Pacific Gas and Electric Company
WE DELIVER ENERGY.

LETTER AGREEMENT NO. 02-36-PGE

IBEW

PACIFIC GAS AND ELECTRIC COMPANY
INDUSTRIAL RELATIONS DEPARTMENT
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INTERNATIONAL BROTHERHOOD OF
ELECTRICAL WORKERS, AFL-CIO
LOCAL UNION 1245, I.B.E.W.
P.O. BOX 4790
WALNUT CREEK, CALIFORNIA 94596
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STEPHEN A. RAYBURN
DIRECTOR AND CHIEF NEGOTIATOR

PERRY ZIMMERMAN
BUSINESS MANAGER

August 26, 2002

Local Union No. 1245
International Brotherhood of
Electrical Workers, AFL-CIO
P. O. Box 4790
Walnut Creek, CA 94598

Attention: Mr. Perry Zimmerman, Business Manager

Dear Mr. Zimmerman:

In Letter Agreement 02-06, the Company and Union agreed to establish a joint committee to review and update the General Construction Apprentice Welder Training Program. The committee has concluded the revision process and presented the attached updated program to the Joint Apprenticeship and Training Committee.

The JATC recommends and approves the revised program to replace the existing GC Apprentice Welder Training Program.

If you are in accord with the foregoing and agree thereto, please so indicate in the space provided below and return one executed copy of this letter to the Company.

Very truly yours,

PACIFIC GAS & ELECTRIC COMPANY

By: [signature]
Stephen A. Rayburn
Director and Chief Negotiator

The Union is in accord with the foregoing and agrees thereto as of the date hereof.

LOCAL UNION NO. 1245, INTERNATIONAL
BROTHERHOOD OF ELECTRICAL WORKERS, AFL-CIO

Aug 30, 2002

By: [signature]
Perry Zimmerman
Business Manager

Pacific Gas and Electric Company

Gas Distribution

GAS DISTRIBUTION & TECHNICAL SERVICES

GENERAL CONSTRUCTION APPRENTICE WELDER TRAINING PROGRAM

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APPRENTICE WELDER TRAINING PROGRAM

I. OBJECTIVE

The Gas Construction Department's Apprentice Welder Training Program is designed to provide the apprentice with the manipulative skills and technical knowledge to function fully and productively in the Welder classification.

II. ADMINISTRATION

1. The training program is subject to the rules and conditions of the General Construction Master Apprenticeship Agreement and the Labor Agreement.

2. Under the direction of the Department Manager, the Program Supervisor is responsible for the overall administration and supervision of the Training Program. The Program Supervisor and/or a Course Instructor will organize, coordinate, and administer the Training Program. The Course Instructor(s) will retain all test results and any other necessary apprentice files.

3. The Area foreman or subordinate(s) will, whenever possible and job conditions permit, assign to the apprentice the work necessary to enable him to complete his required On-The-Job Work Experience training items as soon as possible.

4. Area Foremen, Resident Engineers, Project Superintendents, Foremen, Working Foremen, Course Instructors, and the Program Supervisor will cooperate fully with one another and the apprentice to insure the success of the Training Program.

5. All training program records will be available for review, verification, updating, or counseling by the Training Instructor, Supervision, Union's Business representative, and the Apprentice.

6. The Apprentice welder must be assigned to work under the supervision of a journeyman welder for a period of not less than 2 years. The apprentice welder MUST NOT be assigned to his/her own welding truck, until after they have completed their two (2) years.

7. Rotation of apprentice welders, due to the current work load we are doing, the apprentice welder is not exposed to the varied work situations needed for a well experienced apprentice in one work headquarters. Area foreman will need to temporarily transfer apprentice welders to other areas to gain valued field experience.

III. TRAINING PROCEDURES

The apprentice-training program is 36 months long, divided into 6 time periods with 6 related wage steps.

The apprentice-training program consists of two coordinated parts:

A. Centralized training school, which combine In-Class Technical Courses and In-Shop Welding Practice Lessons. There will be 80 hours of training in the first time period and 40 hours of training in each of the remaining five time periods.

B. On-the-job training and work experiences.

General Guidelines

1. On-the-job field construction training and experience is an important tool of the program and will be stressed throughout. This training is intended to develop new skills, as well as support and refine in-class and in-shop training.

2. The apprentice will obtain on-the-job work experiences by working with a Foreman, Working Foreman, and/or experienced Welder. The apprentice's on-the-job work experiences will grow in complexity and variety as he progresses through the training program. Each step period is meant to establish fundamental skills to build upon, expose the apprentice to the department's varied work situations, and to develop a comprehensive view of the welder's job responsibilities.

3. An apprentice shall perform routine crew work with or without direct supervision as part of a work crew only after being fully instructed and trained in the work to be performed.

4. The Area Foreman will be responsible for the Performance Reviews of each apprentice in their area headquarter. Performance Reviews shall be completed every six months after the two months Probationary Review until the training program is completed.

5. The "Guidelines for Training Periods" will be followed to the extent possible; lack of applicable work, classroom space and/or the apprentice's capabilities may be appropriate causes for temporarily deviating from such guidelines.

6. Any questions on the training program should be directed to the Program Supervisor, Course Instructor(s), or the apprentice's Area Foreman.

7. If the apprentice fails to meet the established "Standards of Achievement" for any step period, written notice of such failure will be given to the Apprentice, his Area Foreman, Program Supervisor, and Union Business Representative. Refer to "General Construction Master Apprenticeship Agreement" for more information on inadequate performance.

8. The Company will provide all books and course materials. However, lost or damaged books will be replaced at the employee's expense. If an employee fails to complete the apprentice-training program, all books and materials must be returned to the Company.

9. The Program Supervisor or the Course Instructor(s) and or Specialists will conduct periodic visits to field locations to audit the Apprentice's Field File, progress of apprentices, and general overall administration of the training program.

10. Within the first 6 months of each new wage step period, the apprentice will be assigned to a centralized school for training. Each session at the centralized training school will be one week in duration. There will be a total of seven weeks of centralized training. There will be 80 hours of training in the first time period and 40 hours of training in each of the remaining five time periods.

11. Training periods exclude any travel time needed to reach the place of training. However, such hours include time needed to prepare materials and equipment.

12. The apprentice may qualify to the code(s) and weld in the field with the assistance of an experienced Welder any time during his 36-month apprenticeship. Such qualification and welding work will not affect the apprentice's wage progression.

13. An apprentice's vacation time shall be scheduled so that it will not interfere with the centralized training school periods.

14. The Program Supervisor shall notify an apprentice who is scheduled to attend the centralized training school no later than 15 working days before their expected attendance.

