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SHEET METAL WORKER, A SUGGESTED TRAINING COURSE.

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THE PURPOSE OF THIS CURRICULUM GUIDE IS TO ASSIST ADMINISTRATORS AND INSTRUCTORS IN PLANNING AND DEVELOPING MANPOWER DEVELOPMENT AND TRAINING PROGRAMS TO PREPARE WORKERS FOR ENTRY-LEVEL POSITIONS IN THE SHEET METAL INDUSTRY. THE MATERIAL WAS PREPARED UNDER CONTRACTUAL AGREEMENT BY OKLAHOMA STATE UNIVERSITY AND REVIEWED BY ADVISORY GROUPS. IT IS DESIGNED TO GIVE THE TRAINEE A BACKGROUND OF FUNDAMENTALS IN MANIPULATIVE SKILLS AND RELATED INFORMATION. THE COURSE OUTLINE CONTAINS UNITS IN (1) MATHEMATICS AND BLUEPRINT READING, (2) DRAWING, (3) JOB PLANNING, (4) PATTERN DEVELOPMENT, (5) FABRICATION, (6) ASSEMBLY, (7) SHEET METAL INSTALLATION IN CONSTRUCTION, (8) MANUFACTURING (QUANTITY PRODUCTION), AND (9) MAINTENANCE AND SAFETY PROCEDURES. THE COURSE COVERS 780 HOURS OF INSTRUCTION IN A PERIOD OF 26 WEEKS. A DISTRIBUTION OF INSTRUCTIONAL TIME FOR RELATED INSTRUCTION AND SHOP PRACTICE IS GIVEN WITHIN EACH MAJOR DIVISION. A CLASS OF 20 OR LESS IS SUGGESTED TO PERMIT TIME FOR THE NECESSARY INDIVIDUAL INSTRUCTION. THE TRAINEE SHOULD HAVE A HIGH SCHOOL EDUCATION WITH AT LEAST ONE COURSE IN MATHEMATICS AND HAVE MECHANICAL REASONING ABILITY, MANUAL DEXTERITY, AND A SENSE OF SPATIAL RELATIONS. SUPPLEMENTARY MATERIALS INCLUDE A LAYOUT OF A TRAINING FACILITY AND A LIST OF MACHINES, TOOLS, EQUIPMENT, AND SUPPLIES FOR A CLASS OF 20 PERSONS. INSTRUCTIONAL TEXTS, REFERENCES, AND FILMS ARE LISTED. (HC)

SHEET METAL WORKER

A Suggested Training Course

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education, Division of Vocational and Technical Education
Manpower Development and Training Program

Developed and first published,
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by

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FOREWORD

THE TRADITIONAL APPROACH to training sheet metal workers has been through an organized apprenticeship program. Vocational educators have worked with organized labor and governmental agencies to provide the related instruction important in developing a skilled journeyman. The schools have offered courses in drafting, mathematics, science, physics, and the like, in either day or evening classes for apprentices in the trade. In addition, some skill development activity has been included in apprenticeship courses where the craft recognized the capability of the schools to provide activity in the advanced manipulative phases of the trade. Apprenticeship, with its on-the-job work experiences, coupled with sound related instruction, has proved to be a basic source of sheet metal craftsmen.

This publication, prepared as a guide for instructors in the field of sheet metal work, should be helpful in developing course content for conducting day-to-day shop and laboratory classes. The guide is intended for administrators who must have information about course content, equipment and supplies, training schedules, qualifications of trainees, and similar items. Arrangement of the contents may be modified to meet local conditions under which training is to be offered.

With the greater use of air-conditioning facilities and of metal coverings for many building construction features, the need for sheet metal workers should continue strong. Preparation of entry-level workers in this apprenticeable occupation should lead to an increase in enrollments in apprentice training courses.

The basic content of this course will provide a foundation from which workers may move into the more demanding areas of sheet metal work.

Prepared under contractual arrangement with Oklahoma State University, the material has been reviewed by competent advisory groups. Recognition is given to Maurice Roney, Director, School of Industrial Education, for having supervised the development of the content.

Walter M. Arnold
Assistant Commissioner for
Vocational and Technical Education

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TRAINING COURSE FOR THE SHEET METAL WORKER

Purpose of the Guide

This training guide has been prepared to assist in planning and developing a course of training for workers in the sheet metal industry. It has been organized in a manner to be of maximum value to school administration personnel who are not themselves specialists in the occupation. Sufficient detail has been included, however, to provide an outline of instruction for the specialists who will be responsible for the operation of the training program.

The suggestions outlined in the training guide are not meant to delineate instruction in every detail. Supplemental material can be found in the suggested textbooks, references, and films. Further, the suggested course outline may not in all cases present topics in chronological order. The sequence of presentation, as well as the final selection of topics for special emphasis, should be determined by instructional specialists and will vary, depending on the needs and background of the trainee group.

