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DEVELOPING INTEGRATED BENCHMARKS FOR DOE PERFORMANCE MEASUREMENT

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DISCLAIMER

FIGURE ES-1
DATA BASE TYPES BY
PERFORMANCE ASSESSMENT CATEGORY (PAC) AND
PERFORMANCE ASSESSMENT FACTOR (PAF)

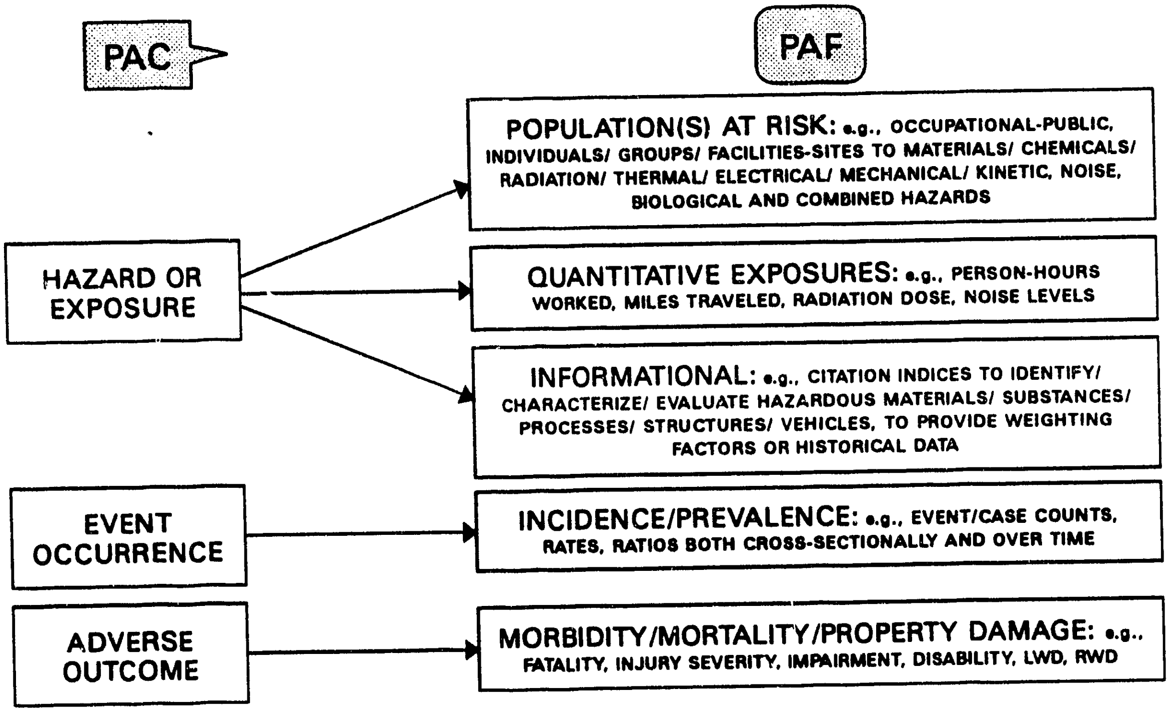
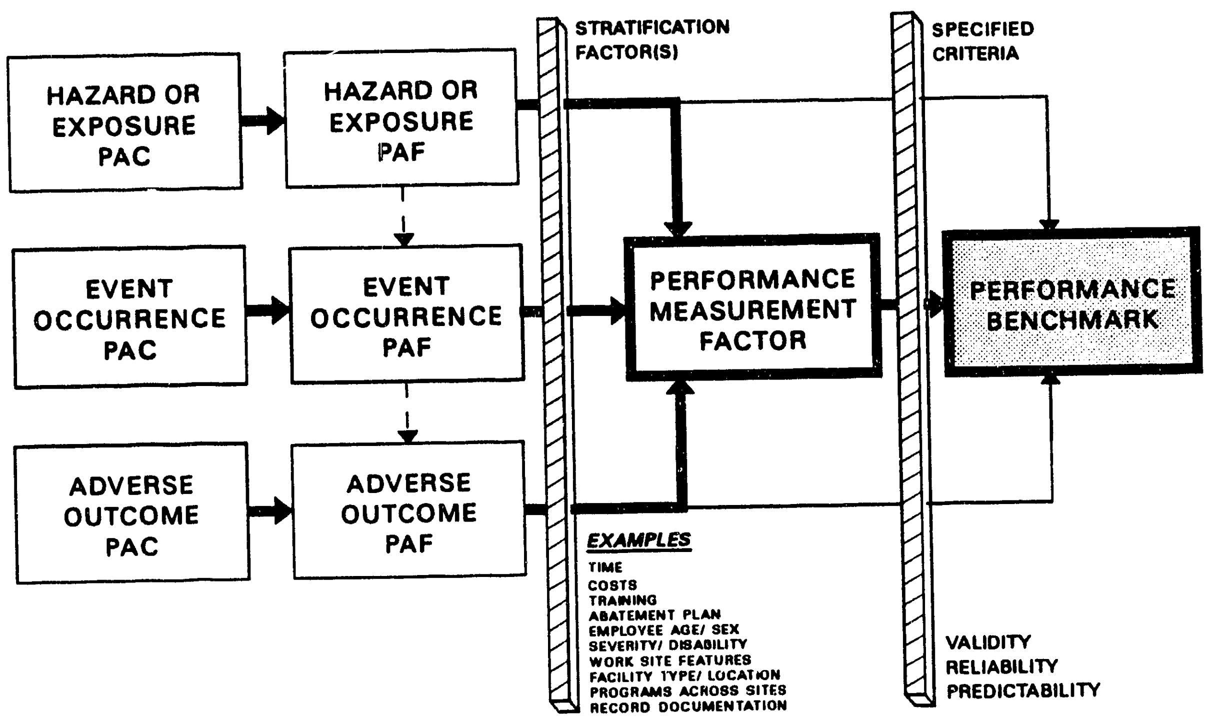


FIGURE ES-2
GENERIC PROCESS FOR OBTAINING PERFORMANCE BENCHMARKS



EXECUTIVE SUMMARY

The objectives of this task were to describe and evaluate selected existing sources of information on occupational safety and health with emphasis on hazard and exposure assessment, abatement, training, reporting, and control identifying for exposure and outcome in preparation for developing DOE performance benchmarks. Existing resources and methodologies were assessed for their potential use as practical performance benchmarks. Strengths and limitations of current data resources were identified. Guidelines were outlined for developing new or improved performance factors, which then could become the basis for selecting performance benchmarks. Data bases for non-DOE comparison populations were identified so that DOE performance could be assessed relative to non-DOE occupational and industrial groups. Systems approaches were described which can be used to link hazards and exposure, event occurrence, and adverse outcome factors, as needed to generate valid, reliable, and predictive performance benchmarks.

Data bases were identified which contain information relevant to one or more performance assessment categories (Figure ES-1). Data from the hazard-exposure, occurrence and outcome categories can be used individually or combined to create performance measurement factors (Figure ES-2). Where appropriate, performance stratification factors can be selected to identify more specific risk categories for such purposes as defining weighting factors for analytic models. Potential candidates for the final benchmarks used to assess DOE performance would be derived from selected performance measurement and assessment factors.

A list of 72 potential performance benchmarks was prepared to illustrate the kinds of information that can be produced through a benchmark development program. These benchmark examples are classified by appropriate assessment categories, data sources, and benefit to the DOE system. The benchmarks are also classified by the following groups: safety program implementation and conformance, exposure, event occurrence, property loss, and occupational injury and illness.

Current information resources which may be used to develop potential performance benchmarks are limited. Certain performance measurement factors are available for all DOE facilities through SPMS or ORPS, although they would be restricted in their use as performance benchmarks. Since CAIRS is now identical to OSHA in its definition of reportable cases, the concerns of the National Academy of Sciences (NAS) with respect to OSHA's measurement of occupational injuries and illnesses also apply to CAIRS. Performance benchmarks should be consistent with NAS recommendations and must meet established predefined criteria for validity, reliability, and predictability.

There is need to develop an occupational safety and health information and data system in DOE, which is capable of incorporating demonstrated and documented performance benchmarks prior to, or concurrent with the development of hardware and software. One approach would dovetail a centralized information system with a distributed network, similar to a BNL technology transfer initiative with the private industrial sector. A key to the success of this systems approach is rigorous development and demonstration of performance benchmark equivalents to users of such data before system hardware and software commitments are institutionalized. Performance measurement efforts at DOE could be "jump started" by implementing an Integrated Performance Benchmark Development Program, as recommended in this report.

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ABBREVIATIONS & ACRONYMS

AIS 85 EM - Abbreviated Injury Scale 1985 Revision with Epidemiological Modifications

AIS - Abbreviated Injury Scale

BLS - Bureau of Labor Statistics

BNL - Brookhaven National Laboratory

CAIRS - Computerized Accident/Investigation Reporting System

CHEMS - Chemical Hazard Emergency Management System

dBA - Decibels

DOD - Department of Defense

DOE - Department of Energy

EH - Environmental Health

EM - Epidemiologic Modifications

FECA - Federal Employees Compensation Act

FRASE - Factor Relationship and Sequence of Events

FTE - Full Time Equivalent

FWP - Field Work Proposal

GAO - General Accounting Office

ICD - International Classification of Disease

ICD-9-CM - International Classification of Diseases, 9th Revision, with Clinical Modifications

IPAG - Injury Prevention and Analysis Group

LWC - Lost Work Day Cases

LWD - Lost Work Days

NAS - National Academy of Sciences

NCHS - National Center for Health Statistics

NEISS - The National Electronic Injury Surveillance System

NFS - Not Further Specified

NHIS - National Health Interview Survey

NIOSH - National Occupational Exposure Survey

NJCHS - National Joint Committee on Health and Safety

NSC - National Safety Council

ORPS - Occurrence Reporting and Processing System

OSH - Occupational Safety and Health

OSHA - Occupational Safety and Health Administration

OTA - Office of Technology Assessment

PAC - Performance Assessment Categories

PAF - Performance Assessment Factor

PAH - Polycyclic Aromatic Hydrocarbons

PB - Performance Benchmark

PMF - Performance Measurement Factor

PSF - Performance Stratification Factors

RAC - Risk Assessment Code

REM - Radiation Exposure Module

RWD - Restricted Work Days

SEER - Surveillance, Epidemiology and End Results Program

SIC - Standard Industrial Classification Codes

SPMS - Safety Performance Measurement System

UAW - United Auto Workers

UOR - Unusual Occurrence Report

WC - Workers' Compensation

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I. INTRODUCTION

The Office of Environment, Safety and Health (EH) has identified a need for an occupational safety and health information system with a focus on performance measurement through exposure/occurrence/outcome (i.e., anticipation/risk/consequence) assessment and control. This system is expected to serve a number of functions for DOE and DOE contractor management. Two major functions are: (1) to serve as a management decision making tool for preventing or minimizing human, vehicle/transportation or property damage and (2) to determine how well line programs in hazard identification, abatement and control are performing throughout the DOE contractor system.

Ensuring that a safe and healthy workplace is provided for all DOE and DOE contractor employees, collaborators and visitors is a primary objective of EH. EH has identified the need to develop integrated performance benchmarks (PB) derived from hazard-exposure/occurrence/outcome measurements to fulfill their compliance and oversight responsibilities.

An integrated PB development program will enable EH to determine the efficacy of facility and programmatic safety and health policies and practices based on currently available data resources and to identify resources and approaches needed to develop additional benchmarks. These PBs are required to: 1) provide a safe and healthy working environment; 2) assure protection of the work environment; 3) protect the public safety and health; 4) protect public and private property against loss and/or damage, and 5) assure that DOE and its contractors are in compliance with applicable laws, orders, and regulations related to protecting the environment and assuring worker and public safety and health.

A. Overall Purpose

The overall purpose of this project is to identify and classify potential performance benchmarks to serve as "tools" for measuring occupational safety and health compliance beginning at the facility and program level with the capability to aggregate the data consistently across sites and over time as needed for compliance and oversight by area/regional/headquarters management. These "tools" (i.e., potential PBs) in turn would be capable of assisting management at all levels, including line supervisors at contractor facilities, to comply with orders and regulations. These PBs would provide guidance in establishing new or modifying existing programmatic goals and objectives; setting new or modifying existing priorities; identifying the type, frequency, and severity of hazardous exposure; and ameliorating human, vehicle/transportation, and property damage through integrated prevention, control, compliance, and oversight activities. This will be accomplished by describing and evaluating existing sources of information on occupational safety and health, categorized by exposure, occurrence, and outcome, as needed to develop integrated DOE performance benchmarks.

B. Specific Objectives

The specific objectives of this task are to: (1) assess the adequacy of existing methods, data bases, and analytic models for measuring exposure/occurrence/ outcomes for generating valid, reliable, and predictive performance benchmarks; (2) outline the strengths and limitations of current data resources for use as performance measurement factors; (3) assist in developing criteria and guidelines for new or improved performance benchmarks based on exposure/occurrence/outcome factors and measurements; (4) assist in enhancing current and developing future performance benchmarks using exposure/occurrence/outcome measurements which are representative of all DOE contract workers (i.e., non-nuclear and nuclear); (5) identify data bases that can provide comparable information on DOE and similar non-DOE worker populations; and, (6) identify systems approaches that can link hazardous exposures and event occurrence to adverse outcomes in preparation for developing predictive performance benchmarks (Figure 1).

C. Topic Selection

Previous efforts to develop performance benchmarks and evaluate performance have focused primarily on single event analysis, such as fault tree analysis or cluster analysis of specific events (1,2). Presently, most occupational safety and health monitoring systems in the U.S. utilize information from the Occupational Safety and Health Administrations (OSHA) reporting forms (3). Any industry or business employing more than 10 persons is required by law to meet OSHA workplace reporting regulations, which includes reporting events which fall within OSHA reporting requirements. DOE through CAIRS must also comply with OSHA rules and regulations (4).

The topics discussed in this document have been selected based on the collective experience of the Injury Prevention and Analysis Group (IPAG) at Brookhaven National Laboratory (BNL) and its predecessor groups in designing, developing, collecting, maintaining, and analyzing large scale complex data bases from a systems perspective. The IPAG focus has been on examining the correlation between hazards/exposures and damage factors, such as the association between transportation hazards and their adverse effects with emphasis on proactive strategies for intervention prior to event occurrence. This document is not intended to be an exhaustive treatise of these topics; instead it is designed to touch on a number of the important topics that can influence system safety and health, mainly from a "bottom line" point of view. For example, do current and proposed occupational safety and health program components contribute to a reduction in human vehicle/transportation, and property damage? Do they contribute equally? If not, which components are most and least effective? Thus, the document is designed to provide DOE management with an overall sense of current exposure/occurrence/outcome information and additional factors needed to develop valid and reliable "tools" for performance measurement with defined, documented and empirically tested capabilities, prior to system-wide implementation. The ensuing discussion addresses a broad range of topics, each one of which could be the subject of a textbook length report.

II. RELATIONSHIP OF OCCUPATIONAL SAFETY AND HEALTH PROGRAM TO PERFORMANCE BENCHMARKS

Draft Order 5483.XX establishes standards that are intended for all contractors, irrespective of facility characteristics, such as size, type or location (5). Major elements of the program that have relevance to performance measurement are reviewed below.

A. Major Program Units

The DOE occupational safety and health program is organized in six major program units: assessment, hazard abatement, management training, record keeping and reporting, risk prioritization and variances. The assessment program is designed to evaluate and control known or potential hazards mainly through self and independent evaluative tasks. The hazard abatement and management training programs are designed to collect, analyze and use hazard related information to mitigate or eliminate a hazard with procedures utilizing abatement logs and plans. The training program is an integral part of the overall initiative required to implement an effective occupational safety and health program, to develop an awareness of personal safety in a work environment, to encourage communications among managers, supervisors and employees in a constructive manner, and to promote involvement and participation in safety and health activities at all organizational levels within and among sites. Record keeping and reporting are the same or more stringent than those meeting OSHA requirements; thus they are subject to similar qualifications regarding operational definitions, especially those related to occupational injury diagnoses and classification. The risk assessment methodology provides a mechanism for measuring selected relative risk factors quantitatively and for establishing abatement priorities based on a probabilistic approach. These risk assessment guidelines provide a first order framework for the development of outcome, "bottom-line" type measures of performance and are important concepts to include in a performance benchmark development process. The subject of variances will not be addressed in this document.

B. Programmatic Objectives and Performance Measurement Needs

Performance benchmarks are needed by line management to carry out conformance, compliance and oversight responsibilities. There is need to assure objective performance criteria in preparation for: (a) selecting valid, reliable and predictable benchmarks, (b) conducting annual program reviews, (c) establishing baseline information on work sites through routine surveillance, (d) inspection and independent assessments, (e) monitoring hazard abatement logs and plans, and (f) determining if correlations can be demonstrated between logs, plans and corrective actions taken to mitigate or eliminate identified hazards.

Program objectives related to performance measurement include developing countermeasure plans to mitigate against incident/injury/illness by such procedures as measuring trends and conformance or non-conformance. In particular there is need to identify both negative and positive changes in trends with a view toward understanding the nature and magnitude of each. In the past attention has been paid more to trends indicating an increase in event occurrences or adverse outcomes, such as spills, fires or injuries. Performance benchmarks are designed to identify outliers in both directions because it is as important to identify and explain what is going right as well as what is going wrong in an organization. Trend analysis for hazard assessment, abatement, recordkeeping and reporting, employee and supervisor training, and program performance are all important performance assessment categories (PAC). Information for performance analysis and management include: hazard identification; work site surveillance; root cause analysis; tracking and reporting data on hazards and on human, vehicle/transportation and property damage; prioritization by hazard severity; initiation of corrective actions; and verification of corrective action effectiveness.

There is also a need to evaluate measurement methods that will allow the identification of elevated and declining safety levels by measurement of hazard occurrence and outcome factors. There is a particular need to demonstrate any direct correlation between hazard prevention and control and event occurrence and adverse outcomes as defined by human, vehicle /transportation and property damage. With regard to hazard prevention and control there is need to detect, correct, and mitigate existing or potential hazards, using engineering controls wherever a hazard is amenable to engineering and technology intervention. This approach should be considered prior to other abatement procedures, such as use of personal protective equipment, administrative controls, or work procedure changes.

Perhaps the most important part of the overall occupational safety and health initiative is the self-evaluation and verification component of the assessment program at the site level. Implementing a comprehensive self-evaluation program is a complex logistical operation at a facility, which requires considerable planning if it is to be effective. Methodology for measuring performance is currently limited to process compliance (e.g., How many employees attended a fire hazard identification or safety training course? Did these employees take a before-after test on course content? What proportion passed the test?). However, self-evaluation must extend beyond process compliance and address the measurement of outcome performance (e.g., change in the frequency of fires at a site before and after self-evaluation). For example, data on reportable individual incidents and occupational injury/illness are prepared for submission to SPMS on form 5484.XX. The data are usually prepared by safety personnel after investigation of an incident. The employee's supervisor is now required to participate in the investigative procedure. Supervisor involvement is potentially an optimal method of verifying data on a particular injury/illness event as prepared by safety personnel, the involved employee and medical personnel. Therefore, it is an important aspect of any performance benchmark development program.

Documentation and consistency of reporting hazard assessments can vary both within and among facilities. Consistency issues will be raised if common protocols for data acquisition and maintenance are not developed for implementation at the individual incident reporting level with verification at the same level if at all possible. Supervisor involvement has the potential to solve this major issue in a constructive manner because it includes the individuals who can most directly contribute to hazard identification, assessment, and abatement. In this manner the concepts of anticipation and pro-action can begin to replace reaction or incident response type approaches to safety. The interchange between a supervisor and an injured employee, for example, can be beneficial in preventing reoccurrence of damaging events, though it can be difficult to quantify without systematic development of performance benchmarks. Thus, coordination of data reporting and recording functions at the individual and contractor level are needed to produce the performance measurement factors required for comparative assessments among facilities and through time.

III. PREVENTION, CONTROL, AND EVALUATION OF HAZARDS IN DOE CONTRACTOR WORK ENVIRONMENTS

It is important that DOE be aware of any exposures or occurrences that could: (a) inadvertently affect the safety and health of DOE contractors and the public; (b) have an adverse environmental effect; (c) impair operations of DOE facilities; and/or (d) result in vehicle/transportation or property loss or damage. It is important that methodologies be developed, piloted and evaluated which enable timely identification of all hazards and potential hazards in order to assess their significance and implement abatement and control actions (5).

DOE Draft Order 5483.XX describes hazard identification, evaluation and mitigation as a line management responsibility. However, training of managers and supervisors needs to be done in such a way that courses and materials are standardized within and among facilities. Failure of managers and supervisors to be aware of hazards and their adverse effects is a sign that occupational safety and health (OSH) training, policies and/or practices as directed through line management involvement are out of compliance.

A comprehensive OSH program should be able to identify existing OSH hazards, anticipate potential hazards, and implement hazard abatement policies in a timely and effective manner. Hazard elimination or mitigation can be accomplished through the application of (a) engineering control techniques; (b) safe work practices and procedures; (c) safety communications and training of all employees; (d) appropriate use of personal protective equipment; (e) administrative controls such as reducing exposure to hazards; and, (f) various combinations of man-machine/equipment/work/environment linkages (6,7). Tools needed to develop efficacious PBs to measure the effectiveness of these programs are discussed in this report.

DOE occupational safety programs are based on comprehensive and coordinated efforts which include "fire protection/prevention, life safety, industrial safety, construction safety, pressure vessel safety, electrical safety, explosives safety, firearms safety, mine and tunnel safety, performance assessment, and safety analysis" (5). DOE occupational health programs are based on comprehensive and coordinated efforts which include "industrial hygiene, occupational medicine, worker health surveillance, and epidemiology" (5). The primary focus of this report is occupational safety although the investigators fully recognize the complementary nature of the safety and health components of comprehensive programs.

A. Evaluation and Control Issues

A first step in the evaluative process is related to clearly defining all activities in a safety and health program which require management input in order to assist in implementing safe work practices. These include hiring and selection, standardized training of supervisors and other staff, safety meetings, job analysis, job observation, and engineering controls. The next step is to develop methods and procedures to quantify the level of management effort required, such as standardized testing and consistency in documentation. For example, to comply with DOE orders and regulations on hazard abatement and control, DOE has requested that line supervisors fill out a report on all injury/illness producing events. By checking all first encounter cases for occupational injury/illness and comparing those with supervisor investigation reports, it can be determined if the investigation rate equals the occurrence rate and what if any discrepancies in rates are identified. This would enable DOE management to determine the effectiveness of a proactive program with emphasis on line management and supervisor responsibility in hazard assessment, abatement and training.

