

Danger : How Much? Who Decides ?

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ABSTRACT

All hardware and equipment, nuclear and non-nuclear, has some probability of causing injury to the user. Control of, and responsibility for, this probability lies with the designer. Two major questions are critical: (1) What is the magnitude of probability of injury and who determines this? (2) What is an acceptable magnitude of probability of injury and who determines this? The designer must devote much attention to answering these questions as he is ultimately responsible. This paper discusses assessment of (1) danger, and (2) the level of acceptability. Suggestions are made to assist designers.

1. INTRODUCTION

Products liability litigation [1] in the United States (which applies to all manufacturers selling in the United States) places great significance on the safety of a given product, whether it is a consumer item potentially affecting large numbers of people or an item intended for industrial use, e.g., a power press. Any manufactured item, no matter how properly and carefully designed and manufactured, has some probability (ranging from very large to very small) of causing injury to the user.

One can see parallels with nuclear energy. Despite great care on the part of nuclear designers and manufacturers and an outstanding record of very few injuries due to specific nuclear causes, the general perception by the public is that use of nuclear energy for peaceful purposes is extremely dangerous. This perception raises questions of safety and probability of injury from nuclear installations.

Enlightened self-interest, apart from any legal considerations, suggests reducing the probability of injury to an acceptable level. What, however, is an acceptable level? How does a designer deal with the problem? To give some insight, this paper is written in terms of products liability litigation in the United States to provide focus and perspective for the nuclear industry.

2. HAZARD, RISK AND DANGER

The words "hazard," "risk," and "danger" are often used interchangeably but they are clearly different concepts in personal injury litigation (Philo and Rine [2]).

Hazard

A hazard is a condition, or changing set of circumstances, which presents an injury potential. Examples of hazards are:

- jaws of a power press,
- a helmet with insufficient energy-absorption,
- a vehicle with inadequate cornering capacity,
- a fork lift truck without overhead guard or load back rest,
- a toxic chemical.

Risk

Risk is exposure to injury (or loss). In evaluating personal injury potential, risk is the probability of injury. Risk is affected by proximity, exposure, attention arresters, noise, light, experience and intelligence of the user, etc. Too many seem willing to categorize risk without knowing the amount of exposure, e.g., an elevator with a ten-person capacity in a busy office building presents, not twice, but hundreds of times the risk, of an elevator with a five-person capacity in a quiet apartment house.

Danger

Danger is the unreasonable or unacceptable combination of hazard and risk.

3. UNREASONABLY DANGEROUS

The American Law Institute [3] says "unreasonably dangerous" means that: "The article sold must be dangerous to an extent beyond that which would be contemplated by the ordinary consumer who purchases it, with the ordinary knowledge common to the community as to its characteristics. Good whiskey is not unreasonably dangerous merely because it will make some people drunk, and is especially dangerous to alcoholics; but bad whiskey, containing a dangerous amount of fusel oil, is unreasonably dangerous."

The American Law Institute [3] also says: "There are some products which, in the present state of human knowledge, are quite incapable of being made safe for their intended and ordinary use ... Such a product, properly prepared, and accompanied by proper directions and warnings, is not defective, nor is it unreasonably dangerous."

For purposes of discussion, let us redefine danger by deleting "unreasonable or unacceptable", i.e., danger is the combination of hazard and risk. Thus we can discuss what is, or is not, reasonable and/or acceptable.

4. IMPLIED QUESTIONS FOR DESIGNERS

The above definitions may be acceptable for legal purposes. For designers, who prefer quantification, these definitions serve as guidelines and require designers to answer two questions:

- (1) (a) What is the danger (combination of hazard and risk)?
(b) Who determines this?
- (2) (a) Is the danger acceptable (or reasonable)?
(b) Who determines this?

Designers are responsible for answering these questions before their products are sold and used. This responsibility must be taken very seriously.

5. ASSESSING DANGER

As Lowrance [4] suggests, measuring danger, i.e., the combination of hazard and risk (probability and severity of injury), is an empirical, scientific activity. Designers are better qualified by education and experience than most people to measure danger. Presumably designers will use organized approaches to cope with the complexity. A design-audit checklist, suggested by Corley [5], can be very helpful.

