Human Factors in Electrical Power Industry Accident Prevention

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***Abstract*— The 2020 spread of the Covid-19 Virus makes for a real understanding of organizational structure, leadership, individual and group beliefs, attitudes and behavior, institutional readiness and response abilities, regulatory arrangements, and industry reach to appreciate real disaster, organization climate, emergency preparedness, and safety climate. All the factors that contributed to this pandemic have changed the workplace and are relevant for understanding how major disasters, serious injury-type, and fatal workplace accidents occur, and our ability to mitigate the effects of these events. This study involves a review of contemporary literature, a review of available accident investigations and a discussion among electric power industry experts for suggestions on human factors and how accidents, serious injuries, and fatalities can be prevented.**

***Index Terms*— human factors, leadership, beliefs, attitudes and behavior.**

I. INTRODUCTION

The impact of major naturally occurring disasters like the earthquakes and tsunamis in the east coast of Japan in 2011, and in the Indian Ocean near Banda Aceh in 2004, the effect of Hurricanes Katrina in 2005 and Maria in 2018 were significant, and yet still, these were with no worldwide reach as the current effect of the Covid-19. In 2018 a tornado in the Merivale substation in Ontario and the 2020 tornado in Putnam County, Nashville, Tennessee, the 2016 fires and 2020 floods at Fort McMurray were recent disasters where the almost unthinkable occurred. Other disasters, not due to naturally occurring causes, like the Deepwater Horizon, Piper Alpha, and Bhopal, all occurred in the working lifetime of current industry leaders. The 1984 Bhopal Methyl Cyanide Gas release disaster remains the worst industrial plant disaster ever. The 1988 North Sea disaster at the Piper Alpha Oil Rig was a colossal failure of safety systems that resulted in death 167 individuals on the rig when it happened. In 2010, the Deepwater Horizon disaster in the Gulf of Mexico became, and still is, the worst oil spill that affected the lives of all who lived on the U.S. states that shared that American coastline.

The question that seemingly always remains unanswered is, why do these disasters happen? The reasons for disasters range from uncontrolled and uncontrollable factors that are, in many cases, not influenced by the activities of human beings. Other disasters are catalyzed by the human activities that stem from willful and deliberate actions by individuals to the unknown and unanticipated result of actions that were either deliberate or unintended. The focus, for this paper, is on the actions of individuals at work, whether deliberate or unintended, that culminate in someone becoming injured or killed. To study the actions of individuals at work where the outcomes are not as expected or a significant departure to those planned, it was necessary to examine extant publicly available literature on accident investigations and current research into leadership, disasters, and workplace accidents. After reviewing contemporary research into workplace accidents, mishaps, and unintended results, short notes on the different articles were shared with nine co-collaborators on the LinkedIn social network, each of whom willingly participated in a semi-formal group discussion. All of the participating individuals communicated frequently on social media and were electric industry experts in the U.S.A., Canada, and the Caribbean, each of whom was practitioners with more than five years in the industry. What follows are the results of the discussion and the consensus and differing views from this exercise.

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II. PROCEDURE: THE PHILOSOPHICAL APPROACH

A. Human Factors Review

Accidents are always followed by anticipation that the investigation, if done, indicates whether an individual or group of individuals breached procedures or did not adopt the prescribed safety measures for the situation. A focus on human (social or personal) issues and factors and an assessment of why people do and how they do, what they do is necessary to appreciate what to do to prevent other individuals from experiencing similar accidents. Human factors review has been the focus of the aviation industry since the 1970s and now have found support in the oil and gas, medical, construction, and other major industries worldwide. Kumar, Barabady, Markeset, and Kumar (2009) described improved human performance in design and how that led to superior individual and organizational performance in the oil and gas industry. Said and Mokhtar (2014) linked superior aviation maintenance results in a fundamental understanding of human risk factors. Oliveira, Araujo, and Jardine (2014) factored situational awareness and human performance in maintenance work and how that awareness was critical to successful outcomes. These and similar benefits can be realized in the electric power industry by the adoption and promulgation of a useful human performance program for organizational and individual success.

B. Early Direction and Learning Opportunities

Aviation is a complex industry, where varied tasks are done by factoring time pressures, many times under challenging environments and conditions (Said & Mokhtar, 2014). The electric power industry is similar to this in many regards.

Complex work arrangements in diverse settings can prove to be overly demanding and challenging for individuals to negotiate safely; this can lead to instances where individuals may err or misjudge situations and not correctly evaluate the risks of the associated dangers and hazards. Early studies in the aviation industry, suggested that workplace problems emanated from human-to-human, human-to-hardware, hardware-to-hardware, software-to-hardware, hardware-environment, human-to-environment, or combinations and permutations of these influencing factors (Said & Mokhtar, 2014). This Aviation Industry philosophy is now widespread and adopted in other industries such as oil and gas, medicine, transportation, and construction to appreciate why workplace accidents, equipment failure, operational problems, and sub-optimal outcomes occur and to explore opportunities to improve performance for organizational success (Kumar et al., 2009; Oliveira et al., 2014). Said and Mokhtar (2014) suggested that a focus on organizational policies, financial strategy, and safety culture can be significant contributors, as human risk factors, to workplace accidents. These are equally relevant in the electric power industry, but regulator influence on organizational policies and practices should undergo scrutiny for a real understanding of how to set and follow direction.

