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ABSTRACT

This report provides results of Phase I of a project that researched the occupational area of sheet metal, established appropriate committees, and conducted task verification. These results are intended to guide development of a program designed to train sheet metal workers. Section 1 contains general information: purpose of Phase I; description of the occupation, including nature of work, working conditions, and related occupations; direction of the occupation, including employment, training and other qualifications, advancement, job outlook, and earnings; program development committee; areas of concern; and State Technical Committee developmental recommendations. Section 2 presents research findings: accreditation and certification; list of typical job titles; and appropriate trade resources and sources, including references and textbooks, audiovisuals, curriculum materials, periodicals, safety manual, shop safety signs, and sources of additional information. A verified occupational duty and task list is comprised of six duties: read blueprints, lay out sheet metal, fabricate mechanical systems, fabricate architectural/roofing sheet metal, fabricate food service sheet metal products, install mechanical systems, and install architectural/roofing sheet metal. Other contents include a tools and equipment list, list of contents of standard tool kit, and staff and facilities recommendations. (YLB)

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SHEET METAL CONTRACT

PROJECT REPORT

PHASE I

WITH

RESEARCH FINDINGS

SHEET METAL CONTRACT

PROJECT REPORT

PHASE I

WITH

RESEARCH FINDINGS

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SECTION ONE

GENERAL INFORMATION

PURPOSE OF PHASE I

Phase I focused on researching the occupations, establishing appropriate committees, and conducting task verification. The results of this phase have provided the basic information required to develop the program standards and guide and set up the committee structure to guide the project.

This program is designed to address the needs of the sheet metal field that use or plan to use graduates as sheet metal workers.

DESCRIPTION OF OCCUPATION

Nature of the Work

Air-conditioning, heating, ventilation, and pollution control duct systems; kitchen equipment; roofs; siding; rain gutters; skylights; and outdoor signs are some of the many products that sheet-metal workers make, install, and maintain. Although some workers specialize in fabrication, installation, or maintenance, most do all three jobs. (This statement does not include workers employed in the mass production of sheet-metal products.)

Sheet-metal workers usually fabricate their products at a shop away from the construction site. Working from blueprints or instructions from supervisors, they measure, cut, bend, shape, and fasten pieces of sheet metal to make duct work, counter tops, and other custom products. In many shops, workers use computerized metalworking equipment. This enables them to determine the layout that would result in the least waste of material. Sheet-metal workers then cut or form the parts with computer-controlled saws, shears, and presses. In some shops, workers cut parts with computer-controlled lasers.

In shops without computerized equipment and for products that cannot be made on such equipment, sheet-metal workers use hand calculators to do the required mathematics and use tapes, rulers, and other measuring devices when performing layout work. They then cut or stamp the parts with machine tools.

Before any piece is assembled, each part is checked for accuracy and if necessary, finishing work is done with handtools such as snips and hacksaws. After the parts have been inspected, sheet-metal workers fasten the seams and joints together with bolts, cement, drive slips, rivets, solder, or by welding.

At the construction site, sheet-metal workers assemble and install pieces fabricated at the shop. They also use hammers, shears, and drills to make parts by hand at the worksite and to alter parts made in the shop.

Workers install ducts, pipes, and tubes by joining them end to end and hanging them with metal hangers secured to a ceiling or a wall. To hold the pieces together, workers may bolt, weld, rivet, or solder, or use specially formed sheet-metal drive clips or other connecting devices.

Molded and pressed-sheet metal, such as roofing and siding, usually is measured and cut on the job. After securing the first panel in place, workers interlock and fasten the grooved edge of the next panel into the grooved edge of the first. They nail or weld the free edge of the panel to the structure. This two-step process is repeated for each additional panel. Finally, at joints, along corners, and around windows and doors, workers fasten machine-made molding for a neat, finished effect.
In addition to installation, some sheet-metal workers may specialize in testing, balancing,

adjusting, and servicing existing air-conditioning and ventilation systems to make sure they are functioning properly and to improve their energy efficiency.

