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VI.5 PROTECTION OF REHABILITATION WORKERS

The rehabilitation of an area affected by a chemical accident involves a complex sequence of activities and a large and multiskilled workforce. The work is generally characterized by risks of accidental injury and potential exposure to chemical and physical hazards. Superimposed upon normally tolerated risks are the consequences of exposure to the contaminant released in the accident.

Large scale activity such as earthmoving, demolition, dredging, skimming, spraying, pumping, abrasive blasting and washing are likely to disturb settled contaminants which may be present at the start of the rehabilitative phase. This disturbance increases the potential for exposure of the workers to airborne contaminants.

The rehabilitation workers have the greatest risk of exposure, both chronic and acute, to the chemical hazards present at the site. The risks will exceed those experienced by the average member of the public, who quite possibly have been evacuated from the area.

The recognition, evaluation and control of chemical and physical hazards which are likely to affect the health or well being of workers encountered in the workplace are the components of industrial or occupational hygiene; whereas analyzing causes of accidents (unplanned events) and designing systems to minimize loss due to accidents is the field of the safety professional.

Elsewhere in this report, the relationship between the source of contaminants and the natural environment is discussed. The nature and concentration of the chemical contaminants changes as they move through the environment from their origin, generally becoming less predictable.

Immediately following an acute chemical emergency, contaminants may be distributed both inside and outside the primary source. The substance may, however, be in storage or in transit to an end user or have been disposed of as a waste. It may be found on or dispersed in water bodies, depending upon its physical and chemical properties. Alternatively, or in addition, it may be found on or under the soil or dissolved in ground water. Variations and combinations of these scenarios may occur and must be taken into account.

Each of these environmental compartments defines a workplace which may be classified as: an open and/or well-ventilated site, a semi-confined, poorly ventilated site or a completely enclosed unventilated confined space. Each category necessitates different and increasingly stringent conditions for acceptable work practices.

The safety professional is an indispensable member of the occupati health and safety team. As described by the American Society of Safety Engineers, the modern safety professional is qualified to

> "identify and evaluate the magnitude of safety problems, to determine the causes of accidents or the existence of loss-producing conditions, practices or materials".

Considerable emphasis is directed toward the loss potential of activity including predictions as to where and how loss and injury may occur and determining the means to prevent them (McLean 1972)

In the following section special attention is given to accidents whic may occur during rehabilitation of a major chemical Accident or other rele of toxic chemicals. The "workplace" is thus the rehabilitation area and "accidents" refer to incidents subsequent to the Accident that is being rehabilitated.

Accident prevention is an integral program or series of co-ordinate activities directed at the control of personal performance or unsafe cor ditions (Heinrich et al., 1980); Lees, 1980; McLean 1979).

It entails two main considerations: in the short term the control of personal performance and environment, and in th lc term, the improvement of worker awareness of hazards and response to th Attaining the latter goals requires a program of training, instruction a education. Additionally, the mechanical hazards within the environment a the unsafe actions of persons which precipitated the accident must also eliminated.

1.1 Indigenous Hazards

Indigenous hazards are generally beyond the control of safety eng neering because of the difficulty in anticipating their presence. Thi a function of the origin of the site, itself the product of an acc an situation or one of neglect.

The indigenous hazards arise primarily due to the chemical natur of the contaminants. These may be explosive or flammability hazards duced by airborne mixtures of gases or vapours or pools of liquid. An these conditions may exist at the site at the time of entry, or may be created following disturbance of soils, structures, or submerged depos Considerable attention must be given to ensuring that the presence of conditions is detected before an accident-producing situation develops Safety procedures must address the specific course to be followed when explosive mixture is detected.

Another danger arises from a lack of oxygen in tanks and pits. It should be realized that not only fire but also bacterial action can consume the oxygen in a confined space converting it to the heavier gas, carbon dioxide. Many workers have been asphyxiated when they entered tanks containing food wastes, sludge or activated carbon, all of which support bacterial action.

A further set of indigenous hazards are toxic and irritating chemicals. Not only the chemicals involved in the accident but also those produced, e.g. by fire, must be considered. Dangers of ingestion are fortunately minor with well trained workers who do not take rest and meal pauses in contaminated areas. More serious is inhalation of vapours and gases and skin absorption, especially of traces of irritating chemicals which may coat surface with nearly invisable films. The use of proper protective equipment is essential and must be enforced.