IV. Guidelines for Training Periods

1st Period - 0 to 6 months step

The centralized training will cover the following items (80 hours):

In-Class Technical Courses (16-24 hours)

Introduction and Outline of Apprentice Training Program

Course 1.0	Welding Introduction: Basic Welding Categories, Sources of Heat Generation, Thermal Cutting processes, and Atmospheric Contamination.
Course 1.1	The Oxyacetylene Welding Process (OAW)
Course 1.2	Introduction to weight calculation and rigging fundamentals.
Course 1.3	Introduction to right triangles.

In-Shop Welding Practice Lessons (OAW) (56-64 hours)

Scope of OAW Training

Setup and Safe Operation of OAW Equipment

Lesson 1.0	Weld Joint Preparation: Weld joint surfaces and end preparation shall be prepared and cleaned prior to welding.
Lesson 1.1	Bead-on-Plate with/without rod & Corner Joint Weld.
Lesson 1.2	Plates, Tee Joint, Fillet Weld.
Lesson 1.3	Plates, Square-Groove, Open Root Butt Joint.
Lesson 1.4	Setup and Safe Operation of Oxyacetylene Flame Cutting Equipment. Cutting, Beveling, and Piercing of Plate and Pipe.
Lesson 1.5	Use and care of External Line up Clamps and Pipe Alignment Tools.
Lesson 1.6	Service Tee Connection Joint
Lesson 1.7	Pipe, 4" Diameter, Standard Bevel, Single-V, Open Root Butt Joint in the 2G and/or 5G Positions.
Lesson 1.8	Preheat, Interpass Temperature, and Postweld Heat Treatment (discussion)
Lesson 1.9	Pipe, 4" Diameter, Sleeve Weld, 5G

<u>1st Period Standards of Achievement</u>

Pass the comprehensive technical course exam and satisfactory completion of all in-shop practice lessons for this period.

Pass the following OAW qualification test to the API code:

(2-1/2 hours to complete)

4" diameter x 0.156" w.t. pipe, standard bevel, single-v open root butt joint, in the horizontal fixed position (5G).

4" diameter pipe, sleeve weld test, in the 5G positions.

¾" x 4 ½" long EH service nipple beveled on 4" diameter pipe, service tee-connection joint.

2^{nd} Period - 7 to 12 months step

The centralized training will cover the following items (40 hours):

In-Class Technical Courses (8-12 hours)

Course 2.0 Metals and Their Properties.

Course 2.1 The Shielded Metal-Arc Welding (SMAW) process.

Course 2.3 Introductions to Inline Offsets.

In-Shop Welding Practice Lessons (SMAW) (28-32 hours)

Scope of SMAW Training

Setup and Safe Operation of SMAW Equipment

Lesson 2.0 12" Diameter Pipe, Standard Bevel, single-V open root butt joint. Weld pipe with SMAW process using:

AWS E6010 electrode, downhill, in the horizontal fixed position.

2nd Period Standards of Achievement

Pass the comprehensive technical course exam and satisfactory completion of all in-shop practice lessons for this period.

Pass the following SMAW qualification test to the API code:

(2-1/2 hours to complete)

12" diameter 0.375" w.t. pipe, standard bevel, single-v open root butt joint using:

AWS E6010 electrode, downhill, in the horizontal fixed position.

3^{rd} Period - 13 to 18 months step

The centralized training will cover the following items (40 hours):

In-Class Technical Courses (8-12 hours)

Course 3.0 Principles of Tapping and Plugging Equipment.

Course 3.1 The Principles of and Welding Procedure for Branch.

Course 3.2 Introduction to Back-to-Back odd elbows.

Course 3.3 Introduction and demonstration to Rolling Offsets.

In-Shop Welding Practice Lessons (SMAW) (28-32 hours)

Lesson 3.0 Layout, cut, fit, and weld a 12" diameter branch, .375" w.t. using:

AWS E6010 electrode, downhill, in the horizontal fixed position.

3rd Period Standards of Achievement

Pass the comprehensive technical course exam and satisfactory completion of all in-shop practice lessons for this period.

Pass the following SMAW qualification test to the API code:

(8 hours to complete)

Full-size Branch connections joint – Layout, cut, fit, and weld a 12" Diameter 0.375" w.t. Branch. The weld will be made with the header pipe axis in the horizontal fixed position and the branch pipe axis extending vertically downward from the header, using:

AWS E6010 electrode, downhill, in the horizontal fixed position.

4th Period - 19 to 24 Months Step

The centralized training will cover the following items (40 hours):

In-Class Technical Courses (8-12 hours)

Course 4.0 The Principles of and Procedure for Hot and Cold Tie-ins

Course 4.1 Repairs to Pipelines by Patches, Repair Cans and Half Soles.

Course 4.2 Introduction to Rolled 90 degree Offsets.

In-Shop Welding Practice Lessons (SMAW) (28-32 hours)

Lesson 4.0 12" Diameter Pipe, Standard Bevel, single-V open root butt joint. Weld pipe with SMAW process using:

AWS E6010 electrode, downhill for the stringer & hot pass and AWS E7018 electrode, uphill for the fill & cap. In the horizontal fixed position.

4th Period Standard of Achievement

Pass the comprehensive technical course exam and satisfactory completion of all in-shop practice lessons for this period.

Pass the following SMAW qualification test to the API code:

(3 hours to complete)

12" diameter 0.375" w.t. pipe, standard bevel, single-v open root butt joint using:

AWS E6010 electrode, downhill for the stringer & hot pass and AWS E7018 electrode, uphill for the fill & cap. In the horizontal fixed position.

5th Period - 25 to 30 Months Step

The centralized training will cover the following items (40 hours):

In-Class Technical Courses (8-12 hours)

Course 5.0 Welding Quality Control

Course 5.1 Introduction to Fixed Point Offsets.

Course 5.2 Introduction to Compound Angles.

In-Shop Welding Practice Lessons

Lesson 5.0 Layout, cut, fit, and weld a 12" diameter branch, .375" w.t. using:

AWS E6010 electrode, downhill for the stringer & hot pass and AWS E7018 electrode, uphill for the fill & cap. In the horizontal fixed position.

5th Period Standards of Achievement

Pass the comprehensive technical course exam and satisfactory completion of all in-shop practice lessons for this period.

Pass the following SMAW qualification test to the API code:

(8 hours to complete)

Full-size Branch connection joint – Layout, cut, fit, and weld a 12" Diameter 0.375" w.t. Branch. The weld will be made with the header pipe axis in the horizontal fixed position and the branch pipe axis extending vertically downward from the header, using:

AWS E6010 electrode, downhill for the stringer & hot pass and AWS E7018 electrode, uphill for the fill & cap. In the horizontal fixed position.

6th Period - 31 to 36 Month Step

The centralized training will cover the following items (40 hours)

In-Class technical Courses (8-12 hours)

Course 6.0 The Gas Metal Arc Welding (GMAW) process.

Course 6.1 In-service welding. (discussion)

Course 6.2 Advanced Pipe Fitting.

