Theories of Accident Causation

Each year, work-related accidents cost the United States almost $50 billion. This figure includes costs associated with lost wages, medical expenses, insurance costs, and indirect costs. The number of persons injured in industrial place accidents in a typical year is 7,128,000, or 3 per 100 persons per year. In the workplace, there is one accidental death approximately every 51 minutes and one injury every 19 seconds.

Why do accidents happen? This question has concerned safety and health decision makers for decades, because in order to prevent accidents we must know why they happen. Over the years, several theories of accident causation have evolved that attempt to explain why accidents occur. Models based on these theories are used to predict and prevent accidents.

The most widely known theories of accident causation are the domino theory, the human factors theory, the epidemiological theory, the systems theory, the combination theory, and the behavioral theory. This chapter provides practicing and prospective safety professionals with the information they need to understand fully and apply these theories.

Domino Theory of Accident Causation

An early pioneer of accident prevention and industrial safety was Herbert W. Heinrich, an official with the Travelers Insurance Company. In the late 1920s, after studying the reports of 75,000 industrial accidents, Heinrich concluded that

• 88 percent of industrial accidents are caused by unsafe acts committed by fellow workers.
• 10 percent of industrial accidents are caused by unsafe conditions.
• 2 percent of industrial accidents are unavoidable.

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Theories of Accident Causation

Heinrich’s study laid the foundation for his Axioms of Industrial Safety and his theory of accident causation, which came to be known as the domino theory. So much of Heinrich’s theory has been discounted by more contemporary research that it is now considered outdated. However, because some of today’s more widely accepted theories can be traced back to Heinrich’s theory, students of industrial safety should be familiar with his work.

Heinrich’s Axioms of Industrial Safety

Heinrich summarized what he thought health and safety decision makers should know about industrial accidents in 10 statements he called Axioms of Industrial Safety. These axioms can be paraphrased as follows:

1. Injuries result from a completed series of factors, one of which is the accident itself.
2. An accident can occur only as the result of an unsafe act by a person and/or a physical or mechanical hazard.
3. Most accidents are the result of unsafe behavior by people.
4. An unsafe act by a person or an unsafe condition does not always immediately result in an accident/injury.
5. The reasons why people commit unsafe acts can serve as helpful guides in selecting corrective actions.
6. The severity of an accident is largely fortuitous, and the accident that caused it is largely preventable.
7. The best accident prevention techniques are analogous with the best quality and productivity techniques.
8. Management should assume responsibility for safety because it is in the best position to get results.
9. The supervisor is the key person in the prevention of industrial accidents.
10. In addition to the direct costs of an accident (for example, compensation, liability claims, medical costs, and hospital expenses), there are also hidden or indirect costs.

According to Heinrich, these axioms encompass the fundamental body of knowledge that must be understood by decision makers interested in preventing accidents. Any accident prevention program that takes all 10 axioms into account is more likely to be effective than a program that leaves out one or more axioms.

Heinrich’s Domino Theory

Perhaps you have stood up a row of dominoes, tipped the first one over, and watched as each successive domino topples the one next to it. This is how Heinrich’s theory of accident causation works. According to Heinrich, there are five factors in the sequence of events leading up to an accident. These factors can be summarized as follows:

1. Ancestry and social environment. Negative character traits that may lead people to behave in an unsafe manner can be inherited (ancestry) or acquired as a result of the social environment.
2. Fault of person. Negative character traits, whether inherited or acquired, are why people behave in an unsafe manner and why hazardous conditions exist.
3. Unsafe act/mechanical or physical hazard. Unsafe acts committed by people and mechanical or physical hazards are the direct causes of accidents.
4. Accident. Typically, accidents that result in injury are caused by falling or being hit by moving objects.
5. Injury. Typical injuries resulting from accidents include lacerations and fractures.

Heinrich’s theory has two central points: (1) injuries are caused by the action of preceding factors and (2) removal of the central factor (unsafe act/hazardous condition) negates the action of the preceding factors and, in so doing, prevents accidents and injuries.
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DOMINO THEORY IN PRACTICE

Construction Products Company (CPC) is a distributor of lumber, pipe, and concrete products. Its customers are typically small building contractors. CPC’s facility consists of an office in which orders are placed and several large warehouses. Contractors place their orders in the office. They then drive their trucks through the appropriate warehouses to be loaded by CPC personnel.

Because the contractors are small operations, most of their orders are also relatively small and can be loaded by hand. Warehouse personnel go to the appropriate bins, pull out the material needed to fill their orders, and load the materials on customers’ trucks. Even though most orders are small enough to be loaded by hand, many of the materials purchased are bulky and cumbersome to handle. Because of this, CPC’s loaders are required to wear such personal protection gear as hard hats, padded gloves, steel-toed boots, and lower-back-support belts.

For years, CPC’s management team had noticed an increase in minor injuries to warehouse personnel during the summer months. Typically, these injuries consisted of nothing worse than minor cuts, scrapes, and bruises. However, this past summer had been different. Two warehouse workers had sustained serious back injuries. These injuries have been costly to CPC both financially and in terms of employee morale.

An investigation of these accidents quickly identified a series of events and a central causal behavior that set up a domino effect that, in turn, resulted in the injuries. The investigation revealed that CPC’s warehouses became so hot during the summer months that personal protection gear was uncomfortable. As a result, warehouse personnel simply discarded it. Failure to use appropriate personal protection gear in the summer months had always led to an increase in injuries. However, because the injuries were minor in nature, management had never paid much attention to the situation. It was probably inevitable that more serious injuries would occur eventually.

