Profiles in safety and health: fabricated structural metal

The industry that forms heavy metal supports for buildings and other structures has one of the highest rates of occupational injuries and illnesses; welder and cutter was one of its most hazardous occupations

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"Whether rain or shine
She's a part of the assembly
line. She's making history
working for victory."
—*Rosie the Riveter*, song by
R. Evans and J. Loeb, 1942

Rosie the riveter, symbol of the industrial resolve of American women during World War II, would encounter a spate of technological changes on today's factory floors. Her riveting hammer, for instance, once the primary method of joining metal parts, has all but disappeared, supplanted by the welding torch and welding machine. This article examines work activities and their associated safety issues in fabricated structural metal, an industry that exists in a factory setting where workers cut, shape, and join metal parts for use primarily in industrial and commercial buildings and, to a lesser extent, in bridges, ship sections, transmission towers, and offshore drilling platforms.[1]

During the latter part of the 1980's, some 2,500 structural metal fabricators, employing nearly 80,000 workers, competed in a $9 billion market for their products.[2] Seven major centers for fabricated structural metal manufacturing—the States of Alabama, California, Illinois, Louisiana, Pennsylvania, Texas, and Virginia—accounted for two-fifths of total employment in this industry.[3] Small establishments (fewer than 20 workers) continued to be numerically important in fabricating structural metal, constituting a clear majority of the industry's total plants; they were, however, but a fraction (about one-eighth) of its total employment.[4]

Through the years, fabricated structural metal manufacturers have experienced a high incidence of workplace accidents and injuries.[5] The industry's 1989 injury and illness rate of 24.4 per 100 full-time workers, for example, was nearly double that for all manufacturing (13.1) and almost triple that for private industry as a whole (8.6). That year, half the injury and illness cases in fabricated structural metal were serious enough to require workers to take time off from their jobs or to be assigned light duties or shortened work schedules.[6]

Disabling (lost worktime) injuries and illnesses in fabricated structural metal took a variety of forms, largely depending on the job and its attendant risks. Of special note were serious eye problems (scratches and flash burns, for example) incurred by many hand welders and cutters and severe back and leg sprains sustained by structural metal workers fitting together and otherwise maneuvering heavy shapes.[7] The following sections examine the injury and illness record of fabricated structural metal in more detail and relate that record to certain industry characteristics, such as staffing and work requirements, that appear to be linked to safety and health on the job.

Safety and health measures

Fabricated structural metal plants remain among the most hazardous workplaces. At 24.4 per 100 full-time workers, the 1989 injury and illness

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rate for these plants ranked 12th highest among rates reported for some 370 individual manufacturing industries.[8] On a positive note, fabricated metal plants appear to be somewhat safer in 1989 than in 1980, when their injury and illness rate of 27.6 ranked fifth highest in manufacturing.

Besides the overall injury and illness rate, there are other measures that the Bureau of Labor Statistics uses to gauge the *severity* of workplace incidents. (See appendix for definitions of such measures.) In 1989, these measures recorded mixed results for the fabricated structural metal industry. While the industry's incidence rates for lost workday cases and for lost workdays were relatively high, its average number of days lost per case was lower than that for the private sector and for all manufacturing. (See table 1.) Put another way, although workers fabricating structural metal face a comparatively high risk of sustaining a serious injury or illness, they return to their regular jobs after such disabilities more quickly, on average, than do workers in most other industries.

Separate State data are useful in spotting variations in injury and illness experience within an industry.[9] For example, in the fabricated structural metal industry, the 1989 injury and illness rate for total recordable cases in California (29.3) was more than double Louisiana's rate (13.2). Overall rates, however, were not necessarily indicative of the severity of accidents in this industry. Recuperation time, for instance, averaged 25 days per lost workday case in Louisiana, 10 workdays more than in California. (See table 1.)

Table 1. **Occupational injuries and illnesses, by type of case, 1989 annual survey**

Industry and State	Incidence rates[1]				Average lost workdays per lost workday case
	Total cases[2]	Nonfatal cases without lost workdays	Lost workday cases	Lost workdays	
Private sector[3]	8.6	4.6	4.0	78.7	20
Manufacturing	13.1	7.3	5.8	113.0	19
Fabricated structural metal, total[4]	24.4	12.2	12.1	198.8	16
Alabama	24.3	12.9	11.4	175.7	15
Arkansas	27.7	13.2	14.5	238.4	16
California	29.3	17.0	12.3	186.0	15
Louisiana	13.2	6.4	6.8	169.4	25
South Carolina	25.7	12.9	12.8	166.7	13

[1] Incidence rates represent the number of injury and illness cases or the number of lost workdays per 100 full-time workers. See footnote 5 to text for method of calculation.

