is the guiding concept for training personnel for machine operations and maintenance and for projecting performance of both man and machine. For these reasons, the validity of the principle, in spite of its cosmic importance, has no meaning nor is it significant that some people will not fall under its influence. Here, it is only relevant because a foreseeable number of people operate on the principle that what has happened once will happen again.

Isaac Newton (1642-1727)

Newton introduced a "four-rule" philosophical method for studying physical phenomena.[5] His fourth rule was to consider every proposition obtained by induction from observed phenomenon to be valid until a new phenomenon occurs and contradicts the proposition or limits its validity. Newton explicitly dealt with the fact that induction does not necessarily produce truth; nevertheless, his method used induction to produce one of the greatest bodies of scientific knowledge ever amassed by an individual.

Cry Wolf

To cry "Wolf!" is to give a false alarm. The allusion to the well-known fable of the shepherd lad has its modern equivalent. Neighbors regularly confronted with a lowered grade crossing gate when no train was present inferred inductively that the "lowered gate" cue was a false signal. Circumvention of the gate eventually led to tragedy.

Emergency Stop Control

Simple induction arising from technology transfer leads to the response of "hitting the red mushroom emergency stop button" when an excursion develops. In a high school woodshop in New York, the school replaced the friction brakes in their machinery with expensive modern electronic brakes. These operated using the principle of reverse plugging, i.e., the forward-running electric motors have their magnetic fields reversed which tend to run the motors backward until all motion is cancelled. The shop teacher did not realize that the master emergency stop control for the entire shop deenergized the system and removed the current required for reverse plugging. Some of the saws coasted for five minutes – no controlled braking was possible.

Pavlov's Dogs

Pavlov sounded a tuning fork on many occasions just before feeding a dog. The dog salivated on receiving its food. Later, the fork was sounded without presentation of food and it was observed that the dog salivated in response to the sound alone. Pavlov termed this reaction *conditional reflex* and showed that it also occurred in mice and monkeys. Through induction he aimed at establishing truly universal laws of learning. He wrote: "A temporary nervous connection is a universal physiological phenomenon in the animal world and exists in us ourselves."[3]

III. HISTORY OF UNIFORM DESIGN

To deal with the problem of inductive inference, this paper will present a design meth-

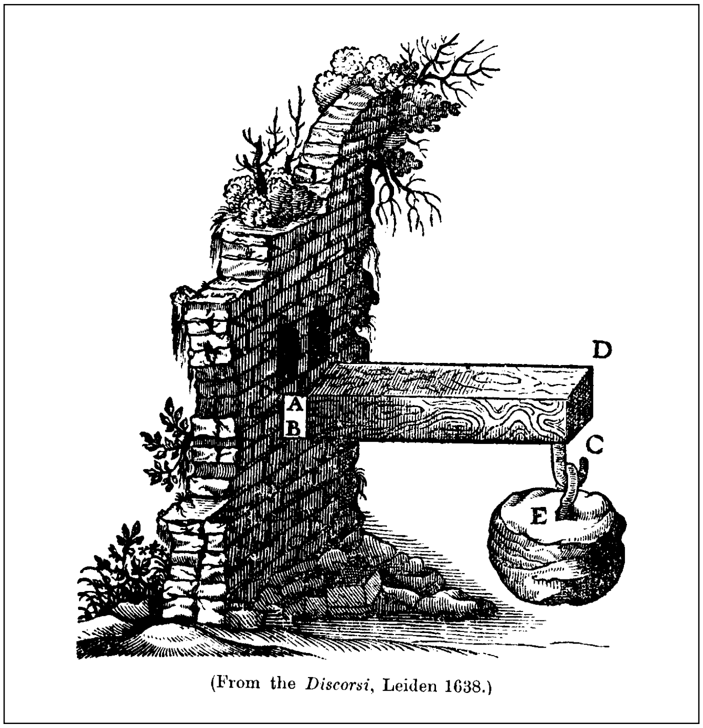


Figure 2. Galileo's 1st Problem[6]

Figure 3. Galileo's 2nd Problem (Triodyne Rendering)

odology called the Principle of Uniform Safety. Uniformity in design is a notion that has very early roots. Its history is explored in this section which is followed by its specific formulation in safety design.

