ACCIDENT CAUSATION THEORIES[1]

[1]The information below is from the following website:

http://www.isplonline.com/accidentcausationteory.htm

HEINRICH'S THEORY

H.W. Heinrich, a pioneer in safety philosophy, first published his work. Industrial Accident Prevention, in 1931. Many of his principles and basic philosophy of accident causation and prevention are confirmed by time and application, but, some are also questioned and criticized. His philosophy is based on his 10 axioms (self-evident truths).

Ten Axioms of Industrial Safety:

1) An injury invariably results from a completed sequence of factors - the last one of these being the accident itself. The accident in turn is invariably caused or permitted directly by the unsafe act of a person and/or a mechanical or physical hazard.
2) The unsafe acts of persons are responsible for a majority of accidents.
3) The person who suffers a disabling injury caused by an unsafe act, in the average case, has had over 300 narrow escapes from serious injury as a result of committing the very same unsafe act. Likewise, persons are exposed to mechanical hazards hundreds of times before they suffer injury.
4) The severity of an injury largely happens by accident or chance that results in an injury which is largely preventable.
5) The four basic motives or reasons for the occurrence of unsafe acts provide a guide to the selection of appropriate corrective measures. These are:
    - Improper attitude
    - Lack of knowledge or skill
    - Physical unsuitability
    - Improper mechanical or physical environment
6) Four basic methods are available for preventing accidents:
    - Engineering Revision
    - Persuasion and Appeal
    - Personnel Adjustment
    - Discipline

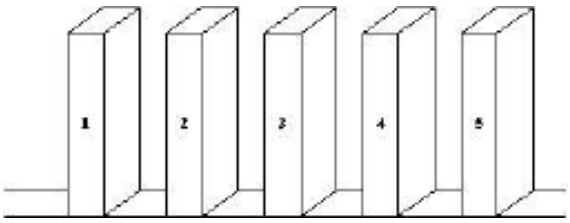
7) Methods of most value in accident prevention are analogous with the methods required for the control of the quality, cost and quantity of production.
8) Management has the best opportunity and ability to initiate the work of prevention; therefore, it should assume the responsibility.
9) The supervisor or foreman is the key man in individual accident prevention. His application of the art of supervision for the control of work performance is the factor of greatest influence in successful accident prevention. It can be expressed and taught as a simple four step formula:
    - Identify the problem
    - Find and verify the reason for the existence of the problem
    - Select the appropriate remedy
    - Apply the remedy
10) The humanitarian incentive for preventing accidental injury is supplemented by two powerful economic factors:
    - The safe establishment is efficiently productive and the unsafe establishment is inefficient.
    - The direct employer's cost of industrial injuries for compensation claims and for medical treatment is about one-fifth of the total (direct plus indirect) cost which the employer must pay.

These axioms were the first set of principles or guidelines ever set before in industrial safety and it has guided all safety activity till today. During the passage of 75 years, some of his axioms are questioned and disbelieved as truths, but, most of them are still true and deal with the important areas of safety, viz. accident causation and prevention, reasons of unsafe acts and conditions, management control functions, responsibility of organization, costs of accident, safety and productivity etc.

FRANK BIRD'S DOMINO THEORY

Heinrich's theory of domino sequence is updated by Frank Bird Jr. to explain the circumstances that lead to losses (injury) in the chronological order of five dominoes.

1) Lack of control – Management
2) Basic causes – Origins
3) Immediate causes – Symptoms
4) Accident – Contact
5) Injury/damage – Loss



Lack of Control

Lack of control is the first domino and refers the fourth function of the management (planning, organizing, directing, controlling and coordinating). It involves accident investigation, facility inspection, job analysis, personal communication, selection and training, 'standards' in each work activity identified, measuring performance by standards and correcting performance by improving existing programs. This first domino may fall due to inadequate standards, programs and follow up.

Basic Causes (Origins)

Basic Causes (origins) are (1) Personal factors lack of knowledge or skill, improper motivation and physical or mental problems and (2) Job factors inadequate work standards, design, maintenance, purchasing standards, abnormal usage etc. These basic causes are origin of substandard acts and conditions and failure to identify them permits the second domino to fall, which initiates the possibility of further chain reaction.

