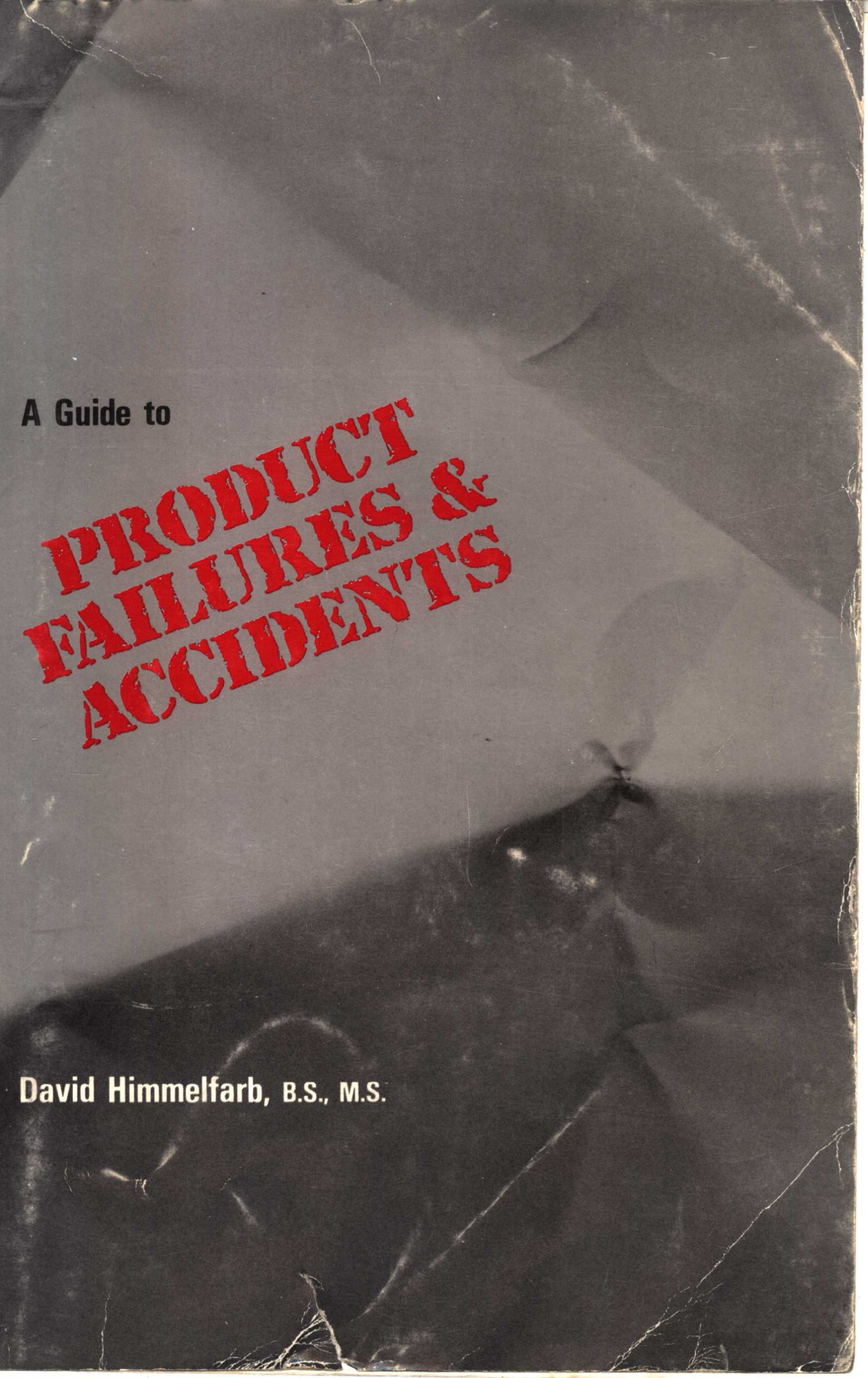
A Guide to
PRODUCT FAILURES & ACCIDENTS
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To the many colleagues and associates who consciously or unwittingly, contributed to my thoughts and broadened my experiences.

