WORKER PROTECTION PROGRAMS IN CONSTRUCTION

Final Report

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Prepared for:

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WORKER PROTECTION PROGRAMS IN CONSTRUCTION

EXECUTIVE SUMMARY

Although injury and fatality rates in many industry sectors have declined significantly in the twenty-three years since the Occupational Safety and Health Administration (OSHA) came into being, this has not been the case in construction, the country's largest industry and one that has consistently registered high rates of workplace accidents. OSHA has had little success in reducing injuries and fatalities among construction workers, despite the fact that it channels a large portion of its resources into the enforcement of health and safety standards on construction sites. Construction workers are exposed to a wider variety of hazards and face a greater risk of work-related injury or fatality than employees in any other U.S. industry; in 1992, according to the most recent annual Bureau of Labor Statistics data, the lost-workday case rate for the construction industry was 5.7 per 100 full-time workers, the highest of any major economic sector. To address the problem of recalcitrant injury and fatality rates in construction, OSHA has recently undertaken a number of initiatives, including creation within the Agency of an Office of Construction and Engineering and redesign of the targeting system used to schedule on-site inspections in this sector.

Within this framework, OSHA's Office of Program Evaluation contracted with Meridian Research to:

- Review the recent business and trade literature to identify successful accident prevention programs in the construction industry;
- Compare the safety management practices applied or recommended by government agencies, States, and national and international organizations for the construction projects they fund and/or oversee;
- Describe the impact of worker protection programs on the accident and injury rates of construction companies that have implemented these programs; and
- Analyze the recent literature to identify any secondary benefits--such as reduced costs, improved employee morale, and enhanced productivity--generated by successful worker protection programs.

Meridian's research found general agreement among authors--from both the academic community and the construction industry--that well-designed safety and health management

programs can indeed cut accident rates dramatically and stem increases in workers' compensation costs. Cost-benefit data generated by companies implementing such programs confirm their "bottom line" advantages. For example, Gulf States, Inc., a large specialty-trade contractor, estimates that its worker protection program prevented 267 lost-workday injuries and saved $5.3 million in costs in a 3-year period, and the M.B. Kahn Construction Company, a much smaller general contractor, reports savings of $725,000 over 3 years and an 80-percent decline in its OSHA recordable incident rate since implementation of its program.

The costs associated with the development and implementation of worker protection programs are minimal compared with the benefits returned by these programs. For example, the Pizzagalli Construction Company estimates that it spends about $100,000 annually on its program but saves six times as much in workers' compensation costs alone. The Corps of Engineers, whose exemplary worker protection program has achieved injury rates approximately one-fifth the national average, estimates that these programs save contractors a minimum of 0.5 to 1.0 percent of total project costs. For the construction industry as a whole, the net cost savings associated with worker protection programs could be as high as $16 billion per year. Construction industry employers should thus regard worker protection programs as opportunities for reducing the death and injury toll in construction while simultaneously realizing substantial cost savings.

I. STATEMENT OF THE PROBLEM

Occupational safety and health professionals have consistently stressed the importance of effective management practices in reducing workplace injury and illness. Of the many OSHA initiatives aimed at promoting effective worker protection programs, two merit special attention in the framework of the present study:

- Publication, in 1989, of voluntary Safety and Health Program Management Guidelines (54 FR 3904) for employers in general industry, shipyards, marine terminals, and longshoring activities;

- Creation of the Voluntary Protection Program (VPP), designed to give public recognition to businesses that have established exemplary occupational safety and health programs and achieved outstanding results in the drive to eliminate worksite accidents and injuries.

Both the Guidelines and the VPP believe that the following elements are essential to an effective worker protection program:

- Management commitment;
- Employee involvement;
- Worksite analysis;
- Hazard prevention and control;
- Safety and health training.

In recent years, interest in worker protection programs (also called accident prevention programs and comprehensive occupational safety and health programs) has increased at the State level and in the U.S. Congress. Since 1990, several States (e.g., North Carolina, Tennessee, Nevada, and Minnesota) have passed laws and regulations mandating the development and implementation of such programs, and two other States (Oregon and California) have redefined and revitalized their existing program requirements. Bills that would require comprehensive accident prevention programs in most workplaces were introduced in the last two Congresses; similar bills are under consideration in the present Congress. Proponents of these measures hope to reduce the number of injuries, occupational illnesses, and fatalities that occur in American workplaces, as well as to stem the ever-increasing growth in workers' compensation claims.

No business sector would appear to have more to gain from these efforts than the construction industry, which has been characterized historically by the highest injury and fatality

rates of any economic sector in the United States except mining. The human suffering behind the statistics defies quantitative measurement: not so the cost of workers' compensation, which has more than tripled over the last 10 years. To address this problem, individual States, some agencies, and a number of national and international organizations with construction oversight authority have used the five elements set forth on the preceding page as a cornerstone for the development and implementation of accident prevention policies and procedures tailored specifically to this high-risk business. The Mecklenburg, North Carolina Engineering Department, for example, has succeeded in reducing its work-related injuries--and their associated costs--by two-thirds over the 1985-1990 period, largely by implementing a comprehensive team safety program. On the single-company level, excellent results have also been achieved within the framework of a comparable program implemented on the opposite side of the country: thanks to a rigorous safety management program adopted at all of its worksites, a Vermont-based heavy construction firm has reduced its lost-workday case rate by 33 percent and its workers' compensation costs by 76 percent, all within a three-year period.

Persuasive evidence in favor of comprehensive worker protection programs in construction is also to be found in the injury and illness records of firms working under contract to the U.S. Corps of Engineers. The Corps imposes contractual requirements on its contractors for written safety and health programs, worksite analyses, hazard prevention and control measures, and safety and health training. It ensures compliance with these provisions by reviewing each contractor's program documentation at all major project stages, conducting frequent on-site inspections, and requiring regular, on-going training for all employees and supervisors. The results of the Corps' program have been dramatic: between 1984 and 1988, U.S. Corps of Engineers contractors registered an average lost-workday case rate of 1.34 to 1.54 per 100 full-time workers, compared with a national construction industry average of 6.8 to 6.9 per 100 full-time workers.

In the industry at large, a growing number of business leaders and construction firms are vigorously moving to address the human costs associated with high injury and fatality rates; the spiraling workers' compensation costs associated with construction accidents hav' also become a major issue. In addition, the recent construction management literature

stresses the mechanisms available to make workplace safety a priority and thus implicitly acknowledges the importance of management commitment to the creation of safe working environments. The emphasis in these articles is placed on management's responsibilities, such as compiling and analyzing accident statistics by contractor (including subcontractors), by facility, and by project; reviewing safety performance by tracking accident rates and their costs--both direct and indirect--and evaluating the accident records of all bidders during the course of the procurement process to avoid the use of high-risk contractors and subcontractors.

Behavioral research in the construction safety field focuses on such issues as the effectiveness of feedback mechanisms, the influence of unions, and the benefits of training. There is a consensus among authors that involving employees in accident prevention programs and providing safety training to all workers on the site are essential to success.

Examples of the training efforts and research studies pertaining to this industry include:

- A program developed by the United Brotherhood of Carpenters and Joiners of America to reduce injuries and lower workers' compensation rates on specific jobs; the union negotiates with the contractor for comprehensive worker safety training, including frequent tool box meetings. If insurance premium dollars are returned to the contractor because injury losses are lower than expected, the program calls for splitting the savings with workers as an incentive (BNA 1990).

- A study that shows that workers' use of safe practices increases if positive feedback is provided on a regular basis (Fellner and Sulzer-Azaroff 1984). These authors found that the use of safe practices increased from 4 to 30 percent when feedback was provided, and a modest but statistically significant reduction in injuries was also observed over the course of the study. Feedback programs are inexpensive to develop and implement, and could be adapted easily to the construction setting.

There is general agreement in the literature that younger workers and new hires are particularly vulnerable to injuries, and that reaching these groups requires special effort (Eastern Research Group 1991). One author has suggested that non-unionized workers are exposed to heightened risks: he argues that OSHA regulations are more strictly enforced at unionized worksites, OSHA inspections are more likely to occur at such sites, and OSHA inspections are more thorough at union compared with non-union worksites (Weil 1992).

The literature on the effectiveness of worker protection programs in construction is largely anecdotal and pertains primarily to large companies. One of the best-documented studies of this type describes the experience of the Pizzagalli Construction Company, a Vermont-based heavy construction firm with approximately 30 worksites in 10 States along the East coast (Bruening 1989). In the two years after Pizzagalli implemented a proactive safety management program, recordable injuries were reduced by almost 48 percent, and the company's lost-workday case rate fell by 33 percent. Improved training, including an orientation program for new employees and weekly safety talks for all workers, was considered the key to the success of this project. Other important elements were visible management leadership of the program, incentives for safety performance, and equipment inspections that were both more comprehensive and more frequent than those required by OSHA.

A common thread running through the recent literature is the importance of management commitment in guaranteeing worksite safety. Management's role may be even more important in construction than in general industry because of the dynamic nature of construction work: the changes in hazards and work crews associated with the various phases of a construction project make proactive, vigorous, and continuous management involvement essential throughout the life of each project. Annual compliance self-inspections performed by the employer may be adequate for the fixed-site operations typical of most general-industry production facilities, but daily (and sometimes even more frequent) inspections are necessary on most construction sites.

The following sections of this report describe the safety management practices endorsed by various organizations with interest in or oversight authority for worker protection on construction sites, demonstrate the successes various organizations have achieved by implementing these programs and practices, and summarize the available cost and benefit data on these programs.

II. CONSTRUCTION SAFETY MANAGEMENT PRACTICES AND CODES OF PRACTICE

Some agencies, national and international organizations, and trade associations involved in construction have developed recommendations or requirements for management

practices designed to reduce hazards and protect the safety and health of construction workers. Exhibit 1 summarizes these provisions in a format that permits a comparison of requirements across organizational lines; Exhibit 2 sets forth individual requirements in detail. The safety codes summarized in this section have been excerpted from:

- OSHA (29 CFR Part 1926), Construction Standards;
- Corps of Engineers (1992), Safety and Health Requirements Manual;
- Bureau of Reclamation (1987), Construction Safety Standards;
- Department of Energy (1993), Construction Project Safety and Health Management Order (draft);
- American National Standards, Basic Elements of an Employer Program to Provide a Safe and Healthful Work Environment, ANSI A10.38-1991;
- American National Standard for Construction and Demolition Operations--Safety and Health Program Requirements for Multi-Employer Projects, ANSI A10.33-1992;
- Association of General Contractors (AGC) (1992), Manual of Accident Prevention in Construction;
- International Labour Organisation (ILO) (1992), Safety and Health in Construction: A Code of Practice; and
- Council of the European Communities (EC) Directive 92/57/EEC (1992), Implementation of Minimum Safety and Health Requirements at Temporary or Mobile Construction Sites.

As Exhibit 1 shows, most of these codes emphasize safety and health program and plan development, hazard prevention and control, worksite inspections, and employee training. The programs, practices, and procedures described in the standards, safety manuals, and publications of these organizations are outlined on the following pages.

EXHIBIT 1. Overview of Construction Safety Management Practices Required or Recommended by Major Organizations

PROGRAM ELEMENTS SPECIFICALLY MENTIONED	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
Safety and Health Programs/Plans	•	•	•	•	•	•	•	•	•
Safety and Health Responsibilities and Accountability	•	•	•	•	•	•	•	•	•
Employee Involvement		•		•		•		•	•
Fitness for Duty	•	•	•	•			•	•	
Hazard Analysis		•	•	•		•	•	•	•
Hazard Prevention and Control/ Abatement	•	•	•	•	•	•	•	•	•
Self-Inspections	•	•	•	•	•	•	•	•	
Emergency Response Plans		•	•	•	•	•	•	•	
First Aid/Medical Requirements	•	•	•	•	•		•	•	•
Accident Investigation, Reporting, and Analysis	•	•	•	•	•	•	•	•	
Recording and Reporting of Injuries and Illnesses	•	•	•	•	•	•	•	•	

EXHIBIT 1. Overview of Construction Safety Management Practices Required or Recommended by Major Organizations (continued)

PROGRAM ELEMENTS SPECIFICALLY MENTIONED	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
Training/Safety Meetings	•	•	•	•	•	•	•	•	
Joint Safety Committees				•				•	
Contractor/ Subcontractor Relationship for Safety and Health	•	•	•	•	•	•	•	•	•

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
SAFETY AND HEALTH PROGRAM/PLANS	Employer must initiate and maintain programs necessary to ensure safe working conditions.	Development of a safety and health program shall be considered for all activities other than office/administrative activities; The employer is responsible for initiating and maintaining a safety and health program; and The prime contractor is to prepare and submit a written accident prevention plan for approval before the initiation of work.	Prime contractor is to prepare a comprehensive written safety program covering all aspects of on-site construction operations and activities associated with each contract. The contractor's written safety program is to be reviewed in detail during the preconstruction safety meeting.	Construction contractor is to establish and maintain a program to protect the safety and health of all persons on the worksite, including: • Employees; and • Employees of other contractors and subcontractors, visitors, the public. A written project safety plan must be submitted to and approved by the construction manager prior to commencement of any activity on the worksite.	Construction employer shall have a written safety and health program that includes detailed program elements and establishes work practices for specific operations, hazards, and program elements.	Project Constructor is to have a project safety and health program specific to the scope of work to be performed and that applies to all contractors and individuals; Contractors are responsible for developing, implementing, monitoring, and enforcing their safety and health programs, unless these requirements are performed by a higher tier contractor; and A special safety and health plan is to be prepared when a contractor has established a pattern of non-compliance with the project safety and health program and/or laws and regulations.	A concise safety policy statement should be disseminated to all managers and supervisors. A procedural manual should be developed from that policy statement.	Employers should establish a suitable program on the safety and health of workers.	Safety and health coordinator shall draw up a safety and health plan setting out the rules applicable to the construction site, taking into account the industrial activities taking place on the site as well as extra-hazardous work operations. Coordinator shall make any adjustments to the plan required to take account of progress of the work or any changes that have occurred.

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

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SAFETY AND HEALTH PROGRAM/PLANS • **Provision of plan to employees**			Every new employee is to be given a copy of the pertinent provisions of the contractor's safety program.	Employees shall be told of the location and means of accessing the approved project safety plan during orientation; plan shall be available at worksite.	Each employee shall receive a printed summary of the employer's safety and health program.	Project Constructor is to provide each employee and supervisor with a summary of the project safety and health program.			
SAFETY AND HEALTH RESPONSIBILITIES AND ACCOUNTABILITY	It shall be employer's responsibility to initiate and maintain programs necessary to comply with this Part.	Responsibilities and accountability of personnel are to be identified in an accident prevention plan; and The prime contractor's accident prevention plan must be signed by a representative of the contractor's project management team. No supervisor shall decline to accept a report of injury from a subordinate.	The contractor is responsible for ensuring that all on-site activities, equipment, and facilities--whether performed by the contractor, subcontractor, or supplier--conform fully with these standards. When the contract does not require the services of a full-time employee, the contractor shall designate a competent and dependable supervisory employee to administer his/her safety program.	Construction contractor must state, in writing, that the construction superintendent is assigned full responsibility and authority for implementing the OSH program.	Safety and health program shall designate the individual responsible for implementation of the program, establish procedures for coordinating safety and health activities with other employers on jobsite, and ensure that no work is performed on site unless designated competent person is on site. The construction employer is ultimately responsible for the implementation of the safety and health program.	Safety and health program must describe the responsibilities and authority of all levels of supervision; Senior Project Supervisor has final authority and responsibility for the Project Safety and Health Program; and Senior Contractor Supervisor has the final authority and responsibility for the Contractor Safety and Health Program.	Management is responsible for accident prevention, with goals of no accidents and lower operating costs. Line management should be responsible for achieving the objectives of the accident prevention program. An individual with basic training in accident prevention should be appointed by management to be responsible for loss control.	Employers should maintain conditions so that, as far as is reasonably practical, there is no risk of accident or injury to health. Employer should appoint qualified and experienced persons to promote safety and health and should provide supervision that ensures that workers will perform with due regard to their safety and health.	Client or supervisor shall appoint one or more coordinators for safety and health matters. Where a client or supervisor has appointed a coordinator for safety and health, this does not relieve the client or supervisor of responsibility for safety and health responsibilities.

