Clearly Defining Loss Control Terms
WILL A JURY UNDERSTAND YOU?

By Dave Curry

IN TODAY'S LITIGIOUS SOCIETY, an OSH professional may be called to testify in front of a jury, regardless of the merit of the case against the individual's firm. Considering this, the individual must be able to communicate effectively with jury members. A serious potential barrier is the language employed by the speaker on the stand. While the OSH professional may know precisely what s/he is speaking about, such knowledge is valueless unless it can be effectively conveyed to the jury members.

In linguistics, semantics is the science relating to the meaning of (or arising from distinctions between) different words or symbols. Most of us probably assume that we are effective communicators because we can generally convey information to others to our own degree of satisfaction. What we may not recognize is that without bidirectional interaction with the recipients of our messages, we have relatively little ability to judge whether the meaning of our message has been accurately received by the listener (even if the words themselves were).

When speaking or writing using words or phrases with concrete, accepted meanings, this is generally not a major hurdle. We have all at one time or another seen a cat or a rock—we can point to such objects and all agree that one is a small, furry creature frequently kept as a pet, while the other is a firm, hard, lifeless object. Communicators rarely become confused in exchanges dealing with such specific referents. The same is usually true of even more abstract concepts that have a mutually accepted meaning within a subset of the general population that shares common experience or training. Difficulties may arise when the definitions are specific, but not exclusive. Defining *horse* as "a quadruped animal usually used for riding with a saddle or pulling loads in an agricultural setting" may seem adequate, until one considers that the same definition might equally well apply to a camel or water buffalo depending on the experience of the listener.

KEY TAKEAWAYS
- **Confusion and miscommunication are common when particular terms of art are the same as or similar to terms within the common vernacular.**
- **This problem becomes even more complex when multiple speakers use the same terms but employ different meanings.**
- **For effective communication to occur, a common understanding must exist for both speaker and listener of what is meant by certain terms.**

An even greater problem begins to emerge when more abstract concepts (e.g., beauty, truth, justice) are discussed. Normally, we make assumptions about such concepts that a general shared understanding of meaning exists, even if nuances of the concept may differ between the sender and receiver. However, problems arise when the nuances are the critical issue. For example, it has been suggested that most men only perceive basic colors (e.g., black, white, red, orange, yellow, green, blue and violet), while women perceive a difference between indigo and iris.

The problem becomes even more acute when vernacular terms are endowed with special meaning under certain circumstances within a subset of the population. This is frequently the case when expert testimony is presented in front of a jury. Terms that the jury members recognize from the common vernacular may not have the same meaning with respect to understanding the issues before them (Figure 1).

The source/sender has a message (the concept to be conveyed) that is held in the mind of the testifying party. Encoding represents the words s/he uses to express that concept. The receivers in such a case are the minds of the jury members. Encoding involves the speaker putting the concept in his/her mind into spoken words (the channel). Decoding is the interpretation of the words used to convey the message by the minds of the receivers. In this example, noise represents the degree loss in the transfer of the original concept during the encoding and decoding process. The greater the overlap in the fields of experience between the sender and receiver, the greater the likelihood that the message conveyed will be that which was intended by the sender.

Often, relatively little overlap exists between the field of experience of a speaker who is knowledgeable in a certain field and that of members of the receiving audience who are not. This is particularly true in cases where experts are testifying in front of a jury. Were there great overlap between the two, the expert would likely be unnecessary, since the jury would already have a sufficient grasp of the issues involved and, thus, not require an expert's input.

Anyone testifying before a jury should be careful to use words and concepts easily assimilable by members of that jury; however, this can be difficult to accomplish in practice (particularly if speakers on the opposing side are using the same terms but emphasizing different meanings). Further, the simplest terms are often the most easily misconstrued or misinterpreted because of

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the assumption of a common understanding between sender and receiver. To use the example noted, if the expert says "purple," the jury may assume that s/he means iris, indigo or some other completely different shade. What if the difference between the two is the crucial issue in the case?

While the speaker may make certain that s/he is consistent and precise in his/her word choice and use, certainly at least some listeners will interpret the meaning differently than does the speaker. Since the speaker on the stand does not receive feedback from the jury (i.e., a two-way flow of communication does not exist), the speaker will often be unable to discern whether the precise meaning conveyed by his/her words has been effectively communicated to the jury members, whether the jury has interpreted the speaker's words with a more common use of the terms employed, or whether the jury has understood the speaker at all. Therefore, it is necessary for the speaker to precisely define the terms so that the jury understands what s/he is attempting to convey, and perhaps even regularly underscore these definitions during his/her presentation.

