Using the Universal Model in Accident Investigation

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It has been well established that the focus of the discipline of "Safety Science" and the practice of the Safety Professional is the anticipation, recognition, evaluation and control of hazards. This can be said to be a major and critical segment of the "scope and function of the Safety Profession". (ASSE)

When examining related disciplines such as the Medical Profession, the Legal Profession and Engineering, one finds that well formalized, extensive and accepted schema exist within these professions for examining, describing and studying phenomena of interest. That is true also to a certain extent in the Safety Profession. The coefficient of friction of flooring surfaces, the design strength of anchorage points, the flash point of liquids and the threshold limits of toxic materials all illustrate well established, formalized, agreed upon principles that are used by the Safety Profession on a regular basis to describe and characterize potential hazards and hazard control measures.

However, in the area of incident causation it would appear that a critical gap exists in our science, in that well established, accepted, generalized principles useful in explaining this phenomenon, are extremely limited. (Manuele 167) And since this is such a vital and central core concept within the "metaphysics" of Safety Science, it is probably no exaggeration to say that such a deficiency undermines the efficacy and validity of our discipline. Even worse, since the related disciplines mentioned earlier do have accepted and operable schema that they use for explaining the phenomena of incident causation, the Safety Profession could one day find itself relegated to a less significant role in applying preventive strategies across the broad expanse of the hazard control spectra. In short, we are missing the "Rosetta Stone" needed to decipher the phenomena of incident causation and we as a profession need to work more diligently to find it.

This is not to say that Safety Science is totally without stepping stones and guideposts to assist us in explaining the incident causation process. Nevertheless, in this age of mapquest and global positioning systems, we need more than a broken, muddy path to lead us to the true causes of incidents.

Terminology Problems

One can certainly understand some of the difficulties encountered in the discussion of incident causation philosophy just by considering the terminology we often use in this subject area. Words of course not only help us communicate complex concepts but imply meanings which may vary significantly from one person to another. As time passes, these interpretations may shift and change for one group of users but not others. It is incumbent upon any profession to clarify and standardize the usage of terminology important to the practice of that profession so as to eliminate unnecessary and counterproductive confusion.

The term "*accident"* has been abolished in the lexicon of the Medical Profession because many in that profession say that it implies an inability for prevention. An inevitable occurrence as it were, negating any organized effort for successful intervention. It is doubtful that many Safety Professionals have ever intended to convey this meaning. However in the interest of improved communications between related disciplines, it may be prudent to limit the use of this term to occasions when no other will do.

No terms have ever been tossed about more freely without conveying a precise meaning than have the terms, *unsafe act* and *unsafe condition.* Setting aside the logical quandary caused when one encounters actions which can not be judged to be "unsafe"; are these acts then to be called, "safe acts"? The greater ill caused by these terms is that they require a subjective judgment which may vary from one individual to another and therefore lack the precision that is essential in such a core philosophy as is incident causation. Scholars of accident investigation tell us that it is highly detrimental to any investigation for implications of blame or responsibility to be introduced in the course of the investigation. (Grimaldi & Simonds 141) Use of these two terms definitely can have this effect and so they will not be used in this paper. Later it will be shown that the judgment in the degree of safety for acts and conditions is not really necessary to explain the causation process.

Consider briefly the question, "*What are we in the Safety Profession really trying to prevent?"* A good answer would probably be, "*injuries, deaths, illness, damage, destruction, loss of productivity and resources."* This is likely to be a universal truth no matter in what segment of the Safety Profession one may practice. What then do we say causes these undesirable effects? One answer would be, *"explosions, fires, contact with hazardous materials, contact with energy, structural collapse, vehicle collisions, ships sinking, overstressing body parts, aircraft crashes, release of radiation, noise exposures, destructive natural phenomena, falls and other such events."* So do we have an established and accepted term which would describe and clearly encompass all of these events? Sadly the answer is probably, *"no".* Still there is a pressing need for the use of some collective term if we are to propose a unified mechanism that can be used to explain all of these phenomena. In this paper we will use the term*, "loss incident*" since it seems to convey the desired meaning and because no other term seems to suffice.

A *loss incident* as the term is used in this paper, can be defined as an event which, without any subsequent events, has the potential to produce death, injury, damage and destruction. Examples were given in the previous paragraph. One can see in these examples that the destructive potential of these events is related to the amount of energy or mass that may be released during the course of the event. Many loss incident sequences can be discerned to involve more than one and sometimes many separate loss incidents each increasing the severity potential of the entire sequence. It is a corollary of the Universal Model theory that one loss incident can lead to one or more other loss incidents.

The issue of "potential" is also important here. The "potential to produce . . ." clause in the above definition is significant in that a given causation sequence does not actually have to produce harmful effects in order to be classed as a loss incident. Vehicles out of control without striking anything, slips without falls, toxic exposures without physiological harm, self- extinguishing fires and minor electrical shocks might be classed as "close calls" or "near hits" but still fall under the definition of loss incidents because of the potential they have for more severe effects.

The Model

First a word about models in general. As a representation of the loss incident causation process, a model can greatly facilitate the description of an occurrence and aid in communicating and recording this information clearly for later use. It provides a basis for analysis that might be performed following the occurrence of an actual loss incident or a hypothetical event that seems possible but has yet to occur. With regard to accident investigation, the model creates a framework for studying relevant states and events that may have significance to understanding the occurrence. And as this paper will later describe, a model helps to identify underlying causes and provides a basis for proposing preventive strategies.

Since the days of H. W. Heinrich, theories of incident causation have periodically been developed, usually to address a particular type of loss incident and to be used by specialists in specific areas of the Safety Profession. Some were originally proposed by specialists trained in other disciplines who were thrust into an incident investigation, and who were striving diligently to better understand the causation process. Most of these theories have not been easily applicable outside of the areas in which they were originally developed and others did not offer a complete picture of the causation process. Still almost all of these had cogent and useful elements that helped all Safety Professionals to see a portion of the causation process more clearly.