To my wife Leah, for her understanding and forbearance.

To my son Martin, for his insights, judgments, and encouragement.

Contents

CHAPTER 1

Accident Development and Involvement

THE NATURE OF THE ACCIDENT

The accident is a chance event, which when associated with personal injury or property damage, becomes a matter relevant to monetary compensation. Contributory conditions for an accident are ever present in daily living. The unforeseen circumstance, the hazardous condition, the unsafe act, the defective product, provide the limitless potential for the accident, to be avoided only by an awareness that succeeds in averting the accident. When the accident occurs and becomes subject to appraisal for compensation, facts pertinent to the accident must be established to provide a basis for such compensation. Investigations in this regard may be simple or complex as determined by the needs of the interested parties. To be established are:

a. the cause of the accident leading to injury or damage,
b. the nature and severity of the injury or damage,
c. the consequences of the injury or damage,
d. except for injuries compensable under Workmen's Compensation Acts, the presence or absence of negligence as a contributor to the accident, i.e. the failure to exercise ordinary care to avoid the injury or damage,
e. the assignment of responsibilities as a basis for assessing compensation.

In any form, the investigation of an accident presumes no fortuitous or unexplainable event. It must establish even on a probable basis existing relationships between cause and event. Assignment of responsibilities, establishment of negligence, and assessment of compensation are determined ultimately by an adjudicating process.

When the accident involves a man-made manufactured or structural product, the concept of negligence as applied to the accident, is extended; not only to use or application of the product, but to its design and inherent defects. Product liability laws impose upon the manufacturer and even those parties supplying the product to the

user, an obligation to protect the user against unreasonable risks of injury.

Millions of accidents leading to fatal and disabling injuries, and representative of billions of dollars in costs, are reported each year in the United States. The motor vehicle, as a manufactured product, is the major contributor to this record. On public ways and in work-related activities, it is involved in almost half the fatalities and one-fifth of the disabling injuries. While there is no statistical assignment of accidents specifically identified with other man-made manufactured or structural products, to the extent that every accident requires a physical or chemical agent to inflict injury or cause damage, every accident is potentially a product-related accident.

THE ACCIDENT TRIANGLE

The accident causing injury or damage is a culmination of three contributory factors: (a) the inflicting agent; (b) the recipient subject or object; (c) the usage conditions which activate the inflicting agent. In terms of a product-related accident, the contributory factors are identifiable with (a) the product, (b) the user, and (c) the usage conditions which caused the product to respond contrary to expectation. The accident may result from one of the contributory factors or from their respective combined effects. A poorly designed or defectively made product may cause an accident or inflict injury upon a careful user. A product abused in service, may result in injury or damage however carefully designed or structured. A usage environment more demanding than usual, imposing service conditions severer than those for which the product was designed, may accelerate deterioration leading to unexpected failure, thereby causing injury or damage.

When the contributory factors impose their combined effects, the establishment of causation becomes increasingly difficult. Even within a framework of factual developments, causation is often expressed in terms of conflicting opinions, leaving causation to the judgement of the adjudicating process.

THE PRODUCT

The manufacturer of any product, be it a complicated machine or a simple plastic gadget, provides a device usable for an expressed pur-

pose. In addition to providing the product, marketing practices demand continuing effort to remain competitive, i.e. to improve design and strive to reduce the cost of manufacture. This dual demand stimulates continuing interest to adapt to changing technology. When such changes are made without provision for accommodating adverse effects apparent only after extended service usage, the manufacturer acquires a liability for injury or damage. Legal precedent has quite well established that product changes must consider the user's interest beyond existing trade standards and usage codes and laws; to prevent injury to the user and others reasonably expected to be affected by use of the product.