General systems theory refines broad general concepts about systems that can apply to diverse settings with a shared understanding; by applying principles and by using tools, work methods, and conventional techniques to solve problems (Boulding, 1956; Von Bertalanffy, 1972). Human factors, as in general systems science, supports focus on improving organizational, individual, and system performance and aims at the prevention of errors and accidents that can result in injuries and harm (Diller et al., 2014; Gross et al., 2019; Parsi, 2004). Gross et al., extended the understanding of human factors to include a systemic framework that factored environmental influences, organizational arrangements, individual behavior, and how these inter-relationships interact to realize performance outcomes.

Diller et al. postulated that root cause analysis is a subjective investigative technique that is not standardized. It supports a focus on the last individual(s) involved before the accident event. Root cause analysis lacks standard nomenclature frameworks that hardly ever exist and not consistently managed in different work settings or from one organization to another. Most importantly, root cause analysis does not lend to consistent learning and lessons from actual events and accidents where working individuals and others become injured or are killed (2014). Diller et al. adopted a modified Human Factors Analysis Classification System (HFACS) approach to realize improved performance, accident, and error prevention in the healthcare industry. Today, root cause analysis is still used in the electric power industry, but examining HFACS should provide for practical application and improved results.

C. Application of HFACS and CRM in Major Industries

Parsi (2004) recalled previous seminal studies in health care, which highlighted that up to 98 000 patients died from medical errors while cautioning that researchers who cite these studies either could be supporting an incomplete picture of health care performance and outcomes or even a skewed analysis on medical errors and preventable deaths. Parsi suggested that a closer analysis of the data would allow for a more informed understanding of the problem and for opportunities to identify and prevent medical errors and to save patients' lives.

Parsi further indicated that critical analysis of previous research should focus on the working structure, term-definitions, and consistency in use, the data collection strategy, the research subject, as well as researcher's ability to analyze the data collected (2004). If the results of data analysis do not align with what happens on the frontline, then opportunities to improve performance, mitigate errors and accidents can go unrecognized and unaddressed.

The broad examination that occurred in this health care focus, while it presented an early indication of medical practice in a supposedly negative light, was vitally critical to the refreshed performances that resulted from this initiative. The electric power industry is ripe for a similar broad study and for any concrete initiative that provides for performance data storage at a single and trusted repository, from which relevant research can be done for an accurate picture to emerge on existing industry safety practices.

HFACS builds on previous works done by Reason, who developed the Swiss Cheese Model to analyze complex problems and to determine how and why accidents occur. HFACS focuses on accident and error causation as well as system and organizational failures. This framework was developed for the U.S. Military to determine why they were experiencing aircraft accidents. Later, HFACS was found useful by investigators of commercial aviation accidents (Diller et al., 2014). HFACS investigation incorporates a focus on individual and group behavior and situational analysis, which can explain why errors occur and lead to accidents and worker injuries. This type of investigation is not commonly done in the electric power industry even though similar human factors issues and situations impact performance; in complex dynamic working arrangements and environments. It may also be useful to review how HFACS can help to address the current deficiencies and challenges and to strengthen and bolster the positive attributes of the existing management-union-worker landscape in the electric power industry. Participants believed that the current management-union-worker political and philosophical alignment could, at times, have unanticipated consequences, many times due to a hard-lined and unflinching approach to work instead of a positive and collaborative effort.

Gross et al. (2019) examined, as part of a comprehensive evaluation of how human factors impacted on the efficient health care delivery, how training in crew resource management (CRM) can impact patient safety and medical practitioners performance outcomes. Gross et al. postulated that practicing CRM was now prevalent in areas of medical practice, including in operating-room management, anesthesiology, surgery, in emergency departments, as well as in post-operative and intensive care. Issues surrounding the definition for CRM, training, common terms agreement, and CRM standards in health care were not as yet universally accepted for implementation in healthcare facilities and organizations.

Said and Mokhtar (2014) posited that technical failures were not always due to complex systems and hazardous conditions

but more due to human factors in combination with system complexity and the dynamic nature of the work environment. CRM provides an array of tools and techniques that can help to manage and prevent errors. CRM supports teamwork, fosters knowledge development, and skill-building while giving rise to strategies and opportunities for improved individual and group behavior and attitudes (Gross et al., 2019). Crew Resource Management is not a standard item found in related research or available documentation for the electric power industry. The benefits of this approach to work performance are sufficient for the immediate adoption of CRM initiatives in the electric power industry. Electric utility crews work, most times, in vast geographic distances from home base and in places where senior supervisors and managers are not always present, similar to aviation cockpit crews.

III. Aviation Lessons: Application in Electric Power

A 1993 domestic, commercial airline flight in Minnesota crash-landed with the plane destroyed, and none of the individuals on board surviving the accident. The accident investigation report listed the likely causes as actions by the captain and a breakdown in crew coordination that resulted in a situational awareness loss, in weather and work conditions that were challenging to negotiate, and where organizational and regulatory failure to manage and effectively address issues directly impacted and contributed to the accident event (NTSB 1994). One main organizational contribution to the accident was a management failure to appropriately address deficiencies in human factors and crew resource management (CRM). Deliberate procedural deviation, the frequent use of unapproved practices by crews, was known to management who failed to correct these. The Federal Aviation regulators provided insufficient and inadequate oversight and surveillance on the airline carrier. In the cockpit, verbal abuse, poor attitudes, and behavior were known and not addressed, and directly contributed to poor communication and the difficulties experienced on this flight (NTSB 1994).

Hayward, Lowe, and Thomas (2019) indicated that CRM optimizes interface between persons and machines in addition to supporting the timely acquisition of appropriate information and bolstering leadership, team effectiveness, formation, composition, and maintenance together with the development of situation awareness abilities, decision-making, and problem-solving skills.

