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CULTURAL ATTITUDES AND RISK MANAGEMENT IN INDUSTRIAL SETTINGS

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Introduction

Petrochemical and other industrial facilities do not operate only in physical and technological environments. These facilities also operate in a cultural environment. This cultural environment interacts with the organizational structure of an industrial facility in some general ways e.g., economic and political pressures. However, from the risk management perspective, the most important impact of the cultural environment on the organizational structure of an industrial facility is the manner in which the cultural environment shapes the behavioral characteristics of individual workers. Cultural environment affects the physical, psychological and educational characteristics of a worker. This environment also affects the social and religious orientations of workers.[1] The study of how cultural environment affects worker behavior is thus necessary to manage risk in industrial settings.

In this discussion, specific examples will be given of how the cultural environment affects worker behavior. These examples (unless stated otherwise) were all personally witnessed by the author in the context of oil pipeline construction; hydroelectric and nuclear power plant construction and operation; petrochemical storage and transfer facility operation and construction; highway and mass transit operation and construction; and commercial building construction. The data from which these examples were taken is wide enough in scope to demonstrate that while cultural groups may differ in specific details of behavior, the general trends illustrated by the examples are valid cross-culturally. Thus, examples of worker behavior in industrialized countries can serve as general guidelines to worker behavior in less developed countries and vice versa.

This paper will examine risk management possibilities for industrial settings in an unconventional manner. Instead of focusing on the top of the organizational hierarchy (e.g., designers and planners) or the middle of the organizational hierarchy (e.g., line management), this paper will focus on the bottom of the organizational hierarchy: the basic implementing worker (BIW).

The basic implementing worker is the person who actually performs repair, maintenance, and construction functions. These functions are critical to the safe operation of the plant.[2] The BIW also frequently performs quasi-operator functions as well. The worker who turns a valve in a remote location in the plant is also an operator of sorts. Usually less trained, this "part-time" operator can, through his actions, cause errors that can have major consequences to plant operating equipment and can be a source of risk of a major plant accident.

The conventional approach to discussion of risk management in industrial settings relies heavily on the use of control theory. In the area of social systems, however, doubts have been raised as to the applicability of control theory. Brehmer stated, "Control engineering was developed in response to needs to control machines automatically. It is therefore reasonable to ask whether this kind of thinking is applicable to the social systems of interest in control of safety".[3] Since the present discussion centers on identifying the qualitative nature of human behavior and its qualitative sources, control theory is not applicable.

Our discussion is divided into five parts. The first part discusses types of risks encountered in industrial systems. The second part discusses the causes of the risks. The third part discusses cultural attitudes of workers. The fourth part discusses approaches to risk reduction. The fifth part summarizes the conclusions of this discussion.

1. Types of Risks

For our investigation, risk types are being discussed according to the type of outcome that results from the risk actually occurring. One can thus divide risks into four types:

- Risks to Personnel;
- Risks to Equipment;
- Risks to the Facility as a Whole;
- Risks to the Environment of the Facility (including the Surrounding Community, if any).

1.1 Risks to Personnel

Risks to personnel can be divided into two major types: Accident and Disease.

1.1.1 Accident

Accidents resulting in personal injuries to personnel can range in severity from the merely annoying to the lethal. Over 10,000 workers die due to workplace accidents each year in the United States.[4] Accidents that injure personnel result in certain immediate costs to the organization such as lost production and higher insurance premiums.

Personal injury of plant personnel also has the potential to generate future costs to the organization. Replacing injured, trained personnel with inexperienced, less-trained personnel, results in training expenses and possible reduced production. In addition, the potential is increased for the occurrence of costs to the organization caused by damage to plant equipment, injury to other personnel, or damage to the plant environment and surrounding community. Thus, an individual's injury because of accident can affect the safety of the plant and therefore can be a source of risk of a major accident in the plant.

1.1.2 Disease

Disease can be caused by various factors operating inside or outside of the workplace. Outside of the workplace, disease is caused by a multitude of factors normally not under the control of the employer or at best susceptible only to indirect control.

Inside the workplace, disease can be induced by intentional or accidental exposure to various physical phenomena.[5] The potential for disease causation is demonstrated, for example, by the fact that sixty per cent of all chemicals used in the workplace have never been studied for their toxic effects on workers.[6] Intentional exposure does not necessarily indicate self-injury but rather exposure that is planned or allowed as a matter of system design. Accidental exposure is the result of unplanned exposure occurring as the result of non-compliance with established plant procedures or as a result of equipment or system failures.

Whether disease causation takes place inside or outside of the workplace and whether it is accidental or intentional does not necessarily affect the progress or severity of the disease itself. Diseases vary in severity of effect, parts of the body affected, and time until symptoms manifest themselves.

The cost of a worker's disease to the organization can take the form of disability payments, medical expenses, lowered productivity (as inexperienced workers replace ones with disease), and higher insurance premiums. Also, depending on the disease, the worker may be affected in a manner that will adversely affect the facility itself. Diseases that result in impairment of the senses or reasoning ability or that cause sudden loss of consciousness can cause misoperation of equipment that can damage the equipment itself and can lead to damage to the entire facility. Thus disease, whether caused in the workplace or encountered outside of the workplace is a source of risk of a major plant accident.