There are tremendous advantages to be gained by having one accepted, workable, valid concept-set for explaining and describing all manners of loss incidents. The unifying effect of bringing under one methodology all of the diverse segments of the profession, would be tremendous. It certainly would improve the understanding of the causation process and could go a long way to eliminate the confusion often found in describing and communicating the process to those both outside the profession and inside of it. Still this model would be only a single tool possessing specific limitations and so the need for other tools and paradigms will always continue to exist.

The Universal Model developed almost 15 years ago was made not of whole cloth but was built by assembling portions of other causation models which had been tested through use and found to be valid in practice and helpful in explaining the causation process. When assembling these pieces, it became clear that there were significant gaps preventing a complete and continuous representation of the entire causation process. This forced the development of additional elements which had not been previously proposed by earlier researchers. (McClay 17)

The question concerning the temporal span that a useful causation model should embrace was answered by using the principle of utility. Of course the causation sequence ends on one hand with the finalization of the harmful effects produced by the loss incident or loss incidents. On the other hand, all of the relevant causal factors should be included without delving so far back in history that either utility or relevance is lost. The Universal Model recognizes two (2) classes of loss incident causal factors:

1. Proximal Causal Factors
2. Distal Causal Factors

Proximal Causal Factors are those states and events that exist within the same specific time frame and location as the loss incident. These include the states and events that in other models might be judged to be *hazards*. These factors can be diagrammed to clearly establish their sequential and logical place in a sequence leading to one or more loss incidents.

Distal Causal Factors are those underlying policies and practices that permit the Proximal Causal Factors to exist. To identify these, the Proximal Causal Factors must first all be clearly identified. But the Distal Causal Factors do not themselves appear in the diagram which identifies the Proximal Causal Factors.

Another temporal issue centers on the question of precisely when in the sequence the loss incident has actually occurred. In a long series of states and events, what point can be used to separate causal factors from other factors that only influence the severity of the final effects? This problem was addressed by defining an imaginary point in the sequence called the "*Point of Irreversibility".* This is the point in the sequence beyond which a loss incident of some sort can no longer be prevented. Beyond this point some undesirable effects will always result. Looking at this in another way, it can be said that until this point is reached, the opportunity for hazard control still exists and the circumstances can be returned to normal without the adverse effects of a loss incident being realized.

Regarding those factors which only influence the severity of the final effects of the loss incident, these also fall into two (2) categories:

1. *Aggravating Factors* are those states and events that cause the final effects of the loss incident to be more severe than they otherwise would be.

2. *Mitigating Factors* are those states and events that cause the final effects to be less severe than they otherwise would be.

Both of the above factors occur after the *point of irreversibility,* so technically they are not loss incident causal factors but they are important nonetheless. By eliminating aggravating factors, the severity of the final effects can be reduced. A Fork Lift driver jumping from his truck as it goes off of the loading dock would be an aggravating factor if it resulted in his being pinned beneath the vehicle. The use of personnel protective equipment is probably the most often encountered mitigating factor. Hearing protectors do not eliminate the noise emissions but they do limit the harmful effects experienced by exposed personnel.

In the Universal Model, Proximal Causal Factors are of three (3) types:

1. *Physical, chemical or biological conditions.* These are states which represent equipment, facilities and environmental conditions that contribute to a loss incident. There is no need to judge whether these are "safe" or "unsafe", as is the case with other models. We do not discriminate between conditions that are recognized as highly dangerous and those which are not. If a condition is necessary to cause a sequence of other states and events to occur and this leads to a loss incident, then this condition is included as a causal factor. Weather conditions, the locations of personnel and structures are other examples of these Proximal Causal Factors.

2. *Human Actions.* What humans do are events known to be important in loss incident causation. Again no judgment or determination about "safe" or "unsafe" actions is needed. Human inactions also fall into this category of causal factors.

3. *Exceeded Functional Limitations* When elements in the system are overstressed and their ability to perform is diminished, this becomes a recognized hazard. The science of Ergonomics studies human limitations in an attempt to prevent these from being exceeded. Reliability Engineering studies non-human system elements in a similar fashion. Each element in the system performs one or more functions and when we speak of limitations, it is in the ability to perform these functions that the limitations are seen. So as one identifies the function of a thing, then he or she has also found where the limitations will exist. As an example, if the blade of a knife has a function to cut and it becomes dull, then its ability to cut could be exceeded by any particular cutting task undertaken. If a metal bar is to hold a particular load and the load is excessive, we say that the (functional) strength of the bar has been exceeded. If a tire is designed to contain air under pressure and the tire is punctured, its ability to contain pressure will be exceeded by whatever pressure is present. In symbolic terms, this would be shown as depicted in Exhibit 1.

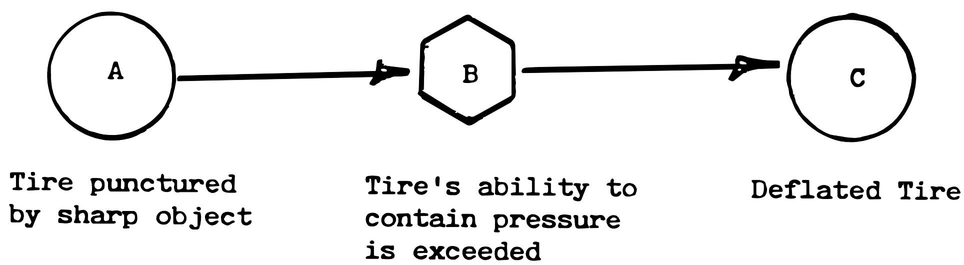


Exhibit 1. This sequence shows how functional limitations can be exceeded

Table 1 lists many human limitations that that have been recognized by Ergonomists and which are often found to have been exceeded in a loss incident scenario.