1.2 Introduced Hazards

Introduced hazards are features inherent in equipment and processes hich are introduced to the site. These hazards, by virtue of their origins, re amenable to engineering treatment. The ultimate success (or failure) f the safety program carried out at the site will depend on recognizing he full extent of the introduced hazards, and recognizing and controlling he interactions between them and hazards indigenous to the site.

Thermal hazards are likely to arise during operation of gasoline or iesel powered equipment, or use of welding or other equipment which acts s a source of intense thermal radiation. Such equipment can act as a ource of ignition in the presence of flammable liquids or explosive mix- ures of gases or vapours. As mentioned in the previous section, the ecessity to bring such equipment onto the site must be given close crutiny. Stringent procedures covering its use must be developed.

Pneumatic hazards are associated with use of compressed gases suc welding gases and compressed air or steam. The latter gases may be em in equipment or processes to be utilized at the site. Tunnelling oper are often conducted under hyperbaric conditions. Special examination these procedures is required, since explosive mixtures of gases or vap could be generated within tunnels or shafts following disturbance of c taminated soils. Pneumatic hazards may also exist in equipment or pro operated under low pressures or vacuum conditions.

Electrical hazards deserve special attention and consideration du design reviews and on-site surveys, since the components of electrical systems can constitute sources of ignition. The spark hazard rating electrical equipment must be assessed thoroughly prior to its admitta to a site in which explosive mixtures of gases and vapours may be gen

Mechanical hazards are those associated with moving parts. Impacts between certain alloys produce sparks which can act as sources of ignition. Materials to be employed where metal-metal contact is likely to occur must be chosen carefully. Mechanical equipment must also be selected for its reliability and serviceability so that breakdowns are few in number, and that decontamination, once the equipment is to be serviced, can be accomplished easily.

Ergonomic hazards are associated with faulty interaction between man and machines, and man and his environment. This category of accident accounts for large numbers of personal injuries and fatalities. Special consideration must be given to these interfaces, especially since heavy reliance may be placed upon the use of personnel protection. This apparel heavy and bulky, and is likely to reduce considerably an individual's mobility, agility and dexterity. The problem introduced by adverse weather conditions, such as extremes of winter and summer must also be considered : specification of work practices.

.3 Hazard Interactions

Recognition of hazards associated with the rehabilitation necessitates an in-depth study of the processes to be employed, and the equipment needed to execute them. The characteristics of the site itself must be known in detail in order to facilitate the planning process. This information can obtained only after entry and exploratory testing. The safety professional is a necessary participant in planning these surveys. The latter will be discussed in more detail subsequently.

Once the safety hazards present at the site have been identified, process planning can be undertaken. The processes to be considered likely involve the use of heavy equipment. The operating characteristics of the latter must be examined for compatability with conditions existing at the site. Where explosive mixtures may be present or may develop, caution must be urged, for example, in selection of equipment or processes likely to provide a source of ignition. If use of such tools or equipment is unavoidable, procedures must be specified to ensure that work is halted and the worksite evacuated prior to development of a potentially explosiv mosphere. Such procedures must also define the conditions and practi be followed during re-entry. These should include air monitoring, de the source of the gas or vapour, and if possible, a means of preventi recurrence of the situation.

1.4 Acquisition of Data

An accident-prevention program is an on-going endeavour in the n industrial context. For this reason an accident-prevention program o evolves during a considerable period of time. Activities carried out rehabilitation site are, however, generally short-term in duration. context an accident-prevention program must be weighted heavily towar vance planning.

The starting point is the acquisition of data concerning the haz conditions likely to exist at the site, as well as hazards associated the processes or equipment to be employed. Analyses of accidents occ during previous operations, as well as those occurring in similar ind can be used to establish potential direct causes. Likely external so of data are the chemical manufacturing and construction industries. and processes of rehabilitation are similar to those utilized at a ch plant undergoing renovation or a construction site. An added conside is the fact that extensive use of personnel protective equipment may cuired. Relevant accident experience in this area needs to be acquir especially for adverse climatic conditions.

A second area from which useful data may be obtained is the expe gained from solutions applied to previous accident-producing situatio The relative success of different solutions provides useful knowledge several choices are available.

Another method by which to reduce accidents is to examine each s the task or process to determine its hazard potential. This techniqu for example, be carried out during rehearsal of a procedure prior to utilization at the site. Accident-producing situations thus identifi be corrected immediately.

