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SAFETY BRIEF

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The Dependency Hypothesis (Part II)—Expected Use†

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Abstract

Safeguarding systems may be introduced to perform specific safety tasks, to comply with some code or standard, or to liability-proof a machine. Whatever the case, the device itself may be perceived to define a safety function and users will expect the device to perform that function. Moreover, one may argue, users have a right to such expectations.

I. Introduction

The notion that a statistically significant number of users will depend on safety systems, the Dependency Hypothesis, was explored in Part I for misuse applications (see *Triodyne Safety Brief, Vol. 2*, No. 3). Here, normal uses of safety systems will be examined.

II. Normal Use

Engineers and lawyers do not always have the same definition of "normal use" of a safety system. To an engineer, the "normal use(s)" is the use he *intended* for the safety system. To a lawyer, the "normal use(s)" is the use expected by the community of users—what a "reasonable person" would do with it under like or similar circumstances. The lawyer's definition employs what people really do rather than merely what they're supposed to do. Note that the two definitions are not mutually exclusive. The engineer's intended use is probably one of the uses of a "reasonable person."

There is nothing cerebral in the supposition that users will depend on safeguarding systems to perform in a normal manner. On the other hand, it is provocative in the extreme to contemplate the possible harm such dependence can lead to in the face of unreliability, ineffectiveness, and sabotage. The behavioral changes resulting from such dependence are discussed in the following sections.

III. Decreased Vigilance

Without safeguarding systems, users of machinery protect themselves by diligently applying their natural abilities to recognize and control danger. The safety literature has recognized the transference of such personal vigilance to dependence on safety devices.

A. Increased Production

The following excerpts refer to eliminating an operator's fear of machinery hazards.

The Principles and Techniques of Mechanical Guarding. OSHA Bulletin 2057. Washington: U.S. Department of Labor (May 1972): p. v.

> "A guarded machine is a safe machine and when the operator's fear of the machine is dispelled, this contributes to production."

DeReamer, Russell, *Modern Safety Practices.* New York: John Wiley and Sons, 1958, p. 130.

> "Examples of improved production following the installation of a well-designed guard are numerous. This is understandable. When a machine operator must divide his attention between the immediate task and an unprotected machine hazard, it is no wonder that production and quality must suffer . . ."

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This article published as *American Society of Agricultural Engineers, Paper No.86-5021, July 2, 1986.*

Accident Prevention Manual for Industrial Operations, 1st ed. Chicago: National Safety Council, 1946, p. 116.

"Sometimes, by removing the operator's fear of his machine or by facilitating the feeding of the machine, even the simplest point of operation guard may increase production."

B. Childproof Bottle Caps[4]

According to Dr. W. Kip Viscusi, a Duke University researcher, as many as 3,500 children suffer from drug poisoning each year because, "Consumers have been lulled into a less safety-conscious mode of behavior by the existence of safety caps. The presumed effectiveness of the technological solution may have induced increased parental irresponsibility."

C. Protective Safety Wear

Overt risk-taking is generally associated with things like donning bulletproof vests or asbestos fire suits. More subtle changes in behavior can be traced to the use of seat belts or motorcycle helmets which in some people gives rise to more reckless driving because of the perceived increase in personal protection. Indeed, to prevent workers from unnecessarily confronting severe missile hazards, safety spectacle manufacturers found it necessary to provide warnings that their lenses are not unbreakable.