Over and beyond meeting marketing demands, the product manufacturer is obligated to protect against unreasonable risks of injury. Up to enactment of product safety and environmental health laws, product-related accidents were generally evaluated within the product-user relationship; to establish responsibilities for the unsafe condition or the unsafe act. The injured product user sued on the basis of breach of warranty, a defect, or negligence in design or manufacture. The product manufacturer, having no basis for countersuit against the user, ordinarily provided a defense which sought to show, among other considerations, that the accident resulted from abuse of the product, or negligence on the part of the user. The concept of product liability now evaluates the accident in terms of strict liability along with negligence. Whereas in negligence, what the manufacturer knows or should have known about the product becomes the essential consideration of the reasonableness of action, in strict liability, knowledge of the dangerous characteristics of the product is attributed to the manufacturer and his agents including the seller, even though not reasonably expected to have such knowledge.

The expectation that the user should have been knowledgeable enough to avoid injury, particularly for a new or technically involved product, is minimized. Assigned to the product manufacturer or supplier is a responsibility for the adverse consequences in the use of the product; the key issue in such accident litigation being whether placing the product on the market was unreasonable.

THE PRODUCT USER

The enormity of costs of accidents, particularly those involving the use and operation of motor vehicles, incurred each year in the United States, has and continues to warrant extensive efforts in the private

and public sectors, to allay accidental injuries and deaths. Accident prevention programs geared to industry and home product users, are commonplace. Yet, the accident toll prevails, enhancing the continuing experience that the user, rather than the product, is the more likely contributor.

Attempts to identify those users more likely than others, to contribute to accidents—accident-prone persons—have not been fruitful. Acts of carelessness, poor judgement, and preoccupation are attributed equally to the young and old, rich and poor, male and female, providing the injured and dead resulting from accidents. Studies of motor vehicle accidents—sharing a commonality of a well established product, a licensed, therefore a knowledgeable user, and a well-defined usage pattern—establishes the good driver, i.e. least likely to be involved in fatal accidents, as emotionally stable and socially well adjusted. Bad drivers are characterized by negative personality signs such as egocentricity, aggressiveness, social irresponsibility, anxiety, conflict with authority, etc. It is also recognized that these negative characteristics may be ascribed to individuals normally good drivers, but who are temporarily emotionally upset. The American Medical Association defines the state of temporary emotional upset as:

1. absorption with a problem to such an extent that the individual is indifferent and inattentive to external conditions;
2. despondence so great as to cause psychometric retardation;
3. heightened aggressiveness or impulsiveness to such degree as to impair judgement and decrease caution.

Such studies, further, have indicated relationships between group classification distinctions shown, and frequency of fatalities for adult drivers:

Age:	Increases with age
Sex:	Decreases for females
Race:	Increases for non-whites
Marital Status:	Decreases when married
Socio-Economic:	Social and work-related activities as established by income level are major contributors; increasing as level decreases
Psychological:	Decreases with individual and group awareness, tempered by group attitudes
Physical and Medical:	Decreases with personal awareness and individual responsive capability
Temporary Behavioral Changes:	Increases according to the effects of alcohol, drugs, emotional disturbances, etc.

Aside from the motor vehicle accidents, the role of the product user as a contributor to the accident remains obscured unless a fatality or the severity of an injury warrants detailed investigation. Blue collar workers and tradesmen are more apt to be injured in the work area. Professional, clerical, management, and office workers are more apt to be injured at home than in the work area. The successful use of any product requires familiarity with the product and awareness of its injury or damage potential. Without these, the risk for accident involvement increases. To the extent that such risks are recognized, accident prevention programs are instituted by employers, insurance indemnifiers, and consumer agencies affected by the extent of injuries or damages. Consumers are alerted and cautioned in regard to product usage hazards; employees manufacturing and servicing the product are instructed and trained to avoid unsafe practices and provided with protective equipment.

The accident prevention program seeks to identify and eliminate the causes of accidents. Causal effects are categorized according to usage practices, prevailing usage hazards, or product defects, to direct action for attaining improvements. Applied with consistency to extend user awareness and the elimination of usage hazards, accident prevention programs are acceptable phases of the development and use of any product.

USAGE CONDITIONS

Repeated usage, time, and environmental conditions affect the functioning and serviceability of the product. Corrosion weakens metal parts, sunlight and heat degrade plastics, vibration dislodges screw threads, insects and microbial organisms provide organic spoilage, etc. All such effects in time become contributors to product malfunctions and breakdowns which in turn may contribute to accidents when the products can no longer function as normally expected.