1.2 Risks to Equipment

Risks to individual pieces of plant equipment or tools are of two major types. The first is damage or destruction of the equipment because of misoperation. Misoperation encompasses the concept of lack of maintenance and the concept of non-compliance with specified operating procedures. Misoperation can result in damage to the equipment and, depending on the equipment involved, damage to the entire facility. Misoperation can, in addition to the direct, immediate damage to other equipment or the entire plant just mentioned, be a source of future damage to other equipment or the plant as a whole. This is the case, for example, when safety equipment is misoperated. No immediate harm may result; but when this equipment is needed, it may not function properly and a harmful event that could have been contained might not be. Thus, misoperation of equipment or tools can be a source of risk of a major accident.

The second most serious risk to individual pieces of equipment or tools in a facility is the theft of all or parts of the tools or equipment. The damage here is that as a result of the theft, a machine potentially will not operate properly, or a critical tool or replacement part will not be available for routine maintenance or in an emergency situation. Theft of relatively small items can thus have an effect on the entire plant facility and be a potential source of risk of a major accident.

1.3 Risks to the Facility as a Whole

Risks to the facility as a whole, other that the ones previously discussed, take two general forms. The first is misoperation. This does not refer to misoperating a specific piece of equipment but rather to line management misoperation of the overall plant system itself in some manner. This type of misoperation (as well as misdesign by planners and engineers) is outside the scope of the present discussion.

The second type of risk to the facility as a whole is defective construction. In other words, the plant is not built as the design specifications require. When construction defects are localized e.g., in one

pipe joint, defective construction resembles misoperation of specific pieces of equipment or theft of specific tools or equipment. The result of localized defective construction may be local failure of equipment with only a local impact or, if the defect is in a critical location, may be damage to the whole facility.

Systematic, widespread defective construction as a result of e.g., poorly trained welding crews, has an obviously greater potential to damage the whole facility; although, again, the damage may remain localized. Systematic defective construction requires the systematic failure of primary construction, inspection, and remedial work (if any). Systematic defective construction is a greater source of risk of a major accident to the entire plant than occasional, localized defective construction because of the increase in potential accident sites.

1.4 Risks to the Environment of the Facility and the Surrounding Community

Any of the previously discussed risks that lead to equipment damage can result in the release of toxic substances into the environment. Any of the previously discussed risks that lead to facility-wide damage will almost certainly lead to the release of toxic substances into the environment. These risks all occur during plant operation and are much discussed. What can be forgotten or given a position of minor importance is the pre-operational phase of a plant where environmental damage is caused by construction of the plant and adjoining infrastructure.

Construction damage to the environment is of two types. These types of environmental damage will occur to some extent in almost every instance of plant construction. However, the damage can be exacerbated or lessened by the techniques used during construction. The choice of these techniques is a direct result of the cultural biases of the construction workers and their supervisors. This cultural aspect will be examined in more detail later in this discussion. The first type of environmental damage is directly related to infrastructure. Infrastructure for plant construction consists of access roads, a prepared plant site, temporary housing, and temporary fabrication and storage facilities.

Access road construction involves several environmental hazards. The road will interrupt existing drainage patterns which can cause flooding and erosion. Acquiring the road material will probably entail excavating on additional land area. Trees and other fauna will be destroyed. The road material (and anything spilled or leaked on it) may erode and pollute nearby water sources. Finally, dust and noise will be created as the road is constructed and used.

Preparing the plant site itself also involves environmental hazards. The site by its very existence will interfere with local drainage patterns. Also, in order to bring the site to the proper grade, soil may have to be removed from the site or added to the site from other land. Standing water may have to be removed from the site and this will destroy the habitats of various forms of wildlife. Trees and other fauna will have to be destroyed. Surface material from the site (and anything spilled or leaked on it) may erode from the site. Noise and dust will be created as additional nuisances as the site is constructed.

Temporary housing construction will entail all of the hazards that plant site preparation will entail because first the site for the housing must be prepared. In addition, waste material will be generated as a result of the

construction of the housing itself. Additional leaks and spills, of materials used to construct the housing and from equipment used to construct the housing, will occur. Noise will be generated during construction.

Temporary fabrication and storage facilities will involve all of the hazards of plant site preparation and temporary housing construction. Also, they will generate additional waste material as a result of the fabrication and storage activities necessary to build the plant itself.

Construction of the infrastructure necessary for plant construction can cause a variety of environmental damage. Local air and water can be polluted, wildlife destroyed or driven away by noise. Also, waste soil and construction waste products will be generated. All of these phenomena have impacts on the environment, some short-term, others long term.

The second type of damage to the environment caused by the construction process is caused by the very existence of the workers at the construction site and its environs. These workers, imported onto the construction site from other countries or regions to build, for example, an oil pipeline in Alaska may engage in the hunting of local fauna and the collection of minerals, flora, and native artifacts. These workers will make demands on the social environment in the context of entertainment and purchase of local commodities of interest. These acts can cause environmental (as well as social and economic (inflation of prices of goods)) damage to the area surrounding the construction site. The scope and time duration of the damage will vary depending on the culture, education and training of the workers, environmental sensitivity of the site, proximity of the site to the local population, and cultural compatibility of the local population and the imported workers and the extent to which the workers' behavior is monitored by their employer and local governmental agencies.

2. Causes of Risks

Having discussed the types of risks on which this paper is focused, I now turn to an analysis of the causes of these risks. The examination into causation will focus on the human element. More specifically, the focus will be on the basic implementing worker-system interface; but from the perspective of the basic implementing worker, not that of the system.

Basic implementing workers make errors that create risks in three different behavioral modes:

- Ignorantly;
- Negligently;
- Willfully.

These modes will be discussed in the order listed.