IV. Change in Safety Philosophy

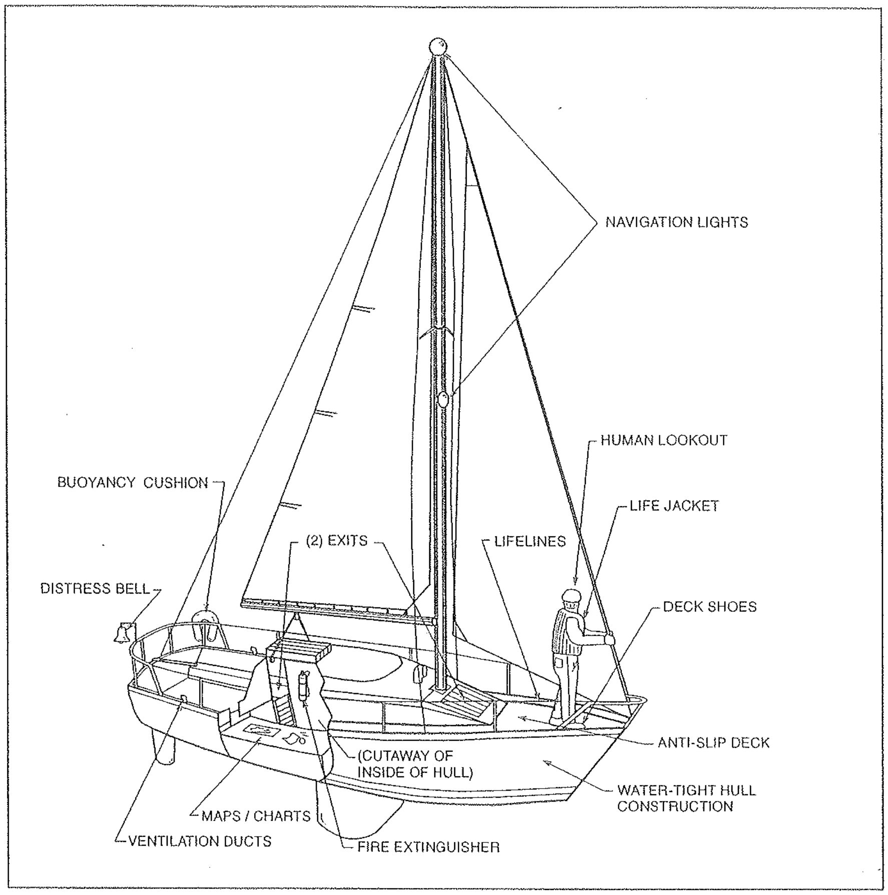
The imposition of safety devices into a system may radically alter the prevailing safety strategy. The examples given here all illustrate systems whose safety is compromised by the named safety device(s).

A. Pleasure Boat Safety Equipment

The following paragraph quoted from an article by Peggy Kramer[5] carries two suggestions: safety equipment will be substituted for seamanship training and safety equipment is inferior to such training.

"Many varieties of safety equipment and clothing are manufactured for pleasure boaters and their craft. A few visits to boat shows will introduce the novice to the hundreds of pieces of boating equipment and accessories manufactured for above and below the decks that can be added to a basic boat. *But while sensible as well as required safety equipment is readily available for every size and type of boat, there also is equipment advertising safety that could lull an untrained or unwary boat operator into a false sense of security. All the equipment designed to provide safety should never be substituted for training, or developing good basic seamanship skills on your boat.*"

"Equipment designed to provide safety should never be substitued for training, or ...good basic seamanship skills."



B. Emergency Stop Controls/ Corn Picker

Since corn pickers are completely automatic, only maintenance functions such as cleaning, unclogging, and lubrication require "hands on" work. Such work can safely proceed using ZMS (Zero Mechanical State) concepts. These provide the most modern and advanced safety maintenance philosophy.

Before starting to maintain the cornpicker, the farmer throws off the Power-Take-Off (PTO) lever, isolating the motion of the entire corn picker. He then disembarks from the tractor and may work in safety. The PTO lever is one of the most popular and most reliable controls on the tractor and provides almost continuous check out and training.

Accidents have occurred when farmers have neglected to disengage the PTO before performing maintenance and it has been proposed that Emergency Stop Controls (ESC's) such as pull cords be provided at the maintenance points.

There are three types of user expectations engendered by emergency stop controls (ESC):

(1) Prevention—They will prevent injuries.

(2) Mitigation—If an injury occurs, the ESC will lessen the severity of the injury.

(3) Invitation—The area near the ESC will be safe when the machine is running. (There are controls there; controls are meant to be activated by people; therefore the control areas must be safe areas.)