[2] Includes fatalities. Because of rounding, the difference between the total and the sum of the rates for lost workday cases and nonfatal cases without lost workdays may not reflect the fatality rate.

[3] Excludes farms with fewer than 11 employees.

[4] Includes data for States other than those whose data are shown separately.

Injury and illness characteristics

The Bureau's annual survey reports on injury and illness rates by industry, but it does not provide information about the characteristics of those workplace incidents. Such information is available, however, at least to some extent, from another Bureau program—the Supplementary Data System—based on the State workers' compensation systems. Unlike the annual survey, the Supplementary Data System does not produce nationwide estimates and lacks uniform treatment among States of what is a compensable workplace injury or illness.[10] Nonetheless, despite these and several other analytical and statistical limitations, the Supplementary Data System does help in spotting general patterns (or the absence thereof) in the characteristics of work-related injuries and illnesses involving lost worktime.

In 1987, nearly 3,000 injuries and illnesses that involved lost workdays in the fabricated structural metal industry were reported to the agencies of the 25 jurisdictions participating in the Supplementary Data System. (These "current cases" either occurred in 1987 or were reported to the agencies that year.)[11] The major characteristics of cases in the fabricated structural metal industry are summarized in the following discussion. The injury and illness profile of the industry, it should be noted, is similar to that for all manufacturing cases reported in the Supplementary Data System.

With regard to the principal physical characteristics of the injury, sprain and strain occurred most frequently among the *nature of injury and illness* categories, accounting for one-third of the cases in fabricated structural metal recorded by the Supplementary Data System. Next in frequency were fractures, contusions, and cuts, each cited in about one-eighth of the industry's cases. Scratches and abrasions (almost always to the eyes) was the only other category mentioned in at least one-twentieth of the cases.

The trunk (especially the back) and the upper extremities (primarily the fingers) were the major *parts of the body affected* by injuries and illnesses. Together, they constituted nearly three-fifths of injury and illness cases in the fabricated structural metal industry. The legs and other lower extremities accounted for another one-fifth of the cases and the head (especially the eyes) for an additional one-eighth.

The two leading *events or exposures* causing injuries in the fabricated structural metal industry were overexertion (usually from lifting heavy

objects) and being struck by a falling or otherwise moving object. Together, these accounted for one-half of the industry's cases. A variety of other events and exposures, including falls, crushing injuries, contact with foreign matter, and slipping/tripping, were cited, but none was common.

Metal items ranging in size from particles to unassembled sections of ships were, by far, the major *source of injury and illness*. They produced or inflicted slightly less than half of the cases in the fabricated structural metal industry recorded in the Supplementary Data System. Other notable sources were indoor and outdoor working surfaces, machines and welding equipment, and vehicles and hoisting apparatus.

The major *occupational group* to which the injured or ill worker belonged was "operator, fabricator, and inspector," accounting for slightly more than two-fifths of the cases in the fabricated structural metal industry recorded in the Supplementary Data System. An additional one-fourth of injured and ill workers were in the "precision, production, and craft" occupational grouping, and another one-fifth were "handlers, helpers, and laborers." Welder and cutter was the leading occupation affected, constituting slightly more than one-fifth of the industry's total cases.

The characteristics of the injuries sustained varied somewhat by occupation, partly reflecting differing work activities, materials and equipment used, and work processes. Eye injuries and illnesses, for example, accounted for one-sixth of the cases recorded for welders and cutters, nearly triple the proportion for structural metal workers. Fractures, on the other hand, were somewhat more prevalent for structural metal workers (one-fifth of the cases in that occupation) than for welders and cutters (one-eighth).

While the Supplementary Data System provides the basic characteristics on injured workers and their injuries, the BLS also conducts, from time to time, small-scale studies of specific work injuries that focus on the circumstances surrounding an accident from the perspective of the injured worker. These studies are requested by the Occupational Safety and Health Administration and are useful in evaluating, revising, and setting safety standards, such as those covering welding and personal protective equipment,[12] and in developing educational and training materials.