B. Hazard Assessment and Abatement

A major objective of the DOE program is to convert the DOE contractor culture to a proactive, anticipatory approach from a reactive, incident response approach. Thus, the emphasis on hazard assessment and abatement must be on risk prevention or amelioration prior to the occurrence of an event that can cause adverse outcomes (i.e. Pre-Event Phase).

1. Pre-Event Phase

DOE contractor facilities may have numerous hazards which have a potential for personal harm and/or property damage. For example, equipment wears out with time, even under the best of circumstances (6). Therefore, hazardous conditions need to be regularly identified and rectified. A preventive maintenance program aimed at negating equipment problems can only be accomplished by a hazard abatement program which includes systematic inspection, documentation, and preventive or ameliorative planning. The program should include: routine inspections and documentation on pressurized equipment (e.g., boilers, pipes), storage containers, flammable and toxic materials, building and structural integrity, atmospheric conditions (e.g., dust, gases, fumes), electrical apparatus, mechanical equipment, power and hand tools, safety equipment (e.g., fire extinguisher, sprinkler systems), structural openings, vehicles, and personal protective equipment. Such an inspection process is essential to identify potential hazards, mitigate known hazards, and to rectify problems prior to human, vehicle/transportation, and property damage.

Assessment and abatement activities are generally documented through the use of hard copy logs maintained on a regular basis. However, there is need to computerize the entire process of abatement log maintenance to (a) assure systematic documentation, preferably on a regular basis, so that the information can used to document abatement plan compliance and (b) link with other safety and health program components (e.g., training and event occurrence reporting). Based on IPAG discussions with safety coordinators, computerization would allow coordinators in research, production, maintenance or other areas to perform their jobs much more effectively by allowing them to organize, maintain and analyze local data promptly and to follow-up on abatement compliance systematically.

One essential tool for identification, assessment, and abatement of hazards in the workplace is "job and job safety analysis" (6). This is accomplished by determining the specific job to be analyzed, breaking down the job into sequential steps, determining key factors related to each step, and performing an "efficiency" check. Initiating engineering controls, establishing regular maintenance and reviewing and updating safety analyses are important aspects of such an initiative. Most hazardous conditions can be predicted or anticipated when developing work standards for facility operations using engineering controls. Inadequate guards and devices, inadequate warning systems, fire and explosion hazards, projection hazards, congestion and close clearances, hazardous atmospheric conditions, inadequate illumination and excessive noise are examples of common causes of human and property damage that can be prevented by effective engineering interventions. Safety and health personnel can assist in the control of hazards by monitoring for programmatic compliance and by conducting periodic audits with documentation of job standards (7).

2. <u>Event Occurrence Phase</u>

Safety and line/operations management specialists must be constantly alert to the needs of workers and applications of a number of principles including deflection, dilution, reinforcement, surface modifications, segregation, barricading protection, absorption, and shielding during the event phase (6). While many of these are provided by effective engineering control at the pre-event phase, some may escape system design criteria. In addition, normal wear and tear and abnormal use requires periodic repair and replacement of materials, structures, and equipment. The use of proper personal protective equipment also affords safety countermeasures during the event stage. However, to be effective, the equipment has to be appropriate for the situation and fit the employee correctly; the employee has to be properly instructed in its use; standards for equipment type and use need to be enforced; and a system has to be in place for equipment sanitation and maintenance (6,7).

Caution must be exercised in relying on personal protective equipment as a primary means of achieving employee safety. Personal protective equipment should be recognized as an important secondary approach to worker safety. Identifying and eliminating hazardous exposures, as accomplished using engineering controls and technology should be the primary focus of any effective safety and health program.

3. Post-Event/Adverse Outcome Phase

Severity of losses involving human or property damage can be minimized by applying specific countermeasures. These include definitive and immediate medical care for injured or ill employees and prompt repairs of defective equipment responsible for a damage producing event. In addition, prompt investigation and reconstruction of all circumstances associated with the event, including root cause analysis, is necessary to prevent future damage.

C. Performance Measurements

The effectiveness of safety and health programs can be measured by cause (e.g., conditions or behaviors), consequence (e.g., actual or potential loss rates), and controls (e.g., training, job analysis, engineering controls). Frequency and severity rates or ratios need to be generated for all cause-specific events, regardless of classification or type, for efficacious prevention and control. A continual effort is needed to broaden the statistical data bases to include all events related to injury/illness, property damage, environmental releases, and "near-miss" events.

D. Description of Property/Transportation Damage Problem

By DOE criteria, reportable property loss is defined as vehicle damage greater than $1000, and fire and non fire losses which result in $1000 or more in property damage. Events with losses less than these amounts do not have to be reported (2). Yet, damage cost estimates can vary within and between facilities because of such factors as regional costs and age of equipment. In order to understand the true magnitude and cumulative effects of the vehicle/transportation and property damage problem, there is need to consider measuring all vehicle/transportation and property loss/damage events regardless of cost with appropriate adjustments for regional differences.

E. Description of Overall Occupational Injury and Illness Problem

1. Definitions of Occupational Injuries and Illnesses

Occupational injury or illness determinations are made by the nature of the original event, or by the exposure causing the injury/illness and not by the resultant condition. By OSHA definitions occupational injuries result from "instantaneous events" in the work environment. "Cases resulting from anything other than instantaneous events are considered illnesses .. including acute illnesses which result from exposures of relatively short duration" (8). It is important to note that repetitive trauma disorders are classified as occupational illnesses rather than injuries and that nearly half of the reported occupational illnesses reported in 1990 were labeled as disorders associated with repetitive trauma (9).

The OSHA definitions and classifications are not universally accepted within the scientific, public health, medical, engineering, statistical, or insurance communities. OSHA definitions are not always consistent with etiologic based approaches, especially with respect to acute and repetitive trauma. One concern in particular is the administrative classification of an occupational injury by "first aid" or "medical" treatment. These classifications have been used to measure relative risk among organizations and regions, and have become a defacto performance measurement factor. This has resulted in a significant underreporting of the true magnitude of the occupational injury problem because OSHA reporting requirements exclude a significant number of injuries classified as "first aid" (10,11,12). CAIRS has the same deficiencies since its reporting requirements are patterned after OSHA.

2. Magnitude and Severity of Occupational Injury and Illness Problem

a. U.S. Overall

In the United States, injuries, as distinguished from illness and disease, are the leading cause of lost person-years of productivity for persons between the ages of 18-64 (9). Productivity losses resulting from injuries are twice those of heart disease, cancer (9), or AIDS (13). Injuries account for approximately 200 million days of work lost annually, accounting for about 1/3 of annual sick leave taken for all reasons (14).

Premature mortality and morbidity resulting from occupational exposures and hazards continue to be an important public safety and health problem (15). While fatalities associated with occupational injuries and illness have continued to decline, nonfatal injuries/illnesses "appear to be increasing". In 1989, reported work related injuries accounted for over 10,000 deaths and an estimated 1.7 million disabling injuries (9). The number or non-disabling injuries is conservatively estimated at over 13 million annually (10).

In fiscal year 1990 injured federal workers received more than 1 billion dollars in compensation for lost wages under the Federal Employees Compensation Act (FECA) (16). The NSC estimated that 1.8 million work related disabling injuries occurred nationally in 1990 and that work related injury costs based on lost wages, medical expenses, insurance administration costs, and other related indirect costs amounted to over 64 billion dollars (9). These estimates exclude non-disabling, medically attended injuries which are estimated to be at least eight times higher than the nationally reported rate (10). In sharp contrast, according to the National Safety Council (9) only 284,000 occupational illnesses were reported during the same time period. In a recent survey conducted by the RAND Institute for Civil Justice, it was determined that 48 percent of strain/sprain/pull injuries nationally are work related and that 36 percent of injured adults take sick leave because of a work related injury. Persons who miss work as a result of a work incurred injury lost an average of 32 days from work (14). These observations demonstrate that the magnitude of the occupational injury problem far surpasses that of occupational illness. It should be noted that one of the few worker representative estimates of occupational non-disabling injuries, including all injury cases classified as either "first aid" or medical, is from a DOE sponsored surveillance project (10).

The inadequacy of occupational injury/illness statistics is so serious that a panel was formed by the National Academy of Sciences (NAS) to address the problem and to make appropriate recommendations to Congress (17). In particular, they expressed concerns about the validity and reliability of reported nonfatal occupational injury/illness statistics. The two major conclusions on the NAS panel were: (1) employers were not collecting all required occupational injury and illness data and (2) "no adequate evaluation of the extent of the underreporting has been conducted". The panel made no attempt to estimate the magnitude of the underreporting of incidence because such data were not available. On occupational illnesses they wrote that "no reliable national estimates exist today, with the exception of a limited number of substance-specific studies (such as asbestos), on the level of occupational disease, cancer, disability, or deaths". They go on to say the "current systems cannot provide data that are useful for measuring the occurrence of most occupational illnesses".

b. Department of Energy

Based on the initial findings of a representative sample of occupational injuries in 10 facilities in the DOE system, conducted by Brookhaven National Laboratory's (BNL) Injury Prevention and Analysis Group (IPAG), it was estimated that in CY 1984 occupational injuries were underreported in OSHA/CAIRS statistics by a factor of eight (10) (Figure 2). In other words

OSHA/CAIRS "recordable" injuries identified only about one injury for every eight injuries that occurred, even though participating organizations were in compliance with OSHA/CAIRS requirements. It should be noted that first aid and non-medically attended injuries which are not OSHA/CAIRS "reportable" constituted a significant proportion of all lost productivity from occupational injuries. The study demonstrated that productive time lost from work for non-LWD occupational injuries nearly equalled the LWD rate, if it is assumed that the average length of time away from work as a result of an injury was approximately 40 minutes (Figure 3). Anecdotal information indicates this is a conservative estimate.

Since the participating DOE contractors represented a diverse group of industrial corporations, these observations may very well be typical of other similar corporations throughout the United States. Thus, current DOE interests in performance measurement could be beneficial, not only to DOE but to the U.S. as a whole if this analytic technology (as distinguished from hardware) is transferred to U.S. industry.

It is interesting to note the concerns expressed by DOE management in 1983 that led to the decision to initiate the task with IPAG in 1984. The DOE system-wide lost work day incidence rate for 1983 was 16% greater than in 1982 (18). DOE was concerned about whether this 16% increase reflected: (a) changes in reporting procedures introduced in 1983, (b) an actual increase in incidence, or (c) unidentified potential confounding factors. For example, such an increase could have been due to a single change in reporting from a large contractor or a complex mix of small and/or large contractors. Differences in the dates of these changes also could have further influenced the result.

c. **Brookhaven National Laboratory Studies**

BNL has conducted two facility wide occupational injury studies that are of direct relevance to the development of integrated performance benchmarks. A retrospective cross-sectional "surveillance" of occupational injuries at BNL for 1984 was followed by a longitudinal analysis of injuries for 1985-1989 in order to determine the magnitude of the occupational injury problem at BNL. These analyses were performed for all injuries irrespective of OSHA/CAIRS reporting status. The results of the cross-sectional analysis, compared to the DOE analysis, indicated that while the incidence and Lost Work Day (LWD) experience at BNL was higher at BNL than at DOE overall, the anatomic severity of injuries at BNL was less than that observed for DOE overall. This discrepancy between outcome measures (LWD and anatomic injury severity) will have important implications when it is time to choose the appropriate performance benchmarks. Also, differences in the causes and types of injuries sustained between BNL and the DOE sample indicate the importance of stratification by important factors such as job type, age and sex. The longitudinal analysis indicated that since 1984 there has been a decrease in occupational injuries overall at BNL, as well as improvements in lost productivity as measured by LWD. Another important feature of these studies was the organization and presentation of the findings in a graphical process control format as distinguished from more traditional presentations of scientific information. Thus, clinical time-trend data were presented in a format well recognized and understood by engineers, quality assurance specialists, managers and others with professional backgrounds outside of the health sciences. These studies represented a first step in the process of establishing overall safety and health performance benchmarks by integrating safety/engineering and medical/health measurement methodologies (Figure 4).

IV. ISSUES IN PERFORMANCE MEASUREMENT

Defining and measuring ideal performance benchmarks to assess EH and line management performance is a primary objective of this document. In order for performance benchmarks to be valid and reliable, parameters must be selected which can be accurately measured and which represent the performance attribute of interest. Specific problems in the use of current data bases to obtain valid and reliable performance measurements which can qualify as performance benchmarks include: (1) the need for sources of accurate and reliable data; (2) the inappropriate use of some measurements as surrogates for others; (3) discrepancies in measurements between data bases which purportedly are measuring the same thing; (4) data not currently available; (5) lack of comparable data for DOE and non-DOE facilities; and (6) development of evaluative technology that assures consistency of information and data from site-to-site and through time.

A. Operational Definitions

Integrated performance benchmarks should consist of a selected set of performance measurement factors which are shown to fully characterize the safety and health environment of DOE and its contractor facilities. Performance measurement factors are obtained as the values, counts or rates/ratios of Performance Assessment Factors (PAFs) from the exposure, occurrence and outcome Performance Assessment Categories (PACs). The exposure PAC consists of those PAFs which measure the usual exposure of workers in their normal workplace environment. The occurrence PAC consists of those measures which identify damaging or potentially damaging events to workers, vehicle/transportation, property, the public or the environment. The outcome PAC includes measures of the amount of damage sustained, either in terms of costs (e.g., property damage loss, workers compensation payments), anatomic damage to people (e.g., number and severity of injuries) or environmental damage (e.g., frequency of spills).

Performance Measurement Factors (PMFs) should consist of frequencies (counts) or ratios of data from one or two of the PACs. To obtain a ratio PMF, two types of data are required, numerator and denominator data. The numerator of the ratio PMF is usually an occurrence or outcome measure, and is defined in terms of number events of interest (e.g., number of motor vehicle collisions, spills, or persons injured) or can be in terms of costs (e.g., estimated total property damage value).

Denominator data can be defined in terms of exposure (e.g., number of hours worked, number of employees, number of miles traveled) or can be a measure from the occurrence or outcome PAF. For example, property damage cost per fire event is a ratio of outcome with occurrence data, and case-fatality ratios (number of injuries resulting in death as a proportion of all injuries) is a ratio of two outcome PMFs.

B. <u>Need for Accurate Data</u>

Most data sources concentrate on obtaining numerator data that describe occurrences or outcomes. Denominator (hazard or exposure) data is usually but not exclusively obtained from separate sources. Unless a database is being developed for a specific purpose, emphasis placed on obtaining numerator data is usually greater than that placed on obtaining denominator data. Inaccuracy or bias in either the numerator or denominator data will invalidate the PMF.

Table 1 contains a list of potential performance benchmarks which are based on PMFs from the PACs exposure, occurrence or outcome, or combinations of PMFs from two of the PACs. Some of the data needed to calculate the proposed performance benchmarks exist in either SPMS or ORPS (e.g., recordable injury counts, occupational radiation exposure), or can be obtained with relative ease from individual DOE facilities (e.g., worker population characteristics from personnel department records).

C. Inappropriate Interpretation of Measurements

Other data are available at the facility level but are subject to data gathering and storage procedures at each facility; therefore, obtaining these data for use as performance benchmarks will be more difficult under the present information system. For example, air and water quality measurements may be collected using different measurement techniques within different time frames, and the parameters measured may be different from site to site. Injury/illness data may be obtained for all medical visits from clinics at each facility, rather than only recordable incidents, but this could be a time-consuming task if medical records are not computerized. Data on workers compensation costs will vary from facility to facility based on individual state laws and procedures, making inter-facility and regional comparisons difficult at best.

A further impedance to the derivation of worthwhile integrated performance benchmarks is the fact that the data bases are not known to have been validated or tested for reliability across facilities/sites or over time.

Criteria for validation and consistency are needed using field and empirical testing prior to or parallel with the development of a new or enhanced DOE safety information system.

D. Discrepancies in Injury/Illness Measurements

The broad discrepancies in fundamental medical and surveillance measurements of nonfatal and fatal occupational injuries indicate that the nature, magnitude and consequences of these injuries and the injury producing events are inadequately understood (11,17). To a lesser degree these observations are applicable to occupational illnesses. Over the last decade, a number of prominent investigators have voiced their concern over the paucity of scientific information on work related morbidity and mortality (19-24). Similar concerns were expressed in the Office of Technology Assessment review of injuries and illnesses in the workplace (17). Most of these investigators have addressed the critical need for conducting safety and health surveillance to define occupational injury/illness morbidity both cross-sectionally and longitudinally. One of them pointed out that a shift in focus from mortality to morbidity was relatively recent (25). This first major population-based study to measure injury incidence, severity, and other outcomes concluded that mortality data cannot be used to predict morbidity (25).

Present occupational injury/illness surveillance and data collection systems are severely limited, particularly for those occupational illnesses with long latency periods, according to the Public Health Service Report "Promoting Health/Preventing Disease: Year 2000 Objectives" (15). The report goes on to say that underreporting of work related injuries and illnesses is a common problem among all data bases. There is no common definition for what constitutes a fatal occupational injury/illness. For example, a heart attack or cancer may result from single or multiple exposures in an occupational environment; yet these events may not be designated as being work related. On the other hand, an exposure may have occurred in a non-work environment, but may be attributed to a work environment. There is general agreement that the number of fatalities from occupational injuries/illness is underestimated in currently available data bases, but the extent of the undercount is unknown.

There are even larger discrepancies for nonfatal occupational injuries/illnesses. This is particularly true for injuries since the various data bases have varying operational definitions of what constitutes a "recordable" occupational injury. There are sharp differences in injury risk estimates between the available data bases from BLS, NCHS, and NSC. Nonfatal occupational injury risk estimates from BLS and NHIS differ by a factor of two. NSC and BLS estimates on fatal occupation injuries also differ by a factor of two.

NHIS estimates are based on relatively small sample sizes (26). The Office of Hazardous Materials Transportation requires that the carrier only report those injuries which in the "judgement" of the carrier resulted from the release of hazardous substances. In the aggregate, these variations and differences in data bases can materially affect the design of valid, reliable, and predictable performance benchmarks.

At present there is no single source of valid and reliable information on all fatal and nonfatal occupational injuries in the United States from which national, regional, or state-to-state extrapolations can be made. In a study of work related deaths in a midwestern state, underreporting of occupational fatalities from death certificates was 24 percent, from workers compensation records 43 percent, and from OSHA reports 65 percent (20). Therefore, caution must be exercised in the analysis and interpretation of information from currently available data bases and statistics on occupational injuries.

Where occupational injury and illness surveillance has been limited to that required for OSHA recordkeeping purposes, illness/disease problems have received far more recognition and attention than injury, even though the most important, persistent, and widespread problem is injury. This observation can be seen in the breakdown of injury and illnesses by "type". All injuries are lumped together into a single category while illnesses and diseases are classified in far more detail (e.g., cancer, skin disorders, dust disease of lung). Thus, the opportunity to understand the cause(s) and nature of injuries and to identify potential intervention strategies is extremely limited when compared to the potential opportunities from illness/disease data bases.

The finding by IPAG that occupational injury incidence rates are underreported by a factor of eight suggested the need to obtain data on all occupational injuries, not just those meeting OSHA/CAIRS recordability requirements (10). In particular, the study further demonstrated that information obtained from OSHA/CAIRS was not worker representative and did not provide adequate information for exposure/outcome measurements. A task is needed to validate CAIRS using stringent, scientific and quality standards and to examine CAIRS potential to provide some performance benchmarks.

E. Incentives for Underreporting/Overreporting

NAS stated that the various recording requirements and incentives for underreporting (i.e., penalties for high injury rates) create an atmosphere in which occupational injuries are underrepresented. The report concluded that there is an urgent need for establishing standardized data on all occupational injuries/illnesses and which can measure risk among and within industries and occupations, by such basic factors as age, sex, or experience (17).

Incentives for overreporting exist primarily in the private sector as a means of avoiding the possibility of an OSHA fine for underreporting when management is concerned about misinterpreting OSHA recordkeeping guidelines. DOE needs to develop performance benchmarks that minimize or eliminate both underreporing and overreporting effects.

F. Variations in Interpretation of Occupational Injury/Illness Data from OSHA/CAIRS and Other Data Bases

For nonfatal occupational injuries/illnesses, there are wide variations in exposure/outcome estimates primarily because the data bases have varying operational definitions for what constitutes an occupational or work related injury. Generally, occupational injury (and illness/disease) monitoring systems utilize information obtained from the OSHA reporting forms. However, these data are based on specific types of injuries (or injury outcomes) defined by OSHA in terms that are subject to variable interpretation. Because of this situation, caution must be exercised in the analysis and interpretation of occupational injury statistics based on OSHA (or CAIRS) recordability status. In particular, important factors on injury, such as anatomic location and severity, are often inadequate for performance measurement purposes. The same type of injury (e.g., laceration) may result in lost time from work for one person, but not for another. This may be dependent on performance related factors such as job type (or job description), workplace regulations, insurance coverage, and workers compensation regulations, all of which may vary from state-to-state and one time period to another. At the facility level two sources of variation merit additional comment: written documentation of changes in data collection and maintenance procedures and lack of standardized job titles and descriptions. Therefore, important factors needed to adequately define the nature and extent of the occupational injury problem, either cross-sectionally or longitudinally, are often inadequate for such analytic purposes as developing performance benchmarks. Differences in interpretation of a "recordable" occupational injury event can result in considerable variation in frequency, severity, and outcome estimates.