The heart of the ZMS approach is to prevent accidents. This may be contrasted

[4]"Expert Raps Safety Caps," *Chicago Sun Times*, Feb. 27, 1984
[5]Peggy Kramer, "Off Watch," *Lakeland Boating* (Oct. 1982): 21-2.

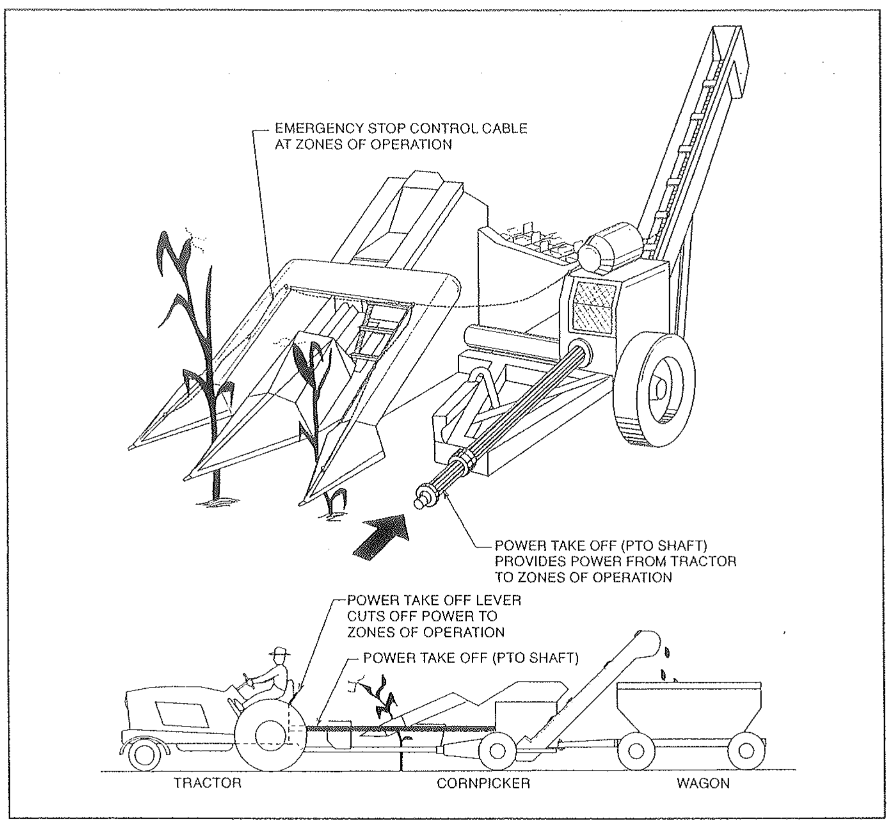
with the proposed use of ESC which can not eliminate injuries which occur faster than one's reaction time. This is particularly devastating in view of the fact that a significant number of farmers will accept the invitation of the ESC. They will be lured into the zones of operation to perform tasks with the corn picker running and with no possibility that the ESC can fulfill the promise of preventing injury.

C. The Crane Electrocution Problem

When any part of a crane contacts a high-voltage line, workmen standing in the vicinity of the crane are in jeopardy of electrocution. Three safety devices have been developed to control this danger:

- Insulated Link—An electrical insulator or dielectric link is inserted in the hoisting line just above the hook. It functions by electrically isolating the hook and any loads attached thereto in the event the boom or hoist line contacts a power line. Other portions of the crane are not protected.
- Insulated Boom Cage—A tubular steel cage is mounted along the top fifteen feet or so near the boom tip. Fiber glass insulators isolate the boom from any power lines that may contact the cage. If the hoist line contacts the power line, the cage will not work.
- Proximity Warning Device—An electronic control box and an antenna sense the presence of an electrical charge on the power lines. The sensitivity of the device is adjusted to signal the operator when the boom comes within a specified distance of the power lines.