Product breakdown is a manifestation of cumulative adverse effects imposed upon the product and its component parts in service. Worn, cracked, or otherwise damaged from usage and service exposure, those characteristics associated with product serviceability are mitigated, to accelerate failure. To the extent that service experience has established a breakdown pattern, concomitant with use of the product, is a responsibility to avert such breakdowns by evaluations prior to use; maintenance programs, inspections, tests, etc. Failure to exercise such responsibility ascribes negligence to the

product owner and depending upon the extent of awareness, to the product user as well. The agents and conditions associated with product malfunction and breakdown, are manifestations of forces contributing to changes in material composition or structure, affecting characteristics that contribute to product functioning. By these changes, the product user becomes liable to be victimized rather than benefitted. As described in the chapters following, the deteriorating forces are many and varied. Their effects are quite often unapparent until occurence of the injury or damage.

THE PRODUCT ACCIDENT—A STUDY

The Events

In the process of hoisting a heavy transformer to be attached to a pole supporting electric power lines, a working crew secured a pulley block to the top of the pole, planning to make the lift using block and rope rigging. In this arrangement, a length of rope in motion between two blocks provides the lifting movement. Rope motion is attained by looping rope turns about a rotating power drum on the service truck, called a winch.

Just as the lift was almost completed, the transformer fell to the ground thereby inflicting serious injury to a crew member and damage to the transformer. In a subrogation suit against the manufacturer of the transformer, the jury found for the plaintiff and awarded compensation for the injury.

The plaintiff's claim ascribed the injury to faulty design of the transformer; that being unable to sustain its own weight when being lifted in normal working fashion, constituted poor design. The defendant, the transformer manufacturer, sought to negate the claim by demonstrating adherence to trade standards and a performance record of no such failure incidents reported by users of many such transformers over a period of many years. The accident was attributed rather, to misuse of a defective hoisting rope.

The Conditions

Investigation of the accident by the electric power company provided no indications of defective equipment or unsafe practices as contributory to the accident. The winch surface was clean and smooth, with no grooves or cracks to snag the rope loops. The secured pulley block remained atop the pole, a short length of rope dangling

freely from its secured end. The transformer, apparently cracked at the top of the casing, was on the ground at some distance from the pole, obviously deflected in its fall when striking a guy wire supporting the pole. The lower block freed from the rope, and slightly damaged, lay alongside the transformer. Interviews with the work crew disclosed no unusual sounds or other indications of rope failure prior to the fall of the transformer. The lifting had been accomplished in two stages. Two wire rope slings had been secured to the lifting eye bolts; one hooked to the lifting boom of the truck hoist, and the other to the rope block. The truck boom had first lifted the transformer to its limit, then the load was transferred to the rope block to continue the lift. The transformer fell when in position atop the pole, ready to be secured, bolted to brackets already in place.

The Winch's Contribution

The winch is a power-driven drum transmitting energy by wrapping rope turns around its surface. Pulled to press tightly on the drum as it turns, the rope moves to exert a pulling force; slackened, the rope loses its pulling force. By tightening or slackening the rope, the winch

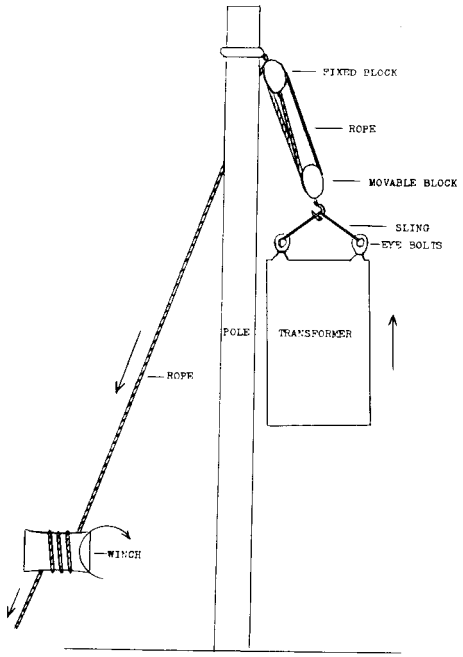

FIGURE 1-1. Hoisting the transformer.

operator controls the tension on the rope required to pull and place the load.

