



Materials Joining Technology

Technical Competency Profile (TCP)



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Introduction

This document is excerpted with permission from Ohio's Emerging Engineering Technologies Technical Competency Profile (TCP).

The Emerging Engineering Technologies Technical Competency Profile (TCP) consists of a foundation core encompassing the National Project Lead-The-Way curriculum and state-of-the-art engineering pathways. The Emerging Engineering Technologies TCP core and pathways are grounded in academic subject areas and built in concert with emerging engineering career fields. The Ohio Board of Regents, the Ohio Department of Education Career-Technical and Adult Education, and the College Tech Prep Curriculum Service Center at The University of Toledo collaboratively developed the TCP. A model and model descriptor of the Ohio Emerging Engineering Technologies Model appears on pages 8 and 9.

The Emerging Engineering Technologies Technical Competency Profile (TCP) includes essential competencies for programs from secondary through a post-secondary associate degree. Each area contains competencies common to a variety of emerging engineering careers. Consequently, this profile design reflects programming flexibility that supports many options for broad-based educational studies and career planning.

In addition to the Project Lead-The-Way curriculum, representatives from a broad cross-section of engineering and engineering technology professionals played a critical role in defining the vision and scope of the TCP, and in defining the essential and recommended skills for current and future engineering and engineering technology employees. Secondary and post-secondary educators representing Ohio schools and colleges leveled the competencies to create career pathways from secondary to associate degree programs. A list of business and industry representatives and educators participating in the development of the profile appears on page 44.

The Emerging Engineering Technologies Technical Competency Profile (TCP) is the basis for the development of an integrated delivery system that provides opportunities for new and challenging programs and courses. The Technical Competency Profile will also enhance and expand the Career-Technical Education, College Tech Prep, and post-secondary degree programs.

The profile is available on the Internet at www.techprepohio.org. Users can download copies of the entire profile or conduct searches on a number of key variables from this location.

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College Tech Prep Program Standards

College Tech Prep programs are rigorous programs of study starting at the secondary school level and continuing through the associate degree and beyond. In accordance with the Carl D. Perkins Vocational Technical Education Enhancement Act of 1998, College Tech Prep programs are seamless, non-duplicative programs of study combining high-level academic and technical preparation in a variety of career fields.

The Carl D. Perkins Vocational and Technical Education Act of 1998 defines College Tech Prep as:

A program that provides technical preparation in a career field such as engineering, applied science, mechanical, industrial or practical arts or trade, agriculture, health occupations, business or applied economics, and must do the following:

- Combines at least two years of secondary and two years of post-secondary education in a sequential course of study without duplication of coursework
- Integrates academic, vocational and technical education, and if appropriate and available, work-based learning
- Provides technical preparation for careers
- Leads to an associate or a baccalaureate degree or post-secondary certificate in a specific career field
- Leads to placement in appropriate employment or further education.

The Ohio College Tech Prep Advisory Council recommended to the Ohio Board of Regents and the Ohio Department of Education the following standards for all College Tech Prep programs:

Academics are taught at a college-preparatory level and are aligned with state models and academic content standards.

In addition to Ohio graduation requirements specified in SB 55, required academic components for College Tech Prep programs include:

- a. Mathematics taught at a minimum level of Algebra II by the completion of high school.
- b. An integrated or stand alone senior-year math component
- c. Three units of science including at least two lab-based science courses

College Tech Prep programs will use a state-developed Technical Competency Profile (TCP) as the basis for pathway development. The pathway document should reflect secondary and post-secondary course work and should be made available for stakeholders. All secondary and post-secondary TCP competencies must be clearly identified and addressed. The TCP is the framework used to develop all associated curricular documents; however, components from other competency profiles such as OCAP's (Occupational Competency Analysis Profile), ITAC's (Integrated Technical and Academic Competencies) and SCANS (The Secretary's Commission on Achieving Necessary Skills—America 2000) may be included and are not mutually excluded from a TCP.

Articulated pathways will be reviewed every two-years at the consortia level.

Pathways operate under an articulation agreement between/among partners in a consortium.

College Tech Prep programs at the secondary level will operate as state-approved, career-technical education programs.

Academic and technical instruction is integrated and delivered in a contextual approach where possible.

Programs have common representation from secondary education, higher education, business, and labor members.

Post-secondary programs contain advanced skills in the TCP document.

Programs must operate under either regionally accredited post-secondary institutions/degrees or approved apprenticeship programs meeting U.S. Department of Labor standards.

College Tech Prep programs, secondary and post-secondary, must comply with the state College Tech Prep Advisory Council's performance measures.