In September 1989, a domestic passenger airline in Brazil left on airport en-route for another airport. This aircraft ended more than 600 miles away from its intended destination and crash-landed in the Amazon jungle. The primary reasons were listed as poor situational awareness, confirmation bias, and diverted attention. The incorrect bearing or magnetic heading was set as 270 degrees and not as the required 27 degrees. The second member of the cockpit crew did not confirm this setting, as was required by the airline and by the crew even after they could not locate the destination airport. The investigation into this crash where 13 persons died, 41 survived, including 34 injured, also revealed that a recent organizational introduced change on the bearing entry requirement was not communicated effectively to flight crews (Varig Flight 254, 2016).

In 1991 and 1994, there were fatal domestic, commercial airline accidents in the U.S.A., where there were no survivors. The NTSB investigation into these two accidents found that there were no known pre-existing medical, behavioral, or fatigue-related issues surrounding the crew members of either flight. In 1996 there was another commercial airline incident where the problems experienced were similar to what occurred in the previous accidents from 1991 and 1994: the only difference was that the flight crew landed the aircraft safely, and there were no fatalities. The NTSB attributed the situational awareness and crew resource management (CRM) of the 1996 crew as significant contributors to the safe landing of the aircraft. In all three instances, there was a common technical design issue that contributed to problems experienced (NTSB, 1999). Good CRM and human factors contributed to positive outcomes in the 1996 event, where the airline landed without loss of life after experiencing significant in-flight difficulties (NTSB, 1999).

IV. Leadership and the Role of Leaders

Paolillo, Silva, Carvalho, & Pasini (2020) showed that if the organizational focus platformed on fair treatment, consistent communication, meaningful involvement and inclusion, then safety behavior, mutually beneficial workplace relationships combined to impact on improved individual and team attitudes, work participation, organizational safety climate, and performance outcomes. These findings were similar for homogeneous and heterogeneous workgroups, even though there was a higher possibility of improved outcomes in homogeneous settings over the latter. Paolillo et al., also found that in cases where perceptions of safety climate were high, the level of safety participation and compliance were correspondingly high. A work environment where safety compliance is enforced results in a high level of safety participation (Jiang, Lavaysse, & Probst, 2019). Jiang et al. acknowledged that safety climate was a critical influencing factor on organizational safety performance but posited that different measures made the safety climate in one industry or work setting different from other industries or work settings. Jiang et al. did not extend this, however, to different working units within the same organization. They found that the actual safety climate influenced unique safe work behavior, but they did not explore if this finding was an intra-organizational challenge. Paolillo et al. (2020) supported that multiple safety climates can exist within the same organization: they also supported that different climates can lead to inconsistent motivation levels that workers can have for safety in the workplace. This inconsistent motivation can influence workgroup acceptance and cause a misalignment of workplace policies and procedures with actual work practices (Jiang et al., 2019).

Schonfeld and Chang (2017) suggested that occupational health psychology was now a significant factor in understanding the working conditions and how that impact workers' mental and physical well-being. This impact included worker's ability to influence workplace decisions, workload, productivity, recognition for performance outcomes, and work-family interactions and balance. This study extended findings from previous research on the safety climate at work by focusing on supervisors' and managers' influence in addition to co-workers and work team composition; An

individual can be influenced and motivated by colleagues in ways that are not controlled by supervisors and managers. The social influence of co-workers nurtures strong attitudinal alignment and results in group dynamics that impact the individual-level perception of fairness. Group communication can motivate a unique safety climate that is different from other organizational climates (Schonfeld & Chang, 2017).

Koshino (2017) researched the impact of working memory on an individual's attention and found that under particular situations and conditions, the influence can be deleterious to the extent that it may eventually lead to workplace errors, misjudgments, and accidents. This working memory can be stressed by a single task as well as if the individual is performing more than one task at the same time. The load impact of each situation is different. In the case of multiple tasks, the individual can become distracted, lose concentration, and working attention. In situations where the individual would be singularly focused, it depends on how intricate the task is and how familiar the individual is at work in high-stress situations. This issue is particularly relevant in the electric power industry as there are frequent occurrences of distraction, a resultant loss of situational awareness, and with negative consequences.

Pang, Byrne, and Worthy (2016) posited that in situations that are ripe with uncertainty, decision making is wide-ranging, inescapable, and crucially important. Working memory is a cognitive function and a crucial link to ethical decision-making. Pang et al. believed that if an individual were to focus on two different tasks with the same level of attention, then there would likely be a lessened sensitivity and a concurrent loss of attention by the individual. This loss of attention is likely a challenge for workers in the electric power industry; further investigation is necessary.

Chatman and O'Reilly (2016) admitted to disunity in the research literature on a standard referencing or theoretical mooring of organizational culture. They posited, however, that once understood, the culture state, individual and group behavior, and attitudes can improve by the promotion of unity, accountability, and shared values among the working groups, crews, and teams. Unity and accountability among working individuals and teams can occur by shared practices and organizational norms, an appreciation of the importance of these, and acceptance by the working population.

Chatman and O'Reilly defined culture as a psychological mechanism that functions through social influence and norms driven by content, consensus, and intensity. Organizational culture and climate are two distinct constructs that influence behavior in separate and different ways. Organizational climate influence individual or shared perceptions by individuals about work tasks, arrangements, the working environment, management, and on organizational issues and situational factors, each of which can impact on worker(s) behavior and motivation. Safety climate is an organizational climate specific to workplace safety and the safety management system. The climate is a reflection of actual work performance, worker turnover, and satisfaction (Chatman & O'Reilly, 2016). Climate is built on a platform of perceptions, while culture is more linked to values and enduring norms. The findings in this study can provide value to operations in the electric power industry; A review should concentrate on updating of training content. Organizational performance and behavior were dependent on the extant culture, values, structure, management practices, and social norms on commitment and meaning (Chatman & O'Reilly, 2016).