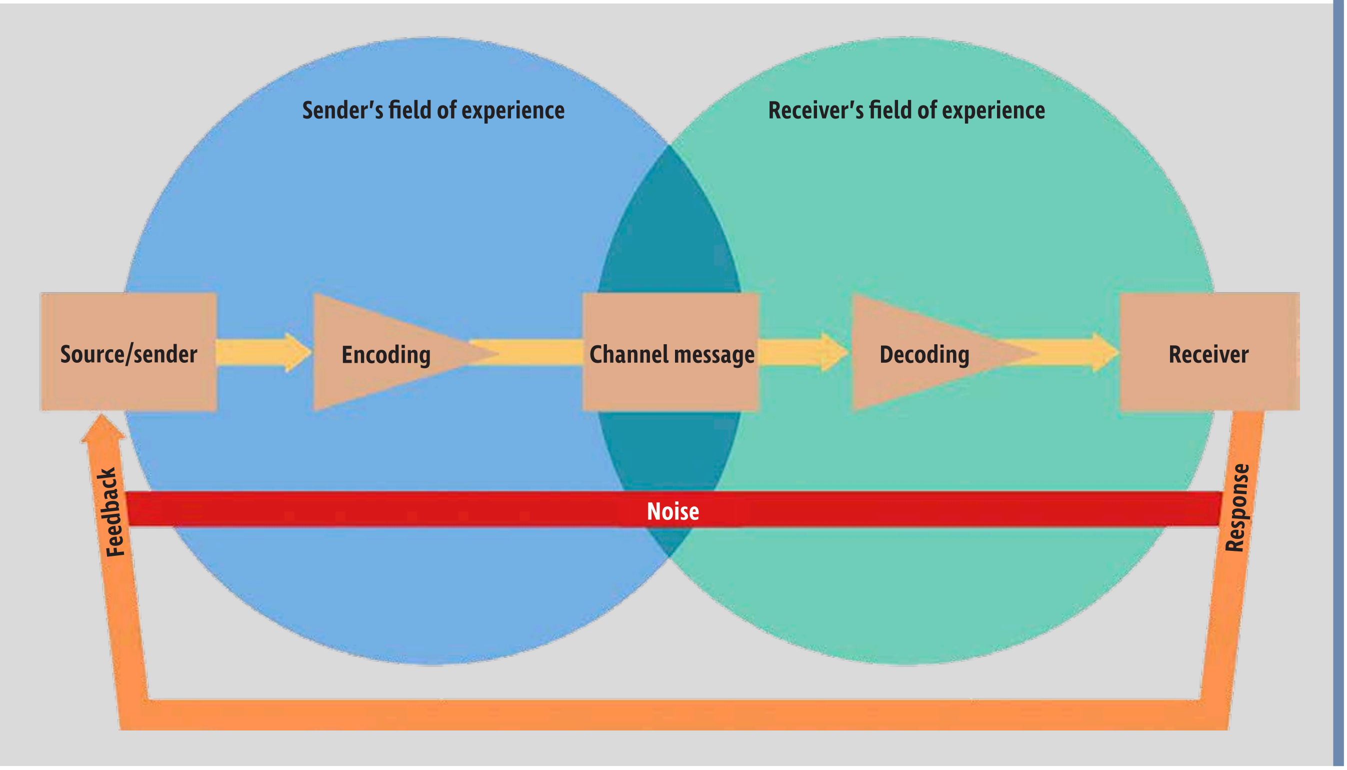
Consider an example. Often, when citing published scientific research in a courtroom, one side or the other will say that "significant" effects have been shown to exist with respect to a change in design or treatment. Typically, such a statement suitably impresses jury members about the efficacy of the suggested change to potentially prevent an incident or injury. Black's Law Dictionary (Garner, 2009) provides no definition of the term *significant*. Webster's New World Dictionary (Webster's hereafter) defines the term as "having or expressing a meaning; full of meaning; important; momentous." Interestingly, this definition has little in common with the meaning of the word *significant* when used in reference to statistical analysis. According to Bryman (2012):

> A test of statistical significance allows the analyst to estimate how confident he or she can be that the results deriving from a study based on a randomly selected sample are generalizable to the population from which the sample has drawn. When examining statistical significance in relation to the relationship between two variables, it also tells us about the risk of concluding that there is in fact a relationship in the population when there is no such relationship in the population. If an analysis reveals a statistically significant finding, this does not mean that the finding is intrinsically significant or important. The word *significant* seems to imply importance. However, statistical significance is solely concerned with the confidence researchers can have in their findings. It does not mean that a statistically significant finding is substantively significant.

In short, the term *significant* when used by a researcher has more in common with the generally used term *reliable*; it may represent little or no meaningful difference whatsoever. To employ a prosaic example, a researcher may determine that oranges grown in Florida have a vitamin C content that is a microgram (a millionth of a gram) higher than those grown in California. These results may be statistically significant, even though they have no discernible effect on taste, color or nutritional value whatsoever.

For an example that may occur in the courtroom environment, an expert may cite research showing that a significant difference exists in reaction time for vehicle operators who are simultaneously speaking on a cell phone, then opine that the use of such a device at the time of an incident likely led to the incident. While the first portion of this may be true, this significant increase in reaction time is generally on the order of 0.1 seconds (Strayer, Cooper,

FIGURE 1
COMMUNICATION MODEL



Turrill, et al., 2013). At 40 mph, this is the time that it takes a vehicle to move approximately 6 ft, or that would allow a vehicle to slow down an additional 1.3 mph by employing heavy braking. In the real world, neither is likely to be causative of either an incident or a substantial increase in the likelihood of injury.

The remainder of this article will focus on a few terms regularly used in the testimony of experts and attorneys during product liability litigation that are frequently confusing to or actively misunderstood by jury members. The sources cited are illustrative rather than necessarily authoritative.

Negligence

Webster's defines the word *negligence* as "failure to use a reasonable amount of care when such failure results in injury or damage to another." Garner (2009) defines the term as "the failure to exercise the standard of care that a reasonably prudent person would have exercised in a similar situation." The latter source also states that a reasonable person is one who "acts sensibly, does things without serious delay and takes proper but not excessive precautions." Heuston (1977) says:

> The reasonable man connotes a person whose notions and standards of behavior and responsibility correspond with those generally obtained among ordinary people in our society at the present time, who seldom allows his emotions to overbear his reason and whose habits are moderate and whose disposition is equable. He is not necessarily the same as the average man—a term which implies an amalgamation of counter-balancing extremes.

The sum of these statements is that an assertion of negligence must be based on the normal behavior of the members of the subject population. If such is the case, then declaring a normal behavior to be somehow negligent is inherently unsupportable.