Force Exerted by Body Members	Visual Acuity
Rate of Force Exertion	Auditory Perception
Endurance	Interpretation of Speech
Speed of Movement	Tactile Recognition
Dexterity	Chemical Recognition (Smell and Taste)
Reach Distance	Balance
Work Load	Reaction Time
Memory Recall	Knowledge / Understanding
Motivation	Attention Span
Number of Things That Can be Attended to at One Time	
Postural Limitations (The body has a limited repertoire of postures and these can be maintained only for limit periods of time)	

Table 1. Some important human functional limitations

The issue of state and event causation is fundamentally critical to describing the occurrence of loss incidents and it is an issue which has concerned philosophers for hundreds of years. David Hume first noted that just because Event A has preceded Event B, does not in fact mean that A has "caused" B. (Hume 131) In Safety Science we can avoid this problem by performing a simple and obvious logic test. If Event B could not have occurred without Event A having first occurred, then for our purposes, Event A becomes a causal factor for B. The same test can be performed on all potential Mitigating and Aggravating Factors.

If Event A is both necessary and sufficient to cause Event B, then one arrow to show this, drawn from A to B is used when constructing a diagram. If A is necessary but not sufficient to cause B, then additional causal factors and arrows leading from them to B will be needed. Exhibit 2 shows that each of the three (3) types of Proximal Causal Factors can contribute to causing both of the other two (2) types. By using just these three (3) types of Proximal Causal Factors, we have been successful in describing a wide variety of loss incident scenarios. If the facts surrounding a loss incident are completely known, it should be possible, using the Universal Model, to completely describe all of the Proximal Causal Factors involved.

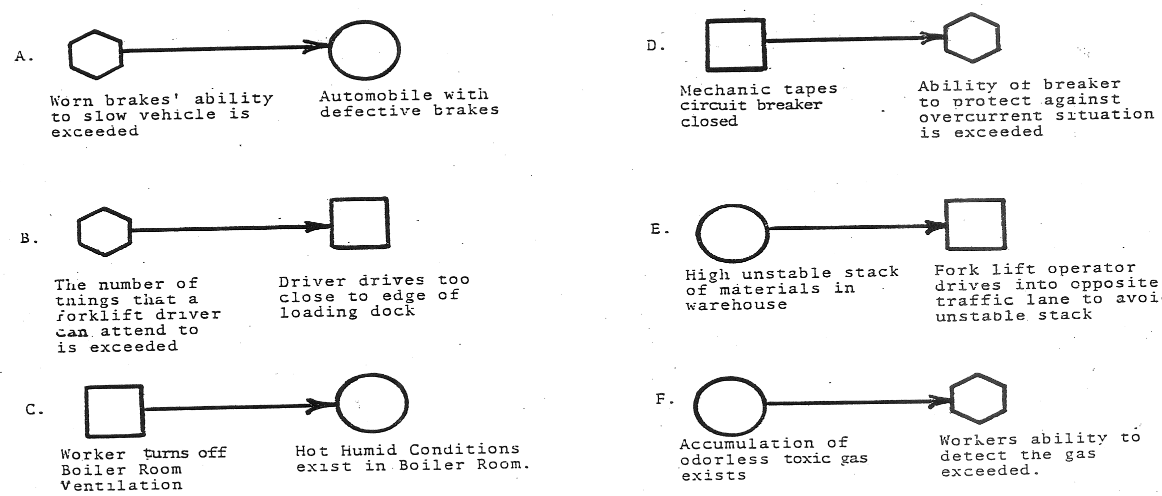


Exhibit 2. It can be shown that each of the three (3) Proximal Factor types can cause both of the other two (2)

Diagramming the Loss Incident

Loss incidents are not simple events with "common sense" causes and Safety Professionals undermine their own credibility by allowing managers to treat them as such. The idea that one (and only one) state or event has caused a particular loss incident is a fallacious notion that prevents other important causal factors from being identified in the course of an investigation. We should correct others when they talk about "the cause" for a particular loss incident when they should be more correctly referring to "causal sets", "causal factors", "causal sequences" or just "causes".

Diagramming loss incidents can be helpful in allowing us to visualize the sequence of causal factors and the relationship between them. It can also help to prevent the inadvertent omission of necessary causal factors that might otherwise be overlooked. First a system of symbols is needed to represent the various states and events that have been discussed earlier in the paper. Exhibit 3 shows the set of symbols that have been selected for this purpose.