Although this training guide has been developed primarily for planning Manpower Development and Training programs, it goes beyond the development of exercises to impart simple manipulative skills. By virtue of the related materials that are included, the trainee can be given a sound foundation in layout, a knowledge of efficient sequences of fabrication, and principles of simple product design. The materials included in the guide should be useful in technical high school programs, area vocational schools, and part-time apprenticeship programs.

Description of the Occupation

The sheet metal worker is involved in an industry that is centered around construction and manufacturing. Workers fabricate and install ducts which are used in ventilating, air conditioning, and other systems requiring movement of air. They also fabricate and install roofing, siding, flashing, venting, commercial stainless kitchen equipment, cabinets, partitions, store fronts, metal framework for advertising signs, and structures used for material movement and collection.

Generally, the sheet metal worker lays out and plans the job, taking the responsibility to determine the size and type of metal to be used. Many parts of a sheet metal assembly may be purchased in a prefabricated condition, effecting an overall saving if the sheet metal worker is aware of which parts to buy and which to fabricate locally. Beginning sheet metal workers should understand aspects of forming, cutting, bolting, riveting, cementing, punching, pressing, drilling, sawing, welding, brazing, and soldering. Workers also need to develop accuracy and speed in the layout process and master pattern construction.

The sheet metal worker uses galvanized sheet, cold rolled carbon steel, hot rolled carbon steel, copper, lead sheet, lead coated sheet, tin plate, nickel alloy, stainless steel, aluminum, and many other types of material of special formulas including several of the plastics.

Opportunities Within the Occupation

Within the next 5 years the sheet metal industry will require at least 25,000 workers to replace those who will leave the field through retirement, death, and inability to keep up with the increased demand for new and different skills. Also, the apprentice programs now in progress in the sheet metal field are not producing

the numbers of skilled tradesmen who will be needed as replacements. Some on-the-job training programs require four (4) years; however, this time may be materially reduced by attendance in a technical or vocational school.

Hourly wage rates for sheet metal apprentices generally start at 50 per cent of the journeyman rate and increase until the journeyman rate is reached. Union minimum hourly wage rates for sheet metal workers in July 1962 averaged $4.17, compared with $4.15 for all journeymen in the building trades, according to a national survey of building trades workers in 53 large cities. Among individual cities surveyed, the minimum ranged from $3.30 to $5.15.

Future opportunities for workers in the sheet metal industry look promising mainly because of the anticipated expansion in the new residential, commercial, and industrial construction. Despite the accelerated construction program in recent years, the industry has not been able to keep up with demand. Two factors which tend to keep the demand high are the population explosion, and the desire of the public to live in contemporary homes. It is quite probable that our cities and industries will require an ever-increasing program of construction and reconstruction.

Furthermore, the nature of the industry itself is changing, as are job requirements and job titles. "Warm air", as an identifying description, may disappear as tomorrow's industry achieves recognition of indoor environmental control. The day when environment control will be understood, accepted, and demanded is not far distant.

The activities of the small shop and local manufacturing are yielding to centralized manufacturing. The manufacturing industry is requiring more, faster and more complex services. This is not expected to reduce the total number of workers, but may place a different emphasis on their type of work.

Qualifications of Trainees

A high school education or its equivalent is desirable in order to progress rapidly in this occupation. Good physical condition and mechanical aptitude are important personal assets, since the sheet metal worker may be required to climb scaffolds or work in restricted enclosures. In general, the successful sheet metal worker must use, care for, and handle safely the tools, machines, equipment, and materials used in the trade.

Persons entering the training program should have completed at least one mathematics course of high school level. Persons with identified weaknesses in mechanical reasoning ability, manual dexterity, or other infirmities should be advised to consider other occupational training programs. A sense of spatial relations is necessary for successful progress in some of the more complex work in pattern development. Wherever possible in the selection of trainees, use of one of the standard tests of spatial relations may be helpful in selecting those persons with the best chance of success.

Suggestions for the Organization of Instruction

The total course presented in this training guide is intended to develop a marketable skill at the entry level, and at the same time to provide the trainee an orientation in the broad field of sheet metal work.

Shop practice, as well as the related class room instruction, should be supplemented, where possible, by visual aids, models, and field trips; this is especially true where is is not possible to obtain certain special purpose machinery. Where this is the case, visits to industries may be required to provide the student

with at least an introduction to certain elements of the instruction which cannot be treated adequately in the training facilities.

