Educator Conference Agenda

• 9:00 – 9:30  Welcome / Introductions
  Duncan Estep

• 9:30 – 10:00  Weld-Ed Overview
  Monica Pfarr

Discussion is centered on the National Center for Welding Education and Training (Weld-Ed) and its contributions to the field of welding education. Changes in the focus of the NSF grant.

• 10:00-11:40  Educators Professional Development Modules
  Mark Baugh- Dan Turner- Rick Polanin- Joel Johnson-Tim Baber

This session provides information about the professional development opportunities offered by Weld-Ed. This includes face-to-face training programs with hands on experience in welding. Weld-Ed also offers customized training catered to the needs of the educators.

• Overview  Duncan Estep
• Module 1 Welding Metallurgy  Mark Baugh
• Module 2 Joining and Cutting Processes  Dan Turner
• Module 3 Design, Assembly & Robot Welding  Rick Polanin
• Module 4 Codes, Standards & Safety  Joel Johnson
• Module 5 Laser Welding  Tim Baber
• Module 6 Teaching Strategies & Instructional Design  Rick Polanin
• 11:40-12:20    Lunch, sponsored by Hypertherm (room ?)    Jim Colt

• 12:30-2:30    Welding Equipment Manufacturers Sessions    Introduction

• These sessions provide information about the latest offerings from welding equipment manufacturers to enhance welding education.

• 12:30 – 1:10    Lincoln Electric    Jason Schmidt

• 1:10 – 1:50    Miller    Steve Hidden

• 1:50 – 2:30    ESAB & Victor Technologies    Dwight Myers

• 2:30 – 3:00    Wrap-Up/Evaluations    Duncan Estep

• Join Weld-Ed in our quest to build a solid foundation of highly trained technicians to fulfill the demand of industry.
Weld-Ed Overview

FABTECH International & AWS Welding Show 2014

Presented by
Monica Pfarr
Principal Investigator
Weld-Ed
National Center For Welding Education and Training
Weld-Ed Professional Development Modules
Overview

FABTECH International & AWS Welding Show 2014

Presented by
Duncan Estep
Director
Weld-Ed
National Center for Welding Education and Training
Implementing Module 1 (Welding Metallurgy) Content into Welding Technology Classes

FABTECH International & AWS Welding Show 2014

Presented by
Mark Baugh
Professor & Program Advisor
Welding Engineering Technology
Weber State University
mbaughr@weber.edu
Implementing Weld-Ed Module 1 Content

Learning outcomes from Module 1 Welding Metallurgy will help students understand:

1. How to identify different types of metals
2. How the metals were made affects their properties and weldability
3. How the welding process will change the microstructure and the properties of the metals they weld on
4. How to determine the best welding procedures for any metal
Many Welding Code requirements have Metallurgical reasons behind their use
Implementing Weld-Ed Module 1 Content

Understanding the reasons behind code requirements makes welders more likely to follow code welding procedures.
Implementing Weld-Ed Module 1 Content

Weld Hydrogen Lab

What are the metallurgical reasons behind code requirements for:

- Low hydrogen welding processes
- Low Hydrogen electrodes
- Proper storage of electrodes
- Limited exposure time for electrodes
- Re-baking of electrodes
- Use of Pre-heat

http://www.rodovens.com/welding_articles/storage_electrodes.htm
Implementing Weld-Ed Module 1 Content

Weld Hydrogen Lab

Module 1
Lab Exercise 7

Title: Hydrogen Diffusion Lab

Objectives:
1. Demonstrate the metals solubility of hydrogen and porous properties
2. Determine how various welding electrodes affect hydrogen content in welds.
3. Determine how different welding processes affect weld hydrogen content.
4. Determine methods to lower hydrogen content in welds.

Materials:
ASTM A36 5/8 to 1 thick, 2' wide, 4 inches long – 7 pieces
1 Quart Clear Glycerin or Mineral Oil, Clear container or buckets
1 Electrode end oven
1 Bucket of water
1 Print marker
Welding equipment: SMAW, GEA, GMAW, FCAW, electrodes E6010, E701K,
ER70S-X, ER70T-X, ER70S-X.
PPE – Safety glasses

Safety:
Wear PPE.
Observe gas and hot metal safety procedures

Reference Material:
CWB Goodenough Modules

Procedure:
1. Hydrogen contamination is a primary concern when welding higher carbon equivalent steels. Steel that is thick, or highly restrained is also prone to cracking caused by hydrogen. This lab will allow
Implementing Weld-Ed Module 1 Content

Weld Hydrogen Lab

What you will need:
Implementing Weld-Ed Module 1 Content

Weld Hydrogen Lab
Implementing Weld-Ed Module 1 Content

Weld Hydrogen Lab

No Visible Hydrogen Gas Bubbles: Test Rank = 0
Implementing Weld-Ed Module 1 Content

Weld Hydrogen Lab

One Visible Hydrogen Gas Bubble: Test Rank = 1
Implementing Weld-Ed Module 1 Content

Weld Hydrogen Lab

Multiple Visible Hydrogen Gas Bubbles: Test Rank = 40
Multiple Visible Hydrogen Gas Bubbles: Test Rank = 40
Implementing Weld-Ed Module 1 Content

Weld Hydrogen Lab

Multiple Visible Hydrogen Gas Bubbles: Test Rank = 60
Implementing Weld-Ed Module 1 Content

Weld Hydrogen Lab

Weld Surface Covered with Visible Hydrogen Gas Bubbles: Test Rank = 100
Implementing Weld-Ed Module 1 Content

Weld Hydrogen Lab

Relative $H_2$ Emission

- E6010 - Damp: 100
- E6010 - Amb: 60
- E7018 - Amb: 40
- E7018 - Hermetic: 1
- GTAW: 0
Implementing Weld-Ed Module 1 Content

Weld Hydrogen Lab

Figure 1. General relationships between potential hydrogen and weld metal hydrogen levels for different welding processes (Bailey et al, 1973).
Hydrogen Induced Cracking - Common Welding Concern with Carbon Steels

