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The Art and Science of Predicting Accidents

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Introduction

The very definition of the word "accident" implies that it is unplanned, unexpected and occurs without forewarning. While that may be so, is the occurrence of an accident nonetheless predictable? Any reader of this paper who has had even a few months of experience as the safety manager in a manufacturing or construction organization, and who has had the opportunity to investigate an accident, has probably heard another worker say words to the effect of "I just knew that, sooner or later, this would happen." While that comment was a generalization and may have been predicated merely upon premonition, it is an important clue that, in fact, accidents are predictable. Those who go to the efforts necessary to make such predictions can take appropriate actions to insure that the prediction will never come true. While this process is neither simple nor quick, its proper execution will prevent human suffering and economic loss that will make the effort a worthwhile expenditure of the necessary time and resources. The purpose of this presentation is to set forth a protocol by which such predictions can be made and demonstrate the use of that process in a few case studies of accidents that have actually occurred.

There are many worldly events for which valid predictions are commonly made through the accumulation of historical data, together with application of the science of the field and the mathematics of statistics and probability. The most common of these are weather, business and finance, sports, gaming, and politics. As will be documented in this presentation, the same principles that enable predictions to be made in those fields can be applied to safety and health. However, there are two primary and important differences between making predictions in those other venues, and doing so with respect to health and safety. First, other predictions can only be made after other related, unpredictable events have already occurred. Second, it is acceptable to sit and observe whether the predictions come true. In the field of health and safety, the object is to make predictions that will prevent those events from ever occurring and, in the assumption that they do not, we will be most satisfied if we never learn whether the events would have occurred.

Background

There are two well accepted ways of performing technical analyses. The first, commonly known as *the inductive scientific method*, is to start with a hypotheses and then test it with known facts. Unfortunately, this will not work for accident prediction because the hypotheses, being the prediction, must be the end, not the start, of the process. We must therefore rely upon *the deductive scientific method*, in which packages of known facts (axioms) are aligned to arrive at the answers (theorems). We do not have the luxury of taking years to philosophize as we choose and align our fact packages, as did the ancients who used deductive reasoning to develop the field of mathematics. We will therefore have to use the modern method of doing so by starting from the known center of our problem, choosing the most obvious and convenient sources of data and working outward toward the most sparse, like spokes radiating from a wheel. That provides two advantages. It gets the job done much faster, and it substantially lessens opportunity for error (mistakes in some of the ancient theorems survived for centuries before being discovered). This process may be intimidating at first, but bear with it. It is a potent safety management tool.

Process

A typical deductive process for predicting a machinery accident is as follows:

Step #1: List the elements within the immediate work environment. These start with the machine itself, and should also include PPE worn by workers, tools used to operate it and equipment that moves materials to and from it;

Step #2: Examine the immediately available clues that can be found in the operation instructions and the warning/caution labels on the machine. Add to that, consensus standards and OSHA regulations. Much of the immediately available cautionary information was written in the blood of a previous accident victim;

Step #3: Review well regarded safety literature. There is a wealth of information available from textbooks, magazines, trade associations and (being very careful and selective) the internet;

Step #4: Look for historic data. It is more than likely that the accident you will wind up predicting has already occurred before. Your own OSHA 200/300 logs, first reports of injuries, OSHA's online records of its inspections of your competitors and other companies that operate the same or similar machinery, and lawsuits against the manufacturer and its competitors. Learn from others' bad experiences;

Step #5: Using the list of hazards that the previous steps have identified, determine the extent of the risk in your workplace by candidly evaluating the number and duration of exposures to those hazards. As you will discover later, it is important that you do not discount those hazard exposures that have never caused an accident or near miss. What you will arrive at, with the conclusion of this step, is a matrix of number of exposures versus duration of those exposures.

Step #6: Conduct a statistical test of your matrix, utilizing software that performs a *chi-squared analysis*. This is a method that compares actual occurrences with the number of occurrences that would be expected in a totally random sample, and presents a result between zero (no relevancy) and one (absolute certainty). Since you will have no idea what the actual number of occurrences will be, you will have to inject a range of estimates. When your test with a particular estimate produces a chi-square of approximately 0.5 (the *critical value*), there is a 50/50 chance that this is the number of accidents that will occur if you fail to undertake remedial steps.

The following are summaries of actual accidents. After reading each one, go back and look at the above steps and ask yourself: Were there enough data available to have predicted that accident? Are there some that you feel you would not have even needed data, to make your prediction?