In-Shop Welding Practice Lessons

Lesson 6.0 TEST **(OPTIONAL)** 12" Diameter Pipe, Standard Bevel, single-V open root butt joint. Weld pipe with GMAW process using:

AWS ER70S-6 electrode, CO^2 shield gas, downhill, in the horizontal fixed position.

Lesson 6.1 TEST **(OPTIONAL)** Layout, cut, fit, and weld a 12" diameter branch, .375" w.t. using:

AWS ER70S-6 electrode, CO^2 shield gas, downhill, in the horizontal fixed position.

Lesson 6.2 Advanced Pipe Fitting Module. Measure, calculate, cut, build and fit double angle offset when the two angles are in different planes.

6th Period Standards of Achievement

Pass the comprehensive technical course final exam and satisfactory completion of all in-shop practice lessons for this period.

TEST **(OPTIONAL)** Pass the following GMAW qualification tests to the API code:

(2 ½ hours to complete)

TEST **(OPTIONAL)** 12" diameter 0.375" w.t. pipe, standard bevel, single-v open root butt joint using:

AWS ER70S-6 electrode, CO^2 shield gas, downhill, in the horizontal fixed position.

(8 hours to complete)

(OPTIONAL) Full-size Branch connection joint – Layout, cut, fit, and weld a 12" Diameter 0.375" w.t. Branch. The weld will be made with the header pipe axis in the horizontal fixed position and the branch pipe axis extending vertically downward from the header, using:

AWS ER70S-6 electrode, CO2 shield gas, downhill, in the horizontal fixed position.

V. EVALUATION QUESTIONNAIRE OF TRAINING PROGRAM

For the purpose of providing a continuing meaningful, effective, and innovative apprenticeship program, meeting management and employee needs, the apprentice will fill out an anonymous questionnaire evaluating the training program.

OUTLINE OF IN-CLASS TECHNICAL COURSES

I. Introduction and Outline of Apprentice Training Program

1. Program Objectives

   To produce welders with the required basic technical knowledge, fundamental manipulative skills, and qualifications to make high quality field pipeline welds. This program will also produce welders with enough skill and knowledge to be of immediate value to the Company. By gaining field experience, they will be able to do work of greater difficulty and responsibility required of the Welder classification.

2. Approach to entire program

   The program will be 36-months long divided into 6 time periods. There will be 80 hours of training in the first time period and 40 hours of training in each of the remaining five time periods in a centralized training location. The apprentice will receive both in-class technical and in-shop manipulative training. After each week of training, the apprentice will return to their field headquarters for on-the-job training.

3. Centralized training school.

   A. Format for presentation of in-class technical course.

   B. Format for in-shop manipulative welding practice lessons.

   C. Required Standards of Achievement for each step period.

4. Format for on-the-job training and work experiences.

II. In-Class Technical Training

Course 1.0 Welding Introduction

Four basic welding categories:

1. Fusion Joining Processes (heated above the melting point, until there is a liquid to liquid melt) – SMAW, GMAW, SAW (double-jointing), OAW, FCAW, and GTAW.

2. Electrical – Resistance Welding Processes (heating is created by passing electric current (resistance to electric current flow), through the parts being joined at a concentrated area, above its melting point, followed by applied pressure) – Spot Welding.

3. Solid-Phase Bonding Processes (solid to solid bond without liquid filler metal with applied pressure) – Forge Welding. Prepared surfaces are in contact under predetermined time, pressure, and elevated temperature.

4. Liquid-Solid-Phase Joining Processes (closely fitting surfaces of the weld joint are heated but no melted, and adding a molten filler metal to form a solid joint) – Silver-Brazing and Braze –welding.

Three basic sources of heat generation:

1. Electrical heat generation – sustained electrical discharge over a gaseous path between two contacts. Electric Arc and Electric Resistance.

2. Chemical heat generation – heat evolved from a chemical reaction between gases or solids. Thermit process and Oxy-Acetylene Welding.

3. Mechanical heat generation – friction from rubbing two surfaces together under proper combination of speed and pressure. Friction Welding.

Thermal cutting processes:

1. Oxygen-acetylene gas.

2. Air-carbon arc.

3. Plasma Arc.

Fluxes, slages, and gases for shielding the molten metal from the air during the welding process.

1. Introduction – the atmosphere is composted of about four-fifths nitrogen and one-fifth oxygen. Most metals when exposed to air have a strong tendency to combine with oxygen and a lesser extent with nitrogen, especially in the molten condition. Oxide surface layers are weak, brittle, loose, and flaky, hindering the welding process.

2. Methods of oxidation prevention – shielding slages, fluxes, controlled atmosphere, vacuum, deoxidizers, and surface coating or plating protection.

<u>Course 1.1 The Oxyacetylene Welding Process</u> (OAW)

Safety information, precautions, and hazards

1. Handling, storing, and use of oxygen and acetylene gases and cylinders
   A. Film: "Oxyacetylene Safety"
2. Work area safety.
3. Personal protective equipment and clothing.
4. Adequate ventilation in confined spaces.
   A. Natural-draft ventilation.
   B. Forced-draft ventilation.
   C. Personal filter respirators or air-supplied masks.
5. Backfires and flashbacks – flashback arrestors on torch or regulators.

Oxyacetylene fusion welding of steel pipe.

1. PG&E Gas Standards and Specifications.
   A. D-20, Oxyacetylene Weld Procedure.
   B. D-30, Welder Qualification for Under 20% of SMYS.
   C. D-20, Oxyacetylene Weld Procedure.
2. Pipe welding techniques and fundamentals.
   A. Welding/Testing Positions for plate and pipe.
   B. Various Joint Designs, Types of Welds, Terms.
   C. Joint preparation (cleaning), alignment (fit-up), use of external line-up clamp, and tack welding.
   D. Forehand direction – away from the completed portion of the weld.
   E. Backhand direction – back against the completed portion of the weld.

3. Shielding the molten metal from oxidation during welding is accomplished by:

   Combustion of oxygen and acetylene at the welding tip creates an inner flame cone where there is the maximum heat generated, and the gases surrounding the area are concentrations of CO (carbon monoxide) and H2 (hydrogen) gases protect the molten weld puddle from oxidation.

Filler material specifications and what they mean.

1. AWS A5.2 is the specification for "Iron and Steel Gas Welding Rods." Three classifications based on mechanical properties and chemical analysis – Class RG45, RG60, and RG65.

2. Filler metal selection based on physical properties and chemical analysis of the piping material and the service requirements.

Advantages of OAW process

1. Control of weld zone temperature, filler – metal deposition rates, and weld shape – Joining thin sheet metal, thin wall tube, small pipe diameters, and assemblies with poor fit-up (heavy sections joined more economically with arc welding).

