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SAFETY BRIEF

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On Classification of Safeguard Devices (Part II)

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In Part I of this article (see *Triodyne Safety Brief,* April 1981) an intrinsic classification system was described which focused on characteristics of individual safeguarding devices. In Part II, we are concerned with the relationships among such devices.

Our initial approach to this relationship classification problem was to establish a sort of pecking order which would allow safeguarding devices to be ranked according to the type of protection offered. Application of our initial scheme showed it to be both useful and internally consistent; however, important safety problems seemed to fall outside of its scope. For example, it did not explain why a knife is not unreasonably dangerous or why all but the very young keep their hands out of a Great Dane's mouth. Moreover, the scheme did not account for the very low injury frequency rate associated with the press brake compared to the mechanical punch press.

It became apparent that proper account of a system's safety profile required the introduction of a category which would deal with those safety characteristics *inherent* in a system. These characteristics, which include simplicity, obviousness, slow motion and widespread user training, are ranked under Zero Order Systems in the following functional hierarchy of safety devices and concepts.

Functional Hierarchy of Safeguarding Systems

Zero Order Safety Systems — Safety properties of a machine or system that derive strictly from man/machine interactions, independent of any safeguarding devices that may be present. Examples would be the open and obvious danger of the knife, the slow speed of the press brake ram relative to human reaction time, and the simplicity of tin snips.

First Order Safety Systems — Safety devices or concepts that eliminate or minimize a hazard or the exposure to a hazard. All of the classical punch press safeguarding devices fall into this category: barrier guards, pull back devices and two hand controls. Note that the first order systems enhance the effectiveness of the zero order systems.

Second Order Safety Systems — Devices or concepts used only to enhance the effectiveness of first order systems. An interlock used as a reminder to keep a guard in place is an example in this category.

Definitions of key words used in text:
Hazard . injury producer
Risk . . . likelihood of injury
Danger . measure of likelihood and severity of injury

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No Charge

Third Order Safety Systems — Devices or concepts used to enhance the effectiveness of second order systems. A second or redundant interlock, which backs up the first interlock on a guard, falls into this category.

Fourth Order Safety Systems — Devices or concepts used to enhance the effectiveness of third order systems. A self-checking system which shuts down a machine if either interlock on a redundant system becomes defective provides an example of a fourth order system.

Higher Order Safety Systems — The extension to higher order systems is self-evident.

The Zero Order Safety System

So far, our research has revealed three very significant subdivisions under which the man/machine relationship bears directly on the safety problem: danger recognition, danger control, and motivation.

Danger Recognition (Perception)

Natural selection, in the Darwinian sense, has produced a community of machine users that recognize immediately certain dangers that are described in the legal literature as "open and obvious" or "patent." Large, fast moving vehicles, open flames, the inrunning nip of a clothes wringer and the reciprocating action of a punch press ram all present dangers that are instantly perceived without training. Neither animals nor aborigines would place their bodies between the closing doors of an elevator.

The importance of danger recognition in safety is brought home when systems are observed in which dangers are hidden, or latent. Young children playing with matches, ingesting tasty, colorful chemicals, touching a "third rail" or darting out into traffic all account for a tragic toll in life and limb. All are examples of man/machine systems where the community of users does not have the training, experience, or cunning to recognize the dangers.

Danger Control

The safety of a machine is greatly enhanced if the user can cope with the dangers presented. This can be accomplished if the user can control either the hazards or the risks.

One of the common ways of dealing safely with *hazards* is to temporarily suspend them by stopping a machine before placing oneself in jeopardy. This may be achieved using the stop buttons, electrical disconnect, or hydraulic valves conventionally incorporated into a machine's control system. These controls are sometimes useful for limiting or minimizing injuries after the hazard has been encountered. They may also be used to protect maintenance men by rendering machines in a zero mechanical state (ZMS).

There are man/machine interactions that enable operators to control *risks* by avoiding hazards or minimizing the probability of encountering them. Speed and directional controls are used by licensed drivers to circumvent accidents, fallen trees and potholes. Construction workers can easily avoid being run over by cranes, concrete spreaders, and asphalt rollers because these vehicles all travel at one-third of walking speed. Knives are considered safe because people can handle them safely thanks to extensive training as children followed by a lifetime of continuous practice.