To prevent a recurrence of the summer-injury epidemic, CPC’s management team decided to remove the causal factor—failure of warehouse personnel to use their personal protection gear during the summer months. To facilitate the removal of this factor, CPC’s management team formed a committee consisting of one executive manager, one warehouse supervisor, and three warehouse employees.

The committee made the following recommendations: (1) provide all warehouse personnel with training on the importance and proper use of personal protection gear; (2) require warehouse supervisors to monitor the use of personal protection gear more closely; (3) establish a company policy that contains specific and progressive disciplinary measures for failure to use required personal protection gear; and (4) implement several heat reduction measures to make warehouses cooler during the summer months.

CPC’s management team adopted all the committee’s recommendations. In doing so, it removed the central causal factor that had historically led to an increase in injuries during the summer months.

HUMAN FACTORS THEORY OF ACCIDENT CAUSATION

The human factors theory of accident causation attributes accidents to a chain of events ultimately caused by human error. It consists of the following three broad factors that lead to human error: overload, inappropriate response, and inappropriate activities (see Figure 3–1). These factors are explained in the following paragraphs.

OVERLOAD

Overload amounts to an imbalance between a person’s capacity at any given time and the load that person is carrying in a given state. A person’s capacity is the product of such factors as his or her natural ability, training, state of mind, fatigue, stress, and physical condition. The load that a person is carrying consists of tasks for which he or she is
Inappropriate activities

Figure 3–1
Factors that cause human errors.

responsible and added burdens resulting from environmental factors (noise, distractions, and so on), internal factors (personal problems, emotional stress, and worry), and situational factors (level of risk, unclear instructions, and so on). The state in which a person is acting is the product of his or her motivational and arousal levels.

Inapproparet Response and Incompatibility

How a person responds in a given situation can cause or prevent an accident. If a person detects a hazardous condition but does nothing to correct it, he or she has responded inappropriately. If a person removes a safeguard from a machine in an effort to increase output, he or she has responded inappropriately. If a person disregards an established safety procedure, he or she has responded inappropriately. Such responses can lead to accidents. In addition to inappropriate responses, this component includes workstation incompatibility. The incompatibility of a person’s workstation with regard to size, force, reach, feel, and similar factors can lead to accidents and injuries.

Inappropriate Activities

Human error can be the result of inappropriate activities. An example of an inappropriate activity is a person who undertakes a task that he or she doesn’t know how to do. Another example is a person who misjudges the degree of risk involved in a given task and proceeds based on that misjudgment. Such inappropriate activities can lead to accidents and injuries. Figure 3–2 summarizes the various components of the human factors theory.

Safety Fact

Pregnancy and Work

Strenuous physical work and pregnancy can be a dangerous combination. Too much strenuous labor can result in a miscarriage. The types of work to be avoided by pregnant employees include the following:

• Standing for more than three hours per day
• Operating machinery that vibrates
• Lifting heavy loads
• Working in extremes of hot or cold

Shift work and workstations that require awkward postures can also put pregnant employees at risk. The third trimester is the most risk-intensive time during pregnancy.
CHAPTER 3

Human Factors Theory in Practice

Kitchenware Manufacturing Incorporated (KMI) produces aluminum kitchenware for commercial settings. After 10 years of steady, respectable growth in the U.S. market, KMI suddenly saw its sales triple in less than six months. This rapid growth was the result of KMI’s successful entry into European and Asian markets.

The growth in sales, although welcomed by both management and employees, quickly overloaded and, before long, overwhelmed the company’s production facility. KMI responded by adding a second shift of production personnel and approving unlimited overtime for highly skilled personnel. Shortly after the upturn in production, KMI began to experience a disturbing increase in accidents and injuries. During his accident investigations, KMI’s safety manager noticed that human error figured prominently in the accidents. He grouped all the human errors identified into three categories: (1) overload, (2) inappropriate response, and (3) inappropriate activities.

In the category of **overload**, he found that the rush to fill orders was pushing production personnel beyond their personal limits in some cases, and beyond their capabilities in others. Stress, insufficient training of new employees, and fatigue all contributed to the overload. In the category of **inappropriate response**, the safety manager determined that many of KMI’s production personnel had removed safeguards from their machines and equipment. All the machines involved in accidents had had safeguards removed.

In the category of **inappropriate activities**, the safety manager found that new employees were being assigned duties for which they weren’t yet fully trained. As a result, they often misjudged the amount of risk associated with their work tasks.

With enough accident investigations completed to identify a pattern of human error, the safety manager prepared a presentation containing a set of recommendations for corrective measures for KMI’s executive management team. His recommendations were designed to prevent human-error-oriented accidents without slowing production.

**ACCIDENT/INCIDENT THEORY OF ACCIDENT CAUSATION**

The accident/incident theory is an extension of the human factors theory. It was developed by Dan Petersen and is sometimes referred to as the Petersen accident/incident theory. Petersen introduced such new elements as ergonomic traps, the decision to err, and systems failures, while retaining much of the human factors theory. A model based on his theory is shown in Figure 3–3.

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**Figure 3–2**

Human factors theory.
Theories of Accident Causation

In this model, overload, ergonomic traps, or a decision to err lead to human error. The decision to err may be conscious and based on logic, or it may be unconscious. A variety of pressures such as deadlines, peer pressure, and budget factors can lead to unsafe behavior. Another factor that can influence such a decision is the “It won’t happen to me” syndrome.

The systems failure component is an important contribution of Petersen’s theory. First, it shows the potential for a causal relationship between management decisions or management behavior and safety. Second, it establishes management’s role in accident prevention as well as the broader concepts of safety and health in the workplace.

