

PROCEDURES USED IN SECURING AND
TEACHING RELATED INFORMATION
FOR
ACETYLENE WELDING

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J. C. Ruppert

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CHAPTER I

INTRODUCTION

The Diversified Occupations Program is one of the newest programs of education, and as is true with all new endeavors, many problems arise in its organization and administration. The most vital problem facing the coordinators is that of presenting related information to the boy or girl who is working in some occupation for one-half of each day and who depends on the school for the information related to his or her occupation.

Coordinators from every section of the country are seeking a solution to this problem and some method or methods which will serve to present the related instruction effectively and efficiently.

The purpose of this study is: (1) to determine the information needed by trainees in each occupation, (2) to select references and other instructional material containing that information, (3) to organize the instruction in a logical and systematic manner, (4) to learn the methods being used in teaching related information, (5) to make recommendations and application of these methods to a specific occupation, and (6) to correlate the technical instruction in school as closely as possible with the job training.

The following procedure has been followed in meeting these objectives:

- (1) Make an analysis of the specific occupation to determine the related information.
- (2) Select reference material that would provide the information.

- (3) Find the methods in use by other coordinators.
- (4) Prepare a chart that will help bring the related study and job training more closely together.
- (5) Prepare typed instruction sheets to illustrate the methods being used.

The following pages will give the details of this procedure and the instruction sheets resulting from this study. The welding trade was selected for this purpose because of the frequency of placements of trainees in that trade or in other trades that involve welding.

It is generally accepted that individual study is necessary to meet the individual needs of such a varied group as is found in a Diversified Occupations Program, since the coordinator has so many occupations represented in his group of trainees. Not only is individual instruction necessary to meet the diversified needs of students in possibly fifteen or twenty occupations, but there are several advantages to this method of instruction. Selvidge gives the following:

- (1) Learning is an individual process.
- (2) There is a wide range in learning abilities and interests.
- (3) Encourages learning progress according to the ability of the individual.
- (4) Makes the individual conscious of his responsibility for learning.¹

It is also assumed that the instruction for such a group must be carefully organized and directed to prevent

¹R. W. Selvidge and Verne C. Fryklund, Principles of Trade and Industrial Teaching, The Manual Arts Press, 1930, p. 122.

rambling in the study, to keep the students from spending their entire time in advertising sections of trade journals, and to insure thorough study of the information related to the daily training on the job.

With these assumptions and explanations, the suggested methods of presenting related information and the instruction sheets illustrating those methods are presented with the hope that they may be of some assistance to the coordinators in teaching related information to welders.

CHAPTER II

WELDING ANALYSIS

The trade analysis on which the related assignments are based was made in cooperation with trade advisers of the welding field. This analysis was made not only to determine the related instruction but also the shop training to be given the boy. This analysis serves also as a guide in the selection of trainees for the occupation and to give the coordinator a better understanding of the work.

It was decided to break the analysis into blocks on the basis of the material to be welded, since that seemed most practical to the trade advisers. The units or type jobs under each block were not given since there would be so much repetition. The operations and technical instruction for welding a broken car frame and other jobs of the same material would be nearly identical.

The operations under each block were stated in the imperative mood: for example, "Light the torch." They are listed in the order in which they will be performed as far as possible. Although there is some repetition of operations, it is necessary to list them to avoid overlooking any related information of importance.

After the job outline of each block was completed, the related instruction outline was listed also with the assistance of the trade advisers. The related instruction was first

listed under several headings like the chart below and later grouped together. This prevented overlooking many topics and gave advisers an idea of the possible topics of related information.

Block 1¹

Jobs	Material and Equipment	Science	Mathematics	Safety Precaution	Trade Terms	Drawing

The job and related study outline were placed in columns opposite each other in order to avoid becoming too general in the topics for study.

There are several reasons for the preparation of a training outline other than the fact that a skeleton outline is required.

- (1) To find how much training there is in the occupation.
- (2) To organize the training in a systematic and logical order.
- (3) To determine the related study.
- (4) To keep the related study correlated with the job training.

¹ Merritt W. Haynes, Technique of Trade Analysis and Course Organization, The Hamilton Company, 1938, p. 47.

- (5) To show the trainee what his objective should be for the training period.
- (6) To aid in the selection of trainees that will fit the occupation.
- (7) To show the school and others the need for related study and study materials.
- (8) To guide the coordinator in making his schedule of processes.
- (9) To determine whether the trainee is receiving the proper training on the job.
- (10) To give the coordinator an understanding of the jobs involved in the occupation.

Outline of Training
for the
Welding Trade

JOB TRAINING

RELATED STUDY

Unit I Care of Generators

- | | |
|-----------|---------------------------------|
| 1. Drain | 1. Composition of gas |
| 2. Refill | 2. Methods of generating gas |
| | 3. Types of generators |
| | 4. Safety in care of generators |
| | 5. Estimating costs |

Unit II Prepare Gas Equipment

- | | |
|--------------------------------|---|
| 1. Connect regulators to tanks | 1. Identification of hose and cylinders |
| 2. Connect hose to tanks | 2. Size of tips |
| 3. Connect torch to hose | 3. Construction of torches |
| 4. Select and install tips | 4. Types of flames and their use |
| 5. Adjust regulators | 5. Types of flux and their uses |
| 6. Light torch | 6. Kinds of rods and their uses |
| 7. Adjust torch | 7. Gas contents and pressures |
| 8. Select rod and flux | 8. Estimating |
| 9. Put on protective equipment | 9. Construction of regulators |
| | 10. Safety practices |

Unit III Welding Heavy Sheet Steel

- | | |
|---------------------------|---|
| 1. Chamfer edges of metal | 1. Proper rod, tips, flames, and joints |
| 2. Tack metal | 2. Types of steel |
| 3. Heat metal with torch | 3. Contraction and expansion of steel |
| 4. Add weld metal | 4. Methods of pre-heating and annealing |
| 5. Anneal | 5. Handling of torch and rod |
| 6. Test weld | |

Unit IV Welding Steel Castings

- | | |
|-------------------------|---|
| 1. Bevel edges of metal | 1. Same as above as applied to castings |
| 2. Pre-heat metal | |
| 3. Add weld metal | |
| 4. Clean weld | |
| 5. Hammer metal | |
| 6. Test weld | |

Unit V Welding Stainless Steel

- | | |
|-----------------|---|
| 1. Set up metal | 1. Composition and characteristics of stainless steel |
| 2. Run the bead | 2. Uses of stainless steel |
| 3. Grind | 3. Proper rod, flux, tip, flame, and joint |
| 4. Polish | |

Unit VI Welding Cast Iron

- | | |
|------------------|---|
| 1. Pre-heat | 1. Metallurgy of cast iron |
| 2. Chamfer edges | 2. Proper rod, flux, tip, flame |
| 3. Clean edges | 3. Contraction and expansion of cast iron |
| 4. Fuse metals | 4. Methods of pre-heating, cooling, and annealing cast iron |

5. Add weld metal
6. Clean weld
7. Anneal
8. Cool
9. Test weld

5. Uses of cast iron
6. Methods of testing

Unit VII Brazing

1. Clean surfaces
2. Pre-heat castings
3. Vee edges
4. Tin edges
5. Run the bead

1. Uses of bronze welding
2. Proper rod, flux, flame, tip
3. Contraction and expansion
4. Pre-heating methods

Unit VII Aluminum Welding

1. Arrange metal
2. Pre-heat
3. Run the bead
4. Clean the weld.
5. Reheat
6. Cool

1. Color of various temperatures of aluminum
2. Composition and characteristics of aluminum
3. Contraction and expansion of aluminum
4. Proper rod, flux, flame, tip
5. Methods of pre-heating and annealing

Unit IX Copper Welding

1. Clean surface
2. Pre-heat
3. Run the bead
4. Anneal

1. Same as above as applied to copper

Unit X Hard Surfacing

1. Clean surface
2. Pre-heat
3. Deposit weld metal
4. Grind surface

1. Uses of hard surfacing
2. Carburizing flames
3. Hard surfacing rods

Unit XI Cutting

- | | |
|------------------------|-----------------------------------|
| 1. Set up metal | 1. Principles of oxidation |
| 2. Apply heating flame | 2. Cutting and heating flames |
| 3. Apply cutting flame | 3. Uses of cutting torch |
| | 4. Construction of cutting torch |
| | 5. Cutting precautions and safety |

Unit XII Lead Burning

- | | |
|--------------------|--|
| 1. Fuse the metal | 1. Uses of lead burning |
| 2. Add filler | 2. Types of torches, tips, and burning bars or wires |
| 3. Smooth the work | |

Unit XIII Soldering

- | | |
|--------------------------|------------------------------------|
| 1. Clean surfaces | 1. Uses of solder |
| 2. Clamp metals together | 2. Composition and uses of flux |
| 3. Pre-heat with torch | 3. Composition and kinds of solder |
| 4. Apply flux | |
| 5. Apply solder | |

Unit XIV Selling Service

- | | |
|------------------------------------|--|
| 1. Meet customers | 1. Customer approaches |
| 2. Determine customers needs | 2. How to find customer needs |
| 3. Give information about the job. | 3. Types of customers |
| 4. Estimate cost of job | 4. Estimating costs |
| 5. Close the sale | 5. Freehand drawing and blue print reading |
| | 6. Methods of closing the sale |

CHAPTER III

METHODS OF TEACHING DIRECT RELATED INFORMATION

A. The Assignment Sheet

Advantages

The assignment sheet has had wide use as an instructional method for teaching related information in industrial arts and trade classes. With the development of cooperative training in Diversified Occupations, it has really filled an important place because of the same advantage that it has had in other industrial subjects. It gives specific directions for study as well as some guide for the study to be done. It is usually accepted that written directions, if prepared carefully or supplemented by oral instructions, are more complete and are understood better. They leave no opportunity for the excuse that certain aspects were forgotten or were misunderstood. "Such sheets will be found of great value in the part-time classes where they are almost indispensable as supplementary work for individual pupils."¹

If the instructor makes the assignment in written form, he usually will spend more time in the preparation, and the result will be a clearer assignment, with more careful selection of material, better arrangement, and organization. These assignments can be filed and used again with some revision.