A. Uniform Strength Design

Galileo (1564-1642)

With the publication of his famous book, *Two New Sciences* in 1638,[6] Galileo provided the first publication in the field of strength of materials and on that date, the history of mechanics of elastic bodies began.

Figure 2 is Galileo's illustration of a horizontal beam, his first problem, where he analyzes incorrectly the strength of beams. In his second problem, he correctly develops the uniform strength design of a constant-width cantilever which we have illustrated in Figure 3. Each cross section in this tapered beam has equal strength and allows a considerable weight savings when compared with a beam of constant cross section.

Oliver Wendell Holmes (1809-1894): The Deacon's Masterpiece

In 1858, Holmes wrote The Deacon's Masterpiece which has become the Holy Grail of minimum weight structural design. Key excerpts follow:

THE DEACON'S MASTERPIECE; OR,
THE WONDERFUL "ONE-HOSS SHAY"
A LOGICAL STORY [7]

Now, in building of chaises, I tell you what,
There is always somewhere a weakest spot,–
In hub, tire, felloe, or spring or thill,
In panel, or crossbar, or floor or sill,
In screw, bolt, thoroughbrace,–lurking still,
Find it somewhere you must and will,–
Above or below, or within or without,–
And that's the reason, beyond a doubt,
A chaise breaks down, but doesn't wear out.

But the deacon swore (as Deacons do,
With an "I dew vum" or an "I tell yeou"),
He would build one shay to beat the taown
'n' the keounty 'n' all the kentry raoun';
It should be so built that it couldn't break daown;
"Fur," said the Deacon, "t's mighty plain
Thut the weakes' place mus' stan' the strain;
'n' the way to fix it, uz I maintain,
Is only jest
T'Make that place uz strong uz the rest."

So the Deacon inquired of the village folk
Where he could find the strongest oak,
That couldn't be split, nor bent, nor broke,–
That was for spokes and floor and sills;
He sent for lancewood to make the thills;
The crossbars were ash, from the straightest trees;
The panels of white-wood, that cuts like cheese,
But lasts like iron for things like these;
The hubs of logs from the Settler's ellum,"–
Last of its timber,–they couldn't sell 'em,
Never an axe had seen their chips,
And the wedges flew from between their lips,
Their blunt ends frizzled like celery-tips;
Step and prop-iron, bolt and screw,
Spring, tire, axle, and linchpin too,
Steel, of the finest, bright and blue;
Thoroughbrace bison-skin, thick and wide;
Boot, top-dasher, from tough old hide
Found in the pit when the tanner died.
That was the way he "put her through."–
"There!" said the Deacon, "naow she'll dew."

[100 years later]

The parson was working his Sunday's text,–
Had got to fifthly, and stopped perplexed
At what the–Moses–was coming next,
All at once the horse stood still,
Close by the meet'n house on the hill.
–First a shiver, and then a thrill,
Then something decidedly like a spill,–
And the parson was sitting upon a rock,
At half-past nine by the meet'n-house clock,–
Just the hour of the Earthquake shock!
–What do you think the parson found,
When he got up and stared around?
The poor old chaise in a heap or mound,
As if it had been to the mill and ground!
You see, of course, if you're not a dunce,
How it went to pieces all at once,–
All at once, and nothing first,–
Just as bubbles do when they burst.

End of the wonderful one-hoss shay.
Logic is logic. That's all I say.