Four factors are required for hydrogen cracking:

- Susceptible microstructure
  - Martensite of high hardness
- Source of hydrogen
  - Moisture in flux
  - Grease/oil on plates
- Stress
  - Residual
  - Applied
- Temperature between -100 and 200°C (-150 and 390°F)

Hydrogen crack at root of multipass weld

Eliminate only one factor and hydrogen cracking goes away!!
Common Examples of Hydrogen Cracks

Root Crack

Toe Crack

Root Crack + Underbead Crack

Underbead Cracks

[Ref.: "Introduction to the Physical Metallurgy of Welding", Easterling]
Carbon Equivalent - Provides Quantifiable Indicator of the Need for Preheat/Post Weld Heat Treatment

\[ CE = \%C + \%Mn/6 + \%(Cr+Mo+V)/5 + \%(Si+Ni+Cu)/15 \]

- Carbon equivalent (CE) measures potential to form martensite, which is generally necessary for hydrogen cracking
  - CE < 0.35: no preheat or postweld heat treatment
  - 0.35 < CE < 0.55: preheat
  - CE > 0.55: preheat and postweld heat treatment
- Preheat temperature requirement increases as CE and plate thickness increase
- In addition, higher carbon contents result in higher hardness of the martensite, and increased susceptibility to hydrogen cracking
Postweld heat treatment (~ 450°C) tempers any martensite that may have formed.

Referred to as a temper treatment - some carbon diffuses out of the martensite reducing hardness, increasing ductility and toughness, and residual stresses are relieved.
Discussion

The course is designed to review the basic concepts of Welding Metallurgy courses taught in a Welding Technician program.

The content and laboratory assignments are written at an appropriate level for college sophomores.

Instructors using the module are encouraged to modify the content to suit the individual needs of their students and local industry.
Thank you!

Questions
Module 2 Joining and Cutting Processes

FABTECH International & AWS Welding Show 2013

Presented by
Dan Turner, MSHE, CWI
Professor & Program Chair
Yuba College
Marysville, CA
530-741-6932
dturner@yccd.edu
Thank you!

Questions
Module 3
Welding Design, Fabrication, and Robot Welding

FABTECH International & AWS Welding Show 2014
Atlanta Georgia

Presented by
Dr. Rick Polanin, CMfgE, CWI
Professor & Program Chair
Illinois Central College
309-694-5404
rpolanin@icc.edu
Weld-Ed Module 3

Purpose of Presentation

1. To describe the objectives and a sample of the module content.

2. To provide an example of the content used to support a laboratory assignment.

3. To explain a few of the laboratory assignments.

4. To answer questions about the module.
Why?

Welding Education Professional Development

• Advance welding technology
• Review fundamental concepts
• Develop additional expertise
• Incorporate new ideas
Weld-Ed Module 3

Module Objectives

• To introduce fundamental terms and concepts of design, fabrication, and robotics

• To explain the mechanical properties and testing methods

• To describe design criteria

• To review the methods and calculations used to determine weld size

• To review major thermal cutting and fabrication methods

• To discuss CNC systems, axes systems, and CNC operations

• To analyze CNC and robot programs

• To discuss robot systems and the elements of robot programs

• To complete laboratory assignments suitable for use in programs that educate and train Welding Technicians.
Module Content

- Fundamental terms & definitions
- Mechanical properties (tensile, hardness, impact, fracture toughness)
- Joint design & allowable stress
- Design by code
- Residual stress
- Distortion control
- Fabrication (1st operation thermal cutting, forming, fixturing)
- Preheat, post heat & carbon equivalent
- Computer Numerical Control (axis systems, positioning, programming, operations)
- Robot welding (axis systems, movement, programming, operations)
- Supporting laboratory assignments
Content Sampler

Example slides (for foundation content supporting the lab assignment)
Design and Testing

Stress-Strain Relationship in Tensile Test

- \( P = \) Elastic limit
- Stress < \( P \), elastic deformation (elastic strain)
- Stress > \( P \), elastic and plastic deformation (elastic-plastic strain)
- Stress for 0.2% elongation = yield strength of material (\( S_y \))
- Stress > \( S_y \), plastic deformation
- Maximum Stress = UTS
- Breaking Stress
Mechanical Properties - Tensile Test

Electro-Tensile Tester
10-50 KN

Gage/Strain
Fixed Grip
Mobile Grip

Controller/Display

Tensile Test Schematics

Typical Force-Strain for Tensile Test of Plastics

Weld-Ed
2014
Mechanical Properties- Rockwell Hardness Tests

• Rockwell hardness test is used for both soft and hard materials
• Most common: “B” scale (HRB) for soft materials and “C” (HRC) for hard materials
Mechanical Properties - Impact Toughness

- Impact toughness with V-notched test specimens: Izod and Charpy
- Impact toughness depends on temperature.
- The test criterion is to define a transition temperature for a critical level of energy (27 J or 20 FT-Lb)
Allowable Stress for Welds - Static Loading

- **Full strength welds- CJP**
  - Allowable stress (WM) = Allowable stress (BM)

- **Partial strength welds- PJP**
  - Partial strength welds in compression perpendicular to the weld axis and in tension parallel to the weld axis:
    - Allowable stress (WM) = Allowable stress (BM)
  - Shear strength in any direction for fillet or partial groove welds: $\tau = 0.30 \times EXX$
  - Fillet Welds:
    - $t_e = 0.707 \times \omega$, $f = t_e \times \tau$
    - $f = 0.707 \times \omega \times 0.30 \times EXX = 0.212 \times EXX$
    - $f$; stress per length unit, $\omega$; leg size, $t_e$; effective throat, EXX; electrode tensile strength
Weld Distortion and Preheat

- Distortion occurs when the residual stresses result in elastic strain.
- Longitudinal and transverse shrinkage stresses cause butt and T joints to distort differently.
- Shown are typical examples, but many factors contribute to distortion and may produce different results than these.