These written instructions will place the responsibility on the student to obtain the information needed or do the

¹ R. W. Selvidge, Individual Instruction Sheets, The Manual Arts Press, 1926, p. 54.

work requested, giving the instructor more time for individual assistance. They will also save the time of both the instructor and the student during the class period, since the instructions can be given in a very short time. If the instructor must give each student his instructions orally at the beginning of each period, much time will be consumed in giving individual directions to each member of the group. While the instructor is starting the welder in his study, the boy in auto mechanics and the girl in office work, may be losing valuable study time by waiting on the instructor.

When the assignment has been completed, the instructor has something to show for the work covered, so that a record may be kept and he has something which he can check to determine the results of the study. Individual conferences are very important and beneficial, but if you have an assignment to be done or that has been finished, an excellent basis for the conference is provided. The conference may be created by some question by the student about the need for the information, where to find it, the interpretation, or it may originate from the instructor after it has been completed to determine the student's understanding of the information.

Disadvantages

With all these advantages, the assignment sheet has several disadvantages which limit their use. The first is the inability of the teacher to prepare written assignments

for several students when each assignment must be different. This can be partially overcome if each coordinator or related subjects' teacher will work with one or two occupations and interchange the results.

Some of these will soon become out of date or will not fit the situation in other communities. Naturally, they must be revised and supplemented to meet changing conditions, but this can be done very easily as they are used each year. If the assignments are made to stress fundamental principles rather than occupational and job procedures, these can be used with trainees in welding in most any establishment or community.

Unless originality and thought are used in the preparation of assignments, they are apt to become monotonous. Repetitive answering questions and solving of problems becomes tiresome without the diversions and other methods of group instruction.

These disadvantages all combine to necessitate considerable time in the preparation. This time will be well spent when the results are estimated and the saving of time in instruction is considered.

However, the coordinator cannot depend upon assignment sheets alone. They must be supplemented by individual conferences and study of new materials and methods that may develop.

Preparation

Perhaps one of the greatest limitations to the use of assignment sheets is the lack of experience and training for this type of instruction. Although any written directions or instructions to do certain studying or work may be considered as an assignment sheet, the complete and effective assignment sheet should have certain characteristics and parts.

Naturally, it should have a title or subject. This subject should be neither too broad nor too limited. The subject should be selected from an analysis of the trade and should be such as will fit some specific phase of the work, if possible. The study must have some specific and definite and fairly immediate application on the job if the student retains the information and benefits by it. The subject of welding tips alone may be too limited but can be combined with the study of torches and applied to the jobs of selecting, lighting, and adjusting the welding torch. It seems advisable to combine the study of welding and cutting torches, since the difference in the operation and construction of each torch is not great. This teaching procedure is advocated, even though the trainee may not learn to use both at the same time. The assignment will have more appeal if a title is used that represents some job such as Lighting and Adjusting the Torch. The related information concerning construction, types, principles of operation, safety precautions can be based around that as a job.

After the subject has been selected, a statement of objectives should be given to motivate the student's interest and to give him an idea of the things he is expected to learn. The creation of interest through the objectives can be done most effectively by showing the need for the information. The following example will illustrate:

The welding of steel is one of the most common and apparently simple types of welding job. However, it actually is a difficult job to give the strength and service that is necessary for such cases as automobile frames, compression tanks, and structural work. You should learn the properties of this metal, the size of rod, and the tip, the proper type of flame, and joint, and methods of heat treatment to be used.

After the incentive for study has been given, a clear description of this procedure or directions for doing the work should be given. This part of the assignment should be brief but exact so that no misunderstanding may arise. However, consideration should always be given the student when he offers suggestions about the procedure or plan to follow. The assignment is not intended to discourage initiative but as a guide post for the student to follow. As in the case of the objectives, the procedure or directions should be stated in the second person to make them more personal.

The first two parts may compose an assignment sheet. If the student knows what he is to study, has been shown a need and a plan for studying it, he will be on the way to obtaining some real value. The most common procedure for

study has been through the use of questions and problems on specific phases of the topic to guide the student's study and to be answered. Since the question and answer procedure has such common usage, some time should be given to the development of this procedure.

Good questions have unlimited value for the encouragement of analytical thinking, development of desirable attitudes and habits, motivation and stimulation of study but poor questions will suppress these essential qualities rather than develop them.

The questions should be clear and definite so that no doubt is left in the student's mind as to the meaning.

Poor--Why isn't a straight bar affected by heating?

Better--Why doesn't expansion of a straight bar affect the welding of the bar?²

The questions should be so stimulating and challenging to the reader that he will want to find the information and solution to it.

Good--If you had a bronze andiron to weld, what kind of rod, flux, and flame would you use?

Poor--What materials would be used to weld a bronze andiron?

The arrangement of the questions and the problems should be logical and unifying. Each question should lead naturally to the next and all should be centered around one topic, not a heterogeneous mixture.

² The heat does affect the bar but the expansion of the bar does not affect the welding since it can expand in all directions without creating any strain.

There are many types of questions that possess those characteristics making it possible to give a variety to the assignment. The factual type question such as, "What is acetylene made from?" has an important place, but the tendency is to overdo this kind because it is easier to prepare. The comparison, judgment, classification and others bring in the necessity for obtaining information but go further and create the opportunity for real thinking.

The following list of types and examples of each will serve as illustrations for questions of various kinds:

Comparison: How do welding and cutting torches differ? Compare their construction, operation, and care.

Judgment: What size rod should be used for welding an automobile fender?

Cause: Why does metal expand when heat is applied?

Effect: What may happen if a match is used to light the torch instead of the standard lighter? Why?

Explanation: Explain the necessity for proper cooling and the best methods to use in cooling cast iron.

Classification: List the welding rods that may be used on your job into groups according to size and use.

Discussion: Discuss the principles of oxyacetylene welding.

Criticism: John, another workman in your shop, has a practice of lighting the torch with a match. What is wrong with that procedure?

Relationship: What relationship is there between the melting point and conductivity of a metal to its expansion?

Case Studies: This is one of the most important types of questions on assignments that may be used. The study of technical information is necessary for the solution of the actual case study, but it also requires a practical application of the theory to an imaginary but practical situation. It necessitates the use of some study, logical thinking, and judgment.

Example: A $\frac{1}{4}$ inch steel plate is brought in to have six 2-inch holes cut in it. The holes are to be evenly spaced in a circle with a 12-inch radius. Make a drawing showing the position of the holes. Give the size of tip, proper pressure, and flame to use in cutting this material.³

The selection of questions can only be made after a complete trade analysis has been made. Even then it is necessary to study thoroughly the subject for study to get a complete picture of the information available and pertinent. The statement of each individual question should receive careful thought and even then, through use, it will be necessary to eliminate and change many of those prepared.

Types of Assignment Sheets

Although the question and answer type of assignment is very common, there are many other forms that will give variety to the related study and will fit the different subjects that arise. Any one procedure becomes monotonous and to keep up the interest of the student the instructor or coordinator must vary the methods of individual instruction.

³ Theodore Struck, Creative Teaching, John Wiley and Sons, 1938, Chapter IX.

The conference chart with varied forms has many advantages over the assignment of questions to answer. This assignment is based on the forms used for group conferences. The following will serve as an example:

Lighting and Adjusting the Flame

Fill in the chart below for the three types of flames that are used in welding and cutting. Give the characteristics of each type such as the sound, length, color, the proportions of gases to produce each, and the uses.

Type of Flame	Proportion of Oxygen and Acetylene	Characteristics	Heat Produced	Uses

This type of assignment gives a fairly complete guide for study of some topics, does not take much time to prepare after the objectives for study are well in mind, and appeals to the student's interest. It will not cover all the information desired for some topics and must be supplemented by questions to cover miscellaneous information that cannot be included in a chart form. The headings of the columns should be arranged in a logical sequence just as you would your questions.

Trade classes at Dunwoody Institute have made effective use of this form for studying materials, tools, and supplies. A chart similar to this may be provided to cover such items as gloves, rods, goggles, flux and other items.

Item	Description	Use	Sizes	Cost	Sources

The heading can be changed to fit various topics or a standard form can be worked out to use for all materials, equipment, and supplies.