FIGURE 4a - THE TYPICAL LEAF SPRING

SIDE ELEVATION

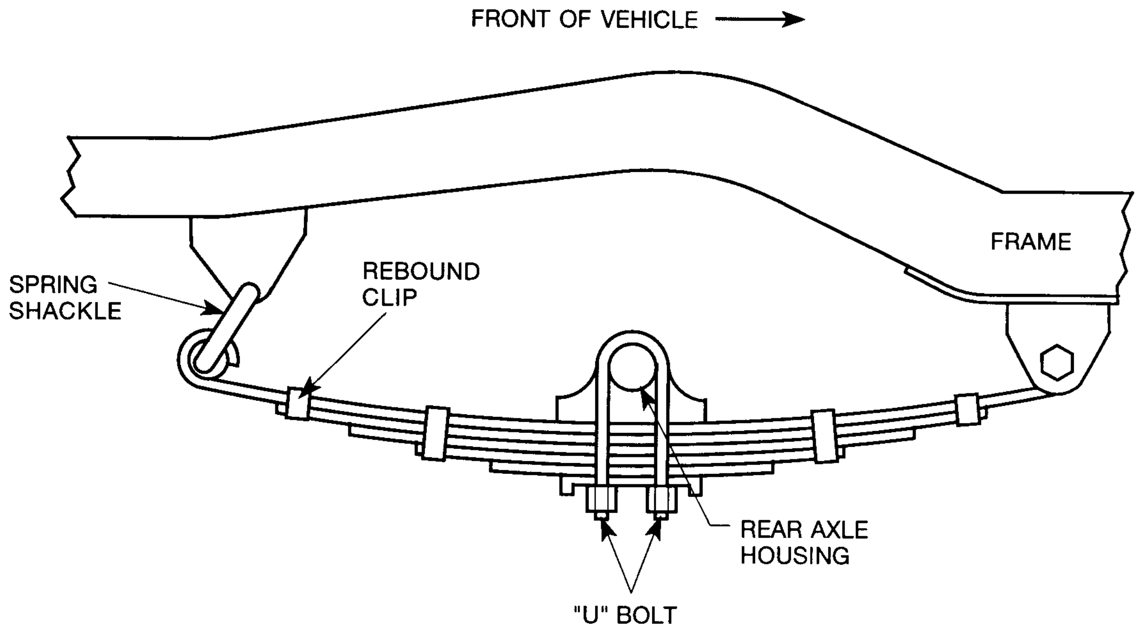


FIGURE 4b -EQUIVALENT LAYOUT OF LEAF ELEMENTS
LEAVES SPLIT AND LAID OUT FLAT

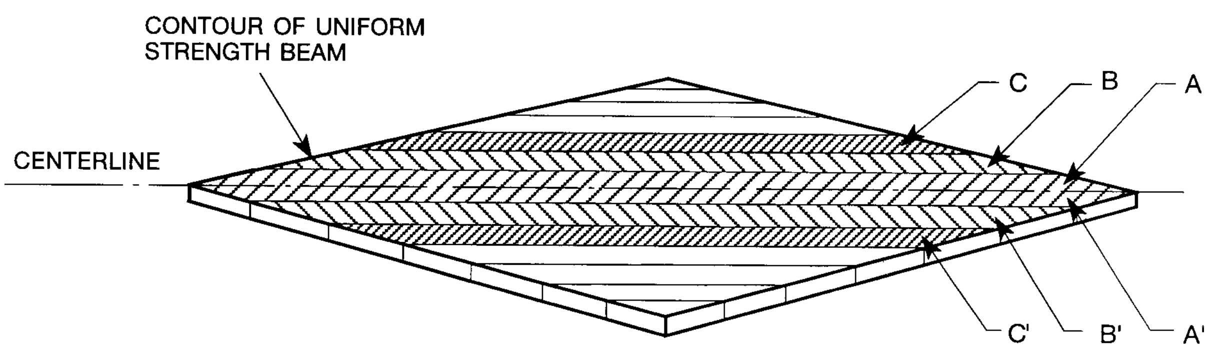
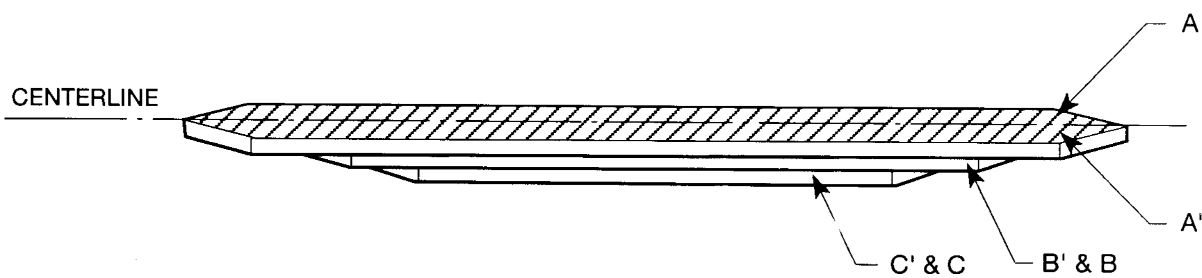
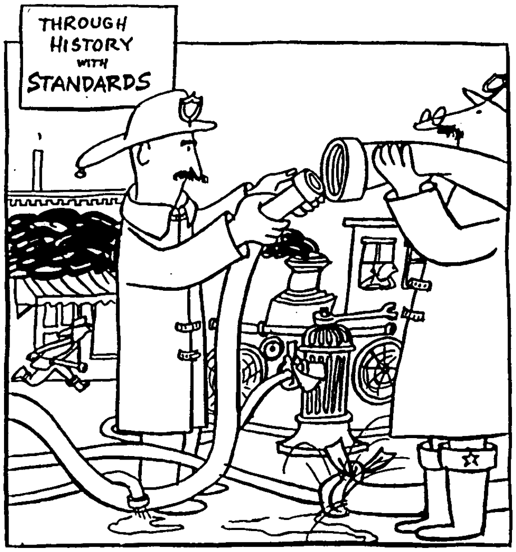


