

**Explosion and Asphyxiation Deaths
Among Contract Employees in Industrial Plants**

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Abbreviations

BLS	Bureau of Labor Statistics
CSB	Chemical Safety and Hazard Investigation Board
CFOI	Census of Fatal Occupational Injuries
OSHA	U.S. Occupational Safety and Health Administration

Explosions and asphyxiations often cause deaths and injuries in chemical- producing and -using industries. A desire to prevent these incidents led to the formation of the U.S. Chemical Safety and Hazard Investigation Board (CSB), which went into full operation in 1998. The CSB works to help prevent chemical injuries and deaths by investigating chemical accidents and hazards and recommending actions to prevent further incidents.

In its first annual report, the CSB (2001) reported on investigations of 11 incidents for 1998 and 1999 involving 40 deaths and 45 injuries in chemical-producing and -using industries. Subsequently, through 2003, the CSB had investigated or was investigating another 17 incidents involving 20 deaths and more than 100 injuries (2003a, 2003b). The 58 deaths involved employees of chemical plants and of construction contractors working at the plants. The investigation reports do not usually distinguish between the roles of plant and contract employees in the incidents.

Contract employees are brought into a plant to perform projects, such as installation of new equipment, renovations, repair and maintenance, and sometimes even operation of equipment. The contract workers often are working in an environment that is new to them, so they may not be aware of special hazards in the plant.

Failure to provide special training about plant hazards and procedures or to enforce safe work practices among contract employees can have serious consequences for contract employees and plant personnel.

Examples of fatal incidents involving contract employees from completed investigations (2003a) are:

- On July 17, 2001, a contract employee was killed and 8 plant employees injured when an arc welding spark ignited vapors in a storage tank at a Motiva Enterprises LLC refinery in Delaware City, Delaware.
- On March 27, 1998, a plant employee was killed and a contract employee seriously injured as a result of nitrogen asphyxiation in a confined space at a Union Carbide plant in Hahneville, Louisiana.
- On March 4, 1998, 4 workers were killed, 3 of them contract employees, during a catastrophic vessel failure that resulted in a fire at a Sonat Exploration Company oil and gas production facility near Pitkin, Louisiana.

This CPWR study examines selected causes of death of contract construction employees in industrial plants in 1992-2001, as reported by the Census of Fatal Occupational Injuries (CFOI) of the U.S. Bureau of Labor Statistics (BLS). No comparable figures on plant employees were obtained for this CPWR report.

The Bureau of Labor Statistics began the current CFOI system in 1992. It compiles comprehensive and timely information on fatal work injuries in the United States. Key information about each workplace death, worker occupation, and other worker characteristics,

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such as age, race, and ethnicity, is obtained from death certificates, workers' compensation and medical examiner reports, and federal and state agency administrative records. Confirmation from at least two of these sources, or one source verified by a survey of the employer, is required before a death is considered work-related. Data compiled by the CFOI program are issued annually, with a lag from data collection to public release of one to two years.

Methods

Construction industry data for the 2-digit Standardized Industrial Classification (SIC) Codes 15, 16, and 17 for 1992 through 2001 were obtained from the Census of Fatal Occupational Injuries.

All deaths involving contract employees (construction workers) in industrial plants were identified by selecting all records that had a location code of 4* (Industrial places and premises). A record was included only when the accompanying narrative indicated the fatal incident occurred at an industrial plant.

Explosion deaths in industrial plants were identified by selecting all records in location code 4* that had an event code of 5* (fires and explosions) or that had the key word "explode" or "explosion" in the narrative. This identified 66 contract-employee deaths.

Similarly, asphyxiation deaths were identified by selecting all records that had an event code of 341 (inhalation of substances), 384 (depletion of oxygen in other enclosed, restricted or confined space), or 389 (other oxygen deficiency, n.e.c.[not elsewhere classified]). Deaths related to vehicle exhaust were excluded. This added 25 deaths of contract employees.

Because some construction workers may be listed in other CFOI categories than those used here, some deaths relevant to this study might have been inadvertently left out.

Results

In the 10 years 1992-2001, 91 deaths of contract employees – 9 deaths per year, on average – are known to have resulted from explosions or asphyxiation in industrial plants.

Explosions

Of the 52 fatal explosions that were identified, 40 (77%) involved single deaths and 12 (23%) involved multiple deaths. In some of the multiple-death incidents, plant employees were killed also, but were not counted here.

The sources of the chemical explosions included chemical tanks or equipment (14), fuel storage tanks, pipelines, and equipment (11), and refinery tanks and equipment (5) (see table 1). Eight of the 11 pressure-vessel explosions involved rupturing of pressurized tanks.

In five of the welding incidents, according to the CFOI narrative, the welder did not know the tank contained flammable materials (see table 2).

Welders and cutters were the occupation killed most often in the explosions (table3).