G. Comparable Data for DOE Contractor and Non-DOE Facilities

Selected performance benchmarks should be used to develop a composite profile of safety and health at each of the DOE contractor facilities in order to promote meaningful inter-facility comparisons within DOE and between DOE and the private sector. These profiles can be developed using stratification factors to develop characteristic-specific benchmarks (e.g., age- and sex-specific injury rates, training levels by facility type) or can be used to develop weighted summary measures (e.g., age-adjusted injury or illness rates). Of particular importance is the development of a consistent classification scheme (such as the Standard Industrial Classification (SIC) codes) across facilities for defining job descriptions (27) so that legitimate comparisons can be made between homogeneous worker populations, using either stratification or weighting for the selected safety and health performance benchmarks. Currently, each DOE contractor facility has its own classification scheme for defining job titles which may or may not have a job description which is consistent with similar job titles at other facilities or at non-DOE sites. Without appropriate adjustments of performance benchmarks using stratification methods, benchmark comparisons would be compromised. The most important stratification factors (Table 2) are those which describe worker population characteristics, time factors, worker job characteristics and work site and environment. In addition, some of these stratification factors can also be used to define facility hazard or exposure benchmarks.

V. DATA BASE AVAILABILITY

A variety of data bases are available which have potential to provide information on hazard-exposure/occurrence/outcome and/or performance for occupational and public exposure resulting from DOE and contractor activities both on and off site; these include (but are not limited to) transportation, high and low level radioactive materials, waste removal and management, fire, explosive or other toxic materials (Appendix Table 1). Some of these are specific to DOE and/or DOE contractors (such as CAIRS (2) and ORPS (28)), while others such as OSHA can be used for measurement and analyses of public safety and health risk resulting from DOE contractor activities or comparisons of DOE contractor performance with that of the private sector. Two studies (the Brookhaven cross-sectional and longitudinal analysis studies) can be used to compare the BNL occupational injury experience with other occupations and industries on Long Island (or elsewhere in New York State) having similar characteristics in order to measure relative performance. Appendix Table 1 contains a list of selected data bases which have the potential to provide the kinds of information needed to develop integrated performance benchmarks for DOE and its contractors, for comparisons with other occupational groups and public health assessment purposes.

The data bases in Appendix Table 1 have been categorized by the three Performance Assessment Categories: hazard-exposure, occurrence or outcome. Some of these data bases have data from two or all three PACs. Data bases which are in the occurrence and/or outcome PACs contain information on Performance Assessment Factors which can be used as, or to compute, Performance Measurement Factors. Data bases categorized as hazard-exposure usually have one of three types of information (Figure 5):

- data on exposure in terms of populations at risk, e.g., number of people in an industry (or an equivalent such as hours worked or person-years worked) or number of people in a specific age group (a stratification factor);
- data on exposures other than population-related, such as explosion or spill abatements, miles traveled for transportation performance assessment, or levels of radiation for radiological risk;
- citation or informational data which provides up-to-date information on the adverse effects (e.g., carcinogenic, mutagenic, or teratogenic) of specific hazardous or toxic substances.

In addition to containing the data bases and PAC, Appendix Table 1 also provides information on the availability and utility of the data contained in each of the data bases. For example, CAIRS can provide exposure/occurrence /outcome information within the DOE system. When CAIRS data are coupled with personnel data from DOE and DOE contractors, performance measurement factors can be produced down to the job-specific or department/division-specific level within a contractor facility, assuming the data have been found to be valid and reliable for the intended use. Comparison groups for occupational injuries/illnesses from the private sector can be obtained using OSHA or state data resources. [Note that these data bases have only limited utility since they are both based on "reportable" events; however, they are now identical in their definition of a reportable event for occupational injuries and illnesses.] For the DOE contractors, radiological information by worker is available through the Radiation Exposure Module (REM), which can be used to obtain levels of exposure to workers.

Caution is needed in distinguishing that which is labeled safety or health. If an exposure results in an acute toxic effect, it is classified in the International Classification of Diseases (ICD) as a toxic effect (29), and programmatically may be defined as a health problem rather than a safety problem. This is particularly evident with respect to chemical exposures.

A. SPMS

DOE's Safety Performance Measurement System (SPMS) is designed to: (1) provide "Accident/Incident" information; (2) "furnish trend and causal factor analysis"; (3) "assist in risk assessments"; and, (4) "provide technical information and communication throughout DOE" (2). CAIRS (Computerized Accident/Investigation Reporting System) is the module within SPMS which contains injury/illness, property, and vehicle loss information for all DOE and DOE contractor organizations. The CAIRS data base is divided into two major groups: (1) age, sex and job classification, and (2) narrative data including event sequence, activities, and corrective action (2,30). Narrative data are encoded using the "FRASE" (Factor Relationship and Sequence of

Events) dictionary. FRASE includes categories for: preexisting conditions, precipitating events, injury producing events, actions taken by employees, activities, hazardous conditions, co-worker involvement, identification of objects, tools, vehicles, equipment, substances, and their characteristics, location, and environmental factors, and corrective actions initiated.

CAIRS has the potential to provide DOE with important information on the cause and prevention on occupational injuries. However, CAIRS criteria for reporting occupational injuries/illnesses are based primarily on OSHA recordability criteria and are subject to the same constraints.

As a data base, CAIRS has the potential to provide DOE with previously unavailable information on hazard-exposure/occurrence/outcome. However, there is need to provide assurance that data from all reporting units within DOE can be (a) aggregated to produce comparable system-wide information (e.g., age, sex, and cause-specific occurrence rates and human and property damage outcome rates or ratios); (b) disaggregated using multivariate techniques to understand complex interrelationships among possible causal factors contributing to safety and health performance; and (c) validated for intended use.

CAIRS has the potential to address a broad range of occupational safety and health questions including: what is the root cause of human, vehicle /transportation, and property damage producing events; what methods can be implemented to prevent human, vehicle/transportation, and property damage events from occurring; and/or what steps can be taken to reduce consequential human, vehicle/transportation, and property damage during or after an event?

Many factors can influence measurements of incidence and severity (31). A data base must have the capability to evaluate multiple diagnostic, causal, and potential confounding factors concurrently and through time (32,33). For example, while CAIRS (and OSHA) data bases provide some information on human, vehicle/transportation, and property damage, they do not provide information on all events, as needed to understand factors that contribute to the overall safety and health problem and their sequelae, nor do they provide information on injury severity and its implications. Most importantly, at present they cannot provide systematic data essential for measuring performance and evaluating intervention programs through pre-defined, validated and demonstrated performance benchmarks, which are requisites for compliance and oversight review.

B. ORPS

DOE's Occurrence Reporting and Processing System (ORPS), which has replaced the Unusual Occurrence Reporting (UOR) Module in SPMS, provides "a centralized data base for the collection, distribution, updating, analysis, and sign off of information in the occurrence reports" (28). Some examples of unusual occurrences are radiation release, personal contamination, classified material loss, selected occupational injuries/illness outcomes (e.g., cases requiring hospitalization, injury producing events involving more than one person), and vehicular/transportation "accidents". It should be noted that some of the parameters in ORPS overlap with SPMS modules.

At present ORPS and SPMS are "stand alone" data bases, each with unique information on event occurrence and outcome. For these data bases to reach their full potential it is essential to develop additional PMFs and data from each of these should have the capability to be combined and aggregated for generating hazard-exposure/occurrence/outcome estimates.

C. Other Selected Data Bases

1. NHIS

The National Health Interview Survey (NHIS) provides national estimates on the number of occupational injury and illness cases and incidence rates. These estimates are based on household interviews and cover a representative survey of all workers. The NHIS defines a "recordable" case as one which was "medically attended" (including those for which a respondent contacted a physician by phone) and those resulting in "more than half a day of restricted activity". A lost-workday case is defined as one causing a respondent to miss "more than half a day from a job or business" (26).

2. NSC and BLS

Several agencies provide national estimates on occupational fatalities. The National Safety Council (NSC), has consistently provided the highest estimates on fatalities. Generally, NSC estimates are twice those published in the BLS Annual Survey, which generally produces the lowest estimates. However, BLS estimates are based only on death occurring in establishments with 11 or more employees, therefore, some differences are expected. In addition, definitions of what constitutes an occupational fatality vary; for example, BLS excludes heart attacks when estimating the total number of fatalities (20).

3. NEISS

The National Electronic Injury Surveillance System (NEISS) provides national estimates for the number of injury cases treated in hospital emergency departments. Data elements include age, sex, the most "severe" diagnosis, body part affected, case disposition, and product(s) causing injury. In some cases, information on occupation and related factors has been collected. However, since most occupational injuries are not treated in hospitals, this data base is not representative of occupational injuries as a whole (34).

4. SEER

The Surveillance, Epidemiology, and End Results Program (SEERS) is a data base maintained by the National Cancer Institute. It contains information about the demographic characteristics, treatment types, and outcomes for persons with cancer. Data are collected from a sample of selected states and metropolitan regions from hospital records, tumor registries, and death certificates (35). While SEERS data are useful for overall cancer incidence, information regarding occupation and occupational exposures is extremely limited. In order to understand the hazard-exposure/cancer relationship exposure/cancer a data base needs to be developed that has the capability of linking various exposure categories (e.g., occupation, smoking history, occupational and other exposures).

5. Other Data Resources

In a Maryland study of fatal occupational injuries, Baker and colleagues identified occupational deaths from four different sources "because no single source of data permits identification of all cases" (36). Only one source, medical examiner records, "identified more than two-thirds of all the cases" that Baker eventually identified. In a Wisconsin study, Baker found that of the 161 occupational injury deaths "identified from review of death certificates and workers' compensation records, only 76% of the total could be identified from death certificates alone, only 57% from workers' compensation records". Most striking was that only 35% were reported to the Occupational Safety and Health Administration (36).

6. Informational Sources for Stratification and Weighting

There are a number of sources of information that can be used to identify and select data for defining performance stratification and/or weighting factors. This is particularly important information for filling in gaps with first order estimates when developing analytic models for performance measurement.

VI. VALIDATION AND ERROR MEASUREMENT

Currently available occupational safety and health monitoring systems lack adequate information on a number of important factors needed to define the nature and extent of the occupational safety and health problems either cross-sectionally or longitudinally (37,38). For occupational injuries in particular, information on injury cause, diagnosis, and anatomic location and severity is often inadequate or missing altogether.

To date there is no common protocol for the federal agencies that collect various data on occupational safety and health. There is a need to assess the adequacy of existing methodologies and data bases for measuring hazard-exposure/occurrence/outcome to all workers and for all events and to determine how DOE is addressing the broad range of occupational safety and health issues in the DOE and DOE contractor system.

A. <u>Reportable/Recordable Occurrence Compared to All Occurrences</u>

By OSHA/CAIRS criteria all occupational illnesses must be reported, but only a subset of events causing property damage or occupational injuries are defined as reportable. Reportable property loss occurrences include vehicle property losses with greater than $1,000 in damage, and fire and non-fire losses which incur $1000 or more in property loss. Reportable injuries are: (1) any injury resulting in a fatality regardless of the time between the injury and death; (2) any injury resulting in day lost from work; (3) any injury which results in transfer to another job, or termination of employment; (4) any injury which results in loss of consciousness, fracture, or restriction of work; and, (5) any injury which requires medical treatment (4,8). Medical treatment is defined as "treatment administered by a physician or registered professional under standing orders from a physician". Medical treatment does not include "first aid", one time treatment and subsequent observation of minor scratches, lacerations, burns, splinters, etc., which do not "ordinarily" require medical care, even though rendered by a physician or health care professional.

Differences in interpretation of these definitions and criteria can lead to wide variations in reporting. Differences in accounting systems, training, or line supervisor oversight between two facilities can cause essentially equivalent event occurrences to be reported at one facility but not at the other. Injury cases classified as "first aid" are specifically exempt from being reportable unless the injury results in work days lost. By OSHA/CAIRS definitions an injury is "reportable" only if the injury results in: fatality, lost or restricted workdays, job transfer, job termination; in loss of consciousness or required "medical treatment". NHIS defines a reportable injury case as one which was medically attended, causes one or more full days of restricted activity, or confines a person to bed for more than 1/2 of the daylight hours on the day of or following an injury (26).

B. Lost and Restricted Workdays

Lost (LWD) and/or restricted (RWD) workdays are often used as a surrogate for anatomic (or physiologic) injury severity, even though there may be no correlation between the anatomic damage and the number of days lost or restricted from work. For injury risk and consequence modeling, there is also need to measure injury occurrence and severity and the direct and indirect impacts of injury producing events. The measurement techniques must use stringent analytic/scientific approaches which incorporate accepted injury/illness classification systems for characterizing the cause, nature, and severity of anatomic injuries, such as the ICD and the Abbreviated Injury Scale (AIS) (39).

Both OSHA and DOE measure occupational injury/illness severity primarily by fatalities and/or work days lost, not by severity of illness/injury or for that matter, type of injury/illness. An occupational injury/illness that leads to a LWD for one person may not for another. Lost work case and day rates have been shown to vary by such factors as the type of work and the injury incurred. For example, a typist/data entry technician with a simple hand laceration may lose time from work because no alternate work can be found and he/she is unable to perform the job. Yet, someone whose skills do not require use of the hand could have the identical injury and not lose time from work. By OSHA/CAIRS definition the first case would be recordable, the second would not.

A systematic approach is needed which would allow investigators to address an issue of primary importance in occupational injury/illness prevention and control: Is work days lost a valid surrogate for anatomic injury/illness severity?

C. **Policy Related Issues**

LWD may vary for the same cause-specific injury/illness because of such differences as state workers compensation laws and administrative procedures, and employer policies on restricted duty. In addition it has been shown that LWD from occupational injuries/illnesses tend to vary directly with worker compensation payments (40).

1. **Workers Compensation (WC) Issues**

State statutes typically limit compensation coverage to all work-related diseases and personal injury caused by "accidents" arising out of and in the course of employment. The attribute of causality for an injury or illness claim is necessary in most cases because "injury or disease must be traceable to a particular job so that the proper employer and insurance carrier can be held responsible" (41).

State program benefits are funded through insurance premium and self-insurance paid by employers. Each state sets its own insurance requirements (42,43). There are five types of insurance claims common to workers compensation. Medical claims are claims for medical and hospital costs only. Death benefits, permanent total disability, permanent partial disability, and temporary total disability are claims for indemnity benefits, that is, cash payment for workdays lost beyond a specified waiting period. These claims may also include medical, hospital, and rehabilitative care. Private insurance carriers paid about 54% of all benefits in 1984; state and federal fund and self-insured payments comprised 27 and 18 percent respectively (41).

A number of studies have been conducted to determine if the frequency and duration of occupational injury/illness claims are sensitive to the level of structure of social insurance benefits provided to compensate workers (44,45,46). In "Some Lessons Learned from the Workers Compensation Program", Worrall and Butler state, "...people respond to incentives. If social insurance benefits increase, applications for beneficiary status will increase" (47). The evidence from the WC program indicates that applications (claim filing), and perhaps risk bearing and injuries, are quite sensitive to changes in the level of benefits. Not only is claim frequency responsive to benefit levels, but what evidence there is indicates that the duration of nonwork intervals associated with the receipt of WC indemnity benefits is a function of the level of those benefits.

In addition, the waiting period for indemnity benefits affects initial claim filing. The longer the waiting period, the lower the claim rate (42). In a study conducted by Worrall and Appel it was found that "benefits affect the duration of a low back claim in a statistically significant way. The less costly it is to stay on a claim and away from the workplace, the longer time on a claim and in a nonwork status" (48).

Therefore, caution must be exercised in the analysis of data based on workers compensation records and reports. Differences within and among states are more likely to be a related to specific WC rules and regulations for filing and collecting compensation, rather than in actual injury/illness rates. These observations need to be taken into account when developing and validating potential performance benchmarks.

D. Industrial and Occupational Classifications

The Bureau of Labor Statistics (BLS) began conducting the Annual Survey of occupational injuries and illnesses in 1972. This survey provides national estimates on the number and incidence rates for fatal and nonfatal injury and illness cases for most private sector industries in the U.S. Industry groups are defined by the U.S. Department of Census Standard Industrial Classification Codes (SIC) (27). However, the survey does not provide detailed information regarding specific occupations, nor does it provide information on other factors such as injury type and cause. For the states participating in the survey (49), statewide representative samples are drawn to determine incidence rates and number of cases. Approximately 280,000 units in private industry with 11 or more employees are selected for the survey annually. Information from the OSHA 200 log and Summary of Occupational Injuries and Illnesses provides the information needed for calculating the numbers and rates.

E. Workforce Representation

The BLS survey estimates have a number of limitations. First, according to the Office of Technology Assessment (OTA) "depending on the type of case, they cover only two-thirds to three-fourths of the U.S. workforce" (17). Second, except for requiring "a brief description of the object or event which caused a fatality" (4 half lines are provided on the survey form), the survey does not collect data on the nature and characteristics of occupational injuries and illnesses. Third, although all illnesses are recordable, only a subset of all injuries are "recordable".

OSHA has found questionable recordkeeping practices in a variety of industries (50). NIOSH researchers in collecting information for the National Occupational Exposure Survey found that maintenance of OSHA logs varied among plants and that many logs were incomplete or not maintained at all.

VII. PERFORMANCE ASSESSMENT

A. Conceptual Models

1. Host-Agent-Environment Model

The modern field of injury/illness assessment, abatement and control is based on scientific concepts derived from the general "host-agent-environment" model (51). The "agent" causing the injury is defined as energy transfer to the human host beyond whole body, body region, or anatomical site damage thresholds. The various forms of energy are mechanical, chemical, thermal, electrical, and radiation. Exposure to energy as an agent is analogous to exposure to a carcinogenic substance or pathogenic microorganism in chronic and infectious disease. A sudden release of steam in a confined space exposes a worker to the risk of a burn. Deceleration in a vehicular crash can cause excess kinetic energy transfer to a vehicle occupant, which in turn can cause varying degrees of anatomic and physiologic damage. The injury producing event usually occurs in a period of time measured in a fraction of a second, as when a head crashes into a windshield or when a finger is hit with a hammer. In contrast, the time needed to cause disease is generally measured in days, weeks, months, years or decades. Thus, the difference between a disease and an injury is primarily dose and time. For example, the single quick contact with the hammer may cause a contusion, whereas prolonged use can result in carpal tunnel syndrome.

It is important to note that the same etiologic agent can cause either injury or disease (52). Arsenic ingested at high doses can cause fatal intoxication in a matter of minutes or hours, while chronic low doses can cause cancer after decades of exposure (32). Similarly, lifting a heavy object can cause immediate injury such as a muscle tear or dislocated disc, while chronic lifting can be associated with degenerative musculoskeletal disease, such as osteoarthritis of the spine.

2. <u>Time-Phase-Categorization Model</u>

Empirical hazard-exposure/occurrence outcome models in occupational injury/illness are all based on the general host-agent-environment model. Clinical, biostatistical, and engineering principles have been applied to injury/illness prevention using an expanded version of the "host-agent-environment" model. The methods based on this model require systematic and meticulous classification and analysis of the events occurring before, during, and after an injury/illness event. Each phase of the event sequence is further classified and evaluated in terms of three major categories: (1) human factors; (2) vectors of energy transfer (e.g., substances, equipment), and (3) physical, chemical, biological, and socioeconomic environment (Figure 6). The matrix formed by these phases and categories serves as a conceptual model for identifying and selecting those elements in the system most likely to reduce the risk of, or damage from, the injury/illness (53). Use of this model enables safety investigators, supervisors and managers, who are responsible for conformance, compliance, and oversight, to select the most effective options for identifying, evaluating and controlling a hazard and for reducing the frequency and/or severity of injury/illness based on analyses of all elements in the system (54). Is also assists in avoiding the classical pitfall of selecting one element, such as human factors in the pre-event phase, to the exclusion of other elements in the system.

One classical pitfall is related to a noteworthy misconception about the relationship between accidents and injuries. Historically, the cultural notion of an "accident" and a related concern for "personal responsibility" to avoid hazards, were considered the primary causes of injuries. Until recently, this notion dominated the field of injury prevention and control and partially limited the introduction of new concepts and programs, based on the time-phase model (55,56). Yet, an injured (or an ill) person may have little direct control over the sequence of events leading to an injury (or illness).

There is need to provide assurance that data from various operating units can be (a) aggregated to produce comparable system-wide information (e.g., age, sex, and cause-specific incident rates and human property damage outcomes) and (b) disaggregated using multivariate techniques to understand complex interrelationships among possible causual factors that contribute to injuries. Many factors can influence measurements of injury/illness occurrence and severity and subsequent analyses of relative and attributable risk (31). A data base that addresses risk management must have the capability to evaluate multiple diagnostic, etiologic, and potential confounding factors concurrently at the contractor, program office and oversight levels of the DOE system (32,33).

3. **Probabilistic Approach**

This approach requires isolating and defining a set of key factors (i.e., parameters, variables, data elements) derived from data bases containing valid and reliable worker representative information which can be used to develop specific exposure/occurrence/outcome models (sometimes referred to as a time phase/host-agent-environment matrix). In turn, the data from this model can be related to task performance models (i.e., work related task demands versus human task performance capabilities) (Figure 7). These two major models, in turn, can be used to provide information for a model for developing hazard abatement strategies aimed at eliminating or mitigating occupational safety and health hazards, which can serve as a basis for risk countermeasure programs and for compliance and oversight monitoring.

B. **Performance Measurement Factors and Performance Benchmarks**

Performance measurement factors are obtained by combining performance assessment factor data in a meaningful way. For the purpose of performance measurement and benchmark evaluation, performance assessment factor data are classified into one of three categories: Hazard-Exposure, Occurrence, and Outcome (Figure 5).

Hazard and exposure date can be defined in any of several ways, i.e., in terms of a population at risk (e.g., the number of workers), in terms of a quantitative measurement of the extent of work performed (e.g., hours worked, vehicle miles traveled), or in terms of an exposure to a hazard, either over a long period of time (e.g., radiation badge levels) or an acute exposure (e.g., toxic waste spills or fumes).

Occurrence data are counts of adverse events (e.g., number of spills, fires, motor vehicle collisions, or injuries). Outcome data are measures of the severity of events, and include such measures as fatalities, number of LWD or RWD, injury severity scales, disability/impairment scales, property damage, and costs.

Performance measurement factors can be obtained directly from occurrence/outcome data, or occurrence/outcome data can be combined with hazard or exposure data to produce a PMF (Figure 1). The three types of performance measurement factors of primary concern are counts (or distributions of counts), rates and ratios.

Counts are useful for determining an overall performance measurement; in addition, breakdown of counts into distributions are also highly informative. For example, the distribution of cases by type may indicate a specific hazard present in the workplace. Likewise, breakdown or malfunction of equipment may indicate the lack of adequate maintenance or monitoring procedures. This type of PMF does not usually utilize exposure data.