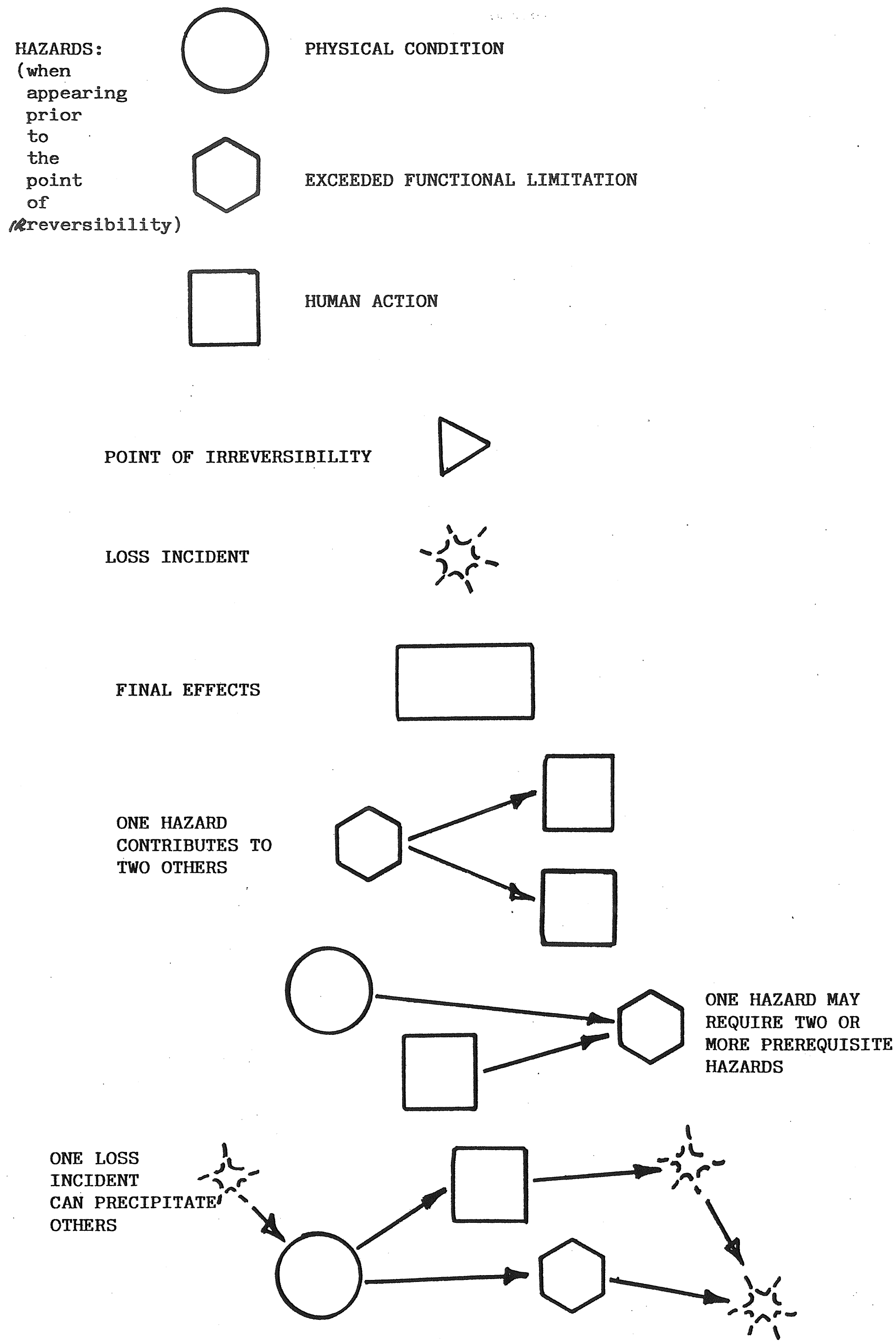


Exhibit 3. These symbols have been selected for use with the Universal Model (McClay 19)

Table 2 shows the steps that should be completed in order to diagram the loss incident once the investigation has uncovered all of the facts surrounding the incident. Identifying the *point of* *irreversibility* establishes an important milestone in the sequence. There is only one point of irreversibility in each loss incident sequence. This also makes it easier to identify the first loss incident since we know the loss incident must occur after the point of irreversibility is passed.

1. Find the Point of Irreversibility
2. Find the first Loss Incident (without any subsequent events or states can produce effects or a near miss).
3. Connect these two points
4. Add any Aggravating or Mitigating Factors
5. Find the next Loss Incident (if any)
6. Add Aggravating or Mitigating Factors between Loss Incidents
7. Find all remaining Loss Incidents (if any)
8. Identify and list the Final Effects
9. Identify Proximal Causal Factors i.e. hazards which immediately precede the Point of Irreversibility
10. Identify the Proximal Causal Factors which precede these hazards
11. Show only hazards that meet both of the following requirements:

    a. States or events which occur in the same time frame as the Loss Incidents
    b. States or events which occur at the same location as the Loss Incidents

12. Do not include supervisory actions or omissions, programs, policies, etc.

Table 2. Steps to follow in constructing a loss incident diagram

Loss incidents along with the Mitigating Factors and Aggravating Factors and the Final Effects are placed on the right side of the point of irreversibility on the loss incident diagram. Loss incidents can be fairly easily identified because they are the events accompanied by a release or transformation of energy and / or mass. They have the potential to cause damage, destruction, injury and death. In a sequence of loss incidents it will always be the case that the severity of the final effects is increased as each loss incident transpires. Table 3 gives some loss incident examples.

Worker Falls	Electrical Current Passes Through Worker'Body
Sharp Edge Penetrates Worker's Skin	Worker is Struck by Forklift
Worker Inhales Toxic Vapor	Tendons in Wrist are Overstressed
Tank Explodes	Methane Gas Ignites
Insulation on Conductor Melts	Sensitizer Contacts Skin
Worker Experiences Heat Exhaustion	Fire Spreads to Ceiling Tile
Driver Loses Control of Vehicle	Water Enters Cargo Hold of Ship
Intruder Fires Weapon	Scaffold Fails

Table 3. Some examples of loss incidents

The first loss incident is connected to the point of irreversibility by asking the question, "Is anything else required in order for this loss incident to occur?" If the answer is, "No" then an arrow is drawn from the point of irreversibility to the first loss incident as in Figure 4A below. If any other state or event must occur in addition to the state or event at the point of irreversibility, then this is a Mitigating or Aggravating Factor and is added to the diagram with arrows indicating causation as appropriate. If this factor is caused, at least in part, by the state or event at the point irreversibility, then the arrow is drawn from the point of irreversibility to the factor. If this factor is not caused by the state or event at the point of irreversibility, then it is recorded as a separate independent factor with causes to be identified. Often there are more than one state or event to the right of the point of irreversibility contributing to the occurrence of the first loss incident. The Safety Professional must then decide if these events or states occur in parallel (independent of each other) or in series (one necessary to cause the other). Exhibits 4 and 5 show how the development of states and events can be accomplished when diagramming the loss incident causal sequence.