2. Equipment is versatile – Preheat, postheating, fusion welding, braze welding, razing, and cutting.

3. Low-cost and portable.

4. Most ferrous and non-ferrous metals can be gas welded.

<u>Course 1.2 Introduction to Weight calculation and Rigging Fundamentals</u>

1. Calculating the weight of steel pipe, plate, and shapes.

   A. Practice problem solving.

2. Calculating the volume inside of pipe and cylinders.

   A. Practice problem solving volume using height, width, and length.

   B. Practice problem solving volume using pipe volume charts.

3. Calculating the weight and fill rates of water in pipe.

   A: Practice problem solving.

4. Methods for finding the center-of-gravity.

    A. Calculating weight and length to find the center-of-gravity.

    B. Measuring to find the center-of-gravity.

5. Slings

    A. Sling types – chocker, bridle, basket, etc.

    B. Hooks and shackles – a means of hauling or lifting loads.

    C. Safe working loads for slings – lifting capacity (tags)

    D. Inspecting slings for safety.

6. Wire rope, chain hoist, fiber ropes.

    A. Strength of different rope materials.

    B. Safety factor and safe working loads.

    C. Care, storage, and inspection.

7. Hoist signals

    A. APR – Code of Safe Practices

<u>Course 1.3 Introduction to Right Angles.</u>

1. Three sides of a right triangle.

    A. Locating side opposite, side adjacent, and hypotenuse.

    B. All three angle of a right triangle equal 180 degrees.

    C. Finding all sides of a triangle using Pythagorean Theorem.

2. Finding Angles

    A. Find all angles of a triangle using trig. Functions, SIN, COS, TAN.

    B. Find an unknown side using trig. functions with one known angle and one known side.

    C. Practice problem solving for right triangles.

3. Odd angle elbows.

   A. Measure and calculate an odd angle out of a 90-degree elbow.

   B. Calculate an odd angle from a random degree elbow.

   C. Calculate the gain of any angle elbow.

Course 2.0 Metals and Their Properties

1. Various Methods of steel pipe manufacturing.

   A. Continuous butt-welded.

   B. Electric-resistance welded.

   C. Electric arc fusion butt-welded.

   D. Spiral welded.

   E. General view of the seamless steel pipe manufacturing operation. Piercing process – a piercing mandrel is forced into an advancing solid round heated bar or billet of proper length and diameter to make the desired size pipe.

2. American Petroleum Institute Specification for steel pipe.

   A. API Specification 5L for Line Pipe, Grade A and B.

   B. API Specification 5L for High-Test Line Pipe, X42 to X70.

3. Classification and discussion of different carbon steels based upon the carbon content.

   A. Increasing carbon content leads to marked increases in hardness and strength with lowered ductility.

   B. Carbon steels – mixture of iron and carbon with small additions of manganese, sulfur, and phosphorus.

      - Low-carbon, to 0.30% carbon.
      - Medium-carbon, 0.30 to 0.45% carbon.
      - High-carbon, more than 0.45% carbon.

   C. High-strength low-alloy steels – improvements to the properties of basic carbon steel by small additions of alloying elements such as nickel, chromium, molybdenum, vanadium, titanium, etc. depending on the specific mechanical property requirements.

4. Properties of metals.

   A. Why are mechanical, physical, and corrosion properties so important? Metal properties are important for material selection and determining service usefulness.

   B. Mechanical properties to be familiar with – using a typical tensile stress-strain diagram for steel we have:

      - Ultimate strength – maximum stress developed by the material based on the original cross-sectional area.

      - Yield strength – is the stress at which the material exhibits a permanent deformation.

      - Proportional limit – the range in which a metal is strained under load and then returns to its original size and shape when unloaded.

      - Fracture appearance (ductile or brittle) – metal fracture is classified into two general categories, 1) ductile and 2) brittle (% of Elongation and % of Area Reduction).

   C. Mechanical property tests.

      - Tensile Strength – a metal's ability to resist change in shape and size when an external pulling force is applied (compressive and shear).

      - Hardness survey from macro-section – measures the resistance to penetration.

      - Guided-bend (ductility) – determines soundness, penetration, and fusion in the weld metal. It also measures the ductility.

      - Charpy V-notch impact (fracture toughness) – to determine the ability of the metal to withstand a sharp high velocity blow.

   D. Physical properties to be familiar with:

      - Density (specific gravity) is the weight in pounds of 1 cubic inch of a metal.

      - Thermal conductivity is the rate of which heat is transmitted through a material by conduction.

      - Melting point or range is an indication of the strength of bonds between atoms, a stronger bond, and a higher melting point.

      - Coefficient of thermal expansion is defined as the expansion and contraction of different substances over a range of temperatures.

5. Shortcomings of iron and why we add alloying elements to form steel.

A. Iron oxidizes at a fairly rapid rate by rusting and scaling even in a mildly corrosive media – alloying elements can substantially improve the corrosion resistance of iron.

B. Iron's mechanical properties can be improved by adding carbon for increased hardness.

C. Alloying elements in steel and their general effects: Carbon, Manganese, Phosphorus, Sulfur, Silicon, Chromium, Nickel, Molybdenum, Columbium, Titanium, Vanadium, Aluminum, Boron, Nitrogen, and Lead.

Course 2.1 The Shielded Metal-Arc Welding (SMAW) Process

1. Safety information, precautions, and hazards.

A. Protection from electrical shocks.

B. "Resuscitation Manual – A Guide for Electric Utility companies," May 1979, Edison Electric Institute. Treatment of electrical injuries (shock and burns).

C. Protective equipment and clothing to minimize or eliminate the effects of arc sparks, slag, ultraviolet, visible, infrared, and heat radiation – welding hood, correct lens shade, and leather protective cloths.

D. Health hazards from the inhalation of chemical and physical substances in the welding environment.

- Introduction: Increased awareness and a demand of those in industry for a safe and health working environment – welding pollutants from the different welding processes, base metals, and consumables are unavoidable and should be the concern of both employers and employees.
- Classifying these pollutants by their potential toxicity levels – and the source of these pollutants. Exposure limits and their effects on the human body.

2. Basic Shielded Metal – Arc Welding Circuit

A. What is an arc? – An arc is an electric current flowing between the electrode and the work through an ionized column of gas. This causes a change of electrical energy into heat.

B. Direct Current Straight (electrode negative) and Reverse (electrode positive) Polarities.

C. Ohm (resistance), Ampere (current or rate of electrode melt off), and Voltage (arc length).

D. Welding electrode holder, cable, ground clamps, and welding machine.

3. Power supplies.

   A. Selection factors – available power, available floor space, initial cost, location of operation (in a plant or in the field), maintenance of machines, versatility, required output, duty cycle, efficiency, and types of electrodes to be used.

   B. Constant-current output (drooping volt-ampere curve required for SMAW).

   C. Engine-driven generators are direct current power sources, all other welding power starts out as alternating current.

   D. Principal characteristics and advantages of DC to AC current and vice versa.

4. Shielded Metal – Arc Welding of Steel Pipe

   A. PG&E's Gas Standards and Specifications.

      - D-22, Arc Welding Procedure – All stress levels.