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
SAFETY AND HEALTH RESPONSIBILITIES AND ACCOUNTABILITY (continued)			In no case may work commence without Bureau approval of the contractor's program.			Project Constructor is responsible for assessing qualifications and performance of Senior Project Supervisor and Senior Contractor Supervisor.			
• Employee Responsibilities/ Disciplinary Policy		Individual employee responsibility for complying with safety and health requirements is to be identified in the accident prevention plan. Each employee is responsible for complying with applicable safety requirements, wearing prescribed safety equipment, preventing avoidable accidents, and for reporting all injuries and occupationally related illnesses to employer or supervisor.	Employees refusing or repeatedly failing to comply or supervisors failing to enforce compliance shall be promptly terminated.	Disciplinary procedures must be addressed in orientation of all employees.	Program shall include procedures for disciplinary action for enforcement of safety and health program. All employees are responsible for complying with established safety and health programs; failure to comply is basis for disciplinary action.	Project Constructor shall establish disciplinary policy and procedures for contractors, supervisors, and employees failing to comply with program.			

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
EMPLOYEE INVOLVEMENT		Employees are to be involved in determining the need for, and the performance of, Job Safety Analyses and Activity Hazard Analyses.		Employee involvement in the form of joint committees required by DOE 5483.XX, OSH program foundation Order.		When appropriate, employees involved in operations should be consulted during preparation of pre-phase accident prevention plans, and such plans should be discussed with the employees who will perform the work.		Safety and health committees representative of employers and workers shall be established; Workers should participate in regular safety and health meetings; Workers should have the right and the duty to participate in ensuring safe working conditions to the extent of their control over the equipment and methods of work; and Arrangements such as committees should be made for the participation of workers in ensuring safe working conditions.	Workers and/or their representatives shall be informed of all measures to be taken concerning their safety and health on the construction site. Consultation and participation of workers and/or their representatives shall take place on matters covered by this directive.

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
FITNESS FOR DUTY									
• Physical, mental, and medical qualifications		All persons are to be physically, mentally, medically, and emotionally qualified for performing the duties to which they are assigned.	Employees are to be physically qualified to perform their assigned duties in a safe manner.				Employees who will work safely should be identified and selected. Preference should be given to applicants familiar with related safety standards.	Employers are to assign workers only to employment for which they are suited by their age, physique, state of health, and skill.	
• Alcohol and drug abuse policy		The prevention of alcohol and drug abuse on the job is to be addressed in the Accident Prevention Plan. Employees found to be under the influence of or consuming alcohol, narcotics, etc. are to be immediately removed from the job site.	Persons under the influence of alcohol or narcotics are not to be permitted on the site. Operators found to be under the influence of alcohol or narcotics cannot operate equipment until satisfactorily completing a medical exam and found to be free from alcohol or drugs.	Drug and alcohol abuse policy is to be addressed in the worksite safety orientation.					

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

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FITNESS FOR DUTY (continued) • Equipment operator qualifications	Employer shall permit only those employees qualified by training or experience to operate equipment and machinery.	Operators of any equipment or vehicle shall be able to read and understand signs, signals, and operating instructions. Duty-time limitations are to be imposed on operators.	Operators of any equipment or vehicle shall be able to read and understand signs, signals, and operating instructions. Physical examinations are recommended for heavy equipment operators and are required for crane and hoisting equipment operators.				All drivers should be required to demonstrate their driving ability in the equipment they will be operating under actual job conditions. Only qualified workers should be permitted to operate heavy equipment.		Only qualified and trained workers shall operate lifting equipment, materials-handling and excavating equipment, and installations, machinery and equipment.
HAZARD ANALYSIS		A Job Hazard Analysis should be prepared and documented for each position if warranted by the hazards of the job; and Activity Hazard Analyses are to be prepared by the contractor prior to the beginning of each major phase of work.	Unless covered in original plan, a supplementary detailed plan is required prior to the start of each major phase of work. The original and supplemental plans must include a timetable for completing required, detailed, specific operating procedures, with hazard analysis.	An approved Preliminary Hazard Analysis (PHA) is required before commencement of work on the construction project; the PHA shall identify: • Anticipated construction phases; • Types of hazards associated with anticipated operations or phases of the project; and		A hazard analysis is to be conducted at the initiation of a construction project and for critical stages of work: • Pre-phase Job Hazard Analyses (JHA) are to be conducted for work operations performed by contractors; • Pre-phase JHA should be devel-	Supplemental safety program for each specific job should be developed and distributed to all supervisors.	Employer should have competent person identify and assess health hazards of different operations.	The coordinator for safety and health shall implement the principles of prevention and safety during the project planning stage for each stage of work.

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
HAZARD ANALYSIS (continued)				• Operations or phases requiring further analyses or the design of special protective measures. An approved Activity Hazard Analysis (AHA) is required before work begins on any phase of the project. The AHA: • Identifies phase-specific hazards; • Includes drawings and/or documentation of any corrective measures needing to be designed by a PE or other competent person; • Identifies qualifications of competent person, or other individual who will conduct inspections required by DOE standards or construction project documents.		oped by the contractor field supervisory personnel who will actually be running the job that is being preplanned; and • Under no circumstances should work be allowed to begin before the JHA has been approved by the Project Constructor.			

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
HAZARD PREVENTION AND CONTROL/ ABATEMENT	The use of any machinery, tool, material, or equipment which is not in compliance with any applicable requirement of this Part is prohibited. Such machine, tool, material, or equipment shall either be tagged or locked out or shall be physically removed from worksite.	Identified safety and health issues and deficiencies, and the actions, timetable, and responsibility for correcting those deficiencies, shall be recorded in inspection reports. Follow-up inspections to ensure correction of any identified deficiencies shall be conducted and documented in a like manner. Means must be provided to record in inspection reports those safety and health deficiencies identified, along with corrective measures, timetable for resolution, and responsibility for correcting deficiencies. Follow-up inspections must be conducted to ensure hazard abatement.	Contractor must ensure that all activities, equipment, and facilities comply with standards. Contractor must discuss, in detail, measures to control hazards incident to major phases of work under contract in preconstruction safety meeting.	A system is to be developed and maintained for tracking the status of all hazards for which corrective action is not immediate or that falls outside of the project scope. All identified hazards shall be immediately corrected or eliminated. If this is not possible: • Interim control measures are to be implemented; • Warning signs are to be posted at location of hazard; and • Employees are to be informed of hazard's location and the required interim control measures.	Employers must establish procedures to ensure correction or abatement of all hazardous conditions and to ensure compliance with safety and health program. Construction employer shall monitor effectiveness of program and take action to correct deficiencies, including development of procedures to address particular hazards.	Written reports describing noncompliance with safety and health standards, project safety and health programs, and hazardous conditions are to be submitted to the Senior Project Supervisor; Senior Project Supervisor is to ensure the correction and abatement of all hazardous conditions and compliance with the safety and health program and is to monitor regularly for potentially hazardous conditions; and All hazards or potentially hazardous conditions and noncompliances observed during daily inspections are to be documented and corrected.	Unsafe acts/conditions should be corrected immediately. Adequate funds should be allocated for traffic control, excavation protective systems, barricades, signs, PPE, adequate work platforms, housekeeping, and other items necessary for the protection of employees, property, equipment, materials, and the general public.	All appropriate precautions should be taken to ensure that the workplace is safe and without risk of injury to worker safety and health, and to protect persons present at or in the vicinity of the site from risks. When acquiring plant equipment or machinery, employers should ensure that it takes account of ergonomic principles, safety, and health.	

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
HAZARD PREVENTION AND CONTROL/ ABATEMENT (continued)								Employers should have a competent person assess health hazards and take appropriate preventive or control measures. Preventive measures should eliminate or reduce the hazard at the source whenever possible. Buildings, plants, equipment, tools, machinery or workplaces in which a dangerous defect has been found should not be used until the defect is remedied.	

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
HAZARD PREVENTION AND CONTROL/ ABATEMENT (continued) • Stop work authority		No person shall be required or instructed to work in surroundings under conditions that are unsafe or dangerous to health.	Contractor shall not require any employee to work under conditions that are hazardous or dangerous to safety or health.	Stop work authority contained in DOE 5483.XX, foundation OSH program Order.	Supervisors, foremen, and construction safety and health coordinators are to stop work that could place employees, equipment, or property in imminent danger.	Imminent danger conditions are to be reported for immediate correction.		Employer should take immediate steps to stop work in cases of imminent danger.	
INSPECTIONS	Safety programs shall provide for frequent and regular inspections of job sites, material, and equipment.	Frequent safety inspections are to be performed by competent personnel--to include worksites, material, and equipment; Contractor Quality Control personnel are to conduct and document daily inspections; and Follow-up inspections shall be conducted and documented.	Contractor is to ensure frequent and regular safety inspections of worksites, materials, and equipment by competent employees; and Detailed written inspection records are to be maintained.	Daily inspections of active construction worksites are to be conducted; All noted hazards and corrective actions are to be documented in required daily inspection records; At least weekly, construction manager is to accompany construction contractor on one of these daily worksite safety inspections; For all projects valued at more than $500,000, project manager is to conduct inspections on at least a weekly basis; and	At least daily inspections are required for detection of hazardous conditions or work performance.	The Senior Contractor Supervisor, or representative, is to conduct, or cause to have conducted, daily inspections. Written reports of these inspections are required.	Periodic jobsite inspections should be made.	Employers should arrange for regular safety inspections by competent persons at suitable intervals. Buildings, plants, equipment, tools, machinery, workplaces, and systems of work are to be covered by inspections.	Safety and health coordinators shall coordinate arrangements to check that the working procedures are being implemented correctly.

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
INSPECTIONS (continued)				For projects valued at less than $500,000, an inspection schedule is to be prepared that assures that a representative sample of ongoing construction projects is inspected on at least a monthly basis.					
EMERGENCY RESPONSE PLANS		Emergency response capabilities are to be addressed in the accident plan. Written emergency plans are to be reviewed with all affected employees, and the plans tested to ensure their effectiveness. Emergency telephone numbers and reporting instructions must be posted at the worksite.	Contractor's safety program is to consider and incorporate provisions for safely and expeditiously handling possible emergency situations. Responsibilities for handling emergencies are to be assigned and proper training provided for personnel handling emergencies. Warning systems must be installed and tested and emergency telephone numbers and reporting instructions posted at the jobsite.	Employee safety and health orientation must include information on firefighting and other emergency procedures.	The employer's safety and health program must include an emergency response plan specifying procedures for handling serious injuries, fatalities, structural failures, or other emergencies, including administration of first-aid and other medical treatment.	A project-specific emergency plan and communication system is to be prepared by the Project Constructor; and Procedures are to be described for events involving serious injuries, fatalities, structural failures, and other emergencies.	At the start of each job, names and locations of nearby emergency medical facilities should be obtained and facilities should be contacted to explain nature of work and type of injuries that could occur. All supervisors should be knowledgeable about emergency procedures. Contact information for emergency personnel should be posted at jobsite.	Worker training should include training in emergency procedures and location of first-aid facilities.	

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
FIRST AID/ MEDICAL REQUIREMENTS	Employer shall ensure availability of medical personnel for advice and consultation; provisions shall be made prior to startups for prompt medical attention in case of serious injury. First aid supplies shall be accessible when required.	Prior to start of work, arrangements shall be made for medical facilities and personnel to provide prompt medical attention and consultation. Where medical facility or physician is not accessible within 5 minutes to a group of 2 or more employees, at least 2 employees per shift shall be first-aid and CPR certified. Individuals who work alone in remote areas must be trained in first-aid. Where fewer than 100 persons are employed, at least one 16-unit first-aid kit/25 persons is required. Where 100-300 persons are employed, a first-aid station with first-aid attendant is required.	Prior to start of operations, contractor shall arrange for prompt medical attention in conformance with this standard. At a minimum, contractor will provide: • Where fewer than 100 workers/shift, first-aid supplies in the form of one 16-unit kit/25 employees, and at least one employee certified in first-aid per shift. • Where 300-1,000 workers are employed, an infirmary equipped to handle outpatient treatment and staffed by nurse or EMT full time.	First aid and medical requirements must be addressed in orientation of all employees.	Where applicable, program shall establish procedures for first-aid and to address occupational health and environmental hazards.		First-aid equipment needs will vary by size and location of job. At least one properly trained person per jobsite should have first-aid responsibilities and supplies.	Employer should provide access to occupational health services consistent with the objectives and principles of Occupational Health Services Convention, 1985 (No. 161) and Recommendation (No. 171). Employer should ensure that first-aid, including trained personnel, is available. National laws or regulations should prescribe manner for providing first-aid services.	Employer must ensure that first aid can be provided and that staff trained to provide it can be called upon at any time. Address and phone number of local emergency services must be clearly displayed.

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
FIRST AID/ MEDICAL REQUIREMENTS (continued)		Where 300 or more persons are employed, an infirmary and properly equipped emergency vehicle or mobile first-aid unit is required. A full-time RN, EMT, or LPN shall be assigned to the infirmary. Where 1,000 or more persons are employed, the full-time services of a licensed physician are required; an EMT in direct communication with a physician may be used when a physician is unavailable. First-aid stations and infirmaries shall be equipped according to the proximity of other medical services.	• Where more than 1,000 workers are employed, infirmary equipped to handle short-term in-patient care, with ambulance service, and staffed by full-time physician and adequate nursing staff. • Dependable ambulance service, regardless of project size, with certified vehicle operators capable of administering first-aid.						

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
ACCIDENT INVESTIGATION, REPORTING, AND ANALYSIS	Must be performed in accordance with 29 CFR 1904.	All accidents that occur incident to the operation, project, or facility will be investigated, reported, and analyzed. On contract operations, prime contractor must record and report all accident exposure and experience of contractor and his/her subcontractors. At minimum, these will be OSHA 200 Logs. Records of exposure to toxic substances shall be kept, and employees and designated authority notified of any excessive exposure. Prime contractor must also maintain access to project's Workers' Compensation Claims Report.	Serious accidents are to be reported immediately. Contractor shall, when ordered by Bureau, conduct a complete independent investigation at own expense, and submit written report of findings. Non-serious accidents/incidents to be reported immediately and investigated. A comprehensive narrative report and Bureau accident form must be submitted within 3 working days. Such accidents/incidents include all other accidents except first-aid cases and property damage amounting to between $2,500 and $250,000.	Contractor is to comply with the accident investigation, reporting, and analysis requirements identified in DOE 5483.XX or contained in contract documents. (These conform fully with OSHA reporting and investigation requirements.) Procedures for reporting accidents and incidents are addressed in the orientation for all employees.	Health and Safety Program shall contain: • Procedures for recording and reporting incidents in accordance with OSHA requirements; • Procedures for investigating job-related accidents and illnesses to determine possible cause; • Specific designation of management person responsible for review of injuries and illness reports; and • Procedures to determine that accident, injury, and illness records are accurate and complete.	Senior Project Supervisor shall maintain all illness and accident records for entire project with sub-records of same for each Contractor. This shall be kept in a daily Project Safety and Health Log. Senior Contractor Supervisor, or representative, is to ensure that all accidents are investigated and measures implemented to prevent recurrence. Safety and health program to provide for accurate and complete accident, injury, and illness records; A Project Safety and Health Record/ Log is to be maintained; and	All accidents, especially serious injuries and fatalities, should be investigated to determine cause and future prevention. Employees are expected to report all injuries immediately and contractor is advised to record, post, and report incident as required by Federal and State law. Employees should report injuries immediately to supervisor. Injuries should be recorded on appropriate forms and posted as required. The contractor should make provisions to comply with applicable Federal and State OSHA requirements for reporting fatal injuries and accidents requiring hospitalization.	All occupational accidents and diseases should be reported in accordance with national laws or regulations. All accidents to workers causing loss of life or serious injury should be reported...and an investigation of the accident(s) should be made. Other injuries causing incapacity for work for periods of time...should be reported.	