Such an assertion, however, is common in the courtroom. Let's examine the issue of speed in roadway collisions. A set of studies conducted by Federal Highway Administration (FHWA) involved testing at more than 150 locations in multiple states to examine actual driver compliance with statutory speed limits (Tignor & Warren, 1990). The results indicate that more than 70% of motorists exceed the posted speed limits in urban areas, with some sites having compliance rates as low as 3%. Less than 10% of the sites tested had compliance rates greater than 50%. The report authors conclude that "most speed zones are posted 8 to 12 mph below the prevailing travel speed and 15 mph or more below the maximum safe speed." Another study focusing exclusively on highway speeds in Arizona concludes that, for the 56 locations surveyed, speed limit compliance rates ranged from 30% to 55% depending on the speed limits in place at those locations (Skszek, 2004). In short, traveling above the posted speed limit represents normal, not extraordinary, behavior on the part of vehicle operators.

According to FHWA, all states and most local agencies are required by law to use the 85th percentile speed of free-flowing traffic (i.e., the speed below which 85% of the traffic is traveling under unconstrained conditions) as the primary factor in establishing speed limits. For a normally distributed variable, one standard deviation in either direction from the mean is considered the normal range and corresponds to the range between the 15th and 85th percentiles. The basic intent of speed zoning is to identify a safe and reasonable limit for a given road section, and the 85th percentile speed reflects the maximum safe speed as assessed by the driving population. This value is then modified based on other criteria. Indeed, the current edition of the Manual on Uniform Traffic Control Devices (MUTCD) requires that:

> Speed zones (other than statutory speed limits) shall only be established on the basis of an engineering study that has been performed in accordance with traffic engineering practices. The engineering study shall include an analysis of the current speed distribution of free-flowing vehicles. (FHWA, 2009)

The same source also states that even after adjustments for other considerations, "When a speed limit within a speed zone is posted, it should be within 5 mph of the 85th-percentile speed of free-flowing traffic."

Given the fact that prevailing vehicle speeds normally exceed posted limits on roadways, it may be surprising to some that even the average speed of travel does not correspond to the lowest probability of incident. Research has repeatedly demonstrated that travel at the 85th percentile speed results in the lowest likelihood of incident involvement.

This relationship was first demonstrated by Solomon (1964) and is colloquially referred to as the Solomon curve. The relationship has been repeatedly confirmed by other researchers as well (Cirello, 1968; Eggert, 2016; Muchuruza & Mussa, 2005). West and Dunn (1971) also obtained similar results regarding crash likelihood, although their results indicate that crash likelihood as a function of vehicle speed is not significantly different within a 15-mph range around the average travel speed on the roadways involved in their testing.

There are various theories regarding why a higher average speed is related to a lower incidence of crashes, but no complete consensus. It may simply represent the fact that travel at the 85th percentile speed or above requires a higher degree of driver attention/concentration than does simply flowing with the pack (i.e., less potential for driver distraction away from the vehicle operation task itself).

Over the years, the driving public has been inundated with statistics such as the fact that speeding is associated with more than one-third of all fatal crashes. On the surface, this statistic is true, but practically begs for further examination. As noted, considerably more than half of the vehicles on a roadway are typically traveling above the speed limit (i.e., speeding.) As such, it would be unsurprising if at least one-third of all vehicles were doing so at the time of a fatal crash. Indeed, if the majority of vehicles are traveling above the speed limit at any given time (a likely probability based on the preceding discussion), this means that the minority, which are traveling at or below the speed limit, must therefore be associated with two-thirds of all fatal crashes. In short, this means that traveling at or below the speed limit results in twice as high a likelihood of being involved in a fatal crash as does traveling faster. This type of data hardly supports the conclusion that the normal driver is somehow necessarily negligent or even acting unsafely in the case of an incident due to simply traveling above the speed limit.

Safe(ty)

Garner (2009) defines the word *safe* as "not exposed to danger; not causing danger" and cites as an example "driving at a safe limit of speed." Garner's (2009) definition and example are internally inconsistent with each other. The mere fact that one is traveling at a particular speed does not render one free from danger. Consider the potential for being injured or killed if one elects to bring one's vehicle to a complete stop in the middle of a roadway. Arguably, based on the amount of kinetic and potential energy involved in the vehicle, a speed of 0 mph under this definition would arguably be the safest speed based on Garner's (2009) definition. Such a position is logically unsupportable. National Safety Council's (NSC) *Accident Prevention Manual* provides a more rational definition of the word *safe* as "a condition of relative freedom from danger" (Hagan, Montgomery & O'Reilly, 2015). The same source defines *safety* as "The control of recognized hazards to attain an acceptable level of risk."

ANSI B11.0-2015 defines the term *acceptable risk* as "a risk level achieved after risk reduction measures have been applied. It is a risk level that is accepted for a given task (hazardous situation) or hazard." ANSI's (2015) notes on this topic state:

> The expression *acceptable risk* usually, but not always, refers to the level at which further technologically, functionally and financially feasible risk reduction measures or additional expenditure of resources will not result in significant reduction in risk. The decision to accept (tolerate) a risk is influenced by many factors including the culture, technological and economic feasibility of installing additional risk reduction measures, the degree of protection achieved through the use of additional risk reduction measures, and the regulatory requirements or best industry practice.

ANSI (2015) notes that "the user and supplier may have different level(s) of acceptable risk." Clearly, the engineering and safety community do not agree with Garner's (2009) extreme interpretation of *safe*.