      - D-30.2, Arc Welder Qualification for Over 20% of SMYS.

   B. Vertical – down pipe welding techniques and fundamentals – this method is proven fast and economical (max. wall thickness limit) for welding cross-country pipelines.

   C. Joint design – open root single-v butt-weld bevel angle, root face, and root opening.

   D. Welding positions (2G, 5G, and 6G).

   E. Joint preparation, fit-up, and tack welding – cleaning, use of external line-up clamps, and striking the arc.

   F. Electrode selection and diameter size.

   G. Welding current, arc length, and travel speeds – will depend upon root opening, wall thickness, length of pipe, and the appearance of the molten weld puddle.

   H. Welding and bead sequence – will depend on joint design and deposition rate of filler metal used.

   I. Electrode angle and manipulation – affects the welding heat and bead shape at different location around the pipe.

   J. Root-pass (stringer bead) – penetration and keyhole size using a "drag technique."

   K. Interpass cleaning – power wire brushing and disc grinding.

   L. Hot-pass (second pass) – melting out of wagon tracks, within 5 minutes of stringer bead.

M. Filler, stripper, and cap passes.

N. Pipe welding techniques and fundamentals for root, hot pass (E6010) vertical – down and fill passes (E7018) vertical –up for 2G and 5G positions.

5. Filler material specification what they mean.

   A. Classification system for carbon and low-alloy steel covered arc-welding electrode (AWS E-XXXX-XX).

      - Initial letter (E R, or B/ ER & RB) of a filler metal designation indicates basic process categories. Four or five digit numbers prefixed with the letters.

      - First two or three numerals indicate minimum tensile strength, E-60XX or E-120XX-X.

      - Next to last numeral indicates the position in which the electrode is to be used, E-601X.

      - Last numeral indicates the recommended power supply, flux covering on electrode, type of arc characteristics, degree of penetration and whether or not the electrode contains iron powder in the coating, E-6010.

      - Suffixes after the last numeral designate the additional chemical compositions of the electrode classification, E8018-B3.

   B. Filler metal selection based on physical properties and chemical analysis on the pipe material and the service requirements.

   C. AWS A5.1 is the specification for "Mild Steel Covered Arc-Welding Electrodes."

      - Characteristics, mechanical, and chemical requirements of some pipeline welding electrodes: AWS E6010 and E7018.

   D. AWS A5.5 is the specification for "Low-Alloy Steel Covered Arc-Welding Electrode."

      - Characteristics, mechanical/chemical requirements of some pipeline welding electrodes: AWS E7010, E8010, and E8018.

   E. Function of electrode covering materials.

      - Arc stabilizer, deposition rate, depth of penetration, shape of deposit, and surface smoothness.

      - Materials for generating protective shielding gases.

      - Ingredients for fluxing agents and slag formers.

- Powdered metals and alloys (deoxidizers and alloying additions).

F. Proper handling, treatment, and storage for:

- Cellulose type electrodes, EXX10.
- Low-hydrogen type electrodes, EXX18.

6. Advantages and disadvantages of the SMAW process.

A. Most versatile and widely used welding process.

B. Least complex, costly, and the equipment most portable of all other arc welding processes.

C. Joint quality and strength can be easily controlled.

D. Metals welded most easily are carbon and low-alloy steels, stainless steels, and heat-resisting alloys.

E. Lacks high-metal deposition-rate and deposition efficiency as compared to GMAW and SAW (electrode change after each length is consumed).

F. Requires slag removal between passes.

Course 2.3 Introduction to Inline Offsets

1. Calculate the angle and travel for a parallel offset.

A. Find the angle of offset using set and run measurements.

B. Find the travel using the set and run measurements.

C. Find the travel can length.

D. Practice problem solving.

2. Calculate the angles and travel for a non-parallel offset.

A. Find both angles of offset, one being greater than the other.

B. Find the travel between angle points.

C. Find the travel can length with two different angles.

D. Practice problem solving.

3. Introduction to roll lines.

    A. Show roll lines on actual pipe.

    B. Show how roll lines are in one plane for inline offsets.

    C. Angle points are the intersect points of roll lines.

<u>Course 3.0 Principles and Operation of Tapping and Plugging Equipment</u>

The Welding of Mueller and T.D.W. Fittings. The Use and Care of Muller Small Diameter Tapping (3/4", 1-1/4", and 2" Dia.) and Plugging Equipment.

1. Divert, repair, or replacement of pipeline without interruption of flow. The obvious technique is to cut off the flow, purge the lines of gas, install new section, and recommission line. The other alternative is performing the operation with the gas still flowing through, using the "hot-tapping" technique.

    A. Outline of the typical operation and function; using both the T.D.W. and Mueller tapping and plugging equipment.

    B. Pressure Control Fittings (C-15.2 to 16.5): Use and care of Mueller tapping machines, 2" O.D. pipe or less, screwed and 3" O.D. or greater, flanged.

    C. Welding procedure used for the T.D.W. and Mueller fittings

2. The Use and Care of Mueller small diameter (3/4", 1-1/4", and 2" Dia.) tapping and plugging equipment.

    A. Outline of typical operation and function of small diameter Service Tee and Save-A-Valve nipples.

    B. Welding procedure and technique used for small diameter fittings.

<u>Course 3.1 Introduction for Back-to-Back Elbows.</u>

1. Calculate angles required for back-to-back elbows using a fixed set.

    A. Practice problem solving.

<u>Course 3.2 Introduction and Demo for rolling offsets</u>

1. Calculate the angles and travel for a rolling offset.

    A. Find the rolled set using set and run measurements.

    B. Find the angles and travel using the rolled set and run.

C. Find the travel can length.

D. Find the roll lines using the rolled angle.

2. Demonstrate a rolling offset. (Hands On)

A. Show how to find roll lines.

B. Show how to measure set and run.

Course 4.0 The Principles of and Welding Procedure for Branch Connections

1. (Hot Tap Tee) with Reinforcement Pad or Full-encirclement Weld Sleeve. (Discussion).

2. Welding procedure for a branch connection. (G.S.S.)

Course 4.1 The Principles of and Procedure for Hot and Cold Tie-ins

1. The advantages and disadvantages between a HOT tie-in and a COLD tie-in.

2. Welding Procedure for Full-encirclement Weld Sleeve. (G.S.S.)

Course 4.2 Repairs to Pipelines by Patches, Repair Cans, and Half Soles.

1. Discussion about different repairs that can be made on pipelines running under 20% of SYMS.

2. Discussion about different repairs that can be made on pipelines running over 20% of SYMS.

3. Welding procedure for main repair. (G.S.S.)

Course 4.3 Introduction to Rolled 90-Degree Offsets.