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
ACCIDENT INVESTIGATION, REPORTING, AND ANALYSIS (continued)		A daily record of first-aid treatment not otherwise reportable must be maintained on prescribed forms. Employees are responsible for reporting injuries and illnesses to the supervisor as soon as possible. Supervisor must report these to designated authority within 24 hours.	Potentially serious accidents must be reported immediately. The equipment and/or worksite involved must be secured until an investigation has been completed by the contractor. Report to Bureau must be submitted within 5 days.		The safety and health program must designate procedures for investigating job-related illnesses to determine possible cause and a management person responsible for reviewing injury and illness reports.	All injuries, illnesses, and accidents for the entire project are to be recorded with subrecords of same for each contractor.		Dangerous occurrences such as explosions, collapse of buildings, cranes, or other structures should be reported to the public authority even if personal injury has not occurred.	
TRAINING/ SAFETY MEETINGS	Employer shall avail him/herself of training programs provided by the Secretary of Labor. Employer shall provide job-specific training. Specialized training is specifically required for those handling toxic substances, plants or animals and for employees entering confined spaces.	Employees must receive indoctrination and continuing training. All OSH programs, documents, and labels must be provided in language understood by the worker. Minimum contents of that training are specified: • General OSH policy and pertinent	On-site supervisors, including foremen, are to receive an annual 4-hour classroom review of applicable safety and health requirements. Contractor shall provide first-aid training for all contractor foremen so that they maintain current first-aid certification.	Each employee must be trained, experienced, and/or certified as having the skills and knowledge needed to perform assigned tasks safely. Each employee is to receive initial worksite safety orientation and continued safety and health training;	Construction employer shall be responsible for employee safety and health training. This shall include: • Supervisory Training; • New-Hire Training; • Job-Specific Training;	Contractors are responsible for the safety and health training of their employees. Supervisory employees are to be trained to carry out their safety and health responsibilities. Non-supervisory employee training shall include:	Training is an important responsibility of management. Supervisors should be competent instructors and should be given supervisory training. Employees should receive orientation in company's safety policies, craft training, and job-specific training.	Safety delegates and safety and health committee members should be trained. All workers should be suitably instructed in the hazards connected with their work and environment and in measures for the	

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
TRAINING/ SAFETY MEETINGS (continued)		provisions of Corps manual; • Accident-reporting requirements; • Facilities and procedures for emergency response and medical treatment; • Unsafe conditions reporting and correcting; and • Job-specific hazards and control measures. Safety meetings shall be held at least weekly for all workers, and meetings must be documented. Employees shall be trained to handle emergency situations. Safety meetings are to be conducted at least once a month for all supervisors; once a week by supervisors or foremen for all workers.	Each employee shall receive training in the recognition and avoidance of job-specific hazards prior to initiating job assignment. On-site training will be provided to those handling specific hazardous materials or tools; Scheduled monthly safety meetings with the Contracting Officer's Representative are to be held to review the effectiveness of the contractor's safety effort, to resolve safety and health problems, and provide a forum for planning safe future construction activities; Supervisors are to conduct regularly scheduled meetings at least monthly; and A minimum of one "on-the-job" or "tool box" safety meeting is to be conducted weekly for employees by each field supervisor or foreman.	Pre-phase training is to be conducted and documented for all employees on the affected work crews; training shall be based on the AHA for that phase; "Tool Box" safety training is to be conducted and documented at least weekly for all employees on the worksite. Additional pre-phase safety training must be conducted for new employees, under changing site conditions, or at the discretion of the construction manager if deemed necessary to reinforce project safety requirements. All training records are to be maintained by the construction contractor on the construction worksite.	• Site-specific training; and • Safety meetings (to be conducted on a regularly scheduled periodic basis).	• New hire orientation; • Job-specific training; • Site-specific training; and • Safety meetings. Safety meetings shall be held for all nonsupervisory working employees to provide safety training and compliance review on a regularly scheduled, periodic basis.	Pre-Job Meeting: Management and safety staff discuss safety after bid documents are received. Start of Job Meeting: Supervisory personnel review safety plans and delegate responsibilities for safety. Supervisory Meetings: Held on a regular basis for review of accidents and hazardous conditions. Tool Box Safety Talks: Held regularly with employees for review of safe methods, accidents, and near accidents.	prevention and control, and protection against, those hazards. Training should be provided in language understood by the worker. Specialized training needs should be identified and training provided.	

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
TRAINING/ SAFETY MEETINGS (continued)		Meetings shall include safety and health training, review of past activities, and planning for new/changed operations.							
JOINT SAFETY COMMITTEES				Employer/employee OSH Committees are required by DOE 5483.XX, foundation OSH program Order.				Employers should establish committees with representatives of workers and management, or make other arrangements consistent with national laws and regulations, for the participation of workers in ensuring safe working conditions.	

EXHIBIT 2. Safety Management Practices Reflected in the Construction Standards and Guidelines of Major Organizations (continued)

MANAGEMENT PRACTICE	OSHA CONSTRUCTION STANDARDS (29 CFR 1926) 1971	CORPS OF ENGINEERS SAFETY AND HEALTH REQUIREMENTS MANUAL 1992	BUREAU OF RECLAMATION CONSTRUCTION SAFETY STANDARDS 1987	DOE CONSTRUCTION PROJECT SAFETY AND HEALTH MANAGEMENT ORDER 5480.9, 1993	ANSI A10.38 BASIC ELEMENTS OF CONSTRUCTION PROGRAMS 1991	ANSI A10.33 PROGRAM REQUIREMENTS FOR MULTI-EMPLOYER PROJECTS 1992	ASSOCIATED GENERAL CONTRACTORS MANUAL OF ACCIDENT PREVENTION IN CONSTRUCTION 1992	ILO CODE OF PRACTICE, SAFETY AND HEALTH IN CONSTRUCTION 1992	EC DIRECTIVE FOR CONSTRUCTION SITES 1992
CONTRACTOR/ SUBCONTRACTOR RELATIONSHIP FOR SAFETY AND HEALTH ACTIVITIES	The prime contractor and any subcontractor may make their own arrangements with respect to obligations which might be more appropriately treated on a jobsite rather than individually....In no case shall the prime contractor be relieved of overall responsibility for compliance with the requirements of this Part for all work performed under the contract. To the extent that a subcontractor of any tier agrees to perform any part of the contract, he also assumes responsibility for complying with the standards in this Part. Thus, prime contractor assumes the entire responsibility...and subcontractor assumes responsibility with respect to his portion of the work.	Requires prime contractor to include subcontracted work in Accident Prevention Plan as well as measures contractor will take to control hazards. Prime contractor shall coordinate and control subcontractor work and shall specify requirements for subcontractor to carry out Accident Prevention Plan. Plan is to be job-specific and include work to be performed by subcontractors and measures to be taken by contractor to control hazards associated with materials, etc., provided by suppliers.	Contractor is responsible for ensuring that all onsite activities, equipment, and facilities, including those of subcontractors, conform fully with requirements of the Bureau. Contractors must include provisions for compliance with the requirements of the manual in the terms and conditions of all contracts, subcontracts, and supply contracts.	Contractor's safety program must protect the safety and health of all persons on site, including subcontractors, and must assure compliance by all worksite subcontractors with DOE Order 5483.XX and safety program requirements. Construction contractor must coordinate with project subcontractors and other site contractors concerning those OSH program elements addressing hazards.	Safety and health program shall establish procedures for coordinating safety and health activities with other employers on site.	A pre-phase planning meeting shall be held to coordinate and assign responsibility for all items identified in the hazard analysis; all affected contractors must attend. Senior contractor, supervisor or designated representative shall: • Evaluate contractor safety and health programs and monitor their implementation; • Ensure contractor compliance with A10.33 and abatement of hazardous conditions; and • Audit contractor safety and health documents at least monthly.	Prime contractor advised to review subcontractor safety program and history before bidding and during construction; to include subcontractor areas in inspections and audits; and to require subs to correct any recognized hazards.	Principal contractor should be responsible for planning and coordinating safety and health measures and for ensuring compliance. If principal contractor is not present at site, should nominate competent person to fulfill that responsibility on contractor's behalf.	The safety and health coordinator shall coordinate implementation of the plan by employers and self-employed persons and ensure that the principles of safety and prevention are applied in a consistent manner. The coordinator shall organize cooperation between employers, including successive employers on the same site, with a view toward protecting workers and preventing accidents and occupational health hazards.

III. DESCRIPTIONS AND DEFINITIONS OF WORKER PROTECTION PROGRAM REQUIREMENTS

Safety and Health Programs/Plans

Authors writing in the trade literature and in academic publications agree that the starting point for any program designed to foster safety on construction worksites is the commitment of management to safety and health. This means that management must consider worker protection the company's top priority and be willing to spend time and money on program development, safety equipment, and employee training.

One of the best ways management can demonstrate its commitment to safety is the development of a comprehensive, written safety and health program that is performance-oriented and general enough to cover the complete range of projects conducted by the company or organization. This document should establish and communicate a clear goal for the program and define objectives for meeting that goal. To unequivocally demonstrate its commitment, top management must actively participate and be "visible" during program implementation.

Copies of the document outlining the program should be distributed to all employees. The written information should include the basics of personal protective equipment, the proper use of tools and power equipment, safe work practices, and any company policies that exceed OSHA requirements (e.g., employees must wear hard hats from project start to finish, even if there is no threat of injury from falling objects). The written program should also outline procedures for formally evaluating or auditing the occupational safety and health program's effectiveness at least once a year.

A written, site-specific safety plan should also be kept at each worksite. At a minimum, this plan should include information on safety responsibilities, emergency procedures, and provisions for hazard communication, accident prevention, inspections, grounded electrical systems, recordkeeping, personal protective equipment, and housekeeping. Many employers append operation-specific safety procedures for various phases of construction activities, e.g., hoisting and rigging, or demolition. This plan should be readily available to all employees at the worksite.

All of the organizations whose programs are summarized in Exhibit 2 require that the prime contractor (also called the construction employer or constructor) develop a safety and

health program and safe operating procedures. Although the requirements of each plan vary, most designate administrative procedures, responsible personnel, methods of controlling and coordinating the work of subcontractors, inspection plans, specific safety programs (e.g., fire protection, fall protection), and plans for conducting hazard analyses as the project progresses.

The corresponding OSHA requirement (29 CFR 1926.20(b)(1)) does not require a written safety and health program.

Safety and Health Responsibilities and Accountability

To ensure that safety is consistently given priority in decision-making, the responsibilities of each member of the organization--from top management to individual construction worker--must be spelled out in the safety and health program. But merely assigning responsibility does not suffice: each person must be held accountable for his/her safety performance, and each individual assigned such responsibilities must be given adequate authority and resources to meet them. Control systems to ensure that responsibilities are being met must therefore be in place. There are different ways of achieving this objective: some companies require that the recordable injury rate for each supervisor be factored into annual review and promotion decisions, while others use a formal tracking system that allows supervisors with good safety records to earn bonuses (LaBar 1992; Walters 1983).

Employees must also be held accountable for complying with safety policies and procedures. The company's overall program should contain a disciplinary component that is clearly expressed, and employees who violate safety procedures should be subject to disciplinary action. The program should establish a hierarchy of disciplinary measures, beginning with verbal and written warnings, proceeding to formal meetings with management, followed by suspension, and, ultimately, by termination.

As Exhibit 2 shows, all of the organizations whose policies were reviewed for this study have requirements governing the designation of personnel responsible for project safety. The Associated General Contractors (AGC) Manual of Accident Prevention in Construction states simply that "line management should be responsible for reviewing the objectives of the accident prevention program," while the Corps of Engineers Safety and

Health Requirements Manual states that the responsibilities of all personnel involved in the worker protection program must be set forth in writing, and that each employee's area of accountability must be delineated in the accident prevention plan.

The corresponding OSHA requirement (29 CFR 1926.20(b)(1)) is non-specific on this point.

Employee Involvement

There is general agreement in the literature and among safety professionals that employee involvement in the design and operation of the safety and health program is critically important. Workers are the ultimate "shareholders" in worksite safety and health; their familiarity with their jobs and with conditions at the site can translate into a unique contribution to safety and health decision-making and to accident prevention. Informed workers who are involved in the program assume responsibility for conducting their work safely and for fostering safe work practices across the site. Employee involvement can take a variety of forms: participation in the development of safety programs and in workplace inspections, membership on joint labor/management committees, and active participation in accident and "near-miss" investigations.

Many of the organizations whose programs are outlined in Exhibit 2 actively encourage employee participation. For example, the International Labour Organisation (ILO), the Council of the European Communities (EC), the Corps of Engineers, the Department of Energy, and the ANSI standard for multi-employer worksites all stress the importance of employee involvement. Joint labor/management committees are required by the Department of Energy's major occupational safety and health Order (DOE 5483.XX, still in draft) and are encouraged by the ILO, while the Corps of Engineers and the ANSI multi-employer standard both recommend employee input in the development of job safety analyses and activity hazard analyses.

There are no specific requirements for employee involvement in OSHA's construction standards.

Fitness for Duty

The construction environment is complex, physically demanding, and hazardous, and workers engaged in construction operations must be physically, mentally, and emotionally qualified to perform their jobs safely. Employee fitness can affect the worker's own safety as well as that of co-workers. Most of the policies outlined in Exhibit 2 make at least a general statement on the importance of overall fitness; some standards, manuals, and codes also specifically prohibit alcohol and drug use on site, and some set specific requirements for operators of specialized equipment, e.g., cranes and excavators.

OSHA has a general requirement (29 CFR 1926.20(b)(4)) stating that employers shall permit only qualified employees to operate machinery and equipment.

Hazard Analysis

Hazard identification begins with analyses of the specific hazards associated with various operations. Through a study of all worksite conditions as well as of each worker's job and each major phase of activity, worksite analyses identify the specific safety, health, and ergonomic hazards associated with a particular operation or process. When the tasks performed by workers assigned to a specific job are analyzed, the result is a "Job Hazard Analysis" (JHA) or "Job Safety Analysis" (JSA); a preliminary review of a major phase of project activity is called an "Activity Hazard Analysis," or AHA. Some organizations also mandate a "Preliminary Hazard Analysis," or PHA; by definition, a PHA is performed before <u>any</u> work on the project begins.

The objectives of hazard analyses are to:

- Identify the hazards associated with a particular job, work activity, or phase of the project;
- Identify the control measures and procedures necessary to protect employees from these hazards;
- Identify activities or phases of work that require further analysis or the development of specifically designed protective measures; and
- Designate and identify the qualifications of the competent person, authority, or engineer who will conduct worksite inspections.

The standards and codes of practice developed by the Corps, the Bureau of Reclamation, the Department of Energy, and ANSI require that each contractor responsible for conducting a particular phase of work (e.g., trenching, concrete work, and masonry) develop an operation- or phase-specific preliminary hazard analysis describing the hazards associated with that phase of the project, methods of reducing or eliminating them, equipment to be used and inspection requirements for equipment, and phase-specific training requirements.

OSHA has no corresponding requirements.

Hazard Prevention and Control/Abatement

Managing worksite hazards effectively is perhaps the single most important element in reducing occupational injuries and fatalities. It is also essential that safe work procedures be established and communicated to employees. In the dynamic atmosphere of a construction worksite, hazard prevention and control require careful planning, analysis of the hazards associated with each major phase of the project (see "Hazard Analysis," above), the design and application of the controls necessary to eliminate or mitigate identified hazards, and routine inspections of the worksite and enforcement of safety rules to ensure that equipment is being maintained and that site conditions pose no unnecessary risks.