Rates are obtained by calculating the ratio of a count to another count, both of which are in the same units, where the denominator is usually an exposure. For example, the occupational injury rate for a facility is calculated as the number of workers who sustained an occupational injury divided by the number of workers; in this case, both of the PAF units are defined in terms of people.

Ratios are also obtained by dividing a count to an exposure, although for ratios the numerator and denominator are in different units. The number of transportation mishaps with or without injuries sustained per 100,000 miles traveled is an example of a ratio PMF.

Any of the performance measurement factors can be obtained for different levels of specificity of either population or exposure by using performance stratification factors (PSF). Simple examples of PSFs are age-specific rates of occupational injury, where the injured persons (Occurrence PAF) and the worker population (Exposure PAF) are stratified into mutually exclusive age groups and the injury rate (PMF) is calculated for each of the strata. PSFs can be combined to create multi-level stratifications, such as age-/sex-/job-specific PMFs. Other PSFs include time, cause of injury, event type, or place.

Performance benchmarks will be that set of PMFs, obtained from valid and reliable data, which accurately measure line program occupational safety and health performance. The benchmarks also must be well-defined in terms of what they measure, and they will preferably have equivalent counterparts in private sector data (or equivalents that can be derived from private sector data) so that direct comparisons between DOE and private sector performance can be achieved.

C. <u>Implications for DOE and the Nation</u>

The implications stemming from inadequate data on occupational safety and health have widespread implications. Without valid and reliable performance benchmarks for occupational safety and health, resources cannot be allocated in equitable and effective ways. For example, a state with workers' compensation data indicating low levels of occupational injuries/illnesses may receive fewer resources than one with data apparently indicating high rates. Or, conversely, inappropriate fines may be applied to organizations with high injury/illness rates. Discrepancies may be attributed to diverse reporting requirements, different criteria for indemnity payments, benefit levels, or other factors related to employer or worker compensation policies rather than to actual differences in rates. However, these differences may not be taken into account when establishing policies to reduce or prevent occupational injuries/illnesses. Inadequate and inappropriate data can lead to inaccurate assessment of attributable risk and inappropriate policies and programs being funded and put into effect.

High quality surveillance data are needed to reduce/prevent injuries and illnesses effectively in the workplace (57). In a 1988 study conducted by Brewer, et al., 99 percent of the cases coming through five outpatient occupational medical clinics in the Chicago region required only outpatient (primarily first aid) care (12). In this study of 14,984 work related injuries/illnesses, 78 percent of the cases clustered around a few injury categories - lacerations, sprains/strains, and contusions. The distribution of the hazards associated with the injuries included metal items (22%), machines (10%), and nonpowered hand tools (5.5%). The leading injury cause was struck by (36%), followed by overexertion (18%). In IPAG's population representative study of injuries in the DOE system the leading cause of injury was struck by/caught between (27%), followed by cutting/piercing (17%). The leading types of injuries were lacerations (29%) and contusions (21%).

VIII. SCIENTIFIC APPROACHES TO PERFORMANCE ASSESSMENT

Various approaches to risk assessment need to be evaluated. Decisions need to be made regarding applying predictive model assessment systems, probabilistic model assessment systems, or a combination of both. Predictive model assessment systems are used primarily to describe risks and consequences of rare events for which there is little if any probabilistic or empirical data available or anticipated. Probabilistic approaches are used for non-rare events in which sufficient empirical or historical data are available. However, the data collected may have been for purposes other than risk assessment. Assumptions that these large empirical data bases provide large quantities of data potentially useful for exposure/outcome assessment may be erroneous. The quality of available data and its potential usefulness to performance assessment and measurement and to injury prevention and control are subject to question.

A. DOE Proposed Risk Assessment Code (RAC) Methodology

Recently the Draft Order 5483.XX was issued by the U.S. Department of Energy defining guidelines for a comprehensive occupational safety and health program to be implemented for line managers (5). The purpose of this program is to ensure that "safe and healthful working conditions" are provided for DOE/DOE contractor employees. This in part can be accomplished by "gathering and analyzing data for the early identification of safety and health trends".

One approach recommended in 5483.XX is the RAC methodology (5). This is a method of calculating the relative risk associated with occupational injuries/illnesses to determine priorities for risk abatement activity. These risk assessment codes (RACs) are determined using severity indices based on 4 outcome parameters and on the probability that an event will occur. The 4 hazard severity categories are (1) catastrophic - injuries/illnesses resulting in permanent total disability, chronic or irreversible illnesses, or death; (2) Critical - injuries/illnesses resulting in permanent partial disability or temporary total disability in excess of 3 months; (3) Marginal - injuries/illnesses causing hospitalization or temporary, reversible illnesses with a variable but limited time period of disability of less than 3 months; and; (4) Negligible - injuries/illnesses not resulting in hospitalization, or temporary, reversible illnesses requiring only minor supportive treatment. The probability code is related to the likelihood that an event will occur. The four probability codes are (A) Frequent - likely to occur immediately or within a short period of time; (B) Probable - probably will occur in time; (C) Occasional - may occur in time, and: (D) Remote - unlikely to occur. The RAC is an expression of risk which "combines the severity and the probability of occurrence code". However, an assessment of this RAC approach is necessary to determine its usefulness as a performance benchmark or to determine whether it needs modification prior to its being implemented as a PB.

This RAC approach has the potential for providing useful information on relative risk. However, to reach full potential as a hazard abatement tool all human and property damaging (e.g., "near miss") events, not just those meeting OSHA recording requirements, need to be incorporated into the matrix to obtain a valid and reliable estimate of risk parameters.

Hazard assessment methodologies, such as the RAC approach, are not consistent with empirical analyses of data from 10 DOE facilities discussed elsewhere in this report and illustrated in Figures 2-4. They are also not consistent with findings from the BNL cross-sectional and longitudinal studies.

B. Systems Approach

A systems approach requires isolating and defining key factors (i.e., parameters, variables, data elements) derived from data bases containing valid and reliable population representative data which can be used to develop indices for incorporation into exposure/occurrence/outcome models (Figure 8). These models, in turn, can be related to task performance models (i.e., work related task demands versus human task performance capability). The two models can than be used to provide information for developing abatement or injury intervention strategies which can serve as a basis for risk countermeasure programs.

At present, methodological gaps in safety and health data bases limit their utility for current and long-term risk consequence assessment. Accurate and reliable population and facility/system-wide representative data are needed to provide useful hazard-exposure/outcome estimates.

C. Overall Approach

There is need to (1) obtain descriptive data on all safety and health related adverse or "near miss" events, not just those meeting recordability requirements; (2) establish valid and reliable prospective data bases based on worker, facility, and DOE system-wide representative data; (3) provide the capability to develop and implement intervention strategies to reduce/prevent human, vehicle/transportation, and property damage both on and off site; and (4) provide the capability to demonstrate the efficacy of selected intervention strategies.

IX. DISCUSSION

For the occupational safety and health program to be effective, it is necessary that the performance measurement data be valid and rigorously evaluated before their implementation as performance benchmarks. Self evaluation of data, small scale evaluation of performance benchmarks and setting research priorities are elements of the OSH system which will ensure a valid and reliable system for measuring safety and line performance.

A. Self-Evaluation

An initiative is needed to evaluate the potential for providing consistent and high quality data, especially at the supervisor-employee level, that can be aggregated into facility level grouped data in preparation for relative performance evaluations among facilities.

Risk based hazard abatement for DOE contractor work site and related activities needs to be initiated because of the broad range of work environments from site-to-site in the DOE contractor organization. Self evaluation at the supervisor-employee level, as previously described, could become a strong foundation for obtaining valid and reliable data. Self evaluation is essentially self-guiding with positive incentives to verify written documentation of hazards, exposures, event occurrences and adverse outcomes. Positive reinforcement can be accomplished if the supervisor-employee interchange is for the purpose of discussion and verification, starting with a view of the completed incident report, and is designed specifically to avoid the need for additional new documentation. The time spent in this process needs to focus on cause and prevention. If these principles are adhered to rigorously, many if not most of the concerns regarding incident data validation can be addressed at or near the time of the incident, which is the time when the most accurate information can be collected. Such a protocol should be considered for pilot testing and evaluation within the DOE contractor organization.

B. Additional Benchmarks

One objective of this project is to develop a set of criteria which can be used to determine if hazard abatement programs used within DOE are effective. Performance benchmarks are the tools which will be used to measure compliance with DOE policies and programmatic performance objectives. In particular, performance benchmarks used for hazard abatement measures signify a transformation in safety and health evaluation from that of a reaction to an event occurrence to one of pro-action, i.e., hazard assessment and abatement prior to the occurrence of a damaging or potentially damaging event.

Unfortunately, hazard assessment and abatement performance measures are not as well understood as those used for occurrence or outcome. Most programs do not have a set of criteria for their evaluation as performance benchmarks. If hazard assessment and abatement initiatives continue without strong evaluative components that are scientifically defensible and that allow comparisons within and among sites, then the pro-action approach as embodied by the occupational safety and health program will be compromised. At the present time the techniques used for event occurrence and outcome measurements have the potential for becoming performance benchmarks in their own right prior to those used for systematic hazard abatement measurement. Scientifically defensible methods need to be employed in the development of hazard and exposure performance benchmarks that can be used for decision making during oversight procedures by DOE management. The risk assessment methodology and codes are expected to contribute to pro-active approaches. Methods and procedures used to determine occurrence and outcome measurements need to be applied to hazard abatement programs to produce equally rigorous PAFs that eventually can qualify as performance benchmarks.

It is vital that the use of hazard assessment and abatement performance measurement factors be evaluated on a small scale prior to their consideration as performance benchmarks, so that validity and reliability of the measure can be ascertained. This step in the process of developing and designating benchmarks is usually overlooked, but is necessary if the performance benchmarks are to have a useful impact on the evaluation of DOE contractor performance at all stages from self-evaluation to oversight review.

Occupational safety and health performance benchmarks need to be identified through a systematic surveillance system, both cross-sectionally and longitudinally, that represents all DOE/DOE contractor organizations. This systematic, ongoing approach is needed for understanding hazard-exposure/occurrence/outcome and for measuring the performance of line supervisors and managers, the state of the DOE system (including its performance relative to private industry), and the efficacy of safety and health intervention programs. One approach might be to create risk/outcome matrices such as the one developed by Kramer, et. al (58) to enable safety and health decision makers in DOE to readily focus on assessment and abatement in specific problem areas and focus on known or potential adverse outcomes.

In a June 1991 GAO report "Health Promotion in DOD the Challenges Ahead", it was stated that DOD needs to collect information about the health status, behaviors, and risks of its population (59). The report further stated "that implementing, monitoring, and evaluating such a program would be difficult and costly" since it would necessitate valid studies on incidence, require recommendations of appropriate interventions, and evaluate the efficacy of those interventions. However, implementing such a program throughout the DOE contractor system would also enable such organizations as

DOD to utilize the pooled generic data for cost-effective interventions targeted at specific occupational groups or populations. An occupational safety and health information system, an expanded version of the injury/illness information system such as the one developed by IPAG, would address DOD's concerns and provide DOE with comprehensive population representative and cost-effective data on work related safety and health. This information system uses well established scientific methodology which cuts across a wide range of occupational and industrial groups involved in research, engineering, production, construction, and service activities.

C. Research Priorities

In order to improve occupational safety and health, a number of research priorities as identified in the Year 2000 Objectives for the Nation need to be addressed, which can be extrapolated to encompass a broader outlook than simply occupational injuries and illnesses. They are as follows: (1) rigorous testing and validation of control technologies (e.g., monitoring, safeguards, lockouts) and administrative techniques (e.g., training, work procedures, policies) need to be conducted; and, (2) valid methodologies that define the scope of the problem, identify various causal factors, and evaluate the efficacy of interventions must be implemented (15). However, in order to accomplish this, scientifically rigorous methodology must be put into place which first measures the incidence, cause, anatomic damage and other adverse outcomes of all work related injuries/illnesses, as a basis for developing safety performance benchmarks. Standardized surveillance procedures that cut across all facilities and utilize nationally accepted coding systems such as ICD and AIS are needed to identify cause-specific injuries/illnesses which should be targeted for intervention strategies. Similar surveillance systems are needed for "hazards" and property damage which can link with human/worker factors when applicable.

In the aggregate, performance benchmarks need to be linked to a centralized information system and a distributed data platform with satellite information systems throughout the DOE organization. Potential performance benchmarks need to be tested for validity, reliability and predictability in accordance with standardized criteria prior to being designated official performance benchmarks. Preferably, the performance benchmarks should reside in a central repository on a distributed network in order to maximize the availability of information to the broad range of users throughout the DOE system. Further, there is need to recognize that individual facilities/sites may require additional performance benchmarks that dovetail with those contained in the central repository and also satisfy facility/site-specific programmatic needs, as distinguished from area-wide or overall DOE needs.

X. CONCLUSIONS AND RECOMMENDATIONS

When adopted, Draft Order 5483.XX will be one of the most comprehensive research-industrial safety and health initiatives with broad compliance and oversight features of any U.S. government agency. The Draft Order requires contractor conformance with standards, program office review of contractor compliance, and headquarters oversight of the entire program. However, the order needs to incorporate explicit provisions for coordination of tasks, projects, and functions to assure the accuracy and consistency of contractor generated data across sites. The lack of data consistency across sites is viewed as a primary impediment in designating performance benchmarks at this time. Because of its many elements and complexity, there is need to introduce an integrated performance benchmark development and demonstration program that will allow DOE line management and DOE contractors to quickly and efficiently implement this DOE order when promulgated in its final form.

There is need to demonstrate that the various conformance, compliance and oversight elements can work efficiently and together in one of the most complex mixes of research-industrial activities managed by any entity, public or private worldwide. To that end, pilot testing of PB development program measurement factors on a small scale is urgently needed prior to system-wide deployment. Such a demonstration will provide DOE management with the information needed to encourage prompt and enthusiastic acceptance of this new program right from the start.

The risk assessment methodology and risk assessment codes designed to quantify selective relative risk factors needed for performance measurements represent a first step in the process, but are not known to have been tested for validity, reliability and predictability using empirical data currently available from selected DOE contractor facilities. Other methodologies for measuring the effect of the adverse outcomes are also available for these purposes. One, the AIS, is a well established quantitative method for measuring the anatomic damage from injury and merits consideration for performance measurement.

IPAG views the introduction of an integrated performance benchmark development program as being analogous to technology transfer from a research/analytical mode to full scale implementation. To accomplish the transfer, it is necessary to take analytical information from research laboratories and rigorously demonstrate and evaluate it before full scale industrial implementation. There is need to emphasize the importance of going through the necessary development and demonstration phase (Figure 9). It is the omission of the development-pilot testing-demonstration stage that often distinguishes effective public/private initiatives from others.

DOE has the opportunity at this point to introduce performance benchmarks at the development/demonstration/piloting stage and benefit from likely enthusiastic acceptance and support for the compliance and oversight aspects of the overall occupational safety and health programs. By doing so line management can be in a position to show which programs are effective and beneficial to the organizations involved. This approach is the basis for the occupational safety and health technology transfer initiative, sponsored by the UAW-Ford National Joint Committee on Health and Safety, that is presently being completed by IPAG.

An important concern of DOE contractors at this point is the need to assure accuracy and consistency of information through time and across facilities and sites in preparation for DOE compliance and oversight review. To accomplish this an integrated performance benchmark development program is recommended. The program should include generic, facility/site level information that can: (a) cut across contractor and programmatic lines; (b) produce accurate and consistent data using uniform operational definitions; (c) reside mainly in machine readable formats; (d) provide user friendly computer hardware/software and input/output through a distributed network (Figure 10); (e) encourage supervisor-employee participation in self analysis and evaluation with optimal efficiency; (f) provide a mechanism for documenting compliance with DOE orders and other regulations; and (g) provide information and data for DOE program office compliance and headquarters oversight responsibilities through the use of integrated performance benchmarks.

The Integrated Performance Benchmark Development Program is viewed as a means of providing practicable and analytical "tools" needed to demonstrate the effectiveness of the DOE comprehensive occupational safety and health program to all employees and line managers and supervisors in DOE and DOE contractor organizations. IPAG anticipates that scientifically developed performance benchmarks with demonstrated validity, reliability and predictability will encourage employee, supervisor, and management involvement in this safety and health initiative.

Specific recommendations for developing an integrated performance benchmark measurement program should include:

- Computerized abatement logs and a related tracking system which can become the basis for documenting prevention or amelioration tasks and for developing new or modifying existing PBs.
- A strong focus on standardized information as distinguished from standardized hardware and software for electronic data interchange.
- Pilot evaluation of all program components at selected sites.
- Emphasis on immediate supervisor interaction with an injured (or involved) employee, as soon as practicable post-event, as a primary mechanism for training, sensitizing, and reaching virtually all employees in a facility within a three year cycle (as opposed to the five year cycle discussed in the draft order document).
- Emphasis on continual improvement of the quality and integration of performance measurement data.

- Emphasis on validity, reliability, and predictability of performance assessment and measurement factors.
- Assurance of usability at the contractor, program office, and headquarter levels of the DOE system.
- Availability of all data and information in computerized format on generic platforms in the work environment, as necessary to measure performance and establish benchmarks.
- Consideration of "fuzzy logic" modeling techniques for event anticipation and/or reconstruction to reduce the effects of variation in factual data specificity and completeness from event-to-event and site-to-site, especially with respect to existing data sources.

REFERENCES

1. U.S. Department of Energy. Reliability and Fault Tree Analysis Guide. EG&G, Idaho Inc. Idaho Falls, Idaho. DOE 76-45/22.

2. U.S. Department of Energy. Safety Performance Measurement System (SPMS) Users Manual, U.S. DOE, Office of the Deputy Assistant Secretary for Environment, Safety, and Health. Wash. DC. 1980.

3. U.S. Department of Labor, Bureau of Labor Statistics. Log and Summary of Occupational Injuries and Illnesses. OSHA No. 200. Government Printing Office 960-502.

4. EG and G Idaho, Inc. ERDA Guide to the Classification of Occupational Injuries and Illnesses. US ERDA, ERDA -76/45-7. SSDG-7 October 1976.

5. U.S. Department of Energy, DOE 5483.XX Occupational Safety and Health Program for DOE Contractor Employees. Draft order April 14, 1992.

6. Kuhlmann, A. Introduction to Safety Science, Springer-Verlag, New York Inc., 1986.

7. Brookhaven National Laboratory. Environment Safety and Health Standards Manual.

8. U.S. Department of Labor, Bureau of Labor Statistics. Recordkeeping Guidelines for Occupational Injuries and Illnesses. U.S. Department of Labor, Bureau of Labor Statistics, September, 1986.

9. National Safety Council. Accident Facts. Chicago, 1990.

10. Barancik JI, Kramer CF, & Thode Jr. HC. "Occupational injury patterns in a well defined worker cohort: initial finding." Abstract, American J. of Epidemiology, 132:4, October 1990.

11. Robertson, L.S. Injury Epidemiology, Oxford University Press, New York 1992.

12. Brewer, R.D., Oleske, D.M., Hahn J., Leibold, M. A Model for Occupational Injury Surveillance by Occupational Health Centers. American college of Occupational Medicine, Vol. 32. No. 8 pp 698-702, August 1990.

13. Campell, Colin, "Bigger Killer Than Aids", New York Newsday, Editorial, June 28, 1992.

14. Hensler, D.R., Marquis, M.S., Abrahamse, A.F., Berry, S.H., Ebener, P.A., Lewis, E.G., Lind, E.A., MacCoun, R.J., Manning, W.G., Rogowski, J.A., & Vaiana, M.E. "Compensation for Accidental Injuries in the United States", RAND, 1991.

15. U.S. Department of Health and Human Services. Promoting Health/Preventing Disease: Year 2000 Objectives for the Nation. Public Health Service, September 1989.

16. GAO, General Government Division. Federal Employees' Compensation Act: Need to Increase Rehabilitation and Reemployment of Injured Workers. United States General Accounting Office, February, 1992.

17. Pollack ES & Keimig DG, eds. Counting injuries and illnesses in the workplace: Proposals for a better system. National Academy Press, Washington, D.C. 1987.

18. U.S. Department of Energy, Injury and Property Damage Summary, January-December 1983, U. S. DOE, Office of the Deputy Assistant Secretary for Environment, Safety and Health.

19. National Committee for Injury Prevention and Control. Injury Prevention: Meeting the Challenge. American Journal of Preventative Medicine, 1989.

20. Baker, S.P., O'Neill, B., Ginsburg, M., and Guohua, L. The Injury Fact Book: Second Edition, Oxford University Press, New York 1992.

21. Kraus J.F. "Fatal and nonfatal injuries in occupational settings: a review:, Annual Review of Public Health, 6, 1985.

22. Polakoff P.L. "Traumatic job injury rate needs to be examined, decreased:, Occupational Health and Safety, 55:11, November 1985.

23. Robertson, L.S. "Occupational injury trends". American J. of Public Health, 78:8, August 1988.

24. Barancik J.I., Kramer C.F., & Thode Jr. H.C. "Epidemiology of nonfatal occupational injuries: magnitude of the problem". American Public Health Association 118th Annual Meeting, New York, New York, September 30 - October 4, 1990.

25. Barancik J.I., Chatterjee B.F., Green J.C., Michenzi, E.M., Fife, D. "Northeastern Ohio Trauma Study I: Magnitude of the Problem. American J. Public Health. 73:7, July 1983.

26. U.S. Department of Health and Human Services, Public Health Service, National Center for Health Statistics. Current Estimate from the National Health Interview Survey: U.S. 1982. 10. No. 150 Hyattsville MD., Sept. 1985.

27. U.S. Department of Commerce, Bureau of the Census. Alphabetical Index of Industries and Occupations: 1980, Bureau of the Census, 1980.

28. National Center for Health Statistics: International Classification of Diseases, ninth revision Clinical Modification, Pub. NO. ICD-9-CM. Ann Arbor, MI: Commission on Professional and Hospital Activities, 1978.

28. U.S. Department of Energy, Occurrence Reporting and Processing System (ORPS) Users Manual, U. S. DOE Assistant Secretary for Nuclear Energy, Office of Nuclear Safety Policy and Standards.