All three of these safety devices have been extensively analyzed and evaluated. Stated simply, the studies show three problems: (1) Ordinary surface contamination of the insulators with dirt or moisture, expected on any construction site, will allow flashover. This will defeat both the insulated cage and link. (2) Electrical proximity warning devices do not reliably detect power lines. In typical power distribution systems consisting of multiple conductors, the variety of transmission line configurations coupled with the movement of nearby trucks, materials, and the crane itself tend to confuse or cancel the sensitivity of the proximity detector. (3) Triodyne Inc. studied the impact resistance of insulating links constructed using glass fibers as load carrying members and found that in spite of very high static load resistance, the impact behavior is extraordinarily low. Consequently, to obtain electrocution protection in those rare instances where a crane contacts a power line, the normal crane functions of lifting, carrying, and holding loads are dangerously compromised.



Tractor-drawn corn picker with controversial Emergency Stop Control cable.

The crane electrocution safety devices (CESD) were introduced into the market place with a lot of puffery but almost no technical research and field evaluation to establish their reliability, limitations, and shortcomings. This deplorable trend was discussed in *Triodyne Safety Brief,* Vol. 1, No. 4. The plaintiff's bar attacked the crane industry by suggesting that the CESD were Type 1 devices (devices that always improve safety) and that they would prevent electrocution if they were incorporated into cranes. When subsequent research revealed that the CESD would fail to protect under a range of realistic field conditions, the plaintiff's bar argued that they are Type 2 devices (devices that sometimes improve safety and at other times leave the system unaffected) and should be incorporated into the original crane design since they may offer protection without compromising the system. The manufacturers argued that the CESD are Type 4 devices (devices that sometimes help and sometimes hurt). Specifically, they invoked a particular form of the Dependency Hypothesis, namely, a "false sense of security." Some of their arguments follow:

1. Allin, George S., Jack T. Wilson, and Richard E. Zibolski, "A Practical Review of High Voltage Safety Devices for Mobile Cranes." *SAE 770778.* Warrendale, PA: Society of Automotive Engineers, 1977, p. 13:
   "All of these (safety) devices tend to give crane operators and working personnel a *false sense of confidence* in their protection against exposure to electrocution. Such unfounded confidence may cause serious accidents or electrocutions to construction workers which could have been avoided through proper safety procedures providing for strict avoidance of power lines."

2. *Crane Handbook,* 1st ed. Compiled by D. E. Dickie. Toronto: Construction Safety Association of Ontario, October, 1975. p. 136:
   ". . . All commercial cage type boom guards, insulating links and proximity warning devices have serious limitations and the use of them can lead to a *feeling of false security.* The use of them does not alter the previous requirements (line approach limitations and the

presence of a signalman to observe and warn the operator of hazards)."

3. Letter Communication: C. G. Lawson to C. W. Dunnam, both of Reynolds Electrical & Engineering Company, Inc., May 4, 1978.