Provisions must also be made to abate any hazards identified through implementation of corrective actions; in all but a few cases, abatement should occur immediately so that work can continue safely. In those cases where immediate hazard abatement is not possible, interim measures that provide employees with full protection should be implemented, and signs should be posted to warn employees of the danger.

Although 29 CFR 1926 does not address hazard prevention and control by name, it does contain a few provisions--such as those for frequent inspections and housekeeping--that address this issue (see, for example, 29 CFR 1926.20(b)(2) and 1926.25). As Exhibit 2 shows, most of the codes and standards developed later by other organizations contain specific requirements or recommendations addressing hazard prevention and control.

Inspections

Frequent worksite inspections are essential to maintaining safe conditions on construction sites. These should be conducted by competent persons and should include inspections of the worksite, equipment, and all materials to be used in performance of the job. Workers should be encouraged to report unsafe conditions to their supervisors promptly, and any unsafe practices identified should be immediately corrected.

Many organizations recommend or require daily inspections because of the dynamic nature of construction worksites, and some require documentation of the results, along with immediate correction of any deficiencies identified. OSHA, the ILO, the EC, the Bureau of Reclamation, and the AGC do not specify inspection frequencies, suggesting only that such audits be conducted at "frequent" or "periodic" intervals.

Emergency Response Plans

Because hazards may develop quickly on construction worksites and accidents may involve more than one employee, emergency response planning is essential. Most of the publications reviewed for this project require that the accident prevention or safety plan specifically address foreseeable emergencies; most also require that all employees at the site be made aware of appropriate emergency procedures. Some, such as the Corps of Engineers and Bureau of Reclamation manuals, require that employees be trained in these procedures and that the procedures be tested, through drills or other exercises, to ensure their effectiveness. Emergency telephone numbers (e.g., to obtain medical aid, police assistance) must generally be available at the worksite.

First-Aid/Medical Requirements

First-aid facilities are common on construction sites; however, the presence of medical personnel or medical facilities is generally reserved for exceptionally large sites or for those located in remote areas. All of the safety manuals and standards reviewed, except the ANSI multi-employer standard, require that first aid be available. Requirements range from the broad statement that procedures for first aid shall be established (in the ANSI standard (A10.38)) to the detailed requirements of the Corps of Engineers and Bureau of Reclamation

manuals, which reflect the fact that these agencies often oversee projects in remote areas and must therefore provide on-site medical facilities and personnel.

Accident Investigation, Reporting, and Analysis

Almost all of the organizations whose programs are summarized in Exhibit 2 recognize the importance of accurate accident reporting, investigation, and analysis of reports to identify trends and determine the root causes of workplace accidents. Some go beyond OSHA requirements and mandate or recommend that the accident history of each contractor and subcontractor be reported separately (see, for example, the Corps of Engineers Manual, the draft DOE Order, and the ANSI multi-employer standard). These more specific accident recording and reporting requirements recognize that the failure to break down injury statistics by contractor and subcontractor can mask the poor safety performance of particular contractors or subcontractors; the maintenance of separate statistics for each contractor and subcontractor is a practice recommended by the construction safety literature and increasingly practiced in the industry. An equally important element of accurate reporting is consistency among contractors and subcontractors in ways of defining lost-time injuries.

Training/Safety Meetings

Training is an essential component of any safety and health program; its effectiveness often depends on the degree to which it is tailored to the hazards of the particular worksite and job. Supervisors, who have day-to-day responsibility for safety and health, must be trained in hazard identification and control as well as in methods of encouraging safe practices and providing effective feedback.

Almost all of the organizations whose policies are outlined in Exhibit 2 recognize the importance of employee training, although some spell out their requirements in greater detail than others. Several require that different kinds of training be offered at different times during the project. For example, some employers may require an initial, formal orientation session, followed by informal weekly "tool box" meetings that address safety or health topics directly relevant to the work being undertaken at the time. The Corps, Bureau of Reclamation, both ANSI standards, and the AGC also require supervisor safety training, and several

of these groups mandate job-specific training for high-hazard work assignments or conditions (e.g., toxic substance handling, unusual heat or cold, exposure to ionizing radiation). A feature unique among the training programs analyzed is a requirement in the draft DOE construction safety management Order that all employees engaged in a particular phase of a project receive training in the hazards identified in a phase-specific Activity Hazard Analysis. On Corps, DOE, and Bureau of Reclamation sites, attendance at training sessions must also be documented.

Joint Safety and Health Committees

Joint labor-management safety committees provide a frequently used and widely recommended vehicle for encouraging employee involvement in the safety and health program. Such committees provide a means for employees to actively participate in safety and health decision-making, receive additional training in hazard identification and control methods, and share their knowledge of hazards and related problems with management. Informed workers also provide an excellent way of leveraging scarce occupational safety and health resources effectively. For example, members of some committees carry out regular inspections of the construction site and make recommendations for hazard control. For joint committees to be successful, they must encourage and reward open discussion of health and safety issues and candid two-way communication between workers and management. These committees should have direct access to top management, hold regularly scheduled meetings, work from an established agenda, keep minutes, and distribute health and safety information to the employees they represent.

Contractor/Subcontractor Relationship for Safety and Health Activities

Maintaining safety and health on construction projects is complicated by the presence on site of many employers, work crews, and tradespeople, as well as by the ever-changing nature of construction work. The contractual and working relationships among these entities and individuals are also complex, and lines of authority, reporting relationships, and work activities must be carefully coordinated if appropriate attention is to be paid to worker safety and health.

To ensure overall project safety, the trend in recent years has been toward greater prime contractor responsibility for subcontractor performance in this area. The justification for this trend is that on the multi-employer project typical of construction work, it is important that safety be uniformly and consistently emphasized by all employers on the site and that the same safety and health policies and procedures be enforced across the site.

Prime contractors are increasingly reviewing the safety records and programs of subcontractors before contracting with them; in some cases, the prime contractor develops a project-specific safety plan that is binding on all subcontractors working on the project. In other cases, the prime contractor conducts weekly safety talks with various subcontractor work crews. Another approach is to have the prime contractor conduct frequent (daily to weekly) inspections of subcontractor work areas and to stop work if serious deficiencies are identified.

All of the publications and standards surveyed for this study address contractor/subcontractor relationships, although the amount of attention dedicated to the topic varies widely. OSHA has no requirements for contractor/subcontractor coordination for the industry as a whole, although specific construction standards, e.g., the construction industry Hazard Communication Standard, contain requirements for multi-employer coordination.

Summary

As demonstrated by this review of the requirements and recommendations of the major organizations involved in construction, increasing emphasis is being placed on the implementation of a defined set of safety management practices; this trend is exemplified by the manual developed by the Corps of Engineers. The following section of this study reports on the effectiveness of a number of health and safety programs already in place.

IV. WORKER PROTECTION PROGRAM SUCCESS STORIES

Although the development of safety and health programs, plans, and procedures is the essential first step in construction safety and health, effective implementation and enforcement of these policies must follow if measurable results are to be achieved. The Corps of Engineers has a reputation for effective oversight of its projects and for achieving accident

and injury rates substantially below the national average for comparable construction work. This reputation is backed up by hard evidence: OSHA recently reported (OSHA 1992) that the Corps achieved a lost workday case rate of between 1.34 and 1.54 per 100 full-time workers in the period 1984-1988. In other words, by insisting that all of its contractors develop, implement, and enforce comprehensive worker protection programs on all of its sites, the Corps of Engineers achieved a lost-workday case rate 70 to 80 percent below the national average for the construction industry in the same period (6.8 to 6.9 cases per 100 full-time workers). To determine what practices the Corps actually implements on site, Meridian interviewed personnel from the Corps' National Office (personal communications, Donald Pettenger, February 1993).

First, the Corps uses the Federal Acquisition Regulations, which govern Corps contracts, to incorporate safety into the procurement process from the very beginning. For example, it requires that its contractors "have the necessary organization, experience, accounting and operations controls, and technical skills...including...safety programs" in place, and that all contracts include a clause requiring compliance with the Corps' Health and Safety Requirements Manual. Inclusion of this clause gives the Contracting Officer authority to stop work if a contractor fails to take corrective action for any hazard that poses a serious or imminent danger to employee safety and health.

The Corps' direct involvement with a contractor's construction safety management program begins even before work is initiated. A contractor must submit and receive Corps approval of its accident prevention plan before work on a site can begin. Hazard analyses for each phase of the project must also be submitted before work can be initiated on that phase. In addition, an accident report must be filed for all lost work-time injuries, a record must be kept of the contractor's self-inspections, and lost-time injury and illness rates are tracked by the Corps on a project-by-project basis.

In addition, every project has an assigned Corps quality control officer whose duties include project safety. For larger projects, the quality control officer is generally on site at all times during the project; even for smaller projects, he/she can be expected to inspect the site at least once a week. The work of each quality control officer is also routinely and

regularly reviewed by a safety professional in each Corps district, and there are trained and experienced safety professionals at each level of the Corps hierarchy.

Thus, the Corps ensures compliance with its construction safety management requirements through:

- Contractual requirements with stop work authority if the requirements are not met;
- Review of written plans before initiation and at each phase of a project;
- Review of self-inspection records;
- Accident report reviews;
- On-site inspections; and
- Higher level reviews of the work of on-site inspectors.

The Corps has found that rigorous implementation and enforcement of its policies ensure that construction safety and health goes beyond mere lip service.

Other success stories from the literature include:

- Bechtel Construction Company, of San Francisco, which employs some 32,000 workers and has won the National Contractors Association's annual accident prevention award in 35 of the last 36 years. More than 130 of Bechtel's projects around the world have exceeded 1 million person-hours of work without a lost-time accident. Bechtel works only with subcontractors who have implemented safety and health programs and have maintained good safety records. Once Bechtel has selected a subcontractor, it develops a site safety and health program that is contractually binding on all employers on the project; if a subcontractor does not comply with these safety requirements, Bechtel cancels the contract. Bechtel's safety manager states that requiring every contractor to have a written safety and health program is a top priority: "Just by having a program and practicing what they preach, [contractors] are going to eliminate some accidents" (LaBar 1992).

- BE&K Construction Company, a general contractor based in Birmingham and employing 5,700 workers, has received special honors for projects conducted on several sites, e.g., the firm's expansion of a DuPont titanium dioxide plant in DeLisle, Mississippi, earned the site membership (at the Star level) in OSHA's Voluntary Protection Program. At another DuPont site, BE&K employees have not had a lost-workday case in more than seven years. The company's injury/illness incidence rate is less than one-third of the industry average of 14.2 per 100 full-time employees. BE&K's safety director notes that "you can't have the top guy saying safety's important and hold the bottom guy [the laborer] responsible

without having the people in the middle--program superintendents, foremen, and line supervisors--believing it, too. We hold them responsible. I can tell you the recordable injury rate for any supervisor in this company." BE&K refuses to accept the usual excuses for the high accident rate in this industry; instead, the company's safety director says that "accidents are not surprises out of the blue. We know what the hazards are, and we know how to control them. It's time for the industry to do what it knows is the right thing to do. We're continuously striving for safety excellence, and it makes sense for everyone else in the industry, too" (LaBar 1992).

- Brown & Root Braun, the petroleum and chemicals business unit of Brown & Root, Inc., a subsidiary of Dallas-based Halliburton Co., has established a safety enhancement program designed to engineer fall hazards out of a project before construction begins. Practices employed in the 100 Percent Fall Prevention Program at this company include the use of remotely actuated pin extractors and full-body protection harnesses. Pin extractors reduce fall exposures by eliminating the need for workers to climb or be lifted to the top of a vessel to disconnect rigging after a lift has been completed. Large load pin extraction is performed hydraulically, and small pin extraction is completed using ropes (one rope releases a safety latch and the second extracts the pin). The company strives to provide continuous fall protection, using retractable lines, for all work performed at elevated heights. Compared with the older waist-belt harnesses, a full-body harness redistributes loads associated with fall deceleration across the body's pelvic region, dramatically reducing the risk of injury. Safety innovations such as these have enabled Brown & Root Braun to maintain a safety record for recordable injuries that is more than five times better than the national average (Occupational Health & Safety 1992).

- The Mecklenburg County (NC) Engineering Department, a 200-person group responsible for drainage, landfill and other maintenance and construction jobs, reduced the number of work-related injuries by 52 percent and cut associated costs by 92 percent in fiscal year 1986. To boost employee morale and curb the increase in occupational injuries, the Department introduced quality circles, an incentive plan, and a team safety program. The safety program includes tool box safety meetings, display of safety performance data, and incentives--in the form of time off--for excellent safety performance. The experience is particularly interesting in that the team safety concept was applied section by section, in groups of approximately 50 workers, over a period of several years; this allowed for comparison of accident trends between covered and non-covered groups of employees. Between 1985 and 1990 for the Department as a whole, the number of injuries fell from 73 to 27, and associated costs dropped from $52,848 to $15,448 (Lanier 1992).

These cases, as well as other success stories, are illustrated in summary form in Exhibit 3, which follows this section of the report.

EXHIBIT 3. Worker Protection Program Success Stories in Construction

COMPANY NAME	DESCRIPTION	SUCCESS MEASURE(S)	KEY ASPECTS OF PROGRAM
Air Products & Chemicals	International supplier of industrial gases, process equipment, and chemicals 180+ locations with 450+ open shop and union contractors 12,000+ employees 1988 CISE Owner Award Recipient*	OSHA recordable injury rate: 5.2--1982 2.2--1987 Zero lost workdays from 1985-88 Estimated savings to Air Products and construction industry: $1.7 million 252 injuries avoided 90 lost workday cases prevented	Line managers and employees responsible for safety performance Safety measures implemented by line management to ensure accountability Constructors selected with safety performance in mind; average Experience Modification Rate for constructors = 0.9 Emphasis on communication
BE&K Construction Co.	General contractor, based in Birmingham, AL 5,700 employees	Injury/illness rate less than 1/3 industry average One worksite has over 7 years without a lost workday	On-site safety professional serves as advisor to line management Safety performance considered in promotion decisions Annual safety conference for managers On-site manager accountable for safety

*Construction Industry Safety Excellence Award, given by the Business Roundtable

EXHIBIT 3. Worker Protection Program Success Stories in Construction (continued)

COMPANY NAME	DESCRIPTION	SUCCESS MEASURE(S)	KEY ASPECTS OF PROGRAM
Bechtel Construction Co.	International contractor with 32,000 workers 130+ projects	Over 1 million worker hours without a lost-time accident Recipient of National Constructors Association Annual Accident Prevention Award in 35 of 36 years	On-site safety professional Site safety and health program contractually binding on all employers on project; will dissolve contract if subcontractor found to be in non-compliance Written safety and health program Supervisors attend safety and health workshop at beginning of each project and during peak activity
Gulf States, Inc.	Specialty trade contractor 2,000 employees on construction and maintenance projects in United States 1989 CISE Constructor Award Recipient*	EMR = 0.88 in 1986 0.55 in 1989 Estimated savings to Gulf States and construction industry (1986-89): $5.3 million 267 lost workdays avoided	Continuous Improvement Process (CIP): all employees responsible for instituting organized change On-going training emphasis Drug program: screening conducted pre-assignment, at random, and post-accident Selection of subcontractors includes consideration of safety record: OSHA Form 200 incident rate, drug and safety program Management commitment to setting goals and measuring performance Complete accident/incident data, including near-misses, must be reported by employees, subcontractors, suppliers, vendors and owners with written report to corporate level in 24 hours; investigation required

*Construction Industry Safety Excellence Award, given by the Business Roundtable

EXHIBIT 3. Worker Protection Program Success Stories in Construction (continued)