Immediate Causes

Immediate causes are only symptoms of the underlying problem. They are substandard practices or conditions (known as unsafe acts and unsafe conditions) that could cause the fourth domino to fall. These causes should be identified, classified, and removed by appropriate measures.

Accident/Contact

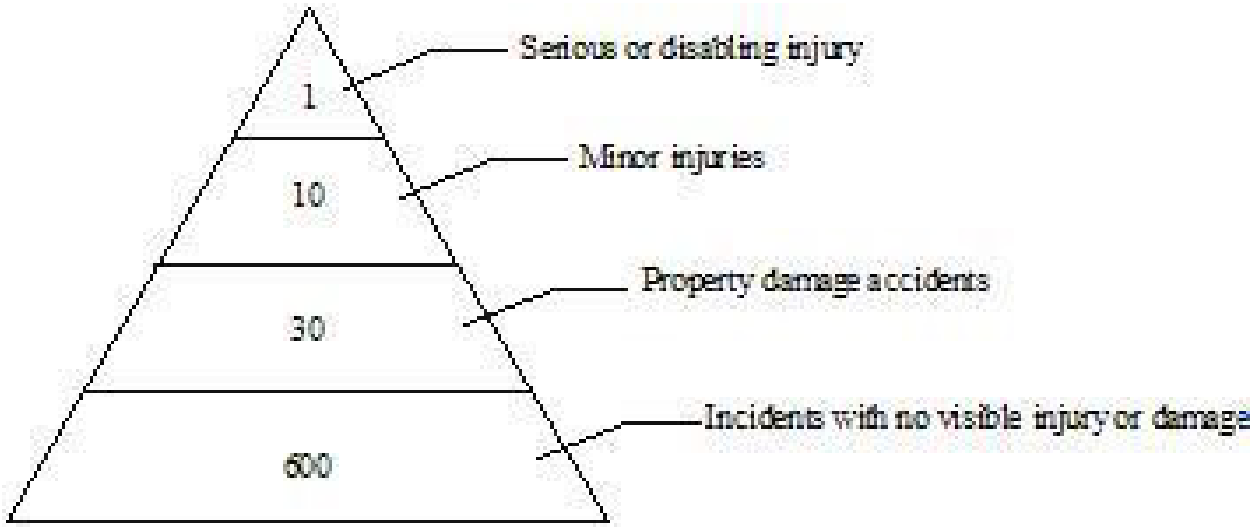
Accident or incident is the result of unsafe acts or/and unsafe conditions. This point is the contact stage. Some counter measures employed are deflection, dilution, reinforcement, surface modification, segregation, barricading, protection, absorption, shielding, etc.

Injury/Damage Loss

Injury includes traumatic injury, diseases and adverse mental neurological or systemic effects resulting from workplace exposures. 'Damage' includes all types of property damage including fire. The severity of losses involving physical harm and property damage can be minimized by prompt reparative action, salvage in the case of property damage and fire control devices and trained personnel.

Frank E Bird, in 1969, analyzed 1753498 accidents reported by 297 companies of America.

Inference of this 1-10-30-600 ratio is that 630 no injury accidents, with 10 minor and I major (serious) injury accidents, provide a much larger basis for many opportunities to prevent any injury accident. Out of total 641 events, only 10 may result in minor injuries and only 1 in major injury. But this can happen at any time not necessarily at the end.



HEPBURN'S THEORY

H.A. Hepburn amplified the above Heinrich's theory and arrived at the principle that an injury accident is the result of the convergence at the same point of time of the following 4 factors:

1) Unsafe actionable
2) Unsafe conditional
3) Proximate casual
4) Personal

Here unsafe actionable and conditional factors are as usual Personal factor means person injured or likely to be injured by an accident and die person causing the accident. The proximate factor is that immediate causative factor such as failure of a brake, sudden exposure to gas etc., which by its reaction causes a sudden closing together or convenience of all the four factors to cause an injury accident He emphasizes that lie four factors are complementary to one another m causation of any injury-accident such that, if any one or more can be withdrawn by any means during or just before convergence, an injury accident can be prevented. The event of an accident will not be prevented by efforts to control any one of the factors to the exclusion of the others.

Remedial measures must be adopted for each of the factors. Like Heinrich he also suggested planning and organizing to prevent unsafe actions and remove unsafe mechanical or physical conditions.