Following are just some of the different ways that systems can fail, according to Petersen’s theory:

- Management does not establish a comprehensive safety policy.
- Responsibility and authority with regard to safety are not clearly defined.
- Safety procedures such as measurement, inspection, correction, and investigation are ignored or given insufficient attention.
- Employees do not receive proper orientation.
- Employees are not given sufficient safety training.

**Accident/Incident Theory in Practice**

Poultry Processing Corporation (PPC) processes chickens and turkeys for grocery chains. Poultry processing is a labor-intensive enterprise involving a great deal of handwork. A variety of different knives, shears, and cleavers are used. Much of the work is monotonous and repetitive. Selected parts of the overall process must be done in cold conditions.
PPC has gone to great lengths to ensure that workstations are ergonomically sound, that personal protection gear is used as appropriate, and that adequate precautions are taken to prevent illness and injuries. As a result, PPC is an award-winning company in the area of workplace safety and health.

Consequently, the poultry-processing industry was shocked when a class action lawsuit was filed against PPC on behalf of over 50 employees, all of whom claimed to be suffering from carpal tunnel syndrome (CTS). Because of PPC’s excellent safety and health record, most observers felt sure that the company would be vindicated in the end.

The company’s policies and procedures relating to safety and health were investigated thoroughly by consultants brought in by both PPC and the attorney for the plaintiffs. Over 100 witnesses gave depositions, and several preliminary hearings were held. By the time the trial finally rolled around, both sides had accumulated mountains of paper and filing cabinets full of evidence. Then, suddenly and without advance notice, PPC offered a substantial financial settlement, which the plaintiffs accepted.

It was one of PPC’s outside consultants who discovered what had caused the increased incidence of CTS. The company had always used a centralized approach to managing safety and health. Responsibility for such tasks as measurement, inspection, correction, and investigation was assigned to the safety manager, Joe Don Hurtle. Hurtle had an excellent record during his 20 years in the poultry-processing industry, with the last 5 spent at PPC. In fact, he was so well respected in the industry that his peers had elected him president of a statewide safety organization. This, as it turned out, is where PPC’s troubles began.

When Hurtle took it over, the safety organization had experienced a three-year decline in membership and was struggling to stay afloat financially. He had been elected as “the man who could save the organization.” Intending to do just that, Hurtle went right to work. For months at a time he worked seven days a week, often spending as much as two weeks at a time on the road. When he was in his office at PPC, Hurtle was either on the telephone or doing paperwork for the safety organization.

Within six months, he had reversed the organization’s downhill slide, but not without paying a price at home. During the same six-month period, his duties at PPC were badly neglected. Measurement of individual and group safety performance had come to a standstill. The same was true of inspection, correction, investigation, and reporting.

It was during this time of neglect that the increased incidence of CTS occurred. Safety precautions that Hurtle had instituted to guard against this particular problem were no longer observed properly once the workers realized that he had stopped observing and correcting them. Measurement and inspection may also have prevented the injuries had Hurtle maintained his normal schedule of these activities.

PPC’s consultant, in a confidential report to executive managers, cited the accident/incident theory in explaining his view of why the injuries occurred. In this report, the consultant said that Hurtle was guilty of applying “it won’t happen here” logic when he made a conscious decision to neglect his duties at PPC in favor of his duties with the professional safety organization. Of course, the employees themselves were guilty of not following clearly established procedures. However, because Hurtle’s neglect was also a major contributing factor, PPC decided to settle out of court.

EPIDEMIOLOGICAL THEORY OF ACCIDENT CAUSATION

Traditionally, safety theories and programs have focused on accidents and the resulting injuries. However, the current trend is toward a broader perspective that also encompasses the issue of industrial hygiene. Industrial hygiene concerns environmental factors that can lead to sickness, disease, or other forms of impaired health.

This trend has, in turn, led to the development of an epidemiological theory of accident causation. Epidemiology is the study of causal relationships between environmental factors and disease. The epidemiological theory holds that the models used for studying
Theories of Accident Causation

Figure 3–4
Epidemiological theory.

and determining these relationships can also be used to study causal relationships between environmental factors and accidents or diseases.9

Figure 3–4 illustrates the epidemiological theory of accident causation. The key components are predispositional characteristics and situational characteristics. These characteristics, taken together, can either result in or prevent conditions that may result in an accident. For example, if an employee who is particularly susceptible to peer pressure (predispositional characteristic) is pressured by his coworkers (situational characteristic) to speed up his operation, the result will be an increased probability of an accident.

Epidemiological Theory in Practice

Jane Andrews was the newest member of the loading unit for Parcel Delivery Service (PDS). She and the other members of her unit were responsible for loading 50 trucks every morning. It was physically demanding work, and she was the first woman ever selected by PDS to work in the loading unit. She had gotten the job as part of the company’s upward mobility program. She was excited about her new position because within PDS, the loading unit was considered a springboard to advancement. Consequently, she was eager to do well. The responsibility she felt toward other female employees at PDS only intensified her anxiety. Andrews felt that if she failed, other women might not get a chance to try in the future.

Before beginning work in the loading unit, employees must complete two days of training on proper lifting techniques. The use of back-support belts is mandatory for all loading dock personnel. Consequently, Andrews became concerned when the supervisor called her aside on her first day in the unit and told her to forget what she had learned in training. He said, "Jane, nobody wants a back injury, so be careful. But the key to success in this unit is speed. The lifting techniques they teach in that workshop will just slow you down. You’ve got the job, and I’m glad you’re here. But you won’t last long if you can’t keep up."