Acquisition of data from multiple sources is absolutely necessary in order to generate a database large enough for proper analysis.

1.5 Analysis

Following acquisition, the data are analyzed to determine the likely primary causes of accidents associated with processes to be employed or site activities. These deliberations consider modes of causation of human machine failure and their associated probabilities. The data are employed generate fault trees. The intent of this analysis is to minimize the probability of failure by modifying individual components or by selecting more reliable alternates, if available. The failure of individual elements can estimated from the database collected during the acquisition phase. The more comprehensive this database, the greater will be the flexibility to consider alternate courses of action. Individual fault trees generated fro human or machine failure may then be combined to investigate the occurrence of multiple failures. If the probability is unacceptably high, the individ contributors must be re-examined to determine where further improvements can be made.

Pertinent accident data can also provide valuable information to the safety professional. Accidents grouped according to causation such as unsafe acts, reasons for unsafe acts, mechanical or physical hazards and unde lying causes (managerial or supervisory) provide insight into the deficienc of procedure, equipment and personnel most likely to be experienced on the site. The long timeframe during which these data were gathered permits examination by hindsight, a luxury unlikely to be afforded during the rehabil itation owing to its relatively short duration.

1.6 Selection of Remedy

~~Once the~~ likely causes of accidents during rehabilitation have been identified, the next st is to select a solution from among the available possibilities. The guidi principle in this process is to design the hazard out of the system, if possible. Less satisfactory a means of control is to add warning and protective devices to the basic design. Least desirable is to include hazard controls into training, operating and maintenance procedures.

Suitable solutions can incorporate engineering controls or modifi behaviour modification, instruction, training and practice and personn protective equipment. The recommended priority of solution is to cons first the application of engineering controls, where justified as feas in cost and in consideration of the duration of the project. This dec should be coupled, as appropriate, with training and instruction.

A rehabilitation project may present circumstances in which the c engineering out the hazard is prohibitive, or the technology does not Use of personnel protective equipment as the first line of defence aga safety hazards may be required. This situation would necessitate the and institution of a comprehensive training and educational program to the effects of the hazards and the need for personnel protection, and instruct and ensure competence in its use. The safety professional is active participant in the design and presentation of such programs to levels of personnel involved in the project. Training aspects will be cussed in Section 4.

1.7 Implementing the Solution

The next step is to apply t corrective action to the accident or the potential accident-producing situation. Under normal circumstances the role of the safety professi does not extend beyond that of a consultant. Project management shoul enact the solution in all cases. Accident-producing situations identi a design review should be corrected by process planners. In the event accident or accident-producing situation occurring during on-site rk corrective action should be undertaken by the appropriate first-line s visor.

The safety professional should avoid unnecessary involvement in t proceedings, but especially so in the latter situation. This individu must avoid creating the perception of being the enforcer of rules; thi is properly the responsibility of the immediate supervisor. The prope ception of the safety professional in the eyes of both management and workforce is essential to operating a successful accident-prevention p and gaining future co-operation at all levels. Supervisory management in a one-way, results-oriented dialogue with the workforce. That the revers flow of dialogue does not occur at an equal level is a factor in acknowledging a superior-subordinate relationship. The role of the safety professional must be structured to foster and maintain a two-way flow of dialog with all members of the workforce.

Another mechanism which may provide valuable input is the on-site safet meeting. This might be chaired by the safety professional in isolation from supervisory management. If the safety professional has maintained a posture aloof from supervision, this may improve communication with the workforce an remove barriers toward topics which may otherwise remain suppressed.

2. Rehabilitation-Oriented Industrial Hygiene Programme

Industrial hygiene is defined by the American Industrial Hygiene Association as the

> "science and art devoted to the recognition, evaluation and control of those environmental factors or stresses, arising in or from the workplace, which may cause sickness, impaired health and well-being or significant discomfort or inefficiency among workmen or among the citizens of a community".

This unique field encompasses many disciplines, including engineering, hemistry and elements of medicine and toxicology.

Rehabilitation poses special challenges to the industrial hygienist, who ormally works in a well-defined production facility. In the latter case con aminants are usually characterized from studies of normal process chemistry. The situation at the site of a chemical incident is, however, vastly dif- erent; since the identity, quantity and distribution of the contaminants ay be totally unknown.