2.1 Ignorance as a Cause of Risk

Lack of training of plant personnel is a favorite topic of discussion in risk analysis. Whether this is because, as has been suggested, focusing on plant personnel saves others from embarrassment or whether lack of training is perceived as a problem subject to a "quick fix", lack of training is a real problem.[7] Unskilled and semi-skilled workers in developing countries are frequently from rural areas and illiterate, and thus have little knowledge or concern about safety issues.[8] Training must correct this situation and if it does not, workers will lack the information necessary to safely operate the plant.

Lack of training can result in two forms of lack of information: lack of information necessary to perform a task or sequence of tasks, operational ignorance, and lack of information about the consequences of failing to follow an instruction in the accomplishment of a task, consequence ignorance.

The first form of lack of information is operational ignorance, which consists of the lack of information necessary to actually perform a task. This type of ignorance is often cured quickly and apparently satisfactorily by classroom training programs, on the job instruction, operations manuals, etc.

The second form of lack of information, consequence ignorance, consists of two additional forms. The first form resembles operational ignorance - the worker doesn't have information about the consequences of his acts in the sense that he actually doesn't know the consequences. This form of ignorance (literal consequence ignorance) can be remedied by the same remedial measures that can eliminate operational ignorance e.g., classroom training programs, on the job instruction, operations manuals, etc.

The second form of consequence ignorance is lack of belief in the reality of the known consequences (consequence non-belief). That is to say, a worker has been instructed that a certain consequence is supposed to occur if he performs a certain action, but he is convinced either that the consequence will not actually occur or that if it does occur, it will not be as detrimental as he has been told.

There are two aspects of consequence non-belief. One aspect is similar to consequence ignorance in that the worker is generally aware of the type of consequence but is not aware of specific details about the consequence (consequence vagueness). Hence, while intellectually being aware of the consequences, he does not change his behavior/belief patterns to take the consequence into account because it is too abstract. The consequence is "two dimensional" not "three dimensional". The worker lacks sufficient details about the consequence to "concretize" the consequence in his mind.

Another aspect of consequence non-belief, although not usually thought of as due to lack of training, is consequence denial. Consequence denial operates when a worker, through detailed training, is fully aware of the existence of a consequence and its potential impact - at least according to his instructors - and still does not integrate this information into his behavior/belief pattern because this received information conflicts with some pre-existing behavior/belief pattern. Action or non-action by a worker based on his consequence denial is willful misconduct but is discussed here under the heading of "Ignorance" because the source of such behavior is worker ignorance.

Denial may be based in the cultural, class, religious or other personal beliefs of the worker. These factors, which constitute the precursors of unsafe acts by workers are "norms" which influence the worker's behavior because he perceives them as being adhered to by persons whom he sees as role models.[9] These factors will be discussed in detail later in this paper.

The conflict between cultural, religious and other personal values and worker job instruction is discussed here, under the general heading of "Ignorance". It is indicated that from the operating system's point of view (of which the worker is a part), these beliefs generate "system ignorance" by

interfering with data the system is trying to transmit to the worker and thus interfering with the system's goals. Action or inaction by a worker based on his consequence denial is willful misconduct but is discussed here under the heading of "Ignorance" because the source of such behavior is worker ignorance. A worker operating under consequence denial will appear to superficial inspection to be a fully-trained, consequence-oriented member of the plant "team". In reality, he is a potential source of risk to himself, other personnel and the plant itself.

Either form of lack of information by workers can be the source of each of the risks discussed in the first part of this paper: risks to personnel, equipment, the facility as a whole, and the environment of the facility and surrounding community. Methods for correcting worker lack of information, especially the subtler form, "consequence ignorance", and its subpart, "consequence non-belief", will be discussed in the third part of this paper.

2.2 Negligence as a Cause of Risk

If a person acts or fails to act, has a duty to act with reasonable care, and breaches the duty by creating an unreasonable risk of harm, then the person has committed a negligent act. This is a legal definition taken from American law, but it can serve as a guide for analysis of worker behavior in the area of risk management. If a worker has been instructed to perform a certain task and does not perform the task he "fails to act". If a worker has been instructed to perform a certain task and he obeys his instruction, he "acts".

If a worker has been instructed to perform a task, he is supposed to perform the task according to instructions and to use reasonable care to avoid risks. Even though "reasonable care" is a legal term of art from the common law legal system, the concept is applicable in other countries because it is a "common sense" concept. Reasonable behavior is a universally understood concept. If a worker does not know his duty to act or not act and to do both in a "reasonable manner" then we have a situation of worker ignorance. This situation and the case where a worker knows his duty but does not believe in it were discussed in the previous section of this paper. The issue to be discussed under the heading of negligence as a cause of risk is, assuming that a worker knows how to perform his task according to plant procedure (and believes he should do so) and knows that he must accomplish the designated steps using reasonable care, why does the worker unreasonably fail to follow procedure or why does the worker follow procedure but in an unreasonable manner?

Even assuming a worker has been properly instructed about the specific steps to take in order to perform a task and the manner in which to perform the steps, negligent behavior can still result because of misapplication of procedure to a factual situation or misunderstanding of a factual situation. Both occur due to mental perception problems or a sensory impairment. That is, the worker will, due to some interference with his mental processes or his senses, not properly perceive the factual situation confronting him or will misapply procedure. The causes of this perceptual interference are discussed below and can be grouped as follows:

- Physical/Mental Fatigue;
- Mental Stress;
- Alcohol and Drug Use;
- Disease, Age, and Physical Damage to Sensory Organs.