In one such cross-industry study of welding and cutting accidents, slightly more than one-third of the 1,364 workers interviewed cited exposure to light (welder's flash) as how their injury occurred. Interestingly, a majority indicated that the offending light emanated from nearby welder's equipment rather than their own. In answer to related questions, one-fourth of all survey respondents recalled that curtains or shields had been used at the work site to protect other workers, and about half of all respondents said that they had been wearing filtered lenses to protect their eyes when the incident occurred.[13] Obviously, a separate, indepth study of fabricated structural metal manufacturing would be required to track the underlying causes of and attitudes toward the current safety and health problems in the industry, including accidents resulting from welding and cutting and those related to manual lifting and other activities.

Industry characteristics

Several other BLS data series (and a few outside the Bureau) contain information that is useful in profiling the fabricated structural metal industry. In many instances, this information sheds some light on the industry's safety and health problems.

First, the metal-fabricating industry continues to be relatively labor intensive, despite its increased use of automated technologies.[14] In 1989, the industry's employers required 62 percent more production worker hours than did all manufacturing to produce an additional $1 in value-added sales.[15] Also in 1989, average capital expenditures for new and used plant and equipment of $3,327 per production worker in fabricated structural metal manufacturing were less than half the corresponding average ($8,256) in all manufacturing, another indication of the industry's high level of labor intensity.[16]

Second, high-risk occupations and activities are common in metal-fabricating operations. To illustrate, hand welder and cutter, one of the largest occupations in fabricated structural metal, constitutes an estimated one-tenth of the industry's production work force[17] and just over one-fifth of its injury and illness cases recorded in the Supplementary Data System. In all manufacturing, by contrast, hand welder is about 1 percent of the production worker total[18] and 3 percent of the Supplementary Data System case total. (The Bureau's 1979 wage survey of the fabricated structural metal industry describes specific duties and responsibilities for workers in some 30 occupations which, at that time, accounted for two-thirds of the industry's production work force.)[19]

Third, over the 10 years ending 1988, productivity increases, as measured by output per hour, were considerably smaller in fabricated structural metal (averaging 2.2 percent a year) than in manufacturing as a whole (averaging 3.5 percent annually).[20] Moreover, they resulted entirely from a decline in employee hours (4.2 percent a year),

which more than offset a drop in output (2.1 percent annually). In contrast, in manufacturing, a 2.9-percent increase in output spurred much of the productivity growth; employee hours declined by 0.6 percent annually between 1979 and 1988.

Finally, labor turnover rates, as tracked by the Bureau through 1981, typically were higher in fabricated structural metal than in all manufacturing. For 1977–81, the last 5 years for which data were available, accession rates, which include rates of new hires and recalls, averaged 4.6 per 100 employees in metal fabrication, compared with 3.8 for all manufacturing. The separation rate, which includes rates of quits and layoffs, was also higher, averaging 4.7 per 100 employees a year, compared with 3.9 for all manufacturing. High turnover rates can retard productivity growth, and, more to the point of this article, they can exacerbate the safety and health problems associated with "green" workers.[21]

Fostering safer workplaces

Most types of workplace injuries and illnesses are considered preventable—through classroom and on-the-job training and by following safety standards prescribed by government, industry, and labor. However, heavy lifting and other manual exertions that commonly lead to many injuries in metal fabricating are difficult to control.[22] The Bureau's cross-industry study of back injuries associated with lifting, for example, showed that most workers lifted without mechanical assistance and that a clear majority of those studied were injured while lifting objects weighing at least the same as the heaviest weight normally lifted on the job.[23]

Industry and government standards specifically address several other prominent safety and health problems in fabricated structural metal, including problems with machinery and machine guarding; welding, cutting, and brazing; material handling, such as the use of overhead and gantry cranes; and hazardous materials, such as spray finishing using flammable or combustible liquids.[24] To disarm such potential hazards, these standards prescribe a variety of preventive actions, such as providing guarding devices and special handtools for use at the point of operation of machines; labeling the dangers of inhaling fumes from heated fluxes and other welding materials; and ensuring that cranes are not overloaded and that their hoist chains or ropes are free of kinks or twists and are not wrapped around the load. These and other measures—for example, wearing appropriate eye and face protection—are effective ways to minimize many safety and health hazards commonly encountered in manufacturing operations such as metal fabricating. □

Footnotes

[1] Fabricated structural metal has been designated industry number 3441 in the 1987 edition of the *Standard Industrial Classification Manual*, prepared by the Office of Management and Budget. The industry is part of a broader grouping of establishments manufacturing primarily fabricated structural metal products (number 344), which includes metal doors and window frames (number 3442), boiler shops (number 3443), sheet metal work (number 3444), architectural and ornamental metal work (number 3446), prefabricated metal buildings (number 3448), and miscellaneous metal work, such as concrete reinforcing bars (number 3449). Establishments engaged primarily in fabrication work at the site of construction are excluded from this grouping of industries.