30. Safety Sciences, Inc., Hardcopy of viewgraph, Outline of Presentation on Capabilities of the CAIRS, Presented at Safety Sciences, Inc. San Diego, CA 1986.

31. Fife, D., Barancik, J.I., and Chatterjee, B.F. "Northeastern Ohio Trauma Study: II. Injury Rates by Age, Sex, and Cause, "American J. Public Health, Vol. 74 No.5, May 1984.

32. Barancik, J.I. and Kramer, C. "Selected Methods in Health Risk Analysis: A Health and Environmental Effects Document, " Chapter 5, November 1982 (in press)

33. Baker, S.P., "Injury control," chapter in Preventive Medicine and Public Health, Tenth Edition, Startwell, P.E., (Editor), Prentice-Hall, Inc. 1973.

34. U.S. Department of Health and Human Services, Public Health Service. 1990 Health Objectives for the Nation: A Mid Course Review. Office of Disease Prevention and Health Promotion, 1986.

35. Lesko, M. The Federal Database Finder: A Directory of Free & Fee-Based Data Bases & Files Available form the Federal Government. Library of Congress, 1990.

36. Baker, S.P., Samkoff, J.S., Fisher, R.S., Van Buren, C.B., Fatal Occupational Injuries, JAMA, Vol. 248, No. 6. pp 692-697. Aug. 13, 1982.

37. Robertson, L.S., Injuries: Causes, Control Strategies, and Public Policies, pp. 148-152, Lexington Books, Mass., 1983.

38. Occupational Injury Surveillance -- United States, MMWR, 30(46), pp. 578-9, Nov. 27, 1981.

39. Joint Committee on Injury Scaling. The Abbreviated Injury Scale (AIS) 1985 Revision. American Association for Automotive Medicine. Park Ridge, Illinois, 1985.

40. Butler, R.J., and Worall, J.D. Work Injury Compensation and the Duration of Nonwork Spells. The Economic Journal, Vol. 95, No. 379, Sept. 1985.

41. Price, D.N., Workers Compensation: Coverage, Benefits, and Costs, Social Security Bulletin, Vol. 49, No. 2, February 1986.

42. Chamber of Commerce of the United States. Analysis of Workers' Compensation Laws--1985 Edition. Washington, DC, 1985.

43. U.S. Department of Labor, Employment Standards Administration, Office of State Liaison and Legislative Analysis, Division of State Workers' Compensation Programs. State Workers Compensation Laws. July 1985.

44. Chalius, J.R. The Influence of Workers' Compensation on Safety Incentives. Industrial and Labor Relations Review, Vol. 35, No. 2, Jan. 1982, pp. 235-42.

45. Burton, J.F. "Compensation for Permanent Partial Disabilities". In: Safety and the Workforce: Incentives and Disincentives in Workers' Compensation, J.D. Worrall, etd., ILR Press, Ithaca, NY, 1983.

46. Butler, R.J. "Wage and Injury Rate Response to Shifting Levels of Workers' Compensation. In: Safety and the Workforce: Incentives and Disincentives in Workers' Compensation, Worrall, J.D., etd., ILR Press, Ithaca, NY, 1983.

47. Worrall, J.D., and Butler, R.J. Some Lessons from the Workers' Compensation System. In Disability and the Labor Market: Economic Problems, Policies, and Programs, Berkowitz, M. and Hill, A.M., etd., ILR Press, Ithaca, NY, 1986.

48. Worrall, J.D., and Appel, D. Some Benefit Issues in Workers' Compensation. In: Workers' Compensation Benefits: Adequacy, Equity, and Efficiency, J.D. Worrall and D. Appel, etc., ILR Press, Ithaca, NY, 1985.

49. Kruager, A.B., and Burton, J.F., Jr. Interstate Differences in the Employers' Costs of Workers' Compensation: Magnitude, Causes, and Cures. Presented at the Seminar on Economic Issues in Workers' Compensation, National Council on Compensation Insurance, November 18, 1983.

50. Robertson, L.S., and Keeve, J.P. Worker Injuries: The effects of Workers' Compensationand OSHA Inspections. Journal of Health Politics, Policy and Law, Vol 8, No. 3, Fall 1983, pp. 581-96.

51. Waller, Julian A. "Injury as a Public Health Problem," In: Maxey-Rosenau. Public Health and Preventive Medicine. 11th edition, Last, John M. editor, Appleton-Century-Crosts division of Prentice Hall, New York 1980.

52. Baker, S.P., "Medical Data and Injuries, " Editorial, American J. Public Health, July 1983, Vol. 73, No. 7.

53. Haddon Jr., W., "On Escape of Tigers: AN Ecological Note,: MIT Alumni Association, Technology Review 72 (7):3, Reprinted AJPH 60 (12) :2229-2234, Dec. 1970.

54. Barancik, J.I., Kramer, C.F., & Thode Jr., H.C. "An information system for industrial safety to improve quality, productivity, and competitiveness". Published proceedings abstracted in J. Occupational Accidents, 12, 1990.

55. Baker, S.P. and Dietz, P.E.; "Injury Prevention", In: From Healthy People, Surgeon Generals Report on Health Promotion and Disease Prevention, Background paper, Washington, U.S. Department of Health, Education and Welfare, 1979.

56. Hadler, N.M., "Occupational Illness, "J. Occupational Medicine, Vol. 26, NO. 8, August 1984.

57. Mendeloff, J.M., Kagey, B.T., "Using occupational Safety and Health Administration Accident Investigations to Study Patterns in Work Fatalities". Journal of Occupational Medicine, Vol. 32 No. 11, Nov. 1990.

58. Kramer C.F., Rybicka K., Knutson A., and Morris S.C. Health Effects of Risk Assessment Categories, BNL 51783, Brookhaven National Laboratory, October, 1983.

59. GAO, Human Resources Division. Defense Health Care: Health Promotion in DOD and the Challenges Ahead. United States General Accounting Office, June 1991.

60. Kramer C.F., Barancik J.I. AIS Training Manual. BNL 52184. Brookhaven National Laboratory. Upton, NY 1989.

61. Kramer C.F., Barancik J.I., Thode H.C., Jr. "Improving the Sensitivity and Specificity of the Abbreviated Injury Scale Coding System". Public Health Reports. 105:4, July-August 1990.

62. Deming E.W. Quality Productivity and Competitive Position., MIT Center for Advanced Engineering Study, 1982.

63. Haddon W Jr. "On escape of tigers: An ecological note." MIT Alumni Association, Techonolgy Review 72:7; reprinted in American J. of Public Health, 60:12, December 1970.

64. Rempell, D.M., Harrison, R.J., Barnhard, S. "Work-Related Cumulative Trauma Disorders of the Upper Extremity", JAMA, Feb. 12, 1992, Vol. 267, No.6 pp 838-842.

65. Thompson, J.S., Phelps, T.H. "Repetitive strain injuries". Post Graduate Medicine, Vol 88 No. 8, pp 143-149, 1990.

66. Goertz, M.N., "Prognostic Indicators for Acute Low-Back Pain", Spine, Vol. 15, No. 12, pp 1307-1310, 1990.

67. Pickett, C.W.L. & Lees, R.E.M. "A Cross-Sectional Study of Health Complaints Among 79 Data Entry Operators Using Video Display Terminals", Soc. Occup. Med. 1991; 41: 113-116.

68. U.S. Department of Health and Human Services, Public Health Service. THE FACTS: Disease Prevention/ Health Promotion. Library of Congress, 1988.

TABLES

Table 1
List of Selected Potential Performance Benchmarks

Potential Performance Benchmark	Performance Assessment Category	Source	Comments	Benefits
OCCUPATIONAL SAFETY PROGRAM IMPLEMENTATION AND CONFORMANCE BENCHMARKS				
Training Frequency by Type of Hazard	Exposure	Facility	E.g., fire safety training	1,3,17,18 21
No. of Newly Implemented Training Programs for Occupational Safety	Exposure	Facility		1,3,17,18, 21
Efficacy of Training Programs	Exposure	Facility	Requires before/after testing for each program	1,3,17,18, 19,21
No. of Newly Implemented Engineering Controls for Hazard Abatement	Exposure	Facility		1,3,4,5, 15,21
Rate of Compliance with Safety Reporting Requirements	Exposure	Facility		1,17,19
Completeness and Timeliness of Required Reports	Exposure	Facility		1,17,19
No. and Type of New Safety Intervention Programs	Exposure	Facility		1,3,4,21
Rate of Employee Compliance with Safety Regulations	Exposure	Facility		1,4,6,13, 14,18
No. of Job Safety Analyses Initiated and Implemented	Exposure	Facility		1,3,17,18, 19
Supervisor Training in Incident Investigation	Exposure	Facility		1,17,18

Table 1 (cont'd)
List of Selected Potential Performance Benchmarks

Potential Performance Benchmark	Performance Assessment Category	Source	Comments	Benefits
EXPOSURE BENCHMARKS				
Avg. Occupational Radiation Exposure	Exposure	REM		1,2,17,18, 19
Hours Worked	Exposure	Facility		16
Worker Population Characteristics	Exposure	Facility	E.g., age, sex; also used for stratification (see Table 2)	16
Worker Job Characteristics	Exposure	Facility	Differences in job descriptions among facilities; also used for stratification (see Table 2)	16,17,18, 19,20
Noise Level	Exposure	Facility		1,2,17,18, 19
Air Quality Measurements	Exposure	Facility	Workplace and environment	1,2,4,5,15, 17,18,19,21
Water Quality Measurements	Exposure	Facility	Workplace and environment	1,2,4,5,15, 17,18,19,21
Characterization of Dump Sites	Exposure	Facility	Radiologic and other toxic substance data bases being developed	1,2,4,5,15, 17,18,19, 21
EVENT OCCURRENCE BENCHMARKS (Including stratification by PSFs, Table 2, especially time factors)				
Frequency of Releases	Occurrence	ORPS	UOR for possible historical comparison if validity demonstrated	1,2,4,5,15, 17,18,19, 21
Frequency of Spills/Discharges	Occurrence	ORPS	"	1,2,4,5,15, 17,18,19,21

Table 1 (cont'd)
List of Selected Potential Performance Benchmarks

Potential Performance Benchmark	Performance Assessment Category	Source	Comments	Benefits
EVENT OCCURRENCE BENCHMARKS (cont'd)				
Frequency of Shutdowns	Occurrence	ORPS	"	1,2,11,12
Motor Vehicle Collision Rates	Occurrence	ORPS	Off-site, on-site and overall	1,2,6,9, 18,21
Total Transportation Incident Rates	Occurrence	ORPS		1,2,6,9, 18,21
Frequency of Fire Incidents	Occurrence	ORPS		1,2,6,9, 18,21
PROPERTY LOSS BENCHMARKS (Including stratification by PSFs, Table 2 especially time factors)				
Total Property Damage ($)	Outcome	CAIRS	Subject to reportability requirements	1,9,18
Avg. Property Cost per Event	Outcome Occurrence	CAIRS	Subject to reportability requirements	1,9
Total Property Damage, Vehicular Events ($)	Outcome	CAIRS	Subject to reportability requirements	1,7,9
Avg. Property Cost per Vehicular Event	Occurrence Outcome	CAIRS	Subject to reportability requirements	1,7,9
Total Property Loss In Fire Events	Outcome	ORPS	Subject to reportability requirements	1,9
Property Loss per Fire Event	Occurrence Outcome	UOR/ORPS	Subject to reportability requirements	1,9

Table 1 (cont'd)
List of Selected Potential Performance Benchmarks

Potential Performance Benchmark	Performance Assessment Category	Source	Comments	Benefits
OCCUPATIONAL INJURY BENCHMARKS (Including stratifications by PSFs, Table 2)				
No. and Rate of All New Occupational Injury Cases (first aid, medical, other)	Outcome Exposure	Facility	Includes cases which are not CAIRS reportable	9,11,12,13, 14,19,20, 21
Reportable Injury Rates	Outcome Exposure	CAIRS	Subject to reportability requirements	1,9,11,12, 13,14
Cause of Injury	Occurrence	-	Not currently available	2,6,17,18, 20,21
Mortality Rates	Outcome Exposure	CAIRS		1,6,8,20
Case-Fatality Ratio	Outcome	CAIRS	Denominator subject to reportability requirements	1,8,20
LWC Rate for Injuries	Outcome Exposure	CAIRS	Subject to definition of LWC	1,10,11,12
LWD Rate for Injuries	Outcome Exposure	CAIRS	Subject to definition of LWD	1,10,11,12
RWD Rate for injuries	Outcome Exposure	CAIRS	Subject to definition of RWD	1,11,12
Injury Rate per Mile Traveled	Outcome Exposure	CAIRS	Vehicular events only	1,2,6,7 21
Hospitalization Rate	Outcome	CAIRS		8,20
Case-Admission Ratio	Outcome	CAIRS		8,20
Frequency of Injury by Type	Outcome	-	Not currently available	17,18,20
Workers Comp. Case Rate	Outcome Exposure	Facility		8,9,10,11, 12

Table 1 (cont'd)
List of Selected Potential Performance Benchmarks

Potential Performance Benchmark	Performance Assessment Category	Source	Comments	Benefits
OCCUPATIONAL INJURY BENCHMARKS (cont'd)				
Workers Comp. Costs	Outcome	Facility		9,10
Total Medical Costs (Dis/Ind)	Outcome	Facility		9,10
Anatomic Location of Injury	Outcome	-	Not currently available	8,16,17,18, 20
Anatomic Severity of Injury	Outcome	-	Not currently available	8,16,17,18, 20
Anatomic Severity Rates	Outcome	-	Not currently available	2,8,20
Repeater Rate	Outcome	CAIRS	Only repeated reportable cases	2,17,18
Percent WDL Cases with Musculoskeletal Conditions	Outcome	-	Not currently available	8,9,10,17, 18,19,20
Cases with 1 or More Musculoskeletal Condition (N710-739, N830-848)	Outcome	-	Not currently available	8,10,17,18, 19,20
Ratio of OSHA Recordable Cases to Total Cases	Outcome	-	Not currently available	8,17,18,19, 20
Ratio of DOE to non-DOE Injury Cases	Outcome	CAIRS/ OSHA	Only for reportable cases	1,17
OCCUPATIONAL ILLNESS BENCHMARKS (Including stratifications by PSFs, Table 2)				
No. of Case Visits for Occupational Illness	Outcome	CAIRS		1,8,9,11, 12,13,14, 21

Table 1 (cont'd)
List of Selected Potential Performance Benchmarks

Potential Performance Benchmark	Performance Assessment Category	Source	Comments	Benefits
OCCUPATIONAL ILLNESS BENCHMARKS (cont'd)				
Illness rates	Outcome Exposure	CAIRS		1,8,9,11, 12,13,14, 21
Cause of Illness	Occurrence	-	Not currently available	2,6,17,18, 20,21
Mortality Rates	Outcome Exposure	CAIRS		1,6,8,20
Case-Fatality Ratio	Outcome	CAIRS	Denominator subject to reportability requirements	1,8,20
LWC Rate for Illnesses	Outcome Exposure	CAIRS	Subject to def. of LWC	1,10,11,12
LWD Rate for Illnesses	Outcome Exposure	CAIRS	Subject to def. of LWD	1,10,11,12
RWD Rate for Illnesses	Outcome Exposure	CAIRS	Subject to def. of RWD	1,11,12
Hospitalization Rate	Outcome	CAIRS		8,20
Case-Admission Ratio	Outcome	CAIRS		8,20
Frequency of Illness by Type	Outcome	-	Not currently available	17,18,20
Workers Comp. Case Rate	Outcome Exposure	Facility		8,9,10,11, 12
Workers Comp. Costs	Outcome	Facility		9,10
Total Medical Costs (Dir/Ind)	Outcome	Facility		9,10
Anatomic Location of Illness	Outcome	-	Not currently available	8,16,17,18, 20

Table 1 (cont'd)
List of Selected Potential Performance Benchmarks

Potential Performance Benchmark	Performance Assessment Category	Source	Comments	Benefits
OCCUPATIONAL ILLNESS BENCHMARKS (cont'd)				
Repeater Rate	Outcome	CAIRS	Only repeated reportable cases	2,17,18
Percent WDL Cases with Musculoskeletal Illness	Outcome	-	Not currently available	8,9,10,17, 18,19,20
Cases with 1 or More Musculoskeletal Illness	Outcome	-	Not currently available	8,10,17,18, 19,20
Ratio of DOE to non-DOE Illness Cases	Outcome	CAIRS/ OSHA	Only for reportable cases	1,17

List of Benefits:

1. Compliance with current DOE orders or other federal regulations
2. Hazard identification and/or evaluation
3. Safety intervention/hazard abatement program benchmark
4. Reduced occupational exposure
5. Reduced public exposure
6. Reduced occupational occurrence
7. Reduced public occurrence
8. Reduced adverse outcome
9. Reduced costs to DOE or DOE contractor
10. Reduced workers compensation outlays
11. Improved productivity at a facility/site
12. Improved productivity at DOE overall
13. Improved work quality at a facility/site
14. Improved work quality at DOE overall
15. Reduced environmental hazards
16. Improves predictive capability of a performance factor
17. Improves capability for operational management decision making
18. Improves capability of line supervisors to prevent or reduce property damage or occupational injury/illness producing events
19. Improves capability of safety and health management at facility/area office/headquarters to determine changes in trends
20. Consistent with NAS recommendations
21. Consistent with U.S. national safety and health goals for the year 2000

Table 2
Illustrated Performance Stratification Factors That Can Be Used for Performance Benchmarks

Performance Stratification Factor	Comments
WORKER POPULATION CHARACTERISTICS	
Age	
Sex	
Education Level	
Marital Status	
Smoking History	
Medical History	
WORKER JOB CHARACTERISTICS	
Job Title	Needs to be standardized between DOE facilities and with private sector
Work Site Exposures	
Equipment Used	
Training Level	
TIME FACTORS	
Time of Day	
Day of Week	
Date of Incident	Used to develop weekly, monthly or other periodic measures of safety/health performance using control chart format

FIGURES

FIGURE 1

GENERIC PROCESS FOR OBTAINING PERFORMANCE BENCHMARKS

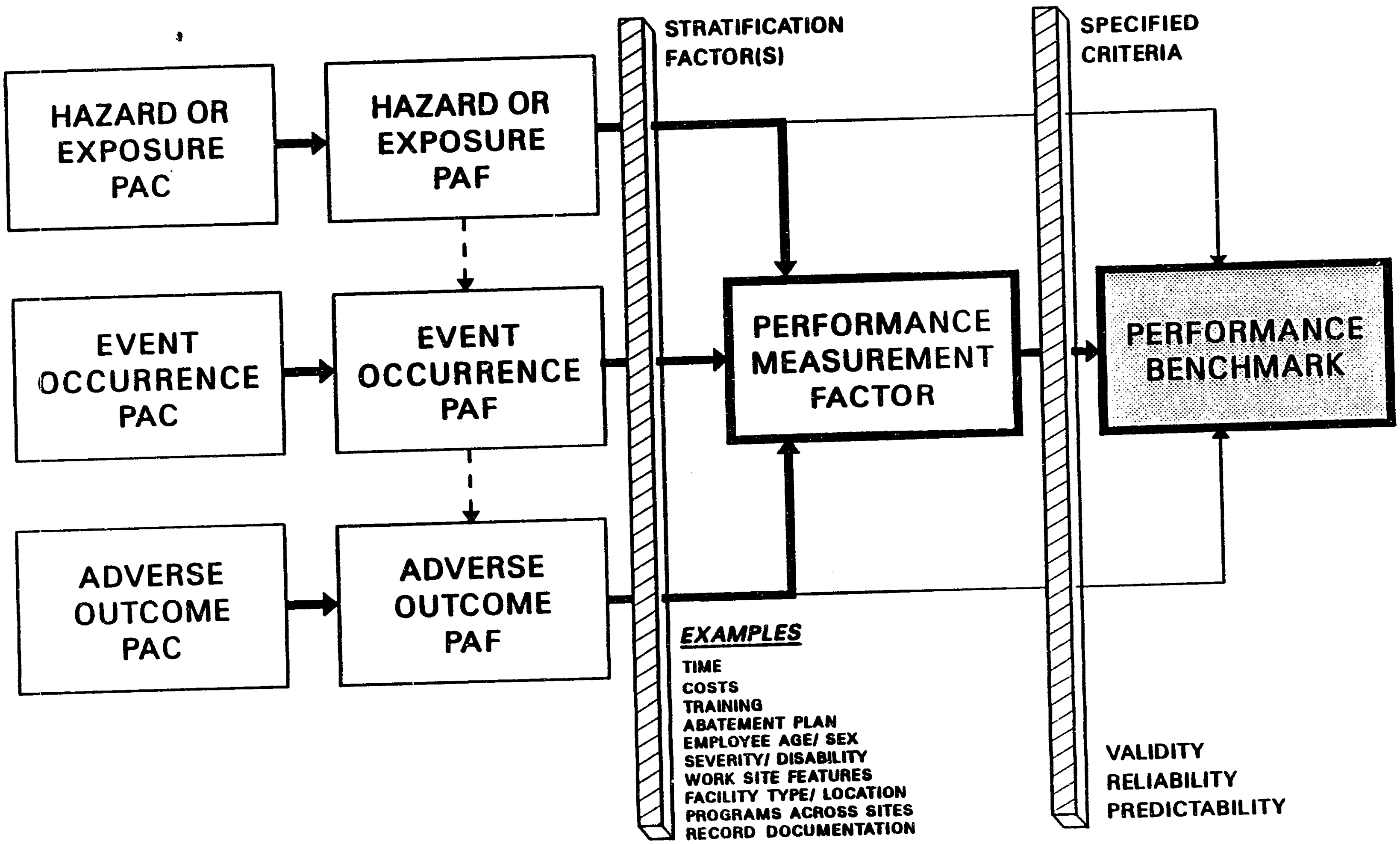


FIGURE 2

OCCUPATIONAL INJURY INCIDENCE RATES

10 DOE & CONTRACTOR FACILITIES, CY 1984

(NO. OF CASES PER 100 FTE EMPLOYEES)