The Final Effects from the loss incident sequence would include a compendium of injuries, deaths, damage, lost time and other losses. It may require many months or even years before the totality of the Final Effects can be fully detailed.

<u>*HYPOTHETICAL LOSS INCIDENT EXAMPLE DIAGRAMMED IN EXHIBITS 4 AND 5*</u>

In an accounting office, contractors were installing new cables for an upgraded computing system. Accounting Department employees continued to work at their desks in the same area where installation work was being performed. One contractor employee was preparing to install an outlet in a wall behind a desk, a task for which he was using a portable electric cord connected drill. He attached an extension cord to the drill's power cord since there were no nearby outlets. Then he laid the cord on the floor across the aisleway in front of this desk. A few moments later, while the contractor employee was operating the drill, the telephone rang on a nearby desk No one was near the telephone but one employee about 40 feet away hurried to answer it. In her haste, the employee did *not notice the cord stretched across the aisleway. She tripped over the cord and fell hard onto the floor. She suffered a broken arm and missed four (4) days work.*

When all of the loss incidents are connected with each other and with the Mitigating and Aggravating Factors as well as the Final Effects and the point of irreversibility, then the Safety Professional is ready to consider the causes for the Mitigating and Aggravating Factors. For each factor, the Safety Professional asks, "What states and events are necessary and sufficient to cause the Mitigating or Aggravating Factor?" Each factor is taken individually and causal factors are added to the diagram as appropriate. For example, this was done in Exhibit 4B. Often a Mitigating or Aggravating Factor affects the severity of the Final Effects but does not share a causal relationship with any other factor. In this case, the arrow is drawn directly from the Mitigating or Aggravating Factor directly to the Final Effects.

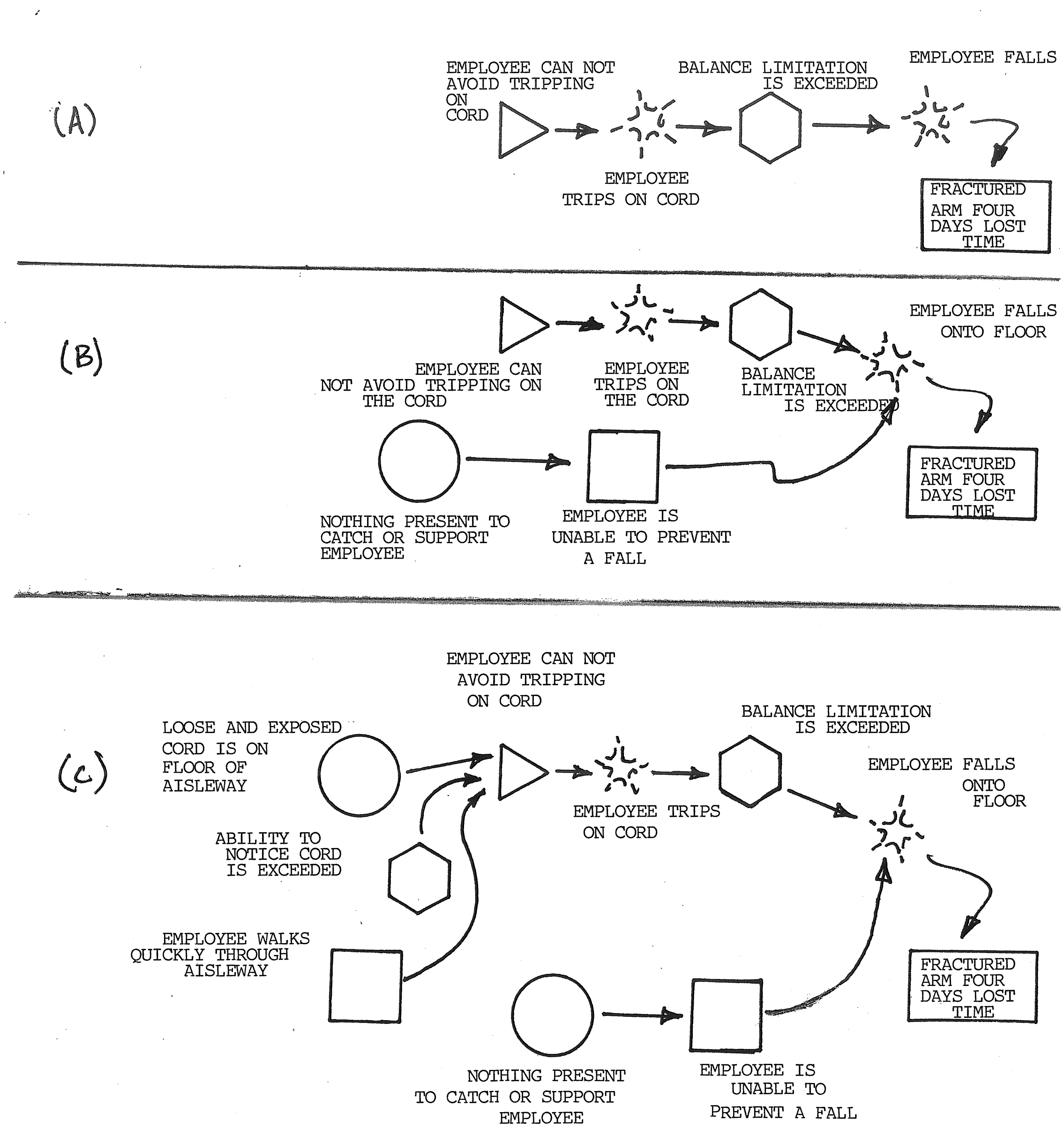


Exhibit 4. Stages in the development of the loss incident diagram for the above hypothetical incident leading to the final version shown in Exhibit 5

When the diagram on the right side of the point of irreversibility has been completed as in Exhibit 4B, the left side is then addressed by asking, "What states and events are necessary and sufficient in order to reach the point of irreversibility?" There is a tendency that must be resisted at this point to randomly begin listing causal factors with little regard to the logical relationship between the causal states and events. For example, in the incident scenario described here, it can be shown that three (3) separate causal factors immediately preceded the point of irreversibility and are *all* required in order for the point of irreversibility to be reached.