2.1 Recognition

The foundation of an effective industrial hygiene program is comprehen- ive knowledge about the contaminants. These data provide the basis for electing appropriate analytical methods for detection and monitoring, ffective engineering controls, personnel protective equipment and a program f medical surveillance.

hazardous materials, including oil and hazardous wastes. In addition, it al provides advice concerning prevention, assessment, containment, control, clean-up, restoration, removal and disposal of these materials. Training courses designed for members of both government and industry are also offere In addition to providing a response capability, the ERT is also mandated to plan, organize, co-ordinate, implement, and direct a national alerting system to provide rapid dissemination of information on personal safety and hazard assessment to protect public health and personnel during environmental emergency activities (Lafornara and Dorrler, 1980).

Often the information amassed from the preceding sources is sufficient identify and quantify the substances present at the site. There are, howeve as mentioned, situations in which the identity of the contaminants is unknow prior to initial entry. The latter circumstance necessitates considerable advance planning in order to ensure the health and safety of personnel making the initial entry into the site.

The most extensive material written to date on the subject of personnel entry into uncharacterized sites of chemical incidents has been prepared by the Office of Emergency and Remedial Response of the Hazardous Response Support Division, United States Environmental Protection Agency. The document, Interim Standard Operating Safety Guides, Revised, September, 1982 is unpublished but is employed as a reference during the training cours given by the EPA. Much of the material discussed in subsequent sections was inspired by ideas expressed in this document (EPA, 1982) and portions are reprduced in appendixes A and B to this Section.

2.2 Evaluation

Evaluation of the hazards posed by contaminants present at the site will vary in complexity depending upon a number of factors, such as the knowledge or ignorance of the identity of the contaminants, their physico-chemical properties, toxicological properties, degree of dispersion, ease o detection, rehabilitation process chemistry, and so on.

Sources of gases and vapours can include open pools of liquid, sludges liquid-soaked patches of soil, slicks contained on the surface of water, liquids confined under vapour suppressive barriers, and leakage from tanks, vessels, pipes or equipment. Less obvious sources can include dissolved, buried or submerged materials overlain by undisturbed surfaces. Seepage may also be present under some circumstances.

If the identity of the contaminants is known, airborne concentrat: can be determined using suitably calibrated instruments. These data ar extremely useful in formulating subsequent choice of engineering contro equipment, personnel protective equipment and decontamination requireme

If the identity of the chemical contaminants is not known, special precautions must be taken. One approach is to select a level of person protection to isolate the individual completely from respiratory or ski contact with contaminants. Initial determination of sources of gases a vapours is made using broad spectrum instruments. The latter are respo gases, vapours and particulates detected at the perimeter of the site. Subsequent on-going data are used to evaluate the appropriateness of t perimeter boundary and to confirm that doses received by the public ar acceptable limits.

The evaluation process should consolidate the previously mentione factors and consider the potential for exposure of two groups: personn working at the site and the public. Workers at the site, although ver to the source of emission of gases, vapours and aerosols receive the b of considerable training in hazard awareness and the protection offere engineering controls and personnel protective equipment. The public i dependent upon the safe conduct of affairs at the site for its first l protection. Its second is the presence of an adequate exclusion zone, which the concentration of contaminants should be below accepted publ: standards for continuous exposure. The third line of defence against exposure is evacuation, a costly, disruptive and demoralizing activit

The program to evaluate site hazards must address these concerns provide adequate response to them.

2.2.1 Background Surveys

The issue of public health and the needs of the rehabilitation p: are addressed initially by conducting a background survey at points s. ing the contaminated area. Data collected upwind from the contaminan plume are used to establish baseline levels. These provide a standar: which all other data can be compared. This reference is used to esta: ultimate success of the endeavour (Turpin, 1983a

Resources from which the required data are obtained may be numerous. The extent to which information must be pursue is a function of the type of incident and the complexity of rehabilitati Potentially the most complete knowledge about the contaminants, their normal and extraordinary chemistry, and methods for safe handling and containment resides with the ufacturer. The greater the dispersal into the anthropomorphic and natur environments, the less that is likely to be known about the identity of contaminants.

The process of recognition begins with acquisition of data concerni contaminants likely to be present at the site. Possible sources of info ation can include technical and medical staff employed by the manufactur shipper's records, trade groups, and emergency response organizations sp sored by industry or contained within governments.