Safety Motivation

Not all people capable of recognizing danger choose to avoid it. In fact, there are people who regularly court or ignore danger: mountain climbers, sky divers, ski jumpers and workers who engage in horseplay or disregard established safety procedures. Legal doctrines such as "assumption of risk" and "contributory negligence" have been used to deny recompense to plaintiffs who were the authors of their own misfortune in that they acted in a manner that their community regards as reckless.

The ability to recognize danger and the ability to control danger are necessary, but not sufficient conditions to minimize the number of injuries and/or their severity. The desire, or motivation, to use these two safety tools has a very significant influence on a system's injury frequency rate.

Consider, for example, these possible scenarios involving the operation of a machine:

a) Maximum Output Method — This is often associated with piecework or bonus compensation. Workers are compensated for the amount they produce. This often leads workers to stress production over safety.

b) Least Work Method — Operators who wish to conserve their energy sometimes do things the "easy way" rather than the "safe way."

c) Work Standard Method — Industrial engineers give operators a prescription for achieving a specified output. Sometimes these instructions fly in the face of proper safety practices.

d) Maximum Safety Method — These work schemes normally minimize danger.

It is devoutly to be wished that a work method will simultaneously produce maximum safety and output with the least demand on the operator. This goal can rarely be achieved in the real world and often it is safety that is compromised.

In spite of its importance, it is interesting that motivation is not addressed in the legal literature on products. On the other hand, danger recognition and control are frequently discussed. Consider, for example, items (iv), (v) and (vi) from John W. Wade's list of seven criteria governing the reasonableness of a hazard:

"(iv) the obviousness of the danger;
(v) common knowledge and normal public expectation of the danger (particularly for established products);
(vi) the avoidability of injury by care in use of the product (including the effect of instructions or warnings)."

The First Order Safety System

Most of our safety codes call for first order systems: guards, emergency stop buttons, back up alarms, etc. They seldom require second order systems such as guard interlocks, warnings not to remove the guards, or hinges on the guards. Further, with few exceptions, codes do not address zero order systems; they contain no admonitions to train operators in hazard recognition, hazard control or safety motivation. With these thoughts in mind, consider the following observations:

- Almost all machines have first order safeguarding systems.
- Most accidents occur on machines that are safeguarded.
- Historically, about 85% of machinery accidents have been caused by the victim.
- Only 5% of accidents are caused by machines, leaving 10% which do not fit any category.
- Introduction of the Restatement 2d Torts 402A in the 1960's created a crisis in product liability which caused machinery manufacturers to spend billions of dollars on new first order safety systems.
- Billions of dollars were spent retrofitting existing machines with first order safety systems under Occupational Safety and Health Administration rules promulgated in the 1970's.
- In spite of the massive outfitting and retrofitting of machines with first order safety systems, the injury frequency rates, incidence rates and the total number of accidents have increased.
- The National Safety Council, which has been steadfast in its emphasis on training, safety posters and safety motivation, published figures which demonstrate three-fold decreases in the injury frequency rates in companies that concentrate on these zero order safety systems.
- It is easier to legislate first order safety systems than zero order systems.

The Higher Order Safety Systems

Under special conditions codes require second order safety systems. Consider, for example, the problem of two-blocking an overhead crane (running the movable pulley block into the upper works or upper block). Full visibility of the movable block and a deadman hoist control constitute a zero order safety system. An upper limit switch is specified by the American National Standards Institute code; this is a first order safety device. When such a crane is used to carry heavy loads over a nuclear reactor, the appropriate code requires a double, or redundant upper limit switch; this second limit switch is a second order safety device.

The instruction manuals for overhead cranes normally contain directions for checking the serviceability of the upper limit switch; these instructions constitute a third order safety system. A warning sign on the crane directing users to read the instruction manual before operating the unit would be a fourth order safety device.

Qualitative Safety Analysis

Notice that if we exclude the zero order safety systems from our discussion of the crane, the first order device is more effective from a safety point of view than the second order device which, in turn, is more effective than the third order instruction manual which, in turn, is more effective than the fourth order warning sign. These conclusions may be helpful when judging whether a machine is unreasonably dangerous. Is a machine that has first order, second order and third order devices unreasonably dangerous because it doesn't have a fourth order device?