Allocation of hours to each unit of instruction serves to indicate the relative emphasis on these units. Changes in the distribution of instruction time may be necessary, depending on the abliity and background of the group in training. Also, the ratio of classroom time to actual shop manipulations may need to be revised in individual situations. While this training guide was designed for a class of 20 persons, the ideal student-teacher ratio of somewhat less students may provide for more effective teaching. A great amount of individual instruction is required to teach the skills of the trade.

Length of Course and Course Units

The training course as outlined covers a period of 26 weeks with a total of 780 hours of related instruction and shop practice. The training is scheduled for 6 hours per day and 5 days per week.

Major Divisions of Instruction

Unit		Suggested related instruction hours	Suggested shop practice hours
I.	Mathematics and Blueprint Reading	20	20
II.	Drawing	40	60
III.	Job Planning	20	60
IV.	Pattern Development	20	80
V.	Fabrication	15	80
VI.	Sheet Metal Installation in Construction	15	115
VII.	Assembly	30	140
VIII.	Manufacturing	15	25
IX.	Maintenance and Safety Procedures	10	15
	Subtotal	185	595
			185
	Total hours		780

COURSE OUTLINE

Description

This training outline is designed to introduce to the trainee a background of fundamentals necessary for him to become a proficient entry level sheet metal worker. In order to provide trainees with salable skills, approximately three-fourths of the training time is devoted to shop practice.

Outline

The instructor, in opening the course, should orient the group to the occupational opportunities in the sheet metal field. Information contained in the opening pages of this guide may be used for this purpose. Topics to be covered should include a description of the work, employment opportunities, and information about the training as suggested by items contained in the course outline.

I. Mathematics and Blueprint Reading

A. Class - 20 hours
1. Geometry of sheet metal layout
2. Bluepring reading
   a. Symbols
   b. Single, multiple, and sectional view drawing
   c. Dimensioning practices
   d. Specifications

B. Laboratory - 20 hours
1. Problems on geometric construction
2. Problems involving bluepring reading

II. Drawing

A. Class - 40 hours
1. Development of freehand sketches, shading and perspective
2. Proper dimensioning
3. Use and care of drawing equipment

B. Laboratory - 60 hours
1. Freehand sketching
2. Mechanical drawing assignments

III. Job Planning

A. Class - 20 hours
1. Selection of materials (Design factors in the use of the following)
   a. Cold rolled steel
   b. Galvanized steel
   c. Copper
   d. Aluminum
   e. Stainless steel
   f. Plastic sheet
2. Procuring necessary measurements
3. Procedure for job layout
4. Design, safety rules, and regulations

B. Shop Laboratory - 60 hours
1. Complete drawings with an emphasis on efficiency of finished sheet metal products.

IV. Pattern Development

A. Class - 20 hours
1. Developing a layout from a bluepring
2. Use of templates for layouts
3. Procedures for the construction of:
   a. Cylinders
   b. Cones and frustums of a cone

3. Procedures for the construction of:
   a. Cylinders
   b. Cones and frustums of a cone
   c. Pyramids and frustums of a pyramid
   d. Intersections of cylinders, pyramids, cones, and irregular figures.
   e. Square to round fittings
   f. Square to rectangular and offset fittings
4. Calculations of allowances for laps, locks, and seams

B. Shop Laboratory - 80 hours
1. Construct a paper pattern of the following:
   a. Cylinder with grooved seam
   b. A cylinder fabricated by resistance spot welding which has 45° intersection of the same diameter.
   c. A rectangular container with straight sides
   d. A rectangular duct fabricated by the use of a Pittsburgh lock
   e. A rectangular elbow fabricated by the use of a Pittsburgh lock
   f. Change a square to a round
   g. An offset section of a rectangular duct.
   h. A standard funnel
   i. An offset funnel
   j. An irregular fitting requiring triangulation

V. Fabrication

A. Class - 15 hours
1. Procedures for cutting stock
   a. Hand operations
   b. Power operations
   c. Others (sawing, pneumatic panel cutter, oxyacetylene, metal inert arc, plasma arc, punching, and drilling)
2. Procedures for forming:
   a. Hand forming on stakes
   b Slip roll forming
   c. Die forming (Acme, Pittsburgh, pressforming, drop forming, hydraulic forming explosive forming and magnetic pulse metal forming.
   d. Bar-folding operations
   e. Forming on the brake
   f. Crimping, grooving, beading, burring
   g. Wiring
   h. Flanging

B. Shop Practice - 80 hours
1. Assignment in cutting
   *a. Cutting straight scribed lines with combination snips
   *b. Cutting irregular lines with aviation snips
   *c. Use ring and circle shear to cut a flange
   *d. Use foot-operated squaring shear to cut rectangle
   *e. Using power plate shear to duplicate rectangular parts
   f. Punching a series of holes using the hollow punch, hand punch, etc.
   g. Drilling a series of holes without burning drill bit
2. Assignments in forming
   a. Hand forming on stakes
   b. Using slip roll to form cylinders
   c. Using lock forming machine to form Pittsburg lock
   d. Using the bar folder to form a grooved lock seam
   e. Wiring the edge of a cylinder
   f. Flanging operations