Andrews was torn between following safety procedures and making a good impression on her new supervisor. At first, she made an effort to use proper lifting techniques. However, when several of her coworkers complained that she wasn’t keeping up, the
supervisor told Andrews to “keep up or get out of the way.” Feeling the pressure, she started taking the same shortcuts she had seen her coworkers use. Positive results were immediate, and Andrews received several nods of approval from fellow workers and a “good job” from the supervisor. Before long, Andrews had won the approval and respect of her colleagues.

However, after two months of working in the loading unit, she began to experience persistent lower-back pain. Andrews felt sure that her hurried lifting techniques were to blame, but she valued the approval of her supervisor and fellow workers too much to do anything that might slow her down. Finally, one day while loading a truck, Andrews fell to the pavement in pain and could not get up. Her back throbbed with intense pain, and her legs were numb. She had to be rushed to the emergency room of the local hospital. By the time Andrews checked out of the hospital a week later, she had undergone major surgery to repair two ruptured discs.

Jane Andrews’s situation can be explained by the epidemiological theory of accident causation. The predispositional factor was her susceptibility to peer pressure from her coworkers and supervisor. The applicable situational factors were peer pressure and the priorities of the supervisor. These factors, taken together, caused the accident.

**SYSTEMS THEORY OF ACCIDENT CAUSATION**

A system is a group of regularly interacting and interrelated components that together form a unified whole. This definition is the basis for the systems theory of accident causation. This theory views a situation in which an accident may occur as a system comprised of the following components: person (host), machine (agency), and environment. The likelihood of an accident occurring is determined by how these components interact. Changes in the patterns of interaction can increase or reduce the probability of an accident.

For example, an experienced employee who operates a numerically controlled five-axis machining center in a shop environment may take a two-week vacation. Her temporary replacement may be less experienced. This change in one component of the system (person/host) increases the probability of an accident. Such a simple example is easily understood. However, not all changes in patterns of interaction are this simple. Some are so subtle that their analysis may require a team of people, each with a different type of expertise.

The primary components of the systems model are the person/machine/environment, information, decisions, risks, and the task to be performed. Each of the components has a bearing on the probability that an accident will occur. The systems model is illustrated in Figure 3–5.

![Figure 3-5](image-url)
As this model shows, even as a person interacts with a machine within an environment, three activities take place between the system and the task to be performed. Every time a task must be performed, there is the risk that an accident may occur. Sometimes the risks are great; at other times, they are small. This is where information collection and decision making come in.

Based on the information that has been collected by observing and mentally noting the current circumstances, the person weighs the risks and decides whether to perform the task under existing circumstances. For example, say a machine operator is working on a rush order that is behind schedule. An important safety device has malfunctioned on his machine. Simply taking it off will interrupt work for only five minutes, but it will also increase the probability of an accident. However, replacing it could take up to an hour. Should the operator remove the safety guard and proceed with the task or take the time to replace it? The operator and his supervisor may assess the situation (collect information), weigh the risks, and make a decision to proceed. If their information was right and their assessment of the risks accurate, the task will probably be accomplished without an accident.

However, the environment in which the machine operator is working is unusually hectic, and the pressure to complete an order that is already behind schedule is intense. These factors are stressors that can cloud the judgment of those collecting information, weighing risks, and making the decision. When stressors are introduced between points 1 and 3 in Figure 3–5, the likelihood of an accident increases.

For this reason, five factors should be considered before beginning the process of collecting information, weighing risks, and making a decision:

- Job requirements
- The workers’ abilities and limitations
- The gain if the task is successfully accomplished
- The loss if the task is attempted but fails
- The loss if the task is not attempted

These factors can help a person achieve the proper perspective before performing the above-mentioned tasks. It is particularly important to consider these factors when stressors such as noise, time constraints, or pressure from a supervisor may tend to cloud one’s judgment.

Systems Theory in Practice

Precision Tooling Company (PTC) specializes in difficult orders that are produced in small lots, and in making corrections to parts that otherwise would wind up as expensive rejects in the scrap bin. In short, PTC specializes in doing the types of work that other companies cannot, or will not, do. Most of PTC’s work comes in the form of subcontracts from larger manufacturing companies. Consequently, living up to its reputation as a high-performance, on-time company is important to PTC.

Because much of its work consists of small batches of parts to be reworked, PTC still uses several manually operated machines. The least experienced machinists operate these machines. This causes two problems. The first problem is that it is difficult for even...
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a master machinist to hold to modern tolerance levels on these old machines. Consequently, apprentice machinists find holding to precise tolerances quite a challenge. The second problem is that the machines are so old that they frequently break down.

Complaints from apprentice machinists about the old machines are frequent. However, their supervisors consider time on the old “ulcer makers” to be one of the rites of passage that upstart machinists must endure. Their attitude is, “We had to do it, so why shouldn’t you?” This was where things stood at PTC when the company won the Johnson contract.

PTC had been trying for years to become a preferred supplier for H. R. Johnson Company. PTC’s big chance finally came when Johnson’s manufacturing division incorrectly produced 10,000 copies of a critical part before noticing the problem. Simply scrapping the part and starting over was an expensive solution. Johnson’s vice president for manufacturing decided to give PTC a chance.