There is a growing body of computerized information available throu trade associations and response groups which may be extremely relevant t this investigation. Some of the previously mentioned information may be available through these services. For example the Canadian Chemical Producers' Association which created the firs tr portation accident response group, provides both telephone and one-scene assistance, as needed*. In the United States both the Co Guard (marine or marine-oriented mishaps) and the Chemical Manufacturer' Association operate 24-hour emergency response centres and also provide formation and on-scene assistance. The Coast Guard centre provides both information system and hazard assessment computer system. The latter ca ates dispersion data for minimizing both flammable and toxic hazards (C and Zercher, 1980). Similar efforts are underway in other jurisdictions.

The Environmental Protection Agency in the United States has also established an Environmental Response Team. This group acts as a focal to offer technical assistance during emergency episodes involving toxic

* See General reference E 4.

Data collected downwind from the source of the contaminant plume are used in conjunction with standards for continuous exposure to establish exclusion limits for the public. Perimeter monitoring is an on-going process since wind direction is not constant. In addition, activities undertaken during rehabilitation are likely to disturb the quiescent status of the contaminants, thereby producing considerable increases in the concentration gases and vapours.

Samples are taken at ground level to identify "hot spots" and also in the breathing zone. The identity of individual components of the gas or vapour can be determined by collecting samples using various media and portable pumps, followed by investigative analysis.

Deposited substances including solid materials can become airborne as aerosols, either particulate or liquid phase, due to the action of wind or falling water. The presence of these contaminants can be assessed initially by the use of portable real-time aerosol monitors. Subsequent air sampling employing cassettes containing suitable filtration media coupled to portable air sampling pumps is used to gain specific information about the identity and concentration of individual contaminants.

Under certain conditions explosive mixtures of gases and vapours may be generated. Occurring simultaneously is the possibility of oxygen deficiency. These conditions are likely to develop in areas in which barriers hinder the normal dispersive action of wind. Examples of such conditions include confined spaces such as tanks, vessels, ships' holds, boxcars, silos, poorly ventilated spaces in buildings, sumps, sewers, culver and natural formations such as gulleys, trenches and caves. Caution is required when entering and surveying any area suspected of possessing these atmospheric conditions.

Tests for explosive gases are important (Weitzman and Jones 1981) but because lack of oxygen may be the only hazard, a specific test for oxygen in the air must also be used. If readings exceed 10% of the Lower Explosive Limit, extreme caution should be exercised. The investigators should leave the area and obtain expert advice if readings approach or exceed 25% of the LEL (Weitzman and Jonas, 1981).

The broad spectrum air monitoring instruments employed during in surveys are insensitive to nonvolatile solids and liquids, as well as several gases and vapours. In situations in which the identity of co ants is not known, air sampling should be supplemented by collection bulk samples of contaminated soils, liquids, sludges, solids, floatin liquids, flowing and stagnant waters, seepage and sediments. Sample leaves and grasses can provide valuable information ab surface contamination.

Additional useful information about the site can be obtained fro visual observation. Abnormal growth of vegetation may indicate surfa deposition or subsurface contamination. Castings from animal burrows easy access to subsurface soils. Labels situated on containers provi information about possible contents.

Conditions likely to produce contamination of subsequent investi due to splashing, contact with unconfined liquids, sludges or solids, so on, should be noted so that appropriate corrective action can be un taken.

As an outcome of the initial survey, a comprehensive map should prepared. The latter should locate all pertinent geographic formatio man-made structures present on the site. The sketch should also outl location and potency of "hot spots" as well as the boundaries and rel magnitude of airborne and land or water-based contaminant plumes. Lo of explosive or oxygen-deficient atmospheres should also be noted.

Data collected by broad-spectrum air monitoring and that arising the various sampling techniques provides the initial input to process and dispersion modellers, as well as occupational health and safety p fessionals. In the latter case the information should be sufficientl detailed to justify selection of the level of personnel protection n during subsequent entry.

In certain situations a large number of chemicals is distribute out the site in unpredictable fashion. The identity of all possible nants, therefore, may not be ascertained following even extensive co and analysis of surface samples. In these cases further investigati required before appropriate remedial measures can be selected by pro planners or the requirements of the occupational health and safety pr can be defined. Exploration techniques such as drilling depth ...

radar, earth resistivity, bathymetry, magnetometry and others may be utilize Garrett and Jerue, 1983; Lord et al., 1980). The logistics of this operati must be planned carefully since equipment employed may provide a source of ignition to explosive mixtures. In addition, disruptive activities such as drilling may expose the operators to toxic materials not identified previously (Franconeri and Spear, 1980).