Pre-Heat and Inter-Pass Temperature

- Carbon Equivalent Method:
  - Carbon Equivalent formula (International Institute of Welding) is valid for steels with contents less than: 0.50 % C, 1.60% Mn, 3.50% Ni, 0.60% Mo, 1.00 %Cr, 1.0% Cu
  - Approximate preheat temperature:
    - $C_{eq}$ up to 0.45 %, preheat is optional
    - $C_{eq}$ =0.45 to 0.60%, preheat is 200 to 400 F
    - $C_{eq}$ over 0.60%, preheat is 400 to 700 F
  - Compare steels with the same carbon equivalent to take into account the thickness and the welding process- AWS D1.1-Table

\[
C_{eq} = \%C + \frac{\%Mn}{6} + \frac{(\%Mo + \%Cr + \%V)}{5} + \frac{(\%Ni + \%Cu + \%Si)}{15}
\]
Computer Numerical Control

CNC vs NC

With the evolution of programmable automation, numerical control machines became computer numerical control machines.

The difference is in the *computer* and the functions of a computer.

Look at the picture. This is a tape reader.

The tape reader was (and still sometimes) used to load the program into the machine controller. You can see some of the tape (yellow) on the left reel.

The tape has a series of holes punched into it. The holes are converted into binary numbers that represent the programming code.
Servo motor

A servo motor is any motor that uses feedback for control of position and velocity.

Encoder feedback

Generally the feedback is a multiple (2 raised to some power) of 2 like 256, 512, 1024 pulses or [ ] per revolution (360°) of the motor shaft.

The feedback is sent to the CPU of the robot through the motor interface for location information.

Ball screw

4 lead – 4 threads per inch (it takes 4 complete rotations for the table to move along the X-axis 1 inch)

493x309  – 4 threads per inch

As the encoder disk rotates the light from the LED shines on the photo-transistor and then it is blocked – this causes the pulses.

For this encoder there would be 8 pulses per revolution or 32 pulses per linear inch – each pulse would cause the table to move 1/32” or 0.031”
Pictured is an operator’s control panel for a CNC vertical machining center (Cincinnati Milacron). The panel includes a CRT (screen), keypad, softkeys (just below the CRT), mode switch (auto, MDI, jog, mpg, edit), feed override switch, MPG dial (manual pulse generator), emergency stop button, operation keys (cycle start, coolant, memory protect).

Keypad – used to input alphabet and number data

MPG – used to move each axis at the resolution set by the feed override switch

Softkeys – change function with the screen displayed on the CRT

E-Stop – stops all operations of the machine

CRT – cathode ray tube – displays information
Robot Operations and Programming

Work Envelope & Tool Mounting Flange

This represents the tool mounting flange of a robot.

The center of tool mounting flange is the **ONLY** point of which the robot controller is aware. When programming, the center point is moved to locations within the work envelope and the coordinate values (X, Y positions) are recorded into the memory of the robot.

The **work envelope** is defined as all of the points (locations) the robot can touch. The envelope may not be a smooth geometric shape.
Robot Programming – Basic Steps to Welding a Simple Joint

The following are typical robot programming steps, but the details will vary with each robot system:

1. Power up robot and turn on teach pendant
2. Use the teach pendant to create a program name
3. Select a coordinate system and robot motion speed
4. Jog robot to home position and record a point
   - The home position is the starting point for each program
5. Jog robot to a welding approach position and record a point
   - This is a position that is close to where the weld will start
   - It is important to establish this movement to ensure the robot doesn’t hit the part or the fixture as it approaches the plate

Typical robot teach pendant
Content Sampler

Laboratory Assignments
Tensile Testing

In this assignment you will be investigating and determining the tensile strength of various metals. Tensile strength is a mechanical property that is defined as a material's resistance to being pulled apart on a single axis. Tensile tests are one of the most common and important tests used to determine material strength.

Using the given data below, determine the following:

<table>
<thead>
<tr>
<th>Test 1</th>
<th>Test 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breaking load</td>
<td>Breaking Load</td>
</tr>
<tr>
<td>25,920#</td>
<td>24,250#</td>
</tr>
<tr>
<td>T = .437</td>
<td>T = .452</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ultimate tensile strength (psi)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Final length</td>
<td></td>
</tr>
<tr>
<td>Elongation</td>
<td></td>
</tr>
<tr>
<td>% elongation</td>
<td></td>
</tr>
<tr>
<td>Major alloy</td>
<td></td>
</tr>
<tr>
<td>Minor alloys</td>
<td></td>
</tr>
<tr>
<td>Published tensile strength</td>
<td></td>
</tr>
<tr>
<td>Mpa</td>
<td></td>
</tr>
</tbody>
</table>

Stress (load)

Strain (length of stretch, inches/inch)
Laboratory Assignment – Carbon Equivalent

Carbon Equivalent
Carbon equivalent (CE) formulas provide a valuable tool to determine the weldability of steels prior to fabrication. There are various CE formulae that are used to determine the ability to change or shape steel based upon chemistry prior to processing. Hardenability, machineability, formability, and weldability are a few examples of formulae available. The rail car strut shown below requires higher strength to withstand multidirectional forces yet smaller mass to reduce weight. To increase the strength, designers are substituting higher strength steel for the low carbon steel common to rail car manufacturer.

The steel selected is ASTM A871 (0.375” thick). However the designers are concerned about the weldability of the steel. Determine the CE for the steel and determine preheat requirements using CE and AWS D1.1. Recommend a welding procedure (process, electrode, parameters, preheat, postheat) for successful fabrication.