An outline to guide the study and work of the student is another variation that may be used occasionally. The change in procedure of study is probably its only advantage over the other forms. Coordinators of Oklahoma have prepared outlines of related information on the same sheet with the outlines of the jobs. References are also given on the same sheet to assist the student in finding the information.

Example

Block VII Welding

References:

Air Reduction Sales Company pamphlets--Oklahoma City, Oklahoma
 Linde Air Products Company pamphlets--Tulsa, Oklahoma

Unit A. Shrinking Fenders

Jobs:

1. Apply heat
2. Hammer metal

Information:

1. Types of tips
2. Types of flames
3. Pressure regulation
4. Safety in handling acetylene
5. Use of goggles
6. Types of welding rods⁴

This outline form is more of a list of topics to be studied rather than an outline of individual topics. They may be broken down further to give a more complete guide for study.

An outline similar to the following can be prepared that may be used for several different topics. This same outline is just as applicable to the welding of one metal as it is another.

Outline of Study for Welding Various Metals

1. Composition of metal
2. Properties of the metal the welder should know
3. Size and type head to use
4. Kind of rod to use
5. Type of flux and method of applying it
6. Type of flame and best method of applying it
7. Preliminary treatment necessary
8. Procedure for welding
9. Annealing process
10. Difficulties to be met

The assignment may not be more than instructions to read certain sections of a reference or to read information on a definite topic related to the present work on the job. However, the assigned reading will be accomplished more effectively if the instructions are written and the references,

⁴ Floyd Hayes, Coordinator of Diversified Occupations, Anadarko, Oklahoma, Analysis of Body and Fender Work.

objectives, and directions are given. In other words, the why, what, where, and how of the study should always be an essential part of any assignment.

Selection of Reference Material

The instructional material used as references for the assignments have been selected from the manufacturers bulletins and the books on the subject of welding by an advisory committee of welders and the coordinator. The welding field has a fine supply of practical pamphlets on various phases of the work. These may be secured from various manufacturers, such as Linde Air Products Company, and Air Reduction Sales Company, without cost.

This material must be evaluated very carefully. The advisors from the trade assisted in the evaluation of the actual value of the material as related study. Other criteria considered in the selection were: the use of illustrations and diagrams to make the meaning clear; the type of print and ease of reading; the level of age for which it was written, organization of the information to fit the units of work.⁵

B. The Information Sheet

One of the greatest handicaps in the widespread use of assignment sheets is the lack of any universal reference books for various fields of work. The assignment sheet prepared by one coordinator is difficult for another coordinator to use because he does not have the same references as those

⁵ R. B. McHenry, Related Instruction, University of Florida, 1939, p. 15.

listed. The information sheet meets this problem by providing the information on the same sheet with the assignment.

The information sheet must be brief, clear, and to the point. Because of their brevity they may lose much of the interest and meat of the subject. Most reference books, manufacturer's bulletins and other material have more thorough information, more pictures, diagrams, and explanation than can be given economically in an information sheet. Too, the person preparing the information must know the subject even more thoroughly than the one who prepares an assignment sheet.

In many cases there are not enough references for the use of all students of the same occupation or subject. Occasionally there is vital information which cannot be obtained from any publications. There is also a possibility that the available information is too technical or too advanced for the student's use. These situations create a need for sheets especially prepared to give information on the particular topic. These have commonly been called information sheets. Selvidge says, "As a matter of fact, the preparation of information sheets consists largely in condensing pages of loosely stated facts and discussion into a few sentences so clearly and simply stated that anyone can understand them."⁶

A sample information sheet may be found in the instruction sheets on welding (assignment number 16, steel specifications).

⁶ R. W. Selvidge, *Individual Instruction Sheets*, Manual Arts Press, 1926, p. 50.

This information has been prepared because the reference from which it is taken is rather expensive just for the one topic and the information can be given accurately in a small space.

The information should be followed by pertinent questions and problems to check the study of the information and understanding of it.

C. Oral Reports

In order to give the student opportunity for practice in oral expression of his ideas, oral reports should have a part in the study of technical information. Too much emphasis can be placed on the use of written work. The oral report gives not only the opportunity for self-expression, but provides a relief from the monotony of individual study.

Although the student's report in welding may not affect directly the other students in a Diversified Occupations Program, the benefit of such reports occasionally will help to familiarize the group with each individual's work and broaden their knowledge of business in general.

At the beginning of the year, each student may give a general report including his place of business, his employer, type of work he does, the hours of work, and some interesting facts concerning his job. Later, at regular intervals, reports may be required on methods of welding, equipment, or special phases of the work of interest.

Trade journals and manufacturer's bulletins, such as those found in the bibliography, are good sources of material. The oral report is a good method of making use of this valuable information and stimulating the study of new ideas. There is nothing we can do that is worth more to the young man going into the welding trade than to encourage the study of service bulletins and trade journals. An example of oral assignment is given in the student's manual, assignment 25.

D. Student Teacher Planning

This method, begun by Kenneth Clark, woodwork and related subjects teacher in the Fort Smith High School, is going through its second year of experimentation and has proven to be an effective aid in teaching related information.

The procedure for the student to follow may be given in outline form as follows:

1. Make an analysis of the work jobs in your occupation or the particular phase of the occupation in which you are now working.
2. List the topics of information related to each phase of the occupation or the specific unit on which you are now engaged.
3. Write up in detail the information related to that unit that is of most concern to you at this time.
4. Give the step by step procedure for doing the job.
5. Prepare a set of at least ten questions on the information which you have obtained. These questions will be used later to test your knowledge of the information.
6. On a separate sheet give the answers to the above questions.

The natural reaction of most coordinators will be: "How can a sixteen year old boy follow such a procedure?" This is a logical and sensible criticism. Experience has shown that it takes around two weeks to prepare the boy or girl for this type of study, but this is not wasted time since the individuals are learning to analyze their own jobs, to see what is involved in their trade or occupations, to realize a need for the study which they are doing.

Since it is generally accepted that vocational training, manipulative or informational, should be based on an analysis of the trade or occupation, we start there with our study of the procedure. It is much simpler for the first semester or first year to analyze each job or unit as the boy progresses from one to the other. Some phase of an occupation represented in the group with which all are partially familiar is listed on the blackboard after an explanation of the meaning and purpose of an analysis is given. Then the instructor can begin as one would in a conference: "What are the jobs that the mechanic has to do to repair and service brakes?" He will soon have a fairly complete list of jobs for that part of automotive service. Units from other occupations may be analyzed until an understanding is reached by all students. Schedule of processes and analyses made in cooperation with employers and workmen may be made available to the students for reference.

The same procedure can be followed for analyzing the information essential for the job. An outline similar to the following will be an aid to the student in determining the topics for study:

UNIT V BRAKES

List of Jobs	Science	Mathematics	Materials	Tools or Equipment	Safety Precaution	Technical Terms	Drawings
1. Reline	Principles of mechanics seal brakes	Estimating costs	Rivets	Hammer	Driving precaution when testing	Bleed	Brake system
2. Adjust			Brake lining 1. Qualities 2. Composition 3. Cost 4. Sources	Brake lining machine			
3. "Bleed" hydraulic line	Principle of hydraulic pressure			Lathe	Precaution for accuracy of adjustments		
4. Repair cylinder	Selling paints		Brake Fluid 1. Purpose 2. Cost 3. Sources	Wire brush			
5. Put in brake fluid	Friction			Testing equipment			
6. Replace parts							
7. Machine brake							
8. Remove grease							

During this preliminary period each student should be given an opportunity to go through all the reference material that may have a bearing upon his occupation to help him determine the possible subjects and to indicate the sources of information. The student is forced to do some searching for information from reference books, pamphlets, encyclopedias, and even the employer.

Some time must also be spent in discussion of the different types of questions and the best methods of stating them. It is not necessary to know the names of all types even though objectives and semi-objective questions are commonly used.

After this preliminary period of discussion has been made, the students can be allowed to attempt a unit of work. The instructor becomes an advisor rather than a teacher or supervisor, assisting them with the analysis of jobs and information, sources of information, and in preparation of questions. It seems advisable to require each student to check with the instructor at the end of each step in the procedure especially for the first few weeks. It will be surprising how well the student can analyze his own job and informational needs after a few weeks.

This method is not the easiest for the instructor to use because it arouses so many questions that require his advice. Students are not used to planning their work and thinking for themselves but the development of initiative, interest, resourcefulness, and real knowledge will pay for the efforts expended.

This plan, originated by Mr. Clark, is based on a combination of the philosophy of Vocational Education which implies that the instruction should be based on an analysis of the occupation and supplement the daily work, and on the principles of progressive education which imply that the instruction should be determined by the student's interest and should be a result of student planning directed by the teacher.

Most of all, this plan meets the test of the four steps in teaching. They are: (1) preparation for the lesson, (2) presentation of the new material, (3) application of the new material by the student, and (4) testing to find whether he understands and can use it.⁷

The question of time needed for each unit cannot be answered definitely since the variation may range from one to five hours. In small communities with trainees in small establishments where the trainee cannot remain in one department or phase of the work for a definite period but is working wherever the opportunity for experience may arise, it will be necessary to organize the work in smaller units. For example, the unit on brakes might be taken up from the standpoint of the type of brakes on which the work is being done that day or into specific jobs as they arise; such as, adjusting or refilling with break fluid.