*Parts to be saved and used later during required fabrications

VI. Assembly

A. Class - - 30 hours
1. Riveting design and procedure
2. Soldering
3. Metal stitching
4. Acetylene welding and brazing
5. Resistance spot welding
6. Inert arc spot welding (consumable and nonconsumable)
7. Metal arc spot welding
8. Fastening (bolt, screws, adhesives, cold welding)

B. Shop Practice - 140 hours
1. Complete riveted joints using: flush rivets, round head rivets, pop rivets, and standard tinners' rivets
2. Solder lap seams on galvanized steel and copper
3. Solder lock seams and hems on aluminum and stainless steel.
4. Join sections of hot rolled steel sheet by the oxyacetylene process in both brazing and welding.
5. Join aluminum and stainless steel structures by oxyacetylene brazing and tungsten inert gas welding.
6. Join cold rolled carbon steel, stainless steel, and galvanized steel by the resistance spot welding method.
7. Join cold rolled carbon steel by the tungsten inert gas spot welding process.

VII. Sheet Metal Installation in Construction

A. Class - 15 hours
1. Roofing (use of seams, locks, lap joints)
2. Flashing and vent installation
3. Guttering
   a. Eave trough
   b. Moulded gutters
   c. Box gutters
   d. Roof gutters
   e. Conductor heads and pipe
4. Skylights
   a. Single pitch installation
   b. Double pitch installation
5. Ducts for heating and ventilating
   a. Design of size and shape
   b. Sound deadening
   c. Insulation
   d. Use of locks, clips, drives, and studs
6. Hotel and cafeteria equipment
   a. Cabinets
   b. Table tops
   c. Drain boards
7. Sheet metal finishes
   a. Care of manufactured finishes
   b. Preparation and application of finishes

B. Shop Practice - 115 hours
1. Guttering
   a. Work from blueprint to complete single pitch 5-12 chimney flashing. Scale $\frac{1}{4}$ original size.
   b. Work from blueprint to complete double pitch 4-12 chimney flashing. Scale $\frac{1}{4}$ original size.
   c. Install a corner section of gutter complete with conductor heads and downspout.
   d. Install a roof gutter on a 4-12 pitch roof complete with conductor heads and downspouts.

2. Skylights
   a. Make up corner section of a skylight to fit a flat, built-up roof
   b. Examine methods to join glass to sheet metal construction
3. Ducts for heating and ventilating
   a. Check air flow of various sizes and shapes of ducts.
   b. Examine methods for controlling noise level of various types of ducts
   c. Install various types of insulation on duct work
   d. Install sections of duct, examining various methods of joining and hanging
4. Hotel and cafeteria equipment
   a. Examine various methods of constructing cabinets
   b. Build cabinet complete with drawers, hinge assembly, and fixture mountings.
   c. Prepare a cabinet for priming and finish with a gloss enamel
   d. Experiment with air dry and baked synthetic finishes.

VIII. Manufacturing (quantity production)

A. Class - 15 hours
   1. Tubes and ducts
   2. Elbows
   3. Guttering
   4. Tanks and containers
   5. Residential and commercial fixtures
   6. Metal spinning
   7. Future trend in the manufacture of products by the sheet metal industry.

B. Shop Practice - 25 hours
   1. Explore the use of jigs and fixtures to aid in quantity production
   2. Design and build a simple fixture for the mass production of an outside yard light.
   3. Use the metal spinning lathe to produce various shapes

IX. Maintenance and Safety Procedures

A. Class - 10 hours
   1. Hand tools
   2. Power equipment
      a. Brake
      b. Punch press
      c. Drill press
      d. Nibbler and portable electric shear
      e. Oxyacetylene welding equipment
      f. Resistance welding equipment
      g. Metal arc welding equipment
      h. Inert gas welding equipment
      i. Turning machines
      j. Bar folder
      k. Lock forming
      l. Press brake
      m. Squaring shear

B. Shop Practice- 15 hours
   1. Examine and complete the sharpening of various cutting and pointed tools
   2. Examine various types of hacksaw blades for expected service, life, and use
   3. Regrind several different sizes of drill bits, noting angle of cutting edge and top clearance
   4. Examine the difference between high speed and carbon steel twist drills (hardness, use and cost)

5. Examine the cleaning equipment and maintenance procedures for oxyacetylene cutting and welding torches.
6. Write lists of safety and maintenance procedures for power equipment frequently enough to establish automatic habits.