The effect of carbon equivalent:
The carbon equivalent (C.E.) may be considered one of the main factors in estimating preheat. Generally, the higher the carbon content of a steel, the greater the tendency to form a hard and brittle microstructures in the HAZ. This necessitates the use of preheat and low hydrogen electrodes. Carbon, however, is not the only element that influences hardenability. Other elements in steel also are responsible for the hardening and loss of ductility that occur with rapid cooling. One of the various empirical formulas used to determine carbon equivalent is given in the Structural Steel Welding Code (AWS D1.1) as follows:

%C.E. = %C + % (Mn+Si)/6 + % (Cr+Mo+V)/5 + % (Ni+Cu)/15

The approximate recommended preheat temperatures based on C.E. are:
- For up to 0.45%..............preheat is optional
- 0.45-0.60%..................200-400°F
- Over 0.60%...................400-700°F
Laboratory Assignment – CNC Programming

Introduction

For this assignment you will be writing a program for a CNC mill and filling out a setup sheet for the process. Review the attached print and setup sheet. Write a program for the part shown in the print. Use the program information to develop the setup sheet.

Program

N05 G00G90G40G80G21
Laboratory Assignment – Robot Programming

Robot Programming

1. Safety Overview
2. Power-up
3. Teach Pendant Overview
4. Robot Programming Air Moves
5. Robot Programming Editing
6. Robot Programming File Operations
7. Weld Program Simple Lap Joint
8. Robot Program Circular Movement Air Moves
9. Weld Program Multiple Motion
10. Setting Tool Center Point (manual and automatic)
11. Adaptive Control
Discussion

The course is designed to review the basic concepts of design, fabrication, and robot welding and act as a foundation for design, fabrication, and automation courses taught in a Welding Technician program.

The content and laboratory assignments are written at an appropriate level for college sophomores.

Instructors using the module are encouraged to modify the content to suit the individual needs of their students and local industry.
Thank you!

Questions
Module 4
Weld Quality and Inspection, Welding Codes, Specifications and Safety

FABTECH International & AWS Welding Show 2014

Presented by

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Weld-Ed Module 4

Purpose of Presentation

1. To describe the objectives and a sample of content.

2. To provide an example of the content used to support a laboratory assignment.

3. To explain one of the laboratory assignments.

4. To answer questions about the module.
Weld-Ed Module 4

Objectives

• Review of concepts and fundamentals, and the best educational practice methods of the weld quality and inspection methods, welding codes, specifications and safety

• Laboratory work consists of setting up and operating the instruments and equipment for identification and characterization of weld discontinuities and defects.
Weld-Ed Module 4

Content

- Weld Quality
- Weld Inspection
- Non-Destructive Examination
- Welding Standards, Codes, and Specifications
- Qualification and Certification
- Safe Practices
Content Examples of Module 4
Weld quality depends on many considerations (continued):

- **Safety**
  - Product must function without presenting a hazard to people and/or property

- **Economics**
  - Product price must be competitive
    - an oversized weld drives up the price

- **Inspection**
  - Appropriate inspection methods and frequency of inspections must be determined

- **Operation and maintenance**
  - Proper maintenance and repair of weldments in many industry sectors is critical to maintaining weld quality
Typical Welding Inspection Activities During and After Welding

• Validation of conformity to welding procedures including tack welds, and preheat and interpass temperatures
• Verification of welders' qualifications
• Verification of proper storage and handling of welding consumables
• Review and confirmation of any distortion control procedures
• Performance of visual weld examination per the applicable code
• Oversight of any repair activities

[Image courtesy of wqcndtinstitute.com]
Liquid Penetrant Testing (PT)

- Very simple, fast, and portable
- Inexpensive
- Requires relatively little training
- No external power required (other than lighting)
- But limited to surface flaws such as cracks and porosity
- Parts must be cleaned before and after testing
- Defects may not be detected if the weld is coated or covered with a scale or oxide

[Image courtesy of Western Technical Services/Accusense]
Definitions of Various Standards

- Codes and specifications:
  - Similar types of standards in that they both make use of the word "shall" to indicate mandatory requirements
  - Become mandatory when they are specified by a government jurisdiction or part of a contractual requirement
  - Codes generally apply to processes
    - Contain minimum engineering information pertinent to an industry or operation
  - Specifications generally apply to products or materials
Qualification Tests

- Procedure qualification testing usually involves welding test plates or pipes.
- In most cases, a butt joint with a full penetration groove weld is used.
- Fillet weld testing is sometimes an additional requirement, or may be permitted as an alternate to groove welds.
- The welding process parameters, materials, and other welding details that will be used during manufacturing must be used to produce the test samples.
- The preparation of mockups or sample joints may also be required to satisfy contractual requirements.

A single V bevel groove weld using 3/8" thick plates is commonly used for procedure qualification.
Protection Against Fumes and Gases – Exposure Factors

• Many factors affect the welder's exposure to fumes and gases, including:
  – The welding or cutting process being used
  – Position of welder's head relative to the fume plume
  – The type of helmet being worn
  – The type of ventilation system and the size of the welding area
  – Whether or not the welder is welding in a confined space
  – The type of metal being welded
  – Coatings, oils, grease, or scale on the metal being welded

[Source: Wikipedia]
AWS D1.1 – Acceptance Criteria – Weld Profiles – Butt Joint
Butt Joint Weld Profile – AWS D1.1: 2000

(b) Reinforcement $R$ shall not exceed 1/8 in. [3 mm] (see 5.24.4).

(D) ACCEPTABLE GROOVE WELD PROFILE IN BUTT JOINT

- EXCESSIVE WELD REINFORCEMENT
- UNDERFILL
- EXCESSIVE UNDERCUT
- OVERLAP

(E) UNACCEPTABLE GROOVE WELD PROFILES IN BUTT JOINTS
Butt Joint Profile – AWS D1.1/D1.1M: 2010

(A) WELD PROFILES FOR BUTT JOINTS
### Table 5.9

Weld Profiles\(^a\) (see 5.24)