State College Tech Prep Advisory Council
Revised and Approved: May 1, 2002

Project Lead-The-Way Overview

Project Lead the Way, Inc., (PLTW) is a not-for-profit organization partnering with public schools, organizations, in the private sector, and higher education institutions to increase the number and quality of engineers graduating from our educational system. The program is partially funded by Charitable Venture Foundation, a private foundation located in Clifton Park, New York. PLTW has a support staff of experience technology educators and college and university partners to support schools as they implement PLTW curricula.

PLTW has developed a four year, flexible sequence of courses which, when combined with college preparatory mathematics and science courses in high school, introduces students to the scope, rigor and discipline of engineering and engineering technology prior to entering college.

The courses are:

- Principles of Engineering
 - Introduction to Engineering Design
 - Digital Electronics
 - Computer Integrated Manufacturing
 - Engineering Design and Development
- (Additional courses in development)

Introduction at this level will attract more students to engineering, and will allow students, while still in high school, to determine if engineering is the career they desire. Students participating in PLTW courses are better prepared for college engineering programs and more likely to be successful, thus reducing the attrition rate in these college programs, which currently exceeds 50% nationally.

PLTW has a comprehensive organizational structure in place to ensure continued participation and success. Key elements provide support at every level of the program. PLTW provides local, state and national organization for leadership and support, a model curriculum, professional development and consultant services. The participating school districts implement the five course sequence based on a plan developed in partnership with colleges and universities, operate a partnership team with members drawn from higher education and the private sector, and serve as models for other school districts. Colleges and universities provide strategic regional leadership, involve industry, and assist school districts to establish partnership teams. Private sector members provide advisors, supporters, mentors and financial support, and assist the colleges and school districts to achieve the goals of the program. School Partnership Teams advise and support the school districts in their operational plans.

A critical component of the Project Lead The Way program is its professional development model. It was developed to provide the most intensive and comprehensive training to teachers becoming part of Project Lead The Way, Inc. The curriculum these teachers are required to teach utilizes cutting-edge technology and software requiring specialized training. Significant attention is paid to assessing teachers' readiness training through online assessment. This

familiarizes teachers with the types of skills they will need during the intensive core training at one of PLTW's National Training Centers during the summer. Ongoing training supports the teachers as they implement the program and provides for continuous improvement of skills.

Understanding that another key to success is awareness, PLTW makes a concerted effort to inform school counselors about the benefits of the program, as well as the wide array of technology jobs and careers available to students who enter the field upon graduation from high school and college. Counselors are supplied with PLTW materials, (available at www.pltw.org) including brochures and a video, to use with students and their parents.

In addition, PLTW has developed an exciting Middle School Technology Curriculum: *Gateway to Technology*. This project-based, cutting-edge curriculum is 40 weeks in length and is divided into four 10-week units: Design and Modeling; The Magic of Electrons; The Science of Technology; Automation and Robotics. Designed for all students the units address national standards in math, science and technology. One of the goals is to increase interest and awareness of females and minority students in technology and related careers. *Gateway to Technology* will also encourage increasing numbers of students to elect the high school program.

Mission Statement

We will create dynamic partnerships with our nation's schools to prepare an increasing and more diverse group of students to be successful in engineering and engineering technology programs.

The mission is achieved by providing:

- A Fully-developed Curriculum for High School and Middle School
- Extensive Professional Development for Teachers
- School Counselor Professional Development Conferences
- Affordability through an Optional National Bid
- Key Partnerships with State Education Departments
- College Level Certification, College Course Credit and Middle School Recognition
- Systematic Evaluation
- Continuous Improvement, using *Curriculum Development Framework*

Strategic Objectives

- By the end of the second year of membership in PLTW, each school will have an effective school partnership team
- By June 2001, a set of criteria and review standards will be established for all PLTW instructional materials; and by the end of 2002, all PLTW instructional materials will meet those criteria and review standards
- By 2004, 100% of PLTW students will meet college entrance requirements for engineering and engineering technology; of those students, as least 90% will successfully complete their first year of further study and at least 75% will graduate from two or four

year engineering and engineering technology programs.

- By 2004, the enrollment of females in PLTW courses will be 10 percentage points higher than the current female national enrollment in engineering and engineering technology programs.
- By 2005, the racial and ethnic minority student population in schools with PLTW courses will be collectively proportionate to the overall state populations.
- By 2006, we will have at least 1000 schools in PLTW and additional, geographically located, university affiliates.
- By 2006, we will increase by 20% the number of graduates from high schools in PLTW who are accepted in engineering and engineering technology programs.