1. The cord must be across the aisleway
2. The employee must be moving through the aisleway
3. The employee can not avoid the cord

Each of these Proximal Causal Factors is then analyzed separately to determine its individual cause(s). For example, the necessary and sufficient causes of, "Loose exposed cord is on the floor in the aisleway" are:

1. Contractor lays loose cord across the aisleway AND
2. Contractor fails to place tape over the loose cord

The proximal causes are thusly identified for each state and event placed on the left side of the diagram until:

1. There is no information available that can be used to identify additional Proximal Causal Factors OR

2. The factors which can be identified represent routine states and events not potentially hazardous in any way.

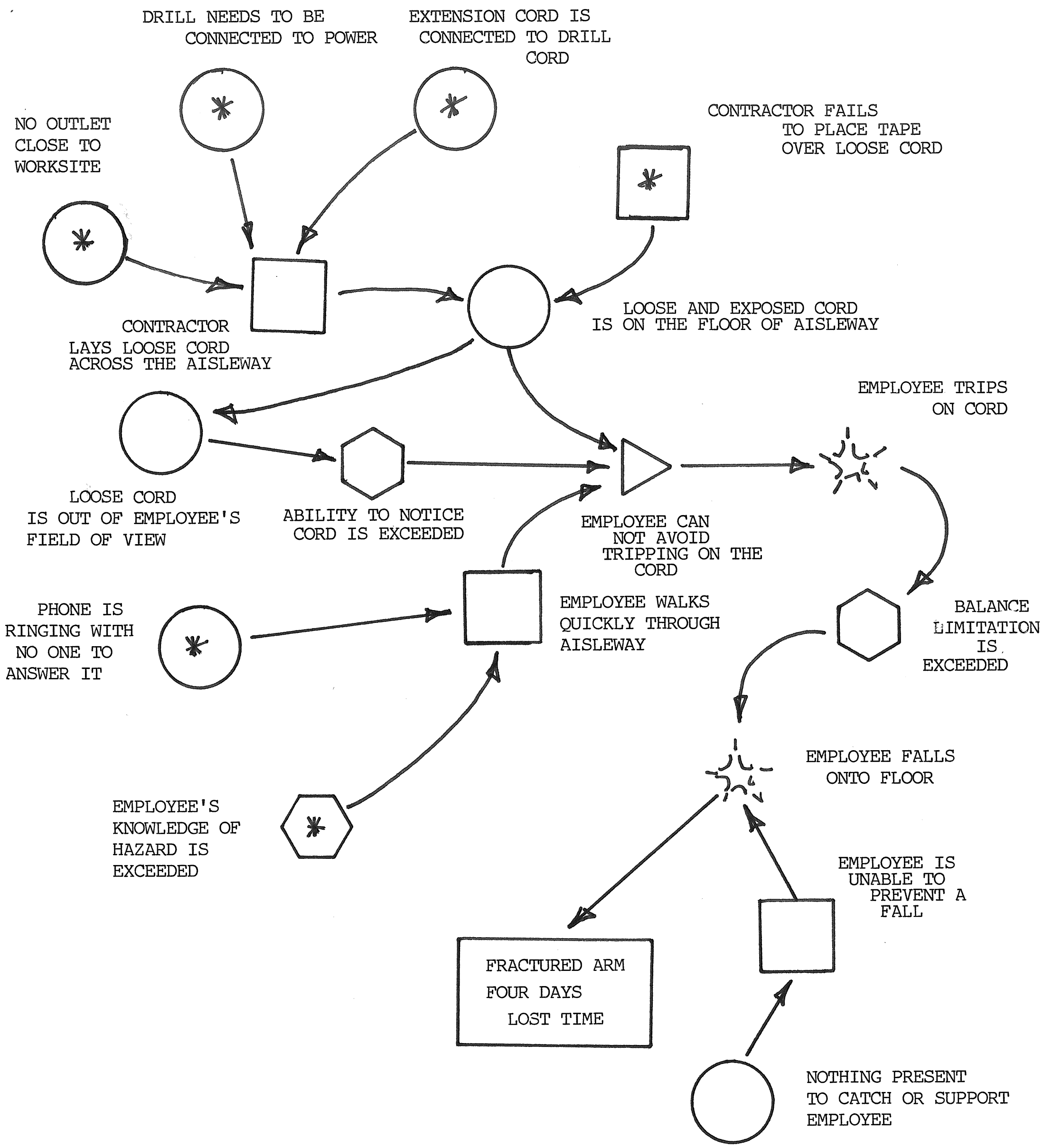


Exhibit 5 Completed Loss Incident Diagram for the hypothetical incident

Proximal Causal Factors are shown on the Loss Incident Diagram but Distal Causal Factors are not. That is because the Distal Causal Factors are of a different regime. They can not be shown as

Chemical, Physical or Biological Conditions, Human Actions or Exceeded Functional Limitations. Distal Causal Factors are management system failures. They are policies, programs and supervisory failures that lead to the Proximal Causal Factors that are shown on the diagram. Failure to train, program deficiencies, lack of enforcement, poor communication are all Distal Factors that should not be placed on the diagram. They can and must be found and the diagram can help do this as will be shown later but the Distal Causal Factors are not themselves placed on the Loss Incident Diagram.