⁷ C. R. Allen, The Instructor, the Man, and the Job, J. B. Lippincott Company, 1919, pp. 148, 149.

Many other variations may be made to fit particular communities or occupations, but the general principles can be followed in any situation.

The work report from La Porte, Indiana, follows this idea in some respects although not as complete in the study of related information.

LA PORTE HIGH SCHOOL

La Porte, Indiana

COOPERATIVE STUDENT'S WORK REPORT

Report of _____ for two weeks, _____, 19__ to __

Employed at _____ Foreman _____

Kind of work done during the period: (give approximate number
of days on each kind of work)

Description of work: (make sketches and give size, material, etc.)

Name of machines used:

New tools or equipment used:

Hours worked: M T W T F S M T W T F S Total hrs. _____

Have you any questions to ask, subjects you would like discussed,
or comments on your school or shop work? If so, state them here.

Signature of student _____ O.K.'d _____

E. Visual Instruction

No emphasis needs to be placed on the value of visual instruction for any instructor realizes the importance of ideas gained through the sense of sight. It is known that approximately 75% of our ideas are obtained in this way, that they are retained much longer, and are much clearer.

Some of the advantages of using motion pictures are:

1. They gain close attention of the students.
2. They may be slowed down or stopped to study detail.
3. Oral explanations given with them are easily remembered.
4. They require less time than a visit to industry to observe the activities which they show.
5. Important operations and processes are emphasized.⁸

Only in the last few years have visual aids been prepared that might be used in vocational classes to any extent. There are many available charts, films, diagrams, and other visual aids for teaching information related to welding. A list of free films is given as a supplement to the bibliography and the other material is a part of the publications listed.

Even with the use of visual aids, the student will not benefit to the greatest extent unless he knows what to look for in a motion picture or chart. He also should understand that there is certain information he is expected to get from the study.

⁸ Gilbert G. Weaver, Shop Organization and Management, The Hamilton Company, 1938, pp. 86, 87.

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Assignment sheets may be prepared for use on various topics with motion pictures as the source for obtaining the information. The charts and diagrams are listed on specific assignment sheets as references. Charts and diagrams also may be posted on the bulletin board or used for making drawings. One diagram was used this year for a student in welding to copy, trace, and make blue prints for use of other students.

The following motion pictures are available without cost. They can be obtained from the Technical Publicity Department, Linde Air Products Company, 205 East 42nd Street, New York, in either 16 mm. or 35 mm. All but one are silent. The following summaries may assist the instructor in the selection of the films for the proper time. Most of them are one reel taking about fifteen minutes to each reel.

Oxwelding and Cutting--the Modern Method of Joining and Severing Metals. 16 mm. or 35 mm., 1 reel, silent. Study of equipment. Shows the internal construction and operating principles of low pressure type cylinders, regulators, torches, and generators, by animated drawings.

Welding and Cutting with Prest-O-Weld--16 mm. or 35 mm., silent, 1 reel. Study of equipment. Similar to the film above but deals with medium pressure types.

Welding and Cutting with Purox--16 mm. or 35 mm., silent, 1 reel. Study of equipment. Shows the same pictures as the first two films but deals with balanced pressure type of equipment.

Oxwelding and Cutting in Production (Part I)--16 mm. or 35 mm., silent, 1 reel. Study of construction work with welding processes. Shows fabrication of automobile bodies, steel grave vaults, gas refrigeration units, airplane fuselages, and aluminum fuel tanks.

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Oxwelding for Profit (Part I)--16 mm. or 35 mm., silent, 1 reel. Study of methods in the small shop. Shows the repair of lawn mower wheel, automobile crankcase, stripped gears, a worn shaft, and other similar jobs.

Oxwelding for Profit (Part II)--16 mm. or 35 mm., silent, 1 reel. Study of methods in industrial plants. Shows hardfacing of worn parts, welding of automobile bodies, welding pipe, cutting, methods with automatic machines and the oxygen lance.

Oxy-Acetylene Welding of Structural Steel--16 mm. or 35 mm., silent, 2 reels. Shows the construction of a large factory entirely by welding processes. Shows the welding operations in construction of the columns, girders, trusses, and actual erection of the building. Includes detail drawing of design features.

The Prosperity Process--16 mm. or 35 mm., silent, 2 reels. Shows methods of fabrication, cutting, repairing and hard-surfacing. Interesting examples are given of each process.

Oxy-Acetylene Welding and Cutting for Repair, Maintenance, and Production--16 mm. or 35 mm., sound, 1 reel. Welding and processes. Shows welding of refrigerating units, cabinets, and other products, repair of broken cast-iron parts, hard surfacing of broken machinery parts. Also shows tests for determining the strength of welds.

Haynes Stellite the Plow Share--16 mm. or 35 mm., silent, 1 reel. Hard surfacing. Shows procedure for adding Stellite to plow shares.

CHAPTER IV

CORRELATION OF JOB AND SCHOOL TRAINING

C. A. Prosser says, "It is a sound rule of teaching that the best time to learn anything is when you need it."¹

If the related instruction is to be of practical value, it must have some direct and immediate application on the job. The direct relation of the study is determined, of course, by the trade analysis but the correlation of the daily training on the job and in school is more difficult.

One of the difficulties is caused from the fact that the trainee cannot always start on one phase of the job, remain there for a definite period of time and then move on to another phase but he must receive his training as the jobs come into the shop. This means that the boy may be working on more than one type of job each day.

There are also certain jobs which require considerable skill but little technical information. The boy must, therefore, be studying some information in advance of his work at the particular time.

The following methods have been used by various coordinators and they have met the problem with varying degrees of success:

¹ C. A. Prosser, Adult Education: The Evening Industrial School, The Century Company, 1930, p. 223.

1. Weekly or daily work reports to give the phase of the work being learned and the problems on the job.
2. Conferences with the employer to determine the phase of work being learned and the weaknesses or problems with which the school can assist the boy.
3. Parallel outlines of the job and school training such as have been developed by the coordinators of Oklahoma. (See p. 17)
4. Student-teacher analysis of the unit on which he is working and the related information. (See p. 21)
5. Trade analysis and progression sheet such as the one on the following page prepared by P. T. McHenry, former coordinator, Huntsville, Alabama.

From the various methods in use a method was sought that would combine the advantages of them all and would meet the difficulties mentioned. The combination analysis, work and study progress chart was the result. This form is not perfect but may be changed to meet the desires of other coordinators if it has any merit. Each day the student puts a check in the square opposite the particular phase of the work which he did that day. In the column of related assignments the boy can find the number of the assignment or assignments which are particularly related to that job. When he has completed each assignment, the date of completion should be placed in the last column.

If during the first week of the job training, the boy refills the generator on Monday and Saturday and assists with the equipment on the other four days he will put check marks in the first and sixth squares opposite that unit on Refilling Generator, and in the second, third, fourth, and fifth squares opposite Preparing Equipment. See sample work and study progress chart shown on page 40. The squares are lined off in weeks, with four weeks in each major square, and four weeks' periods.

This chart will serve for four school months or practically one semester.

As the boy checks the jobs which he did, he finds that he should be studying assignments one and two and from three to nine. If he starts on assignment one and completes it, the date is placed in the right hand column.

This chart has several advantages that may overbalance the apparent weaknesses in it. They are:

1. It is a simple method for the student to record his work experience.
2. It gives the coordinator, at a glance, the picture of the boy's work experiences over a period of four months and makes it easier for him to tell whether the student is getting the necessary varied experiences on the job.
3. It helps the student to find the study related to his daily work.
4. It becomes a permanent record showing the job and technical training that the student has received.
5. By leaving off the title of the jobs and the number of the related assignments, the chart can be used for any occupation.

CHAPTER V
WELDING INSTRUCTION SHEETS

The twenty-six instruction sheets are the result and the application of the investigation of the methods of teaching related information. They are based on the training outline prepared in cooperation with the advisers from the trade and on the reference material selected with their guidance.

Although these sheets do not cover the related information entirely, an effort has been made to cover the fundamental problems. Several of the instruction sheets may be used for more than one topic. The outline form in assignment 17, the student planned lesson in assignment 18, as well as the special reports, may be used for any number of topics.

An attempt has also been made to prepare sheets illustrating each method of teaching related information. No one method is the best but a composite of all these methods will give variety and prevent monotony.

ASSIGNMENT I

PRINCIPLES OF OXY-ACETYLENE WELDING AND CUTTING

REFERENCES:

Oxweld Instruction Manual, by Linde Air Products--pp. 3-6.

PROCEDURE:

Read the references using the questions to guide your study. Answer all questions neatly and completely.

QUESTIONS:

1. What are the two main principles behind oxy-acetylene welding?
2. What are three uses of oxy-acetylene?
3. What is the difference between fusion welding and using a welding rod?
4. What is usually the composition of the welding rod?
5. Which metals can be bronze welded? Why?
6. What is meant by hard facing?
7. What is used for cutting metals?
8. What treatment must be given the metal before cutting?
9. Explain what happens to metal in the cutting process.
10. Which is more easily cut--wrought iron or cast iron? Why?