Bye and Aalberg (2020) found that there were identifiable reasons for violation of workplace safety procedures. These ranged from the work procedure, the work task or activity, the training necessary for the task, work-team composition, work planning details, the management or work procedures, supervision of the work when done, and the socio-technical environment at work. Bye and Aalberg (2020) investigated workplace safety non-compliance by focusing on why maritime transportation work procedure violations were frequent and done knowingly. The influence of this study was a previously conducted industry regulator performance review and an initiative where the operating companies collaborated and coordinated strategies for improved performance (Bye & Aalberg, 2020; Nielsen, Grytnes, & Dyreborg, 2019). Frequent ferry accidents, identified as groundings and contacts, caused injuries and resulted in companies revising work procedures and implementing changes communicated to workers; Accidents, however, continued to happen. A significant finding from the regulator review was that safety violations were common among the different companies. Bye and Aalberg investigated if there were common understanding of work procedures; why there were, if any, variation in worker interpretation of these procedures; attitudinal issues; and why workers do not follow work procedures. Bye and Aalberg (2020) found that workers viewed procedures as being too prescriptive, not covering all possible workplace situations, not useful for many work activities, set to provide the company protection against possible liabilities, an avenue to leave blame for accidents on individuals performing work at the time of an accident, and worker responsibility for safety and accountability for work done. Departure from prescribed rules and procedures are almost always regarded as violations and attracts, more often than not, individual sanctions and blame. There was almost no reflection, from accident investigators, on the usefulness of or how comprehensive the rule or procedure was and whether it was simple to apply in the situation where the departure occurred: Despite a significant level of information from previous studies that show violations as being attributed to work activity, the organization, the workplace situation, environmental factors, management and supervision, and organizational climate and culture (Bye & Aalberg, 2020; Lee et al., 2020). Violations are also due to individual-to-individual influence, organizational norms, schedules and demands, management-leadership influence, work-team composition, diversity, experience, collective skills (individual and group), ability to recognize hazards and to mitigate risks, workload, time pressures, individual and group attitudes, behavior, motivation levels, and job satisfaction. These are fundamental

everyday issues that electrical industry workers grapple.

Lee et al. (2020) confirmed that organizational, individual, and cultural understanding and factors are critical to understanding how workplace safety and health awareness, and risk mitigation occur. Organizational factors included management influence, consistency, support, organizational systems, work schedules and procedures, and working environment, interpersonal influence, and dynamics. Individual influences accounted for attitudes, behavior, motivation, and perception. Lee et al. posited that workers' knowledge was fundamental to their ability to mitigate risks due to the hazards they encounter while at work. Management and supervisors were instrumental in ensuring that individuals at work were suitably capable of performing the work. Management and supervisors were to maintain operating practices and a paradigm where constant vigilance of work activities was critical to performance outcomes. Organizational factors, including interpersonal influence, were core safety issues: when accidents or worker injuries occur, there must be a more in-depth assessment of the safety management system and management influence on the appropriate functioning of this system. Individuals at work, including the frontline workers, carry responsibility for ensuring that the work they do is safe and does not place any person at risk of becoming injured, including themselves. These are electric power industry-relevant issues that require a significant focus for improved human performance and organizational success.

V. KEEPING SAFE AND MITIGATING RISKS

A. Individuals and Impact

Nielsen, Grytnes, and Dyreborg (2019) investigated why apprentices frequently were injured at work by reviewing the roles that managers and company owners have in ensuring that workplace training and work processes are sufficient to prevent accidents and mishaps. Nielsen et al., reviewed workplace factors, working environment and norms, safety climate, supervision, individual motivation and obligation from responses provided by trainers and managers and purported that it was possible to prevent apprentice-accidents and injuries. Young and temporary workers and apprentices were more likely to become injured at work because of not being adequately trained or introduced to the work tasks and activities, situations where permanent workers and individuals in senior positions can stymie opportunities to voice an opinion (Nielsen et al., 2019).

Apprentice-reluctance to raise safety-related concerns linked to co-worker influence, the overarching desire to become permanently appointed to the company, and to maintain good relations at work. Apprentice related accident prevention efforts can be worthwhile if pegged on a climate to a review of workplace practices and norms to augment training that includes knowledge, human factors, and skills development (Nielsen et al., 2019). If work practices and norms are not-aligned to safe work and outcomes, preventing accidents and worker injuries can become tenuous. Electric power industry apprentices very often are injured at work. The focus on work arrangements and systems involving apprentices is essential as these individuals can become seriously injured or even killed if they do not recognize and effectively mitigate dangerous conditions and hazards, while at the same time maintaining situational awareness. It is imperative and necessary for electric power organizations to contribute data to a single repository on workplace accidents and events involving apprentices. This data can then be used for research, and for electric industry organizations to benefit from the experiences of other organizations operating in similar environments performing complex-type dangerous work.

Koropets, Fedorova, and Dvorakova (2020) examined organizational toxicity and its socio-psychological impact on workplace relationships and by the individual, management, and organizational culture influence on worker stress and burnout. Koropets et al., ascribed worker productivity, physical well-being, individual exhaustion, and enthusiasm to perform work as resultant factors and the effect of an individual ability to balance work demands with activities outside of work and family support. Koropets et al. found that toxic management influenced negative employee emotions, behavior, and attitudes (2020). Participants did not believe in the widespread existence and issue of worker-management toxic influence in the electric power industry even though there was no full dismissal of the issue: A more realistic influence was for a worker-individual manager/supervisor challenging environment in the workplace. Further assessment of the impact of workplace toxicity-effects in the electric power industry is necessary.

