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Talking Paper on Three Types of Evidence (Human, Material, and Environmental)

Human Factors

Introduction. This section provides procedure and format to perform a systematic and comprehensive investigation of human factors. For discussion purposes, the human factors assessment will be addressed within the context of the following areas: **human error, accident survival, emergency egress and rescue/survival, autopsy procedures, personal protective clothing and equipment, and facilities/services**. The objectives of the human factors investigation is to identify system inadequacy (i.e.) within the interactions of man, machine, and environment.

Human influence.

(1) *Recording accident data.* Accident data recorded to date indicate most accidents can be ultimately traced to human errors. When an accident investigation team lists human error(s) as causal, it does not necessarily mean that anyone did something intentionally to cause the accident (as the use of the term “human error” might imply). For this reason, the human factors investigation must be broad in scope.

(2) *Identifying human error(s).* The first step in identifying human error(s) is to develop a chronology of events before, during, and when appropriate, after the accident. The need for placing events in order is to view human performance in the context that it occurred. The logical sources of information are the individuals involved in the planning, preparation, supervision, and execution of the operation. All of these individuals should be interviewed. During these interviews, the operational expert may detect possible errors or at least suspect errors on the part of the individual being interviewed or the individual who is being discussed. Some errors may not become evident until much later in the investigation when the relevant chronology has been developed. For example, investigation into the causes of material failures may ultimately be traced to a human error. An error by an individual may be traced to other errors committed by supervisors, trainers, and so forth. Regardless of when or how factor(s) are detected, it is important that the investigator get all the available information about those factor(s). Without this information, it will be difficult for the team to “define” the factor(s) and identify its causes(s). Individual, supervisory, and support personnel tasks are identified in publications, policies, or standing operating procedures.

(3) *Explaining human error(s).* Regardless of the task involved (for example, road maintenance, working on a hill side, changing brake pads/shoes, and so forth); the explanation of how it was improperly performed should identify the policy or standard; and the performance deviated from or not complied with. The fact that an error occurred in it’s self has little meaning until its consequence(s) and relevance to the accident are also explained. Therefore, the defining and explanation process for human errors is not complete or meaningful until—

(a) The duty position of the individual involved is identified.
(b) The task the individual performed improperly in the context of the accident sequence is explained.
(c) The human error(s) is identified.
(d) The proper procedure for performing the task is identified.
(e) How the human error(s) caused or contributed to the accident is identified.

(4) Causes of human errors. Theory- The basic belief behind the investigation of human errors is that there is some reason for all human behavior. Once this reason is identified and sufficiently defined, it can be modified/improved, thus reducing the probability of similar human errors and their consequences in the future. Therefore, the causes of human errors should be identified in terms of one or more system inadequacies.

Identifying system inadequacy (i.e.) (what allowed the mistake/error to happen). The best way to identify system inadequacy (i.e.) is to work backwards from a mistake/error by asking questions aimed at "illuminating" the error. The most direct source of information is the individual who made the error. The interviewer will have to use judgment on how best to phrase the questions. The most practical approach is to establish the circumstances for the witness and allow them to recognize the error. If the witness acknowledges the error, the simplest method will probably be to come straight to the point and ask why they erred. Asking "why" can be extremely helpful in identifying the cause(s) of the improper task performance. On the other hand, if the witness does not recognize or acknowledge the error, it may be best for the interviewer to continue with other questions. In doing so, the interviewer lessens the possibility of making the witness defensive or uncooperative. The interviewer can continue by asking questions intended to identify possible system inadequacy (i.e.) which caused or allowed the error. After this indirect questioning, the interviewer can return to more direct questions about the error. This approach will usually produce the most reliable information. The human factors investigator will also have information from other sources. These include individual records, office records, and other individuals who may have knowledge about the individual or the accident. A post–accident medical examination may identify physiological factors; for example, acute fatigue, alcohol, carbon monoxide, drugs, impaired vision, and so forth.

Material Factors
Note. (In this paragraph, the term "equipment" is utilized to indicate the piece of equipment involved in an accident investigation (end–item); such as, aircraft, vehicle, structure, heavy equipment, component, part, and so forth).

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Introduction

(1) This paragraph provides procedures for performing a systematic and comprehensive investigation of material factors associated with an accident. The objectives of the material factors investigation are as follows:

(a) To establish the equipment's condition at the time of the accident.
(b) To describe the damage that occurred during the accident sequence.
(c) To identify material failures/malfunctions that resulted in an accident (what happened).
(d) To identify the system inadequacies for the material failures/malfunctions (what caused it).

(2) The investigation of material factors requires, as a minimum, the assistance of a maintenance or technically qualified individual.

Material failure/malfunction.

(1) Equipment, or a part thereof, is considered to have failed or malfunctioned when one of the following occurs:
(a) Becomes completely inoperable.
(b) Is still operable but no longer able to perform its intended function satisfactorily.
(c) Has deteriorated to the point where it is unreliable or unsafe for continued use.
Note. (This explanation does not apply if the equipment achieves any of these three states because the required operational situation/condition that it was employed in exceeded its design capability or operating limits.)