Winch operation is hazardous. Handling rope standing in close proximity to the rotating drum provides ample opportunity for injury. A cracked or otherwise flawed winch surface causes uneven rope movement or overriding of turns to provide unanticipated hazards. A rope handler guiding the rope as it exits the winch surface may be pulled into the winch when an overriding turn changes the direction of rope movement.

The physical condition of the winch surface and the fact that the lifting was essentially completed without incident or injury, attests to the elimination of the winch as contributory to the accident.

The Rigging's Contribution

The Blocks

Examination of both fixed and movable blocks after the accident, showed each to be in proper working condition with no indications of being contributory to the accident. Both were structured and in size consistent with use of the ¾-inch diameter manila rope involved. Each block provided three free-running pulleys to sustain the weight being lifted and impart the mechanical advantage inherent in the rigging, thereby imposing upon the rope a pulling force much lower than that exerted by the weight of the transformer; the weight being sustained by the six rope lengths emanating from the movable block. So long as the pulleys remain free-running, tensions imposed upon any portion of the rope moving from block to winch, are equalized. Rope movement at the winch however, is six times greater than movement at the movable block sustaining the weight being lifted.

The damage to the movable block noted, was of a minor nature incurred as a result of the fall and not affecting the block's functioning.

The Rope

Examination of the rope confirmed its manufacture as a high grade manila rope. Such rope was required to attain a minimum breaking strength of 5,400 pounds, when new. As evident visually, service usage and exposure had obviously deteriorated the rope. When upon test, the rope had attained a breaking strength of 1,800 pounds, the extent of deterioration was confirmed by the measured strength loss to one third its strength new.

The rope length left dangling secured to the fixed block after the accident, established that at the time when the rope had parted, both

blocks were in close proximity to one another. Parting had occurred at a point on the rope just emerging from the fixed block when the tensile pull matched the rope's breaking strength. Cuts, tears, or other rope surface damages noted, were not contributory to parting.

That rope deteriorates with age and usage, is a fact well-known to experienced rope users. The signs of deterioration are visually apparent. The twisted structure is loosened. The fibers darken, becoming embrittled and splintery. Unexposed inner surfaces, though shielded from the atmosphere, become soiled and chafed from internal abrasion. A deteriorated rope provides a usage hazard; its use for the rigging constitutes an unsafe practice. Another indication of unsafe practice in the lifting operation lies in the attainment of a pulling force high enough to cause the rope to part, i.e. 1,800 pounds. So long as the pulleys were free-running, as evident from examination of the blocks, in consideration of the mechanical advantage, the pulling force responsive to the transformer weight being lifted would not have exceeded 300 pounds. The conditions under which the 1,800-pound force would have prevailed required that the blocks be jammed together or that the transformer movement be restrained, either of which, if allowed to occur, would provide additional hazard to the lifting process.

The Transformer's Contribution

An industrial product like the transformer, because of extensive use is generally manufactured to comply with the industry-wide standards. These establish identifiable product characteristics which express design, performance, structural, or material requirements. It was by comparison with such standards requirements, that the composition of the transformer's aluminum alloy casing was determined to be substandard.

All defects attributed to the transformer contributory to its failure —the poor design manifest in metal sections too weak to fully sustain the eye bolts by which lifted, eye bolts too short to provide full threaded joint strength, and the substandard composition—collectively established inability to sustain imposed service stresses. The fact that the lifting operation was successful just short of the final positioning of the transformer, showed that the design was adequate only for the lifting condition in which the weight of the transformer freely suspended, imposed stresses upon the two eye bolts equally. For a transformer weight of 1,000 pounds, its design would have been adequate if the stress imposed upon each eye bolt had been limited to 500 pounds. However, when the lifting conditions imposed much