ASSIGNMENT 2

CARE AND OPERATION OF GENERATORS

REFERENCES:

1. Oxyweld Instruction Manual by Linde Air Products--pp. 18, 19.
2. Oxy-acetylene Welding by Potter--pp. 5-7.
3. Installation and Operation of Oxy-acetylene Welding Equipment by Air Reduction Sales Company--pp. 6-12.
4. Safety in Handling and Using Oxy-acetylene Equipment by Air Reduction Sales Company--p. 363.
5. Oxyweld Acetylene Generators by Linde Air Products Company.

OBJECTIVES:

The acetylene generator provides gas at approximately half the cost of dissolved acetylene. For this reason, many shops provide their own generators. Care of the generator may be one of your earliest experiences on the job. You should know the principles of operation and construction, the methods of generating gas, and the precautions to be followed in working with the generator.

PROCEDURE OF STUDY:

Study the references listed above, keeping the objectives in mind. Answer in your own words the questions and problems in the following assignment.

QUESTIONS:

1. What materials are used for producing acetylene?
2. What proportion of materials should be used?
3. How much acetylene may be generated from a pound of carbide?
4. Compare the low pressure and the high pressure generators as to construction, use, and operation.
5. Make a diagram of the generator you use and explain its construction.
6. List the precautions for draining and refilling generators and explain the necessity for the precautions.

APPLICATION:

1. Give the step by step procedure for draining and refilling the generator.
2. Find the correct proportion for carbide for the following quantities of water and the amount of acetylene that will be produced, using $1\frac{1}{2}$ gallons of water to each pound of carbide:
 - a. 132 gallons
 - b. 10 gallons
 - c. 50 gallons
 - d. 25 gallons

ASSIGNMENT 3

CARE OF HOSE AND CYLINDERS

REFERENCES:

1. Oxweld Instruction Manual by Linde Air Products--pp. 38-43.
2. Installation and Operation of Oxy-acetylene welding and Equipment by International Acetylene Association--pp. 17-25.
3. Safety in Handling and Using Oxy-acetylene Equipment by Air Reduction Sales Company--pp. 353 - 356.
4. Care of Oxygen Acetylene Cylinders by Air Reduction Sales Company.

OBJECTIVES:

The knowledge of the proper care and handling of cylinders and the understanding of the gases contained in them is a fundamental essential for anyone working around acetylene equipment. This work assignment should help you to get this information and make your work safer for you and others. The more you understand the materials you are handling, the better you can do your job.

PROCEDURE OF STUDY:

Study the references concerning the topic and the suggested objectives. Work out thoroughly the following questions and problems.

QUESTIONS:

1. How can the acetylene hose and cylinder be distinguished from the oxygen equipment?
2. What is the purpose of the safety fuse in the cylinder?
3. How is the pressure on the acetylene cylinder decreased?
4. Why is it necessary to decrease the pressure of acetylene in a cylinder?
5. What is the normal pressure of oxygen in the cylinder? Of acetylene?
6. What may be the result of improper handling of cylinders? Why?
7. How does heat affect the content of the cylinders?

APPLICATION:

1. From your study of the general principles of construction of cylinders and from your reading fill in a chart similar to the one below to cover the precautions for handling, storing, and use of cylinders.

Precautions	Need for Precautions

ASSIGNMENT 4

REGULATION OF GASES

REFERENCES:

- Oxy-acetylene Welding by Potter, pp. 10-12, 16.
Oxweld Instruction Manual by Linde Air Products Company,
 pp. 10-13.
Installation and Operation of Welding and Cutting Equipment
 by Air Reduction Sales Company, pp. 26-28.
Welding and Cutting Apparatus Instructions by Air Reduction
 Sales Company, pp. 10-12.
Safety in handling and Using Oxy-acetylene Equipment by Air
 Reduction Sales Company, pp. 364-366.
Three New Oxweld Regulators by Linde Air Products Company.

OBJECTIVES:

This assignment is to direct your study of the regulators and gauges used in regulating and measuring the oxygen and acetylene pressures. You should know the purpose, kinds, construction, safety precautions, care and operation of the regulators.

PROCEDURE:

With the aid of the instruction manuals and manufacturers catalogs, fill in a chart similar to the one below. Make your chart as neat as possible and include all essential details. Attach drawings to make your explanations clear.

Types	Purpose or Use	Method of Operation (include drawing)	Necessary Cost	Cost	Manufac- turers

ASSIGNMENT 5

OPERATOR'S CLOTHING

REFERENCES:

Oxweld Price List by Linde Air Products Company
 Welding and Cutting Apparatus Instructions by Air Reduction
 Sales Company, pp. 15-18.
 Installation and Operation of Oxy-acetylene Equipment by
 Air Reduction Sales Company, p. 367.

OBJECTIVES:

The purpose of this assignment is to make a study of the clothing such as gloves, goggles, shoes; that the operator should use for his own protection. You should learn the types, sizes available, uses, approximate cost, source of equipment, and characteristics of them.

PROCEDURE:

Go through the instruction manuals and catalogs for the information suggested in the objectives. Fill in a chart similar to the one below. Make your chart neat and complete in details.

Name of Article	Size & Types	Uses	Characteristics	Approximate Cost	Sources

ASSIGNMENT 6

ADJUSTING THE FLAME

REFERENCES:

Oxy-acetylene Welding by Potter, pp. 17-19
 Oxweld Instruction Manual by Linde Air Products, pp. 26-27

OBJECTIVES:

A mixture of acetylene and pure oxygen burns with a nearly colorless flame but there are several types of flames for different purposes. You should learn the types of flames, how to recognize them, and their use.

PROCEDURE OF STUDY:

Study the references, keeping those objectives in mind. Describe the types of flames and give their uses as requested in the questions and chart.

QUESTIONS:

1. What is acetylene made from? How?
2. What is meant by a neutralizing flame? A reducing flame? An oxidizing flame?
3. Fill in this chart for neutralizing, reducing and carbonizing flames:

Types of Flame	Proportion of Oxygen, Acetylene	Results or Uses	Color and Shape of Flame	Sound of Flame	Heat Produced

ASSIGNMENT 7

USE OF JIGS AND CLAMPS

REFERENCES:

The Design of Jigs and Fixtures by Linde Air Products Company.
Oxy-acetylene Welding by Potter--pp. 119-122.

OBJECTIVES:

The use of jigs and clamps for holding the job in position for welding saves time and aids in making more accurate welds. You should know the uses of jigs and some of the types that may be used for various purposes.

PROCEDURE:

Study the references given above for the information suggested by the objectives and questions. Answer the questions in detail. Use drawings to illustrate the devices that may be used.

QUESTIONS:

1. What are the purposes of jigs for welding?
2. Give three advantages of the use of jigs.
3. What is the difference between a jig and a clamp or fixture?
4. What types of materials require clamps?
5. List 5 qualities that jigs or clamps should possess.

APPLICATION:

1. Fill in a chart similar to the one below for such types of jigs and clamps as the C-clamp, the H-clamp, angle iron, straps, and wedges, others that are more suitable for your work may be substituted:

Type of Jig or Clamp	(Use drawings) Prescription	Types of Jobs to be Used with	Advantages

2. Select the clamp or jig most suitable for the following types of jobs:
 - a. Broken fender
 - b. Two flat sheets of light steel
 - c. Sheet metal to be made into cylinder
 - d. Holding vertical pieces in a framework.

ASSIGNMENT 8

WELDING RODS AND FLUXES

REFERENCES:

Oxweld Welding Rod by Linde Air Products, pages 3-15.

OBJECTIVES:

The understanding of the materials used in welding is of great importance in doing a good job. If you are to be a real welder, you should be able to select the rod that is best suited for each job. This study of rods and fluxes is to help you in the selection and use of various rods and fluxes for the different types of materials that may come in.

PROCEDURE:

Read the references using the questions to guide your study. Answer all questions and application neatly and completely.

QUESTIONS:

1. What is the importance of a good rod for welding?
2. What tests are applied to rods before being approved?
3. Name the three main types of welding rods.
4. What uses does the No. 1 steel rod have?
5. What advantages does it have over other rods? Disadvantages?
6. What is the purpose of the manganese in the steel rod?
7. What is the difference between the steel rod and the drawn iron rod?
8. Give the uses of the bronze rod.
9. Give the advantages of the bronze rod.
10. For what purposes is the cupro rod used?
11. For what purposes is the cast iron rod used?
12. Why does the aluminum rod need to harden slowly after melting?
13. What is meant by a flux? What is its purpose?
14. Why are different fluxes used for various types of metals?
15. Give the qualities of a good flux.
16. What minerals are contained in the fluxes?
17. What are common sizes of welding rods?
18. How are welding rods bought?

APPLICATION:

1. Give the rod which you think would be best for each of the following cases:
 - a. steel plates requiring great strength
 - b. steel plates requiring less strength
 - c. automobile spring
 - d. teeth of dipper on steam shovel
 - e. cylinder blocks
 - f. street car rails
 - g. castings (cast iron)
 - h. aluminum castings

ASSIGNMENT 9

WELDING TORCH

REFERENCES:

- Safety Practices for Installation of Oxy-acetylene Equipment by Air Reduction Sales Company, pp. 31-34.
Oxy-acetylene Welding by Potter, pp. 7-9, 15.
Safety in Handling Oxy-acetylene Equipment by Air Reduction Sales Company, pp. 360-365.
Welding and Cutting Apparatus Instructions by Air Reduction Sales Company, pp. 8, 9, 15.