Working Conditions

Sheet-metal workers usually work a 40-hour week. Those who fabricate sheet-metal products work in shops that are well-lighted and well-ventilated. They stand for long periods and may have to lift heavy materials and finished pieces. In addition, working around high-speed machines can be dangerous, and workers must follow safety practices. They often wear safety glasses and must be careful not to wear jewelry or loose-fitting clothing that could easily get caught in a machine.

Those doing installation work do considerable bending, lifting, standing, climbing, and squatting, sometimes in close quarters or in awkward positions. Because they often have to adjust the fabricated pieces, they may get cuts and burns from materials and tools.

Although installing duct systems and kitchen equipment is done indoors, the installation of siding, roofs, and gutters involves much out-door work.

Related Occupations

To fabricate and install sheet-metal products, sheet-metal workers combine metalworking skills and knowledge of construction materials and techniques. Other occupations in which workers lay out and fabricate metal products include layout workers, machinists, metal fabricators, metal patternmakers, shipfitters, and tool-and-die makers. Construction occupations requiring similar skills and knowledge include heating, air-conditioning, and refrigeration installers; glaziers; and insulation workers.

DIRECTION OF THE OCCUPATION

Employment

Sheet-metal workers held about 93,000 wage and salary jobs in the construction industry in 1986. Construction employers include air-conditioning and heating, roofing, and sheet-metal contractors and general contractors engaged in residential, industrial, and commercial building. Unlike many of the other construction trades, very few sheet-metal workers are self-employed.

Jobs for sheet-metal workers are distributed throughout the country in about the same proportion as the total population.

Training, Other Qualifications, and Advancement

Sheet-metal contractors consider apprenticeship the best way to learn this trade, although some workers learn informally on the job. The apprenticeship program consists of 4 or 5 years of on-the-job training and at least 144 hours per year of classroom instruction. It provides comprehensive instruction in both sheet-metal fabrication and installation. The programs are administered by joint committees of locals of the Sheet Metal Workers' International Association and local chapters of the Sheet Metal and Air-Conditioning Contractors' National Association, or by local chapters of the Associated Builders and Contractors.

On the job, apprentices use the tools, machines, equipment, and materials of the trade. They learn to measure, cut, bend, fabricate, and install sheet metal. They begin with basic duct work and gradually advance to more difficult jobs, such as pressed fiberglass, plastics, and acoustical tile which may be substituted for metal on some jobs.

In the classroom, apprentices learn drafting, blueprint reading, trigonometry and geometry applicable to layout work, the use of computerized equipment, welding, and the principles of heating, air-conditioning, and ventilating systems. Safety is stressed throughout the program. In addition, apprentices learn the relationship between sheet-metal work and other construction work.

Workers who pick up the trade informally usually begin by carrying metal and cleaning up debris in a metal shop while they learn about materials and tools and their uses. Then, as employers permit, helpers learn to operate machines that bend or cut metal. In time, helpers go out on the job site to learn installation. Those who acquire their skills on the job often take vocational school courses in mathematics or sheet-metal fabrication to supplement their work experience.

Applicants for jobs as apprentices or helpers should be in good physical condition and have mechanical aptitude. Local apprenticeship committees require a high school education or

Training, Other Qualifications, and Advancement (cont.)

its equivalent. Courses in trigonometry, geometry, mechanical drawing, and shop provide a helpful background for learning the trade.

Some experienced sheet-metal workers take additional training to improve or to acquire new skills. Often this training is provided by the union or their employer.

Sheet-metal workers may advance to supervisory jobs. Some take additional training in welding and do more specialized work. Others go into the contracting business. Because a sheet-metal contractor must have a shop with equipment to fabricate products, this type of contracting business is more expensive to start than other types of construction contracting.

Job Outlook

Employment of sheet-metal workers in construction is expected to increase about as fast as the average for all occupations through the year 2000. Demand for sheet-metal installation should increase as more commercial, industrial, and residential structures are built. Growing demand for more energy-efficient air-conditioning, heating, and ventilation systems in existing buildings and other types of renovation and maintenance work also should boost employment opportunities. In addition, the increased use of decorative sheet-metal products and increased architectural restoration is expected to increase demand for sheet-metal workers. Despite this growth, most job openings will arise as experienced workers retire or leave the occupation for other reasons.