Few would contend that such mundane products as beds, bathtubs, blankets or stairs are inherently unsafe, even though the use of these products routinely kills people around the world each year. According to NSC (2016), the following number of Americans were killed in 2013 for each of these example products:

- drowning and submersion while in or falling into bathtub: 464;
- fall involving bed, chair or other furniture: 1,170;
- accidental suffocation and strangulation in bed: 903;
- falls down stairs: 2,233.

For each of these products, technically feasible alternatives are available at little or no cost. The authors can find no reported instances of someone drowning in a shower stall. Most individuals do not inherently need to sit or sleep on an elevated surface. The need for sheets and blankets can be eliminated by simply turning up the thermostat by 1 or 2 degrees. Single story buildings or elevators could be mandated. In all these cases, the alternatives are arguably safer under Garner's (2009) definition, but the public has elected not to embrace them because there is general consensus that these products have acceptable/tolerable risk levels.

Another example is smaller versus larger vehicles. Most members of the general public can intuitively determine which vehicle would fare better in a head-on collision between a large old SUV and a new Smart car. The current prices of the two vehicles are comparable or in favor of the larger vehicle. If safety were the only concern, no one would purchase a Smart car and everyone would be driving 1990's-era Suburbans. Such is demonstrably not the case. Obviously, both the manufacturers and purchasers of the Smart car find the risk acceptable to themselves in light of other considerations.

In a litigation environment, it is often contended that a product is either safe or unsafe (i.e., that safety is somehow a dichotomous, either/or variable). It is often contended that no level of risk is acceptable and that all products must be risk-free to be considered safe. It is (and has been for many years) widely recognized within the professional safety community that a completely safe product does not exist and that a state of zero risk is inherently unattainable. As such, this contention by opposing attorneys is unsupportable. The safety of a product represents a continuum, and the mere fact that a safer alternative may be available does not render a different incarnation of a product to be unsafe.

The situation is analogous to that of relative height. The mere fact that we all agree that former NBA player Shaquille O'Neal at 7-ft 1-in. is tall does not somehow render Michael Jordan at 6-ft 6-in. to be, by definition, short. One is simply taller than the other, and both considerably exceed the average height of an American male (5-ft 9-in.). Likewise, the fact that if all buildings were to be built underground, one could neither fall off the roof or out the window does not render multistory or above-ground structures inherently unsafe.

This fact is explicitly recognized in both the engineering and professional safety communities. Brauer (2006) says:

> What is accepted as safe is neither constant nor absolute. Each person and society establishes what level of safety and health is acceptable. Not everyone agrees on whether things are safe enough. People would like to be free from risks. However, every activity has some risk. The level of risk that society finds acceptable is a moral issue, not just a technical, economic, political or legal one. Society participates in deciding what risk is acceptable and at what price. The standards are not constant. They change over time, may vary by location, and are also affected by who is paying for the risk reduction. . . . There is a region of uncertainty between that which is acceptably safe and that which is unacceptably dangerous. Engineers face a dilemma in dealing with this middle region because they cannot depend on their own intuition to decide what is safe enough. To achieve acceptably safe products and environments, engineers must be able to recognize hazards and apply current standards of society found in laws, regulations, judicial interpretation and public expectation. There is a trend toward lowering levels of acceptable risk, requiring engineers to anticipate tighter standards than exist at the time they design something. There will never be a final answer to the question "How safe is safe enough?"

All product design represents a series of trade-offs between various alternatives with different strengths and weaknesses relative to each other. A viable absolute best alternative rarely exists across all of the variables that must be considered in the design of a product, nor is continuous risk reduction the only criterion of importance. Even when risk reduction is determined necessary, ANSI B11.0 specifically notes the following:

> Not all potential risk reduction measures are **practicable** [emphasis added]. Many factors determine if the risk reduction measure is practicable. It is **necessary** [emphasis added] to evaluate the application of the risk reduction measure against the following factors:
> - regulatory obligations;
> - effectiveness;
> - usability;
> - durability and maintainability;
> - ergonomic impact;

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- economic feasibility;
- introduction of new hazards;
- productivity;
- machine performance;
- technological feasibility.

Of note: both economic and technological feasibility are mentioned in this list. Cost must always be weighed against the return on investment derived from increasing the safety of a product. It makes little sense to significantly raise the cost of a product to gain a minimal increase in potential safety, although the opposite is frequently argued in court. An increase in safety is only of value if it is necessary to raise the product safety to the acceptable level. To use an extreme example, operating a car wearing both a scuba suit and a crash helmet may marginally improve your safety in the event that your vehicle somehow ends up at the bottom of a river, but few of us elect to do so. The vehicle is already acceptably safe.

Many attorneys are reluctant to make such an argument before members of a jury, but, if presented properly, doing so may not be perceived negatively by them. The most important element of such a presentation is making it apparent that the engineer or manufacturer is not being miserly or callous in making such a comparison. Consumers (including members of the jury) continually make such decisions themselves during their daily lives. Like the example of the Suburban versus the Smart car, it is easy for consumers to read available published data to determine the safest type of vehicle in the event of a collision. The fact that this type of vehicle is not the only type of vehicle that they purchase is prima facie evidence that safety is not the only criterion they use in making a selection. Consumers tend to select a vehicle that they determine is acceptably safe, then increase the relative weighting of other considerations in their choice. The same is true of both engineers and manufacturers.

Likewise, technical feasibility must also be a driving factor in the evaluation of alternative designs. Webster's defines the word *feasible* as "capable of being done or carried out; practicable; possible." Garner (2009) does not define the term at all. Webster's definition is inadequate for use in either a court of law or an engineering design studio because it ignores the critical issues of viability and usability. Based on Webster's definition alone, a submarine equipped with screen doors rather than watertight hatches would be feasible in that it could be done or carried out. The fact that such a vessel would not survive its maiden voyage appears to be immaterial based on Webster's definition.