GROSE'S MULTIPLE CAUSATION THEORY

As per this theory many contributing factors combine together UK random fashion, causing accidents. Such factors should be identified. Mostly man, machine and media interact with each other to generate causes for accident and management has to identify them and provide necessary safety measures.

In this theory:

1) Man includes workers, public, etc.
   - Characteristics include age, sex, height, skill level, training, motivation, etc.
2) Machine includes equipment, vehicle, etc.
   - Characteristics include size, weight, speed, shape, material of constriction, energy etc.
3) Media includes environment, weather, roadways, etc.
   - Characteristics include pressure, temperature, content, contaminants, obstruction on road etc.
4) Management means within which above three parameters operate, i.e. to be controlled by the management.
   - Characteristics include structure, style, policy, procedure, communication etc.

Example 1

A simple example of this theory is a man slipping due to walking on a banana skin lying on the road. The main contributing factors are:

1) Man - A man walking on the road
2) Machine or object or vehicle - Slippery banana skin
3) Media - Hard road

All above causes are interacting with each other to lead to the accident. Absence of any one cause can avoid the accident This indicates that slippery banana skin should be removed from the road or man should be more attentive for not walking on it or the road should not be so hard to cause slipping.

Example 2

Let us take another example of a worker falling from a ladder. As per the multiple causation theory some of the contributing factors surrounding this accident can be found out by asking:

1) Why was the defect in ladder not found in normal (past) inspections?
2) Why did the supervisor allow its use? Why did he not get it repaired urgently?
3) Didn't the injured worker know he shouldn't use it?
4) Was he properly trained or not?
5) Was he reminded or cautioned?
6) Did and do the supervisor examine the job first?

The answers to these and similar questions would suggest the following measures:

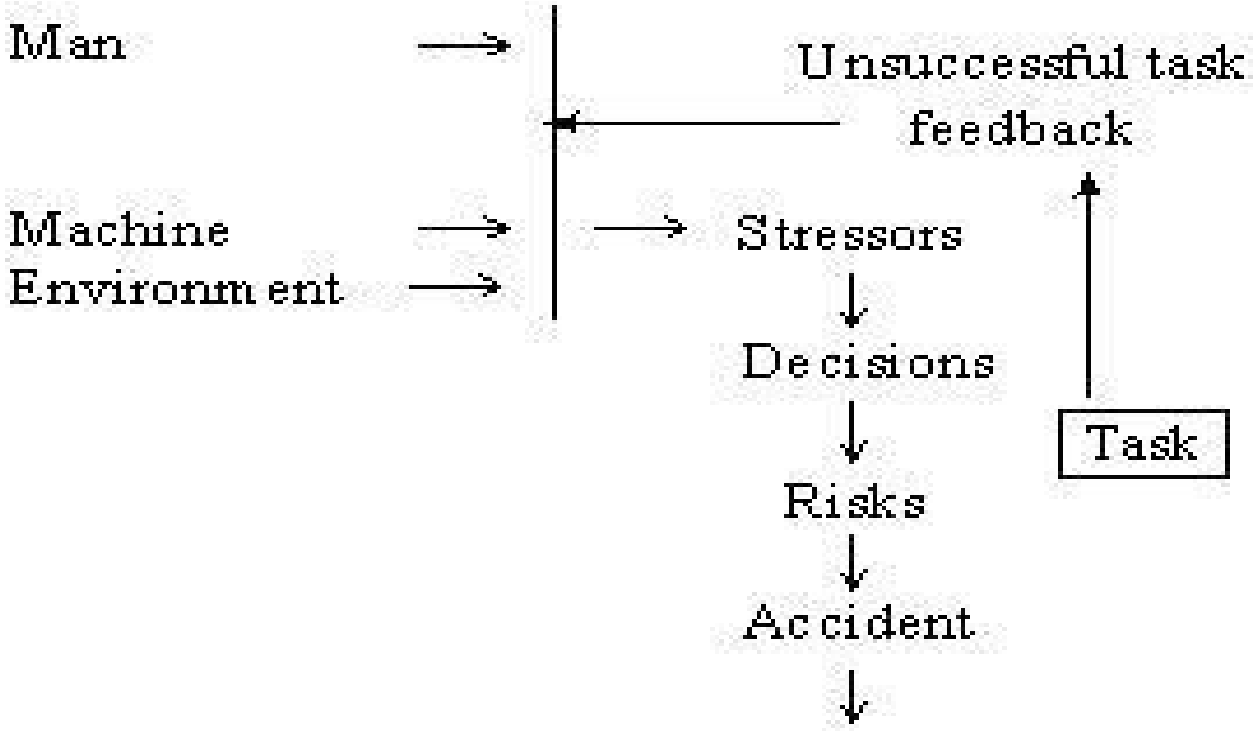
1) An improved inspection procedure.
2) Repairing the ladder (machine-tool, job etc.) immediately i.e. not waiting for an accident.
3) Improved training and supervision.
4) Better fixation of responsibilities.
5) Pre job planning and checking by supervisors.