2.2.1 Physical and Mental Fatigue

Physical/mental fatigue are caused by the number of hours worked, the difficulty of the tasks performed, and the physical health of the worker. An increase in the first and second factors increases fatigue as does a lowering of the third factor. Fatigue lowers mental perceptual abilities and can thus be a cause of negligent acts.

2.2.2 Mental Stress

Mental stress is defined as "mental [or] emotional...tension, strain, or distress".[10] Mental stress is caused by physical or mental fatigue, personal (legal, family, financial, health) problems, and job dissatisfaction (terms and conditions, supervisor or co-worker actions, job content).[11] Mental stress interferes with the mental perception of situations and can cause negligent actions by workers.[12]

2.2.3 Alcohol and Drug Use

The third major source of negligent behavior relevant to workers in large industrial facilities is the alteration of mental processes caused by the use of alcohol or other drugs.[13] (Workplace chemicals may also act as "accidental drugs" that alter the mental perceptual abilities of workers.)[14] Workers who use drugs are nearly four times as likely to be involved in accidents while working.[15] Certain drugs (e.g., marijuana, cocaine) may be used either before, after, or during work. Other drugs are used mainly during meal breaks and after work (e.g., alcohol). The cultural context of the plant has a great influence on the extent of drug use; for example, alcohol abuse is a very slight problem in most Moslem countries. Also, local cultures may condone the use of certain-perception altering drugs (e.g., coca leaves, glue, opium, khat).[16]

It is apparent that cultural attitudes toward working long hours, working several jobs, and toward use of perception-altering substances affect these sources of negligent acts. Cultural attitudes as they affect other risks in large industrial facilities will be discussed in another section of this paper.

2.2.4 Disease, Age, and Physical Damage to the Sensory Organs

Damage to the sensory organs has several causes. As previously mentioned in the first part of this paper, disease can be a cause of damage to parts of the body. These parts can include the sensory organs.

Age also can impair the functioning of sensory organs. As workers grow older, their sight and hearing require artificial aids to function normally.

Physical forces can also damage sensory organs. These forces, for example, loud noise or bright light, can be present inside or outside the workplace.

All of the previously listed factors can damage workers' sensory organs. When these organs are damaged, a worker will perceive reality inaccurately. This misperception can lead to negligent acts being performed by the worker. Since negligent acts can lead to the risk of major plant accidents, all of the causes of sensory organ damage can be said to contribute to the risk of a major plant accident.

2.3 Willful Misconduct as a Cause of Risk

Willful: "Intending the result which actually comes to pass; designed; intentional; not accidental or involuntary"[17]

According to the above definition, willful misconduct is misconduct performed knowingly with awareness of the result of the action. Willful misconduct in the context of the present discussion is misconduct performed by workers that results in harm to the facility, its equipment or tools, or its personnel. In this context, the worker is aware of his action and its consequences and intends that the consequences occur.

The topic of willful worker misconduct will be discussed in five parts:

- Worker "Play"
- Mental Stress
- Drug Use
- Worker Dissatisfaction with Working Terms or Conditions
- Monitoring/Modifying Worker Output

The five subparts are somewhat interrelated but merit separate discussion.

2.3.1 Worker "Play"

Worker "play" appears to be on the borderline between willful misconduct and negligent misconduct but will be treated as willful misconduct in the present discussion. This "play" frequently takes the form of practical jokes on co-workers but can manifest itself in other ways. Practical jokes on co-workers can range from the relatively safe (if any misconduct at an industrial facility can be called safe) and friendly to the malicious and clearly dangerous. Examples of the former include hiding a co-worker's work clothes, food, and writing various words on his clothing, tools, etc. Further examples of the latter include hiding protective headwear and other safety equipment, spraying co-workers with grease, paint or other substances, and changing the operating procedure of certain tools or equipment so that when operated they will behave in an unexpected manner and "surprise" the operator. The two types of "play " are somewhat interchangeable and which category a specific act falls into depends on the intent of the worker performing the act.

All of the above-described behavior is personally dangerous to some extent to the actual worker who is the target of such behavior. This personal danger may or may not be apparent to workers, but what is usually not apparent to workers when they engage in such behavior is the potential for secondary effects on the safe operation of the plant itself.

Another form of worker "play" is the misuse of tools or equipment by workers for their own subjective amusement. Examples of this include driving automobiles or other transportation too fast from one area of the plant to another, intentionally spilling various substances because the color and/or pattern of the spilled substance is amusing, and dropping or throwing objects from great heights to see the effect when they contact the ground or other surface. This type of misconduct is also personally dangerous to some degree to the person engaging in it or passing near it. Again, workers frequently do not understand the potential for this type of misconduct to detrimentally affect the safe operation of the plant.

2.3.2 Mental Stress

Mental stress is not in itself willful misconduct but can be either the result or cause of it. The definition and causes of mental stress were discussed in the section about negligent worker conduct.

A worker in a stressed condition may react in a manner different from his usual manner. Reactions tend to be less thought through and more forceful than usual. This distortion can cause unsafe conditions by itself or in combination with other worker misbehavior.

By itself, mental stress can cause a worker to perform tasks in an unsafe way by causing him not to follow procedures either because the stress obscures the seriousness or the existence of the consequences of non-compliance with procedure. This is stress-induced distortion of the worker-machine interaction. Also possible is a distortion of worker-worker interaction where mental stress causes a worker to misinterpret the normal acts of fellow workers.