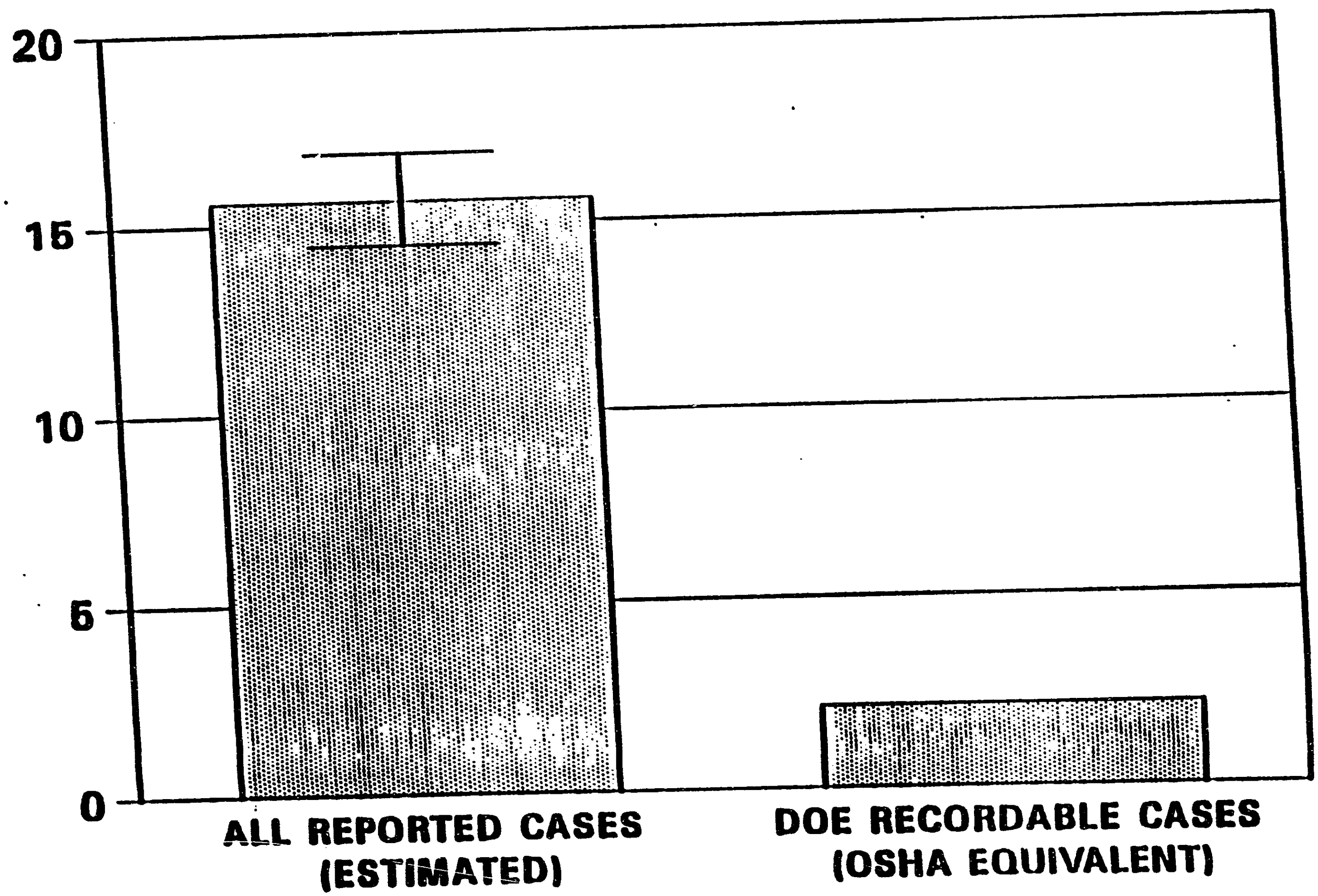


FIGURE 3

POTENTIAL CONTRIBUTION OF NON-WDL CASES TO LOST PRODUCTIVITY

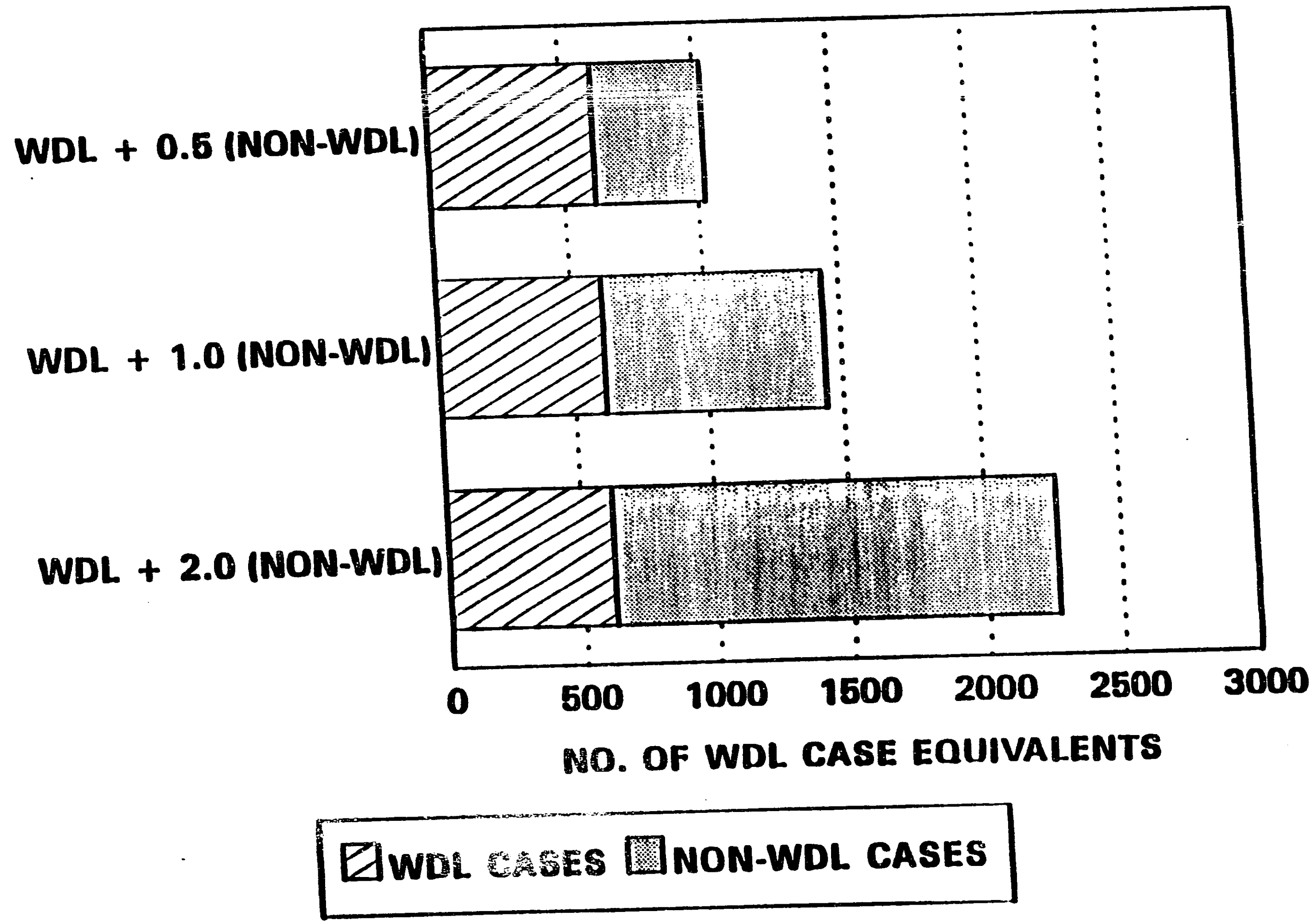
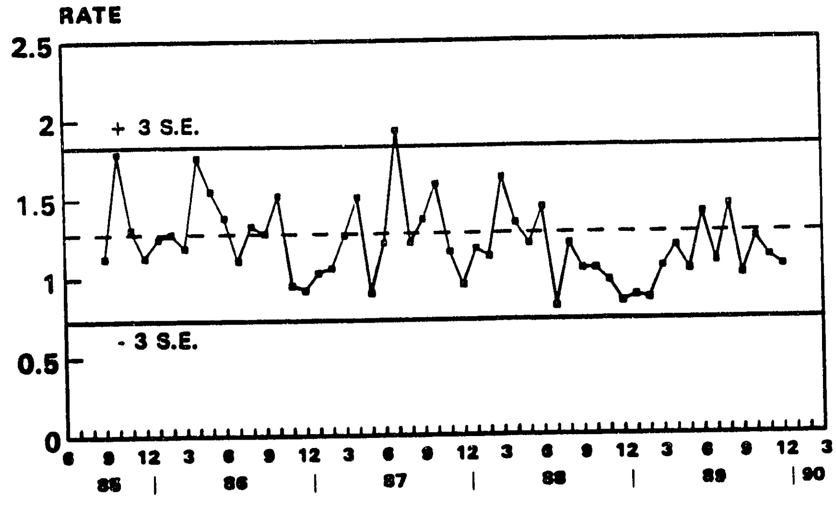


FIGURE 4

EXAMPLES OF TWO TYPES OF BNL/IPAG PROCESS CONTROL CHARTS FOR DISPLAYING THE SAME TIME TRENDED DATA

STANDARD u CHART

OCCUPATIONAL INJURY INCIDENCE RATE
(No. of Cases per 100 Person-Months)



CUSUM CHART

OCCUPATIONAL INJURY INCIDENCE RATE
(No. of Cases per 100 Person-Months)

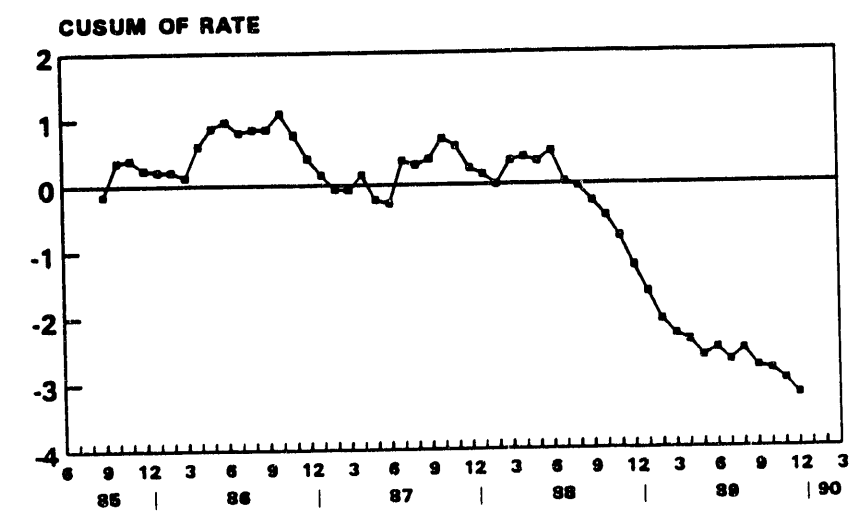


FIGURE 5

DATA BASE TYPES BY PERFORMANCE ASSESSMENT CATEGORY (PAC) AND PERFORMANCE ASSESSMENT FACTOR (PAF)

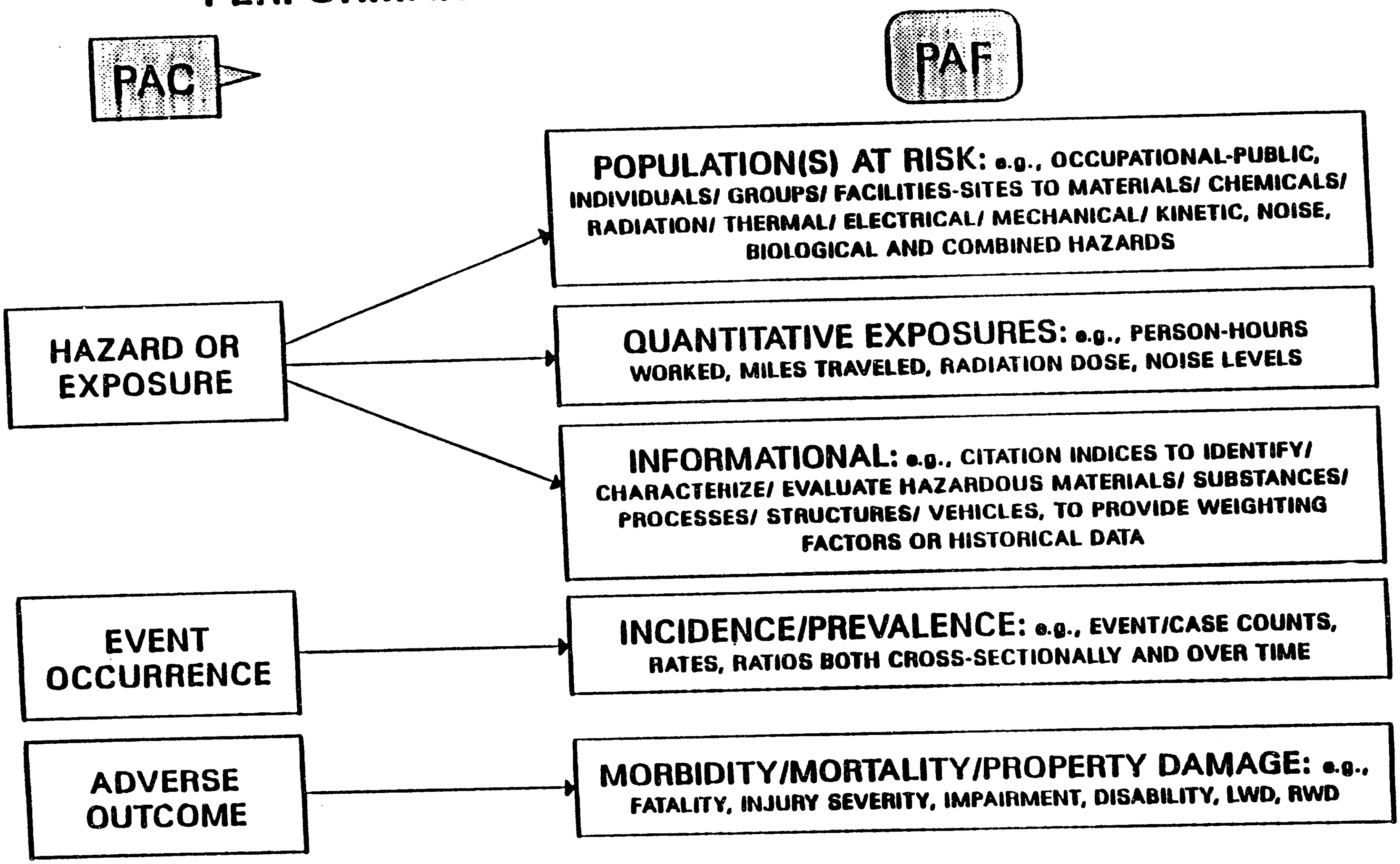


FIGURE 6

TIME-PHASE/RISK-CATEGORY MODEL

TIME PHASE	EXPOSURE-OUTCOME RISK CATEGORIES				
	HUMAN FACTORS	ENERGY TRANSMISSION VECTORS/AGENTS	EQUIPMENT PRODUCT SUBSTANCE MACHINERY FACTORS	ENVIRONMENTAL FACTORS OR HAZARDS	
				Physical Chemical Biological	Socioeconomic
PRE-EVENT					
EVENT					
POST-EVENT					
OUTCOME HUMAN DAMAGE PROPERTY/OTHER					

FIGURE 7

Task Performance Model

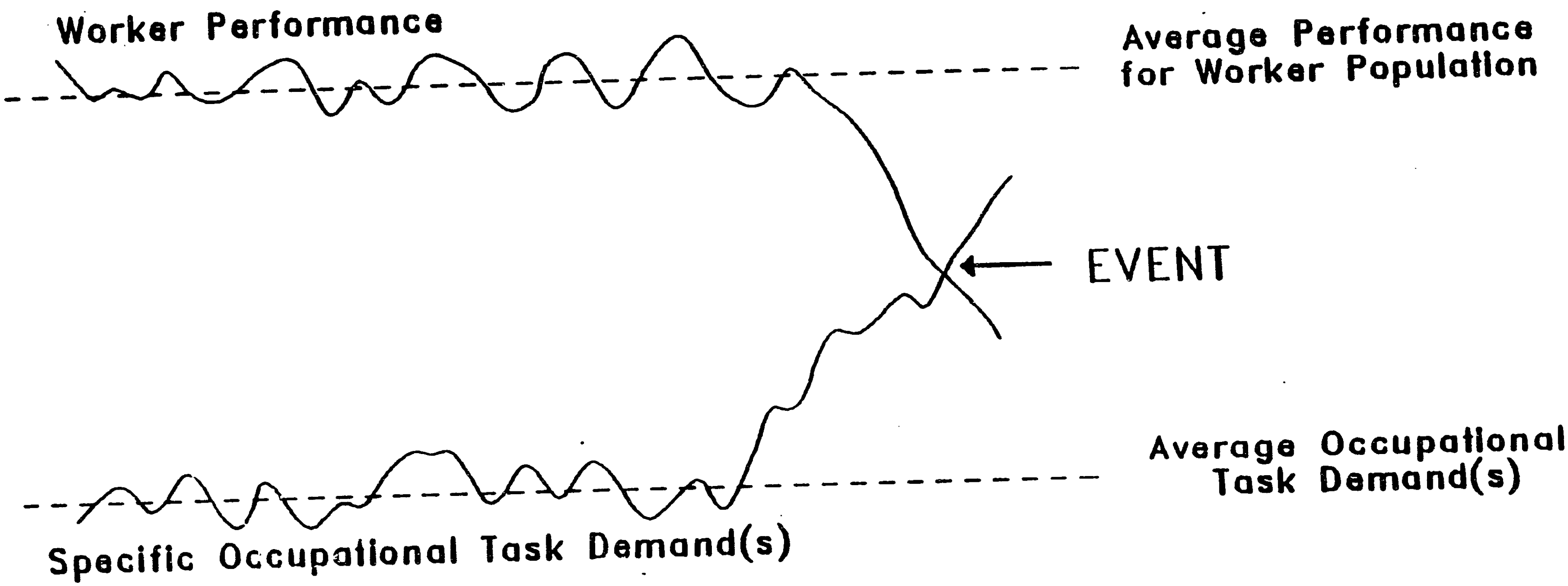


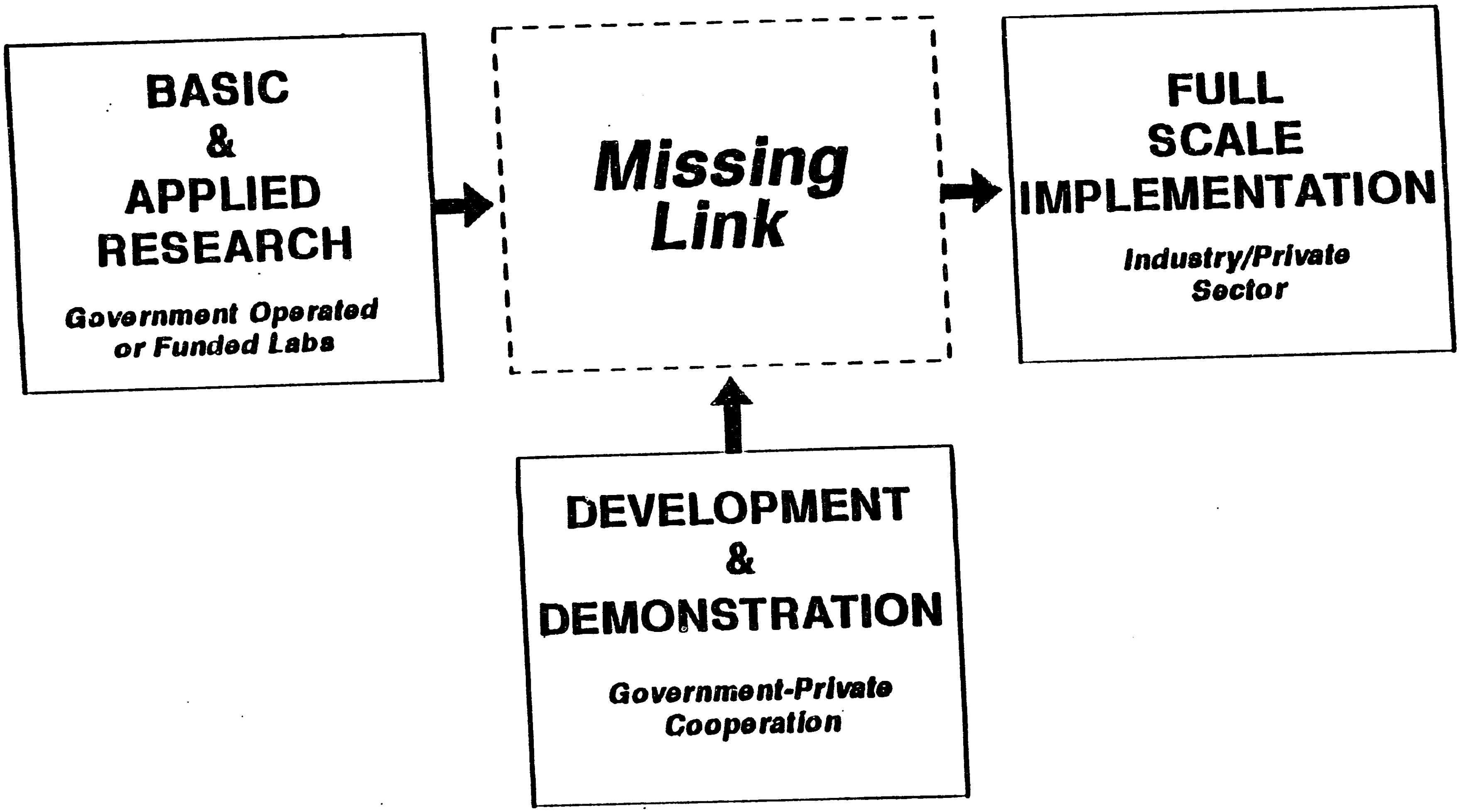
FIGURE 8

IPAG'S ACTION PLAN APPROACH TO MEASURE PERFORMANCE OF COMPLEX INDUSTRIAL SYSTEMS

- DOCUMENT EXISTING PRODUCT, PROCESS AND QUALITY CONTROL APPROACHES
- DEVELOP NEW PRODUCT, PROCESS AND QUALITY CONTROL STRATEGY
- IDENTIFY SENTINEL HUMAN, WORK ENVIRONMENT, AND AGENT/ENERGY FACTORS
- CORRELATE HAZARDOUS EXPOSURES WITH HUMAN INJURY/ILLNESS & PROPERTY/MATERIAL DAMAGE OUTCOMES
- CONVERT EXPOSURE-OUTCOME DATA TO FIT PRODUCT QUALITY, PROCESS CONTROL AND SYSTEMS MODELS
- SELECT KEY FACTORS FROM ESTABLISHED MODELS
- LINK AND APPLY DEMING AND HADDON PRINCIPLES TO IMPACT EXTERNALLY ON SYSTEM
- TEST, DEMONSTRATE AND FINE TUNE AT CAREFULLY SELECTED FACILITIES/SITES BEFORE FULL SCALE IMPLEMENTATION
- PROVIDE COMMUNICATIONS & FEEDBACK THROUGOUT EACH PHASE OF PROJECT/TASK DEVELOPMENT & DEMONSTRATION
- EMPHASIZE THE "BOTTOM LINE": PRODUCTIVITY, QUALITY AND COMPETITIVENESS