OBJECTIVES:

The welder should know the types of torches, the principles of operation, sizes of tips for various purposes, method of lighting and manipulation, and the safety measures for handling the torch.

PROCEDURE:

Use the objectives and questions to guide your study of the references. Answer the questions in detail. Following the steps of logical thinking, give your solutions to the application.

QUESTIONS:

1. What is the purpose of the torch or blowpipe?
2. Compare the low pressure and medium pressure welding torches.
3. Make a drawing of the type torch used in your shop. Label each part and explain the principles of operation and construction.
4. Compare the welding torch and the cutting torch.
5. What is the proportion of oxygen and acetylene used in the welding torch? the cutting torch?
6. In what sizes can tips be obtained?
7. Why is it important to use the right size tip?
8. What is the basis for the selection of the tip?
9. Explain the procedure of lighting the torch.
10. List five important precautions for the care and use of the torch and give the reason for the precaution.
11. Give the procedure for connecting the torch and the tip.

APPLICATION:

1. Select the proper size tip, the correct pressure, and figure the amount of gas used for the following jobs: (Time 30 minutes for each job)
 - a. Car fender
 - b. Car bumper
 - c. 2 inch iron rod
2. Give the procedure for welding two flat pieces of $\frac{1}{2}$ inch iron. Include the sizes of tip, installation of tip, lighting and manipulation of torch.

ASSIGNMENT 10

PROPERTIES OF METAL

REFERENCES:

Metallurgy by Jongson, Deane, and Gregg--pp. 2-15
 Procedure Handbook of Arc Welding--p. 99
 Oxy-acetylene Welding by Reaveaveg Potter--pp. 27-29

OBJECTIVES:

A knowledge of the proper ties of different metals is necessary for a welder in order for him to know how to weld each one properly. This assignment is to help you in studying the properties of various metals and the problems arising with each.

PROCEDURE:

Study the reference using the questions to guide your reading. Answer all questions completely and fill out the chart under applications as directed.

QUESTIONS:

1. Define the following terms: oxidation, tensile strength, solubility, malleability, brittleness, conductivity, melting point.
2. Explain how each of the factors in number 1 affect the weldability of metals.
3. How may weaknesses in each of the factors in number 1 be eliminated or corrected?
4. Why does low carbon steel need a flux when being welded?
5. How does the carbon context of steel affect its weldability?
6. How may a steel with aluminum alloy be welded successfully?

APPLICATION:

Fill in the chart similar to the one below for each of these metals: stainless steel, manganese steel, high carbon steel, cast iron, steel castings, malleable iron, wrought iron, forgings, copper, brass, aluminum.

Metal	Characteristic	Composition	Welding Procedure
Example: Manganese steel	tough, hardens when cold, high resistance to abrasion and shock, rock crushers, steam shovel buckets railroad crossings	12% to 14% Manganese 5% to 1.25% Carbon	a. use same metal for rod b. cool in air c. grind off all rust d. Place weld in pods e. ball peen pod while welding f. use low heat as possible g. give metal time to cool between beads

ASSIGNMENT 11

METAL ALLOYS

REFERENCES:

Metallurgy by Johnson, Deane and Gregg--p. 40
Consumer Goods by Richard Seigler--pp. 342-347

OBJECTIVES:

All metals contain a certain amount of another metal, an alloy that give to the original certain characteristics. You should become familiar with the alloys and the metals produced with them, and the properties that the alloys give.

PROCEDURE FOR STUDY:

Study the reference with those objectives in mind. Describe the alloys listed using the questions and chart to guide your description.

QUESTIONS:

1. What is the purpose of alloys?
2. Fill in a chart similar to the one below for zinc, nickel, manganese, chromium, magnesium, vanadium, silicon, tungsten.

Alloy	Source	Metal used with	Qualities produced as an alloy

ASSIGNMENT 12

PRE-HEATING

REFERENCES:

Oxy-Acetylene Welding by Potter--pp. 27-35

OBJECTIVES:

The effect of expansion and contraction on metals is of great importance to the welder. It is impossible to produce satisfactory repairs unless he knows the principles of expansion and contraction, the amount usual for different metals, the results of it, and the methods of handling.

PROCEDURE:

Study the reference to find the information suggested in the objectives. Answer the questions and application in detail.

QUESTIONS:

1. Why is it important to know the melting point of metals?
2. What effects do the melting point and conductivity of metals have upon expansion. Give example.
3. What is meant by the coefficient of expansion?
4. Compare the expansion of some of the common metals?
5. What causes expansion of metals?
6. What is the effect of contractions and expansions on metals?
7. How can contraction and expansion be handled to prevent warping and cracking? Give three methods.
8. Why isn't a straight bar affected by contraction and expansion?
9. What are three reasons for pre-heating?
10. How hot should the pre-heated metal be?
11. What means may be used for pre-heating? Give the advantages and disadvantages of each.

APPLICATION:

1. Give the method that you would use in these cases to prevent poor results from improper expansion and contraction:
 - a. Straight steel rod.
 - b. Two pieces of sheet aluminum.
 - c. Cracked cylinder.
 - d. Cast iron stove grate.
2. Give the procedure and contraction in welding a broken cast iron flywheel.

ASSIGNMENT 13

IRON AND STEEL

REFERENCES:

Metallurgy by Johnson, Deane, and Gregg--pp. 48-50, 128-141

OBJECTIVES:

Iron and steel are two of the most common metals with which the welder must work. You should become acquainted with the differences in the many kinds, their uses, and the alloys that make each different.

PROCEDURE OF STUDY:

After studying the reference, describe the various kinds of iron and steel according to the questions and chart below.

QUESTIONS:

1. What is the importance and effect of carbon in iron and steel?
2. Fill in the chart below for each of the kinds of iron and steel:

Kind of Metal	Amount of Carbon	Other Alloys	Qualities	Uses

ASSIGNMENT 14

WELDING CAST IRON

REFERENCES:

Oxy-acetylene Welding by Potter--pp. 59 to 66
What Process Should Be Used, by Air Reduction Sales Company,
pp. 5-10.

OBJECTIVES:

Cast iron is so different from other metals in its properties and is so difficult to handle that it is important to make a separate study of its problems. You should know the qualities of cast iron, proper rods, fluxes, and flame to be used, the special heat treatment for this metal, and other problems in the use of the torch.

PROCEDURE:

Study the reference with those objectives in mind. Answer in detail the questions and application.

QUESTIONS:

1. What properties of cast iron make it different from other metals? List at least four.
2. Why is expansion and contraction a greater problem with cast iron than other metals?
3. How can the strain from excessive contraction and expansion be prevented?
4. Describe the best type of rod for welding cast iron.
5. Why is a flux especially necessary in welding cast iron?
6. How should the flux be applied to produce the best results?
7. What preliminary preparation should be given the metal?
8. What procedure should be used in vertical welding of castings?
9. Describe the proper manipulation of the torch for cast iron welding.
10. How can blowholes be removed?
11. Why should the weld be cleaned as soon as possible. What method of cleaning should be used?
12. Explain the necessity for proper cooling and the best methods to use in cooling cast iron.

APPLICATION:

1. List several objects made of cast iron that may come into your shop for welding.
2. Select one of the most recent jobs of welding cast iron which you have had and give the rod, type of weld, flame, method of pre-heating and after treatment that should be used.

ASSIGNMENT 15

S.A.E. STEEL SPECIFICATIONS

REFERENCE:

Metallurgy by Johnson, Deane, Gregg,--pp. 127, 128.

OBJECTIVES:

The Society of Automotive Engineers (S.A.E.) has adopted a numerical system for describing and identifying grades of steel. The steel is described by four numbers and descriptions on drawings, purchase orders or others may have only these numbers to give the specifications. The following paragraphs will explain the system and give the meaning of different numbers.

The first number gives the alloy that is contained in the steel. The second number gives the per cent of the alloy and the last two numbers give the approximate per cent of carbon contained in the metal. Example SAE2540--The 2 stands for nickel, the 5 for 5% nickel, and the 40 for 40% carbon. All steels contain carbon but those that have no other alloy are called "carbon steels." Thus, S.A.E.1030 means: (10) carbon, (0) no other alloy, (30) 30% carbon in the steel.

The numbers for different alloys of steel are: (1) carbon, (2) nickel, (3) nickel-chromium, (4) molybdenum, (5) chromium, (6) chromium-vanadium, (7) tungsten, (9) silicon-manganese.

PROCEDURE:

From the information above and from any available references answer the following questions and application.

QUESTIONS:

1. What does S.A.E. mean?
2. How are specifications of steel commonly given?
3. What does the first number represent? the second? the third and fourth?
4. What element is always found in steel?