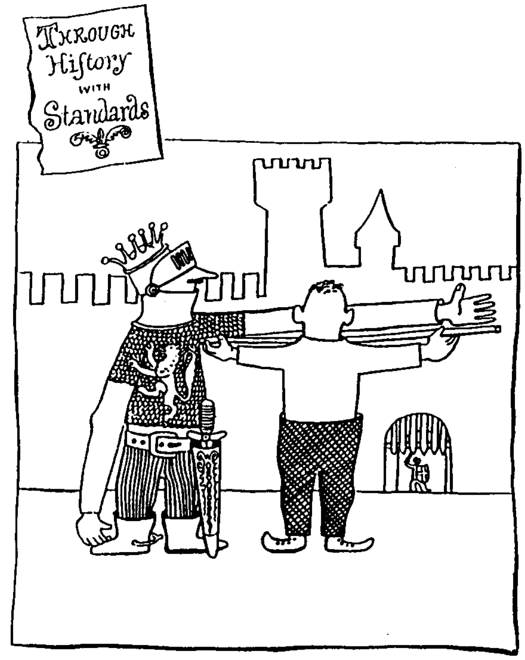
FIGURE 4c - STACKING LEAF ELEMENTS TO FORM LEAF SPRING





While I was musing the fire burned. Psalms XXXIX:3

Figure 5. An Example of Non-Standardization[8]



What are thou? Have not I an arm as big as thine?
SHAKESPEARE, Cymbeline

Figure 6. The Definition of the Yard[8]

The Leaf Spring

Fig. 4a shows a typical vehicle leaf spring. The spring itself is equivalent to the triangular uniform strength beam shown in Fig. 4b. If this latter beam is split along the lines indicated, the resulting elements may be reassembled and stacked as illustrated in Fig. 4c. We observe that the leaf spring geometry emerges.

B. Standardization

One method of imposing uniformity on a system is standardization; interchangeability and simplification both follow. In the 15th and 16th centuries standardized design of Venetian trading vessels with its attendant interchangeability gave rise to the first true assembly line. Using 16,000 workmen, the Venetian Arsenal could build a galley of war in one day and could convert ten trading vessels into fully armed galleys "between the hours of three and nine".[8]

Mass production began in the U.S.A. at the end of the 18th century. Vice President Thomas Jefferson gave the inventor of the cotton gin, Eli Whitney, a contract to build 10,000 muskets. To control the uniformity of his production, Whitney utilized four innovations: drilling by template (pattern), filing by jigs (guides), milling irregular forms and maintaining accurate tooling. In an unprecedented demonstration, Whitney appeared in Washington, DC, before Congressmen and government experts, where he assembled muskets by randomly selecting parts from piles of standardized components.

The early and original benefits of standardization were cost savings, rapid production and convenience through interchangeability. From the safety point of view, there are three significant implications associated with standardization. One arises from interchangeability, another from simplicity and a provocative contribution is related to uniformity.

Interchangeability

"Lack of interchangeable fire-fighting equipment cost citizens of Baltimore millions of dollars when their city burned in 1904. A fire broke out on Sunday, February 7, and when it got beyond control the local fire department called on Washington, New York, and Philadelphia for help. Special trains rushed apparatus from these three cities on cleared tracks. Then the equipment stood idly by while 150 acres of the old business section was destroyed. Their hose couplings would not fit the Baltimore hydrants.