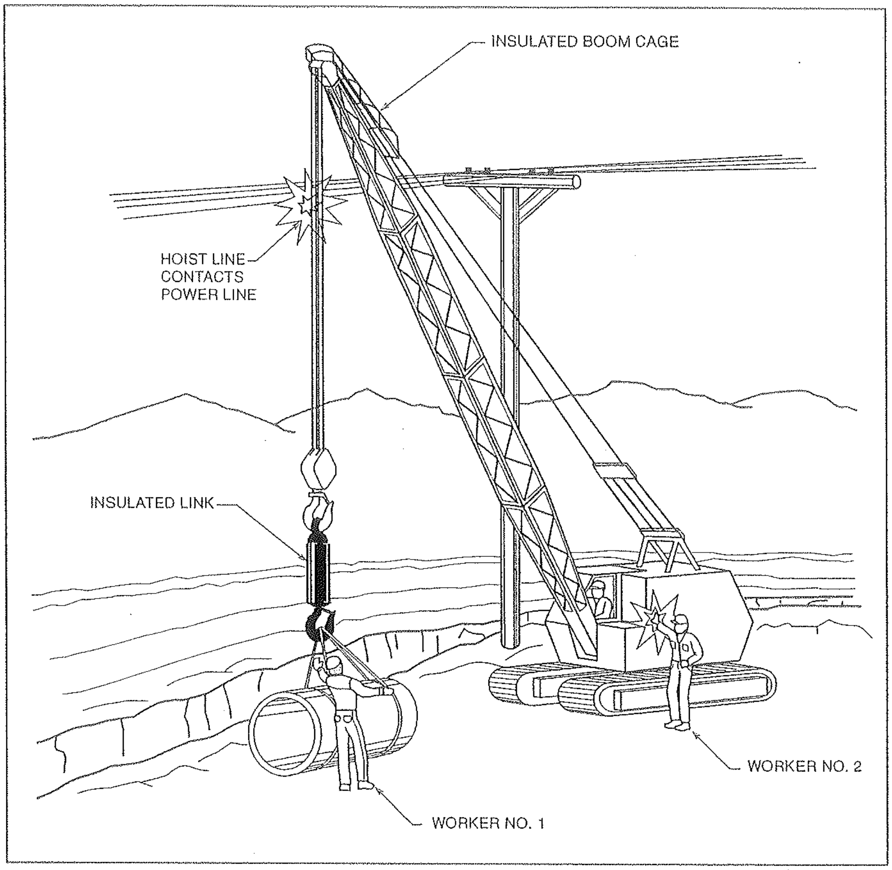
"... electronic devices installed on mobile cranes to sense the proximity of an electrical charge on a power line (were evaluated).... we are removing all proximity sensors from mobile cranes in the interest of improved safety against electrocution . . . Even when the sensitivity of the sensor is 'properly' set, these conditions can allow a boom within arcing distance of a power line before an alarm sounds. Using such a device gives a *false sense of confidence* to operators . . . the only real safety comes from careful job planning . . ."

4. *Evaluation of Electrical Insulating and Warning Devices for Mobile Cranes.* Report volume 1. Naperville, IL: Packer Engineering Assoc., April 11, 1975.

"The insulating capacity of these devices (insulated links) under actual working place conditions is an important criteria.(sic)These have been tested . . . and the device is found to be reliable as an insulator only in certain special conditions which do not typify the conditions which exist in the general construction work place. Accordingly, these devices must be considered not only ineffective as regards their intended mission, but insidiously dangerous in that they destructively modify the man-machine-environmental system and can be expected to create conditions of operation and activity by the workmen which place them in greater jeopardy of serious injury.

"Elaborate and soundly-based procedures have been developed by the electrical industry for safe working in and around high voltage wires. These include such things as specialized selection and training of personnel, insulated protective clothing, tools and guarding for the various conductors and potential ground paths, with repeated testing and inspection of the equipment. This inspection is at closely-spaced intervals within the period of time when exposure is possible.... The addition of an insulating link or an insulated boom cage does not eliminate the need for such procedures outlined above and, absent them, reliance on any such safety device will predictably lead to serious injury.

The crane operator is safe from electrocution as long as he stays in the cab. Worker No. 1 is protected by a clean insulated link. Worker No. 2 is unprotected by either safety system. The above scenario does not involve the insulated boom cage.



"The increased hazard inherent in the operator's response in the working place with an unsafe 'safety device,' such as the boom shield concept or the insulated link, provides an in- creased hazard or risk of injury. This requires that under the present-day constraints in the construction *work place*, these units must not be used or considered as effective devices in preventing injury. This also applies to field sensing or proximity warning devices."

A highly-developed set of construction management procedures exists for controlling the crane electrocution hazard. Procedures include insulating power lines, demarcating wire conductors, deenergizing power lines, rerouting transmission lines, barricading regions containing power lines, maintaining strict clearances from high-voltage conductors, and using signalmen to ensure power line avoidance. The concern expressed by the various researchers of crane electrocution safeguards is that users will assume that these multi-thousand dollar devices will perform as promised and that the operators will substitute them for the more reliable standard construction management procedures. In short, the electrocution safeguard devices will encourage users to operate near and about power lines because they will feel protected by the devices whose only function is to provide such protection.