While the OSH professional may know precisely what s/he is speaking about, such knowledge is valueless unless it can be effectively conveyed to the jury members.

In the real world, a product must be not only buildable but also functional, usable and accomplish its intended purpose. It would be a wonderful world indeed if all potential solutions to a problem were equally feasible, but such is not normally the case. The mere existence of an ineffective method of reducing risk does not suggest that it should be incorporated into a product any more than an outboard motor should be attached to a refrigerator simply because one is available. A solution to a problem that cannot be relied on or that introduces new or greater risks is not truly a solution.

As noted, determining the acceptable risk level is often difficult in the abstract. One reasonable approach is to evaluate the question in terms of relative risk in comparison with some familiar product that is considered generally and acceptably (although not necessarily absolutely) safe. For this purpose, we will use motor vehicles and National Highway Traffic Safety Administration (NHTSA, 2016) data for 2015. Some of the following numbers are approximations due to the relative coarseness of the underlying data.

- total vehicle miles traveled: 3,095,373,000,000;
- fatal incidents: 32,166;
- injury incidents: 1,715,000;
- registered vehicles: 281,312,446;
- licensed operators: 218,084,465;
- odds of a fatal incident per mile: 1 in 96 million;
- odds of injury incident per mile: 1 in 1.8 million;
- odds of fatal incident per operator: 1 in 6,780;
- odds of injury incident per operator: 1 in 127;
- odds of fatal incident per hour of operation (assumed average speed of 30 mph): 1 in 3.2 million;
- odds of fatal incident per hour of operation (assumed average speed of 25 mph): 1 in 3.85 million;
- odds of injury incident per hour of operation (assumed average speed of 30 mph): 1 in 60,163;
- odds of injury incident per hour of operation (assumed average speed of 25 mph): 1 in 72,195.

An alternative method of evaluating risk is in terms of relative risk of injury across multiple types of products per hour of exposure. Such an approach is illustrated as follows (product and the number of hospital-treated injuries per million hours of use):

- electric hedge trimmer: 104;
- scaffolding: 65;
- axe: 21;
- bicycle: 20;
- automobile: 13.9 to 16.6;
- stepladder/household ladder: 10;
- car jack: 9;
- hammer or mallet: 7;
- gas lawnmower: 6;
- handsaw: 6;
- stove pot: 4;
- bathtub: 3;
- wheelbarrow: 2 (Hayward, 1996; NHTSA, 2016).

As noted, in the courtroom, juries are frequently presented with no comparative injury frequency information, being left to rely on their own knowledge of a product (or lack thereof) to assess its relative safety. Such a situation can be disastrous for the defense. For members of the general public, the normal method of assessing the potential risk of a product is based primarily on their familiarity with the product, the perceived complexity of a product and any experience (whether personal or otherwise) that they have or have heard about regarding potential incidents with the product. A familiar example of this is commercial aircraft. Most people who are afraid of flying focus on stories of commercial aircraft disasters without regard to how infrequently such incidents occur. One has a far higher likelihood of perishing in a crash traveling to or from the airport in one's own automobile than while traveling in the aircraft.

Prior personal experience with a product or practice, on the other hand, can operate in a much more complex fashion when evaluating safety. Two examples will serve to illustrate this:

1) Imagine two workers (a novice and a highly experienced journeyman) confronted with the need to travel 15 minutes back and forth across the workplace to lock and tag out an electrical circuit prior to working on it. Which worker is more likely to decide that the effort of doing so is not warranted because his level of expertise compensates for the obvious risk and allows the worker to wire the circuit hot?

2) Consider two drivers, one a 16-year-old boy who has just obtained his license within the past few months, the other a 35-year-old man with a wife and children. Which driver is more likely to elect to perform a risky maneuver in his vehicle to amuse his friends?

The probability of a person electing to be exposed to the stated risk is likely different in each case. In both examples, the decision is largely determined by the perceived hazardousness of the activity, the benefit to be derived in exposing oneself to it and the subjectively assessed skill level of the individual in dealing with the hazard. In the first example, the journeyman may accurately perceive himself to have a greater level of skill and competence than the novice, and thus may assess the risk to be sufficiently low in comparison with the benefit to be derived that he elects to perform the task hot. The hazard remains the same in both cases, only the perceived likelihood of suffering consequences is assessed differently between the two individuals. In the second example, the more experienced operator likely will more accurately assess his competence to perform the risky maneuver and may also assess that he has more to lose and less to gain in the accomplishment of the maneuver. It is likely that he will choose not to undertake the risky maneuver.

Risk

The word *risk* has been used occasionally in the preceding discussion, as it often is in the litigation arena. Garner (2009) defines *risk* as "The uncertainty of a result, happening or loss; the chance of injury, damage or loss; esp., the existence and extent of the possibility of harm." This is not unlike the way the word is typically used by both engineering and safety professionals. Brauer (2006) defines *risk* as "a measure of both the likelihood and the consequences of all hazards of an activity or condition. It is a subjective evaluation of relative failure potential. It is the chance of injury, damage or loss."

ANSI B11.0 defines the term as "The combination of the probability of occurrence of harm and the severity of that harm," while DiBerardinis (1998) maintains that risk is "the possibility of an undesirable occurrence. The only justification for taking a particular risk is that the reward clearly exceeds the penalty if the associated accident takes place." A common element to almost all these definitions is the recognition that risk is a function of both a hazard and the likelihood and the consequences of encountering it.