PTC’s management team was ecstatic! Finally, they had an opportunity to partner with H. R. Johnson Company. If PTC could perform well on this one, even more lucrative contracts were sure to follow. The top managers called a company-wide meeting of all employees. Attendance was mandatory. The CEO explained the situation as follows:

Ladies and gentlemen, we are faced with a great opportunity. I’ve just signed a contract with H. R. Johnson Company to rework 10,000 parts that their manufacturing folks produced improperly. The rework tasks are not that complicated, but every part has got to go through several manual operations at the front end of the rework process. This means our manual machining unit is going to have to supply the heroes on this job. I’ve promised the manufacturing VP at Johnson that we would have his parts ready in 90 days. I know that’s a lot to do in so short a period of time, but Johnson is in a real bind here. If we can produce on this one, they won’t forget us in the future.

This put PTC’s apprentice machinists on the spot. If PTC didn’t perform on this contract, it would be their fault. They cursed their old machines and got to work. The CEO had said the rework tasks would not be “that complicated,” but, as it turned out, the processes weren’t that simple either. The problem was tolerances. Holding to the tolerances specified in the Johnson contract took extra time and a special effort on every single part. Before long, the manual machining unit was behind schedule, and management was getting nervous. The situation was made even worse by the continual breakdowns and equipment failures experienced. The harder the unit supervisor pushed, the more stressed the employees and machines became.

Predictably, it wasn’t long before safety procedures were forgotten, and unreasonable risks were being taken. The pressure from management, the inexperience of the apprentice machinists, and the constant equipment failures finally took their toll. In a hurry to get back on schedule, and fearing that his machine would break down again, one machinist got careless and ran his hand into the cutter on his milling machine. By the time the machine had been shut down, his hand was badly mutilated. In the aftershock of this accident, PTC was unable to meet the agreed-upon completion schedule. Unfortunately, PTC did not make the kind of impression on H. R. Johnson’s management team that it had hoped.

This accident can be explained by the systems theory. The person-machine-environment chain has a direct application in this case. The person involved was relatively inexperienced. The machine involved was old and prone to breakdowns. The environment was especially stressful and pressure packed. These three factors, taken together, resulted in this serious and tragic accident.

COMBINATION THEORY OF ACCIDENT CAUSATION

There is often a degree of difference between any theory of accident causation and reality. The various models presented with their corresponding theories in this chapter attempt to explain why accidents occur. For some accidents, a given model may be very accurate. For others, it may be less so. Often the cause of an accident cannot be adequately
explained by just one model or theory. Thus, according to the combination theory, the actual cause may combine parts of several different models. Safety personnel should use these theories as appropriate both for accident prevention and accident investigation. However, they should avoid the tendency to try to apply one model to all accidents.

Combination Theory in Practice

Crestview Grain Corporation (CGC) maintains 10 large silos for storing corn, rice, wheat, barley, and various other grains. Because stored grain generates fine dust and gases, ventilation of the silos is important. Consequently, all of CGC’s silos have several large vents. Each of these vents uses a filter similar to the type used in home air conditioners that must be changed periodically.

There is an element of risk involved in changing the vent filters because of two potential hazards. The first hazard comes from unvented dust and gases that can make breathing difficult, or even dangerous. The second hazard is the grain itself. Each silo has a catwalk that runs around its inside circumference near the top. These catwalks give employees access to the vents that are also near the top of each silo. The catwalks are almost 100 feet above ground level, they are narrow, and the guardrails on them are only knee high. A fall from a catwalk into the grain below would probably be fatal.

Consequently, CGC has well-defined rules that employees are to follow when changing filters. Because these rules are strictly enforced, there had never been an accident in one of CGC’s silos—that is, not until the Juan Perez tragedy occurred. Perez was not new to the company. At the time of his accident, he had worked at CGC for over five years. However, he was new to the job of silo maintenance. His inexperience, as it turned out, would prove fatal.

It was time to change the vent filters in silo number 4. Perez had never changed vent filters himself. He hadn’t been in the job long enough. However, he had served as the required “second man” when his supervisor, Bao Chu Lai, had changed the filters in silos 1, 2, and 3. Because Chu Lai was at home recuperating from heart surgery and would be out for another four weeks, Perez decided to change the filters himself. Changing the filters was a simple enough task, and Perez had always thought the second-man concept was overdoing it a little. He believed in taking reasonable precautions as much as the next person, but in his opinion, CGC was paranoid about safety.

Perez collected his safety harness, respirator, and four new vent filters. Then he climbed the external ladder to the entrance–exit platform near the top of silo number 4. Before going in, Perez donned his respirator and strapped on his safety harness. Opening the hatch cover, he stepped inside the silo onto the catwalk. Following procedure, Perez attached a lifeline to his safety harness, picked up the new vent filters, and headed for the first vent. He changed the first two filters without incident. It was while he was changing the third filter that tragedy struck.

The filter in the third vent was wedged in tightly. After several attempts to pull it out, Perez became frustrated and gave the filter a good jerk. When the filter suddenly broke loose, the momentum propelled Perez backward and he toppled off the catwalk. At first it appeared that his lifeline would hold, but without a second person to pull him up or call for help, Perez was suspended by only the lifeline for over 20 minutes. He finally panicked, and in his struggle to pull himself up, knocked open the buckle of his safety harness. The buckle gave way, and Perez fell over 50 feet into the grain below. The impact knocked off his respirator, the grain quickly enveloped him, and Perez was asphyxiated.

The accident investigation that followed revealed that several factors combined to cause the fatal accident—the combination theory. The most critical of these factors were as follows:

- Absence of the supervisor
- Inexperience of Perez
- A conscious decision by Perez to disregard CGC’s safety procedures
- A faulty buckling mechanism on the safety harness
- An unsafe design (only a knee-high guardrail on the catwalk)
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BEHAVIORAL THEORY OF ACCIDENT CAUSATION

The behavioral theory of accident causation and prevention is often referred to as behavior-based safety (BBS). BBS has both proponents and critics. One of the most prominent proponents of BBS is E. Scott Geller, a senior partner of Safety Performance Solutions, Inc., and a professor of psychology. It is appropriate that Geller is a professional psychologist because BBS is the application of behavioral theories from the field of psychology to the field of occupational safety.