COMPANY NAME	DESCRIPTION	SUCCESS MEASURE(S)	KEY ASPECTS OF PROGRAM
Gulf States, Inc. (continued)			Weekly safety meetings Hazardous work permits Equipment inspected before each use Monthly safety audits
M.B. Kahn Construction	General contractor and construction manager, based in Columbia, SC 500+ employees	Medical incidents level: 28--1987 9--1991 Three-year estimated program savings of $725,000; yearly distribution of $30,000+ in awards and bonuses	Management commitment Written safety program In-house competition, recognition and awards that capitalize on strong competitive spirit among construction workers including: • quarterly newsletter and safety report • published list of superintendent and project managers in order of safety performance • employee recognition in newsletter • President's Quarterly Safety Award for superintendent who demonstrates superior safety performance • annual accident prevention safety awards breakfast for all supervisory employees • safety awards raffle open to hourly employees based on project performance

*Construction Industry Safety Excellence Award, given by the Business Roundtable

EXHIBIT 3. Worker Protection Program Success Stories in Construction (continued)

COMPANY NAME	DESCRIPTION	SUCCESS MEASURE(S)	KEY ASPECTS OF PROGRAM
Mecklenburg County (NC) Engineering Department	County government department responsible for maintaining waterways, landfills, and performing some construction 200 employees working in 4 separate teams	Work-related injuries reduced from 73 in 1985 to 29 in 1990 Associated costs reduced from $53,000 to $15,000	Preliminary hazard analysis by management preceded implementation Tool box safety meetings at frequency decided by work crew Safety performance awards--vacation time--given quarterly to entire team, not individual workers Display of injury records on daily basis Annual prize to team with best safety performance
Monsanto Chemical Co.	Chemicals, detergents, man-made fibers, and some construction operations 200+ union and open shop contractors 1989 CISE Owner Award Recipient*	50% reduction in total injuries since 1986 OSHA recordable incident rate: 4.0--1985 2.3--1989 Estimated savings to Monsanto and industry: $22 million in direct and indirect costs	Adopted Business Roundtable recommendations from A-3 Report Decentralized management: site managers have primary responsibility for safety in field Instituted comprehensive safety management program including: • constructibility review • contractor selection • safety requirements in contract • daily construction audits • substance abuse policy • on-site safety coordinator • safety permit system for hazardous activity • worker orientation • safety training • safety recognition and awards • weekly safety walk-throughs and meetings • accident investigation and reports

*Construction Industry Safety Excellence Award, given by the Business Roundtable

EXHIBIT 3. Worker Protection Program Success Stories in Construction (continued)

COMPANY NAME	DESCRIPTION	SUCCESS MEASURE(S)	KEY ASPECTS OF PROGRAM
Pizzagalli Construction Co.	Heavy construction firm 30 worksites in 10 States	Annual worker compensation costs reduced 76% from 1986 to 1988 General liability costs dropped 96% from 1986-88 Approximately $1 million returned in worker compensation premiums in 1988 due to improved safety record	Training, including mandatory site orientation and weekly safety meetings Awards and incentives, including monthly safe project award, yearly superintendent award and savings bonds for hourly field employees Drug and alcohol testing when accident occurs Fines for non-compliance by subcontractors Personal safety equipment inspection program Management commitment to safety
Shamrock Farrell Construction Co.	General contractor, Houston-based 150 employees CISE* and National Safety Award winner	Low worker compensation costs; increased productivity	Free flow of communication between hourly workers, supervisors, and managers, in keeping with modern management principles Management reviews every accident, including first-aid incidents Tool box safety talks daily and whenever workers move to new site Weekly safety training sessions Local safety council used for low-cost consulting and training Gift certificates and small gifts to reward safety excellence

*Construction Industry Safety Excellence Award, given by the Business Roundtable

EXHIBIT 3. Worker Protection Program Success Stories in Construction (continued)

COMPANY NAME	DESCRIPTION	SUCCESS MEASURE(S)	KEY ASPECTS OF PROGRAM
Shell Oil Co.	Oil, gas, and chemical company 30,000+ employees 1990 CISE Owner Award Recipient*	OSHA 1989 incident rate: 1/10th national average Lost-workday rate steadily declining since 1985 Estimated savings/year for Shell and contractors: $2 million 85 lost workday cases	Total quality management Comprehensive construction safety program including: • ensuring safety in design • contractor screening: EMR of 1.0 or less • safety requirements written into contract • owner participation in and management of field safety program • contractor safety results reported weekly and quarterly Safety representative for every project Weekly and quarterly safety meetings Accident reporting to management within 48 hours; investigation required

*Construction Industry Safety Excellence Award, given by the Business Roundtable

V. COSTS AND BENEFITS OF WORKER PROTECTION PROGRAMS IN CONSTRUCTION

This chapter analyzes the costs and benefits of implementing a comprehensive worker protection program in the construction industry. It also estimates the potential net benefits and rates of return associated with such programs.

Documented information on the costs of implementing worker protection programs in construction is scarce, although some work has been done in this area. For example, the Pizzagalli Construction Company estimates that its program costs about $100,000 annually. The Business Roundtable, citing data collected from a significant sample of contractors working at various construction sites in 1980, reports that "the cost of administering a construction safety and health program usually amounts to about 2.5 percent of direct labor costs." Among the costs of administering such a program, the Roundtable lists salaries for safety, medical, and clerical personnel and the costs of conducting safety meetings, inspecting tools and equipment, conducting orientation sessions, carrying out inspections, providing personal protective equipment, and providing miscellaneous supplies and equipment. Projecting to 1990 on the basis of the Roundtable's data, the cost of such programs for the industry as a whole would have been approximately $2 billion.

The most direct way of estimating the benefits potentially associated with worker protection programs in this industry is to look at the costs of the work-related construction injuries these programs would prevent. There is substantial agreement among unions, industry representatives, and academic researchers about the unacceptably high human costs of current injury and fatality rates in the construction industry. There are, however, some differences of opinion on how best to measure the economic impact of work-related accidents. Hinze and Applegate (1991) calculated an average direct cost of $519.14 for every medical-case injury and an average direct cost of $6,909.98 for every restricted-activity/lost-workday case; they calculated the ratio of indirect to direct costs as 4:1 for medical-case injuries and 20:1 for restricted-activity/lost-workday cases. Among the indirect costs associated with construction accidents are those related to lost productivity, disrupted work schedules, administrative time for investigations and reports, training replacement personnel, paying wages to injured workers and other workers for time not worked, cleaning up and repairing damages, adverse publicity, and third-party liability claims against the contractor (Chaney 1991). If

these authors' estimates of the direct costs of injuries and lost workdays are projected to the construction industry as a whole, the total direct costs in 1991 would have been $2.1 billion; the total direct and indirect costs of work-related injuries for the industry as a whole in 1990 would have been $40.4 billion. The Business Roundtable (1982) reports that the ratio between indirect and direct costs ranges from 4:1 to 17:1, depending on the particular study. Overall, the Roundtable's Construction Industry Cost Effectiveness Project estimates that accident costs account for 6.5 percent of industrial, utility, and commercial construction costs. If this percentage is projected to the construction industry as a whole, the total costs of accidents in 1990 would have been $28.2 billion. Thus, these sources agree that work-related accidents and injuries are costing employers in this sector between $28 and $40 billion annually.

Several studies suggest that accident and injury costs can be significantly reduced by the implementation of effective worker protection programs. For example, the Business Roundtable found that, for a sample of contractors with good construction safety and health programs, the average OSHA recordable injury incidence rate for 1977 to 1980 was only 36 percent of the average rate for the construction industry as a whole (as published by the National Safety Council). In 1980, according to the Roundtable, these contractors had workers' compensation losses averaging 6.1 cents per hour worked; had they experienced losses at the national average, their losses would have been 16.9 cents per hour, almost 3 times as much (Business Roundtable, January 1982). If implementing comparable programs industry-wide is assumed to reduce injury rates for the construction industry as a whole by a comparable percentage, the savings would be between $10.3 billion (using the Hinze and Applegate estimate) and $18.0 billion (using the Roundtable estimate). The experience reported by one Vermont-based construction company--Pizzagalli Construction--confirms the benefits of these programs. Since 1986, their worker protection program has reduced the company's workers' compensation costs by 76 percent, from $896,603 annually to $213,328, for a $683,275 per-year saving; between 1986 and 1988, the firm's general liability insurance costs dropped by 96 percent, from $407,867 to $16,731, for a savings of $391,136 in a 3-year period.

The potential net savings of worker protection programs in this sector are thus substantial. Based on Business Roundtable data, industry-wide programs costing $2 billion per

year could achieve cost savings of $10.3 to $18 billion per year, for a net savings of $8.3 to $16 billion per year for the construction industry as a whole. The ratio of cost savings to program costs for these programs is thus between five to one and nine to one. The work of Barrie and Pulsion (1984) confirms this estimate: these authors report that, for each dollar invested in safety, a $4 to $8 return can be expected. Other estimates of the potential net savings of these programs are more conservative but still impressive. For example, Levitt and Samuelson (1987) state that "the minimum net savings to be expected from introducing an effective safety management program is 4 percent of direct labor costs." If this percentage is extrapolated to the construction industry as a whole, such programs would have saved $4.4 billion in costs in 1990. The U.S. Corps of Engineers reports that compliance with its safety standards achieves a minimum cost savings for its contractors of 0.5 to 1.0 percent of total project costs, mostly in the form of reduced workers' compensation costs (personal communication, Dan Peterson, Corps of Engineers, February 1993). If extrapolated to the construction industry as a whole, this would mean a net cost savings in 1990 dollars of $2.2 to $4.4 billion.

Aside from cost savings, effective worker protection programs in construction have been credited with a number of indirect benefits, including improved communication within the organization (Mattila and Hyodynmaa 1988), increases in productivity and production due to a decrease in accidents and injuries (Lattanzio 1991), and a beneficial effect on labor-management relations (Boden, Hall, Levenstein, and Punnett 1984).

VI. CONCLUSION

These case studies and qualitative assessments of the practices of some major organizations active in construction demonstrate that introducing safe management practices can have dramatic impacts on accident and injury rates. In addition, the experience of many firms and organizations indicates that the costs of implementing such programs are only a fraction of those associated with worksite accidents. In summary, worker protection programs that are characterized by management commitment, employee involvement, worksite analysis, hazard prevention and control, and safety and health training offer the best hope of breaking the cycle of injury, death, and spiralling costs that threatens to overwhelm this industry.

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APPENDIX A

Review of the Recent Construction Safety Management Literature

APPENDIX A. REVIEW OF THE RECENT CONSTRUCTION SAFETY MANAGEMENT LITERATURE

OVERVIEW OF THE LITERATURE

A review of the recent (post-1980) construction industry literature* reveals that, like OSHA, firms in this sector are concerned with the human costs associated with high injury and fatality rates; the spiraling workers' compensation costs associated with construction accidents are also a major issue. The recent literature can be classified under three headings:

- Business and trade literature, which focuses on the implementation of safe management practices;
- Behavioral studies, which address the attitudes of workers and managers to safety issues and ways of changing them; and
- Articles describing specific construction safety management programs.

The business and trade literature emphasizes mechanisms for making workplace safety a management priority, and thus implicitly acknowledges the importance of management commitment to the achievement of a safe working environment. Topics covered include:

- The importance of compiling accident statistics by individual contractor, facility, and project;
- The importance of reviewing safety performance by quantifying and analyzing accident rates, workers' compensation costs, and the indirect costs of accidents; and
- The savings that can be generated by evaluating the safety records of contractors during the bidding process.

In general, studies in the business management literature focus on the safety performance of specific companies rather than on the relative effectiveness of any particular component of the company's program. The authors' main objective is to encourage construction managers to emulate the practices of the best firms in the industry or to emphasize the importance of considering safety performance when choosing a contractor.

The behavioral research studies focus on issues such as the effectiveness of feedback mechanisms, attitudes toward safety, the influence of unionization on safety practices, and the effectiveness of training. There is general agreement among authors that involving

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* Appendix A contains a brief overview of the recent literature, abstracts of the articles and books reviewed for this study, and a bibliography of these sources.

employees in accident prevention programs and providing safety training to all workers on the site are essential to success. The literature recognizes that younger workers and non-unionized workers are particularly vulnerable to injuries and that reaching these groups requires special effort (Eastern Research Group 1991).

The literature on construction management practices tends to be anecdotal, and it is primarily concerned with "success stories." For example, one of the better studies of this kind describes the experience of the Pizzagalli Construction Company, a Vermont-based heavy construction firm with approximately 30 worksites in 10 States along the East coast (Bruening 1989). In the three years after Pizzagalli implemented a construction safety management program, recordable injuries were reduced by almost 48 percent, the lost-workday rate fell by 33 percent, and workers' compensation costs were cut by 76 percent. Improved training, including an initial orientation program for new employees and weekly safety talks for all employees, was considered the key to the success of this program. Other important elements, according to Pizzagalli, were a drug and alcohol abuse program, incentive awards for safety performance, and equipment inspections that were both more detailed and more frequent than those required by OSHA.

In summary, the recent literature on the construction industry is unanimous in emphasizing the importance of management's role in achieving worksite safety. This focus is even more appropriate in construction than in general industry because of the dynamic nature of construction work: the changes in hazards and work crews associated with the various phases of a construction project make active and continuous management involvement and oversight essential if a safe work environment is to be maintained. For example, annual compliance self-inspections performed by the employer may be adequate for the fixed-workstation, steady-state operations typical of most general-industry production facilities, but daily (and sometimes even more frequent) inspections are necessary on most construction sites.

All of the articles and publications reviewed here were published after 1980. For ease of discussion, the literature is grouped into the three categories identified previously: business management literature, behavioral research studies, and reviews of construction safety and health programs. The first category includes literature on construction cost accounting, insurance, liability, and the bidding process. The second category consists largely of experimental studies that evaluate the effectiveness of behavior modification tech-

niques in improving safety performance. The final category includes articles underlining the need for safety management and reports describing specific practices that can be incorporated into worksite safety and health programs. Some of the comprehensive texts cited span all three categories. In these cases, cross-references to other categories are provided. The review highlights key management concepts and practices; for details on methodology or program implementation, the reader is directed to the original text. This appendix first discusses the major themes that emerge in each category of literature, while the final section contains reviews of the major articles and publications, grouped by category.

BUSINESS MANAGEMENT LITERATURE

One of the most comprehensive sources of business management literature on construction safety is the Business Roundtable. The Roundtable is a 215-member association representing some of the largest firms in all business sectors, including major buyers of construction services. In the early 1980s, the Business Roundtable launched an ambitious study, the "Construction Industry Cost Effectiveness Project" (Business Roundtable 1982) in an attempt to analyze and improve cost effectiveness in this industry. Safety was one of the topics studied, and safety and skills training have since been identified as the two areas likeliest to lead to the greatest improvements in cost effectiveness. An important aspect of the Business Roundtable's 1982 report, and a topic which is also discussed in Levitt and Samelson's (1987) text on construction safety management, is the role buyers of construction services can play in influencing safety. Dick Kibben, head of the Business Roundtable's construction research project, states that the Roundtable emphasizes construction purchasers for two reasons. The first is group membership: many Roundtable members are major buyers of construction services; the second, and perhaps more significant, has to do with the structure of the construction industry, which is characterized by numerous small firms. Ninety percent of all construction firms--general contractors, heavy construction contractors, and subcontractors--have fewer than 20 employees. These firms account for 44 percent of the 5 million construction employees counted by the Census Bureau in 1987. Only 23 percent of all construction employers, or fewer than 1 percent of firms, are represented by

establishments of 100 or more employees.* According to Kibben, a surprising number of contractors do not know their own experience modification rate (EMR), a multiplier applied to the contractor's workers' compensation premium based on past safety performance. Because the technical capabilities necessary to manage costs and track safety performance may not be readily available at small firms, the Roundtable and other analysts view construction services purchasers as a leverage point in safety management. By making a contractor's safety record part of the competitive bidding process, construction buyers indirectly manage safety by awarding contracts to those firms with the best safety performance. Safety performance is reflected in a firm's EMR, OSHA incidence rates for recordable injuries and illnesses, and formal safety management policies. When safety is well-managed, injury and lost-time incidence rates can be reduced to a fraction of those reported by the National Safety Council; firms chosen by Roundtable members have an injury incidence rate of approximately 3/200,000 exposure hours and a lost-time incidence rate of 0.02/200,000 exposure hours, compared with national averages of 14 and 6 per 200,000 exposure hours, respectively. The Roundtable estimates that the savings potentially achievable through effective safety management are approximately 4 percent of project costs (Business Roundtable 1982).