Garner (2009) defines *hazard* as "Danger or peril; esp., a contributing factor to a peril." ANSI/ASSP Z690.1-2011 defines the same term as "Source of potential harm," while ANSI B11.0 defines it as "a potential source of harm." It is noteworthy that the legal source cited describes a hazard as necessarily dangerous or perilous, while the two engineering standards simply refer to it as potentially harmful, and do not automatically consider its mere existence to represent a dangerous condition per se. Hagan, Montgomery and O'Reilly (2015) take a more middle-of-the-road position, simply defining it as "a term applied to the individual or combined assessments of 'probability of loss' and potential amount of loss." This definition makes no assertion either that a hazard must be controlled or that hazards, if not controlled, are necessarily unacceptably dangerous in and of themselves. This decision can only be made after an assessment of both the level of risk and the potential means of mitigating it.

ANSI/ASSP Z690.2-2011 states, "All activities of an organization involve risk. Organizations manage risk by identifying it, analyzing it and then evaluating whether the risk should be modified by risk treatment in order to satisfy their risk criteria." It is noteworthy that the standard does not state that all risks must be eliminated or even addressed, rather that they must be evaluated, then a determination must be made about whether they should be addressed. The process of evaluating the risks associated with a product or practice is known as risk assessment. Techniques for accomplishing this are covered in ANSI/ASSP Z690.3-2011. All these techniques involve three main steps: risk identification, risk assessment and risk evaluation. Risk identification is the process of finding, recognizing and recording risks. Risk assessment involves determining the consequences and their probabilities for identified risk events, considering the presence and effectiveness of any existing controls. Risk evaluation involves comparing estimated levels of risk with risk criteria defined when the context was established, to determine the significance of the level and type of risk. These steps almost always involve at least some subjective evaluation on the part of both the manufacturer and user.

According to ANSI/ASSP Z690.2:

> A common approach is to divide risks into three bands:
>
> a) an upper band where the level of risk is regarded as intolerable whatever benefits the activity may bring, and risk treatment is essential whatever its cost;
>
> b) a middle band (or "gray" area) where costs and benefits are taken into account and opportunities balanced against potential consequences;
>
> c) a lower band where the level of risk is regarded as negligible, or so small that no risk treatment measures are needed.
>
> The as low as reasonably practicable or ALARP criteria system used in safety applications follows this approach, where, in the middle band, there is a sliding scale for low risks where costs and benefits can be directly compared, whereas for high risks the potential for harm must be reduced, until the cost of further reduction is entirely disproportionate to the safety benefit gained.

The last sentence is particularly noteworthy in that it specifically acknowledges that costs must be weighed against the benefits to be derived. If the likelihood of an event is sufficiently low, it may be that no further reduction in risk is warranted, no matter what

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the potential for injury. For example, doubling the price of a product to reduce the probability of a risk from one in a billion to one in two billion may not be warranted, no matter the level of potential injury to the user may be. Further, costs in such an evaluation cannot always be equated to simple monetary factors. Other issues such as technical feasibility, viability, and the likelihood of engendering risks of other types of hazards or increasing risk elsewhere also must be included in the evaluation.

Even once risk analysis determines that a risk should be addressed, how that should be accomplished remains to be determined. This is not necessarily a straightforward decision. ANSI/ASSP Z690.2-2011 explicitly states:

> Selecting the most appropriate risk treatment option involves balancing the costs and efforts of implementation against the benefits derived, with regard to legal, regulatory, and other requirements such as social responsibility and the protection of the natural environment. Decisions should also take into account risks which can warrant risk treatment that is not justifiable on economic grounds, e.g. severe (high negative consequence) but rare (low likelihood) risks.

In many cases, attorneys make reference to "the" risk reduction hierarchy, which is then expressed as design, guard, warn. In reality, many different hierarchies exist. Barnett and Brickman (1985) identify 45 different published safety hierarchies, some of which differ significantly in terms of the number, order, types and descriptions of hazard-control methods advocated. The authors conclude that "there is no such thing as **the** safety hierarchy; there are many hierarchies." Further, it is incorrect to assume that such a hierarchy must be followed in addressing risks until all are eliminated or minimized. Hall, Young, Frantz, et al. (2011), provide a masterful response to such an assertion:

> Safety hierarchies do not distinguish between "acceptable" and "unacceptable" risk. In fact, they do not consider risk at all. They provide no guidance as to when additional efforts to reduce risk are no longer necessary or appropriate (i.e., when one has reached a level that is deemed "acceptable").
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> Determining the extent to which risks need to be mitigated or eliminated involves value judgments that fall outside the domain of safety hierarchies. The mere presence of a risk does not, in itself, require that it be eliminated or reduced. In fact, we as a society regularly and willingly accept and seek out many risks in return for various practical benefits (e.g., increases in efficiency, capability, quality, enjoyment, comfort, satisfaction, etc.). We also accept some degree of risk to the extent that the costs of reducing it (in terms of time, effort, resources, esteem, social standing, etc.) are viewed as disproportionate to the benefits gained by a reduction in the risk. Such value judgments (balancing these benefits and costs) can change over time and across situations, further complicating the application of safety hierarchies.

The authors point out that, in many cases, some degree of risk may be a desirable quality in and of itself. It is self-evident that advertising such activities as riding the "world's lowest, slowest roller coaster," downhill skiing on "breathtakingly flat slopes," or viewing auto races consisting of motionless vehicles would likely have little or no appeal to the general public, although each of these events would be markedly safer than the alternatives. Risk reduction methodologies, when employed, must be evaluated in conjunction with other criteria and real-world constraints, not predefined hierarchies.