Where appropriate, additional air monitoring should be considered in order to establish a concentration profile of gases and vapours under different atmospheric conditions. Suitable locations include areas either knc or suspected of being "hot spots" (Turpin, 1983a). Since the concentration contaminants is influenced by such atmospheric factors as wind speed and direction, temperature, rainfall, snow cover and possibly cloud cover, considerable variation is likely to occur at a given location. Multiple determinations are required to provide a satisfactory level of confidence about the data.

2.2.2 Routes of Exposure

Toxic substances and hazardous conditions are likely to be encountered by anyone entering the environs of a chemical incident. The toxicological properties of contaminants are the determinants which govern the effects of these exposures upon the unprotected human organism. Toxic substances ente the body by inhalation, ingestion and absorption through broken, or in some cases, intact skin. They may also be destructive to the skin.

These substances exhale from the ground or become airborne due to site activity. Some examples are: earthmoving, excavation, demolition, bulking of materials, dredging, skimming, spraying, pumping, abrasive or other blasting and high pressure water cleaning, to name a few. The degree to which the status quo is disturbed influences the potential for worker exposure to airborne contaminants. Liquids' handling exposes the skin throu splashing or immersion. Following sufficient intake by absorption or inhalation, substances may cause various effects up to and including death.

Rehabilitation workers are likely to come into close proximity to sources of toxic materials under controlled conditions. The magnitude of unexpected releases of material should be considerably less than those encountered during the emergency. Examples of such situations include loss of containment in systems handling liquids, gases or vapours, entry into confined spaces, bulking operations, suspension of particulate matter caused by abrasive or explosive blasting, demolition, or high pressure water clea additional acute exposure may occur due to splashing or immersion durir liquids' handling.

2.2.3 Hygienic Standards

Hygienic standards adopted in many jurisdictions are based upon t Threshold Limit Values (TLVs) recommended by the American Conference o Governmental Industrial Hygienists and contained in "TLVs, Threshold L Values for Chemical Substances in Workroom Air Adopted by ACGIH for 19 from which the following quotations are abstracted (ACGIH, 1983).

> "Threshold Limit Values refer to airborne concentrations of contaminants and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect". TLVs have been established to provide "protection against impairment of health" or "reasonable freedom from irritation, narcosis, nuisance or other forms of stress". They are recommendations and should be u d as guidelines for good practice" and "should not be used s fine lines between sa e and dangerous concentrations". "These limits are intended for use in the practice of industrial hygiene and should be interpreted and applied only by a person trained in this discipline".

Three categories of TLVs are specified.

<u>Threshold Limit Value - Time Weighted Average (TLV-TWA)</u> is the

"time weighted average concentrations for a normal 8-hour workday and 40-hour work week".

<u>Threshold Limit Value - Short Term Exposure Limit (TLV-STEL)</u> is t

> "maximum concentration to which workers can be exposed for a period up to 15 minutes continuously without suffering from irritation, chronic or irreversible tissue change or narcosis

of sufficient degree to increase accident proneness, impair self-rescue or materially reduce work efficiency". The TWA-STEL is a 15 minute time-weighted average which should not be exceeded; it may be experienced for no more than four exposures per day, each separated by a minimum period of 60 minutes, provided that the daily TLV-TWA also is not exceeded . The TLV-STEL is not a separate independent exposure limit.

Threshold Limit Value-Ceiling (TLV-C) is the "concentration that shoul not be exceeded even instantaneously".

If any of the three TLVs is exceeded, a potential hazard from that substance is presumed to exist.

Certain substances are designated "Skin" to refer to the:

"potential contribution to overall exposure via the cutaneous route which includes mucous membranes, and eyes, either by airborne or more particularly by direct contact with the substance".

Mixtures of airborne gases or vapours require special consideration.

When two or more hazardous substances which act upon the same organ system are present, their combined effect rather than that of either individually should be given primary consideration. In the absence of information to the contrary, the effects of the different hazards should be considered as additive. Exceptions may be when there is good reason to believe that the chief effects of the different harmful substances are independent, as when purely local effects in different organs of the body are produced by various components of the mixture".