One obvious place for assessing danger is the design review process. Design review is a most valuable aid, but is not a substitute for adequate design. A formal design review board, specific to the individual product, should be composed of: (1) a variety of design engineers; (2) representatives from management, sales, insurance, legal, and finance departments; (3) a products liability attorney; (4) representatives from vendors and users, if possible. These individuals should not only be expert but practical. They should be able to evaluate and constructively criticize so the designer can make further analyses and investigations, as appropriate. Finding proper answers to the right questions can substantially reduce danger and potential products liability litigation or eliminate them. When the design work is completed, including the input of a design review board, how does one know if it has been effective? Using a product safety program evaluation checklist, such as suggested by Bartels [6], may provide an answer.

In the nuclear context in the United States, each designer/manufacturer has internal equivalents of the design review panel. In addition, there is the Advisory Committee on Reactor Safeguards (ACRS). This group of experts, predominantly with technical education and experience, conducts an in-depth examination of major proposals. The ACRS conducts a probabilistic risk [i.e., danger as defined in Section 3] assessment with public health and safety as the overriding consideration. There may be many iterations of the examination process until the ACRS is convinced it is reasonable to proceed. The ACRS is well qualified to perform this task.

6. ASSESSING ACCEPTABLE DANGER

As Lowrance [5] suggests, judging the acceptability of danger is a normative, political activity. Assessing danger is not a simple matter. Assessing the acceptability of danger is far more complex. As Lowrance [5] says: "By employing the word 'acceptable' it emphasizes that safety decisions are relativistic and judgmental. It immediately elicits the crucial questions, 'Acceptable in whose view?' and 'Acceptable in what terms?' and 'Acceptable for whom?' Further, it avoids all implication that safety is an intrinsic, absolute, measurable property of things." These questions are crucial. They are also extremely difficult to answer.

Focus of Assessment Task

In assessing acceptable danger, one major task is determining the distribution of danger, benefits, and costs. This is both a political issue and an empirical matter. It involves questions such as:

- (1) Who will actually be paying the costs?
- (2) Will those who benefit be those who pay?
- (3) Will those endangered be those who benefit?

Answers to these questions may be based on quantifiable data but often must be based on estimates or surveys. A related major task is to determine the equity of distribution of danger, benefits, and costs. This is a question of fairness and social justice for which answers are a matter of personal and societal value judgment.

Changing Conditions

Changing conditions alter the level of danger one may consider acceptable. To use a simple (perhaps trivial) example, consider the following. The danger of dashing across the street against a red light with vehicles moving on the green is unacceptable to most people on a pleasant, sunny day. Some of these people will dash across the street under the same traffic conditions when it is raining hard. The latter situation is obviously more dangerous than the former but the individual perceives it as acceptable at that time.

Both danger and its acceptability can change with time. In the early days of steam boilers people apparently regarded explosions as "Acts of God" or due to "natural causes" and accepted the danger. Over the years, there have been many fatalities and injuries associated with steam boilers. Since the beginning of use of the atom as a power source, there have been very few fatalities, injuries, or exposure to radiation associated with nuclear power plants. Nonetheless, it appears that large segments of the public consider nuclear-fueled plants unacceptable, yet accept fossil-fueled plants (despite potential problems such as environmental pollution and acid rain).

Cultural Bias

Acceptability of danger may differ on a cultural or national basis. For example, in Japan, one can obtain beer and sake from coin-operated dispensers at any time. In the United States, buyers of alcoholic beverages must be a minimum age with sales restricted to specific hours in licensed stores. In the United States, one regularly reads newspaper accounts of serious injury and/or fatalities from automobile accidents in which a driver had been drinking. Laws exist in the United States forbidding driving while intoxicated. A common view is that these are neither stringent nor vigorously enforced. Similar accidents are rare in Japan where every licensed driver is regarded as a professional driver and punishment for driving while intoxicated is swift and severe. One can only infer that (1) the acceptability of obtaining and using alcohol and (2) the acceptability of driving after using it differ greatly between the United States and Japan.