TRAINING FACILITY CONSIDERATIONS

An attempt has been made in the layout of the physical plant (see Appendix C) to arrange equipment in a manner suitable for production practices. Several factors have been considered in arriving at the shop arrangement--such as: Space requirements per man in each work area, handling and fabricating sequence related to flow of materials, considerations of safety precautions, and a due regard for traffic problems in the handling of materials.

In the suggested floor plan storage of raw materials is adjacent to layout areas. This makes it possible for work to move from the planning area to the shear area where the final layout is reduced to size. Here the layout pattern is broken, folded, or punched as needed, and sent to the area for joining or locking. If required, the final fabrication is then sent to the spray booth which is near the exit door for priming or finishing.

In the event it is necessary to reduce the expenditures for shop equipment, considerable savings may be effected by removing from the suggested list of tools and equipment, some of the items marked with an asterisk (see Appendix D). While the machines so marked represent the least priority items, they are required equipment for an optimum facility. For example, the list includes two resistance spot welding machines which differ quite radically. The large machine, a 50 K.V.A. model, contains electronic controls and multiple adjustments to control heat, squeeze and hold cycles. When this machine is properly adjusted, quality welds may be expected, regardless of the skill of the operator. The small machine, a 10 K.V.A. model, is a simple mechanical device which may produce welds that will vary widely in quality, depending on the operator's skill. The 50 K.V.A. resistance spot welder will handle 10-gage members of mild steel and aluminum up to .051 inches thick. This is well beyond the capacity of the 10 K.V.A. resistance spot welding machine. Other machines marked with an asterisk may be considered by industry as necessary for efficient production, while for this training program the smaller, less complex, and lower cost machinery may suffice.

The specifications shown for the suggested list of machines, tools, and equipment are necessarily simplified, and are intended to be used primarily for estimating the cost of instructional facilities. Additional and more complete specifications will be required for purchase orders. In any case, the final determination as to the number, kinds and quality of items to be purchased should be made by experienced sheet metal teachers.

APPENDIX A. TEXTS AND REFERENCES

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Underwood, F. A. Textures in Metal Sheets. London: MacDonald & Co., 1961

APPENDIX B. FILMS

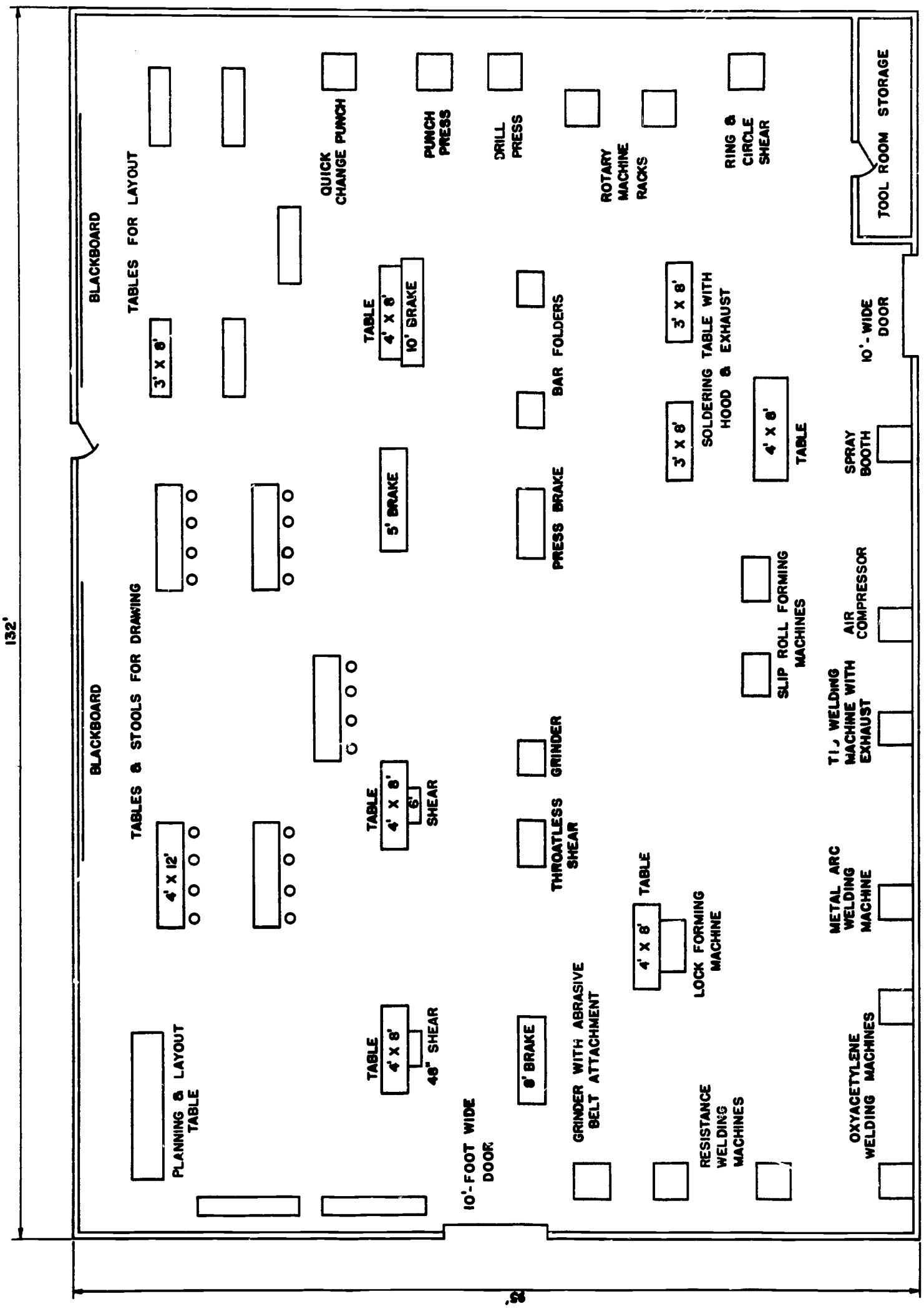
Forming and Bending of Stainless Steel. Republic Steel Corp. Made by Wilding, 1962