<table>
<thead>
<tr>
<th>Weld Type</th>
<th>Butt</th>
<th>Corner—Inside</th>
<th>Corner—Outside</th>
<th>T-Joint</th>
<th>Lap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groove (CJP or PJP)</td>
<td>Figure 5.4A</td>
<td>Figure 5.4B(^b)</td>
<td>Figure 5.4C</td>
<td>Figure 5.4D(^b)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Schedule A</td>
<td>Schedule B</td>
<td>Schedule A</td>
<td>Schedule B</td>
<td>N/A</td>
</tr>
<tr>
<td>Fillet</td>
<td>N/A</td>
<td>Figure 5.4E</td>
<td>Figure 5.4F</td>
<td>Figure 5.4E</td>
<td>Figure 5.4E</td>
</tr>
<tr>
<td></td>
<td>N/A</td>
<td>Schedule C</td>
<td>Schedule C or D(^d)</td>
<td>Schedule C</td>
<td>Schedule C</td>
</tr>
</tbody>
</table>

\(^a\) NOTE: Groove Weld Schedule A
### Table 5.10
#### Weld Profile Schedules (see 5.24)

<table>
<thead>
<tr>
<th>Schedule A</th>
<th>(t = thickness of thicker plate joined for CJP; t = throat size for PJP)</th>
<th>R min.</th>
<th>R max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>R min.</td>
<td>R max.</td>
<td></td>
</tr>
<tr>
<td>≤ 1 in [25 mm]</td>
<td>0</td>
<td>1/8 in [3 mm]</td>
<td></td>
</tr>
<tr>
<td>&gt; 1 in [25 mm],</td>
<td>0</td>
<td>3/16 in [5 mm]</td>
<td></td>
</tr>
<tr>
<td>≤ 2 in [50 mm]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 2 in [50 mm]</td>
<td>0</td>
<td>1/4 in [6 mm]a</td>
<td></td>
</tr>
</tbody>
</table>
The Laboratory Exercise

The student welds a CJP or PJP Butt Joint using a proper WPS. Cut the plate in cross section pieces with the same view as the weld profiles shown. Prep the sections by sanding to a smooth finish. Possibly etching.

Discussion

Discuss the weld profile in accordance with the AWS code book. Also discuss grain structure and defects in the weld. Have them fill out an inspection sheet using inspection criteria.

Additional: Test with the PT method.
Thank you!

Any Questions?
Module 5
Laser Welding

FABTECH International & AWS Welding Show 2014

Presented by
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Professor
Department Chair – Welding and Manufacturing Technology
College for the Canyons
Tim.baber@canyons.edu
Implementing Weld-Ed Module 5 Content

Purpose of Presentation

1. To describe the objectives and a sample of content.

2. To provide an overview of the proposed content and the delivery strategy used during class.

3. To explain how the laboratory assignments reinforce the major concepts of the Weld-Ed module.

4. To answer questions about the module and the delivery of the content in Welding Technology classes.
Module 5 course content includes:

1. Light and Lasers
2. Laser Safety
3. Laser Welding Characteristics
4. Laser Welders and Systems
5. Laser Welding of Metals
6. Laser Beam Welding Codes and Standards
7. Laser Beam Welding Metrology & Weld monitoring
8. Weld Joint Geometry
9. Optics
Foundation Content

The National Core Curriculum Model was used to determine the student learning outcomes needed to function as a welding technician.

For this example of content implementation, the theory how a laser beam is focused is delivered, followed an example of a corresponding lab activity.

The foundational content includes fundamental terminology, description of the components in laser beam optics and focusing lens.

Delivery strategies include traditional lecture/discussion, demonstration, guided practice, independent student research of suggested internet sites, and completed projects within specified parameters and tolerances.
Laser Focusing

• To be useful for welding, cutting, drilling, or machining, the laser beam emitted by a typical industrial laser is too large for high power density and has to be focused.

• Usually for welding, the surface of the work to be processed is located very close to the point where the focus spot size is smallest where the energy density it highest enough to heat and vaporize the material.
Because they come from an optical cavity, laser beams have low divergence.

By optics, low-divergence laser beams can be focused to a very small spot.

Thus focus spot power density is large.
For most lasers, weld penetration is largest when the focal point elevation is slightly below the surface. Shorter focal length (smaller spot size) usually penetrates more than long focal length.
Content Examples of Module 5
Laboratory Assignment – Finding the working focal length of the focusing

First Lab Assignment

Objectives:
• To identify the working focal length
• Determine the accuracy (repeatability) of this method

Materials:
• Weld coupon: Carbon steel, flat stock, ~ 2” x 2”, minimum 0.125” thick
• Calipers (digital or analog) or dial indicator
• Lab jack, 6”x6” platform, adjusted to midrange of its travel.
• Inert shield gas – Argon. Flow rate: 40 SCFH thru a ¼” delivery nozzle.
• Double sticky tape or hold down clamps.
• Shade #6 shade lens or weld helmet insert window.
Laboratory Assignment – Finding the working focal length of the focusing

First Lab Assignment (cont’)

Safety:
• This work must be done on a (Safety) Class I laser welding system. (No laser safety glasses are needed).
• The operator MUST NOT view the target via the optical viewer during welding!
• Pending on the specification of the glass-filter on the viewing port, you may need to secure a welder’s window SHADE 6 to that viewing port, to block the UV emitted during laser welding.
• Handle hot metal with appropriate pliers and/or clamping device
• Use hearing protection as needed
• Follow all shop safety rules and policies
Laboratory Assignment – Finding the working focal length of the focusing

First Lab Assignment (cont’)

Procedure:
• Program the suggested laser settings in to the laser controller.
• Secure the coupon material to the lab-jack or the table of the motion system with double sticky tape or hold down clamps.
• Locate the tip of the shield gas delivery tube above the weld coupon, at approx. 45 degrees to the surface of the coupon, near the area where the spot welds will be made.
• Turn ON the shield gas to confirm the flow and flow rate.
• Target the laser somewhere in the center of the weld coupon.
• Focus the target. Adjust the distance between the weld coupon and the final focusing lens so that the surface of the weld coupon appears ‘sharp’ in the viewing scope.
• Record this information (distance) and the starting point of this test.
Laboratory Assignment – Finding the working focal length of the focusing

First Lab Assignment (cont’)