1. Calculate a rolled 90-degree offset less than the gain of one 90-degree elbow.

A. Find the angle of roll using a fixed set.

B. Find the total advance of the offset.

C. Practice problem solving.

2. Calculate a rolled 90-degree offset more than the gain of a 90-degree but less than two.

A. Find the angle of roll using a fixed set.

B. Find the total advance of the offset.

C. Practice problem solving.

Course 5.0 Welding Quality Control

Quality Control

1. The codes and requirements that govern the welding of pipe in PG&E's Gas Construction Department.

   A. CPUC, General Order No. 112-E.

   B. American Petroleum Institute, API 1104 (Latest Edition), Standard for Welding Pipe Lines and Related Facilities.

   C. PG&E's Gas Standards and Specifications, requirements on construction materials and procedures to be used throughout the Gas Department.

   D. Manufacturer's recommended guidelines for the use of their products.

2. How is a Welding Procedure Developed?

   A. Research, past experiences, educated guess, and trial and error.

   B. Written welding procedure specifications.

   C. Essential variables.

3. What is a Welding Procedure Qualification test to API 1104?

   A. Destructive testing – cut location, type and number of test specimens, specimen preparation, test methods, and acceptance requirements.

   B. Records.

4. What is the Welder Performance Qualification test to API 1104, ASME, and AWS Codes?

   A. Single/Multiple Qualification.

   B. Essential Variables.

   C. Visual Examination and Destructive or Radiographic test.

   D. Requalification and Records.

5. The role of inspection (Quality Assurance before, during, and after).

   A. Visual inspection.

   B. Radiographic inspection.

   C. Hydrostatic testing.

   D. Skilled and qualified welders.

   E. Other Nondestructive tests – Magnetic particle, Dye-penetrant, and Ultrasonic examination.

Welding caused difficulties and defects.

Introduction – There are no perfect welds. Some imperfection can always be found. NDT specialist term imperfections as discontinuities – variation in the normal average properties of the material. Discontinuities are defects when found to be damaging to the performance of the material or weldment, according to codes and standards. In making any weld, limit imperfections to harmless discontinuities.

1. Problems arising in the welding process.

   A. Arc strikes and starting porosity.

   B. Inadequate joint penetration and incomplete fusion (root, interpass, and side-wall).

   C. Absorption of gases by molten metal (oxygen, nitrogen, and hydrogen).

   D. Surface contaminants.

   E. Tack welding.

2. Difficulties during welding (manipulation).

   A. Slag inclusions and wagon tracks.

   B. Undercut.

   C. Excessive weld spatter.

   D. Overlapping (cold-lap).

   E. Burn-through and excessive penetration.

   F. Magnetic arc-blow.

   G. Improper moisture content in electrodes.

H. Fingernailing of electrode tip.

I. Protection against environment (enclosure).

3. Difficulties during cooling.

A. Solidification shrinkage cracks.

B. Blowholes (worm holes) and subsurface porosity.

C. Crater cracking – longitudinal and transverse cracking.

D. Root (stringer bead) cracking.

E. Fusion line and underbead cracking.

F. Cracking from hydrogen.

G. Cold cracking/ Hot cracking.

4. Minimize and control of welding distortion.

Introduction – A frequent problem in fabricating weldments is to be certain that the finished article conforms to the required dimensions. The inaccuracies in dimension or form is unavoidable because of localized heating by the welding process, but they can be minimized.

A. Terms and Definitions –

- Shrinkage – weld metals shrinkages upon solidification, but this has little to do with the distortion problem in weldments. Some dishing or deformation of the weld face of the weld metal upon solidification but it can not generate stresses capable of decreasing the overall size or pull a portion of the weldment out of shape.

- Contraction – contraction of solid metal during cooling can generate stress equal to or less than the yield strength of the weld metal at the particular temperature.

- Distortion – is the deviation from a desired form. Distortion occurs as a result of welding from localized thermal expansion and contraction. If the magnitude of these welding stresses exceeds the member's yield strength, permanent dimensional change and/or a distortion will result. In some situations, strain occurs in the elastic range and stresses are contained internally within an undistorted weldment.

- Residual stress – is the internal stress remaining in the weldment after the joining operation, having been generated by localized heating and cooling. These residual stresses within the elastic range are balanced in the overall weldment.

B. Shrinkage of weldments.

- Shrinkage transverse to a butt weld (perpendicular to long axis of weld) – cumulative shrinkage of several circumferential butt welds could be enough to shorten the longitudinal dimension. The amount of shrinkage will depend on the cross-sectional area of the weld metal deposited.

- Shrinkage longitudinal to a butt weld (parallel to weld axis) – longitudinal shrinkage is also a function of the cross-sectional area of the weld metal and the cooler surrounding base metal. This parallel shrinkage tends to reduce the diameter of the pipe.

- Distortion of weldments – the distortion problem starts at the localized area along the path of the arc, thus distortion in varying degrees occur in all weldments.

- Angular distortion – angular distortion for single-bevel plate butt welds and T-sections from welding is the angular change of members extending from a weld area.

- Longitudinal bowing – longitudinal bowing of long members are caused by shrinkage forces from welding on one side of the neutral axis of the member.

- Buckling and twisting – this sheets often buckle and twist because of low-torsional resistance.

C. Methods to control and minimize distortion

- Avoid overwelding (minimum amount of weld metal deposited to gain desired strength).

- Avoid narrow root and wide face joint profile.

- Deposit weld metal in the fewest possible number of passes (use a high-deposition rate process), few passes with large electrode.

- Alterations to the essential variables of a qualified welding procedure may decrease or increase the distortion.

- Balance welding around the neutral axis of the weldment.

- Intermittent and staggered welding.

- Skip welding sequence.

- Copper backing bars.

- Use of clamps, jigs, fixtures, and strongbacks to maintain fitup and alignment.

- Preheat, postheat treatment, and interpass temperatures (uniform heating and cooling reduces quench rate).
- Thermal flame straightening (localized).
- Minimize welding time; less heat input (optimum welding speed with maximum penetration).

Course 5.1 Introduction to Fixed Point Offsets.

1. Calculate a fixed point offset using a fixed set and a fixed run.

   A. Find the angle of offset using set and run.

   B. Find the new run.

   C. Find the travel and travel can using the set and new run.

   D. Practice problem solving.

Course 5.2 Introduction to Compound Angles.

1. Calculate a compound angle using angle of turn and angle of rise.

   A. Practice problem solving.

Course 6.0 The Gas Metal Arc Welding Process. (GMAW)

1. Safety information, precautions, and hazards.

   A. Protection from electrical shocks.

   B. Protective equipment and clothing to minimize or eliminate the effects of arc sparks, slag, ultraviolet, visible, infrared, and heat radiation – welding hood, correct lens shade, and leather protective cloths.

   C. Health hazards from the inhalation of chemical and physical substances in the welding environment.

      - Introduction: Increased awareness and a demand of those in industry for a safe and health working environment – welding pollutants from the different welding processes, base metals, and consumables are unavoidable and should be the concern of both employers and employees.
      - Classifying these pollutants by their potential toxicity levels – and the source of these pollutants. Exposure limits and their effects on the human body.