According to Geller, there are seven basic principles of BBS: (1) intervention that is focused on employee behavior; (2) identification of external factors that will help understand and improve employee behavior (from the perspective of safety in the workplace); (3) direct behavior with activators or events antecedent to the desired behavior, and motivation of the employee to behave as desired with incentives and rewards that will follow the desired behavior; (4) focus on the positive consequences that will result from the desired behavior as a way to motivate employees; (5) application of the scientific method to improve attempts at behavioral interventions; (6) use of theory to integrate information rather than to limit possibilities; and (7) planned interventions with the feelings and attitudes of the individual employee in mind.

Those who have studied psychology will recognize BBS as an innovative and practical application of standard behavioral theory to the field of occupational safety. These theories are relevant in any situation in which certain types of human behaviors are desired while others are to be avoided. Positive reinforcement in the form of incentives and rewards is used to promote the desired (safe) behaviors and to discourage undesirable (unsafe) behaviors.

Proponents of BBS use the “ABC” model to summarize the concept of understanding human behavior and developing appropriate interventions when the behavior is undesirable (unsafe). Geller explains the model as follows:

Behavior-based safety trainers and consultants teach the ABC model (or three-term contingency) as a framework to understand and analyze behavior or to develop interventions for improving behavior. As given in BBS principle 3 . . . the “A” stands for activators or antecedent events that precede behavior (“B”) and “C” refers to the consequences following behavior or produced by it. Activators direct behavior, whereas consequences motivate behavior.

Two other advocates of BBS, Bruce Fern and Lori Alzamora, propose the expansion of the ABC model to ABCO. The “O” stands for outcomes. They explain the addition as follows:

“Outcome” refers to the longer-term results of engaging in safe or unsafe behavior. For example, an antecedent of a sign requiring employees to wear safety goggles could produce the behavior of putting on the goggles, the consequence of avoiding an eye injury, and the outcome of being able to continue working and enjoying time with the family. On the other hand, the consequence of not wearing goggles could be an eye injury with a potential outcome of blindness, time off the job, and a reduced quality of life. Failure to address the issue of outcomes represents a lost opportunity to give employees a good reason for engaging in safe behaviors.

Behavioral Theory in Action

Mark Potter is the safety manager for Excello Corporation. Several months ago, he became concerned because employees seemed to have developed a lax attitude toward wearing hard hats. What really troubled Potter was that there was more than the usual potential for head injuries because of the type of work done in Excello’s plant, and he had personally witnessed two near misses in less than a week. An advocate of BBS, he decided to apply the ABC model in turning around this unsafe behavior pattern.

His first step was to remove all the old “Hard Hat Area” signs from the plant and replace them with newer, more noticeable signs. Then he scheduled a brief seminar on
head injuries and cycled all employees through it over a two-week period. The seminar took an unusual approach. It told a story of two employees. One was in a hospital bed surrounded by family members he did not even recognize. The other was shown enjoying a family outing with happy family members. The clear message of the video was “the difference between these two employees is a hard hat.” These two activities were the antecedents to the behavior he hoped to produce (all employees wearing hard hats when in a hard hat area).

The video contained a powerful message and it had the desired effect. Within days, employees were once again disciplining themselves to wear their hard hats (the desired behavior). The consequence was that near misses stopped, and no head injuries have occurred at Excello in months. The outcome of this is that Excello’s employees have been able to continue enjoying the fruits of their labor and the company of loved ones.

DRUGS AND ACCIDENT CAUSATION

One of the most pernicious causes of accidents on the job is chemicals—but not the kind industrial hygienists generally concern themselves with. The chemicals alluded to here are the illicit drugs and alcohol used by employees. Drugs and alcohol are the root cause or contributing cause of many accidents on the job every year. Consequently, safety professionals need to be on guard for employees who are drug and alcohol abusers.

According to Stephen Minter,

The workplace cannot be separated from the society around it, and substance abuse continues to be a serious and costly health and safety issue for employers. According to surveys by the Department of Health and Human Services, some 77 percent of drug users are employed—more than 9 million workers. An estimated 6.5 percent of full-time and 8.6 of part-time workers use illicit drugs. More than a third of all workers between the ages of 18 and 25 are binge drinkers. . . . Alcoholism alone causes 500 million lost days annually (125 million days are lost each year due to work-related injuries). . . . Some 20 percent of workers report that they have been put in danger or injured, or had to work harder, redo work or cover for a co-worker, as a result of a co-worker’s drinking.18

These discouraging statistics are why so many companies implement drug-free workplace programs. In fact, since 1989 federal contractors have been required to do so. Such programs typically include the following components: drug-free workplace policy, supervisory training, employee education, employee assistance programs, and alcohol and drug testing.

Establishing drug-free workplace programs is typically the responsibility of the human resources department. However, safety and health professionals should be aware of the workplace problems that can be caused by alcohol and drug abuse. Further, if a cross-functional team of representatives from various departments is convened by the human resources department for the purpose of developing a drug-free workplace program, the chief safety and health professional for the organization should be a member of that team.

DEPRESSION AND ACCIDENT CAUSATION

An invisible problem in today’s workplace is clinical depression. People who suffer from clinical depression are seriously impaired and, as a result, they pose a clear and present safety risk to themselves, fellow workers, and their employer.19 Mental health professionals estimate that up to 10 percent of the adult population in the United States suffers from clinical depression. This translates to 1 in every 20 people on the job.