Other types of worker misbehavior or error can combine with mental-stress-induced distortion of behavior to create or worsen worker misconduct. A worker in a stressed condition may overreact to co-worker "play", especially if directed at the stressed worker. This can result in return behavior ranging from non-use of safety equipment/procedures (the "I'll ignore them" attitude) to "repayment" of offensive behavior with disproportionate return behavior (the "I'll show them" attitude) and even physical violence among workers. The consequences of such behavior range from individual worker physical injury or death to misoperation of tools and plant equipment with all the implications for accident inducement that this implies.

A worker who is suffering from mental stress will be less tolerant of a co-worker's ignorant or negligent behavior. That is, the stressed worker will be less willing to stop other workers from committing errors due to lack of training or due to negligent behavior. The stressed worker will also be less willing to instruct other workers in the proper procedure for performing an act.

2.3.3 Alcohol and Drug Use

Alcohol and drug use alter the mental perceptions of the user. In the context of the present discussion, willful misconduct by a worker using alcohol or drugs means that even though the worker might not have performed the act of misconduct while not using alcohol or drugs, the worker actually did, under the influence of these substances, perform an act intentionally, not "accidentally" or negligently. The concept of diminished mental capacity due to alcohol or drug use is not relevant to the present discussion because no legal result is required in the present context.

As discussed under negligence, some drugs can interfere with a worker's sensory perceptions of reality. This can cause him to act in an objectively unreasonable manner even though the worker is acting subjectively in a reasonable manner. Certain other drugs affect some individuals by inducing them to commit willful misconduct. These drugs induce feelings of superiority, paranoia, hostility, or aggressiveness. These drugs can cause workers to commit acts of willful misconduct either in the worker-machine interaction or in the worker-worker interaction.

Feelings of superiority vis-a-vis more highly trained or educated persons can induce workers to alter set procedures for repair or operation of tools or equipment. A worker may feel that he has to "show" the other person that he, the worker, really best understands the work situation under discussion. Alternatively, the worker may feel so superior that he believes his way of performing the work task is really the best way.

Feelings of hostility, aggressiveness, or paranoia can cause workers to react in abnormal ways with respect to their co-workers. Innocent co-worker actions can be misinterpreted and induce hostile return behavior ranging from hostile speech and direct physical violence to sabotage of tools or equipment that another co-worker uses or operates. Non-innocent but non-hostile behavior such as co-worker "play" can also cause overreactive return behavior similar to the circumstance of a worker subject to mental stress.

All of the above-discussed drug-induced misconduct pose hazards that are essentially "local" in nature. Typically, this misconduct directly affects a part of a plant, not all of it and some employees, not all of them. Of course, there might be cases where hostility/paranoia would induce behavior directly involving the whole facility and all of its personnel, e.g., a worker could set fire to the facility or detonate an explosive substance; but this is not the usual case. However, even localized damage or non-compliance with procedure can have a ripple effect on total plant operation and safety so the safety implications of the above-discussed drug-induced misbehavior are facility-wide.

2.3.4 Dissatisfaction with Working Terms/Conditions

While dissatisfaction with working terms or conditions is a cause of mental stress and can thus contribute to willful acts caused by mental stress, such dissatisfaction can also cause worker misconduct not based on mental stress. Such misconduct is caused by unhappiness that can be quite calm and rational, not the extension of a "nervous" mental condition. Work conditions include safety, housing, food, and entertainment. This type of misconduct may take place in a collective bargaining context, but such a context will not be examined in the present discussion.

Working terms include pension, wages (amount of money paid and number of hours worked), and medical/life insurance. Worker misconduct as a result of dissatisfaction with working terms or conditions can be of two major types. One type of misconduct is aimed directly against the offensive condition itself. Examples of this include burning worker housing and wrecking worker cafeterias. The second type of misconduct is used to protest offensive terms of employment and also offensive working conditions without attacking them directly. Examples include production slowdowns, falsifying sickness, and damaging plant equipment or tools.

Each type of worker misbehavior associated with working term/condition dissatisfaction has both localized and more general implications for plant safety. Destruction is usually intended to be localized in nature since the workers normally want to keep their jobs and in order to do that the facility itself must exist. As in other instances of worker misconduct however, acts

intended to be limited in effect can have more general effects. For example, a fire can spread beyond its intended "target", depending on the layout of the facility. Damaged equipment can cause unforeseen (at least by the workers who damage it) ripple effects in other equipment and ultimately in the entire facility. Thus dissatisfaction of workers with their working terms or conditions can have a direct impact on plant safety and can be a source of risk of a major accident.

2.3.5 Monitoring/Modifying Worker Output Requirements

A worker's output requirement consists of his assigned job tasks. These tasks can be monitored or modified both qualitatively and quantitatively by the worker's supervisors or by his co-workers. This type and degree of supervisory control is acknowledged as critical to industrial safety.[18]

The monitoring of a worker's output by a supervisor can be a source of errors in the worker's performance. Any interaction with a superior can cause a generalized, unfocused mental stress which can induce negligent or willful worker misconduct. In addition, monitoring that is perceived by the worker as untrusting, unfriendly, or unfair can cause specific types of negative changes in worker behavior.

If a supervisor's behavior is perceived as untrusting, the worker may react by becoming annoyed or angry and engaging in willful misconduct e.g., passively lowering his job performance (the "if they don't trust me, why should I try" effect); by fearing that he will be fired; or by some combination of these reactions. All of these reactions will increase the worker's chances of making an error in the performance of his work. An increased error rate means an increased chance that a major accident will occur in the facility.