Procedure:
• Measure the distance between the surface of the weld coupon and the hardware that secures the final focusing lens. You may also measure the distance of the surface of the weld coupon above the base plate of the work station.
• As the tests proceed, you will need to decrease and then increase the distance between the weld coupon and the focusing lens in increments of ~ 0.020”. Using the calipers, determine how much you need to turn the handle of the lab jack to achieve this increment of motion.
• Re-establish the distance between the surface of the weld coupon and the focusing optics so that the image of the surface appears sharp in the viewing scope.
• Turn ON the laser and be ready for manual firing.
• Turn ON the shield gas.
Laboratory Assignment – Finding the working focal length of the focusing

First Lab Assignment (cont’)

Procedure:
• Fire the laser – one pulse. Observe the height of the plume.
• Decrease the focus distance by 0.020”. Slide the weld coupon side ways about 0.100” between shots.
• Fire the laser – one pulse. Observe the height of the plume.
• Repeat Step 14 and Step 15 until the plume is very small – but is still visible.
• Return to zero-distance (reference) between the surface of the weld coupon and the focusing optics.
• Increase the focus distance by 0.020”. Slide the weld coupon side ways about 0.100” between shots.
• Fire the laser – one pulse. Observe the height of the plume.
• Repeat Step 18 and Step 19 until the plume is very small – but is still visible.
• Return to zero-distance (reference) between the surface of the weld coupon and the focusing optics.
Laboratory Assignment – Finding the working focal length of the focusing

First Lab Assignment (cont’)

Dynamic Focus Test. Determination of the focal length of the final focusing optics using actual laser welding process parameters. The tallest ‘plume’ above the material represents the working focal distance of the final focus optics. (schematic).

Typical accuracy of this method is +/-0.005 inch (+/-0.1 mm).
Laboratory Assignment – Finding the working focal length of the focusing

First Lab Assignment (cont’)

Analysis:

• How accurately did you manage to find the distance where the plume was the tallest? (inches).
• How accurately did your colleague do this test – do your results agree?
• Was the original ‘focus distance’ as seen thru the viewing optics the correct focal distance?

Teaching Suggestions:

• It is helpful to have the instructor show the student how to perform this test. The extensive written instructions above reduce to simple repetitive tests.
• The instructor should make sure that the laser parameters are set correctly
• Allow approximately two hours to complete this assignment.
• This test may be performed by 2 or 3 persons at the work station. One person would target the laser beam and fire the laser. The others would make the observations: note the height of the weld plume.
Here is an example of improperly focused laser beam

Note the evidence of a weld “plume” around the outside of the finished weld area.
Discussion

The course is designed to review the basic concepts of a laser welding and applied applications taught in a Welding Technician program.

The content and laboratory assignments are written at an appropriate level for college sophomores.

Instructors using the module are encouraged to modify the content to suit the individual needs of their students and local industry.
Thank you!

Questions
Module 6
Instructional Design & Teaching Strategies for Welding Instruction

FABTECH International & AWS Welding Show 2014
Atlanta Georgia

Presented by
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Illinois Central College
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Weld-Ed Module 6

Purpose of Presentation

1. To describe the objectives and a sample of the module content.

2. To provide an example of the content used to support a laboratory assignment.

3. To explain a few of the class and assignments.

4. To answer questions about the module.
Objectives

1. Describe changes in technology and work requirements that demand closer attention to effective and efficient teaching and learning.

2. Describe data gathering methods for the development of a welding program

3. Discuss some old and new learning theory and how the theory is used to develop classroom and lab content.

4. Discuss laboratory physical facility and curriculum development

5. Review some learning styles and implications for learning activity development.

6. Discuss methods for developing curriculum.

7. Review some learning activities and lab content to improve learning.

8. Review evaluation techniques used to improve understanding and retention.

9. Practice developing a lesson plan to assure teaching at higher cognitive and psychomotor levels.
Weld-Ed Module 6

Content

• Introduction to Welding Technician Education & Training
• Program Needs Assessment & Sources of National Welding Curriculum
• Program & Course Objectives
• Learning Theory
• Learning Style
• Teaching Methods
• Laboratory Teaching & Development
• Classroom Management
• Evaluation & Assessment
• Fundamentals of Statistics
• Qualification & Certification of Welding Programs and Students
Foundation Content

The National Core Curriculum Model used to determine the student learning outcomes needed to function as a welding technician is only part of the information required for development of Welding Technology courses.

Local needs as gleaned from advisory committees, facility and equipment considerations, historical foundation of technical education (don’t reinvent the wheel), how students learn (learning theory), who your students are (learning style), and how to determine if your students learned anything and grades (assessment & evaluation) are all part of the course development process.

There are many aspects to developing a quality course that reasonably assures you students are employable or prepared to continue their education.

Module 6 helps introduce or review some ideas and methods to help.
Content Sampler

Example slides (for foundation content supporting the class & lab assignment)

Laboratory assignment
Historical Perspective of Welding Education

Progress, far from consisting in change, depends on retentiveness. When change is absolute there remains no being to improve and no direction is set for possible improvement: and when experience is not retained, as among savages, infancy is perpetual. **Those who cannot remember the past are condemned to repeat it.**

George Santayana, The Life of Reason Volume 1, 1905

Often it is advisable to look to technical education programs and innovations to determine what has worked, what has not worked, and how often good ideas seem to be repeated. Many so called education experts have paid no attention to education programs, methods or ideas that have been used in the past.
Some Contributions to Technical Education

Johann Heinrich Pestalozzi (1746-1827), Swiss educator and educational reformer. Sometimes called the “father of manual arts”. His motto “Learning by head, hand, and heart”, remains a principle in many modern schools. After failing in law, politics, farming, Pestalozzi opened an industrial school on his farm. His educational philosophy was student-centered and he used objects and models to help develop language and skill.

John Dewey (1859-1952) believed that learning was active and should be taught through experience. His theory of experience continues to be much read and discussed not only within education, but also in psychology and philosophy. Dewey's views continue to strongly influence the design of innovative educational approaches in adult training, and experiential learning.