Foreseeability

Garner (2009) defines *foreseeable* as "the quality of being reasonably anticipatable," while Webster's defines it as "of an action or event, that it was predictable or should be anticipated." Garner defines *reasonable* as "fair, proper, or moderate under the circumstances," while Webster's defines it as "a standard for what is fair and appropriate under usual and ordinary circumstances; that which is according to reason; the way a rational and just person would have acted." Under tort law, manufacturers are responsible for designing their products in anticipation of normal and "reasonably foreseeable misuse." ANSI B11.0 defines *reasonably foreseeable misuse* as "the use of a machine in a way not intended by the supplier or user, but which may result from readily predictable human behavior." A note from the same source says:

> For example, a risk assessment should address the following human factors (not intended as an all-inclusive list).
> •inappropriate actions as a result of mistakes, errors and poor judgment, excluding deliberate abuse of the machine;
> •inappropriate actions or reactions taken in response to unusual circumstances such as equipment malfunction;
> •the tendency to take the "path of least resistance" in carrying out a task; and
> •misreading, misinterpreting or forgetting information.

ANSI B11.0 does not define the associated terms *error*, *mistake* or *poor judgment*, although Garner (2009) does address the first two. *Error* is defined as "an assertion or belief that does not conform to objective reality; a belief that what is false is true or that what is true is false," while *mistake* is defined as "an error, misconception, or misunderstanding; an erroneous belief."

While potentially laudable in theory, many aspects of these definitions are lacking when examined considering simple practicality. The equipment manufacturer is not equipped with a means of foreseeing the future, nor is it capable of anticipating all the potential ways a product might be misused. The ways a product may be misused are theoretically infinite. Might someone elect to use a spray can as a hammer? Might one elect to drive on the opposing side of the roadway? Might one elect to fire bottle rockets by holding them between one's buttocks? Might someone elect to drop a shopping cart from an upper floor of a building onto passersby on the ground below? Perusal of the Internet shows that all these events have occurred. This does not mean that the product manufacturer is responsible for ensuring that its products cannot be misused in such ways. The manufacturer can only make a judgment about what is and is not reasonable based on both an assumption of rational behavior on the part of the product users and an assessment of the probability of such events occurring in the real world. Producers and manufacturers can and should attempt to design their products where possible to reduce the risk of actions or incidents that are likely to occur on an ongoing basis. Such a position is both reasonable and proper. Holding the manufacturer liable for aberrant, intentionally risk-taking or unlawful behavior on the part of product users is not.

One potential test for such behavior lies not in the simple fact of its occurrence, but in its overall rationality. Such an evaluation, however, requires a working definition of the concept of rationality. Such a definition can be adapted from Garner's (2009) definition of rational choice theory: "The theory that behavioral choices, including the choice to engage in criminal activity, are based on purposeful decisions that the potential benefits outweigh the risks." In short, a decision is rational if its potential benefits outweigh its potential risks. Such a definition is in accordance with Garner's definitions of *irrational* ("not guided by reason or by a fair consideration of the facts") and *reasonable* ("fair, proper, or moderate under the circumstances").

To use a prosaic example, the simple fact that a vehicle is unlikely to traverse a stretch of road at 3:00 a.m. does not make a pedestrian's choice to not look both ways before crossing either rational or reasonable; the risks far outweigh the potential benefit of eliminating the effort of looking. Conversely, the fact that one is fleeing from a collapsing building and must reach the other side of the street as rapidly as possible to avoid falling debris may make the same decision both rational and reasonable. The situation alters the relative benefit in the latter case.

Simple expediency does not render a product user's high levels of risk-taking either rational or reasonable; the potential benefit is unlikely to outweigh the risk in such cases. It must be recognized, however, that much like the discussion of formal risk assessment of a product, the perceived levels of risk and benefit by the product user are assessed subjectively. What may seem to be a reasonable risk will likely differ from one person to another. One person may judge it reasonable to bet money at even odds that the Chicago Cubs will win the World Series in any given year. Such a decision on the part of the individual is neither right nor wrong by any objective criteria but is unlikely to be felt reasonable or even rational by most of the baseball-viewing public (apologies to Cubs fans). The reasonableness of a course of action in a court of law is, of course, within the provenance of the jury. Likewise, the reasonableness of the protective measures employed on a product is within the provenance of the manufacturer, owner and user, hopefully based on prior experience and a thorough risk assessment.

A key point to recognize is that the perceived reasonableness of a course of action may change or evolve over time as a function of various factors such as product familiarity, level of expertise, experience or even the addition of safety features. Examples of such changes are detailed in the following paragraphs.

Assessments of product safety and the perceived risk level associated with a product tend to be directly related to the perceived hazardousness of a product. A familiar product whose benefits, risks and operations are well-known by the user will normally be judged as less hazardous than one whose hazards are unknown. Unfamiliar products are generally not pushed near the edges of their performance envelope or the edge of safe operation, while familiar products may be (i.e., users of unfamiliar products tend to stay well within the limits of safety for that product). As the level of familiarity with a product increases, the subjective level of perceived risk in using that product closer to its safety margins drops; users push the envelope progressively more over time.

Expertise in product use (which may or may not be the same as familiarity with a product) also has a profound effect on risk-taking behavior. Neophytes in a field of endeavor tend to follow rules and instructions to a greater degree than those who have wittingly or unwittingly traveled well beyond the limits of those rules in the past. The previous example of working on electrical circuits demonstrates this well. The higher the level of expertise, the lower the perceived risk of taking a particular action may be, under the assumption that the greater skill level of the operator compensates for the increased risk (i.e., the probability of a negative consequence decreases, although the cost of such a consequence remains the same).