FIGURE 9

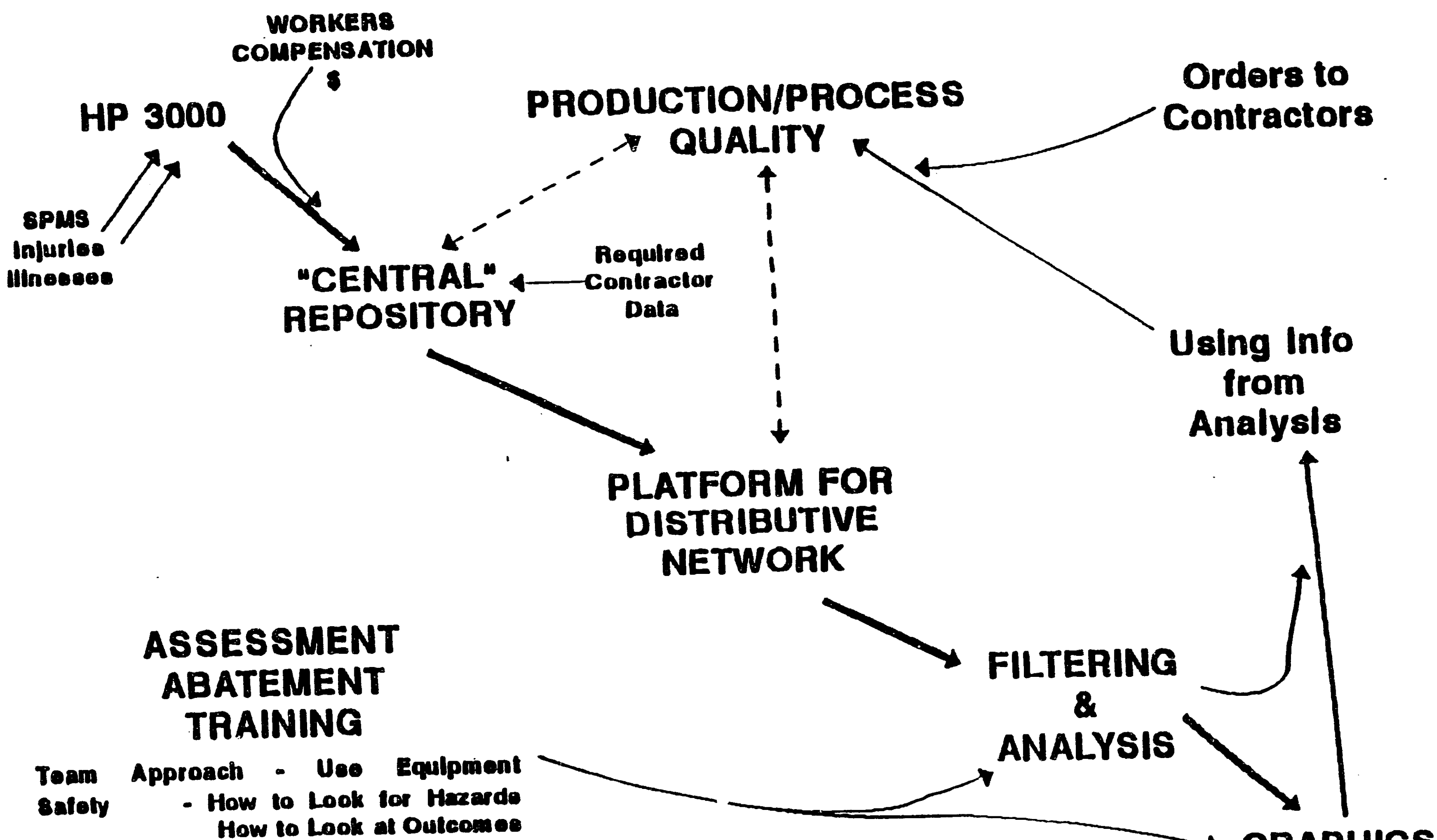
TECH-TRANSFER



From Government to Private Sector
From Government to Government Agency

FIGURE 10

DISTRIBUTED COMPUTER SYSTEM FOR PERFORMANCE MEASUREMENT



APPENDIX

A-I. CLASSIFICATION OF INJURY DIAGNOSES

Classification of injury diagnoses is a complex procedure requiring the use of standardized systems which would allow valid and reliable comparisons within and among various data bases. The International Classification of Diseases is a well established and accepted system for coding the cause and nature of injury and illnesses (28), while the Abbreviated Injury Scale (AIS) is a well recognized system for classifying severity of injury (39). For surveillance and intervention purposes it is important that the capability exists to classify injuries/illnesses by cause, type, anatomic site, anatomic severity, and outcome.

While OSHA/CAIRS do provide some outcome parameters (e.g., LWD/RWD, loss of consciousness, sutures) there is no systematic way, particularly for injuries, to determine cause, type, and anatomic location and severity. Using such standardized systems as the ICD and the 1985 Abbreviated Injury Scale with Epidemiologic Modifications enables (60,61) identification of specific cause (e.g., mine shaft/tunnel collapse, construction vehicle collision, fall from loading dock), type (fractured skull, hand laceration), and anatomic severity of cause specific injury. In addition ICD enables coding the nature of an illness to far greater specificity than that allowed in OSHA and CAIRS definitions.

Presently ICD-9-CM (International Classification of Diseases. 9th revision with Clinical Modifications) is the most widely recognized and utilized system for coding the nature of illness and injury, cause of injury, and medical procedures performed (e.g., suture, incision and drainage, surgical repair of hernia). ICD codes are required on all Medicare forms and on most private insurance forms (20).

AIS 85 is a system that classifies injuries by body region injured and organ or specific anatomic site within the body region (39). For each injury diagnosis a six digit numeric code is assigned. The first digit of that code identifies the overall body region (e.g, head, upper extremity), the second two digits identify specific site within a body region (e.g., hand), and the fourth and fifth digits denote the progression of severity within the specific site (e.g., Rib fracture (fx) NFS, 1 rib fx, 2 ribs stable chest). The exception to this coding structure is the AIS body region designated "external". In this category, any injury that occurs to the external part of the body is classified to the "external" region (e.g., contusions, abrasions, lacerations, burns). The sixth digit for both anatomic site specific and external designates the severity of the specific injury. The severity levels are as follows: 1=minor, 2=moderate, 3=serious, 4=severe, 5=critical, and 6=maximum injury, virtually unsurvivable (Figure A-1).

AIS 85-EM (epidemiologic modifications) was developed by IPAG to improve upon and expand the capabilities of AIS 85 primarily to meet surveillance, research, and evaluation needs (60,61). AIS 85 does not enable the coding of "external" injuries to a body region, nor does it allow for coding statement such as body contact ("I bumped against...") or pain to a body region. Yet, these descriptors are often the only statement in the medical record regarding the outcome of an injury (e.g, "my back hurts", "I bumped my head"). IPAG developed AIS 85-EM to enable coding of this type of information which is routinely available on medical records, but could not be coded using the standard AIS 85 coding system. A recent IPAG modification to AIS was the development of a separate code to denote whether a burn was thermal or chemical of origin. This is an important distinction for evaluating exposure cause and effect in an occupational setting.

A-II. IPAG OCCUPATIONAL SAFETY AND HEALTH INFORMATION SYSTEM

IPAG has designed selected components needed for performance measurement using system safety approaches which draw on the combined strengths of safety and systems engineering, "accident" analysis techniques (54), biostatistics, and clinical medicine. The overall objective is to develop and evaluate capabilities for exposure/occurrence/outcome assessment. To date limited available resources have been used to development the occurrence/outcome phase of the system. The development work has been completed in such a way that it can be linked to the exposure/occurrence data with validity and reliability.

The IPAG information system incorporates the Deming (Figure A-2) and Haddon (Figure A-3) strategies to an action oriented approach (62,63) aimed at hazard abatement. The IPAG system focuses on information, as distinguished from computer hardware and software. This information approach is suitable and adaptable to virtually any computer system, though the emphasis has been on linking a distributed network with a central data repository as needed. The IPAG system recognizes the need to approach prevention and control issues from a complex systems perspective (Figure A-4). The system links analytic models from human factors, engineering, medicine, and statistics, and addresses the need to develop minimum data sets rather than maximum data sets in order to provide managers of large complex systems with usable data evaluation for decision making. It utilizes established scientific abstracting and coding protocols to document cause, mechanism, nature, severity (for injury) of and adverse outcomes of hazardous events, regardless of OSHA recordability status. Thus, for example the initial encounter (such as the first visit to an occupational medicine clinic) becomes the basis for the case ascertainment, occurrence measurement, and outcome assessment. It is designed to be adaptable to a broad range of organizational types and settings and uses source documents (e.g., medical records, incident reports) and data bases to establish information representative of the organization (Figure A-5). It is capable of generating specific information appropriate to various levels of supervision, management, and administration.

The IPAG system components include (a) characterizing events systematically by measuring the incidence and outcome of cause-specific (injuries illnesses); (b) establishing a worker representative data base; (c) using this data base to set priorities for hazard abatement by applying findings from exposure/outcome, countermeasure, and related models; (d) ascertaining the feasibility of developing and implementing intervention strategies for hazard abatement; (e) demonstrating the effectiveness of selected intervention strategies before full scale implementation; and (f) utilizing this information or engineering control for policy and programmatic decision making to improve quality, productivity, and competitiveness.

The initial program designed and conducted by IPAG established a valid and reliable baseline of information on all occupational injuries occurring in 10 DOE contractor facilities employing over 46,000 full time equivalent (FTE) workers, representing a wide range of occupational and industrial groups. Comprising this work force are groups involved in research, engineering, production, construction, and service activities in these facilities. Each of the 10 facilities has individual methods and procedures for documenting occupational injuries/illnesses which needed to be converted to standardized injury exposure, occurrence, and outcome codes. These facilities are located in nine states, each with different administrative procedures for handling workers compensation cases. An abstract of the initial findings is presented in the Appendix.

A-III. KEY SELECT INJURY/ILLNESS ISSUES

A. Cumulative Trauma Disorders

Cumulative trauma disorders such as low back pain, carpal/tarsal tunnel syndrome, tendinitis, bursitis, epicondylitis are becoming major problems in the workplace (15). Cumulative trauma disorders due to the performance of repetitive tasks account for over 50% of occupational illnesses in the US (64). Thompson and Phelps called these disorders the "epidemic of the 1990's" (65). Repetitive motion related illnesses may initially manifest as occupational injuries (e.g., strains/sprains) or as nonspecific symptomatology (e.g., backache). Yet, these type of injuries and complaints are not considered "recordable" unless they result in lost or restricted work days, or require "medical treatment".

Low back pain is the complaint related to nearly 1/4 of all workers compensation cases and approximately 50 percent of workers' compensation costs (66). Surveillance systems that have the capability to focus on events leading to back pain (e.g., lifting, fall) would enable early identification of factors in the environment that could be controlled. Pickett, et al. found a high prevalence of physical complaints among data entry operators using video display terminals (67). Yet, other than the IPAG information system, no other current system exists which can track workers who "present" with complaints of pain when no definitive treatment or restriction is given. Surveillance systems are needed to identify early potential manifestations of physical and psychological trauma in order to identify potential problems before they meet "recordability" requirements, thereby enabling intervention measures prior to long term adverse health effects. However, at present no baseline data exists for cumulative trauma disorders and their causes.

Therefore, there is no baseline from which to determine the efficacy of intervention strategies.

B. Noise Induced Hearing Loss

An estimated 8 million workers in US manufacturing are exposed to work place noise levels of 80 dB or more daily; nearly one-third of these workers will eventually develop some level of hearing impairment (68). Yet, these workers exposed to industrial noise may not manifest the hearing loss initially. It may take as long as 10 years for initial onset of symptoms, since the destruction of the sensory cells in the ear is a gradual process (8). While OSHA now requires that audiometric tests be administered to noise exposed workers, results of these tests need to be collected over time to assess the scope of the problem and to determine the efficacy of selected intervention strategies.

C. Occupational Lung Disease

A number of chronic lung diseases are associated with occupational exposures. Among these are asbestosis, berylliosis, silicosis (exposure of persons in mining, sand and gravel operations, foundries, glass manufacturing, etc., to silica), byssinosis (primarily effecting cotton workers), and coal workers pneumoconiosis (68). Most of these, particularly asbestosis, have long latency periods, which can be 15 or more years. Cancers associated with asbestosis may not manifest until 20-40 years after the exposure. Confounding the issue is the interrelationship of other factors, such as smoking. At present there is no reliable data regarding exposure in the workplace, other concurrent exposures or potential early manifestation of symptoms that could be predictive of later respiratory diseases (15).

D. Ionizing Radiation

Ionizing radiation can directly disrupt cell nuclear material (DNA and RNA). This in turn can disrupt, permanently or temporarily (dependent on dose) the normal cell functioning (58). The largest man-made source of human irradiation is in the field of medical diagnosis and treatment. Other sources of radiation include exposure to radon (e.g, from burning of coal and natural gas and emanation from building materials).

Nuclear energy technologies produce radioactive substances normally found in nature at infinitesimally small levels. Persons in occupational categories related to the production of nuclear fission, nuclear research, x-ray technology, or high altitude flying are annually exposed to radiation above natural background levels. Various exposure limits exist for the general public and for those occupational groups routinely working with or exposed to ionizing radiation in the work environment.

While acute effects of large doses of radiation are well documented (e.g., blood dyscrasia, loss of hair), effects due to low levels of exposure are not known. Presently it is impossible to determine what the effects (if any) are of very low dose levels (1 rem or below). Of primary concern is the long range cumulative effects on various organ systems (e.g., tumor formation, leukemia) and the genetic effects which would manifest in offspring of exposed individuals.

Effective occupational injury/illness surveillance systems need to have the capability to track worker populations over periods measured in decades in order to determine if there are any long term exposure health effects.

E. Nonionizing Radiation Effects

Nonionizing radiation includes electromagnetic waves at lower frequencies such as microwaves, radio frequency transmission, and radiation from electrical distribution networks (58). While a number of researchers have expressed concern over the long term effects of nonionizing radiation (Wertheimer, etc), no definitive data to date has substantiated any direct correlation of nonionizing radiation and adverse health effects.

F. Select Toxic Effects

A number of chemicals used in industry have been shown to impair reproductive function. Various studies (primarily conducted on animals) have implicated heavy metals such as lead and cadmium, volatile organochlorines, pesticides, and organic solvents to adverse reproductive effects (58,68). Chromosomal abnormalities and increases in spontaneous abortions have been reported among wives of workers exposed to vinyl chloride (58).

Other chemicals and compounds have known carcinogenic effects. Benzene and polycyclic aromatic hydrocarbons (PAH) are examples of such chemicals. Benzene has been linked with an increased incidence of leukemia, and anthracene (a PAH), a derivative of coal tar has been shown to produce skin and scrotal cancers. Metallic compounds such as nickel have caused an increased risk of nasal cavity and lung cancers in workers who are heavily exposed to crude nickel ore dust, and arsenic exposure has been strongly associated with skin and lung cancer (58).

In addition, there are a number of chemicals that have been related to various other toxic effects. For example, acid gases, phenols, and various alcohols are powerful skin irritants. Carbon monoxide (CO), formaldehyde, and select nitroaromatics have shown to effect the central nervous system.

Chronic low ambient air levels of carbon monoxide have been demonstrated to effect psychomotor performance, visual perception, and concentration (58).

While the overall effect of toxic substance exposure in the workplace is unknown, various studies to date have linked workplace exposure to various physiological and psychological effects. Occupational injury/illness information systems need to address the confounding factor of toxic exposures (including exposures within accepted threshold limits) when developing exposure/outcome measurements.

G. Motor Vehicle Injuries

Motor vehicle injuries are the leading cause of work related fatalities. In 1990, 35 percent of all work related deaths, and 3 percent of all work related injuries involving disability, were attributed to motor vehicles (9). DOE's focus on the safety and transportation of waste and hazardous materials have failed to address the most fundamental problem inherent to this issue, that of injuries/death resultant from crash events.

H. Leading Work Related Injuries and their Causes

Based on a study conducted by IPAG the leading types of work related injury are lacerations and contusions. Leading causes of injuries were struck/caught and cutting/piercing. However, the leading cause of work day lost injuries was overexertion/strenuous movement (10). According to the Bureau of Labor statistics nearly 31 percent of all disabling work injuries in 1988 resulted from overexertion, 24 percent from being struck by or against an object, and 17 percent from falls (9).

TABLES AND FIGURES

TABLE A-1

Selected Potential Data Sources for Performance Benchmarks

DB No.	Data Base	Agency/ Source	Time Span	Minimum Unit of Specificity			PAC	Comments
				Place	Population	Time		
01A	CAIRS (Computerized Accident/Incident Reporting System)	DOE-EG & G Idaho	1981 -	Site/Dept.	Case	Date	Occurrence Outcome	Limited to "reportable" events
01B	CHEMS (Chemical Hazard Emergency Management System)	DOE-EG & G Idaho	N/A	N/A	Chemical & Hazardous Material	N/A	Exposure (informational)	Provides safety and health information on specific substances
01C	CATS (Computer Assisted Tracking System)	DOE-EG & G Idaho	N/A	N/A	N/A	N/A	Exposure	N/A
01D	REM (Radiation Exposure Module)	DOE-EG & G Idaho	1986 -	Site	Case Facility	Annual	Exposure	Annual dose to individuals obtained using locator files
01E	UORS (Unusual Occurrence Reporting System)	DOE-EG & G Idaho	N/A	Site/Dept.	Occurrence	Date	Exposure	N/A
01F	ORPS (Occurrence Reporting and Processing System)	DOE-EG & G Idaho	N/A	N/A	N/A	N/A	Exposure	N/A
2A	DOE Occupational Injury Study	DOE-BNL	1984	Facility	Case	Date	Occurrence Outcome	N/A
2B	BNL Cross-sectional and Longitudinal Analysis	DOE-BNL	1984-1989	BNL	Case	Date	Occurrence Outcome	N/A
03	RAC (Risk Assesment Categories)	DOE-BNL	N/A	BNL	N/A	N/A	Exposure	N/A
04	Airport	DOE-ORNL	N/A	Individual airport	Individual airport	N/A	Exposure	N/A
05	County Level Data	DOE-ORNL	N/A	County	N/A	N/A	Exposure	N/A
06	Decommissioning Nuclear Facilities	DOE-ORNL	N/A	N/A	N/A	N/A	Exposure	N/A
07	Environmental Mutagen, Carcinogen and Teratogen Information Program	DOE-ORNL	Current	N/A	Substance	N/A	Exposure (informational)	Provides safety and health information on specific agents

TABLE A-1
(Continued)

DB No.	Data Base	Agency/ Source	Time Span	Minimum Unit of Sp[illegible]ity			PAC	Comments
				Place	Population	Time		
08	Highway	DOE-ORNL	N/A	N/A	N/A	N/A	Exposure	N/A
09	Interline	DOE-ORNL	N/A	N/A	N/A	N/A	Exposure	N/A
10	Nuclear Operations Analysis Center	DOE-ORNL	1965-?	N/A	Event	N/A	Exposure	N/A
11	Data Base of Historical and Archaeological Sites in the USOC	DOE-ANL	N/A	N/A	N/A	N/A	Exposure	N/A
12	Information on Nuclear Sites	DOE-ANL	N/A	N/A	N/A	N/A	Exposure	N/A
13	Crude Oil Production	DOE-Bartlesville	N/A	N/A	N/A	N/A	Exposure	N/A
14	NIPER (National Institute for Petroleum and Energy Research)	DOE-Bartlesville	N/A	N/A	N/A	N/A	Exposure	N/A
15	GURF (Generating Unit Reference File)	DOE/NEIC	N/A	N/A	Individual generating units	N/A	Exposure	N/A
16	National Energy Technology Data Center	DOE/NETDC	N/A	N/A	N/A	N/A	Exposure	N/A
17	NOx Data File	DOE/NETDC	N/A	N/A	N/A	N/A	Exposure	N/A
18	Utility Data File	DOE/NETDC	N/A	N/A	N/A	N/A	Exposure	N/A
19	National Uranium Resource Evaluation	DOE/USGS	N/A	N/A	N/A	N/A	Exposure	N/A
20	RAMPAC (Radioactive Materials Packaging)	DOE/SAIC	N/A	N/A	N/A	N/A	Exposure	N/A
21	Residential Energy Conservation	DOE/EIA	N/A	N/A	N/A	N/A	Exposure	N/A
22	TIMS (Transportation Information Management System)	DOE-Battelle (WA)	N/A	N/A	N/A	N/A	Exposure	N/A
23	TLDB (Transportation	DOE-Battelle	N/A	N/A	N/A	N/A	Exposure	N/A

TABLE A-1
(Continued)