Twenty-three years later, in 1927, fire-fighting equipment from 20 neighboring towns helped save Fall River, Massachusetts from total destruction in another great fire. The difference was in standardization. All equipment from the 20 communities worked interchangeably. The hydrant and hose connections had been standardized".[8]

Simplicity

Standardization reduces aspects of the design problem from infinite to finite, e.g., screw sizes. The resulting simplicity improves all aspects of the design including safety.[9]

> *"The best design is the simplest one that works."* –Albert Einstein

Uniformity

Referring to the consensus standard for the safety of portable metal ladders, ANSI A14.2-1990, which is promulgated by the American National Standards Institute,[10] we find:

> **5.3 Rung and Step Spacing**
> The spacing between ladder rungs or steps shall be on 12-inch centers ± 1/8 inch, except for step stools where the spacing shall be uniform but not less than 8 inches ± 1/8 inch nor more than 12 inches ± 1/8 inch measured along the side rail. On articulated and combination ladders, the 12-inch spacing shall be maintained across hinged sections.

To comply with this standard, the word *shall* makes rule 5.3 mandatory which suggests that there is something special about 12 inches (30.48 cm). Are we to believe that a rung spacing of 1/3 the arm length of King Henry I of England in 1120 has the intrinsic property of optimizing ladder safety? Indeed, the safest rung spacing is unknown. The ladder standards promote safety purely by *uniformity*; all ladders train you for other ladders.

IV. PRINCIPLE OF UNIFORM SAFETY

Uniform safety intervention techniques should be used whenever inductive inference and generalization can compromise the safety of a device or system. This treatment will promote standardization, simplicity, and uniformity with all their functional and safety advantages.

> ***Principle of Uniform Safety: Similarly perceived dangers should be uniformly treated.***

Here, the word *danger* characterizes a hazard with respect to its injury severity and injury frequency. To illustrate the use of the Principle by safety designers, consider the following examples:

A. Warning Signs

As indicated in the abstract, if you invite one, you must invite all third cousins to the wedding. Likewise, with respect to product warning signs, if you warn against any hazard, you must warn against every hazard whose danger is equal to or greater than the one considered. As warning signs address lower and lower danger levels, more and more will be required. Danger levels will be encountered where the number of warnings is too large for them to be effective: clutter.[9] Use of a few warnings to protect personnel from the most severe dangers is better than using so many that all are lost as leaves in a forest.

Sometimes the warning sign must serve to differentiate behavior that might be falsely characterized by inductive inference. For example, to indicate that the stability (rollover resistance) of certain panel trucks and recreational vehicles is lower than other more familiar vehicles, a warning may be placed on the driver's sun visor describing the machine's high center of gravity and rollover potential. Similarly, because of our enormous experience with flat mirrors, curved automobile mirrors generally contain an admonition that "Objects viewed in this mirror are closer than they appear."

B. Interlocked Barrier Guards

Imagine a machine with fifteen similar hazards protected by fourteen interlocked barrier guards and one non-interlocked guard. Operators continually exposed to the interlocked barriers may easily conclude by inductive inference that powered operation will not occur when a guard is open. Have we not set a trap for operators who will eventually open the non-interlocked guard? Have we not instilled a false sense of security? The Principle, of course, demands uniform treatment of all fifteen barrier guards; they must **all** be interlocked or they must **all** be non-interlocked.

C. The Standardization Dilemma[11]

The overall safety of a collection of machines can be compromised by adding newer machines with modern safety devices. Because of the safety devices, the level of personal vigilance on the new machines will be lower than that required on the older units. If personnel are transferred from the newer to the older machines, they are no longer protected by the modern safety devices and initially their personal vigilance will be inadequate. The early safety code writers for mechanical power presses were aware of this standardization dilemma, specifically with reference to single-stroke capability.

The dedicated continuous operation of full-revolution clutch power presses will find the presses bobbing up and down like sewing machines with automatic systems for loading the workpieces and unloading the scrap and finished parts. In 1937, these maximum output operations did not require power presses with single-stroke safety devices. The use of such contrivances guaranteed that only one stroke could be obtained by activating the controls regardless of the time they were held in the "cycle" position. A second stroke required the release and reapplication of the controls. When single-stroke work was attempted on "continuous" machines without single-stroke devices, holding the controls in the activated position for even a fraction of a second longer than one complete cycle period produced at least one additional full cycle. Holding the control for a moment too long, followed by reaching into the point of operation to retrieve the finished part, all too frequently resulted in tragedy.