APPLICATION:

Give the meaning or description of the following steels:

- | | | |
|---------|---------|---------|
| a. 4310 | d. 9270 | g. 6140 |
| b. 1050 | e. 5320 | h. 7290 |
| c. 2630 | f. 3460 | |

ASSIGNMENT 16
TYPES OF JOINTS

REFERENCES:

Oxy-acetylene Welding by Potter--pp. 43-52.
Welding Instructions and Standards by United States Steel Corporation--pp. 33-57.

OBJECTIVES:

The welder should know the type of welds or joints to use with different thicknesses and kinds of metal, and different shapes in order to weld satisfactorily. This assignment gives you a study of the types of joints, the uses of each, the advantages of each, and the methods of preparing them.

PROCEDURE:

Fill in a chart similar to the one below for the following types of joints: lap, butt, flange, and edge, corner and tee. Make your chart neat and complete in details. Use drawings to illustrate.

Type of Joint	Uses	Advantages or Disadvantages	Methods of Making (Use Drawings)

ASSIGNMENT 17

WELDING STEEL

REFERENCES:

Oxy-acetylene Welding by Potter--pp. 37-56
What Process Should Be Used by Air Reduction Sales Company--
 pp. 11-18.

OBJECTIVES:

The welding of steel is one of the most common and apparently simple types of welding job. However, it actually is a difficult job to give the strength and service that is necessary for such cases as automobile frames, compression tanks, and structural work. You should learn the properties of this metal, the size of rod, and the tip, the proper type of flame and joint and methods of heat treatment to be used.

PROCEDURE:

Study the references keeping the objectives in mind. Answer thoroughly the questions and solve the applications on the basis of the information obtained.

QUESTIONS:

1. What is the relative expansion of steel to other metals?
2. What is the importance of selecting a rod according to the thickness of the metal?
3. What type of flame should be used in welding steel? Why?
4. Compare the methods of heat treatment which may be used for welding steel as to procedure and results.

APPLICATION:

Use the outline below to give the necessary information for the type or types of jobs on which you work. This outline may be used for anyone or all types of steel welding such as light and heavy sheet steel, steel castings, and stainless steel or may be considered from the object to be welded such as drums and tanks, light steel racks, fenders, bumpers, pipes, axles, etc.

TYPE OF MATERIAL OR OBJECT TO BE WELDED

- a. Thickness or size.
- b. Composition.
- c. Qualities of material.
- d. Size of rod and tip to be used.
- e. Type of flame.
- f. Type of weld and joint to be used.
- g. Preliminary treatment such as beveling, chamfering, tacking, pre-heating.
- h. Application of torch.
- i. After treatment including cooling, cleaning, and grinding.

ASSIGNMENT 18

ALUMINUM WELDING

REFERENCE:

Oxy-acetylene Welding by Potter--pp. 91-95.

Current Practices for Welding Aluminum by Linde Air Reduction Company.

Welding Aluminum by Aluminum Company of America.

What Process Should Be Used by Air Reduction Sales Company, pp. 3, 4.

OBJECTIVES:

You have studied several phases of the principles of welding as directed by the instructions and questions. These have been given to guide your study of the principles of each topic. All related instruction is based on an analysis of the occupation and should be studied at the time that you can use the information in your work. If you have noticed, the assignments previous to this are tied up with some specific type of job. By now, you should be able to analyze some part of your work to determine the information related to that particular type of job and be able to find that information. It is important that you learn to use your own initiative in selecting the information to read and study because you will be thrown on your own responsibility very largely after you are out of school.

PROCEDURE:

1. List the jobs that are to be done in this phase of your work.
2. List the topics of information that are related to this phase of your work as indicated by your list of jobs. You should consider the study of materials, equipment, safety precautions, technical terms, mathematics, science principles, methods, and procedures for doing the work.
3. Study available references for the topics which you have listed. Write up in detail the information concerning the topics.
4. Prepare a set of at least ten questions on the information
4. which you have written. These questions will be used later to check your understanding of the information.
5. On a separate sheet of paper prepare a key or set of answers to the questions.

This is your job and the instructor is serving only as an adviser. Check with him at the end of each step for any suggestions he may have. If this works satisfactorily and if you like this procedure, you may use it with other units of your own selection.

ASSIGNMENT 19

COPPER, BRASS, AND BRONZE WELDING

REFERENCES:

Oxy-acetylene Welding by Potter--pp. 95-98.

What Process Should Be Used by Linde Air Products Company,
pp. 5-8.

Oxwelding Brass and Bronze by Linde Air Products Company.

OBJECTIVES:

Copper and its alloys are not the most common metals to be welded, but because of their peculiar properties, the welder should know those, the equipment, and procedures to use to obtain the best results.

PROCEDURE:

Study the references using the objectives and the outline to guide your study. Use the following outline to write up the information concerning either of the three metals. Give the reasons for the information wherever possible. Answer carefully the situations in the application.

OUTLINE:

1. Composition of the metal
2. Properties the welder should know
3. Size and type head
4. Kind of rod to use
5. Type of flux and method of application
6. Type of flame and best method of applying it
7. Preliminary treatment necessary
8. Procedure for welding
9. Annealing process to be used
10. Difficulties to be met

APPLICATION:

1. Give the type rod, flame, head, and methods for welding a light copper tubing.
2. If you have a bronze and iron to weld, what kind of rod, flame, flux, and method of welding would you use?
3. Explain the procedure, type of weld, and material you would use for welding a 1/8 inch brass pipe.
4. Find the cost of welding brass piping that took 30 minutes time, 23 cubic feet of oxygen, 1 1/2 thirty-six inch welding rods, and 25 cubic feet of acetylene. Use local prices on material and labor.

ASSIGNMENT 20

BRAZING

REFERENCES:

Oxy-acetylene Welding by Potter--pp. 77-80
How to Bronze-Weld by Linde Air Products Company
Bronze-Welding of Cast Iron Boilers by Linde Air Products
 Company

OBJECTIVES:

Brazing or bronze-welding is one of the common types of jobs of the welder because it is faster and less expensive than other methods. You should know which metals and objects can be brazed, the material and equipment to use, the methods of best treatment, and after treatment.

PROCEDURE:

Study the references with the objectives in mind. Try to remember some brazing job which you have observed and apply the information to your work. Answer the questions and answer in detail.

QUESTIONS:

1. What is meant by bronze-welding?
2. List the metals which can and cannot be bronze-welded.
3. Compare the bronze-welding process with the fusion method of welding.
4. What is the bronze-welding rod made of? What are its qualities?
5. Why is bronze-welding not usable for welding where there is very much strain or heat?
6. Why is it important to clean the metal thoroughly? What methods may be used?
7. Which type of flame should be used for bronze-welding? Why?
8. Why is it necessary to do just the proper amount of pre-heating? How is this done?
9. What is the importance of proper tinning the metal to be welded?
10. How is the tinning process done?

APPLICATION:

1. Sort the following into two columns. Under one column list those you would bronze-weld and under the other list those you would use standard method of welding. Give your reason for method used in each case.

a. worn shaft	e. broken car frame
b. cracked compression tank	f. cracked engine head
c. broken stove grate	g. cracked fender
d. cracked cast iron wash pot	h. aluminum cylinders
2. Select one of the type jobs above which may be bronze-welded or one of your own choice and give procedure for welding.

ASSIGNMENT 21

HARD SURFACING

REFERENCES:

Oxy-acetylene Welding by Potter--pp. 80-84
Haynes Stellite Wearing Surfaces by Haynes Stellite Company
Steel Hard Facing Procedure by Linde Air Products Company
Flame Hardening by Air Reduction Sales Company

OBJECTIVES:

Hard surfacing has grown to great importance during the last few years because worn parts can be rebuilt at little expense to give longer service than new ones. You should know the uses of hard surfacing, the procedures and equipment to use, the preliminary and after treatment needed to give best results.

PROCEDURE:

Study the references listed to obtain the information suggested in the objectives and the questions. Answer the questions and application as directed.

QUESTIONS:

1. What is meant by hard surfacing?
2. List ten uses of the hard surfacing process?
3. What metals can be hard surfaced satisfactorily?
4. What preliminary treatment should be given the metal to be hard surfaced?
5. What type of flame should be used in re-surfacing? Why?
6. What type of rod should be used?
7. How much heat treatment should be given the parent metal?
8. What treatment should be done after the hard surfacing has been applied?
9. How may the after treatment be done?

APPLICATION:

1. Give three points that may be used in selling a customer on a hard surfacing job.
2. Give the procedure for applying a hard surface to some job which may come into your shop.

ASSIGNMENT 22

CUTTING

REFERENCES:

Oxyacetylene Welding by Potter--pp. 99-105
Gas Cutting of Structural Steel by Linde Air Products Company
Preventing Welding and Cutting Fires by Air Reduction Sales Company
Welding and Cutting Apparatus Instructions by Air Reduction Sales Company--pp. 27-33.

OBJECTIVES:

The oxy-acetylene cutting process is very common in repair shops, automobile repairing, and construction work. You should learn the principles of cutting, metals that can be cut, use of the cutting torch, and procedure for cutting.

PROCEDURE:

Read the references for the information suggested in the objectives. Answer the questions and application thoroughly.