Thus, application of the multiple causation theory leads us to deep causation analysis and improved management systems are suggested to eradicate the problem from its origin. The range and depths of the multiple causation factors provide much details of long-run safety measures.

SYSTEMS MODEL THEORY

Similar to Grose's Multiple Causation Theory, Bob Firenze developed a system model theory as:

> Interaction between man, machine, and environment (basic pre-elements for any accident) leads to an accident if the information available to the important element of the system is inadequate.
>
> If the risk is high and the decisions based on information are illogical and unsound, an accident occurs resulting into incompletion of the task. Bob Firenze's system model is shown below:

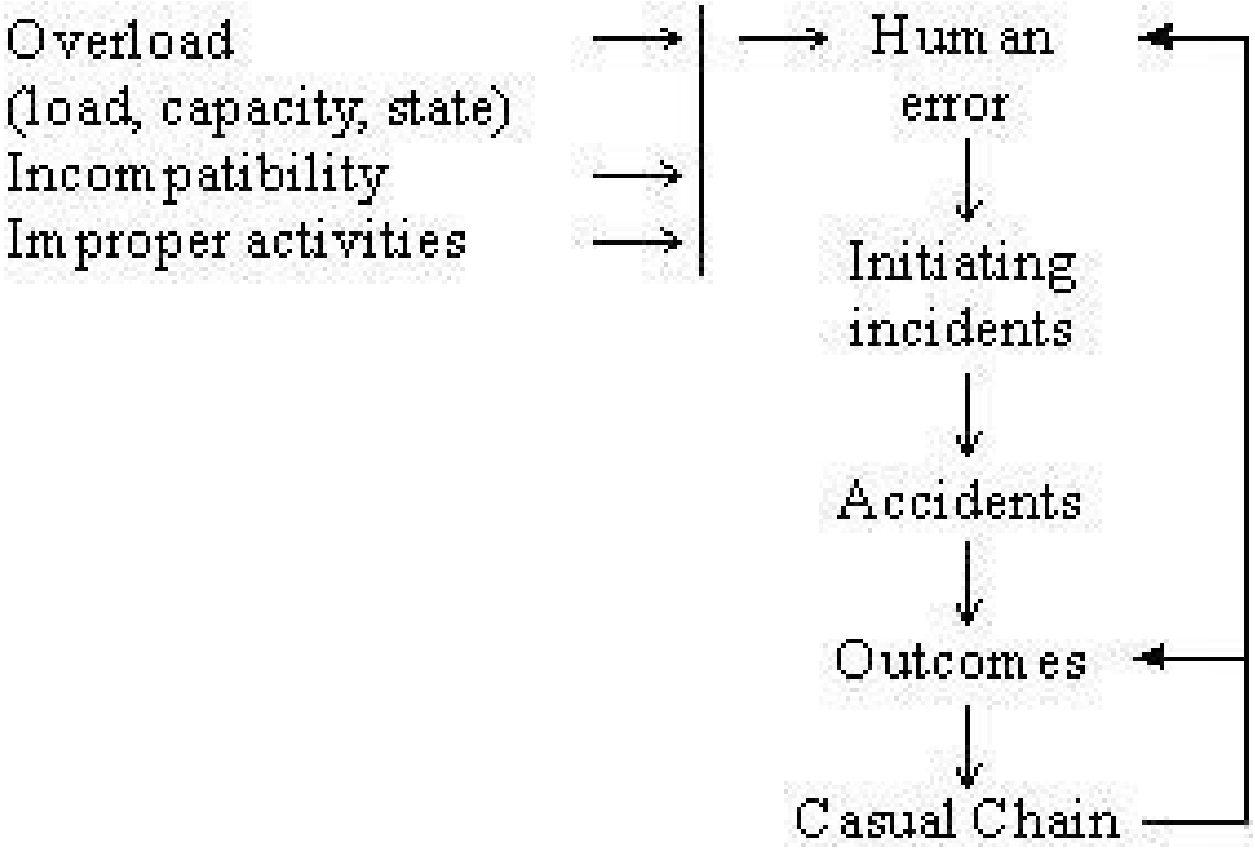


This necessitates the introduction of feedback system (as shown in diagram) to find out the faults/ causes in man, machinery, and environment. The information that the man possesses can be strengthened through training. The stressors can be precedent in the following form:

1) **Psychological stressors:** Anxiety, aggressiveness, fatigue
2) **Environmental stressors:** Glare, temperature extremes and low levels of illumination, also includes 'Machine stressors' like unguarded machines at the point of operation, transmission of power and other dangerous parts
3) **Physiological stressors:** Narcotics & Alcohol

FERRELL'S HUMAN FACTORS THEORY

Dr. Russell Ferrell, Professor of Human Factors at the University of Arizona, gave this theory of accident causation as shown in diagram.



This theory states that accidents are the result of a casual chain (as in multiple causation theory), one or more of the causes being human error, which is in turn caused by three situations - overload, incompatibility, and improper activities.

Factors affecting these three situations are as follows:

1) **Overload** (A mismatch of capacity, load and a state) due to-
    a) Load
        - Task (Physical, information processing)
        - Environment (Light, noise, distraction, stressors, that requires active coping)
        - Internal (worry, emotional stress)

- Situational (Ambiguity of goals or criteria, danger)

b) Capacity
   - Natural endowment, physical condition, safe of mind, training, drugs, pollutants, pressure, fatigue, stressors that impair ability to respond

c) State
   - Motivational level and arousal level

2) **Incompatibility** (incorrect response or mismatch) due to –

a) Stimulus – Response	Due to control – display
b) Stimulus – Stimulus	Due to inconsistent display types
c) Response – Response	Due to inconsistent control types or locations.
d) Work station	Size, force, reach, feel

3) **Improper Activities** due to
   a) The worker did not know how to do it.
   b) He deliberately took risk due to
      - low perceived probability of accident
      - low perceived cost of accident

Since this is basically human factor model, greater emphasis is placed on the first two causes of human error, overload, and incompatibility.

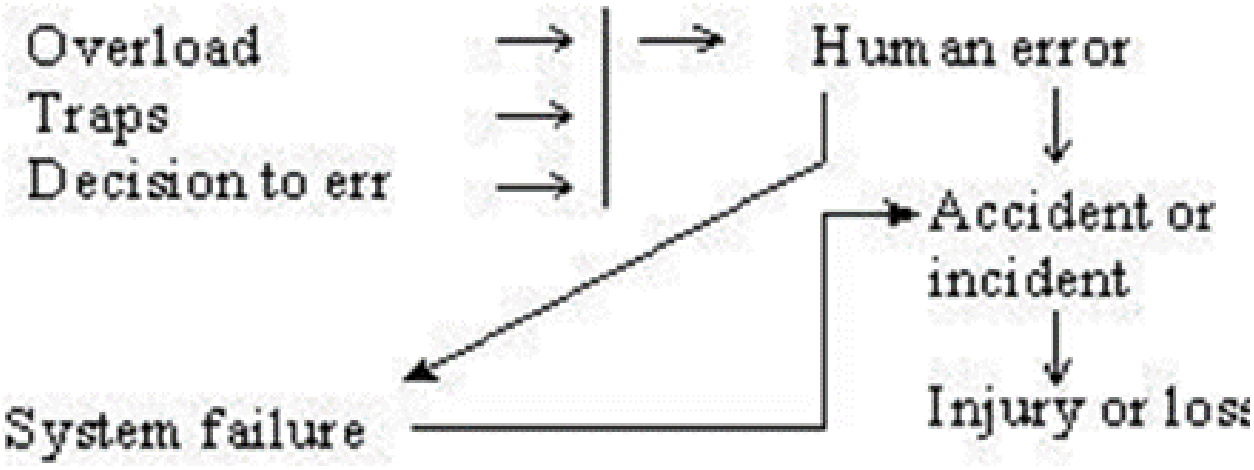
PETERSEN'S ACCIDENT-INCIDENT CAUSATION THEORY

This theory adapts Ferrell's human factors of overload (also Heinrich's domino theory) and states that causes of accident/incident are human error and/or system failure. Human error is due to overload, traps and decision to err. Human error may directly cause accident or may cause system failure which may cause accident resulting in injury or loss as shown in the diagram.