In a follow-up companion publication to the 1983 Report, "The Workers' Compensation Crisis... Safety Excellence Will Make a Difference" (Business Roundtable 1991), the Roundtable offered the following recommendations for owners or construction services buyers:

(1) Understand how the workers' compensation premium is affected by work site accidents;

(2) Require contractors to provide, for the past three years, their State workers' compensation insurance rate sheets and OSHA 200 logs;

(3) Establish target EMR's and injury and lost-time incidence rates to prequalify contractors, and allow only those contractors who meet these targets to bid;

(4) Ensure that all contractors bidding have and implement on-site safety performance programs;

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* These figures are from the Construction Statistics Division of the U.S. Bureau of the Census. An establishment is a physical business location; a single firm may have multiple establishments.

(5) Commit to a "zero injury" goal at the highest management level, encourage the same commitment in contractor companies, and require routine and frequent safety performance reports be sent to the CEO;

(6) Following a lost-time accident, conduct a site visit within 24 hours with top management from owner and contractor companies to review accident plan preventive measures;

(7) Reward safe performance; and

(8) Maintain separate accident statistics for each contractor on the site.

In its publications on construction cost-effectiveness, the Business Roundtable does not discuss the use of accounting methods that will reflect the true costs of accidents. This issue was addressed by Stanford University, however, in a 2-year study in which 13 companies agreed to use the Stanford Accident Cost Accounting System, designed to highlight accident costs. (The results of this study are discussed in Levitt and Samelson (1987). Although participating companies found that the accounting system only captured direct costs, its use increased management awareness of the high price of accidents. Circulating an accounting report that reflected accident costs to project managers and supervisors also increased the sense of accountability for safety. Levitt and Samelson, as well as other authors, enumerate the indirect costs of accidents, which may include delays and overtime; loss of work crew efficiency; training of replacement workers; clean-up, repair, or replacement of damaged equipment; work rescheduling; costs for safety and clerical personnel time related to the accident; OSHA fines; and the cost of legal assistance. Studies of the ratio of direct to indirect costs, as reported in this literature review, indicate that this ratio can range from 4:1 for medical injury cases to 20:1 for restricted-activity or lost-time injuries in construction.

Contractor liability for overall site safety is also a significant management concern. Although there is some disagreement among authors on the best method for handling liability when negotiating for the services of contractors and subcontractors, a recurring point is that construction managers cannot shield themselves from liability for safety and that the best way to avoid liability is for management to be an active participant in the safety program, as demonstrated by written policies and actions. This emphasis on management commitment, considered one of the most important components of any safety program, is echoed in the behavioral research and occupational safety and health program literature.

BEHAVIORAL RESEARCH

The two major themes explored in construction safety behavioral research are causal attribution and motivation. As it relates to safety management, attribution research examines how the perception of causality for an accident affects the structure of a safety program. Generally speaking, individuals tend to "overattribute" accidents to workers, or in other words to assume that greater care by the worker could have prevented an accident even in cases where this is obviously not true. This attitude often finds expression in punitive safety programs with numerous rules and regulations, but little communication between labor and management. In a review article on attribution research, DeJoy (1985) summarizes its implications for safety programs: (1) workplace accidents should be investigated by a qualified person from outside the workgroup and not tied to line management; (2) summaries of all accident investigations should be disseminated to all workers and managers involved; (3) safety messages in all forms should be carefully developed to take into account the sources of bias that may influence the recipient's interpretation of the message; (4) a plan should be developed for reporting and analyzing near-miss and minor-loss accidents; (5) supervisor safety training should touch on the issue of attributional bias and its implications for accident investigations; and (6) managers need to be made aware of the multi-causal nature of accidents and the need to integrate safety into the total management system.

Recent studies (Fellner and Sulzer-Azaroff 1984; Zohar 1980) on motivating safe performance suggest that immediate, posted feedback is an effective, economical way to improve performance and increase the use of personal protective equipment. In the studies cited, the immediate posting of inspection results in a location accessible to workers significantly improved work conditions and practices, and immediate posting of auditory test results significantly increased earplug usage, even among new workers. Researchers suggest that posting feedback heightens awareness and improves communication, encouraging safe behavior among both workers and management.

WORKER PROTECTION PROGRAMS IN CONSTRUCTION

This heading covers literature that provides company and industry statistics on the need for safety management as well as articles that identify specific safe management practices. In a Business Roundtable study (1989) of worker absenteeism and turnover, unsafe

conditions were found to be the primary factor leading to worker absences. Unsafe behavior and ignorance about safe practices were found by two authors to be more common among young workers, although a study of fatal construction injuries in Washington State found higher mortality from injuries among older workers (Buskin 1987). The importance of managing safety is summarized in a recent article by LaBar: more than 2,000 deaths and 630,000 injuries result yearly from construction accidents, for an annual cost to the industry of $30 billion. LaBar's 1992 article and several others offer specific management recommendations, some of which were provided to the authors by companies with successful safety records.

Throughout the literature, the importance of demonstrating management commitment to safety is emphasized. For example, Dedobbeleer (1987) found that a worker's attitude toward safe performance might be less related to training than to management's attitude toward safety. A second key element of effective safety management was a written site safety program. The most succinct summary of effective safety management practices is provided by the Business Roundtable's 1991 publication, "The Workers' Compensation Crisis...Safety Excellence Will Make a Difference." In future editions of this publication, the Roundtable will track the experience of 11 owner firms and 32 contractor firms it has recognized in its Construction Industry Safety Excellence Award Program. All of these companies set a zero-injury goal and use some or all of the following practices to achieve it:

- Prequalification of potential contractors;
- Safety performance hurdle rates for qualifying contractors;
- Safety-specific contract language;
- Substance abuse program;
- Absentee and turnover audits;
- Safety orientation, which includes:
  - Orientation;
  - Safety and loss prevention review;
  - Accident/incident reporting requirements;
  - Emergency phone system/numbers; and
  - Emergency alarms/responses;

- Safety training, which covers:
  - Basic safety rules and emergency procedures;
  - Hazard communication (Right To Know);
  - Lock-out/tag-out procedures;
  - Proper use of respirators; and
  - Heavy equipment certification;
- Supervisory training, covering:
  - Attitude and behavior;
  - Disciplinary guidelines;
  - Accident/incident reporting and investigation; and
  - Incentives/recognition programs;
- Weekly site safety meetings;
- Site safety inspections;
- Hazardous work permits;
- Constructor safety performance evaluation;
- Statistical reporting and feedback; and
- Recognition of superior safety performance.

This report's specific recommendations for owner firms or buyers of construction services are listed in the business management section of this summary. Below are some of the specific suggestions for contractor firms:

Construction contractors should:

- Understand the total workers' compensation insurance premium (WCIP) concept and how it is affected by worksite accidents.
- Ascertain that the manual rate classification codes used to calculate the WCIP accurately represent the work of the crafts employed.
- Set Experience Modification, Total Recordable Incidence and Total Lost Workday Incidence "Hurdle Rates" as targets of acceptability for prequalifying subcontractors, and allow only prequalified subcontractors to bid.
- Start every meeting with emphasis on the safety performance of the company. Ensure that people at all levels understand that safety is of paramount importance.

- Ensure that accident and injury reporting is immediate and has the highest profile. The CEO should promptly receive a personal call when a lost-time, or potential lost-time, injury occurs.

- Insist that a jobsite visit by senior level executives of subcontractor, contractor, and owner occur no later than the day following a lost-time accident to review what occurred and plan steps to prevent further incidents.

- Determine that dynamic safety programs are operational on the worksite at all times.

- Consider incentives for safety performance. Put a project level "cents per hour" incentive in place to reward craftspeople for lost-time and injury-free-work.

- Ensure that management at all levels is evaluated on safety performance as well as other critical evaluation factors.

- Develop means to ensure that the costs of safety non-performance are charged to each project before the profit or loss generated by that project is calculated.

- Make the goal of zero accidents a direct line management responsibility from the CEO down to and including the workers at the jobsite.

BUSINESS MANAGEMENT LITERATURE

Arden, P. Subcontract for safety first. Safety & Health, pp. 44-47. November, 1992.

This article discusses the importance of subcontractor safety to overall construction safety and particularly to the success of the prime contractor's work on any given project. Ways to ensure that subcontractors are serious about safety include:

- Making them complete a prequalifications questionnaire dealing with their safety record;
- Evaluating their Experience Modification Rate;
- Reviewing the subcontractor's OSHA 200 logs;
- Reviewing the subcontractor's formal safety program;
- Visiting a worksite of the subcontractor;
- Documenting the subcontractor's safety responsibilities in writing;
- Including safety requirements in contract documents;
- Requiring subcontractors to develop site-specific safety plans;
- Building awards or penalties for safe performance into the contract;
- Requiring subcontractors to have safety specialists; and
- Monitoring/auditing subcontractor's worksites regularly.

Britt, P. Owners own up to contractor safety. Safety & Health. National Safety Council, pp. 44-48, December 1993.

This article describes efforts to improve contract labor safety and health in the petrochemical industry since 1989. It discusses the opinion, reflected in recent court decisions and OSHA cases, that the company that hires the contractor is responsible for the contractor's job safety experience and also holds contractors responsible for subcontractor job safety and health. OSHA penalties for the owner are "likely to be double or triple that assessed against a guilty contractor," according to an attorney practicing before OSHRC. Examples of how safety pays include Mobil Oil Corporation's experience at its Joliet

Refinery: Mobil requires prospective contractors to fill out a questionnaire on workers' compensation/insurance experience and to furnish a written copy of their safety program. In addition, contractors must provide Mobil with Material Safety Data Sheets (MSDSs) for all materials they intend to bring on site. Some companies require prospective contractors to pass a written safety and health proficiency examination.

Mobil credits a cooperative company/contractor safety training program for reducing incidence rates to one-quarter the published industry average at the Joliet Refinery. Incidents dropped 75 percent over 3 years after the implementation of strict safety rules. This plant is a VPP site. On a recently completed large construction project, the refinery's incidents were one-seventh the industry's national average.

Burati, J.L., Matthews, M.F., and Kalidini, SN. Quality management in construction industry. Journal of Construction Engineering Management 117(2):341-359, 1991.

This article reports on a study of the management practices in place at 19 owner and contractor firms involved in heavy industrial, manufacturing, and commercial construction. It documents the introduction of total quality management (TQM) in the construction industry. A majority of the companies participating in the study have implemented or are implementing TQM techniques. A major finding was that personnel interviewed believe that safety, deadlines, cost, and quality are all equally important and are interdependent, i.e., that safe, high-quality projects are more likely than others to be on budget and on schedule. If personnel ranked these items separately, they ranked safety first, followed by quality, deadlines, and cost. Principal findings of the study were:

- Management participation in the implementation process is essential; and
- Topics and examples used in training should be integrated with the work processes of the individuals being trained.

Business Roundtable. 1988. Improving Construction Safety Performance: A Construction Industry Cost Effectiveness Project Report. Report A-3, January 1982.

This is the second report from the Construction Industry Cost Effectiveness Project. Among the information provided is a list of steps owners can take to improve the on-the-job safety performance of contractors. All owners with better-than-average construction safety records require their contractors to obtain work permits for specific activities. In awarding contracts, owners with good safety performance consider the contractor's safety record. During construction, "safe owners" conduct formal site inspections and regularly audit con-

tractors' safety practices. They use goal-setting with contractors to reduce accidents and they keep statistics separately by contractor. Safe owners establish construction safety departments to monitor and confer with contractors, and stress safety during pre-bid activities and at site visits. Contract specifications of safe owners often surpass OSHA regulations, and the owners themselves are frequently involved in training sessions on hazards and safety procedures for construction site supervisors and workers. This report reviews a Stanford University survey of experience modification rates (EMRs) for workers' compensation to identify the potential percentage variation in insurance costs (and hence total project costs) that occur as a result of variations in safety performance. The EMR, as a multiplier for worker compensation rates, varied in this study from 50 to 205 percent. A form was developed for use by owners to prequalify contractors according to their safety attitudes and practices; that form is included in the printed report.

Business Roundtable. The Workers' Compensation Crisis...Safety Excellence Will Make A Difference. Companion Publication to CICE Project Report A-3, 1991.

This safety management report from the Business Roundtable was published 9 years after the A-3 report. As the authors point out, despite efforts to reduce injury frequency, the OSHA Recordable Incidence Rates and Lost-Time Frequency Incidence Rates have not improved significantly since the original A-3 report was published in 1982. The report provides a brief history of worker compensation insurance and rate trends since 1979. Detailed explanations are given for calculating worker compensation insurance premiums in construction; these rates are based on 1) the EMR; 2) the manual rate (an insurance premium based on the type of work performed; and 3) payroll units (calculated by dividing the employer's total annual direct labor cost by 100). Manual rates vary widely among States and construction crafts. The average manual rate by craft--which suggests relative hazard--and a 50-State comparison of manual rates are provided. The report also describes briefly how workers' compensation insurance is provided in each State: with State as sole source, through State programs and specifically licensed companies, or through insurance companies alone. The equation for calculating the EMR is given and the effect of accidents on the EMR is discussed. Finally, using the safety programs of owner and contractor firms that have received the Roundtable's Award for Safety Excellence, the report lists the elements of an effective

construction safety program. It then provides separate lists of management practice recommendations for owner and contractor companies.

Chaney, P. The hidden costs of jobsite accidents. Constructor 73(4):40-41, April 1991.

Chaney discusses the Experience Modification Rate (EMR), which is used in calculating workers' compensation premiums. The EMR is multiplied by a standard rate associated with a particular type of construction, and the EMR for a particular company is then determined by dividing the expected number of losses (as determined by the insurance industry) by the company's actual losses. The lower the EMR, the lower the company's workers' compensation rate.

A list of indirect cost elements is provided and an example is used to illustrate how the total cost of an accident compares with the amount paid out by workers' compensation. Contractors are advised that owners may consider a bidder's safety record and EMR when awarding contracts, and that an effective safety program (lower EMR) will make a bidder more competitive.

Freeman, S. 1990. Control of construction site safety. In: Proceedings of the National Conference on Construction Safety and Health, sponsored by the AFL-CIO and NIOSH, Seattle, WA, September 25-27, 1990.

Freeman's paper is a general discussion of the issue of contractor versus subcontractor management of project safety and the associated liability. He lists the pros and cons of general contractor control of subcontractor safety, and legal remedies that may protect the contractor from excessive liability. He also offers a "Blueprint for Control of Construction Site Safety" that enumerates the safety responsibilities of construction managers (which could include general contractors, prime contractors, owners, engineers, or architects), and subcontractors. The Blueprint specifies and defines key job functions in the safety plan, including those of the project manager, safety professionals, subcontractor manager, crew supervisors, owners, architects, and engineers.

Hinze, J. and Applegate, L. Cost of construction injuries. Journal of Construction Engineering and Management 117(3):537-550, 1991.

and

Gorman, E.J., III. Workers' compensation: Labor/management proposals to reduce injuries and illness. In: Proceedings of the National Conference on Construction Health and Safety, Seattle, WA, September 25-27, 1990.