DB No.	Data Base	Agency/ Source	Time Span	Minimum Unit of Specificity			PAC	Comments
				Place	Population	Time		
24	Annual Electric Generator Repor (Report)	DOE(NTIS)	1986	N/A	Individual Generating Units	N/A	Exposure	N/A
25	Electric Power Use Industries (Report)	DOE(NTIS)	1972-	N/A	Industry	Monthly	Exposure	N/A
26	End Use Energy Consumption Data Base: Transportation Sector (Report)	DOE(NTIS)	1967-1976	State	N/A	Annual	Exposure	N/A
27	Employment Hours and Earnings	DOL/BLS	N/A	N/A	N/A	N/A	Exposure	N/A
28	Annual Survey of Occupational Injuries and Illnesses	DOL/BLS-Office of Occupational Safety and Health Statistics	N/A	N/A	N/A	N/A	Occurrence Outcome	N/A
29	Work Injuries and Illnesses Supplementary Data System	DOL/BLS - Office of Occupational Safety and Health Statistics	N/A	N/A	State	Annual	Occurrence Outcome Exposure	Workers Compensation cases only; not all states participate
30	LABSTAT (Labor Statistics)	DOL/BLS	N/A	N/A	N/A	N/A	Occurrence Outcome Exposure	N/A
31	Annual Survey of Occupational Injuries and Illnesses	DOL/BLS	1972-	State	N/A	N/A	Occurrence Outcome	Sample; limited to private sector establishments with eleven or more employees
32	Current Population Survey	DOL/BLS	N/A	N/A	N/A	N/A	Exposure	Limited to workers with work disability
33	Occupational Employment Statistics	DOL/BLS	1977-	N/A	N/A	N/A	Exposure	N/A
34	OWCP (Office of Workers Compensation Programs Files)	DOL/Employment Standards Administration	N/A	N/A	N/A	N/A	Outcome	Federal employees and longshore/ harbor workers; only those receiving benefits

TABLE A-1
(Continued)

DB No.	Data Base	Agency/ Source	Time Span	Minimum Unit of Specificity			PAC	Comments
				Place	Population	Time		
35	MSHA (Mine Safety and Health Admininstration)	DOL/MSHA	N/A	Mine	N/A	Annual	Occurrence Outcome Exposure	Only mines with ten or more employees
36	Ohio Industrial Commission	State	N/A	N/A	N/A	N/A	N/A	N/A
37	Nevada State Industrial Insurance System	State	N/A	N/A	N/A	N/A	N/A	N/A
38	Texas Industrial Accident Board	State	N/A	N/A	N/A	N/A	N/A	N/A
39	Division of Occupational Safety and Health, Texas	N/A	N/A	N/A	N/A	N/A	N/A	N/A
40	Washington State Work Injury and Illness Summary	N/A	N/A	N/A	N/A	N/A	N/A	N/A
41	Official State Vehicular Crash Report Files	Individual State	N/A	N/A	N/A	N/A	N/A	N/A
42	Insurance Industry Casualty/Health/ Medical/Disability	Individual Company Industry Associations State Insurance Departments	N/A	N/A	Individual Cases and Group Data	N/A	N/A	Varies by source
43	Occupational Injury and Death Rates, National Safety Council	NSC	N/A	N/A	N/A	N/A	Occurrence Outcome	N/A
44	Injury Incidence by Principal Injury, National Safety Council	NSC	N/A	N/A	N/A	N/A	Occurrence Outcome	Estimates compiled from a number of data sources

TABLE A-1
(Continued)

DB No.	Data Base	Agency/ Source	Time Span	Minimum Unit of Specificity: Place	Population	Time	PAC	Comments
45	Workers' Compensation Cases, National Safety Council	NSC	N/A	N/A	N/A	N/A	Outcome	Summaries statistics from official sources
46	National Vital Statistics Mortality Data	NCHS (National Center for Health Statistics, United States Public Health Service)	N/A	Minor Civil Division	N/A	N/A	Outcome	100% U.S. morbility
47	National Hospital Discharge Survey	NCHS	N/A	National Regional	N/A	N/A	Occurrence	N/A
48	FARS (Fatal Accident Reporting System)	DOT/NHTSA (National Center for Statistics and Analysis, National Highway Traffic Safety Administration)	1975-	County Municipality	Event	N/A	Occurrence Outcome	100% U.S. events involving fatality within 30 days post-crash
49	NASS (National Accident Sampling System)	DOT/NHTSA	N/A	Regional	Case	N/A	Occurrence Outcome	U.S. representative sample, vehicular injuries
50	NEISS (National Electronic Injury Surveillance System)	Consumer Product Safety Commission Selected Occupational Data	1972-	National	U.S. representative sample	Annual	Occurrence Outcome	Surveillance of sample of hospital emergency departments
51	NTOF (National Traumatic Occupational Fatality)	National Institute for Occupational Safety and Health, Division of Safety Research	N/A	N/A	N/A	N/A	N/A	N/A
52	Behavioral Risk Factor	Centers for Disease Control	N/A	N/A	N/A	N/A	N/A	N/A

TABLE A-1
(Continued)

DB No.	Data Base	Agency/ Source	Time Span	Minimum Unit of Specificity			PAC	Comments
				Place	Population	Time		
53	NFIRS (National Fire Incident Reporting System)	National Fire Data Center	N/A	N/A	N/A	N/A	N/A	N/A
54	United States Department of Justice	Federal Bureau of Investigation	N/A	N/A	N/A	N/A	N/A	N/A
55	National Crime Surveys	Bureau of Justice Statistics	N/A	N/A	N/A	N/A	N/A	N/A
56	BARS (Boating Accident Reporting System)	USCG - State Boating Law Administration	N/A	N/A	N/A	N/A	N/A	N/A
57	DAWN (Drug Abuse Warning Network)	National Institute on Drug Abuse, Division of Epidemiology and Statistical Analysis	1980-	N/A	N/A	N/A	Occurrence Outcome	Hospital emergency room visits in 26 metropolitan areas
58	National Burn Registry	NBIE (National Burn Information Exchange)	N/A	N/A	N/A	N/A	N/A	N/A
59	Regional Spinal Cord Injury Systems	National Spinal Cord Injury Statistical Center	N/A	N/A	N/A	N/A	N/A	N/A
60	AAPCC (American Association of Poison Control Centers) National Data Collection	National Capital Poison Center	N/A	Regional	N/A	N/A	Occurrence Outcome	N/A
61	Vital statistics records	State offices of vital statistics	N/A	Town	N/A	N/A	Outcome	N/A
62	UHDDS (Uniform Hospital Discharge Data Sets)	Varies by state	N/A	State	N/A	N/A	N/A	N/A

TABLE A-1
(Continued)

DB No.	Data Base	Agency/ Source	Time Span	Minimum Unit of Specificity: Place	Population	Time	PAC	Comments
63	Medical examiners'/coroners' reports	Coroners' offices, medical examiners' offices	N/A	Locality	Case	Date	Outcome	N/A
64	Medicaid/Medicare	Varies by state	N/A	State	N/A	N/A	N/A	N/A
65	Emergency room records	Hospital emergency rooms	N/A	Locality	Case	Date	Occurrence Outcome	N/A
66	Ambulance and emergency medical service records	State bureaus or divisions of emergency medical services	N/A	Locality	Case	Date	Occurrence Outcome	N/A
67	Police reports	Local and state law enforcement agencies	N/A	Locality	N/A	N/A	Occurrence Outcome Exposure	N/A
68	State fire marshal records	State fire marshal's office or equivalent	N/A	Locality	N/A	N/A	Occurrence Outcome Exposure	N/A
69	Trauma registers	Level 1 regional trauma centers, varies by center	N/A	Locality	N/A	N/A	Occurrence Outcome	Center to center variability in data definition and collection
70	Air Emissions from Treatment Storage and Disposal Facilities for Hazardous Waste	EPA	N/A	N/A	N/A	N/A	Exposure	N/A
71	Asbestos Information System	EPA	N/A	N/A	N/A	N/A	Exposure	N/A
72	GENETOX (Mutagenicity Data Base)	EPA	Current	N/A	Substance	N/A	Exposure (informational)	Contains mutagenicity information on chemicals
73	Occupational Radiation Data Files	EPA	1970, 1980	N/A	N/A	N/A	Exposure	N/A
74	CHEMTRACK	EPA/NIEHS	Current	N/A	Substance	N/A	Exposure (informational	Toxicity test data for chemical compounds

TABLE A-1
(Continued)

DB No.	Data Base	Agency/ Source	Time Span	Minimum Unit of Specificity			PAC	Comments
				Place	Population	Time		
75	U.S. Census	N/A	1990	Minor Civil Division	Census tract	1990	Exposure	N/A
76	DARTS (Defense Accident Reporting and Tracking System)	DOD	N/A	Worldwide United States Armed Forces	N/A	Monthly Reports	Occurrence Outcome	Differences between services reporting methods
77	Nuclear Information Center	N/A	N/A	N/A	N/A	N/A	N/A	N/A
78	Survey of Disability and Work	N/A	N/A	N/A	N/A	N/A	N/A	N/A
79	CDHS (Continuous Disability History Sample)	DHHS	1966-	N/A	Case	N/A	Exposure Outcome	Limited to persons filing for SS disability benefits; sample of all cases
80	SMIS (Safety Management Information Systems)	DHHS	N/A	N/A	N/A	N/A	N/A	N/A
81	NAMCS (National Ambulatory Medical Care Survey)	DHHS(NTIS)	N/A	N/A	N/A	N/A	Occurrence Outcome	Sample of ambulatory visits to physicians in an office setting
82	NHIS (National Health Interview Survey)	DHHS(NTIS)	1969-	N/A	N/A	N/A	Occurrence Outcome	N/A
83	NMCUES (National Medical Care Utilization Expenditure Survey)	DHHS(NTIS)	N/A	N/A	N/A	N/A	Exposure Occurrence Outcome	N/A
84	RAIRS (Railroad Accident/Incident Reporting System)	DOT/Federal Railroad Administration	N/A	N/A	N/A	N/A	Occurrence Outcome	Limited to "reportable" events; railway injuries (occupational and other)
85	TRANSIS (Transportation Safety Information System)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
86	AIDS (Accident/Incident Data System)	DOT/FAA	N/A	Aircraft	N/A	Event	Occurrence Outcome Exposure	Aviation industry only

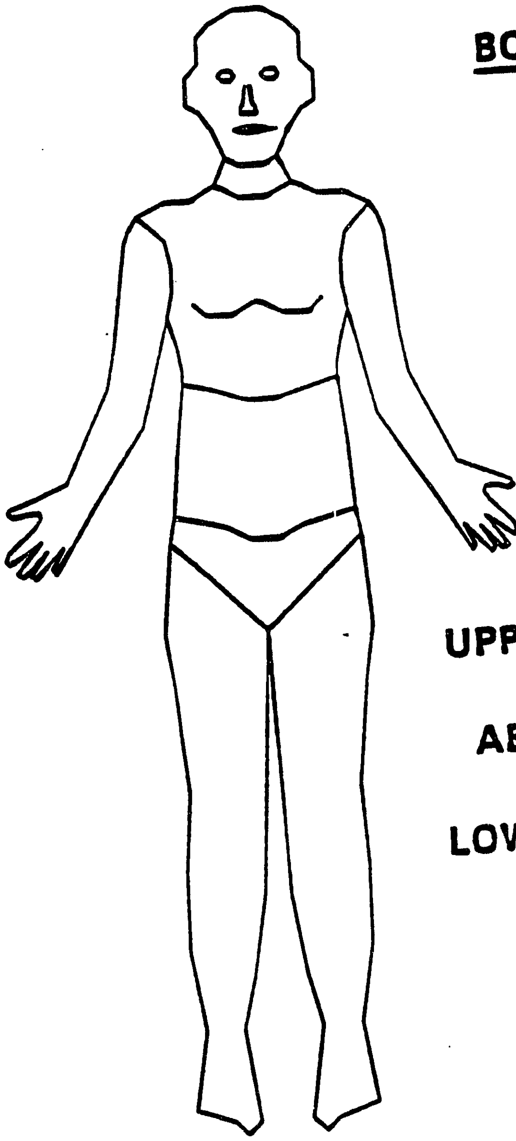
TABLE A-1
(Continued)

DB No.	Data Base	Agency/ Source	Time Span	Minimum Unit of Specificity			PAC	Comments
				Place	Population	Time		
87	HAZMET or HMIS	DOT	1976-	N/A	N/A	N/A	N/A	Injuries/illnesses/fatalities as a direct result of hazardous material
88	Commercial Vessel Casualty File	DOT/USCG	1963-	Vessel	Case	Date	Occurrence Outcome Exposure	N/A
89	Pollution Incident Reporting System	DOT/USCG	1973-	N/A	N/A	N/A	Exposure	Oil/chemical spills in U.S. waters
90	Truck Accident File	DOT	1973-	N/A	N/A	N/A	Occurrence Outcome Exposure	For those in interstate or foreign commerce
91	AIIRS (Occupational Accident/Injury/Illness Reporting System)	DOL/OASAM	N/A	N/A	N/A	N/A	N/A	N/A

NOTE: N/A Not available from published bibliographical and related documents available for review during the report preparation period.

FIGURE A-1

AIS 85-EM



BODY REGIONS

HEAD

FACE

NECK

THORAX

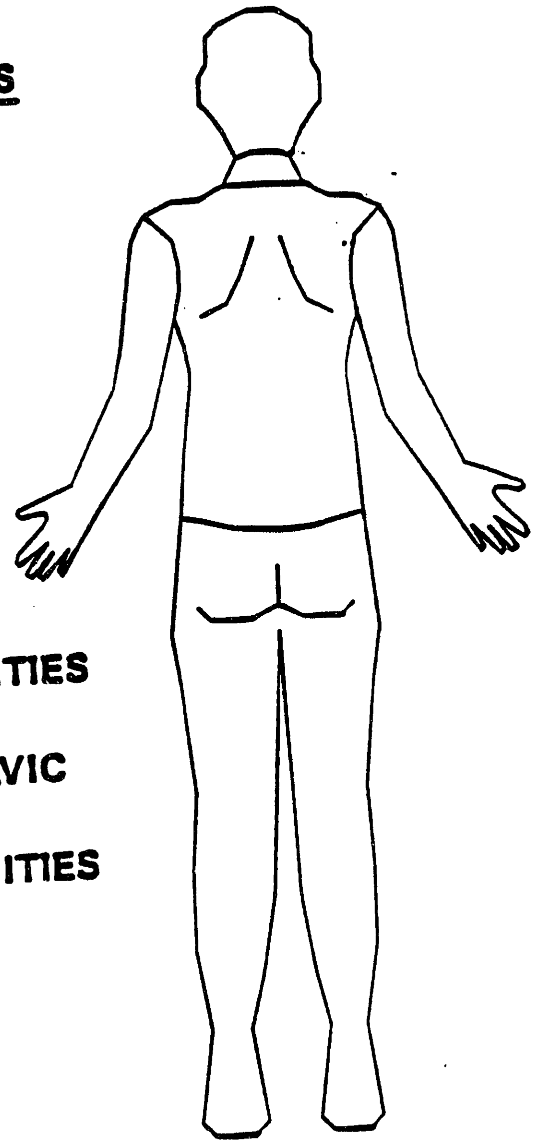
BACK

UPPER EXTREMITIES

ABDOMEN/PELVIC

LOWER EXTREMITIES

EXTERNAL



SEVERITY CODES

1 MINOR
2 MODERATE
3 SERIOUS
4 SEVERE
5 CRITICAL
6 MAXIMUM INJURY, VIRTUALLY UNSURVIVABLE

0 NO INJURY
7 PAIN
8 RULE OUT
9 CONTACT

FIGURE A-2

DEMING'S 14 POINTS

- CREATE CONSTANCY OF PURPOSE
- ADOPT THE NEW PHILOSOPHY
- CEASE DEPENDENCE ON MASS INSPECTION
- CONSTANTLY AND FOREVER IMPROVE THE SYSTEM
- REMOVE BARRIERS
- DRIVE OUT FEAR
- BREAK DOWN BARRIERS BETWEEN DEPARTMENTS
- ELIMINATE NUMERICAL GOALS
- ELIMINATE WORK STANDARDS
- INSTITUTE MODERN METHODS OF SUPERVISION
- INSTITUTE MODERN METHODS OF TRAINING
- INSTITUTE A PROGRAM OF EDUCATION AND RETRAINING
- END THE PRACTICE OF AWARDING BUSINESS ON PRICETAG
- PUT EVERYBODY TO WORK TO ACCOMPLISH THE TRANSFORMATION

FIGURE A-3

CRITERIA FOR PERFORMANCE BENCHMARKS*

- PREVENT THE CREATION OF THE HAZARD IN THE FIRST PLACE
- REDUCE THE AMOUNT OF THE HAZARD BROUGHT INTO BEING
- PREVENT THE RELEASE OF THE HAZARD THAT ALREADY EXISTS
- MODIFY THE RATE OR SPATIAL DISTRIBUTION OF RELEASE OF THE HAZARD FROM ITS SOURCE
- SEPARATE, IN TIME OR SPACE, THE HAZARD AND THAT WHICH IS TO BE PROTECTED
- SEPARATE THE HAZARD AND THAT WHICH IS TO BE PROTECTED BY INTERPOSITION OF A MATERIAL BARRIER
- MODIFY RELEVANT BASIC QUALITIES OF THE HAZARD
- MAKE WHAT IS TO BE PROTECTED MORE RESISTANT TO DAMAGE FROM THE HAZARD
- BEGIN TO COUNTER THE DAMAGE ALREADY DONE BY THE ENVIRONMENTAL HAZARD
- STABILIZE, REPAIR, AND REHABILITATE THE OBJECT OF DAMAGE

* ADAPTED FROM HADDON'S 10 FACTOR INTERVENTION STRATEGY

FIGURE A-4

ALTERNATIVE APPROACHES TO OBTAIN DATA FOR DECISION MAKING IN COMPLEX SYSTEMS

CURRENT EMPHASIS

Maximum Data Sets

Engineering Focus

CAUSAL SEQUENCE

- *"accident" investigation*
- *event reconstruction*
- *precursors*

Medical Focus

ADVERSE EFFECT

- *trauma registries*
- *acute care*
- *antecedent factors*

Detailed Data on Limited Number of Events

Tendency to Focus on Low Prob/High Consq Events

Concerns about Predictive Capability

NEEDED EMPHASIS

Minimum Data Set

IPAG Focus

CAUSE ⇄ EFFECT

- *links engineering & medical with epidemiologic*
- *builds on representative minimum data set*
- *selects priorities systematically*
- *cross-sectional & longitudinal analyses*

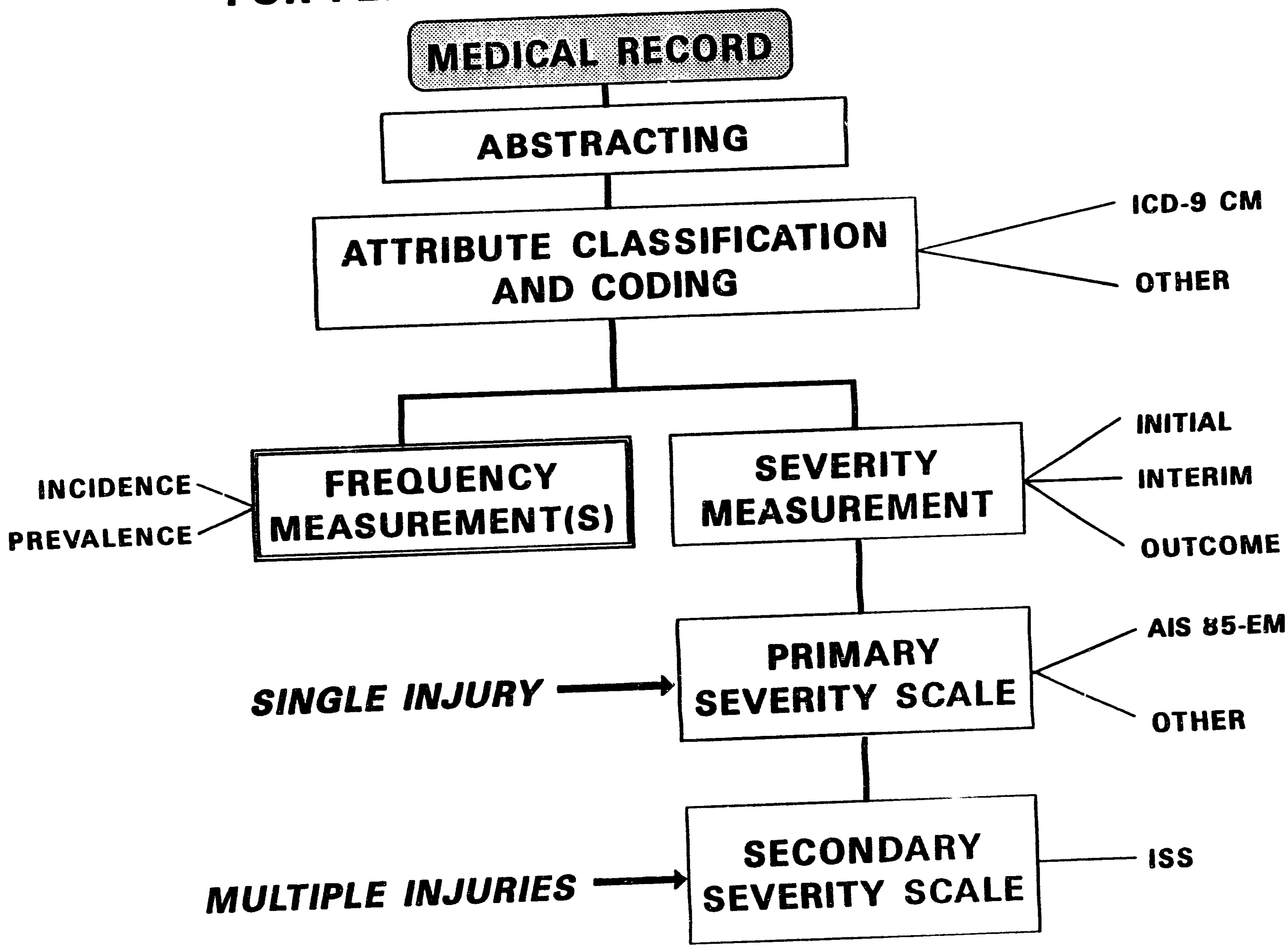
Data on ALL Injury/Illness Producing Events & Their Costs

Identification of Relationships between High Prob/Low Consq and Low Prob/High Consq Events

Improved Predictive & Preventive Capabilities

FIGURE A-5

PRIMARY EVENT OCCURRENCE DATA RESOURCE FOR PERFORMANCE BENCHMARKS



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