Ohio Emerging Engineering Technologies Model

The Ohio Emerging Engineering Technologies Model provides a solid foundation for the College Tech Prep career plan. This plan generally consists of two years of programming in high school, two years of learning at the community college level, and for many, two additional years of study at the baccalaureate level. The nucleus of the model is grounded in rigorous academic requirements and an Emerging Engineering Technologies Core. Although College Tech Prep generally begins in the junior year of high school, the Emerging Engineering Technologies TCP may be completed through a two, three, or four year delivery model.

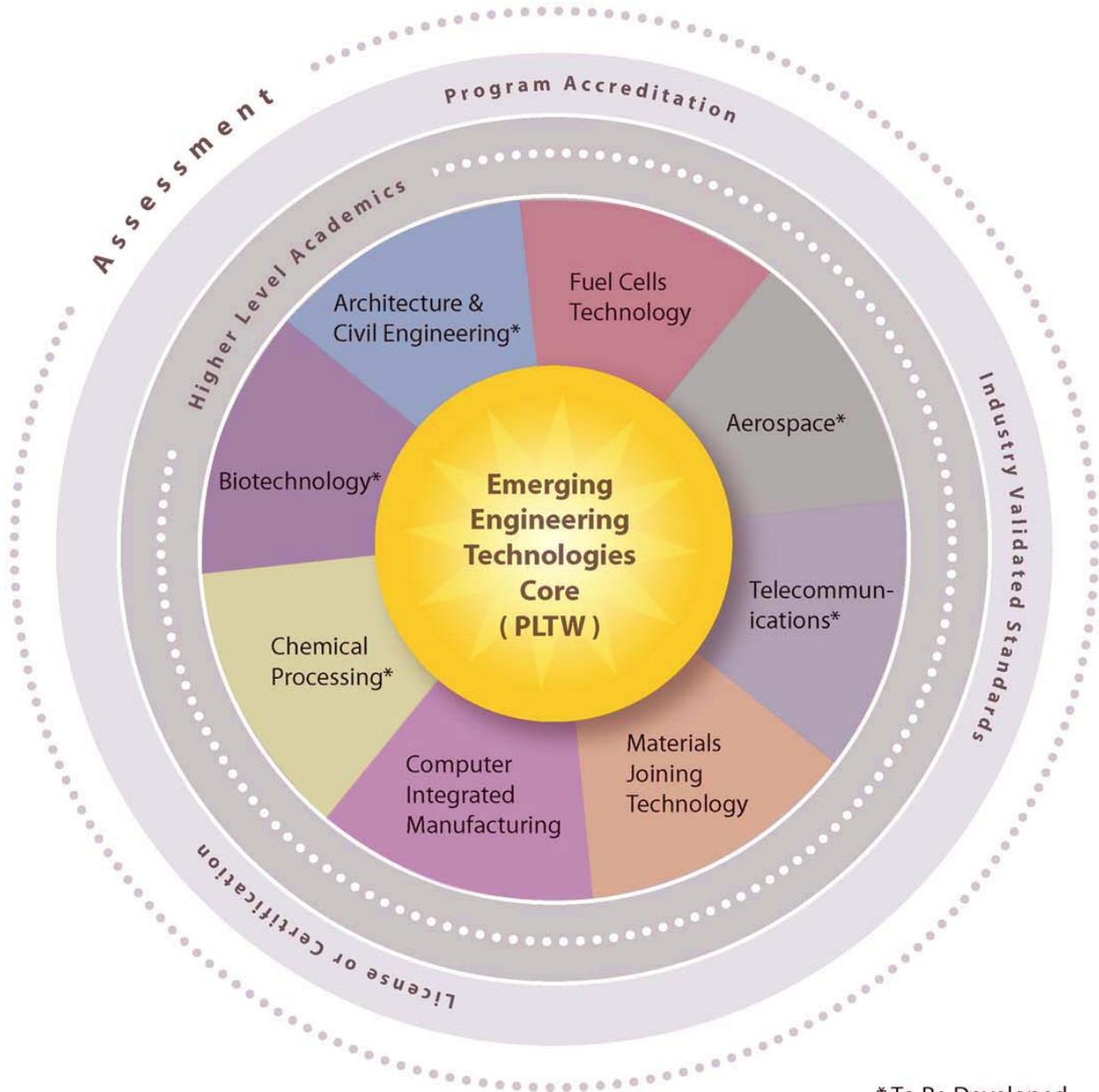
The Emerging Engineering Technologies Core illustrates the fact that there are common skills and knowledge required for each of the pathways. Experiences grounded within the core are designed to assist students to select the appropriate pathway. Located on the perimeter of the Emerging Engineering Technologies Core are the various pathways associated with careers in engineering and engineering technology. Each career pathway enhances, expands, and customizes units from the core to reflect the needs of the career professionals.