One must be cautious and test the logical necessity of each Proximal Causal Factor as it is placed on the diagram. Sometimes states and events are erroneously listed because they appear in a time sequence of occurrences on the accident investigation report and not because they were causal factors necessary to produce a subsequent state or event. Exhibit 6 illustrates this common incorrect methodology. One can clearly see logical errors here as Event A can not cause Event B in the actual loss incident sequence nor can State C cause Event D. Just because one factor follows another does not mean that there is causation.

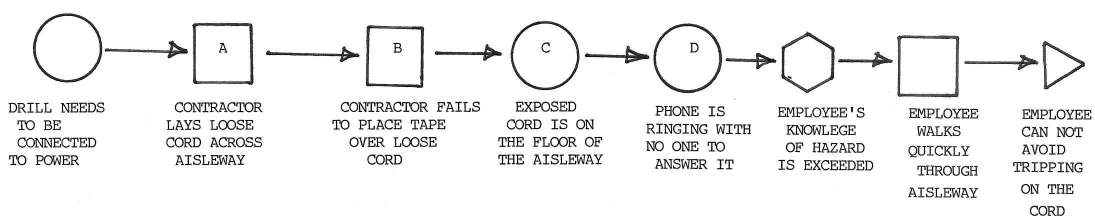


Exhibit 6. Incorrect relationship shown between Proximal Causal Factors

In the research and use of this methodology over the past 15 years, the most difficult step noted for users has been to perform the logical operations just described above. Despite this difficulty, if a group sits down and discusses how the diagram should look, there is almost always agreement on a single best solution. However for those investigators who want to take a short cut and not worry about the precise logical relationship between Proximal Causal Factors, it is possible (though not advisable) to make lists of each of the three types of Proximal Causal Factors in a brainstorming session of the accident investigation team. The risk here is that it will be easier to miss a causal factor or two (2) in the process of saving a few minutes time.

The Accident Investigation Process

Much has been written about the accident investigation process so little of that will be repeated here. There is general agreement in the literature about the methodology that should be followed and the planning process that must be established before an incident occurs to provide for an effective investigation.

Every organization must have a policy in place for specifying what type of investigation is to be performed on loss incidents of varying degrees of severity. Obviously the type of investigation appropriate for an OSHA non-recordable case is not appropriate for an incident involving a fatality. (Hartshorn 2) The type of investigation would detail who is to perform the investigation, the resources available for the investigation, the techniques to use, the nature and distribution of the incident report and the follow-up required following the investigation.

There is no arguing the point that the objective of the incident investigation should be to find out what happened specifically at the time and place of the loss incident and more generally, to learn all of the facts surrounding the occurrence. A standard approach for acquiring the evidence is called, "The Four P Approach". (Kuhlman 76) The four (4) P's stand for types of evidence that must be collected.

1. People
2. Position
3. Parts
4. Paper

People evidence includes the recollection of witnesses at the scene or the incident as well as supporting evidence from other people who have relevant knowledge regarding the occurrence. Usually this evidence is collected by interviewing the people who have theinformation needed. This evidence is thought to be very fragile (easily lost or contaminated) and so it is collected as soon as possible in the investigation. The longer that investigatorswait to gather this information, the more suspect it becomes.

Position evidence consists of information about the location of people, objects, equipment, markings, structures, etc. at the scene, immediately following the incident. With this information and knowledge of where these things were previously located, some inferences can be drawn about the occurrence. There exist various charting and diagramming techniques which are used to show these locations on a chart or diagram. Photographs of the scenetogether with appropriate identification tags are also very useful in this process.

Parts are solid objects, liquids and gases that are found to be present at the scene of the incident. Most of these parts will be scientifically analyzed following the incident to identify substances, forces, patterns and stresses that can give clues as to those events that have led to the loss incident(s). Anyone who has watched the CSI television shows is now aware of how much information can be produced from tiny scraps of evidence found at the scene. It is important though to have location diagrams, photo logs and parts logs to keep track of all the parts sent from the scene to be analyzed at some other location.

Paper evidence as the name implies, consists of records, logs, procedures, programs and other documentation most of which is now computerized. This is very durable evidence rather than fragile and so is usually collected last in an accident investigation. Though lawyers constantly encourage organizations to destroy this type of evidence for fear of liability, it can be enormously helpful in generating background information vital to a complete investigation. Much of this material is required to be kept on hand by regulatory agencies as well.

Evidence is collected in the manner outlined above without any intention of finding fault or placing blame and when everything that can be known about the incident, is known, the evidence will be carefully analyzed. It should be remembered though that if the accident investigation is incomplete, then the Loss Incident Diagram is also likely to be incomplete. However by studying the diagram as it is constructed, the investigation team can recognize unexplained causal factors which can show where the investigation team needs to seek and find more evidence. Exhibit 7 shows a process that structures the analysis and is designed to determine which potential causal factors are logically supported by the collected evidence. It is a process of literally putting the pieces of the puzzle together. This then establishes a basis for the construction of a Loss Incident Diagram.