2. Power supplies.

   A. Selection factors – available power, available floor space, initial cost, location of operation (in a plant or in the field), maintenance of machines, versatility, required output, duty cycle, efficiency, and types of electrodes to be used.

   B. Constant-voltage output verse constant-current output.

   C. Engine-driven generators are direct current power sources; all other welding power starts out as alternating current.

3. Filler material.

   A. Solid wire. A solid wire combined with an externally supplied gas shielding to protect from contaminants. (GMAW)

   B. Flux core. The flux core arc welding process involves a self-shielding weld for the MIG welding process. The wire is fabricated with flux in the core. (FCAW)

   C. Dual shield. The dual shield welding process involves welding with a fabricated electrode in an atmosphere of carbon dioxide or a mixture of carbon dioxide and argon. In addition to the externally supplied gas.

4. Gas Metal Arc Welding of Steel Pipe.

   A. Vertical – down pipe welding techniques and fundamentals – this method is proven fast and economical (max. wall thickness limit) for welding cross-country pipelines.

   B. Joint design – open root single-v butt-weld bevel angle, root face, and root opening.

   C. Welding positions (2G, 5G, and 6G).

   D. Joint preparation, fit-up, and tack welding – cleaning, use of external line-up clamps.

   E. Electrode selection and diameter size.

   F. Welding voltage, stick out, and travel speeds – will depend upon root opening, wall thickness, and the appearance of the molten weld puddle.

   G. Welding and bead sequence – will depend on joint design and deposition rate of filler metal used.

   H. Electrode angle and manipulation – affects the welding heat and bead shape at different location around the pipe.

   I. Root-pass (stringer bead) – penetration and keyhole size.

   J. Interpass cleaning – power wire brushing and disc grinding.

   K. Filler, stripper, and cap passes.

5. Advantages and Disadvantages of the GMAW process.

   A. Commonly used high deposition rate welding process.

   B. Wire is continuously fed from a spool and is therefore referred to as a semiautomatic welding process.

   C. The ability to weld a larger gap on an open root butt-weld than SMAW.

   D. More costly and complex than SMAW.

   E. The external gas shielding is very sensitive to wind and can cause weld defects easily. (Porosity, etc.)

<u>Course 6.1 In-Service welding</u>

Introduction to In-Service pipeline welding. In-Service welding is the recommended welding practice for making repair to or installing fittings on pipelines and piping systems that are in service. In-service pipelines and piping systems are defined as those that contain crude petroleum, petroleum products, or fuel gases that may be pressurized and/or flowing. (REF G.S.S. D-23 In-service welding and D-30.4 Welder Qualification)

1. Three Hydrogen Levels of the welding process to be selected for In-Service welding procedures.

   A. ($\leq$ 4 ml./100 gm.) is for applications where low-hydrogen electrodes or the GMAW process will be used and the conditions are favorable in terms of moisture and contamination on the consumables and on the pipe and fitting surfaces.

   B. ($\leq$ 8 ml./100 gm.) is for applications where low-hydrogen electrodes cannot be cared for, such as where electrode holding ovens are not available, or where conditions are unfavorable in terms of moisture and contamination.

   C. (40-60 ml./100 gm.) is for applications where cellulosic-coated electrodes are to be used.

2. Pipe Wall Thickness.

   A. Pipe wall thickness is very influential on the weld-cooling rate.

   B. Pipe wall less than .250" should be independently evaluated for the risk of burn through.

3. Thermal Severity Level.

   A. For pipe wall $\leq$ 0.5" thick the thermal severity must be determined. There are two methods of determining thermal severity, one is the methane flow rate and the other is the heat sink capacity method.

B. There are two categories for thermal severity, category I (high thermal severity), and category II (low thermal severity).

4. Pipe Material Chemical Composition.

   A. There are two required parameters that need to be measured, that is the % of carbon and the carbon equivalent.

   B. The procedure selection should be made on the least favorable of the materials being welded. (The pipe material or the fitting material, whichever has the highest carbon equivalent)

5. Welding Heat Input.

   A. Run-Out-Ratio equals length of weld deposited divided by length of electrode burned.

   B. Heat Input (kJ/inch)/min. equals (amps times volts times 60) all divided by (travel speed (inch/min.) times 1000)

<u>Course 6.2 Advanced Pipe Fitting</u>

1. Calculating multiple angles in different planes.

   A. Find the angle needed using various measurements.

   B. Find the travel cans needed.

   C. Calculate the total cross measurement between welds.

   D. Find cut marks for tie-in welds.

OUTLINE OF IN-SHOP WELDING PRACTICE LESSONS

I. Scope of Oxyacetylene Training

Setup and Operation of OAW Equipment

1. Setup, operation, and safe practices in welding, cutting, and heating equipment.

   A. Oxyacetylene apparatus/description, function, and setup of: gas cylinders, oxygen and acetylene pressure regulators, welding hoses, welding, torch handle, cutting attachment, cutting tips, welding tips, multi-flame heating nozzle, turning on cylinders, and gas pressures.

   B. Lighting the torch and adjusting the flame.

   C. Lighting and extinguishing the torch.

   D. Three types of welding flames – reducing, neutral, and oxidizing.

   E. Cone shape, color, sound, torch adjustment, gas pressure, and temperature for the different welding flames.

   F. Temporarily stopping work.

   G. Close cylinders.

   H. Bleed (relieve) gas pressure from hoses.

   I. Stopping work.

   J. Disconnect pressure – reducing regulators.

   K. Replace safety cap on cylinder.

II. In-Shop Lessons and Demonstrations for OAW

Lesson 1.0 Cleaning and Preparation of Weld Joint

1. Demonstrate grinding and buffing of weld joint.

Lesson 1.1 Bead-on-Plate

1. Bead-on-flat-plate without burn through, without rod.

2. Corner joint weld without rod in the flat position.

3. Bead-on-plate with welding rod.

4. Forehand technique in flat (1G) position.

5. Slight-weave-on-plate with rod.

6. Forehand technique in 1G position.

Lesson 1.2 Plate, Fillet Weld

1. Fillet weld, 1/8" thick plate, single pass in the 2F, 3F, and 4F positions.

Lesson 1.3 Plates, Square-Groove, Open Root Butt Joint

1. Butt weld with 1/8" thick plate in the 2G, 3G, and 4G positions.

Lesson 1.4 Setup and Safe Operation Oxyacetylene Flame cutting Equipment. Cutting, Beveling, and Piercing of Plate and Pipe

1. Setting-up cutting equipment including proper size cutting tip.

2. Inspect all setting surfaces and "0" rings.

3. Connect cutting attachment to welding torch.

4. Light and adjust the preheat and cutting flame.

5. Principal and technique of cutting and beveling operation.

6. Quality cuts.

7. Manual plate and pipe, cutting and beveling.

Lesson 1.5 Use and care of External Line up Clamps and Pipe Alignment tools.