Although employment of sheet-metal workers is expected to increase over the long run workers may experience periods of unemployment when construction projects end and when economic conditions reduce the amount of construction activity. However, employment of sheet-metal workers is less sensitive to declines in new construction than employment of some other construction workers, such as carpenters. Maintenance of existing equipment--which is less affected by economic fluctuations than new construction--makes up a large part of the work done by sheet-metal workers. Installation of new air-conditioning and heating systems in existing buildings also continues during construction slumps as individuals and businesses seek more energy-efficient equipment to cut utility bills. In addition, a large proportion of sheet-metal installation and maintenance is done indoors; therefore, these workers usually lose less work time than other construction workers due to bad weather.

As the construction industry expands, apprenticeship opportunities should be good. However, when construction activity falls, apprenticeship opportunities often decline and as a result, the outlook for apprentices may vary from year to year and by geographic area.

Earnings

According to data from the sheet-metal national training fund, union sheet-metal workers' total compensation averaged $17.50 per hour in 1986. Apprentices generally start at about 40 percent of the rate paid to experienced workers. Throughout the course of the apprenticeship program, they receive periodic increases as they acquire the skills of the trade.

In addition to their hourly wage, sheet-metal workers usually receive fringe benefits supplied by either the local union or their employer. Typical benefits include health and life insurance, pension plans, and training opportunities. In addition, in some areas, union workers receive supplemental wages from the union when they are on layoff or shortened workweeks.

A large proportion of sheet-metal workers are members of the Sheet Metal Workers' International Association.

The information presented in **Description of the Occupation** and **Direction of the Occupation** is adapted from public domain material, originally published in the *Occupationally Outlook Handbook*, Bulletin 2300, by the Bureau of Labor Statics, U.S. Department of Labor, Washington, DC 20212.

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AREAS OF CONCERN

The State Technical Committee reached consensus that there is a shortage of qualified job applicants:

a. having work habits and attitudes consistent with employment as sheet metal workers;

b. having an adequate background in algebra; and

c. competent in the fundamentals of sheet metal layout, fabrication, and installation.

STATE TECHNICAL COMMITTEE DEVELOPMENTAL RECOMMENDATIONS

The State Technical Committee recommended that:

1. A diploma-level program of study be developed.

2. The program developed should address the employment market needs for sheet metal workers.

3. The program of study should include, but not be limited to:

   Basic metalurgy and standard trade measurement systems.
   Hand and power tools.
   Machine tools.
   Fasteners and hardware.
   Fabrication techniques.
   Layout and methods of development.
   Blueprint reading and uniform building codes.
   Soldering and resistance welding.
   Psychrometrics and duct sizing.
   Architectural sheet metal and plastics.

SECTION TWO

RESEARCH FINDINGS

ACCREDITATION AND CERTIFICATION

There are no national or state requirements for program accreditation or certification established. There are no individual certification or licensure requirements which job applicants must meet prior to entry into occupation in the sheet metal field.

TYPICAL JOB TITLES

Phase I research has included an examination of the occupation areas for the sheet-metal field and has revealed seven job titles for which training may be required. The *Dictionary of Occupational Titles* code and title are as follows:

616.360-018	**MACHINE OPERATOR** (any ind.) I fabricating-machine operator.
616.360-022	**MACHINE SETTER** (any ind.)
616.360-026	**MULTI-OPERATION-FORMING-MACHINE OPERATOR** (any ind.) I
619.685-062	**MACHINE OPERATOR** (any ind.) II
619.685-066	**METAL FABRICATOR HELPER** (any ind.)
619.686-022	**METAL FABRICATING SHOP HELPER** (any ind.) helper, steel fabrication; plate-shop helper; production helper; structural-shop helper.
804.281-010	**SHEET METAL WORKER** (any ind.) sheet-metal mechanic.

APPROPRIATE TRADE RESOURCES

References and Textbooks

Betterley, M. L. (1977). *Sheet metal drafting.* (2nd ed.). New York: McGraw-Hill.

Bics, J. D. (1985). *Sheet metal work.* New York: Macmillan.

Budzik, R. S. (1979). *Precision sheet metal shop theory.* (2nd ed.). Chicago, IL: Practical Publications.