A supervisor's behavior that is perceived as unfriendly or unfair will probably generate the same reactions listed above with respect to a supervisor's untrusting behavior. However, the anger reaction may tend to be more dominant. This increases the danger of actively destructive willful return behavior. That is, the worker may direct willful misconduct either directly against the offending supervisor or against plant equipment or product. The higher the worker's perceived hostility from his supervisor, the more extreme the negative return behavior will be. Such negative behavior can indirectly cause major plant problems by incapacitating certain equipment or personnel, or the behavior could possibly result directly in a major accident if the worker decides to retaliate against the entire facility.

In addition to the monitoring of a worker's output by his supervisor, a worker's output may be modified by his co-workers.[19] When job functions are interdependent and one worker does not perform his job or does it incorrectly, then workers whose functions are dependent upon the performance of the task of the first worker can't perform their jobs properly, if at all. This is a relatively obvious phenomena. More subtle is the problem of one worker inducing another to misperform his function so that the first worker can perform his own function earlier so that he can go home (in the case of crews that all leave together), go to lunch, etc. or so that he can perform his own function more easily. For example, during pipeline construction several work crews may travel together to and from the work site. If one crew is slower

finishing work, the other crews must wait for them. This "encourages" the slow crew to work faster and less carefully. A hole for an oil pipeline support may not be excavated as deeply as necessary, or an x-ray of a pipeline weld may not be performed (extra x-rays may been taken of other welds and one of these substituted for the x-ray not taken). The quality of the final facility is lowered, and the workers who lower their job performance may form bad work habits that carry over into other situations.

Further illustration of worker-worker induced performance modification is available in the inspection function. Here, one worker inspects the work of other workers. Since the inspector works with, eats with, and frequently lives with the workers whose performance he inspects, the inspector's performance can be modified (performed less thoroughly, more quickly) either internally by the inspector himself without direct co-worker pressure or usually as a result of direct pressure from the workers under inspection. Such modification of inspection performance results in the risk of the occurrence of localized or even catastrophic accidents. Inspection is a "backstop" or barrier to worker performance error. Since one inspector usually inspects more than one worker, impairment of an inspector's performance has a higher accident risk potential than impairment of the performance of a worker from any other category presently being discussed.

3. Cultural Attitudes

In previous sections, worker cultural attitudes were briefly touched upon in the context of general types of worker misbehavior (ignorant, negligent, willful). In this section, cultural attitudes themselves will be more fully explored. The criteria used by an individual worker to best perform his work are significantly influenced by the culture and social norms of his co-workers and employer.[20] The culture of the society in which the worker lives also has a major impact on his judgmental criteria. For the purposes of this paper, a cultural attitude is a belief by a worker induced by social customs, religious or political beliefs, or business customs.

The examination of cultural attitudes will be discussed in four parts:
- Cultural Attitude Towards Self;
- Cultural Attitude Towards Other Persons;
- Cultural Attitude Towards Property of Other Persons;
- Cultural Attitude Towards the Environment.

3.1 Cultural Attitudes Towards Self

As an aid to the study of cultural attitudes towards self, it would be enlightening for systems designers to stand outside a factory or construction site in, for example, the United States on a rainy day and count how many men leave the plant using umbrellas. This is a good example of a cultural attitude towards self: use of umbrellas is perceived as somehow "unmanly". This is an example of the masculinity-femininity dimension of a national culture.[21] This attitude carries over to the use of safety equipment and reporting of safety violations in job situations. Compliance with safety

requirements is understood to be a prerequisite to keeping one's job, but latent resistance is present nevertheless. In other cultures (for example, India, Iran) the wearing of beards or certain head coverings has religious or social (masculinity implications) significance. In these cultures use of certain safety equipment (respirators, hard hats) pose special problems when they interfere with a person's necessary self image.

For example, to work safely around diethylene dioxide, used to make paints, plastics, and pharmaceuticals, a chemical cartridge respirator must be worn. Wearing a respirator when one has a beard is certainly less comfortable and probably less effective (due to possible leaks caused by the beard) than when one does not have a beard. However, if the wearing of a beard is deemed necessary by the worker for social or religious reasons, he will probably keep the beard and endure the discomfort and reduced security; or he may even discard the respirator if it is not absolutely necessary (but merely a preventive measure).

3.2 Cultural Attitudes Towards Other Persons

One's attitudes towards oneself are fashioned by what one perceives to be societal norms. Therefore, one expects others to behave as one does oneself. In the work environment in the United States for example, this means that a worker who complains about poor working conditions or safety violations may be viewed by his co-workers as "unmanly". The attitude among workers, that one must be "tough" to do certain types of work, discourages showing signs of discomfort and encourages stoic behavior. Feedback on safety conditions to higher levels of the organization is affected by this attitude.

Many workers who perform maintenance and construction functions lack extensive formal education. A high value is placed by such workers on "practical", on-the-job experience. Persons with little actual field experience are viewed with mistrust. Unfortunately, many workers are directly supervised by engineers or inspectors who are both better educated or trained and less experienced than the workers they are supervising. Thus workers may not have much confidence in the instructions given by their supervisors. This situation increases the risk of accidents occurring in the facility.