Hasanzadeh, Dao, Esmaeili, and Dodd (2017) suggested that cognitive processes contributed towards workplace accidents when human factors feature as prominent causal agents. Cognitive systems and processes include individual and group working memory, memory capacity, and ability to recognize hazardous conditions and to mitigate the associated risks appropriately. Hasanzadeh et al. equated working memory to a situation awareness cognitive process that individuals at work use to negotiate danger and dangerous conditions that exist or arise while doing work; the likelihood of accident prevention is dependent on the how well workers remain safe while performing complex tasks in varying environments and changing and dynamic work conditions. The ability, individual and group, to make sound judgment and to ensure high-quality work outputs while maintaining acceptable levels of production is key to preventing situations that can evolve into unmanageable challenges, with elevated accident risks. Hasanzadeh et al. believed that by understanding worker(s)-behavior, there could be opportunities to prevent accidents. Participants concurred that this was a relevant factor in accidents that occur in the electric power industry and that opportunities exist for significant improvement in work performance, consistent worker-supervisor communication, management support for supervisors, and a requirement for supervisors to insist on full compliance to work procedures while maintaining cognitive control and situational awareness at all times.

Na et al. (2019) examined, despite a plethora of previous studies to the contrary, whether cognitive styles are attributed to complex, cross-cultural, diverse-demographic social orientation, and to review the role of culture on an individual's

behavior and thought process. Social orientation includes individual emotions and personality. Cognitive styles describe individual reasoning ability, memory capability, and attention. Na et al. posited that individual personality could be different, depending on the situation, but strong within any single instance; an individual can be an aggressive vehicle driver, for example, regardless of the vehicle type or location, and the same individual may be a quiet composed and polite individual in another setting. It is essential to know how individuals react or behave in situations where complex work activities occur, especially when hazardous conditions may exist. Cognitive control of an organization's requirement for operating in different and diverse environments in homogeneous and heterogeneous groups is a real and necessary requirement for working in the electric power industry. Participants believed that relevant changes and paradigm shifts are occurring and accepted by industry practitioners.

B. Vision and Approach to Best Safety Performance

Teperi (2019) described the Vision Zero strategy as a safe work commitment and accident prevention effort, originally intended as an ethical business initiative while focusing on productivity, work performance, and output quality. Teperi believed that opportunities existed for organizations to perform data re-engineering for reducing levels and incidence of workplace accidents while not becoming safer. Teperi, however, posited that Human Factors (HF) standpoint could facilitate better diagnostic knowledge, positive human action, and workplaces that can enable open and meaningful discussions for better safety outcomes (2019). Teperi supported a new focus where organizations can embrace individuals at work to realize organizational opportunities for superior safe work outcomes where individuals can learn from actual work experiences and events. These opportunities were reflective of a feedback control loop for safety work arrangements and improvements. Some of the issues Teperi (2019) identified as challenging in the existing safety management landscape were the preponderance type search for individual misjudgment, which generally result in incorrect conclusions from accident events and drive remedial action that does not inspire worker commitment or motivation.

Teperi (2019) believes that the Vision Zero networking (intra and inter-organizational) can be better to align the people/human-centered safety approach for superior safety results and to prevent accidents; as required by the ISO 45001 and a strategy that is already implemented in the airline, nuclear, maritime, railway, construction, and medical industries. Teperi expects benefits of this new focus to be a comprehensive understanding of positive people (individual, group, unit, and organizational) influence on operations related variability and a commitment to successful work performance and organizational outcomes. Vision Zero and ISO 45001 are accepted and implemented in the electric power industry with measured success from these initiatives. Participants admitted that, even so, serious injury-type and fatal accidents continued to occur even if the number of total accidents decreased over the years that these programs were in effect. Previous to the adoption of ISO 45001, the OHSAS 18000 standard found acceptance by leaders of the utility companies. Participants believed that a significant overhaul of existing work safety program arrangements may now be needed, and the initiatives espoused in research conducted by Teperi (2019) were likely to provide opportunities for improved practice and prevent accidents in the electric power industry.

Lu, Wu, Shao, Liu, and Wang (2019) underscored the importance and value of encouraging the reporting of, reviewing, and analyzing near-misses as opportunities to prevent accidents and worker injuries and death and reviewed the different styles, and how leadership moorings and the safety climate that can best facilitate this objective. Lu et al. investigated and found that safety specific leadership provided for improved near-miss recognition learning, reporting, management, and performance outcomes, mainly when its top leaders actively support the organizational safety climate. Participants accepted that this is an electric industry-relevant study, and it should support near-miss reporting and mitigation strategies for improved safe work performance.

Aksenov, Zavyalov, Chaplygin, and Sorokina (2020) posited that the less than adequate work planning, poorly organized work, procedural violations of technical and complex work operations, non-availability and improper use of personal protective equipment (p.p.e.), the absence of adequate and appropriate levels of supervision, and deliberate work rule violations all contributed to less than appropriate work performance outcomes. These were the primary causes of fatal workplace accidents among power system electricians, where they contacted electrical systems and fell from heights. Aksenov et al. researched the railway industry, which adopted the Vision Zero philosophy, where the focus was on accidents with zero injuries: the experience was that 12 workers died and another 45 individuals became injured in two years from 2017. This study highlights common issues identified in the electric power industry for serious injurious accidents and fatalities. A significant leadership effort and focus are required for near-miss reporting, meaningful efforts to address reported near-miss events and concerns, a significant paradigm shift that requires heightened levels of situation awareness, and a program of positive reinforcement and recognizing workers for raising issues where, if addressed, opportunities to prevent workplace accidents can be maximized.