Budzik, R. S. (1980). *Sheet metal shop fabrication projects including over three hundred fifty graded parts.* Chicago, IL: Practical Publications.

Budzik, R. S. (1982). *Fittings used today that require triangulation including the theory of triangulation.* (2nd ed.). Chicago, IL: Practical Publications.

Budzik, R. S. (1982). *Round fittings used today including methods and techniques of fabricating round work.* (2nd ed.). Chicago, IL: Practical Publications.

Budzik, R. S. (1987). *Specialty items used today (sheet metal) including methods of design and fabrication and important trade topics.* (3rd ed.). Chicago, IL: Practical Publications.

Budzik, R. S. (1987). *Today's forty most frequently used fittings.* (3rd ed.). Chicago, IL: Practical Publications.

Daugherty, J. S., & Powell, R. E. (1975). *Sheet metal pattern drafting and shop problems.* (4th ed.). New York: McGraw-Hill.

Iron & Steel Society. (1988). *Sheet steel carbon, high strength low alloy and alloy coils and cut lengths: Including coated products.* Warrendale, PA: Author.

Meyer, L. A. (1979). *Sheet metal layout.* (2nd ed.). New York: McGraw-Hill.

Meyer, L. A. (1975). *Sheet metal shop practice.* (4th ed.). Homewood Hills, IL: American Technical.

Reid, H. B. (1981). *Sheet metal layout simplified (3 volumes).* Ann Arbor, MI: H. B. Reid.

Rudman, J. (1989). *Gang foreman (Structures - Group D) (Sheet Metal).* Syosset, NY: National Learning.

Rudman, J. (1989). *Sheet metal fabrication.* Syosset, NY: National Learning.

References and Textbooks continued

Rudman, J. (1989). *Sheet metal worker.* Syosset, NY: National Learning.

UNIPUB. (1981). *Sheetmetal occupations 1981: Equipment planning guide for vocational and technical training and education programs.* Lahnam, MD: Author.

Vocational-Technical Consortium of States. (1982). *Sheet Metal Worker: A catalog of performance objectives.* Atlanta, GA: Author.

Wendes, H. C. (1982). *Sheet metal estimating handbook.* New York: Van Nos Reinhold.

Zinngrabe, C. J. (1980). *Sheet metal blueprint reading: For the building trades.* Albany, NY: Delmar.

APPROPRIATE TRADE RESOURCES

Audiovisuals

The following materials are available from:

American Association for Vocational Instructional Materials
120 Driftmier Engineering Center
Athens, GA 30602

Format: Slide/tape

Developing Shop Skills (221 slides)

The following materials are available from:

Bergwall Production, Inc.
P.O. Box 238
Garden City, NY 11530-0238
1-800-645-3565

Format: Videotape

Reading a Ruler
Basic Math: Fractions and Decimals

Audiovisuals continued

The following materials are available from:

Mid-America Vocational Curriculum Consortium
1500 West Seventh Avenue
Stillwater, OK 74074-4364
1-800-654-3988

Format: Transparency

Sheet Metal Transparency Set

Format: Filmstrip or Filmstrips on Videotape

Measuring Tools Explained
The Grinding Machine
Bench Metalwork
Sheet Metalwork
Art Metalwork
Metal Corrosion Explained
Metric Measuring Tools Explained
Math for Fabicators & Welders
Shop Math
The Drill Press Explained
The Horizontal Surface Grinder
Sheet Metal Fabricating

APPROPRIATE TRADE RESOURCES

Curriculum Materials

The following materials are available from:

The University of Texas at Austin
Extension Instruction and Materials Center
P.O. Box 7218
Austin, TX 78713-7218

Format: Instructor's Guide, Student's Manual
Additional Tests and Work Sheets

Sheet Metal Worker (1982)

The following materials are available from:

American Association for Vocational Instructional Materials
120 Driftmier Engineering Center
Athens, GA 30602

Format: Instructor's Guide, Student Text, Student Workbook

Developing Shop Safety Skills

The following materials are available from:

Mid-America Vocational Curriculum Consortium
1500 West Seventh Avenue
Stillwater, OK 74074-4364