Galaxy Plan, 1961

1. To provide each student with a more efficient opportunity to learn about the world of work.
2. To provide each student with a better opportunity through actual laboratory experiences to choose a career they would like to follow.
3. To provide each student with manipulative skill that would be of immediate value to an employer.

Program structure included four clusters: Materials and processes; Visual communication; Energy and power, Personal services.
Instructional Design

Instructional Design is a systematic process used to identify, develop, and evaluate strategies which are developed to successfully implement an instructional goal (program, course, learning activity).
Working with Advisory Committees

The purpose of an Advisory Committee is to validate, recommend, and guide new and existing technical programs (and academic programs if the faculty aspires to progressive teaching).

Validate
- Review course offerings, course content, and equipment.
- Determine if the program fits local and national workforce needs.

Recommend
- Recommend additions and changes to course offerings, course content, and equipment.
- Provide information about current technology used in industry.

Guide
- Provide direction to the balance of courses (stick vs. mig).
- Help with specific skills needed for employment.
Objectives

Global

- Large in scope
- Takes years to achieve
- Helps define a vision
- Represents a body of learning

Educational

- Moderate in scope
- Can take months to achieve
- Helps to define a curriculum
- Represents a unit or module of instruction

Instructional

- Specific in scope
- Can take hours or day to achieve
- Helps to define lesson plans
- Represents activities, exercises, and experiences
Learning Theory

There seems to be an unending number of opinions about how humans learn.

Biological, physiological, psychological, behavioral schools of thought litter learning research and scholarly articles about learning.

For me, a few main “schools of thought” cover the important theories.

Schools of Thought or Major Focus of Learning Theory …. Just a few

- Behaviorism
- Cognitive Science
- Constructivism & Schema
- Connectivism
- Transformational Learning
- Active vs. Passive Learning
Lesson Planning using Learning Theory

Trying to achieve higher cognitive and creative thinking

Bloom & Krathwohl Cognitive Domain Example

GMAW (mig) Theory & Setup

<table>
<thead>
<tr>
<th>Cognitive Domain Levels</th>
<th>Task Description</th>
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<tbody>
<tr>
<td>Knowledge</td>
<td>Simple terms – volts, wire speed, gas type, gas flow</td>
</tr>
<tr>
<td>Comprehension</td>
<td>Description of voltage needed for .250 carbon steel</td>
</tr>
<tr>
<td>Application</td>
<td>Setup of the welding parameters on a welding machine for .375 carbon steel – short circuit</td>
</tr>
<tr>
<td>Analysis</td>
<td>Determine adjustments needed to reduce spatter</td>
</tr>
<tr>
<td>Synthesis</td>
<td>Setup of welding parameters on a welding machine for .125 stainless steel open butt joint</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Determine parameter adjustments required to eliminate defects and optimize deposition</td>
</tr>
</tbody>
</table>
Learning Style

Simple methods to determine learning style and a discussion about why style is important to retention of content.

VARK Questionnaire

It is somewhat beneficial to determine one’s learning preference. As the VARK questionnaire is a simple instrument that can be evaluated quickly, let’s try the questionnaire.

The results may or may not surprise you. Later in this section of the module, we will discuss the criticism of knowing your learning style or teaching to a specific learning style.
Fundamentals of Statistics

Descriptive vs. Inferential Statistics

Descriptive statistics seek to report and organize data. Sport statistics are good examples – batting average, earned run average, yards after catch, etc.

Inferential statistics seek to generalize data and to compare to chance. Inferences about the effectiveness of a specific teaching method may be made after collecting data. In welding, inferences may be made about deposit rates of wire or penetration depths depending upon gas mixtures.
Lesson Plan Assignment

Introduction
Lesson plan development is the key to assuring efficient and effective student learning. Although formal lesson plans are the best for organizing and developing a curriculum, less formal plans are also used to provide proper sequencing of learning activities.

Many experienced teachers use daily outlines or a modified course syllabus to organize classes. However, teachers with experience in education theory develop lessons and learning activities utilizing techniques that employ higher level thinking, evaluation of personal and collective attitudes, and improvement of individual skill.

Lesson plans provide the attention to detail need to augment the overall planning and curriculum development for effective delivery of course content. Although an entire course requires daily planning utilizing input from instructor expertise, local industry, current technology, and existing knowledge, generally little attention is given to the best practice to assure student learning.

Good teaching however, always requires planning with a minimum requirement within the lesson plan of objectives, content (with teaching methods), learning activities, and evaluation criteria. It is often a function of teaching experience that allows the choice of less formal lesson plans instead of developing a comprehensive lesson plan.

For new classes, concepts, or skills the formal approach will provide more assurance that all of the needed information for the lesson has been planned and is in written form. The use of formal lesson plans provides a permanent record for future teaching and often a critique of the lesson for improvement. Some school districts require formal plans for all classes. As state and national standards become more important for program accreditation formal lesson plans provide written documentation of conformance to the standards.

Objectives
Upon completion of the case study, you will be able to:
1. Write objectives for a specific lesson at all levels of Bloom’s taxonomies.
2. List the important content to assure coverage of the critical concepts for a class.
3. Develop learning activities at all levels of the learning taxonomies and levels of knowledge.
4. Use varied methods of delivery to cover the differences in student learning preferences.

Develop assessment and evaluation techniques to determine the extent of student learning
Collaborative Learning Assignment

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<tbody>
<tr>
<td></td>
<td></td>
<td>Sheet 3 of 3</td>
</tr>
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</table>
Statistical Analysis Assignment
Discussion

The course is designed to review the foundations of technical education and some of the contributors to technical education, course development through the understanding of learning theory, teaching methods, and evaluation techniques.

It is very important that you think about how to best help improve the welding skill of your students through your teaching methods. But it is equally or more important that you prepare your students for lifelong learning.

Hopefully the information you learn in Module 6 will revive the reasons you chose teaching as a career.

Remember, teaching is about bringing out the best in your students. We all learn in different ways. The technical content and teaching content presented in Module 6 allows experimentation with your curriculum. Most of all remember that teaching, although requires really hard work, should also be some fun.
Thank you!