QUESTIONS:

1. Explain the process or principle involved in cutting.
2. What metals can easily be cut with the torch? Which ones cannot? Why?
3. Compare the cutting and welding torches.
4. Give the necessary care of the welding torch.
5. Why is it important to obtain the proper pressure of oxygen?
6. Give the procedure for lighting the cutting torch.
7. Why is it so important to be careful of fires when cutting metal with the torch?
8. Give the procedure for cutting metal with the torch.
9. Why should dirty or rusty metal be cleaned before cutting?
10. What determines the size tip to be used?
11. Describe the clothing that the operator should use in cutting.

APPLICATION:

1. Name three uses of the cutting torch in your place of business.
2. Give five precautions to follow when using the cutting torch.
3. If you have a $1\frac{1}{2}$ " steel rod to cut, what size tip would you use? How much pressure? Give the procedure for cutting.
4. Give the size tip, amount of pressure, and procedure for cutting size 2" holes in a $\frac{1}{8}$ " steel plate. The holes are to be spaced in a circle with a 12" radius. Use drawings.

ASSIGNMENT 23

LEADING AND SOLDERING

REFERENCES:

Oxy-acetylene Welding by Potter--pp. 84, 85
Expert Soldering by The Stanley Works
Manual of Body and Fender Repair Work by The Stanley Works
How to Use Handy Silver Solders by Air Reduction Sales Company

OBJECTIVES:

The ability to solder is necessary to the body mechanic and is a common type of job involving the welding torch. You should know the materials and the methods that are used as well as the purpose of soldering.

PROCEDURE:

Read the references using the objectives and questions as a guide. Answer the questions in detail. Keeping in mind the information learned and the steps of thinking; give your solution to the application.

QUESTIONS:

1. What is the purpose of soldering bodies?
2. Why is it important to clear the surface thoroughly?
3. Compare the soldering process with welding.
4. How may the cleaning of the metal be done?
5. Describe the method of tinning the metal?
6. What is the purpose of a flux? What fluxes may be used?
7. Explain the procedure for applying the solder.
8. What materials are used in making the solder? What characteristics does the solder have that affects its use?
9. How much heat should be applied to the metal? to the solder?

APPLICATION:

1. Describe your method of applying solder to the rear panel of an automobile.
2. Give the solder, flux, and procedure for soldering a gutter pipe of galvanized iron.

ASSIGNMENT 24

FIGURING PRICES

REFERENCES:

How to Figure Oxwelding and Cutting Costs by Linde Air
Products Company
Oxy-acetylene Welding by Potter--pp. 123-125
Price lists and catalogs

OBJECTIVES:

If the welder is to receive a fair profit for his work, he should be able to figure the cost of the materials and labor for each job. No matter how much work he does, he cannot stay in business if he does not clear something on his work. Experience is the best basis for estimating but you can get information on measuring gas, cost of materials, such as rods and flux, and approximate time for various jobs.

PROCEDURE:

Fill in a chart similar to the ones below for acetylene, oxygen, rods, and labor for various types of metal. Use local prices if possible. In the second chart, select five jobs and give the amount and cost for each item.

I.

Item of Supplies, Equipment or Labor	Method of Measurement	Approximate Cost	Source
Example: 1. Oxygen	cubic feet or number of cylinders. Cubic feet determined by reading on regulator at beginning and close of job.		Linde Air Products Company, New York. Air Reduction Sales Company, New York, Compressure Industrial Local sources

II.

Thickness and Length of Metal	Time Required	Acetylene	Oxygen	Rods	Total Cost

ASSIGNMENT 25

ORAL REPORT ON MODERN PRACTICES

REFERENCES:

Oxy-acetylene Tips (any recent issue)
Iron Age
Manufacturer's Bulletins

OBJECTIVES:

It is necessary that the successful welder keep up-to-date with new ideas and practices just as it is for the manager of a store, a doctor, or a lawyer. This assignment will give you an opportunity to read some recent article in one of the trade journals or publications and pass your reading on to other members of the group.

PROCEDURE:

Select some article from one of the recent trade journals or bulletins that is of special interest to your work and may have general interest to the group. These journals contain articles on such topics as new materials and their uses, new methods of repairing, new equipment, and new ideas on the operation of the shop. Make enough notes on the article that you will be able to remember what you are to say.

ASSIGNMENT 26

ORAL JOB REPORT

REFERENCES:

See bibliography

OBJECTIVES:

Most of your study has been individual and written work. You should have an opportunity to express yourself before a group to develop that ability and to inform other members of the group of your work. This is a chance for you to get other members of the group acquainted with your service.

PROCEDURE:

Select some job which you have worked on that may be of particular interest. Go through the references on that particular type of job for further information. Write up your notes or an outline for the report. Notify the instructor when you are ready to give your report to the class. Be sure that you have everything well in mind before you start and that you are able to answer any questions they may ask. Avoid using too many "ands," "wells," and "uhs."

Your report should include such points as the description of the job, the materials and procedures used, other possible procedures or methods, any principles involved in the job, difficulties which you had, short cuts used, and the results obtained.

CHAPTER VI

CONCLUSION

As was stated in the introduction, the purpose of this study is: (1) to determine the information needed by trainees in the welding trade, (2) to select the references and other instructional material containing that information, (3) to organize the instruction in a logical, interesting, and systematic manner, (4) to learn the methods being used in teaching related information, (5) to make recommendation and application of these methods to the welding trade, (6) and to correlate the instruction in school as closely as possible with the job training.

An effort has been made to meet these objectives as far as possible. A welding analysis was made with the advisers in the welding trade to determine the information needed by trainees. This analysis is given and discussed in Chapter II. With the assistance of advisers, reference books, bulletins, charts, and motion pictures were selected that would give the needed information and would be in harmony with the criteria used for evaluative instructional material. The outline of information was then organized in a sequence according to learning difficulty and to the order experienced on the job. The latter order will generally be used when these two procedures are in conflict.

The next procedure was to learn what methods were being used to teach direct related information in all occupations. Several methods were found to be in general use and to be effective. Coordinators and vocational instructors, especially in the Southern Region, were contacted to find what methods were most effective and the general conclusion was that no one procedure was best but that a combination of several methods was necessary to make the instructions interesting and to meet all situations. These methods were discussed in Chapter III.

The most important problem was to adapt these various procedures to the welding trade. All of the diversified suggestions including assignment sheets in outline form, in questions and problem form, and in chart form, information sheets, oral reports, and student-teacher planned assignments, were used in preparing the twenty-six instruction sheets in Chapter V.

When the instruction was organized, the problem of correlation of job and school training arose. The various methods given in Chapter IV were studied to find a combination of all the ideas that would apply to the welding trade as well as other occupations. The work and study progress chart on page 40 was the result.

These findings and recommendations have been devised to meet the educational needs of prospective welders, and in such form as might be used in the organization of the instruction in other fields of vocational training. There is need for further study in the development of instructional material in other common occupations in the Diversified Occupations Program. If coordinators in several states each select an occupation with which he is familiar, prepare instruction sheets on it and exchange with other coordinators, the related instruction as well as the efficiency of the program would be rapidly improved.

Such a practice should not lead to a standardized product but to more rapid development of tentatively acceptable Adequate experimentation with various type student instructions would ultimately produce materials of the greatest assistance to learners.

T E C H N I C A L
B I B L I O G R A P H Y

- | | |
|--|--|
| Air Reduction Sales
Company, New York | <u>Care of Cylinders</u>
<u>Flame Hardening</u>
<u>How to Use Handy Silver Solders</u>
<u>Installation and Operation of</u>
<u>Oxy-acetylene Welding Equipment</u>
<u>Safe Practices for Installation and</u>
<u>Operation of Oxy-Acetylene</u>
<u>Equipment</u>
<u>Safety in Handling and Using Oxy-</u>
<u>acetylene Equipment</u>
<u>Welding and Cutting Apparatus</u>
<u>What Process Should Be Used</u> |
| Aluminum Company of
America | <u>Welding Aluminum</u> |
| Chaffie, W. J. | <u>New Profits in Arc Welding,</u>
Hobart Brothers Company, Troy, Ohio,
1936 |
| Johnson, Dean, and Gregg | <u>Metallurgy</u>
American Technical Society, Chicago, 1939 |
| Lincoln Electric Company | <u>Procedure Handbook of Arc Welding</u> |
| Linde Air Products
Company, New York | <u>Current Practices for Welding Aluminum</u>
<u>Design of Jigs and Fixtures</u>
<u>Gas Cutting of Structural Steel</u>
<u>How to Figure Oxwelding Costs</u>
<u>How to Bronze Weld</u>
<u>Oxwelding Brass and Bronze</u>
<u>Oxweld Instruction Manual</u>
<u>Oxweld Welding Rod</u>
<u>Oxy-acetylene Welding and Cutting</u>
<u>Principles and Operation of Oxy-</u>
<u>acetylene Equipment</u>
<u>Rebuilding Worn Parts</u>
<u>Steel Hard Surfacing</u>
<u>Temperature Date Chart</u>
<u>Welding and Cutting Chromium Steel</u> |
| Mersereau | <u>Materials of Industry,</u>
McGraw Hill Book Company, New York,
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<u>Welding, American Technical Society,</u>
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<u>Manual of Body and Fender Repair</u> |
| United States Steel
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TYPIST: T. Anne Cochran