Format: Teacher's Guide, Student Manual

Sheet Metal Basics (1983)
Basic Sheet Metal Layout and Fabrication (1983)
Advanced Sheet Metal Layout and Fabrication (1983)
Architectural Sheet Metal (1983)

APPROPRIATE TRADE RESOURCES

Periodicals

Fastener Age
Fastener Age Inc.
Boston Post Rd. Box H
Guilford, CT 06437

Journal of Materials Shaping Technology
Springer - Velag Journals
175 Fifth Ave.
New York, NY 10010

Metal Fabricating News
Metal Fabricating Institute Inc.
Box 1178
Rockford, IL 61105

Metal Finishing
Plastics Publications Inc.
One University Plaza
Hackensack, NJ 07601

Metal Forming
Precision Metal Forming Association
27027 Chardon Road
Richmond Heights, OH 44143

Metal Working Digest
Gordon Publications, Inc.
Box 1952
Dover, NJ 07801

Metal Working News
Fairchild Publications Inc.
7 E. 12th Street
New York, NY 10003

Sources
Precision Metal Forming Association
27027 Chardon Road
Richmond Heights, OH 44143

Periodicals continued

Metal Producing
McGraw-Hill Publications, Co.
11 W. 19th Street
New York, NY 10011

APPROPRIATE TRADE RESOURCES

Safety Manual

Barth, John H. (1987). *School materials safety manual.* Schenectady, NY: Genium.

APPROPRIATE TRADE RESOURCES

Shop Safety Signs

This material is available from:

Curriculum Instructional Materials Center
1500 West Seventh Avenue
Stillwater, OK 74074-9990

APPROPRIATE TRADE RESOURCES

Sources of Additional Information

For more information about apprenticeships or other work opportunities, contact local sheet-metal contractors or heating, refrigeration, and air-conditioning contractors; a local of the union mentioned above; a local joint union-management apprenticeship committee; or the nearest office of the state employment service or apprenticeship agency.

For general information about sheet-metal workers, contact:

National Training Fund for the Sheet Metal and Air Conditioning Industry
Edward F. Carlough Plaza
601 N. Fairfax St., Suite 240
Alexandria, VA 22314

Associated Builders and Contractors of America
729 15th St., N.W.
Washington, DC 20005

VERIFIED SHEET METAL TASK LIST

DUTY A: READ BLUEPRINTS

A01 Interpret detail drawings.
A02 Read symbols used in blueprints and drawings.
A03 Develop lists of materials from blueprint information.
A04 Develop shop drawings.

DUTY B: LAYOUT SHEET METAL

B01 Layout rectangular straight duct.
B02 Layout rectangular square throat and square heel duct elbows.
B03 Layout rectangular duct Y branch.
B04 Layout round straight duct.
B05 Layout round duct elbows.
B06 Layout round duct offset.
B07 Layout round duct taper (transitional).
B08 Layout round duct lateral (round tap).
B09 Layout batten seam metal roof panel and cap.
B10 Layout square hopper.
B11 Layout materials using parallel line techniques.
B12 Layout materials using radial line techniques.
B13 Layout materials using triangulation techniques.

DUTY C: FABRICATE MECHANICAL SYSTEMS

C01 Fabricate rectangular radius throat and radius heel duct elbow.
C02 Fabricate rectangular square throat and square heel duct elbow.
C03 Fabricate round straight duct.
C04 Fabricate round duct elbow.
C05 Fabricate round duct Y branch.
C06 Fabricate round duct offset.
C07 Fabricate round duct lateral (round tap).
C08 Fabricate round saddle tap.
C09 Fabricate flat S.
C10 Fabricate barlock (standing S).
C11 Fabricate drive cleat.
C12 Fabricate pocket/government lock.

DUTY D: FABRICATE ARCHITECTURAL/ROOFING SHEET METAL

D01 Fabricate standing seam metal roof panel.
D02 Fabricate metal flat-look roof panel.
D03 Fabricate flashing.
D04 Fabricate roof coping.
D05 Fabricate gravel stop.
D06 Fabricate metal siding panel.
D07 Fabricate louver.
D08 **(ADDED) Fabricate fascia.**

(DROPPED) DUTY E: FABRICATE FOOD SERVICE SHEET METAL PRODUCTS

(DROPPED) E01 Fabricate food service counter top.
(DROPPED) E02 Fabricate food service shelving.
(DROPPED) E03 Fabricate food service cabinet shell.
(DROPPED) E04 Fabricate food service cabinet door.