ACGIH also lists substances in industrial use known to be carcinogeni to man, or to have induced cancer in experimental animals. Carcinogens listed are those for which a TLV has been assigned and also those for w environmental conditions have not been sufficiently defined to assign TLV". Those substances in the latter group are subdivided further.

Group 1 No exposure or contact by any route - "respiratory, skin oral, as detected by the most sensitive methods - shall be permitted". Under such circumstances the rehabilitation worker should be properly equipped to ensure virtually no contact with the carginogen.

Group 2 Worker exposure by all routes should be "carefully contr to levels consistent with data arising from animal and human experience ACGIH also states the criteria by which a substance is judged to qualif as a carcinogen in experimental animals.

Threshold Limit Values have been prepared for approximately 7(ai borne chemical contaminants, and several physical agents. They do not however, for most of the thousands of chemicals presently known or in u Some toxicological data are available through various computerized data which may be adequate permit specialists to propose a criterion for human exposure during the rehabilitation process. Under these circumstances safety factors shoul applied.

The ACGIH also defines Biologic Limit Values in the TLV booklet. values

> "represent limiting amounts of substances (or their effects) to which the worker may be exposed without hazard to health or well-being as determined in <u>his</u> tissues and fluids or in <u>his</u> exhaled breath".

The biologic limits may be used as an adjunct to the TLVs for air or in place of them. Measurement of exposure may be made by analysis the amount of substance or its metabolites present in body tissues and fluids, hair, nails, blood and urine or exhaled breath. Individual se tivity can be estimated biochemically from changes in activity of a cr enzyme or some critical biochemical constituent or physiological funct

Measurement of these responses can provide a superior estimate of the physiological status of the worker.

An indirect determination of the effect of the substance on the body can be made by measuring tissue or organ function. The specific concentrat indicating excessive buildup of contaminants or metabolites within the body is not known with any certainty. In addition, the kinetics of accumulation and elimination must be established. Sampling should be undertaken at or beyond the point in time at which an equilibrium concentration is expected. Care must be exercised in collecting the data, since the kinetics influence the interpretation (Klaasen, 1980, Soule, 1978).

Little or no toxicological data exist, however, for many thousands of compounds. This would suggest that the derivation and application of a criterion for human exposure is, at best, based on guesswork.

The appropriate response of the health and safety professional, then, is to design rehabilitative operations and work practices which , to the maximum extent possible, err on the side of safety.

2.3 Procedural Reviews

Once the strategy for rehabilitation has been selected, process plann undertake next to produce detailed worksite procedures for carrying out th project. These should receive careful review by occupational health and safety professionals. Aside from faulty or poorly designed equipment, ill conceived operational and maintenance procedures are the main cause of emp exposure to chemical and physical hazards.

All procedures should cite appropriate reference material in the even that future justification of feasibility is required. This documentation should also identify availability of additional resources such as consultants. Requirements for personnel protective equipment should be specified Procedures should be prepared and reviewed for clarity (Dalton and Dalton, 1980).

Hazards unrelated to those caused by exposure to the chemical con nants or process chemicals, such as noise or vibration, are often inh in the operation of construction or process equipment. These should overlooked, despite the natural inclination to devote attention to th chemical contaminants.

Activities conducted in areas of contamination should be restric rehabilitation practices or precedures. Those unrelated to the rehab should not be permitted unless absolutely necessary. This policy eli unnecessary interaction between contaminants, and processes employed peripheral activity. A second benefit of this policy is reduced cont of personnel and equipment.

All procedures should be field tested prior to utilization withi rehabilitation site. This permits the operators the opportunity to g familiarity with the equipment and to encounter any difficulties inhe in its operation. For example, the use of personnel protective equip may compromise safe operation. While affording protection to the wea against a hostile environment, this equipment is often bulky, thus te to reduce manual dexterity. These practice sessions permit review an appraisal by occupational health and safety professionals. As a resu review may identify an ergonomic problem associated with operation of equipment, which can be corrected prior to its utilization inside th

In situations in which explosive atmospheres may develop, speci siderations are required. An example is the use of gasoline or dies powered excavating equipment. Disturbing the soil could release tra gases or vapours. One solution is the use of continuous monitoring explosive mixtures (Muller et al., 1983). Where possible, explo on or nonsparking tools and equipment should be specified (Weitzman and 1981). Another such situation occurs during exploratory drilling. could release pockets of gas (Franconeri and Spear, 1982). Continuo monitoring for explosive mixtures should also be contemplated in this stance.