The causes of clinical depression are many and varied, but the most common causes are biological (too few or too many of the brain chemicals known as neurotransmitters).
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cognitive (negative thought processes), genetic (family history of depression), and concurring illnesses (strokes, cancer, heart disease, Alzheimer’s, and other diseases can increase the incidence of depression).

According to Todd Nighswonger,

Depression results in more than 200 million lost workdays and costs the U.S. economy $43.7 billion annually. Much of that cost is hidden, including $23.8 billion lost to U.S. businesses in absenteeism and lost productivity. Beyond productivity issues, studies suggest that depressed workers may be more prone to accidents. Stephen Heidel, M.D., MBA, an occupational psychiatrist in San Diego, notes a lack of concentration, fatigue, failing memory and slow reaction time as reasons that workers who are depressed may not work safely.25

Warning Signs

Safety and health professionals are not mental health professionals and should not attempt to play that role. However, they should be alert to the warning signs of clinical depression in employees. These signs are as follows:

• Persistent dreary moods (sadness, anxiety, nervousness)
• Signs of too little sleep
• Sleeping on the job or persistent drowsiness
• Sudden weight loss or gain
• General loss of interest, especially in areas of previous interest
• Restlessness, inability to concentrate, or irritability
• Chronic physical problems (headaches, digestive disorders, etc.)
• Forgetfulness or an inability to make simple decisions
• Persistent feelings of guilt
• Feelings of low self-worth
• Focus on death or talk of suicide

Safety and health professionals who recognize any or all of these symptoms in an employee should avoid the natural human tendency to help the employee deal with the problems. Rather, the appropriate action is to get the employee into the hands of competent mental health professionals right away. The best way to do this is to approach the employee’s supervisor and recommend that he or she refer the employee to the organization’s employee assistance program (EAP) or to the human resources department. If the supervisor is uncomfortable approaching the employee in question or does not know how to go about it, recommend that he or she use the following statement suggested by the Society for Human Resource Management:

I’m concerned that recently you’ve been late to work often and are not meeting your performance objectives. I’d like to see you get back on track. I don’t know whether this is the case for you, but if personal issues are affecting your work, you can speak confidentially to one of our employee assistance counselors. The service was set up to help employees. Our conversation today and appointments with the counselor will be kept confidential. Whether or not you contact this service, you will still be expected to meet your performance goals.25

Sources of Help

Because clinical depression in employees has become such an all-pervasive problem that increases the risk of accidents and injuries on the job, safety and health professionals need to learn all they can about this problem and keep up-to-date with the latest information concerning it. The following sources may help:

MANAGEMENT FAILURES AND ACCIDENT CAUSATION

One of the leading causes of accidents in the workplace is the failure of management to do its part to ensure a safe and healthy work environment. Different levels of management have different levels of responsibility. The level of management with the most direct, hands-on, day-to-day responsibility for workplace safety and health is the supervisory level. Supervisors play a critical role in making sure that employees work in a safe and healthy environment.

Role of the Supervisor in Workplace Safety and Health

Safety and health professionals cannot do their jobs effectively without the full cooperation and day-to-day assistance of first-line supervisors. Supervisors and safety professionals must be partners when it comes to providing a safe and healthy workplace for employees. Supervisors should be assigned responsibility for the work environment and for the safety of employees in their units. Safety and health professionals should be readily available to help supervisors fulfill this responsibility.

Key responsibilities of supervisors relating to workplace safety and health include the following:

• Orienting new employees to the safe way to do their jobs
• Ensuring that new and experienced employees receive the safety and health training they need on a continual basis
• Monitoring employee performance and enforcing safety rules and regulations
• Assisting safety and health professionals in conducting accident investigations
• Assisting safety and health professionals in developing accident reports
• Keeping up-to-date on safety issues
• Setting a positive example for employees that says “the safe way is the right way”

Typical Management Failures That Cause Accidents

Management failures represent a major cause of accidents on the job. If management is serious about providing a safe and healthy work environment for employees it must (1) show employees that safe and healthy work practices are expected by including such practices in job descriptions, monitoring employee work practices, and setting an example of safe and healthy work practices; (2) provide training in how to work safely, including orientation training for new employees as well as ongoing updated training for experienced employees; (3) include safe and healthy work practices as criteria in the periodic performance appraisals of employees; and (4) reinforce safe and healthy work practices by rewarding and recognizing employees who use them. Common examples of management failures include the following:

Poor housekeeping or improper use of tools, equipment, or facilities. Management either has not developed the necessary requirements, or has but does not enforce them. The management failure in this case could be lack of safety procedures (failure to let employees know the expectations), lack of training (failure to give employees the knowledge and skills they need to work safely), or failure to properly supervise (failure to monitor employee actions).

Pressure to meet deadlines. Sometimes management has developed a good safety and health policy, established good safety and health procedures, built safety and health expectations into job descriptions and performance appraisals, and provided the necessary training only to put all this aside when a rush order comes in. This may be the most problematic of the many different types of management failures that can occur because it can undermine all of the organization’s safety and health efforts. When management allows safety and health procedures to be ignored or, worse yet, encourages them to be ignored to speed
up production in the short run, employees soon get the message that safety and health are important only when there is no rush. This is an example of management failing to set the proper example.

**OBESITY AND ACCIDENT CAUSATION**

Researchers at Ohio State University found that extremely obese people are more likely than normal-weight people to injure themselves. This is bad news for what an Australian study conducted at Queensland University calls “sedentary workplaces”—those that involve a lot of sitting at desks. It is bad news because the Australian study concluded that the more people sit at desks during the workday, the more likely they are to be overweight.