Both of these papers discuss the same study; they differ only in some of the comparisons they draw from the data. The goal of the study was to calculate the indirect costs of accidents: Heinrich suggested a four-to-one ratio of indirect to direct costs for construction in a 1931 paper; the more recent analysis was an attempt to re-examine that ratio. Participation was sought from member firms of the Construction Industry Institute, Associated Builders and Contractors, the National Constructors Association, and other contractor associations. A total of 573 injury reports from 103 construction firms were used for this analysis. A survey form that allowed calculation of indirect costs was developed and used for each accident report (this form is reprinted in the Hinze and Applegate paper). The figures that were derived show a ratio of 4:1 for medical injury cases and 20:1 for restricted activity or lost workday injuries. Cost comparisons by construction trade yielded no statistically significant differences, nor did comparisons between the ratios for merit shop and union shop projects. When stratified by type of contract, the data indicated that indirect to direct cost ratios tended to be higher on cost-reimbursable contracts than on lump sum contracts, and on larger projects overall.

Lattanzio, R. 1991. Managing construction site safety. Occupational Health and Safety, pp. 38-39, February 1991.

This article provides a brief summary of the daily responsibilities of site safety management in terms of compliance with safety standards. It lists the benefits of employing an independent safety professional: reductions in violations and insurance premiums and claims payouts, increases in productivity, freeing the construction manager or general contractor to attend to construction, and access to additional liability insurance that a contractor cannot otherwise obtain.

Smith, G. and Roth, R. Safety programs and the construction manager. Journal of Construction Engineering and Management 117(2):360-371, June 1991.

In this paper, Smith and Roth discuss how the construction manager's liability is defined in contract documents. They review the responsibilities of the construction manager as

defined in contracts by the American Institute of Architects, Associated General Contractors, National Society of Professional Engineers, and Construction Management Association of America. They then discuss recent case law regarding construction manager liability for safety, emphasizing that this is a relatively new area. The authors close with the assertion that since construction managers cannot shield themselves from liability, the best idea is to become an active participant in the safety program. Among the factors listed which decrease construction manager liability are: a safety program that decreases the risk of accidents, a contract that clearly delineates the safety responsibilities of all parties, a contract clause that indemnifies the construction manager from negligent acts of others, and making every reasonable effort to prevent and correct safety deficiencies. Factors that increase construction manager liability and requirements for contractors are also specified.

Synnett, R.J. Construction safety: A turnaround program. Professional Safety, pp. 33-37, October 1992.

This article describes the experience of the M.B. Kahn Construction Company, a general contractor and construction manager that employed more than 500 people and had a sales volume of $243 million in 1991. In 1988, the company's sales volume was $105 million; its workers' compensation premium that year was $500,000, and its Experience Modification Rate (EMR) was 1.49 (1.00 is the standard). To address this problem, in 1988 the company introduced an accident prevention and safety program and simultaneously began to self-insure its workers' compensation program. Previously, by its own admission, the prevailing attitude in the company toward safety was "poor." The new program emphasizes management commitment, the safety responsibilities of key employees, training for new hires, accident investigation and reporting procedures, frequent job-site inspections, refresher training, and a close working relationship with OSHA. The company credits in-house competition, recognition, incentives, and management commitment with the program's success. Savings for the overall program are estimated to be $725,000 over 3 years.

Ward, S.C., et al. Advantages of management contracting--critical analysis. Journal of Construction Engineering and Management 117(2):195-211, June 1991.

A management contracting system is one in which an outside organization is retained to coordinate the design and construction phases of a project and to control construction. Four types of management contracting systems are listed, although the article focuses on the situation in which the management contractor directly employs work contractors to undertake

all construction packages. No construction work is done by the management contractor, but this contractor firm does provide coordination and time, cost, and quality control. The advantages for safety of this approach include better planning and control, which can mean improved safety performance if an effective safety management program exists, and fewer documented claims. The disadvantages include blurring of lines of liability and whatever increased risks may arise as a result. The authors discuss the types of projects for which management contracting is best suited: large or complex projects, ones which require flexibility because of rapidly-changing technology, or ones for which there is a strong economic advantage to early start and completion. They conclude with a list of provisos that ought to accompany any such management agreement.

BEHAVIORAL RESEARCH

Business Roundtable. Construction Labor Motivation: A Construction Industry Cost Effectiveness Project Report. Report A-2, March 1992.

This is a general report on worker motivation prepared on the basis of a review of both construction and general industry literature. In a specific section on safety, the report states that workers will be motivated if top management expresses strong concern for project safety. Safety incentive programs that reward project managers or supervisors for their safety record are also cited as a means of improving the morale of both supervisors and workers. Job orientation for new workers, regular job safety meetings, and supervisor awareness of hazards were all found to be motivating factors. The studies supporting these claims are referenced.

Dedobbeleer, N. and Beland, F. A safety climate measure for construction sites. Journal of Safety Research 22:97-103, 1991.

This study tests a safety climate model developed for production workers or construction workers. Climate was defined as "molar perceptions people have of their work settings." A self-administered questionnaire was used to survey 384 non-residential construction workers in Baltimore, MD, and the response rate was 71 percent. The survey assessed workers' perceptions of management's commitment to safety and workers' perceptions of their own involvement in safety. The study revealed that construction workers, unlike production workers, perceive management's words and deeds as a single dimension, and that these workers perceive safety as a joint responsibility between workers and management.

Based on these results, the authors conclude that "management's safety concerns and actions should be highly publicized among the workers," and that "workers' involvement can include participation in the development of safety programs, conduct of safety audits, and identification of solutions."

DeJoy, D.M. Attributional processes and hazard control management in industry. Journal of Safety Research 16(2):61-71, Summer 1985.

DeJoy reviews attribution theory research in this paper and provides a useful summary of its implications for safety management programs. Perceptions of causality influence how workers appraise workplace hazards and influence the design of safety programs. A safety program with punitive enforcement measures, extensive rules and regulations, and little two-way communication between labor and management suggests that management views most accidents as the fault of the worker and reflects the belief that little attention needs to be given to environmental factors. The policies and actions of top management influence the perceptions of workers and first-line supervisors as well. If causal attribution is incorrect, it can lead to inappropriate safety policies and programs that may magnify rather than correct the problem.

DeJoy cites studies that identify strong management commitment to safety. Safety programs in these companies typically share the following features: safety matters are given a high priority at company meetings and planned activities; top managers are personally involved in safety activities; safety officers are given relatively high rank and status in the company; open, two-way communication exists between labor and management on safety issues; importance is given to safety inspections, environmental control, and general housekeeping; and distinctive methods are used to promote safety awareness.

In summarizing the implications of attribution research for safety programs, DeJoy offers the following recommendations: (1) workplace accidents should be investigated by a qualified person outside the workgroup and not directly tied to line management; (2) summaries of all accident investigations should be distributed to all workers and managers involved; (3) safety messages of all forms should be carefully developed to take into account the sources of bias that may influence the recipient's interpretation of the message; (4) a program should be developed for reporting and analyzing near-miss and minor-loss accidents; (5) supervisor safety training programs should inform supervisors of the types of attributional

bias likely to operate in accident assessment and the implications of such bias; and (6) managers need to be made aware of the multi-causal nature of accidents and the need to integrate safety into the total management system.

Dejoy, D.M. Supervisor attributions and responses for multi-causal workplace accidents. Journal of Occupational Accidents 9:213-223, 1987.

This paper is a study of how those in supervisory roles attribute responsibility for and respond to workplace accidents. Subjects read industrial accident reports that varied in terms of the description of cause (e.g., worker failure versus machine failure) and severity of outcome. Severity of outcome did not substantially affect how evaluators attributed responsibility or selected remedies. The gender of the study subjects also had no observable effect on decision-making. Overall, however, subjects "overattributed" accidents to lack of effort on the worker's part; that is, when worker ability or task difficulty were apparently related to the accident, they stressed that greater worker effort, rather than improved supervision or management, might have remedied the situation. The researchers suggest that this behavioral tendency shifts the responsibility to the worker and is likely to result in a safety climate in which little training, task analysis, or hazard control is attempted, and inadequate measures are used to control losses.

Denton, D.K. Safety Management: Improving Performance. New York, McGraw-Hill, Inc, 1982.

This book is based on the assumption that making safety management more employee-centered will improve safety performance by increasing worker awareness of and responsibility for safety. Case studies to support this assumption are supplied. The authors discuss management practices to shift emphasis to the employee, as well as motivation theories, styles of communication, decision-making, training, and statistical methods for tracking safe performance. The information in this book will be useful to the safety manager or trainer interested in improving communication; some specific management practices described, such as the creation of worker safety committees, may also be useful in the development of standard operating procedures.

Fellner, D.J. and Sulzer-Azaroff, B. Increasing industrial safety practices and conditions through posted feedback. Journal of Safety Research 15:7-21, Spring 1984.

This concise and interesting paper describes a well-documented study on the use of posted feedback as a behavioral technique to improve safety performance. The authors begin

by reviewing the literature on the use of performance feedback to promote safety. They cite a number of studies that have found that individual or public feedback, accompanied by goal-setting, effectively increased safe conditions and practices. This particular experiment was designed to determine whether positive and specific feedback posted weekly would increase safe practices and conditions and consequently decrease injuries. Although the study was conducted in a paper mill, the techniques employed could be used in construction operations.

The researchers established baseline rates for safe conditions and practices in the mill. They then conducted weekly inspections in each of 17 rooms and posted feedback on safe conditions in an area visible to all employees in that room. Brief (10-minute) meetings were held with hourly and salaried employees to discuss the feedback. After four months, a similar procedure was followed to give feedback on work practices.

Statistically significant improvements in working conditions were found in rooms with posted feedback; safe practices increased from 4 percent to 30 percent; the percentage of nonhazardous work zones overall increased from a baseline of 79 percent to 85 percent. Posted feedback also increased safe practices overall from a baseline of 78 percent to 85 percent. There was a modest though significant reduction in injuries over the course of the study.

The authors emphasize that the program was inexpensive to develop and implement. Additionally, although the feedback did not specifically address injuries, the injury rate decreased after the program was implemented. The study suggests that providing and displaying positive fedback from construction inspections could be an effective, inexpensive method for improving construction safety.

Landeweed, J., et al. Risk taking tendency among construction workers. Journal of Occupational Accidents 11:183-196, February 1990.

The behavior of construction workers is often mentioned as one of the most important micro-level factors in the occurrence of accidents. Intentionally unsafe behavior at work and a willingness to take risks have been considered significant risk factors. This study, conducted in the Netherlands, evaluated construction workers' risk-taking tendencies in relation to their involvement in accidents and their safety performance. Risk-taking was also compared to that of male alpine skiers and male patients of general practitioners. Statistical corrections were made for gender, education, and age. Behavioral tests were used to

evaluate risk-taking tendencies. Construction workers did not score higher on willingness-to-take-risk measures than the male patients, and construction workers also scored relatively low on the TAS (Thrill and Adventure Seeking) scale and reported little need to engage in risky physical activity. This was significantly different from the findings for alpine skiers. As a result, the authors indicate that safety campaigns in construction must involve structural change at the worksite if improvements are to be expected. They also indicate the need for further study and validation of their results.

Lanier, E. Reducing injuries and costs through team safety. Professional Safety. American Society of Safety Engineers 7:21-25, July 1992.

The author describes the results achieved by the Mecklenburg County (NC) Engineering Department in its attempts to cut occupational injuries through implementation of a safety program based on the team concept popular in modern management theory. The Department's managers decided to develop the program in 1985, when the 200-person staff registered 73 injuries at a total cost to the County of over $50,000. Introduction of the safety program was preceded by a hazard analysis conducted by management. The decision was made to test the program first in the 50-person drainage crew, which had consistently experienced the highest number of injuries. The program consisted of tool box safety meetings held on-site at a frequency determined by the workers themselves. Injury results were recorded and displayed daily. On a quarterly basis, rewards--in the form of time off--were given to the team with the best safety performance. Based on the success achieved in reducing injuries among members of the drainage crew, management decided to extend the program to the landfill crew. The results were disappointing. Management determined that the poor results were due to the fact that landfill workers saw their work as being more independent and skilled and resented being assigned to teams. A second attempt, in which landfill workers picked their own team members, yielded excellent results. In 1990, following extension of the program to the remaining two divisions, the Engineering Department as a whole recorded only 29 injuries, at a cost of $15,448.

Mattila, M. and Hyodynmaa, M. Promoting job safety in building: An experiment on the behavior analysis approach. Journal of Occupational Accidents 9:266-267, 1988.

The aim of this study was to determine whether behavioral methods can be effective in improving safety in construction. Four building sites were selected--two experimental

sites and two control sites. A system of safety targets and feedback was used at the experimental sites. Attainment of the safety performance targets and the site's accident rate were used as measures of success. Focusing on feedback during the inspection process was judged to improve the safety inspection function overall. Posting of graphic feedback was found to be more effective than written feedback in achieving safety targets. Compared with the control sites, accident rates at the experimental sites were lower, and accidents were less serious. The researchers concluded that behavioral methods and a simple safety goal-setting and feedback program could be effective in improving construction safety conditions. It is also conceivable that because experimental site participants were told about the study, that additional attention alone yielded improved safety behavior.

Zohar, D. Promoting the use of personal protective equipment by behavior modification techniques. Journal of Safety Research 12(2):78-85, Summer 1980.

This is a review article that considers three studies in which behavioral approaches were used to increase the use of personal protective equipment. In the first study, pre- and post-shift audiograms were used on a portion of a worker population to promote earplug usage. Test results were both posted and given directly to individual workers. This technique increased earplug usage from 35 percent to 85 percent in a metal fabrication plant where group lectures, poster campaigns, and disciplinary actions had already been tried. One of the most important observations was that the 85 percent usage level was obtained after the treatment phase of the experiment had ended. The interpretation of this finding was that supervisor behavior had changed during the course of the experiment; earplug usage was made compulsory in production areas and punitive actions accompanied violations. This change in the environment was thought to have reinforced desired behavior.

Token economy systems were used in the other two experiments reviewed in this study. In one experiment, individual earplug usage recorded during randomly timed daily tours of a textile plant was rewarded with a token that could be exchanged for consumer goods. The second experiment also rewarded earplug usage with tokens, but varied the value of the tokens according to the total number of workers in compliance in the department. In both of these studies, earplug usage increased sharply and remained steady throughout a follow-up phase. Usage levels were maintained at the higher levels over time despite high employee turnover rates.

In their discussion, the reviewers state that a change in manager awareness and behavior results from being called upon to develop and implement such a program. Maintenance of modified behaviors seems to be reinforced by program success. Earplug usage may also be self-reinforcing in that, after an initial adaptation period, the noise reduction is appreciated by workers. The reviewers admit that these studies may not be predictive for other personal protective equipment, but they argue that the extremely low cost of such a program warrants experimentation. As with posted feedback studies, prompt access to test results or immediate reinforcement of desired behavior may be necessary to reinforce desired behavior.

WORKER PROTECTION IN CONSTRUCTION

Bruening, J. Pizzagalli Construction: Performance-oriented safety pays off. Occupational Hazards, pp. 45-48, June 1989.

This article details the safety management practices of Pizzagalli Construction Co., a firm that halved its recordable injury rate from 1986 to 1988 and reduced its lost workday rate from 7.9 to 5.2 over the same period. As a result, the firm has achieved a 76 percent reduction in workers' compensation costs and a 96 percent reduction in general liability insurance costs. The safety manager attributes the program's success to three components: training, awards and incentives, and drug and alcohol testing. The article describes each of these aspects of the overall safety program. Subcontractors are expected to meet the same high standards and can be fined for non-compliance. Contrary to frequently expressed concerns about drug and alcohol testing programs, the safety program manager states that the majority of employees support the program. The importance of a strong, positive safety message from management is also stressed.

Business Roundtable. Absenteeism and Turnover: A Construction Industry Cost Effectiveness Project Report. Report C-6, September 1989.