Questions
Lunch and Speaker from Hypertherm

FABTECH International & AWS Welding Show 2014
Welding Equipment Manufacturers Sessions

Overview

FABTECH International & AWS Welding Show 2014

Presented by
Duncan Estep
Director
Weld-Ed
National Center for Education and Training
Welding Equipment Manufacturers Sessions

Lincoln Electric

FABTECH International & AWS Welding Show 2014

Presented by
Jason Schmidt
Welding Equipment Manufacturers Sessions

Miller

FABTECH International & AWS Welding Show 2014

Presented by
Steve Hidden
Welding Equipment Manufacturers Sessions

ESAB & Victor Technologies

FABTECH International & AWS Welding Show 2014

Presented by
Dwight Myers
We are very pleased that ESAB Welding and Cutting Products now includes Victor Technologies:
New Products

See us at Booths: C 2444, C 2445 and C 2466
SWIFT ARC ML
MOBILE LEARNING ROBOT CELL

Features

- The Swift Arc ML is a fully-contained robotic welding system
- The compact design is a perfect match for educational institutions and portable or on-site training facilities
- This educational module facilitates an enhanced level of training with hands-on exercises required in the robotic production environment
- The safety system and operator control panel enable troubleshooting instruction and programming techniques that will be required in the real world, empowering students with the knowledge to succeed in the manufacturing industry

System Components

- ESAB Aristo® U5000iw power source
- KUKA KR6 R 900 6 axis robot
- KRC4 compact controller
- KUKA Smart Pad touch screen robot pendant
- Expandable cell walls
- Interlock safety system
Crossbow
Portable, Economical, Flexible
CNC Cutting Machine

Features
- Compact oxy-fuel/plasma CNC cutting system that is portable and economical
- Equipped with plasma, oxy-fuel or both:
  - plasma cut mild steel or aluminum up to 20 mm (3/4 in.), stainless steel up to 15 mm (5/8 in.)
  - using oxy-fuel cut mild steel up to 100 mm (4 in.)
- Fully integrated CNC, eliminating the need for the user to add a controller to the system
Crossbow
Portable, Economical, Flexible
CNC Cutting Machine

Flexible Solutions

Plug and play
  Very easy set up

Can be equipped with Plasma, oxy fuel or both

CNC features comprehensive library
  of 24 common shapes
    minimizes programming and set up

Custom programs are supported through
  basic M- and G Code programming

Off line NC files easily transferred
Innovative New 400 Series Cutting Attachment and Handle

The Innovative New 400 Series Cutting Attachment and Handle

*We Listened. We Delivered!*

Victor® has been the leader in gas equipment since our humble beginnings in 1913. We couldn’t have done it without you, our users. Developing innovative products can be a difficult task. That is why we listened to our End-Users, and with your support and feedback, we have developed the new 400 Series Cutting Attachment & Handle. All designed to be durable, comfortable, and easy to use, for YOU the User.
Tweco 3 in 1
MIG, Stick, TIG Power Sources

Overall Design Advantages

3 in 1 Process Capability
Weighs less than 33 pounds
Fast Control Response
13 micro seconds
Accessory Ready
Spool Gun
MIG Gun
TIG Torches
Foot Control
Digital Meters
Voltage and Amperage / Wire speed
Educational Resources
# Educational Resources

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<tr>
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<th>Duration</th>
<th>Date</th>
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<tr>
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<td>5 minutes</td>
<td>Oct 10, 2014</td>
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<tr>
<td>Arc Welding Gas Basics</td>
<td>3 minutes</td>
<td>Jul 01, 2013</td>
</tr>
<tr>
<td>Arc Welding Safety</td>
<td>5 minutes</td>
<td>Oct 10, 2014</td>
</tr>
</tbody>
</table>
Educational Resources

Arc Welding Gas Basics
Release Date: Jul 01, 2013

Arc Welding
Shield Gas Basics

GMAW & GTAW
(MIG) & (TIG)
Educational Resources

Arc Welding Gas Basics

Release Date: Jul 01, 2013

Things you will learn

- Purpose of a shield gas.
- Which gases work best for MIG.
- Which gas works best for TIG.
Educational Resources

Arc Welding Gas Basics
Release Date: Jul 01, 2013

GMAW (Gas Metal Arc Welding)

MIG Welding
Educational Resources

Arc Welding Gas Basics
Release Date: Jul 01, 2013

MIG Gases

Argon & CO₂ Blend

100% Argon

100% CO₂

Helium, Argon & CO₂ Blend

Drag the metal away to reveal what it is.

Home  Back  Next
Educational Resources

Arc Welding Gas Basics
Release Date: Jul 01, 2013

MIG Gases

Argon & CO₂ Blend
100% Argon
Helium, Argon & CO₂ Blend

Has areas that refer the student to additional information that is available and downloadable.
Education Program

Look for a new consolidated Educational Program
Will cross all brands
Will continue to offer an aggressive discount to schools and trades

Will continue to provide Free Teaching Aides
Educators CD-ROM
Filler Metal Technology Course
Safety Handbooks
Filler Metal Data Book
Process Handbooks
Training Posters
• Welding Positions
• AWS Classifications
• Defect Types
• Safety
• Weld Symbols
Education Program

Will continue to be a Trades / School advocate
  Provide Liaison between trade/school and ESAB for ease of ordering
  Identify and meet the facilities welding and cutting needs
  Provide support materials
  Will provide safety training
  Provide a guest lecturer when requested
  Conduct an “ESAB Day”
    Utilize the Demo Van when available

Be a student advocate in industry
  Support the students
  Help with job opportunities
  Help with Internship opportunities
Lastly: If you don’t ask, you won’t be told no.

But if you do ask, you just may be told yes.

If you have ideas what a manufacturer’s Educational Program should look like to help you, please let me know

See me at Booths: C2444, C2445 and C 2466
Wrap-Up and Evaluations

FABTECH International & AWS Welding Show 2014