França and Hollnagel (2019) observed work activities, focused on human factors, and modeled offshore drilling work using the Functional Resonance Analysis Method (FRAM). Offshore drilling work involves construction, maintenance, high energy exposure, and complex work activities in challenging situations and environments that can be hazardous and dangerous. FRAM was suitable for human factors analysis and evaluation of emerging risks in complex systems, accident investigations, and risk assessments on offshore platforms (França & Hollnagel, 2019). Human Factors analysis involves an examination of individual and group dynamics, leadership, and human and physical attributes that contribute to

workplace culture, climate, socio-technical performance, and outcomes. Participants unanimously supported electric power industry initiatives for recognizing human factors, and how to optimize these issues for superior organizational outcomes and individual success. Seven of the participants explicitly identified existing arrangements that support human factors assessment, analysis, and adoption. One participant indicated a 2019 initiative but lamented that it was built on a 1998 platform that was not modified to adequately cater for the complex dynamic work environment that exists today. Participants agreed that full attention to human factors and plans derived from this focus is necessary for improved outcomes in the electric power industry.

Arjunan, Habidin, Yusof, and Muniandy (2020) used a balanced scorecard to assess safety practice and performance and for informed decision making for improved outcomes. Arjunan et al. cited workplace culture and worker motivation as crucial factors that influence performance and that managers and leaders must recognize the significant impact they can have in guiding overall organizational success. The balanced scorecard is useful for measuring resource use efficiency, work activities against set procedures, and work arrangements while ensuring that tasks and efforts are aligned to realize performance outcomes (Arjunan et al., 2020). Managers can, therefore, use the balanced scorecard to demonstrate active safety involvement and support safety culture, by encouraging participation, consistent communication and improved workplace initiatives that build on a framework of regulatory compliance, training, capable hazard identification skills, risk assessment abilities, and worker involvement in work planning and arrangements. Participants believed that while the balanced scorecard method can derive merit and positive outcomes. It is not as yet a tool that they would unhesitatingly support. They believed that a more significant review on human factors, HFACS, and CRM, and the initiatives espoused by Teperi (2019), is necessary before a significant focus on the widespread use of balanced scorecards may become necessary.

Namian, Albert, Zuluaga, and Jaselskis (2016) supported workplace training on hazard recognition and risk assessment as necessary for safe work performance and accident prevention. Despite that, however, individuals at work frequently misdiagnose the risks that hazards present, or they even fail to recognize hazards even though trained and certified as competent. The net effect of ineffective hazard identification or risk assessment and mitigation is that accidents occur, many times with serious injuries to workers and, in the worst cases, with fatal outcomes. Namian et al. posited that effective hazard identification and risk mitigation are prerequisites to safe work and accident prevention. Training knowledge not-at-all or inconsistently applied for ultimate safe work success is sufficient for review of the training arrangements, individual and group behavior, attitudes, and commitment, and organizational arrangements to maintain work operations where full compliance with safety requirements are the absolute minimum requirements for work performance. Organizational leadership, managers, and supervisors must recognize the situational realities when work activities and performance misaligns with organization, industry, and regulatory objectives and requirements and adopt strict, consistent, and appropriate re-alignment strategies to prevent recurrence and to maintain a safe work environment. The need for individuals and workgroups to always recognize hazards in the workplace, determine risks, and to mitigate these risks resonated with participants. The electric power industry is one where hazardous work conditions exist. Workers and industry practitioners must be proficient at performing these tasks. All efforts to continuously maintain that competence are encouraged.

Samimi, Cortes, Anderson, and Herrmann (2020) reviewed strategic leadership skills that can enable leaders and managers to guide performance effectively and posited that leadership and management influence organizational direction and performance, implying that ultimate success or failure of organizations can and are a top-down focus. Strategic Leaders motivate and influence ethical performance for optimal performance outcomes. Samimi et al. focused on leadership behavior and attributes, strategic approach and direction and organizational context, which they believed can impact and affect overall performance outcomes and results: They constructed a strategic framework to examine the roles of top organizational leaders, how these impact performance, and the ways that this happens. Samimi et al. indicated that strategic leadership roles involved decision making, stakeholder engagement, managing human resources and administration, information and communication, and addressing technical and social issues and conflicts, organizational operations, and appropriating organizational efforts to fit demands (2020). Participants agreed that more significant support from the top leadership of organizations is required to support frontline work management and supervisory initiatives, This, participants felt, were mainly lessened by the existing leadership-union working arrangements and by a management perception that this relationship did not change to remain aligned with current reality. Participants agreed that detailed research was necessary for this area of electric power industry operations.

C. Hazards and the Management of Hazards

Loh, Idris, Dormann, and Muhamad (2019) posited that organizational safety climate does influence worker health; a negative environment can be deleterious to individual health and wellness. Loh et al. indicated that safety climate not only covers workplace accidents where workers are injured or killed, but the advent of near-misses, worker behavior, health and wellbeing, work-related stress, and individual burnout. The concept of organizational climate is useful for examining individual and group experiences in the workplace as it connects human attitudes and behavior with performance outcomes and results. Situational realities, work policies, rules, procedures, standards, practices, and worker perceptions are factors that describe organizational climate. Organizational culture, on the other hand, is more a construct of shared values, organizational norms, rituals, and traditions. Managers and supervisors directly impact on organizational

climate; they can build trust and belief to influence worker response, and behavior positively. Loh et al., also postulated that unsafe behavior is more influenced by safety climate than by leadership initiatives and focus, individual or collective knowledge, socio-technical or group support (2019). Participants were unanimous in support of a continued emphasis on worker wellbeing and health. Electric industry workers are, just as workers elsewhere, challenged with individual and personal issues and health challenges that impact on workplace performance.