The Construction Industry Cost Effectiveness Project was a long-range effort to "develop a comprehensive definition of the fundamental problems in the construction industry and an accompanying program for resolution." It focuses on the industrial, utility, and commercial sectors and was developed from the point of view of the owners or users of construction. This particular report is based on the results of a questionnaire developed by owners and contractors and completed by more than 1,000 workers at job sites ranging from 125 to

3,000 workers. The questionnaire was designed to measure worker attitudes toward their jobs and reasons for absenteeism or turnover.

The most significant finding in relation to construction safety was that the No. 1 reason cited by workers for absences from work was unsafe working conditions. On a scale of relative strength of response, this was given a rank of 9; followed by excessive rework and travel distance at rank 8; poor craft supervision at rank 6; poor overall management at rank 5; and personal and family illness at rank 4. Safety was not among the top factors affecting turnover. The reasons for turnover reported by workers included their relationship with the boss (10); overtime available on another job (7); poor craft supervision (6); poor overall job management (5); poor planning (4); excessive surveillance by owner (3); and inadequate tools and equipment (2).

There were no significant differences in the ranks assigned to these factors by union or non-union workers or by workers from different geographical areas. The study also found that a relatively small fraction of the workforce was responsible for most of the absenteeism and voluntary job turnover. Among the report's conclusions were that most reasons for absenteeism and turnover, including unsafe working conditions, were controllable. The study team also attempts to calculate the economic impact of absenteeism and turnover and provides formulas for these calculations. Finally, recommendations for methods by which contractors, owners, and unions can decrease absenteeism and turnover are offered.

Buskin, S. and Paulozzi, L. Fatal injuries in the construction industry in Washington state. American Journal of Industrial Medicine 11:453-460, 1987.

Fatal injury records for construction workers in Washington State were examined for the period 1973-1983. Falls, cave-ins, and electrocution accounted for almost half (45.4 percent) of these deaths. Mortality increased significantly with decreasing company size, with the mortality rate among companies with one to four employees being almost three times that of the largest (1,000+) companies. Age-specific proportionate mortality ratios (PMRs) indicated significantly higher mortality among older workers. Drilling machine operators, welders, flame-cutters, reinforcing-iron workers, and heavy equipment operators had the highest PMRs. These data were lower overall than national data, and the authors felt that under-estimation may have occurred because a sizeable number of non-production workers were included in the denominators (however, since the inclusion of non-production workers

is standard practice nationally as well, relative rates should not be affected). The authors suggest that equipment redesign may be one of the most effective means of reducing risk, since smaller companies have limited resources to dedicate to safety.

Culver, C. Build a safer construction site. Safety & Health, pp. 74-76, March 1993.

In this article, the head of OSHA's Office of Construction and Engineering presents construction safety statistics taken from a 1990 study conducted by that office. Databases used for the study included OSHA's records of fatality investigations and records for construction injuries from the Bureau of Labor Statistics, the Army Corps of Engineers, and the Bureau of Reclamation. The data showed that specialty trade contractors experienced a higher percentage of injuries than general contractors or heavy construction contractors. Low-workday injury rates, however, were consistently higher for heavy construction. Most injuries, including lost-workday injuries, occurred during the peak period of construction, from June to October, and on Mondays. Fewest injuries occurred on Fridays. The causes of injuries were essentially the same for all three types of construction. Injury rates were highest for young workers and decreased with worker age. Injury rates were higher during the first few weeks on a job site, regardless of worker age. Among the construction trades, carpenters and laborers accounted for 40 percent of the injuries, although this may be attributable to the composition of the workforce and the number of workers engaged in each trade rather than to job-related risks. The author recommends that these statistics be used by managers to implement preventive measures.

Davies, V.J. and Tomasin, K. Construction Safety Handbook. London: Thomas Telford Ltd, 1990.

This book is geared toward civil engineers and their work as managers of project safety. The initial chapters present accident statistics, the legal obligations of employers, and pertinent occupational health and safety laws and their enforcement. The discussion focuses on laws in the U.K. The next several chapters present the activity-specific hazards of construction and offers suggestions on how to control them. The final third of the book discusses management systems for safe construction. Safety management policies for firms of varying sizes and examples of safety audit forms and checklists are presented. Brief descriptions of training, personal protective equipment, and first aid are also provided.

Dedobbeleer, N. and German, P. Safety practices in the construction industry. Journal of Occupational Medicine 29(11):863-868, November 1987.

This paper is part of a larger cross-sectional study of factors related to construction workers' safety performance. Here, the authors examined construction workers' safety practices in relation to individual and situational factors. Multilinear regression was used to correlate each of seventeen variables with safety performance; these variables explain 51 percent of the variance. The "predisposing factors" of age and attitude toward safety performance accounted for most of the variance. Perceived control over personal safety and training exposure also affected worker compliance with safety regulation. The youngest construction workers were found to have low safety performance scores, little knowledge of safety practices, and unfavorable attitudes toward safety performance; the authors suggest that this group of workers requires special attention and that mandatory safety training before employment may be advisable. The findings also indicated that attitude toward safety performance was only weakly related to safety training and not related to attendance at safety meetings. The authors therefore suggest a need for more effective safety initiatives based on learning by observation.

Dedobbeleer, N., et al. Safety performance among union and non-union workers in the construction industry. Journal of Occupational Medicine 32(11):1099-1103, November 1990.

The results are part of a larger cross-sectional study of factors related to construction workers' safety performance. A self-administered questionnaire was used to collect data from 384 workers at nine non-residential construction sites in the Baltimore area. Information was collected on demographic and occupational characteristics, safety practices, safety training, knowledge of safety practices, attitudes towards safety practices, and other factors. The authors stratified their sample based on union membership and observed several differences between groups. Union members were likely to be older, have more stable employment, and to have been exposed to more safety training (76 percent of union members versus 33.7 percent of non-union workers). Union members also reported more often that proper equipment was available, that regular safety meetings were held, and that co-workers had a favorable attitude toward safety. When the effect of age difference was removed, however, there was no significant difference in the on-site safety practice of union and non-union workers.

Among the authors' conclusions was that non-union construction sites need special safety attention because they attract the youngest workers, those most likely to exhibit poor safety performance; a second conclusion was that unions serve the important functions of providing safety training and increasing the workers' perception of control over their safety on the job. Union and non-union perceptions of management's safety attitudes and practices did not differ, and the authors theorize that this may reflect the difficulties unions face in attempting to influence management attitudes.

Fullman, J.B. Construction Safety, Security and Loss Prevention. New York: John Wiley & Sons, 1984.

Fullman integrates a knowledge of work-site hazards with an understanding of human behavior in construction to provide a guidebook for construction safety. As he discusses the various phases of construction, the author describes the types of activity in each phase; provides a profile of the associated job sectors and their accident statistics; discusses some existing regulations, the physical hazards and personal behavior which might lead to accidents during a given activity or phase; and offers field examples and suggestions for management practices. Included in these suggestions are descriptions of personal protective equipment and sampling/testing devices. The author's recommendations are based on his experience in the construction industry, and specifically on observations regarding the risks associated with common work-site hazards. The book does not set forth a code of management safety practices; it does, however, offer suggestions about the principles to keep in mind when planning for construction safety.

Hislop, R.D. A construction safety program. Professional Safety, pp. 14-20, September 1991.

The author is an environmental and safety manager at Argonne National Laboratory, and his article is a succinct summary of construction safety program components. He lists these components as: a company safety policy, project constructibility reviews, contractor screening, a pre-bid safety meeting, pre-construction meetings, employee orientation, tool box talks, manager-contractor meetings, safety inspections and audits, accident reporting and investigation, housekeeping, and safety cost accounting. Brief explanations of the nature and importance of each component are provided.

LaBar, G. Breaking new ground in construction safety. Occupational Hazards, pp. 58-63, May 1992.

LaBar's article is an overview of the issues behind the growing interest in construction safety management, above all the annual toll of over 2,000 deaths and 630,000 injuries, with a cost to the industry of about $30 billion, or 6 to 9 percent of total project costs. He offers examples of firms with excellent safety records, like Bechtel Construction and BE & K Construction Co., and describes specific measures taken by these companies to develop successful safety programs. Included among these are (1) providing a general construction safety handbook to all employees, (2) developing site-specific safety plans and providing site-specific safety training, and (3) ensuring that subcontractors have a safety program in place. On-site managers are held accountable for the safety of their projects, and injury rates are calculated for each project supervisor and considered in promotion decisions. Annual safety conferences or hazard awareness classes are offered for managers, and supervisors attend a safety and health workshop at the beginning of each new project and again during peak project activity. The companies use either an on-site safety professional or off-site safety professionals to conduct frequent inspections.

Recommendations from OSHA, NIOSH, and other safety organizations are also offered. Included among these is the suggestion that property owners prequalify contractors by reviewing their safety records. After subcontractors have been selected, Bechtel develops a site safety and health program that is binding on all employers on the project. A smaller firm, Pepper Construction, provides safety meetings and training for subcontractor employees and gives its on-site safety officers authority to inspect and require corrections of hazards in subcontractor work. Written safety and health programs were the single most frequently recommended tool in improving site safety.

Levitt, R.E. and Samelson, N.M. Construction Safety Management. New York: McGraw-Hill, 1987.

This book is a comprehensive manual for construction managers. Its purpose is to demonstrate the cost savings of safety management and to provide managers at all levels with proven effective techniques for safely managing construction work. Research was carried out by the authors and their colleagues at Stanford University's Civil Engineering Department, and the techniques presented emphasize the behavioral side of construction safety. The introductory chapters present cost accounting methods that reflect the full financial burden of

accidents. Results of a Stanford Cost Accounting System study are presented; the authors also discuss how modification of the accounting system to reflect accidents can increase line awareness of safety issues. Separate chapters on management techniques are provided for CEO's, the job-site manager, the foreman, and safety professionals. Information on training, communication, and incentive programs is included. The final chapters address owners and the bidding process and offer a questionnaire for evaluating contractor safety.

Occupational Health & Safety Staff. Nobody takes a fall. Occupational Health & Safety, p. 57, January 1992.

This article describes a "safety enhancement" program initiated by Brown & Root Braun, Inc. to eliminate fall hazards, which account for 30-35 percent of construction fatalities. The program was developed by a task force of representatives from all craft disciplines. Fall-prevention engineering is used to create a safer working environment. Remotely actuated pin extractors, full-body fall-protection harnesses and retractable lines are used to provide continuous fall protection. Brown & Root Braun's safety record is five times better than the national average for recordable injuries, and the company's "100 Percent Fall Prevention Program" exceeds the requirements of OSHA's proposed fall protection construction standard.

Rademaker, K. Activate your fall protection defenses. Occupational Hazards, pp. 40-43, December 1991.

In both 1989 and 1990, falls were the second leading cause of death in the workplace. Safety experts suggest that the fatality rate remains high because both employees and supervisors mistakenly view falls as a random occurrence. The article reviews and compares the advantages of safety belts, harnesses, and retractable lifelines. The importance of safety training is emphasized; employers are advised against assuming that union workers from apprenticeship programs have received training in fall protection. Regular maintenance of fall protection equipment is also a priority.

Robinson, J. Workplace hazards and workers' desires for union representation. Journal of Labor Research 9(3):238-249, Summer 1988.

Using data from three surveys conducted between 1977 and 1982, the researchers found that workers exposed to significant health and safety risks on the job were more likely to express a pro-union attitude than were comparable workers not similarly exposed. The actual extent of unionization, however, appeared to be related to management resistance

rather than to worker interest in unionization. Lack of promotions was the second most influential factor in explaining workers' pro-union stance, followed by injury rates, unpleasant surroundings, and lack of training.

Robinson, J.C. The rising long-term trend in occupational injury rates. American Journal of Public Health 78(3):276-281, 1988.

This article documents long-term trends in occupational injury rates in the manufacturing, construction, and trade sectors. The period covered includes the late 1950s through 1985; data were collected from the national establishment survey published by the Bureau of Labor Statistics for the United States as a whole and workers' compensation data for the State of California. The article focuses on manufacturing but reports the following for construction:

- Disabling injuries per million hours worked in construction increased steadily after 1975, both in the United States as a whole and in California;
- Injury rates in manufacturing, construction, and the trade sectors have fluctuated in recent years around levels not witnessed since the 1940s and 1950s or earlier; and
- Work-related fatalities relate poorly to less serious work injuries.

Suruda, A., et al. Deaths from trench cave-ins in the construction industry. Journal of Occupational Medicine 30(7):552-555, 1988.

Information from OSHA investigation reports, DOT files, and newspaper clippings were used to characterize trench cave-in fatalities occurring from 1974-1986. A total of 306 deaths for which sufficient data were available for analysis were identified. The authors provide a breakdown of fatalities by SIC code; most of the deaths occurred in the sewer construction industry. Fatalities were skewed toward the younger ages, although a standardized mortality ratio (SMR) analysis indicated that this was statistically significant only for the 20- to 24-year-old age group. Most deaths occurred in shallow trenches, with a mean depth of 11.4 feet, and workers in smaller firms had an increased risk of death. In only one death was the employee killed while inside a trench box, and almost all cases occurred in trenches without shoring. This study was done in response to an OSHA call for comment on the need to revise its standards for trenches and excavations. The authors point to California as a State which has been able to cut its trench cave-in fatalities by more than half, and suggest

that the California requirement that contractors obtain a permit from the Health Department for any trench deeper than five feet may be significant.

Trent, R. and Wyant, W. Fatal hand tool injuries in construction. Journal of Occupational Medicine 32(8):711-714, 1990.

Although there has been research on occupational hand tool injuries, this study is the first to focus specifically on fatalities linked to hand tools, as reported in 62 OSHA reports filed between 1979 and 1982. The researchers confirmed their hypothesis that fatalities, like injuries, could be differentiated by source of energy contact. But although non-fatal injuries occur mostly at the point of energy transfer (e.g., drill points, saw blades, hammer faces, points of torches, welders, steamers and irons), fatal injuries are caused primarily by low-voltage supply energy. The study also found that most deaths caused by falls or being hit by objects are preventable with the proper application of known protective measures. All the reported electrocutions could have been prevented by the use of a ground fault circuit interrupter. The authors cite the significant risks of three hazards that are often not recognized on construction sites: low-voltage energy, working at heights, or working with unsupported overhead materials.

Walters, N.K. Safety management accountability process: An effective approach at DuPont. Professional Safety, pp. 35-38, August 1983.

Walters' article provides a summary of safety management principles applicable in any business setting. DuPont's safety record, at the time of publication, was said to be 22 times better than that of the average chemical company and 68 times better than the average industrial company, using National Safety Council statistics. The company has received NSC's Award of Honor 34 times.

The seven safety principles cited by the author include: (1) all injuries can be prevented, (2) management at all levels is responsible for preventing injuries and illnesses, (3) all operating expenses can be controlled, (4) safety is a condition of employment and each employee must be responsible for working safely, (5) employees must be thoroughly trained, (6) all deficiencies must be immediately corrected, and (7) it is good business to prevent injuries and illnesses.

DuPont develops a safety program for every level of the company--corporate, departmental, site and process--and workers are trained that safety is the number one priority.

First-line supervision is the primary conduit for all safety and health communications from top management to hourly employees. Hazard communication is described as a combination of active training and passive communication through labeling and signage. A Safety Division exists to ensure that all sites meet safety and health goals. Top management demonstrates its commitment to safety frequently; the company reinforces safe behavior throughout the organization by making safety a major yardstick of management performance. Key elements of the DuPont program include feedback mechanisms to identify weaknesses in the system and open discussion of inspection results. At weekly management meetings, safety is always the first topic on the agenda. Lost-time injuries must be reported to the executive committee within 24 hours, and fatalities must be reported immediately to DuPont site managers worldwide. According to the author, the program has resulted in improved operating effectiveness, high employee morale, improved community relations, and cost savings.