ASA B11-1937, the voluntary consensus safety standard for power presses that was issued in 1937 by the American Standards Association, states the following:

> **7.5 Single-Stroke Attachment**
> 7.5.1 On positive-type clutch presses a single-stroke attachment should be provided, by which the treadle or operating lever is disconnected after each stroke. If single-stroke attachments are provided on some of the presses in a department, they should be provided on all of the positive-type clutch presses in the department so that there will be less likelihood of confusion and, therefore, of accident when operators are changed from one machine to another.[12]

It should be noted that the uniform treatment recommended by the standard is entirely consistent with the Principle of Uniform Safety.

D. Technology Transfer

As workers move from job to job, some remain in their specialties and some move into new areas requiring different skills. All of these workers carry a lot of "old baggage" with them in the way of training, experience, habit and learned responses. To make sure their backgrounds do not compromise their safety in their new assignments, it is desirable to transfer their safety skills. By concentrating on the commonality among machines, the Principle will try to impose a uniform safety profile on all machines.

For example, whenever possible the clockwise rotation of a steering wheel should cause a vehicle to turn to the right. Depressing an emergency stop button should impose a safety state onto a machine. The layout of foot controls should remain the same among automobiles so we may continue to check our vehicles with parking attendants. A maintenance safety philosophy like *Zero Mechanical State* (ZMS) or *Lock Out/Tag Out* (LO/TO) should apply universally to machines and systems.

V. CONCLUSION

Try to do good; but, more importantly, do no harm. The Principle of Uniform Safety speaks eloquently to this philosophy.

CITED REFERENCES

1. *Romans* 8:30.
2. Pappas, Theoni, *The Joy of Mathematics*. San Carlos, CA, Wide World Publishing/ Tetra, 1989, p. 190.
3. Gregory, Richard L., *The Oxford Companion of the Mind.* New York, Oxford University Press, 1987, p. 819.
4. Norman, Donald A., *The Psychology of Everyday Things*. New York, Basic Books, Inc., 1988, pp. 117, 125, 127.
5. Newton, Isaac, *Sir Isaac Newton's Mathematical Principles of Natural Philosophy and His System of the World, Vol. II: The Motion of Bodies.* Translated by Florian Cajori. Berkeley, University of California Press, 1934, p. 400.
6. Galilei, Galileo, *Dialogues Concerning Two New Sciences*. Translated by Henry Crew and Alfonso de Salvio. New York, Dover Publications, 1954, p. 116.
7. Petroski, Henry, *To Engineer is Human; The Role of Failure in Successful Design.* New York, Vintage Books, 1992, pp.35-39.
8. Glie, Rowen, ed. *Speaking of Standards*. Boston, Cahners Books, 1972, pp. 39, 61.
9. Barnett, Ralph L. and William A. Switalski, "Principles of Safety," *ASAE 87-5513*. Paper Presented at the American Society of Agricultural Engineers Meeting, Dec. 17, 1987.
10. "American National Standard for Ladders - Portable Ladders - Safety Requirements," *ANSI A14.2-1990.* New York, American National Standards Institute, approved Nov. 12, 1990.
11. Barnett, Ralph L., Gene D. Litwin and Peter P. Barroso, Jr., "The Dependency Hypothesis (Part II) - Expected Use." *Triodyne Safety Brief* vol. 3 no. 1 (December l984): 1-6.
12. "American Standard Safety Code for Power Presses and Foot and Hand Presses," *ASA B11-1937*. New York, American Standards Association, approved Oct. 22, 1937.

GENERAL REFERENCES

13. Angeles, Peter A., *The Harper Collins Dictionary of Philosophy*, 2nd ed. New York, Harper Collins Publishers, 1992.
14. Barrow, John D., *Theories of Everything; The Quest for Ultimate Explanation.* New York, Fawcett Columbine, 1991.
15. Dugas, Rene, *A History of Mechanics*. Translated by J.R. Maddox. New York, Dover Publications, 1988.
16. Flew, Antony, *A Dictionary of Philosophy*, 2nd rev. ed. New York, St. Martin's Press, 1981.
17. Feldman, R. S., *Understanding Psychology*. New York, McGraw-Hill, Inc., 1993.

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