**Obesity** has long been associated with such chronic diseases as high blood pressure, coronary heart disease, diabetes, and certain types of cancer, but these studies now tie it to workplace injuries too. The ramifications for safety and health professionals are profound. The World Health Organization estimates that there are more than 300 million obese people worldwide. In the industrialized nations of the world—nations such as the United States—the number of people considered obese is growing rapidly. These studies used a standard body mass index (BMI) score of 30 or above to define obesity.

In the study conducted by Ohio State University, researchers collected data on more than 2,500 adults. The data show that 26 percent of extremely obese male subjects reported personal injuries. The percentage for extremely obese women was only slightly lower at approximately 22 percent. Researchers compared these percentages with those for normal-weight people and found a noticeable difference in the percentages of males and females who reported injuries (17 percent for males and 12 percent for women). Researchers used a BMI of 18.5 to 24.9 to define “normal weight.”

The most common causes of injuries to obese people were the result of overexertion (35.2 percent) and falls (29.9 percent). Underweight people—BMI of 18.5 or less—reported the fewest number of injuries. According to the study’s author, Huiyun Xiang, “There is undeniably a link between obesity and injury risk in adults. Efforts to promote optimal body weight may reduce not only the risk of chronic diseases, but also the risk of unintentional injuries.”

**SUMMARY**

1. The domino theory of accident causation was one of the earliest developed. The theory posits that injuries result from a series of factors, one of which is an accident. The theory is operationalized in 10 statements called the Axioms of Industrial Safety. According to this theory, there are five factors in the sequence of events leading to an accident: ancestry and social environment, fault of person, unsafe act/mechanical or physical hazard, accident, and injury.
2. The human factors theory of accident causation attributes accidents to a chain of events ultimately caused by human error. It consists of three broad factors that lead to human error: overload, inappropriate response, and inappropriate activities.
3. The accident/incident theory of accident causation is an extension of the human factors theory. It introduces such new elements as ergonomic traps, the decision to err, and systems failures.
4. The epidemiological theory of accident causation holds that the models used for studying and determining the relationships between environmental factors and disease can be used to study causal relationships between environmental factors and accidents.
5. The systems theory of accident causation views any situation in which an accident may occur as a system with three components: person (host), machine (agency), and environment.
6. The combination theory of accident causation posits that no one model or theory can explain all accidents. Factors from two or more models may be part of the cause.
7. There are seven principles of behavior-based safety: intervention; identification of internal factors; motivation to behave in the desired manner; focus on the positive consequences of appropriate behavior; application of the scientific method integration of information; and planned interventions.
8. Drugs and alcohol are the root or a contributing cause of many workplace accidents every year. Approximately 77 percent of drug users are employed, and more than a third of all workers between 18 and 25 are binge drinkers. Alcoholism alone causes 500 million lost days annually.
9. Clinical depression is an invisible problem in the workplace. However, it can be a major cause of accidents. One in 20 people suffer from clinical depression, which is the root cause of more than 200 million lost workdays annually.
10. Management failures are another leading cause of accidents on the job. If management is serious about workplace safety and health, it must establish expectations, provide training, evaluate employee performance with safety in mind, and reinforce safe and healthy behavior.
11. There is a strong correlation between obesity and injuries, suggesting a need to promote optimal body weight as an injury prevention strategy.

**KEY TERMS AND CONCEPTS**

- Accident/incident theory
- Ancestry
- Axioms of Industrial Safety
- Behavior-based safety (BBS)
- Causal relationship
- Central factor
- Clinical depression
- Combination theory
- Domino theory
- Environment
- Environmental factors
- Epidemiological theory
- Ergonomic traps
- Hazardous condition
- Human error
- Human factors theory
- Inappropriate activities
- Inappropriate responses

- Industrial hygiene
- Internal factors
- Mechanical hazards
- Neurotransmitters
- Obesity
- Overload
- Physical hazards
- Preceding factors
- Predispositional characteristics
- Situational characteristics
- Situational factors
- Social environment
- Stressors
- Systems theory
- Unsafe acts
- Unsafe behavior

**REVIEW QUESTIONS**

1. Explain the domino theory of accident causation, including its origin and its impact on more modern theories.
2. What were the findings of Herbert W. Heinrich’s 1920s study of the causes of industrial accidents?
3. List five of Heinrich’s Axioms of Industrial Safety.
4. Explain the following concepts in the domino theory: preceding factor; central factor.
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5. What are the three broad factors that lead to human error in the human factors theory? Briefly explain each.
6. Explain the systems failure component of the accident/incident theory.
7. What are the key components of the epidemiological theory? How does their interaction affect accident causation?
8. Explain the systems theory of accident causation.
9. What impact do stressors have in the systems theory?
10. List five factors to consider before making workplace decisions that involve risk.
11. Explain the principles of behavior-based safety.
12. What is the role of the safety and health professional with regard to handling employees who might be drug or alcohol abusers?
13. List the warning signs of clinical depression.
14. What must management do if it is serious about providing a safe and healthy work environment for employees?
15. Explain the connection between obesity and injuries.

ENDNOTES

2. Ibid., 24.
3. Ibid., 26.
5. Ibid.
6. Ibid.
7. Ibid.
8. Ibid.
11. Ibid.
12. Ibid.
14. Ibid., 44.
16. Ibid.
18. Ibid.
20. Ibid., 40.
21. Ibid., 42.
24. Ibid., 3.