1. Discussion and hands-on demonstration.

Lesson 1.6 Service Tee-Connection Joint (D-30 and C-10-14)

1. ¾ inch nipple fillet welded to a 4-inch diameter pipe.

Lesson 1.7 Pipe, 4" Diameter, Standard Pipe Bevel, Single-V Open Root Butt Joint

1. 2G position (vertical axis fixed) using the forehand method.

2. 5G position (horizontal axis fixed), uphill, using the forehand method.

Lesson 1.8 Preheating, Interpass Temperature, and Postweld Heat Treatment

1. Preheating (vary from 100-200 degrees) – prevent cold cracking, reduce residual stresses, improve notch toughness, and prevent cold cracking from welding at low ambient temperatures.

2. Interpass temperature (for multi-0layered welds) – influence quench rate (susceptibility to cracking), residual stress, distortion, and grain size. Usually the minimum interpass temperature will correspond with the minimum preheat temperature.

3. Postweld stress – relief heat treatment – heating (below critical range 900-1250 degrees) holding (one hour per inch of thickness), and cooling done slowly and uniformly to relieve stresses, improve toughness, increase strength, improve corrosion resistance, and remove cold work.

Lesson 1.9 Pipe, 4" Diameter Sleeve Weld

1. 5G position, uphill, using the Forehand method.

III. Scope of SMAW Training

Setup and Operation of SMAW Equipment

1. Safe practices and precautions.

   A. SMAW equipment description, function, and setup of: power supply, welding leads, current control, ground clamp, and electrode holder.

   B. Personal protective equipment including eye protection and light filter.

   C. Demonstration and adjustment of welding machine.

Lesson 2.0 12" Diameter Pipe, Standard Bevel, single-V open root butt joint.

1. AWS E6010 electrode, downhill, in the horizontal fixed position.

2. Striking, maintaining, and breaking an arc, AWS E6010.

3. First pass, Stringer bead using a drag technique and practice inward and downward force.

4. Second pass, Hot-pass using a flagging motion to create a hotter weld puddle to melt out wagon tracks created by stringer bead.

5. Filler pass, Fill V-groove using an oscillating motion staying on front edge of weld puddle to prevent slag inclusions. (May require more than one pass.)

6. Final pass, Cover pass or cap using a side-to-side oscillating motion. Cover pass should have adequate weld reinforcement to be above apparent material and have no under cutting along the edges.

<u>Lesson 3.0 Layout, cut, fit, and weld a 12″ diameter branch, .375 w.t.</u>

1. AWS E6010 electrode, downhill, in the horizontal fixed position.

2. Layout of fish mouth, cutting, and grinding for proper fit up of a 12 inch by 12 inch branch connection

3. Welding bead sequence and bead placement with the header pipe in the horizontal fixed position and the branch pipe extending vertically downward from the header.

4. Multiple cover passes, Cover passes should be uniform in appearance and have 50% overlay form one bead to the other with no external under cutting.

<u>Lesson 4.0 12″ Diameter Pipe, Standard Bevel, single-V open root butt joint.</u>

1. AWS E6010 electrode, downhill for the stringer bead & hot pass and AWS E7018 electrode, uphill for the fillers & cap. In the horizontal fixed position.

2. Striking, maintaining, and breaking an arc, AWS E7018.

3. First pass, Stringer bead using a drag technique downhill with AWS E6010 electrode

4. Second pass, Hot-pass using a flagging motion to create a hotter weld puddle to melt out wagon tracks created by stringer bead. Use AWS E6010 downhill for this process.

5. Filler pass, Fill V-groove using side-to-side motion staying on front edge of weld puddle to prevent slag inclusions. This pass(es) is welded uphill using AWS E7018 electrode. (May require more than one pass.)

6. Final pass, Cover pass or cap using a side-to-side motion. Cover pass should have adequate weld reinforcement to be above apparent material and have no under cutting along the edges. This pass is welded uphill using AWS E7018 electrode.

<u>Lesson 5.0 Layout, cut, fit, and weld a 12″ diameter branch, .375″ w.t.</u>

1. AWS E6010 electrode, downhill for the stringer bead & hot pass and AWS E7018 electrode, uphill for the fillers & cap. In the horizontal fixed position.

2. Layout of fish mouth, cutting, and grinding for proper fit up of a 12 inch by 12 inch branch connection

3. Welding bead sequence and bead placement with the header pipe in the horizontal fixed position and the branch pipe extending vertically downward from the header.

4. First pass, Stringer bead using a drag technique downhill with AWS E6010 electrode.

5. Second pass, Hot-pass using a flagging motion to create a hotter weld puddle to melt out wagon tracks created by stringer bead. Use AWS E6010 downhill for this process.

6. Filler passes, Fill weld groove using side-to-side motion staying on front edge of weld puddle to prevent slag inclusions. These passes are welded uphill using AWS E7018 electrode.

7. Multiple cover passes, Cover passes should be uniform in appearance and have 50% overlay form one bead to the other with no external under cutting. This pass is welded uphill using AWS E7018 electrode.

Lesson 6.0 (OPTIONAL) 12″ Diameter Pipe, Standard Bevel, single-V open root butt joint.

1. AWS ER70S-6 electrode, CO^2 shield gas, downhill, in the horizontal fixed position.

2. First pass, the stringer bead is a downhill process keeping the electrode on the front edge of the weld puddle.

3. Filler pass, Fill V-groove using a side-to-side motion staying on the front edge of weld puddle to prevent cold rolling of the weld metal. (May require more than one pass.)

4. Final pass, Cover pass or cap using a side-to-side oscillating motion. Cover pass should have adequate weld reinforcement to be above apparent material and have no under cutting along the edges.

Lesson 6.1 (OPTIONAL) Layout, cut, fit, and weld a 12″ diameter branch, .375″ w.t.

1. AWS ER70S-6 electrode, downhill, in the horizontal fixed position.

2. Layout of fish mouth, cutting, and grinding for proper fit up of a 12 inch by 12 inch branch connection

3. Welding bead sequence and bead placement with the header pipe in the horizontal fixed position and the branch pipe extending vertically downward from the header.

4. Multiple cover passes, Cover passes should be uniform in appearance and have 50% overlay form one bead to the other with no external under cutting.

Lesson 6.2 Advanced Pipe Fitting Module. Measure, calculate, cut, build and fit double angle offset when the two angles are in different planes.

1. Locate roll lines, measure the set and run, and calculate the rolled set, the travel, and the angles required.

2. Layout and cut the odd elbows for the angles of interest. Layout and cut the travel can.
3. Build the offset with the elbows & travel can; locate the roll lines on the offset.
4. Cut-in the offset and weld the tie-in weld points.