For an account of the various primary and secondary products manufactured by these industries, see *1987 Census of Manufactures: Fabricated Structural Metal Products*, MC87-I-34C (Bureau of the Census, 1990).

[2] *1987 Census of Manufactures: Fabricated Structural Metal Products*, table 1a, industry number 3441.

[3] *Employment and Wages, Annual Averages, 1989*, Bulletin 2373 (Bureau of Labor Statistics, 1990), p. 231.

[4] *County Business Patterns, 1988: United States*, CBP-88-01 (Bureau of the Census, 1990), table 1b.

[5] *Incidence rates* represent the number of injuries or illnesses, or both, per 100 full-time workers and were calculated as

$$N/EH \times 200{,}000$$

where

N = number of injuries and/or illnesses;

EH = total hours worked by all employees of the industry during the calendar year; and

200,000 = base for 100 full-time equivalent workers (employees working 40 hours per week, 50 weeks per year).

A variety of useful incidence rates may be computed by making N equal to the number of injuries only, or the number of lost workday cases, and so forth. In each instance, the result is an estimate of the number of cases or days per 100 full-time workers.

[6] See *Occupational Injuries and Illnesses in the United States by Industry, 1989*, Bulletin 2379 (Bureau of Labor Statistics, 1991), table 1. For fabricated structural metal, the injury and illness rate for lost workday cases (12.1) was 50 percent of the rate (24.4) for total cases. For all manufacturing, the corresponding calculation came to 44 percent.

[7] Derived from the Supplementary Data System, as discussed later in the text.

[8] *Occupational Injuries and Illnesses*, text table 2 and table 1. Notes to text table 2 explain that the top rankings of industries with high rates of injury and illness were all filled from the manufacturing sector.

[9] For a variety of reasons, injury and illness estimates tend to be more volatile from year to year for individual States than for the Nation as a whole. Thus, the 1989 State data are more illustrative of geographic variability than of longer term relationships among individual States.

Another source of local information on fabricated structural metal is the individual State agency that oversees workplace safety and health. See, for example, *California Fabricated Metal Products Industry*, Research Bulletin No. 4 (California Department of Industrial Relations, 1978).

[10] The Supplementary Data System is not statistically representative of the Nation as a whole because the data cover only the jurisdictions participating in the system. In 1987, these were the Virgin Islands and the following 24 States: Alaska, Arizona, California, Colorado, Hawaii, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Michigan, Mississippi, Missouri, Nebraska, New Mexico, Ohio, Oklahoma, Oregon, Tennessee, Virginia, Washington, Wisconsin, and Wyoming.

Moreover, States differ in the kinds of cases they require by law to be reported to workers' compensation agencies. While some States require reports for all occupational injuries and illnesses, regardless of length of disability, others require reports only for cases of sufficient duration to qualify for indemnity compensation payments, and still other States require reporting of cases involving a specific number of lost workdays, regardless of the indemnity "waiting period." Thus, the file of the Supplementary Data System is not a complete census of all "disabling" injuries and illnesses in the jurisdictions studied.

The Supplementary Data System, however, does standardize the classification of data using the 1972 *Standard Industrial Classification Manual*, the 1980 *Census of Population, Alphabetical Index of Industries and Occupations*, and the 1962 *American National Standards Method of Recording Basic Facts Relating to the Nature and Occurrence of Work Injuries*, published by the American National Standards Institute (ANSI) and often referred to as the Z16.2—1962 standards, or simply, Z16.2.

[11] The total for the 25 jurisdictions in the Supplementary Data System is slightly more than one-third of the annual BLS survey estimate of about 8,000 lost workday cases in the fabricated structural metal industry in 1987. See footnote 10 for some limitations pertaining to the range of cases included in the Supplementary Data System.

[12] See, for example, *Accidents Involving Eye Injuries*, Report 597 (Bureau of Labor Statistics, 1980); *Accidents Involving Foot Injuries*, Report 626 (Bureau of Labor Statistics, 1981); and, most recently, *Heat Burn Injuries*, Bulletin 2358 (Bureau of Labor Statistics, 1990).