That current crane electocution safety devices are not sufficiently reliable is recognized by standards which admonish users not to abandon construction management procedures in favor of the devices (emphasis added):

1. "Cranes and Derricks," *29 CFR 1926.550.* Washington: Occupational Safety and Health Administration, originally effective April 24, 1971 (as published in 39 FR No.122 (June 24,1974): 22844-22846).

"(a) (15) (v). Cage-type boom guards, insulating links, or proximity warning devices *shall not alter the requirements of any other regulation* of this part even if such device is required by law or regulation."

2. "Mobile and Locomotive Cranes," *ANSI/ASME B30.5-1982.* New York: American National Standards Institute, issued October 31,1983.

"5.3.4.5 Operating Near Electric Power Lines. (a) Except where the electrical distribution and transmission lines have been de-energized and visibly grounded at the point of work, or where insulating barriers not a part of, or an attachment to, the crane have been erected to prevent physical contact with the lines, cranes shall operate so that no part of the crane or load enters into the 'Danger Zone . . .' (b) If cage-type boom guards, insulating links, or proximity warning devices are used on cranes, such devices *shall not be a substitute* for the requirements of (a) above, even if such devices are required by law or regulation. In view of the complex, invisible, and lethal nature of the electrical hazard involved, and to lessen the *potential of false security*, limitations of such devices, if used, shall be understood by operating personnel and tested in the manner and intervals prescribed by the manufacturer of the device . . ." P.39.

3. Letter Communication: Jack T. Buck land, Supervisor, Safety Engineering Section, Workmen's Compensation Board of Oregon, to Mr. A. C. Gregr, Product Manager-Sigalarm, May 11,1973.

"This will confirm that after viewing a demonstration of your 'Sigalarm' unit, we find it acceptable as a high voltage proximity warning system for crane booms and similar aerial equipment. This acceptance is based on the understanding that the product *is in no way recommended as a substitution* for maintaining the required clearance from high voltage electrical lines."

4. "Crawler Locomotive and Truck Cranes," *29 CFR 1910.180.* Washington: OSHA, effective August 27, 1971 (as published in 36 FR, No. 105 (May 29, 1971): 10622-26).

"(J) (1) Clearances. Except where the electrical distribution and transmission lines have been de-energized and visibly grounded at point of work or where insulating barriers not a part of or an attachment to the crane have been erected to prevent physical contact with the lines, cranes shall be operated proximate to, under, over, by, or near powerlines only in accordance with the following: (i). For lines rated 50 kv or below, minimum clearance shall be 10 feet. (ii). For lines rated over 50 kv, clearance shall be 10 feet plus 0.4 inch for each kv over 50 kv or twice the length of the line insulator but never less than 10 feet . . . (2) Boom guards. Cage-type boom guards, insulating links, or proximity warning devices may be used on cranes, but the use of such devices *shall not operate to alter the requirements* of subparagraph (1) of this paragraph."

V. Obedience

Safety information is communicated in various forms that are regarded as authoritative. Accordingly, significant numbers of people will rely on written, audible, and visual warnings, instructions, codes, standards, manuals, and safety publications. Verbal admonitions from supervisors or instructors are often very compelling methods for modifying or reinforcing safety behavior.

Misadventures stemming from obedience to safety misinformation are particularly insidious since they arise from conscientious behavior. The following communication shortcomings highlight the problem:

A. Incomplete Information

The Occupational Safety and Health Administration requires that skylights have the "capability of supporting the weight of a 200 lb. man." One manufacturer meticulously satisfied the language of this requirement by applying 200 lbs. of sand uniformly distributed over the surface of their 4 ft. by 4 ft. skylight. Unfortunately, the skylight collapsed when a roofer stepped onto it.

B. "A Little Bit of Knowledge"

Consumer power table saws are the most dangerous of woodworking machines. In an attempt to "liability-proof" their machines, some manufacturers have incorporated a safety instruction plate containing a half dozen or so admonitions. This carries with it the implicit suggestion that strict adherence to the safety instructions qualifies one to operate the table saw safely. When the safety plate is compared to the safety training program administered by typical high school woodworking shops, the contrast is immediate and frightening.