Examples

Case #1

The trip and fall. This is, perhaps, the easiest example to deal with. It has been well established that sudden vertical changes in the elevation of a walking or working surface that fall between one-quarter inch and three-quarter inch in height are the most dangerous. Average shoe lengths are approximately 12 inches for a male and 9½ inches for a female. An average stride length is 28 inches for a male and 22 inches for a female. If we are to break up an average stride, minus a shoe length, into quarter-inch intervals, then there are 64 different foot positions for a male's toe and 50 positions for a female's toe, one of which will place a toe into the precise position that will make it vulnerable to a trip and fall. Assume that a study has been done, concluding that only three percent of all persons approaching the change in elevation failed to notice it. Also assume this study reveals that, of those who failed to notice the change in elevation, 15 percent will actually fall, while the others will stumble and recover, and of those who fall, one of the three will suffer an injury that is substantial enough to require medical treatment. Without belaboring the mechanics of the statistical analysis, which is beyond the scope of this presentation, our conclusion is that there is a 50/50 chance that one of every 3,200 males and every 2,500 females who approach the change in elevation will have a 50/50 chance of falling and becoming injured as a result of tripping at it.

Case #2

The "Timing" accident. A timing accident is one in which a worker is injured at a machine that makes repetitive evolutions at timed intervals, where the operator can reach into the production process to make a minor adjustment during the intervals, and an accident will occur in the event the operator's timing is incorrect, resulting in a part of the operator's body becoming entrapped in moving machinery. In our example case, there is a plastic injection molding machine with a ram that moves back and forth every four seconds. Before the end of each shift, the floor man has been instructed to climb up onto the machine and straddle the injection molder's barrel. He then shuts the hopper gate at the charging port where the pellets are fed into the barrel, and swings the hopper away. He next proceeds to push the small amount of remaining pellets into the charging port by hand. If there are too few pellets, he pushes more into the port, just before the ram moves forward. If there are too many, he sticks two or three fingers into the charging port to pull out the excess. He does this four or five times every day to save approximately 30¢ worth of pellets from being wasted. Is it predictable that, just once in the space of a few years, his timing will be off, and the ram will start advancing before he removes his fingers from the charging port?

Case #3

The "If I'm careful" accident. In this example, there is a takeaway conveyor that transfers cartons of baked goods from the packing station to the staging area for loading cartons onto a pallet at a bakery. The conveyor is 40 inches off the floor at its high end. The start/stop pushbutton is on the opposite side of the conveyor from the packing station, and the operator must walk a distance of approximately 40 feet around to the other side of the conveyor, in order to turn the conveyor on and off. The packer has discovered that, if she is careful, she can duck under the conveyor instead of walking around it. Is it predictable that, just once in the space of a few years, she will misjudge the height of the conveyor and not duck low enough to avoid bringing her head against the moving conveyor belt, which could then pull off the hairnet she is wearing and entrap her hair between the belt and a guide roller?

Case #4

The "Too much trouble" accident. Just four weeks before his retirement, the electrical maintenance foreman for a large industrial facility found himself on the roof, peering into an open dust removal system's electrical cabinet and discovering that he needed to determine whether the 480 volt power supply had been turned off or not, but he had no meter to use to make this test. When it was suggested that he use his radio to call for a volt meter to be brought up to him, he spit on his right index finger and tapped the bus bar with it. Fortunately, his hunch that the power had been turned off was correct. The plant engineer, who was standing next to him at the time, had to decide whether or not to discipline a highly regarded and valuable employee on the afternoon before his retirement dinner. If no action was taken, is an electrocution or, at the least, a bad electrical burn accident predictable in that facility's future?

Case #5

The "Distraction" accident. Workers at the open edge of a construction project, forty feet above grade, are being monitored by a "competent person" whose cell phone rings. In the seconds it takes to pull the phone out of his belt holster, a load suspended by a crane swings into a worker whose back is turned to it, sweeps him off the edge, and tears the lanyard loose from his harness. It's a tough call to say that this was predictable, but give it some thought. Was it sufficient to have ordered the foreman not to look away, even for a few seconds, or should he have been told to never answer or even carry a cell phone to his work station?

As you walk through your work place, look around you with a fresh perspective. Along with watching for workers committing unsafe acts, look at all the warning labels you will encounter, think of the operating instructions, OSHA regulations, ASSE, ANSI, ASTM standards that apply, and try to predict the next accident. If you take just one preventative step and no accident occurs, claim success! Who could argue with you?