The most compelling use of this classification system is as a systematic safety analysis of a machine or system, in conjunction with the intrinsic classification system of individual safety devices described in Part I of this article. Together these classification systems provide a complete method for the qualitative safety analysis of machines or systems. We may, for example, take the devices in each order and use the intrinsic classification system from Part I to determine whether they help or hurt the system's safety, all or part of the time. A curved rearview mirror offers a good illustration of this analysis.

In the functional hierarchy, a curved rearview mirror would be a first order safety device. In the intrinsic classification system, it would be a Type IV device; it sometimes improves safety and sometimes increases danger by distorting images and giving false impressions of distance. Here, a second order system is required to improve the mirror's safety effectiveness. Indeed, curved mirrors now carry a warning about their propensity to distort images.

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WHAT IS A DEFECT (Part II)

This article continues our cataloging of definitions of the term "defect" used in the courts in each state. Each issue of this newsletter will contain relevant case decisions from several states. Again, we appeal to our readers to update our collection and extend our thanks to those of you who have already contributed.

ARIZONA

Brady v. Melody Homes MFR, 589 P.2d 896 (1979) In this case, the Supreme Court of Arizona stated that:

> "While the Restatement definition of defective condition as being a condition not contemplated by the ultimate consumer, which will be unreasonably dangerous to him, has been subject to criticism, it does have the virtue of providing a legal standard by which judges and juries can measure the concept of defect. Moreover, the definition seems to work reasonably well in the manufacturing defect cases, that is, if something goes wrong in the manufacturing process and the result is a product which the manufacturer did not intend, nor the consumer contemplate."

The court also states that for design defect cases or cases that do not fall within the above Restatement definition of defect, then, standard principles of negligence will be applicable. That is, the conduct of the manufacturer will be considered. Liability will be imposed where a showing is made that the manufacturer was negligent in not adopting a better design or if the manufacturer could have feasibly made the product safer. The pertinent factors used in **Byrns v. Riddell, Inc.** 113 Ariz. 264, for making this determination are:

1. The usefulness and desirability of the product
2. The availability of other and safer products to meet the same need
3. The likelihood of injury and its probable seriousness
4. The obviousness of the danger
5. Common knowledge and normal public expectation of the danger
6. The avoidability of injury by care in use of the product
7. The ability to eliminate the danger without seriously impairing the usefulness of the product or making it unduly expensive."

ARKANSAS

The **Arkansas Statute Annotated** § 85-2-318.2 adopts the theory of strict liability in substantially the terms of the Restatement 2d of Torts § 402A. This statue provides the following:

> "A supplier of a product is subject to liability in damages for harm to a person or to property if:
> (a) the supplier is engaged in the business of manufacturing, assembling, selling, leasing or otherwise distributing such product;
> (b) the product was supplied by him in a defective condition which rendered it unreasonably dangerous; and
> (c) the defective condition was a proximate cause of the harm to person or property."

The Restatement of Torts defines a product as defective if it is in a defective condition and unreasonably dangerous. Defective condition means that the product leaves the seller's hands in a condition not contemplated by the ultimate user, which will be unreasonably dangerous to him/her.