C. False Information

One of the classic cases of misdirection arises from the use of safety status lights that indicate a danger when lit. When the bulb burns out, a safe condition is falsely indicated.

D. Dangerous Instructions

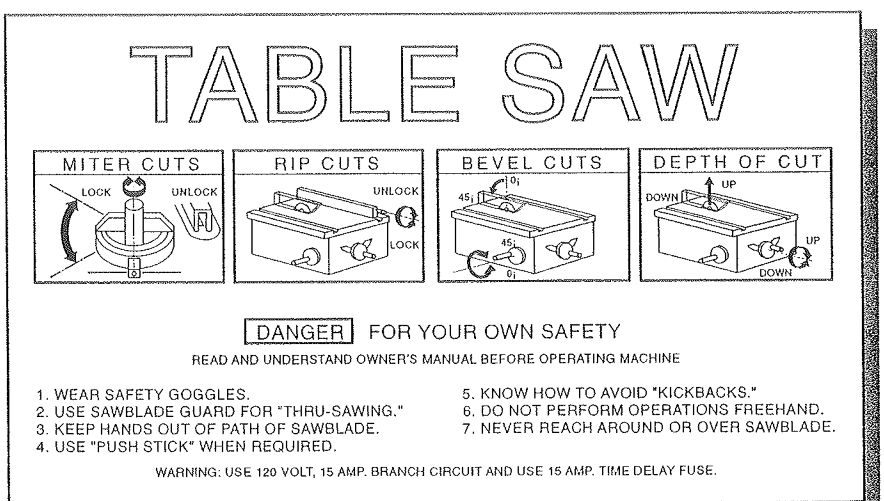
OSHA provides written instructions for testing the upper hoist limit switch on overhead and gantry cranes. Their written procedures are dangerous:

29 CFR 1910 1 79(k)(1)(ii)[6]:

"The trip setting of hoist limit switches shall be determined by tests with an empty hook traveling in increasing speeds up to the maximum speed. The actuating mechanism of the limit switch shall be located so that it will trip the switch, under all conditions, in sufficient time to prevent contact of the hook or hook block with any part of the trolley."

29 CFR 191 01 79(n)(4)(i):

"At the beginning of each operator's shift, the upper limit switch of each hoist shall be tried out under no load. Extreme care shall be exercised; the block shall be 'inched' into the limit or



[6]OSHA 2206, Revised March 11.1983.

run in at slow speed. If the switch does not operate properly, the appointed person shall be immediately notified."

Note that the tester and bystanders are in jeopardy when the procedure reveals a defective limit switch by dropping a hoist block on them.

VI. Conclusions

The Dependency Hypothesis does not speak to the issue of whether or not reliance on safety systems is good or bad; it suggests only that secondary effects exist as a consequence of behavior modification in the presence of such systems. The evaluation of safety systems must include consideration of these secondary effects which sometimes compromise the entire safety program. From the designer's view- point, the Dependency Hypothesis manifests itself in two cogent areas: introduction of misuse and substitution to lower safety profiles.

Some people misuse safety devices by performing tasks that differ from the designer's intent. Examples include misuse as controls, misuses in kind, and misuses in magnitude. There are three reasons why these misuses intrude on the design process:

A. Sellers/Manufacturers have a duty in most states not only to design products for normal use but also for reasonably foreseeable misuse.

B. New hazards may be introduced through the misuse of safety devices.

C. Compromising secondary effects may outweigh the benefits of the safety devices.

The most provocative behavioral characteristic associated with the normal use of safety systems is substitution. It appears in three areas:

- The substitution of safety systems for personal vigilance.
- The substitution of one safety system for another.
- The substitution of authoritative direction for personal wisdom and experience.

There is nothing intrinsically wrong with these substitutions but they must be examined in the light of their potential for mischief. New systems must not be inferior to the originals. Furthermore, substitutions which introduce new hazards must be measured against the prevailing philosophy relative to dangerous safeguarding devices (*Triodyne Safety Brief,* Vol. 1, No. 4) or against operable value systems such as consensus standards, regulations, or the judicial value system.

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