Factors causing overload are much the same in Ferrell's model. Traps are due to defective workstation, design and incompatible displays or control.

Decision to err are caused by illogical decision under situation, unconscious desire to err and perceived low probability.

System failure is due to error in policy, responsibility, authority, accountability, measurement, inspection, correction, investigation, orientation, training, selection, safe operating procedure, standards, hazard recognition, records, medical and others.



EPIDEMIOLOGICAL THEORY

Suchman stated epidemiological definition of accident as "An unexpected; unavoidable, unintentional act resulting from the interaction of host (accident victim), agent (injury deliverer) and environmental factors within situations which involve risk taking and perception of danger".

This originated from the study of epidemics. Casual association between diseases or other biological processes (accidents) and specific environment are studied. A classic example of epidemiological method was given by Snow who discovered that persons using a particular water supply had a higher death rate from cholera than others. Gordon and McFarland supported that accidental injuries could be studied with the same techniques.

SURRY'S DECISION THEORY

Jean Surry developed this theory stemming from .the epidemiological model of Suchman. It assumes that by a person's action or inaction, danger occurs to the person. If any negative responses to the question are shown during the danger build-up cycle, the danger becomes imminent. If all replies are positive, the danger diminishes. A negative response to one of the questions will lead to inevitable injury. An accident can be the result of many different routes through the model (20 routes). There are fewer routes leading to no-injury situations.

ENERGY RELEASE THEORY

Dr. Leslie Ball, former Director of Safety for NASA, introduced a causation theory. His thesis is that all accidents are caused by hazard, and all hazards involve energy, either due to involvement with destructive energy sources or due to a lack of critical energy needs. This model is most useful to identify hazards and to understand system safety.

Gibson noted that injury to a living organism can be only by some energy interchange. Hence it was suggested that the energy exchange should be considered as the injury agent. The energy exchange resulting in an injury could be mechanical, chemical, thermal, electrical etc. This concept is useful in understanding the way injury is caused and examining the solutions. When a grinding wheel is in stop- position it does not make accident, but if it runs and fingers trapped, it makes accident because of its kinetic energy.

William Hadden, m 1970, explained 'energy transfer or release' as the main factor for accident causation and said that accidents and injuries are caused because of transfer or release of energy between objects, events or environment interacting with people.

Ten strategies were suggested by Hadden to prevent or reduce losses asunder:

1) Prevent the transfer or origin of energy, e.g. safe substitution – using toluene instead of benzene, not keeping the car running, dipping instead of spraying shot blasting instead of sand blasting.
2) Reduce the amount of energy trailer, i.e. drive vehicle or machine at slow speed, and reduce quantity or concentration 'of hazardous chemicals.
3) Prevent release of energy, e.g. flameproof electric fitting in flammable area, fall arrester device, dyke to stop spread of .chemical, safe overflow pipe or level cut off device.
4) Change the rate of release or distribution of released energy, e.g. reduce the road slope, use inhibitor to reduce rate of reaction, sprinkler to reduce rate of burning, scrubber to scrub toxic gas, condenser to liquefy organic vapor.
5) Divert (separate) the energy released in time or space, e.g. separate paths for vehicles and pedestrian traffic, keep electric wiring or pesticide out of reach discharge gases at height
6) Provide barrier between the energy released and a structure or a person likely to be affected, e.g., guards on machines, radiation shield, filter, safety goggles, earplugs, insulation on hot surface, blast wall against explosion energy.
7) Make the surfaces of structure safe e.g., rounded corners, blunt objects, big handles of tools and no sharp edges.
8) Strengthen the structure or person susceptible to damage, e.g. fire resistant wall, training to workers and vaccination for disease.
9) Early detection ,of damage and actuate counter effect, e.g. fire detectors with sprinklers, high level alarm and tripping of feed pump, temperature alarm and starting of cooling system.
10) Speedy measures to restore normal condition, e.g. rehabilitation of injured worker, repairing of a damaged machine or vehicle.