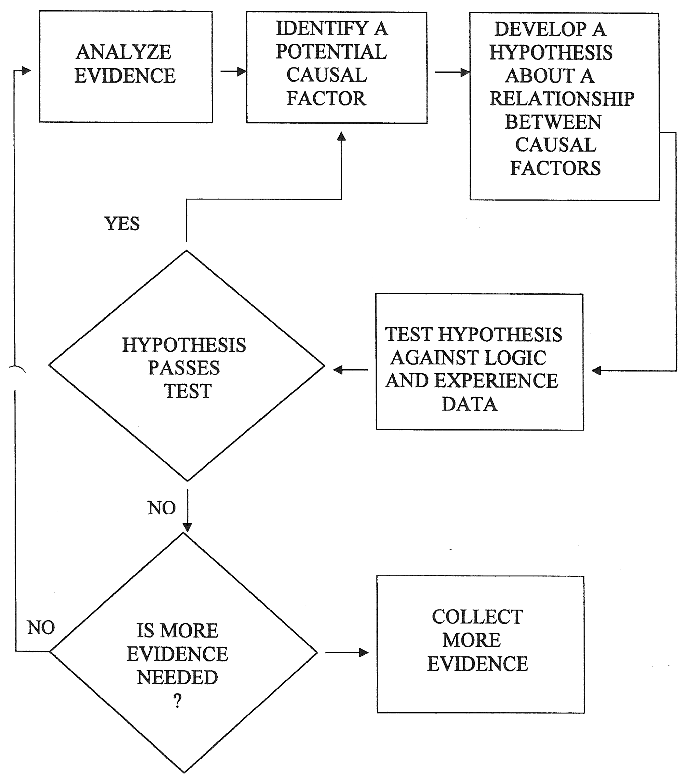


Exhibit 7. A process for identifying potential causal factors from collected evidence

Finding the Distal Causal Factors

As one will recall, Distal Causal Factors were the management system deficiencies that allowed the Proximal Causal Factors to exist. Rather than being overtly present at the time and place of the loss incident, these factors must be identified by the trail they leave. The lack of a Lockout-Tagout Program is a Distal Causal Factor and can be the fundamental reason behind an employee failing to lockout prior to working on a machine. This human action (or inaction) is, time after time, implicated in serious loss incidents. The Distal Causal Factors are the "underlying causes" that every investigator says that he / she wants to identify. They are not shown on the Loss Incident Diagram but the Loss Incident Diagram can be used to track them down.

A number of ways can be used to identify the Distal Causal Factors with the Loss Incident Diagram as a useful tool. Perhaps the easiest and most direct method to accomplish this is with the much-maligned "5Y's Technique". Though this device might lack the glamour and sophistication that some might like to see, this is a very effective tool when used by trained investigators. It starts by examining the Loss Incident Diagram to identify those Proximal Causal Factors furthest to the left, away from the point of irreversibility, those factors whose causes were not shown; at the beginning of the chain of states and events as it were. We might call these Proximal Causal Factors, "Prime Causal Factors" since they occur at the beginning of the loss incident sequence. In Exhibit 5 these factors are identified with an *.

One (1) Prime Causal Factor at a time is taken for analysis. Investigators list the Prime Causal Factor on a simple table like Table 4 in the leftmost column. The next column on the right is the first "Why?". The investigation team asks themselves, "Why did this Proximal Causal Factor occur?" The answer they place in the second column from the left. Obviously there needs to be discussion among the team members and often even more investigation to find the answer. In Table 4, the reason, "The contractor failed to place tape over the loose cord" was concluded to be, "The contractor has no tape handy to serve this purpose". Then the question is asked, " Why did the contractor have no tape handy that would do this job?" The best answer that can be found is listed in the third column from the left; "The contractor does not usually use tape for this purpose". We ask again, "Why?" and eventually we complete the 5Y Analysis with entries in all six (6) columns. Should the team find more than one answer to any one of the "Why?" questions, then another line of entries is started on the line below. In this way all credible causes can be considered.

By the time the team have reached to the fifth "Why?", some clear management system deficiencies are sure to have appeared. And after the 5Y is completed for each of the Prime Causal Factors as shown on the Loss Incident Diagram, we will find that we have a whole collection of underlying causal factors that need to be corrected. These can then be prioritized and addressed in the final Accident Investigation Report. (National Safety Council 152)

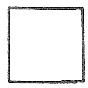
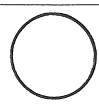
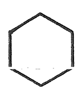
PROXIMAL CAUSAL FACTOR FROM DIAGRAM	WHY???	WHY???	WHY???	WHY???	WHY???
 Contractor fails to place tape over loose cord	Contractor has no tape handy to serve this purpose	Contractor does not usually use tape for this purpose	Contractor training does not specify this practice	Written work practices do not address this hazard	Inadequate Safety input and review of written work practices
 Telephone is ringing with no one to answer it	Accounting Office was short-handed on this particular day	One employee called in sick and others had to perform her work	Voice Mail System was not working so all calls had to be answered	Telephone service vendor slow in installing and servicing telephones	Contract issued based on price with little consideration for service
 Employee knowledge of hazard is exceeded	Employee did not expect to encounter this hazard	Employee was relatively new and experienced	New Employee Indoctrination did not address this hazard.	Safety Indoctrination for new employees has not been updated or revitalized in years	Inadequate Safety input in new employee indoctrination

Table 4. Using the 5Y Technique to identify Distal Causal Factors

Summary

This paper has described one method for identifying the underlying causes of loss incidents so that these can be corrected and repeated occurrences avoided. The methodology involves the development of a Loss Incident Diagram which can show the following features of the incident:

1. The Final Effects
2. Mitigating and Aggravating Factors which influence the severity of the Final Effects
3. The Point of Irreversibility which is a benchmark separating causal factors from non-causal factors
4. Proximal Causal factors or hazards which acted jointly to cause the Loss Incident.
5. Prime Causal Factors which are a subset of these Proximal Causal factors and which can be analyzed further to find the Distal Causal Factors.

Other analysis techniques including the 5Y method can be used to find the underlying causal factors which allow the Prime Causal factors to occur or exist. These underlying or Distal Causal Factors are those management system failures which must be corrected and which should be the focus of any accident investigation.

This methodology has evolved from and is based on The Universal Model for loss incident causation which has been researched and tested over the past 15 years. This model has proved useful in diagramming loss incidents of every type and can provide a clear method of describing, explaining, comparing and communicating information about loss incident occurrences.

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