The greater the degree of benign experience using a product in an unsafe fashion, the more likely that such behavior will be repeated. A familiar example of this is driver speed choice. If a driver occasionally travels at a speed higher than that allowed by law without being ticketed for speeding, the driver's propensity for such behavior increases over time. The longer the driver goes without being cited, the more frequent the speeding behavior becomes (i.e., the driver's subjective assessment of the perceived likelihood of encountering a negative consequence drops, so his/her willingness to engage in the behavior increases provided s/he experiences a positive benefit). Once caught and cited, what normally follows is a much closer adherence to the speed limit due to reevaluation of the probability of encountering the negative consequence. The driver's probability assessment continues to evolve over time if s/he is not again cited for speeding, normally followed by a resumption of prior speeding behavior in accordance with his/her current assessment of the potential for suffering negative consequences.

The incorporation of additional safety features into a device may have positive or negative effects on overall safety over time. If users of a device were comfortable with the prior level of safety on the device, they may elect to use the increased safety margin engendered by the new features to return themselves to their prior level of acceptable risk. One example of this would be the cable cars in San Francisco, CA, which for safety reasons travel at a maximum of 9.5 mph. When riding the cars, one often sees passengers attempting to board or leave the cars while they are in motion. Conversely, one rarely sees passengers on buses, which travel in accordance with higher local speed limits, attempting to disembark from them while in motion even if the doors remain open. The higher potential speed of travel acts to increase the perceived risk of such an action, thus discouraging the unsafe behavior.

Other examples of this are windshield wipers and headlights on automobiles. At first blush, most would categorize these devices as safety features, but are they? Research indicates that driving in rain results in more than a 100% increase in collision rates and a 70% increase in injury incidents compared to nonrainy driving (Andrey, Mills & Vandermolen, 2003; Torbjorn & Kecklund, 2001). A similar increase in incident rates accompanies night driving (Doherty, Andrey & MacGregor, 1998). This poses an interesting question: regardless of whether the addition of headlights and wipers make driving under such inclement conditions safer, would we not be safer yet if vehicles were not equipped with such equipment and we simply did not operate vehicles under those conditions? Can equipment that encourages engaging in an inherently less safe activity be considered safety equipment?

The preceding paragraphs highlight the fact that the perceived reasonableness of an action may evolve over time and is not subject to control by the product manufacturer. Nor can the reasonableness of the action always be determined in such simple terms as *right* or *wrong*. The determination of the reasonableness of an action is solely under the control of the individual performing the action. Placing the burden for injury on the manufacturer of a piece of equipment in some cases may be akin to blaming a casino for a gambler's decision to bet his life's savings on a given number on a roulette wheel. The fact that the gambler's action resulted in a negative consequence for the person reflects the person's own judgment of the payout value versus the potential likelihood of the ball landing in that slot on the wheel. The fact that the gambler may have won when making the same bet in the past does not change the absolute level of risk when he bets again. Even making a safe bet (e.g., betting on both red and black) does not remove the potential for the ball to land on zero or double-zero, resulting in a loss for the gambler.

In the case of the manufacturer of a product or a piece of machinery, it may be reasonable to expect the manufacturer to try to mitigate the effects of honest mistakes or even potentially genuine carelessness on the part of an operator. It is not, however, reasonable to impose on the manufacturer the costs of bad judgment or intentional risk-taking on the part of the product user. Returning to the casino example, if a passerby trips and his chips go flying and land on the table as he walks past it, it is reasonable to expect the casino to not consider this a purposeful bet. It is not, however, reasonable to expect the casino to refund a gambler's money on an intentional wager when the outcome is simply not as the gambler had hoped. It is even less reasonable to expect the roulette wheel manufacturer to refund the gambler's money under the theory that the wheel was somehow defective or presented an unreasonable risk. The gambler himself has already determined the risk in such cases is both acceptable and reasonable in his own eyes, or he would not have placed the bet.

Conclusion

To achieve successful communication between safety professionals and members of their listening audience, consensus is needed on definitions of four critical concepts, negligence, safety, risk and foreseeability, along with several related terms. Such an understanding is necessary regardless of whether the listening audience is a jury evaluating the merits of a case or members of company management to which the speaker is presenting. The lack of such a consensus results in the members of the listening audience each potentially evaluating the relative merits of the material presented based on individual interpretations and widely varying criteria. Note that the terms discussed here are representative of potential misunderstandings, not all-inclusive.

The questions that remain, however, are how to reach a meeting of the minds between speaker and listener on the meaning of terms, and how to maintain continuity and coherence regarding the terms throughout a presentation or trial testimony. This is particularly difficult when the opposing side of the debate is doing its best to advance alternative definitions or even confuse the listeners by using the same terms with different meanings (whether implied or expressly stated). Perhaps the best way to address this issue is to explain and attempt to reach common agreement on the meaning of each term prior to exposing the audience/jury to it, and to frequently reiterate that meaning during the presentation, testimony or cross-examination. Reaching such a common understanding is paramount, else the speaker may be left in the position of being completely correct yet having lost the argument in the listeners' minds. PSJ

Dave Curry, CSP, CHFP, is the chief scientist of Solution Engineering Group, where he leads the human factors and safety consulting practice. He is the author of more than 50 technical papers dealing with issues relating to applied human performance, safety and incident investigation. He holds graduate degrees in experimental, human factors and cognitive/perceptual psychology, industrial engineering and business. He holds several patents and has served as a member of national standards development committees for various organizations. Curry is a professional member of ASSP's Three Rivers Chapter.

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