Metal Shop Safety. McGraw-Hill Book Co. Made by Centron Corp., 1959
Shows shop students' common hazards found in metalworking, and describes safe procedures to follow in a metal shop.

Metal Working Trades No. II: Sheet Metal Worker. Federal Department of Labor, Ottawa, Canada. By National Film Board of Canada, 1958
Overall picture of the type of work performed by the sheet metal worker in modern industries, the training required, and the future of the trades.

Pagent of Steel. Bethlehem Steel Co. Made by Mode-Art Pictures. Released by Modern Talking Pictures Service, 1959

The Production of USS Steel Sheets. United States Steel Corp. Made by Jam Handy Org., 1957



SHEET METAL SHOP FLOOR PLAN

APPENDIX D. SUGGESTED LIST OF MACHINES, TOOLS, AND EQUIPMENT FOR A CLASS OF 20 PERSONS

Unit	
1	Squaring shear, foot operated, bed width 48 inches, 18-gage capacity
*1	Squaring shear, power operated, bed width 6 ft., 14-gage capacity
*2	Unishear, motor driven, 16-gage capacity
*1	Ring and circle shear, 24-inch throat, 22-gage capacity
*1	Engel shopmaster or equal, bed size 36 X 120 inches, cutting capacity, 18-gage, notching capacity 22-gage
2	Throatless shear, 10-gage capacity
1	Brake, standard cornice, bed width 5 ft., 16-gage capacity
*1	Brake, standard cornice, bed width 8 ft., 16-gage capacity
*1	Brake, box and pan, bed width 10 ft., 16-gage capacity
*1	Punch, quich change, hand operated, 17 punches and dies, 5/32 to 2-inch capacity
1	Punch press, 10-ton capacity
1	Punch press, punch and die set, single and multiple units
*1	Nibbler, portable electric-powered, 14-gage capacity
1	Press brake, bed width 48 inches, 18-gage capacity
1	Drill press, 1/2-inch capacity chuck
4	Drill, electric hand, 1/4-inch capacity chuck
*2	Drill, electric hand, 1/2-inch capacity chuck
1	Air compressor, air delivery @ 100 psi - 15 cu. ft./ min.
2	Spray gun, external mix, 1-quart capacity
2	Air hose, 25-foot length, 1/4-inch internal diameter
2	Air moisture trap with pressure regulator, 0-150 psi
1	Spray booth with exhaust fan, minimum size, 4 X 4 X 8 ft.
20	Respirator for spray booth
2	Oxyacetylene, portable unit complete with welding and cutting tips
2	Oxyacetylene, face shields equipped with #3 lens
*2	Generator, motor-driven for metal arc welding, direct current, 250-ampere capacity
1	Power supply, AC-DC, gas and water controlled, 250-ampere capacity, complete with TIG spot-welding timer
1	Tungsten inert gas welding torch, 1/4" maximum electrode capacity
3	Arc welding helmets equipped with #10 lens
1	Inert arc spot-welding torch
1	Metal arc spot-welding torch, complete with power supply and timing device, maximum electrode size 3/32 inch
1	Resistance spot-welding machine, minimum throat depth 12 inches, minimum power 10 K.V.A.
*1	Resistance spot-welding machine, minimum throat depth 24 inches, minimum power 50 K.V.A.

* Items marked with an asterisk represent a certain grouping of machinery which may be deleted without destroying the usefulness of the training program. The complete list represents an optimum facility rather than either a minimum or an ideal facility.