In addition, religious customs, coupled with economic necessity and a certain type of self image can affect plant safety. During the Moslem holy month of Ramadan, workers fast during the day and are therefore working in less than normal physical and perhaps mental condition. Due to economic necessity and the probable attitude by workers that they are strong enough to endure the physical depletion, workers continue to work in critical positions during this time. This practice can affect plant safety.[22]

3.3 Cultural Attitudes Towards the Property of Other Persons

Even in societies where workers have had extensive experience as owners of property of some value (car, stereo, furniture etc.) workers do not necessarily treat the property of their employer with care. In the US and many European countries (but not limited to these areas), the attitude of workers is that "they" (the plant owners) because they have so much money can afford the damage to or loss of equipment no matter how large the loss is. This is a reflection of the societal notion that factories are owned by "them" and operated by "us". The fact that large companies are frequently owned by shareholders, among the largest of which are pension funds which pay pensions

to individuals similar to the operating workers, is obscured by political or economic rhetoric. The result is less care by workers than might otherwise be exercised. Another attitude held by many workers is that the monetary effect of damage to equipment as a result of worker misconduct is relatively small vis-a-vis the huge corporate enterprise and its impact is therefore harmless to the organization.

3.4 Cultural Attitudes Towards the Environment

Cultural attitudes can also affect workers' attitudes toward the environment and measures to prevent environmental damage. Workers raised in more developed countries may have a "throw away" mentality because of the consumer goods waste disposal habits developed in such countries. Each day, three and one half pounds of garbage is produced by each person in the United States while in Japan, each person produces 1.9 pounds of garbage per day.[23] Thus, workers may not view certain consequences of industrial processes as worthy of serious concern.

However, a lack of negative consumer-goods-waste-disposal habits in a culture does not necessarily indicate that a worker will be concerned about damage to the environment. In developing countries, job security can easily override environmental concerns. The lack of alternative jobs is more acute in developing countries so this attitude, although also present in developed countries, is more widespread in developing countries. Also, environmental political movements are a smaller part of the culture in developing countries, so workers are less exposed to discussion of environmental issues. Thus, workers in developing countries may manifest little concern for environmental damage caused by their work tasks.

Also, cultural rhetoric (where it exists at all) treating all environmental problems of the same qualitative nature alike, regardless of the quantitative nature of the problem, engenders, at a minimum, confusion about and at a maximum contempt for environmental safety issues. This rhetoric frequently is institutionalized in work procedures where, for example, an oil spill of a few liters is treated procedurally (reporting and cleanup procedures) as importantly as a much larger spill. Workers are thus "taught" over time by their work and social cultures that environmental issues are exaggerated. If this attitude is added to the aforementioned initial lack of concern for the environment, it is easy to see that workers will frequently be unsympathetic to environmental issues. This lack of sympathy can lead to misconduct by workers (failure to follow environmental protection procedures at work - especially those connected with waste handling, storing, and disposal) that can damage the environment.

4. Reduction of Risks

The first two parts of this discussion dealt with the types of risks encountered in industrial facilities and some of the causes of such risks. The third part of this discussion deals with action that can be taken to avoid these causes of risks.

4.1 Eliminating Ignorance as a Cause of Risks

4.1.1 Operational Ignorance

In order to eliminate operational ignorance, instruction is needed. Since this is a much discussed area of risk reduction, only a few points will

be made. First, the instruction should be in a form that is assimilatable by the worker (e.g., manuals, videos, interactive computer simulations, etc.). A guideline for how to structure the instruction is offered by the data in Table 1.[24]

Table 1

Method of Instruction	Three day information recall
telling	10%
showing	20%
telling and showing	65%
people generally remember:	
what they read	10%
what they hear	20%
what they see	30%
what they hear and see	50%
what they say	70%
what they say as they do a task	90%

Second, the instruction should be continuous. That is, initial instruction should be followed by periodic "refresher" instruction.

4.1.2 Consequence Ignorance

The first type of consequence ignorance, literal consequence ignorance, results from instruction emphasizing unthinking compliance with procedures. Consequences of non-compliance are not discussed at all during worker instruction. The remedy for literal consequence ignorance is to instruct workers in the consequences of failure to comply with operational procedures using the same instruction techniques used for operational ignorance.

The second type of consequence ignorance is consequence non-belief. The first type of consequence non-belief, consequence vagueness, can be eliminated using the same techniques as those used to eliminate operational ignorance. This type of consequence non-belief exists because of vague, generalized instruction on the consequences of not following procedures. Specific, preferably visual, information about negative consequences of procedure violation will eliminate or reduce consequence vagueness.

The second type of consequence non-belief, consequence denial, is more difficult to eliminate. As stated in the second part of this discussion, a worker who engages in consequence denial can appear outwardly to be a model worker. He may have been well instructed and may be able to recite the correct answers to questions testing procedural knowledge. What is needed as a first step to eliminate (to the extent possible) consequence denial is a belief feedback loop in the training program. What this means is that after proper instruction, a worker must be tested not only to see how much data he has retained from the training, but also he must be tested to see if he believes the data.

A possible method of testing worker belief (and reinforcing memory of procedures at the same time) could be based on the last item in Table 1: having a worker "talk" his way through a given procedure. The examiner can try to judge by the worker's demeanor whether he really believes what he is saying. If he does not, the source of the disbelief must be discovered and new instruction given so as to eliminate the disbelief. The exact details of the process will of course vary depending on the source and strength of the consequence denial.

4.2 Negligence

To eliminate physical and mental fatigue, one must eliminate their causes. Shorter working hours or increased break time are possible solutions. Altering the difficulty level of work tasks so that a worker is not always operating at maximum output levels is another remedy. Monitoring the physical health of workers and encouraging physical fitness is a third possible action.