CALIFORNIA

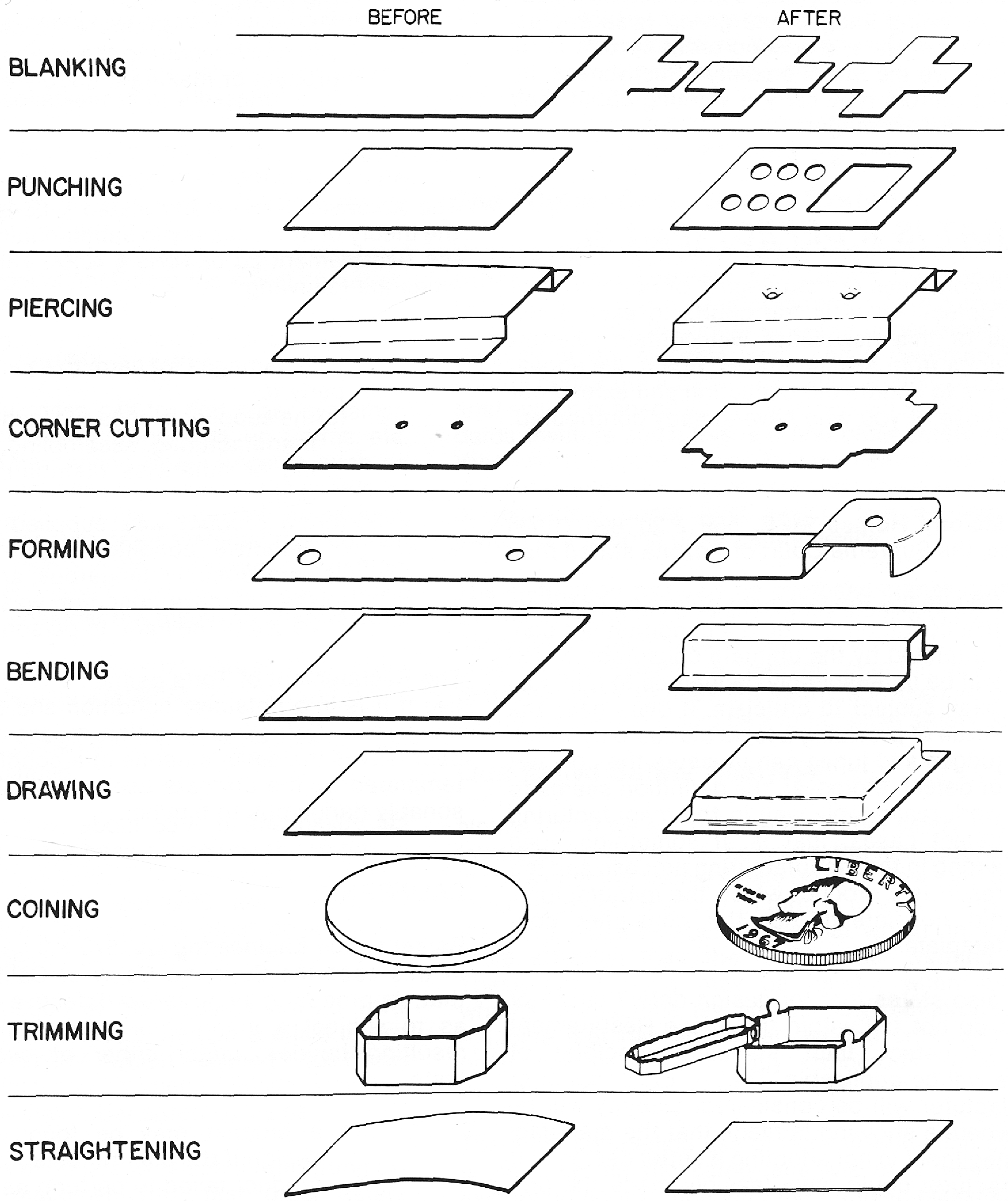
Barker v. Lull Engineering Co. 573 P.2d 454 (1978) In this case the Supreme Court of California stated that, "a product may be found defective in design, so as to subject a manufacturer to strict liability for resulting injuries, under either of two alternative tests...

> 1. a product may be found defective in design if the plaintiff establishes that the product failed to perform as safely as an ordinary consumer would expect when used in an intended or reasonably forseeable manner.
> 2. a product may alternatively be found defective in design, if the plaintiff demonstrates that the product's design proximately caused his injury and the defendant fails to establish, in light of

Continued pg. 5, col. 1

PUNCH PRESS

MULTIFUNCTIONAL CHARACTER



Graphics by Mary A. Misiewicz

Punch Press Multifunctional Character is one of a series of safety posters available from our graphics division. The posters depict the areas where each of the classical safety devices is inapplicable and the circumstances where it is unsafe.

relevant factors, that, on balance, the benefits of the challenged design outweigh the risk of danger inherent in such design."

Among the "relevant factors" the jury may consider when weighing the benefits of the design against the risks, in the second test, are:

> "(a) the gravity of the danger posed by the challenged design;
> (b) the likelihood that such danger would occur
> (c) the mechanical feasibility of a safer alternative design;
> (d) the financial cost of an improved design;
> (e) the adverse consequences to the product and to the consumer that would result from an alternative design."

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