Unit	
*1	Metal-stitching machine
1	Lock-forming machine, 22-gage capacity
2	Rotary racks, complete with the following: 1. Turning machine 2. Wiring machine 3. Beading machine 4. Crimping machine 5. Burring machine 6. Flanging machine
1	Grooving machine, 48-inch throat depth, 22-gage capacity
1	Double-seaming machine, 22-gage capacity
5	Tables, for drawing, 3X8 ft. top
5	Tables, for workbench and layout, 4 X 8 ft. top
5	Tables, for workbench and layout, 4 X 12 ft. top
2	Workbench, for soldering, 3 X 8 ft. top
2	Storage racks, vertical dividers to hold 10-foot-long sheets, 10 compartments
*1	Grinder, 1-hp. capacity, grinding wheel width 2 inches, double arbor
1	Grinder, 1/2 hp. capacity, grinding wheel width 1 inch, double arbor to power 2" flexible abrasive belt
1	Lathe, metal spinning, 1-hp. motor, 12-inch swing
2	Bar folder, bed width 26 inches, 22-gage capacity
2	Slip roll forming machine, 2-inch diameter rolls, working length of rolls 36 inches, 22-gage capacity
*1	Slip roll forming machine, 5-inch diameter rolls, 5-hp. motor, working length of rolls 72 inches, 11-gage capacity
4	Bench plate for assorted bench stakes
2	Bench stake set as follows: 1. Double seaming 2. Beakhorn 3. Bevel-edge square 4. Needle case 5. Hatchet
3	Universal stake holders and Universal stakes: set, complete as follows: 1. Double seaming 2. Beakhorn 3. Bevel-edged square 4. Needle case 5. Hatchet 6. Blowhorn 7. Bottom
4	Hollow mandrel stakes
5	Universal hand dolly
2	Punch set, solid, taper, 1/8, 1/4, 1/2, 3/4 inch
2	Punch set, hollow, 1/2, 3/4, 1 inch
10	Punch set (one prick, one center)
20	Needle-nose pliers, 2-inch nose
20	Flat-nose pliers
2	Shears, double-cutting hand-operated
20	Combination snips, 3-inch jaw

Unit	
10	Standard straight snips, 3-inch jaw
5	Circle snips, 2 1/2-inch cutting edge
20	Aviation snips, 10-inch length, 2-inch cutting edge right-hand cutting
20	Aviation snips, 10-inch length, 2-inch cutting edge left-hand cutting
2	Trojan snips, 12-inch length, 2 1/2-inch cutting edge
20	Scratch awls
20	Wing dividers, 10-inch
2	Beam trammel points
10	Soldering coppers, set as follows: 1. One-pound (one each, pointed and bottom) 2. Three-pound (one each, pointed and bottom) 3. Four-pound (one each, pointed and bottom) 4. Six-pound (pointed)
5	Furnace, gas-fired, complete with 2 burners, 2 valves, and pilot light
5	Hand groover set with groove widths as follows: 1. 1/8-inch 2. 7/32-inch 3. 5/16-inch 4. 7/16-inch
5	Rivet set, containing numbers 680 to 689, inclusive
10	Mallet, leather-faced, 2-inch diameter face.
10	Mallet, leather-faced, 4-inch diameter face
10	Mallet, plastic-faced, 1 1/2-inch diameter face
10	Hammer, setting, sheet metal
10	Hammer, raising, sheet metal
10	Hammer, riveting, sheet metal
5	Hammer, 3-lb., sledge
10	Square, roof-framing
20	Square, combination
5	Rule, circumference
20	Rule, 24-inch
2	Micrometer, 0-1-inch opening
5	U. S. standard sheet-metal gage
5	Vise, solid base, 3 1/2-inch jaw, 4-inch opening
5	Vise, swivel base, 3 1/2-inch jaw, 4-inch opening
20	"C" clamps, 8-inch opening
20	Vise grips
5	Chisel set, 1/2, 3/4, 1-inch blade
10	Screwdriver set, standard blade as follows:

Blade		Tip	
Length	Diameter	Thick	Width
3"	7/32"	.032"	7/32"
4"	1/4"	.037"	1/4"
6"	5/16"	.041"	5/16"
10"	3/8"	.050"	3/8"