To eliminate or minimize mental stress, a number of actions can be taken. First, eliminate mental and physical fatigue as suggested above. Second, provide counseling to workers on legal, family, and financial matters. Third, provide channels of communication which workers can use to voice their job-related grievances. Also, action must be taken to address the worker grievances - either change or explanation of why change is not possible.

Alcohol and drug use is a major industrial work problem. To reduce or eliminate it is a top priority in most industrial settings. Education, testing and rehabilitation programs are some of the tools being used by employers.

4.3 Willful Misconduct

The elimination of willful misconduct by workers can be accomplished by several means. First, worker "play" can be shown to be the dangerous activity that it is, thus making workers aware of the consequences of their actions. Also, penalties for "play" and some form of behavior monitoring can be instituted. However, the monitoring must be benign or it can cause more problems than it solves.

To eliminate dangerous over-reaction as a result of mental stress, it is necessary to eliminate mental stress. The methods discussed above to eliminate mental stress as a cause of negligence can be used to eliminate mental stress as a cause of willful misconduct.

Alcohol and drug use can also cause willful misconduct. Eliminating alcohol and drug use as a cause of negligence will also eliminate it as a cause of willful misconduct.

4.3.1 Dissatisfaction with Working Terms/Conditions

The methods used to eliminate worker dissatisfaction with working terms or conditions as a source of mental stress that causes negligence can also be used to eliminate such dissatisfaction when it causes willful misconduct (either induced by mental stress or rational "thought-out" mental processes). The main elements to eliminate are the feelings of worker helplessness and the workers' perceptions that the employer doesn't care about them. Communication and feedback are the key tools to use in eliminating these elements.

4.3.2 Monitoring/Modifying Worker Output Requirements

Supervisor conduct should be accompanied with as much explanation as necessary to eliminate false perceptions in the mind of the affected worker. Again, communication is the key ingredient to eliminating a source of misunderstanding and resentment. Clearly stated guidelines for work modification, while bureaucratic and somewhat clumsy, help eliminate the worker's feeling of helplessness and can help give him the assurance that he is being treated fairly. Such guidelines act as a "backstop" in case supervisors (as they all too often do) fail to exercise sufficient communications skills with the workers they supervise.

Pressure by co-workers to modify work performance can be difficult to eliminate. Since this pressure can affect inspection and other supervisory functions and can originate either from workers of equal or lower rank, it is an especially important cause of risk of accident and must be eliminated to the extent possible. Probably the best way to do this is to periodically bring personnel from outside the plant to inspect inspectors and supervisors. These outsiders can serve as "lightning rods" for inspected or supervised worker dissatisfaction and can allow the local inspectors and supervisors to spread the "blame" for unpopular decisions. However, this must be a balanced and fair approach so that resentment is not just transferred "upstairs". This would result in negative attitudes among workers that can be just as harmful as those induced directly by local inspectors and supervisors. The "I don't like it either but they do have a point" attitude is probably the best that can be used by local inspectors and supervisors under these circumstances.

4.4 Cultural Attitudes

Cultural attitudes affect all modes of worker misbehavior: ignorant, negligent and willful. Therefore, a much greater emphasis needs to be placed on taking these attitudes into account when trying to shape worker behavior.

The first step in this process is the enumeration of the basic cultural values of the subject worker group. Detailed national and regional surveys, followed by specific local surveys are required to compile the necessary information.

Once the cultural values are listed, risk-reducing instruction programs need to be created that embody these cultural values. Respect for the workers themselves, company equipment, other workers, and the environment needs to be taught to workers in terms that they can understand and respect.

Also, the method of instruction, as well as the content, needs to embody the cultural values. For example, to use a young, obviously field inexperienced, female to instruct a group of workers that consists of older males on environmental or other matters sabotages the instruction program no matter what the actual content of the program may be. If one wishes to enlighten such workers on the modern trends on female equality, perhaps a team of instructors or an older woman might be used. Obviously, as cultural values in a society shift, such methods of instruction can be eliminated.

Once workers have been properly instructed using instructions and instruction techniques that embody the cultural values of the workers, the workers must be supervised using techniques sensitive to cultural value. Currently, supervisors frequently learn their supervisory "skills" on the job; that is, they learn by trial and error with little or no instruction on basic management techniques much less on the cultural values of the workers and the supervisory problems these values can create. This "sink or swim" system must be replaced by detailed pre-job instruction telling supervisors as much as possible about worker attitudes and how to deal with them.

Finally, as an aid to designers and planners, it is highly recommended that they spend some, preferably anonymous, time among workers for whom they are designing systems and operating and maintenance instructions. The inevitable absorption of behavior patterns such an experience would bring about, would prove invaluable in planning back at "the office".

5. Summary

From the discussion in the previous parts of this paper, it is clear that the human causes of risks are varied and complex. One could write volumes of specific recommendations for action. However, most specific recommendations would be project-specific and not of general interest. These specific recommendations would logically flow from the following general recommendations:

1. Enumerate the factors determining worker misconduct actual or potential.

2. Specifically enumerate the cultural values determining worker misconduct.

3. Design and implement instruction systems embodying these cultural values and respecting them.

4. Design the instruction of supervisors to deal with the causes of worker misconduct.

5. Test workers to see if they believe job instruction, not just if they can remember it. This would require development of a "belief" feedback mechanism.

It would be greatly beneficial if an organization such as UNIDO surveyed national or regional cultural attitudes relevant to workers' behavior in risk management situations.[25] These surveys could serve as a basis for detailed government or industry surveys of smaller, specific groups of workers.

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