Keiser and Payne (2019) reviewed how impression management can influence responses from different samples of research participants and the impact these responses can have on the credibility of any research project: they studied self-reports about safety practice among participants in three different settings. They found inconsistent safety beliefs amongst different workgroups even when intra-group consensus existed. This study has significance in the interpretation of research results where individuals indicated preference or opinions about workplace issues, especially when experiences, knowledge, motivation, beliefs, understanding, and trust were significant result indicators. Participants were pragmatic on the findings from this study. They recognized that different individuals have unique understandings but believed that a consensus could develop on a unified approach to work management. The current and actual work issue and how that developed and where it occurred also must be factored as these impact the final resolution to workplace problems. This consensus typically evolves as work crews discuss the work to be done and the role of each worker in accomplishing the task. Each worker may have original ideas on how to do the job, but that is subservient to the group-agreed approach to doing it.

Hasanzadeh, Esmaeili, Dodd, and Pellicer (2017) posited that hazard recognition and identification is a learned skill and cognitive process whereby the individual attention, ability to learn and practice what was learned are vital to successful outcomes. Hasanzadeh et al., researched how construction workers identified hazards by cognitively associating what they saw to what they were trained to recognize and learned in training programs: the aim was to determine how well these workers correctly associated what they saw to their response by measuring the eye movement of the participants. Hasanzadeh et al. believed that the results of this study could assist in identifying individual employees who can be at risk of not recognizing hazards and are likely candidates to become seriously or fatally injured. The participants in this study work in environments where common hazards include working at heights, close to energized power sources, and where the workplace can become cluttered with debris and other items. Hasanzadeh et al. found that participants were affixed on obvious hazards and imminent danger-type situations and not on hazards that were inconspicuous. Participants unanimously supported consistent and effective hazard identification and risk assessment initiatives: nothing that can assist in preventing accidents shall remain undone. One participant shared a recent experience where a live conductor on a distribution line fell when a circuit was re-energized after it tripped under faulted conditions. The actual fault was located elsewhere on the circuit, and a visual inspection of the remaining lines did not reveal any dangerous conditions. Another similar situation occurred when a Distribution Crew was making preparations on a job where a live conductor was sagging lower than normal. Before the crew completed their initial assessment, the live conductor fell off the pole onto another conductor at a lower level and caused the circuit to trip. Closer inspection revealed that the insulator on which the fallen conductor was installed, broke, and the conductor became free.

Azevedo, Duarte and e Moura (2020) confirmed that live work on electrical transmission systems is complex and intricate activities that require individuals to be particularly skilled and certified to perform in that environment, and where working arrangements are restricted and controlled by industry-specific and critically essential requirements. Azevedo et al. conducted a risk assessment exercise of live-work activities by employing three different strategies and compared the results of these assessments: they posited that working in an energized environment and at heights where the significant risks and these were consistent outcomes from the three risk assessment methods. This finding implied that cognitive recognition of the significant hazards in electrical environments require heightened worker attention, constant supervision, and organizational system requirements; to prevent individual overconfidence, negligence, and deliberate disregard for safe work arrangements, and which should never become underestimated as the worst consequences are almost always the likely result. Participants unanimously supported consistent and effective hazard identification and risk assessment initiatives: noting their full support always to do what is needed to prevent accidents and to address near-misses. In the electric power industry, hazards vary from dangerous animals such as snakes, alligators, and bears, to extreme weather conditions, dangerous situations due to uncontrolled forest fires, storms, vehicles striking poles, chemical dust, abnormal or premature component failure in addition to working at heights and electricity. Electric industry workers must remain cognizant of these dangers and remain situationally aware at all times, despite, as one participant revealed, finding venomous snakes inside of an electric panel or a bear in a substation. In 2020, with the current Covia-19 pandemic, these workers now negotiate another invisible and dangerous virus while mitigating the other dangerous hazards. Participants unanimously agreed that electric power industry workers are specially trained and highly skilled individuals who, once adequately supervised, can safely negotiate workplace challenges and prevent accidents.

D. The Importance of Leadership Vision and Direction

BİÇER (2020) suggested that the role of leaders was to motivate others consistently and to align efforts with organizational goals and philosophies. This philosophical mooring was long-term and long-lasting, which transcends individual tenure of particular leaders or even the time-span of particular individuals. The role of leaders is, therefore, a core component of organizational culture - norm and tradition. If not recognized, the impact on an organization of leadership that creates disharmony with the organizational culture can exist long after the individual's term in office. BİÇER (2020) also postulated that when workers perceive mistreatment from organizational leaders, they become insecure and stressed and which lead to instances of unacceptable behavior and

attitudes, underperformance, and even a higher rate of turnover and unplanned retirements. Managers and supervisors require worker commitment to accomplish tasks consistently. Workers, in return, require meaningful involvement in work discussion, that planned daily work programs and activities are set to reasonable schedules, that tools, materials, and equipment are available, and adequate levels of supervision are afforded them when performing work. This manager-supervisor-worker relationship can become strained by organizational issues, politics, group dynamics, and demanding individuals. If unmanaged and unresolved, this relationship can degrade into irreconcilable situations where dangerous work conditions can exist and where errant individuals can contribute to workplace errors, misjudgment, and unsafe work activities, possibly with serious injuries or fatal consequences. Leaders, managers, and supervisors must be adept at recognizing situations where workplace issues can contribute to unintended consequences and initiate mitigating action to catalyze desirable results (BİÇER, 2020). Participants fully supported the findings from this study but stressed that with the significant amount of training and opportunities for workers to learn and to develop skills at mitigating danger, there must be similar efforts aimed at convincing workers of their responsibilities to review work settings continually and to raise concerns as and if unexpected situations arise. Participants agreed that they are responsible for creating and maintaining that working arrangement and environment where workers can raise concerns and inform of possible danger while conducting work.