Unit	
10	File, flat-bastard, 10-inch
10	File, smooth-mill, 10-inch
10	Screwdriver set, for Phillips head screws as follows: 1. No. 4 and smaller 2. No. 4 to 9, inclusive 3. No. 10 to 16, inclusive 4. No. 18 and larger
10	Tubular hacksaw frame, adjustable for 10-inch to 12-inch blades
1	Grinding wheel dresser
2	Abrasive bench stones, combination coarse, and fine grit
	Adjustable wrench set complete as follows: 1. 6-inch 2. 8-inch 3. 10-inch 4. 12-inch
4	Twist drill set, carbon steel, 1/16" to 1/4" by 1/64", 13 drills
4	Twist drill set, high-speed steel, 1/64" to 1/2", 32 drills
	Metal spinning tools, complete as follows: 1. Flat tool 2. Pointed tool 3. Cut-off tool 4. Beading tool
20	Drawing sets complete as follows: 5 1/2" compass, 3" extension bar, interchangeable pen, 4" combination spring bow pen and pencil, 4" spring bow divider, 4 1/2" ruling pen
20	Drawing outfit complete as follows: 48" T-square, triangular architect's scale, triangle 30" X 60", acrylic 8-inch, triangle 45" X 45" acrylic 6-inch, curve (irregular) 8-inch, pencil pointer, drawing pencil H. drawing pencil 3 H, drawing pencil 6 H, eraser, protractor (acrylic), drafting tape, drawing board brush
20	Drawing boards, steel edge
20	Stools, steel frame construction with 13" diameter wood seat

APPENDIX E. SUGGESTED LIST OF EXPENDABLE SUPPLIES

Quantity	Description
10	Cold rolled steel sheet, 18-gage, 36" x 96"
10	Cold rolled steel sheet, 20-gage, 36" x 96"
60	Cold rolled steel sheet, 22-gage, 36" x 96"
10	Cold rolled steel sheet, 26-gage, 36" x 96"
60	Cold rolled steel sheet, 28-gage, 36" x 96"
2	Zinc sheets, 20-gage, 30" x 96"
60	Galvanized steel sheet, 22-gage, 36" x 96"
60	Galvanized steel sheet, 28-gage, 36" x 96"
20	Copper flat sheets, soft temper, 16-oz. (.022) 1.0 lbs per sq. ft. 24" x 48"
20	Copper flat sheets, cold rolled, 16-oz. (.022) 1.0 lbs per sq. ft. 24" x 48"
20	Aluminum flat sheets, 16-gage, (.051), 17.18 lbs per sheet, 36" x 96", half hard temper
20	Stainless steel sheet, type 304, polished one side, 36" x 96" sheets, 24-gage
40	Steel strip, hot rolled mild steel, 20 ft.-lengths 1/8" x 1/2", .213 lbs per ft.
40	Steel strip, hot rolled mild steel, 20 ft.-lengths 1/8" x 1", .425 lbs per ft.
1000 ft	Steel angle, hot rolled mild steel 1/8" x 1 1/4" x 1 1/4"
50	Tin plate, 20" x 28" sheets, 28-gage (D15)
100 lbs	Solder, 50% tin and 50% lead
500 ft	Galvanized wire, #8 gage
500 ft	Galvanized wire, #10 gage
5 gal	Machine oil, for general lubrication and rust prevention
50	Abrasive belts, 2" x 60", 100-grit
20 lbs	Solder, 60% tin and 40% lead
5 gal	Hydrochloric acid
20	1-pound blocks of Sal-Ammoniac
20	6-oz. tins of rosin paste
20 lbs	Soldering salts
5	Pint jars of aluminum soldering flux
5	Pint jars of aluminum brazing flux
10 lbs	Aluminum soldering rod
10 lbs	Aluminum brazing rod
10 lbs	Stainless steel solder
5	Flux for soldering stainless steel, (6 oz.)
1 gross	Flux and acid brushes
200	Steel stove bolts with square nuts, 3/16" diameter 1/2" long
8 lbs	Tinners' rivets, 8-oz.
8 lbs	Tinners' rivets, 1-lb.
8 lbs	Tinners' rivets, 2-lb.
4 gross	Pan head rivets, #6 size, 1/4-inch long
50 lbs	Arc welding electrodes, E-6024, 3/32"-diameter
50 lbs	Arc welding electrodes, E-6024, 1/8"-diameter
50 lbs	Mild steel, oxyacetylene welding rod, 1/16"-diameter
50 lbs	Mild steel, oxyacetylene welding rod, 1/8"-diameter
160 oz	Silver solder, 1150° melting temperature

Quantity	Description
4 lbs	Silver solder paste flux
20	Cartons epoxy glue, 8-oz. containers
5 gal.	Metal primer
10 gal.	Synthetic enamel
20 gal.	Lacquer thinner
2 gal.	Synthetic enamel reducer
5 gal.	Synthetic finish for galvanized metal, aluminum, or ternplate surfaces
5 gal.	Wrinkle finish
20	Hacksaw blades, 18 teeth per inch, .025 thickness
20	Hacksaw blades, 24 teeth per inch, .025 thickness
20	Hacksaw blades, 32 teeth per inch, .025 thickness