(2) The success of the material factors investigation is dependent upon determining the difference between failures/malfunctions that may have caused the accident and damage caused by the accident. The procedures to be followed are generally the same for all accidents, regardless of damage.

(3) The first step in identifying material failure/malfunction is to document the most obvious evidence available at the accident site by taking notes, photographs, and drawing diagrams. By the time these tasks have been completed, the human factors investigation will usually have some preliminary information from witnesses that may further indicate the most probable failures/malfunctions. These possibilities should be carefully examined. Even though the investigation begins by examining components that most probably failed, this examination is not complete until all major components and systems have been examined for evidence of failure/malfunction. In cases where preliminary evidence, for example, witness statements, indicates no

failures/malfunctions occurred, the examination is still required. The purpose of the examination in this case would be to describe damage along with substantiating the lack of evidence supporting a failure/malfunction. The next step is the shipment to a tear down analysis facility of those components that the team identified or suspected of having failed/malfunctioned. The tear down analysis is important since the board may not have the capability to determine how and why a component failed. The last step for the material factors investigation is to determine the cause of the failure/malfunction.

Causes of material failure/malfunction.
(1) *Overview.* As in the case of human error, the causes of material failure/malfunction can usually be traced to an inadequate systems element. Once identified, corrective action can be taken to prevent the probability of similar material failure accidents in the future. Thus, the causes of material failure/malfunction will be identified in terms of one or more system inadequacy (i.e.). A material system inadequacy is defined as a tangible or intangible element that did not operate as intended or designed and caused, allowed, or contributed to a material failure or malfunction.

(2) *Identifying system inadequacy (i.e.) (what caused it).* Once the material factors investigation has identified or at least suspects a failure/malfunction, it must continue the search for evidence to substantiate the cause of the failure. For example, could maintenance have caused a failure of this part, component, or system? To answer questions like this, the investigator must examine records and standard operating procedures, whether they are written or not. The material factors investigation must interface with the human factors investigation to search for errors/mistakes that may have resulted in the material failure. The investigator should try to gather evidence that will substantiate or eliminate each of the system elements that is within his/her capability to investigate. Thus, the procedure can be described as a process of elimination. If the investigation is unable to uncover evidence of a system inadequacy locally, the determination of the cause should be delayed until a thorough tear-down and analysis can be completed.

Special investigations

(1) Investigation involving highly technical phases of the accident, as described herein, will require further study and special investigations. In many cases, this cannot be accomplished in the field, and the work must be continued by technically qualified personnel at a laboratory or other specialized facility. If mechanical failure occurred or is suspected, adequate photographic coverage must be provided and the suspect failed parts retained for further evaluation. Sketches, history, and explanatory material must accompany the parts and should contain enough information to give a clear picture of what happened. If a control switch, handle, or knob, were used improperly because of its design, or if one control was mistakenly operated when the operator intended to use another, the location, size, shape, method, or operation of the control may prove to be an underlying cause and must be examined. Statements of operator's deficiency should

include his proficiency in the equipment involved in the accident as well as others. Different equipment may have controls or instruments in reversed positions from others operated by the operator and this could contribute to the accident. Accidents that are particularly difficult may require investigative techniques beyond the examination of physical evidence. The only limit to a good investigation is the imagination of the investigator.

Environmental Factors

a. Environmental factors are those environmental elements or conditions such as noise, illumination, weather conditions (for example, precipitation, temperature, humidity, pressure, wind, and lightning, and so forth) having an adverse affect on the performance of the individual or equipment so that an accident results or could result.

b. Assessment of environmental elements (for example, contaminants, noise, vibration, artificial illumination, acceleration, deceleration, radiation, adequacy of work surfaces/space, and weather conditions) should be accomplished to determine their influence on human and/or materiel performance. Contaminants (fumes, chemicals, and so forth) can lead to respiratory problems; noise (radio static, engine, and transmission noise) can distract attention, interfere with effective communications and lead to fatigue; inadequate illumination can cause reduced visibility; inadequate work space (cluttered, poorly designed drivers compartment) can contribute to procedural errors or limit outside visibility. Knowledge of environmental elements does not eliminate them as factors influencing errors, injuries or failures. To determine if an environmental factor should be assessed as a causal factor, the central question to ask is:

> Did this factor adversely influence human and/or equipment performance; was the environmental element unknown or unavoidable at the time of the accident/injury/occupational illness?

c. Environmental factors can be divided into those which could not have been avoided and those for which precautions could have been implemented to reduce or eliminate its adverse effects on personnel and/or equipment. An environmental deficiency should not be assessed as a causal factor if it was known and could have been avoided before the accident. if there is any evidence of an external energy influence on the equipment or its subsystems. Consider cockpit/instrument indications reported by surviving crewmembers, eyewitness reports, and other physical evidence. This is especially important where the physical evidence indicates that the equipment was out of control or malfunctioning prior to the accident.