Priest (2019) posited that a Transactional/Transformational style of leadership, which supported a relationship between the two widely known leadership disciplines and focused on rewards and punishment as a reasonable expectation for work performance, was dependent on the leader's strategy, behavior, and motivation towards improving organizational performance. Leaders must recognize that organizational constructs are equivalent to social structures and situations that they can steer and align organizational accepted behavior with individual and group behavior (Priest, 2019). Unfortunately, this is not always so as leaders are unprepared for this challenge, and many times they heuristically rely on intuition and experience, only, instead of blending them with knowledge. Priest also confirmed that at the individual-individual level, there was no advantage to this Transactional/Transformational leadership style as it does not influence the leader-follower relationship. A recognized advantage of the transformational leadership style is individual-individual shared vision and goals encouraged and considered as a dyadic alignment for symbiotic partnerships. Priest (2019) suggested that transactional leadership skills were necessary for encouraging work rules/procedures compliance-type behavior, the provision of rewards, and punishment avoidance. Priest blended Transactional/Transformational leadership with a focus on motivation and suggested that worker development can occur when organizational and individual goals are met: a vital and desirable objective. Participants unanimously confirmed that this is a necessary framework for good leadership, to encourage accident prevention, and for superior organizational outcomes. Participants supported that candidates for supervisory and management positions in the electric power industry should complete leadership training and be continuously performance-evaluated for the organizational desired leadership qualities and attributes. That way, a consistent approach to leadership and management within each organization can evolve.

VI. Discussion

Occupational safety and workplace dynamics cannot be separated, and therefore it is useless reviewing safe work practices and experience in isolation. It is also an unrealistic and futile endeavor to critique organizational performance and outcomes solely on accidents in the workplace. At the same time, the prevention of workplace accident experiences where workers suffer serious injuries or become killed will likely not happen if there remains a disconnect between main organizational objectives such as superior financial achievement and excellent stakeholder, especially shareholder and customer needs. Workers must be willing to work with managers and supervisors as it is in their best interest to remain safe and not become injured. Managers must always remember that no achieving success is possible without workers' support and contribution. It, therefore, means that workers need their supervisors and managers in just the same way as the managers and supervisors need workers: success is not possible without this understanding and acceptance. The electric power industry workplace is a dangerous, complex-dynamic, highly technical, and diverse setting. Individuals who work in this environment undergo significant training, are expected to handle workplace challenges that are, at times, not adequately considered before or as work plans are developed.

Workers must rely on their abilities and that of their supervisors and co-workers when performing complex tasks to recognize dangerous conditions and hazards and maintain situational awareness at all times. A failure of any link in this arrangement, if unnoticed or not mitigated, can very likely develop into an unmanageable challenge where accidents can happen. The importance of top leadership and worker-union support for this working harmony cannot be underestimated or downplayed. Leadership magnanimity must be equally supported by meaningful worker-union contributions to support organizational initiatives in an ever-demanding and changing technical arena. It is no longer acceptable for hardline positions and stalling to factor in the electric power industry work setting.

Managers, supervisors, and workers must be able to strategize effectively, collaborate, communicate, experience, support one another, effectively address challenges without acrimony, and to successfully negotiate work challenges for performance success and superior outcomes. Organizational top leadership and worker-unions must now bear responsibility for supporting mediating arrangements to handle issues that may arise rather than to continue with an uncompromising, rigid, and regimented approach to human (social and personal) issues in the workplace. Workplace safety is all about human wellbeing. Industrial relations invariably surrounds the management of human factors and influence in the workplace. The realization of ultimate success can very likely be hinged on a new formula to merge all human

factors issues into one collaborative umbrella focus supported by leadership and worker-unions under a framework not rigidly structured but philosophically moored on the best outcome depending on the issue or challenge.

VII. CONCLUSION

The prevention of workplace accidents and for workers not to become seriously injured or killed at work requires a re-emphasis on human factors and a re-orientation on human values and thinking that has never before been more necessary. The workplace in 2020 is not the same; it was a decade ago. The technologies available today and the technological possibilities for the next decade and beyond can see significant changes to the work done in the electric power industry and the ways of doing the work. As an example, fifty years ago, workers climbed ladders, mostly, to work while today, they primarily work from aerial platforms and buckets. These require specific skills that are different. Reviewing the rules of engagement and the existing leadership/worker-union framework is necessary for continued relevance and successful negotiation of existing hazards in the workplace. Work rules, standards, and specifications set more than a decade ago are not as effective as in their early years. These add significantly to the human factors challenges that managers, supervisors, and workers face, experience, and regularly negotiate. The problem becomes even more complicated when individual and group beliefs, attitudes, and behavior contribute to complicating these challenges further. CRM and HFACS can become useful tools for adoption in the electric power industry. Prevention of serious injuries and fatalities is possible.

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