[13] The survey of welding and cutting accidents was conducted by the BLS during the period from July through November 1978. Highlights and tabular results are available upon request.

[14] For a detailed discussion of means of mechanized material handling, such as the beam line, as well as of new welding applications, see *The Impact of Technology on Labor in Five Industries*, Bulletin 2137 (Bureau of Labor Statistics, 1982), chapter 4.

[15] *1989 Annual Survey of Manufactures*, M89(AS)–1 (Bureau of the Census, 1991), table 2.

[16] *1989 Annual Survey of Manufactures*, tables 2 and 5.

[17] Two sources were used to estimate welders and cutters' employment share of the production work force of fabricated structural metal: *Industry Wage Survey: Fabricated Structural Metal, November 1979*, Bulletin 2094 (Bureau of Labor Statistics, 1981), table 3; and the Bureau's Occupational Employment Statistics program, 1989 data for industry number 344.

[18] Based on the Bureau's 1988 National Industry-Occupation Matrix, available from its Office of Employment Projections.

[19] *Fabricated Structural Metal*, appendix B.

[20] Productivity data are available from the BLS Office of Productivity and Technology. For a comprehensive account of productivity trends in metal fabrication during the period 1958–78, see Phyllis Flohr Otto, "Productivity growth below average in fabricated structural metals," *Monthly Labor Review*, June 1980, pp. 27–31.

[21] The 1987 Supplementary Data System includes current case files for 16 States that code for work experience. These files show that nearly half of those disabled in the fabricated structural metal industry had at most 1 year's time with their employer (or on the job) when injured. See also Norman Root and Michael Hoefer, "The first work injury data available from new BLS study," *Monthly Labor Review*, January 1979, pp. 76–80; footnote 3 in their article lists studies that relate work injuries to work experience.

[22] For a compendium of research papers on manual material handling, see *Safety in Manual Material Handling*, DHEW (NIOSH) Publication 78–185 (National Institute for Occupational Safety and Health, 1978).

[23] *Back Injuries Associated with Lifting*, Bulletin 2144 (Bureau of Labor Statistics, 1982).

[24] See, for example, *General Industry: OSHA Safety and Health Standards* (29 CFR 1910), OSHA 2206 (Occupational Safety and Health Administration, Revised 1981), pp. 201–10, 377–88, 437–38, and 485–510. Based on 972 inspections of the industry conducted by the U.S. Department of Labor's Occupational Safety and Health Administration between June 1987 and May 1989, many fabricated metal plants did not comply fully with one or more of these work standards.

APPENDIX: Work injury definitions

In this article, definitions of occupational injuries and illnesses and lost workdays conform to the recording and reporting requirements of the Occupational Safety and Health Act of 1970 and Part 1904 of Title 29, Code of Federal Regulations. Supplemental information pertaining to these definitions is in the booklet, *Recordkeeping Guidelines for Occupational Injuries and Illnesses* (Bureau of Labor Statistics, 1986).

Recordable occupational injuries and illnesses are:

1. occupational deaths, regardless of the time between injury and death or the length of the illness; or
2. nonfatal occupational illnesses; or

3. nonfatal occupational injuries that involve one or more of the following: loss of consciousness, restriction of work or motion, transfer to another job, or medical treatment (other than first aid).

Occupational injury is any injury, such as a cut, fracture, sprain, amputation, and so forth, that results from a work accident or from exposure involving a single incident in the work environment.

Occupational illness is any abnormal condition or disorder, other than one resulting from an occupational injury, caused by exposure to environmental factors associated with employment. It includes acute and chronic illness or disease that may be caused by inhalation, absorption, ingestion, or direct contact.

Lost workday cases are cases that involve days away from work, or days of restricted work activity, or both:

1. *Lost workday cases involving days away from work* are those cases that result in days away from work or that result in a combination of days away from work and days of restricted work activity.
2. *Lost workday cases involving restricted work activity* are those cases that result in restricted work activity only.

Lost workdays—away from work are the number of workdays (consecutive or not) on which the employee would have worked but could not because of occupational injury or illness.

Lost workdays—restricted work activity are the number of workdays (consecutive or not) on which, because of injury or illness:

1. The employee was assigned to another job on a temporary basis; or
2. The employee worked at a permanent job less than full time; or
3. The employee worked at a permanently assigned job but could not perform all duties normally connected with it.

The number of days away from work or days of restricted work activity does not include the day of injury or onset of illness or any days on which the employee would not have worked even though able to work.

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