1. Types of explosions involved in deaths among contract employees in industrial plants, United States, 1992-2001

<u>Type of explosion</u>	<u>Incidents</u>		<u>Deaths</u>	
	<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>
Chemical explosion	37	71%	51	77%
Pressure vessel explosion	11	21%	11	17%
Arc flash/arc blasts	–	–	–	–
Total	52		66	

– = No data were reported or data do not meet BLS publication criteria
Source: U.S. Bureau of Labor Statistics data.

2. Worker activity at time of explosion, deaths among contract employees in industrial plants, United States, 1992-2001

<u>Activity</u>	<u>Incidents</u>		<u>Deaths</u>	
	<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>
Welding	20	38%	26	39%
Repairing/maintenance	11	21%	14	21%
Operating equipment	7	13%	8	12%
Installing	5	10%	7	11%
Testing/inspecting	–	–	5	8%
Other	5	10%	6	9%
Total	52		66	

– = No data reported or data do not meet BLS publication criteria
Source: U.S. Bureau of Labor Statistics data

3. Occupations of contract employees killed in industrial plant explosions, United States, 1992-2001

<u>Occupation</u>	<u>No. deaths</u>	<u>%</u>
Welders and cutters	23	35%
Construction laborers	9	14%
Heavy equipment mechanics	6	9%
Other trades	28	42%
Total	66	100%

Note: Other trades included plumbers, pipefitters and steamfitters, electricians, supervisors, boilermakers, carpenters, and structural metal workers (ironworkers).

Source: U.S. Bureau of Labor Statistics data.

Asphyxiations

Twenty of the asphyxiation incidents affecting contract employees involved single deaths (table 4). Inhalation of toxic chemicals caused about 56% of the deaths. Chemicals included hydrogen sulfide, carbon monoxide, sewer gas, and smoke. Oxygen deficiency made up most of the other deaths, and usually resulted from working in confined spaces without adequate precautions.

4. Causes of asphyxiation deaths of contract employees in industrial plants, United States, 1992-2001

Cause	Incidents		Deaths	
	No.	%	No.	%
Chemical inhalation	12	55%	14	56%
Oxygen deficiency	8	36%	9	36%
Other	—	—	—	—
Total	22		25	

— = No data reported or data do not meet BLS publication criteria.

Source: U.S. Bureau of Labor Statistics data.

Contract employees had been doing repairs or maintenance in 9 of the incidents (41%) and 11 of the deaths (44%). Four incidents involving 5 deaths happened while installing equipment.

The asphyxiation incidents included 9 instances of contract employees' entering chemical tanks or pipelines (41%), 6 instances involving working on or near chemical tanks or pipelines (27%), and 5 instances involving working inside manholes or similar confined spaces (23%).

Supervisors suffered 5 of the asphyxiation deaths (25%). Trades suffering asphyxiation deaths included plumbers, pipefitters, and steamfitters; welders and cutters; construction laborers; structural metal workers; electricians; and insulation workers.

Discussion and Conclusions

This study is based on a small number of deaths, so the data should be interpreted cautiously.

Clearly, contract employees in industrial plants are being killed by explosions and asphyxiation. Most of the deaths have involved specialized plant equipment or environmental conditions.

The use of outside contractors working in industrial plants should be reviewed to determine the unique safety risks and needs for this group. The first step would be **a more-comprehensive review of Chemical Safety Board investigations of past incidents** to determine the circumstances involving contract employee deaths and injuries in explosions and chemical releases in chemical plants. The CFOI records do not have enough detail to determine root causes of these deaths.

OSHA has two standards that apply, at least in some cases; both standards describe contractor responsibilities. OSHA's confined space standard requires that a host employer inform contractors about the hazards and permit requirements associated with confined space entry (29 CFR 1910.146(c)(8)). A second standard requires that the host employer inform contractors of process safety hazards and safe work practices (29 CFR 1910.119(h)). And Appendix C to the process safety management standard recommends that host employers train contract employees. However, the process safety management standard does not apply to all chemical-producing or -using industries.

In addition, the hazard communication standards (29 CFR 1910.1200 (e)(2) and 29 CFR 1926.59 (e) (2)) require employers to have procedures and follow those procedures to ensure that

the other employers have on-site access to material safety data sheets for each hazardous chemical the other employers' employees may be exposed to while working.

A second step would be **more stringent requirements for chemical plant safety procedures when outside contractors and vendors are present**. Such issues as training, contractual relationships, and multi-employer allocation of responsibilities can affect the safety of contract employees in chemical plants. One issue requiring attention is whether existing OSHA regulations are adequate and are enforced.

Third, **new procedures for welding on or near chemical or fuel tanks or equipment**, in particular, could help make sure a worker knows what materials might be inside and whether they are flammable. An adequate hot-permit system – as is required by OSHA in general industry – could ascertain in advance the nature of past or present contents of the tanks and determine whether welding can be done safely or if special precautions are needed.

Fourth, two **safety bulletins** could prove valuable. One would be a CSB bulletin on welding in industrial plants that provides general background information for contract employees and plant supervisors, with information on the types of hazards to look for and recommendations for working safely. This safety bulletin could be used in orientation training for contract employees. Similarly, a bulletin for contractors on the hazards they face and management systems that do or do not work could help.

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