DUTY F: INSTALL MECHANICAL SYSTEMS

F01 Install rectangular duct fittings.
F02 Install round duct fittings.
F03 Install single wall equipment casing/housing.

DUTY G: INSTALL ARCHITECTURAL/ROOFING SHEET METAL

G01 Install batten seam metal roof panel and cap.
G02 Install standing seam metal roof panel.
G03 Install ogee gutter.
G04 Install half-round gutter.
G05 Install rectangular downspout/conductor.
G06 Install offset in rectangular downspout/conductor.
G07 Install conductor head.
G08 Install flashing.
G09 Install gravel stop.
G10 Install metal siding.
G11 **(ADDED) Install fascia.**

SHEET METAL
Tools and Equipment

Adjustable wrench
Air drill
Allen wrench
Ball peen hammer
Band saw
Bar clamp
Beading machine
Bench vise
Bench (Pedestal) grinder
Bench plates, w/assorted stakes
Box and pan brake
Bulldog snips (W-5)
Burring machine
Button punch
"C" clamps
Cape chisel
Caulking gun
Center punch
Chalk line
Chipping hammer
Chisels, assorted types and sizes
Circle snips
Circumference rule
Clip punch
Combination notcher
Combination square
Combination pliers
Combination rotary machine
Common (carpenter's) square
Crimping machine
Disc sander-grinder
Double cutting snips
Drill press
Drill press vise
Easy edger
Electric screwdriver
Electric drill
Files, assorted
Flat nosed pliers
Folding rule, inside reading
Gas tungsten arc welder (GTAW)
Gas metal arc welder (GMAW)
Grinding wheel dresser
Grooving tool
Hacksaw
Hand stapler
Hand notcher
Hand seamer (tongs)
Hand brake
Hand dollys, assorted sizes
Hole saws, assorted sizes
Horizontal band saw
Impact wrench kit
Iron working machine
Level
Metal gauge, U.S. standard
Oilstone(s)
Oxyacetylene cutting torch
Pipe wrench
Plasma torch
Plumb bob
Power shear (Unishear)
Prick punch
Protractor
Punch, Whitney
Punch, barrel
Radius gage
Ratchet
Razor knife
Rivet set, assorted sizes
Riveting hammer
Rubber mallet
Safety shield, bench tool
Screwdriver set, assorted types & sizes
Scribe, adjustable
Shielded metal arc welder (SMAW)
Slip rool forming machine, 3 ft.
Snips, aviation, M1, M2, M3, M5
Socket set, 3/8 drive
Socket set, 1/2 drive
Soldering iron
Spot welder
Standard hand brake
Tap and die set
Tinner's hammer
Trammel points
Turning machine
Wing dividers

Wire brush
Wooden mallet
Wrench set, box-end, assorted sizes
Wrench set, open-end, assorted sizes

SHEET METAL
Standard Tool Kit

Adjustable scribe
Apron
Awl
Bench rule (circumference)
Bulldog shears
Chalk line
Combination shears
Combination square
Ear plugs
Gloves
Grooving tool
Hacksaw
Measuring rule, folding, inside reading
Pliers, assorted
Plumb bob
Punch set, assorted types and sizes
Quik set (dividers)
Rivet set, assorted sizes
Safety glasses
Safety goggles
Screwdrivers, assorted types and sizes
Snips, aviation, M1, M2, M3, M5
Steel measuring tape
Straight tongs
Tinner's hammer
Tool box
Trammel points
Vise grips
Wooden mallet

STAFF

It is anticipated that the program standards and the program guide developed as a result of this project will not change present staffing levels and certification requirements.

FACILITIES

The State Technical Committee members recommended that facilities be maintained in accordance with or exceed industry standards for the sheet metal field and those established in the Institutional Standards and General Program Standards.