Assessor of Acceptability

Who determines the acceptable level of danger? In terms of ability to judge acceptability, designers and/or engineers are no better qualified than any other group of people and, in general, are less qualified than many others. It is often alleged that engineers (because of their inherent characteristics, education and experience) are less sensitive to societal influences of their work and products than others. Like most stereotypes, there is some truth in this. Having designers/engineers make decisions on the acceptable level of danger seems to be a major problem with both consumer products and nuclear design. The ACRS (predominantly composed of technical experts) makes this judgment for itself. It is obvious that many in the general public perceive this judgment as unacceptable. But if not the designer (or the ACRS), then who?

With reference to products liability, some have proposed that competition will establish the level of acceptable danger of a given product. This is much too simplistic. Cost includes all that must be paid in terms of manpower, material resources, social options, individual freedom, and other goods, as well as direct financial burden. Further, there is evidence that some segments of industry (all manufacturers producing a given type of competing products) are delinquent, in that use of their products results in serious injury or death although ample technology exists to provide reasonable redesign and/or accident prevention measures at relatively low cost. These measures could reduce, if not completely eliminate, the danger. In terms of nuclear power, this approach is clearly untenable.

One suggestion for products liability is to establish a danger review board specific to the product. This board should be composed of people with a variety of capabilities. Certainly engineers, especially human factors engineers, should be on the board. As with the design review board, management, legal counsel, etc., should be represented. But there should also be a number of people, such as sociologists, psychologists, and consumers/users, who are not company employees. The latter group has no vested interest in the product and would provide a better view of public acceptability of danger. The danger review board would be charged with assessing the acceptability of danger and making consensus recommendations to top management which then decides on a course of action. Something of a similar nature might be appropriate for nuclear power. In other words, a body similar to the ACRS but with a broader spectrum of membership; in particular, responsible individuals who would clearly represent the general public.

One might conduct an "opinion" poll, somewhat like a market survey, to obtain substantial input from the general public. In conducting such a survey, however, there are two major considerations: (1) obtaining an adequate and truly representative sample and (2) phrasing questions very carefully, with extensive "cross check" questions, so there is minimum bias in the responses. With respect to nuclear power, such a poll might help to alleviate the concern and volubility of those who perceive nuclear power as unacceptable under any circumstances.

The foregoing comments represent suggestions. They clearly do not provide complete answers. Specific assessment methods or routines must be developed for each situation. Reference to Lowrance [4] and to Schwing & Albers [7] can be helpful in developing further sensitivity to assessing an acceptable level of danger.

Potentially Acceptable Level of Danger

It has been indicated that the average United States citizen appears willing to accept danger of fatalities of about 1 in 10⁶ per hour for automobile travel, thus this might be considered a reasonable level for other products that involve public safety. Is this an acceptable level? This rate represents about 50,000 automotive fatalities per year. This hardly seems acceptable for consumer products. This level is totally unacceptable for nuclear energy applications.

There is no one level of acceptable danger. Each situation must be judged independently. Some guidance for products liability is provided by a California Supreme Court decision (cited by Peters [8]) which said that a product is defective in design if there is "excessive preventable danger."

This exists if a danger-benefit analysis shows that dangers outweigh benefits when measured against five criteria: (1) the hazard, or severity of consequences in event of a failure; (2) risk, or probability that such a hazard will occur; (3) technical feasibility of safer alternative designs; (4) economic feasibility of safer alternative designs; and (5) possible adverse consequences (danger) to user and product resulting from alternative designs. In general, United States courts are saying that if a product can be made safer at a reasonable cost without introducing other dangers, then such action must be taken. If there is substantial potential of injury and no technically feasible safer alternative design can be found, the danger may still be judged acceptable if potential benefits outweigh potential damages. A similar approach might be applied to nuclear energy danger assessment.

7. SUMMARY

The task of assessing danger is difficult. The task of assessing acceptable danger is far more difficult, but not impossible. Technical people are generally capable of, and qualified for, measuring hazard, risk, and danger. Technical people, however, are no better qualified than the general public to make value judgements of the level of danger acceptable to the general public. Nonetheless, the assessment and a decision must be made.

The designer (1) must assess the danger and determine its acceptable level, (2) needs assistance from the general public in determining an acceptable level of danger, (3) has the ultimate responsibility for whatever level of acceptability is chosen and built into the product. Whatever methods are used, they must be more effective and more convincing.

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