As research and development progresses, multiple career options and opportunities will become available within each pathway, some at the associate degree level and many at the baccalaureate degree level. For example, individuals desiring a career in fuel cells technology will see opportunities develop in research, production, distribution, storage, etc. Other pathways, such as aerospace, materials joining technology, etc., will offer similar options and career opportunities.

The model is designed to support lifelong learning beyond the formal classroom by requiring high-level academic, as well as, technical skills and knowledge. Individuals undertaking the Emerging Engineering Technologies Core and any one of the career pathways should view their College Tech Prep experience as preparation for more than an entry-level position. Successful career pursuits and advancement in the future will rely on an individual's ability to change and adapt to a changing workforce. The implementation of the Ohio Emerging Engineering Technologies Delivery Model will enhance a student's ability to address those changes.

Ohio Emerging Engineering Technologies Model

Secondary → Associate Degree → Bachelor's Degree



Key to Profile Codes

Importance of Competencies

All of the competencies in this document represent the minimum requirements for a College Tech Prep program. It is the responsibility of the local consortia to further define and/or expand, as needed, the key indicators for each competency. Each competency will be taught at either the introductory or proficiency level by the completion of the Tech Prep program, which is the minimum of an Associate Degree. A minimal number of competencies have been identified as Introduce (I) at the Associate Degree level. These may require further higher education.

This document integrates college prep academics with technical skill. Technical skills are a required component.

I = Introduce (Learner will demonstrate knowledge and comprehension of the competency.)

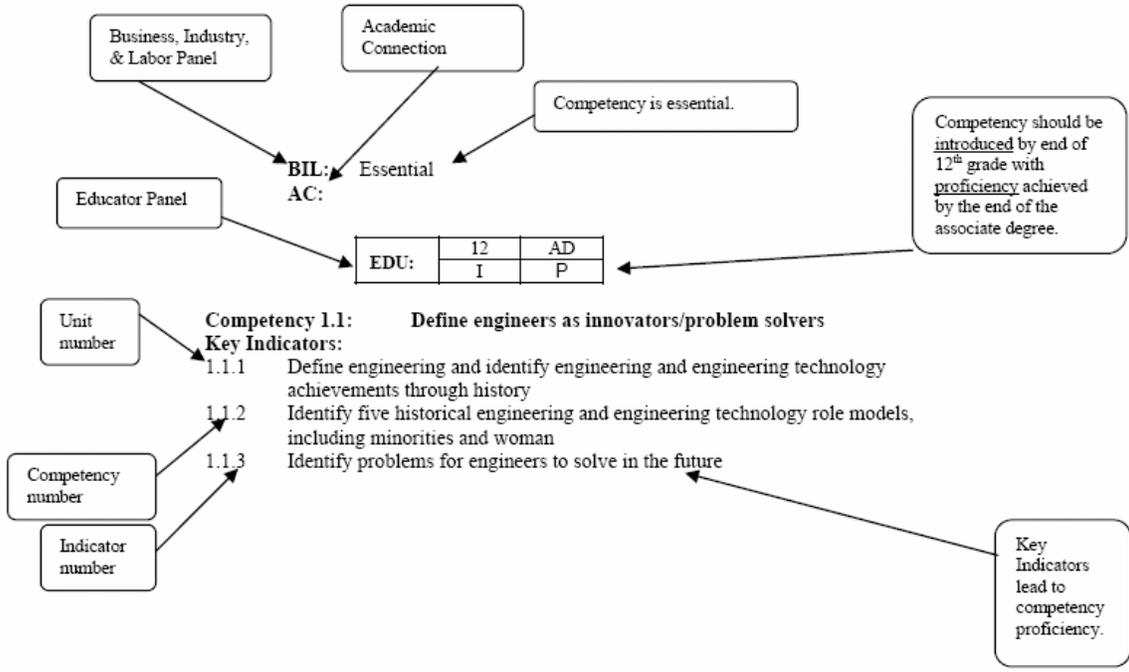
P = Proficient (Learner will demonstrate ability to apply knowledge of and/or perform the competency.)

R = Reinforced (Competencies marked proficient at the secondary level are to be reinforced at the associate degree level.)

Grade Level: **12** = by the end of grade 12
 AD = by the end of the Associate Degree

ACADEMIC CONNECTION

As rigorous programs of study, College Tech Prep programs require academics to be taught at a college-preparatory level, and contextually within the technical content. State academic mathematics, language arts, science, and social studies benchmarks are embedded within each Technical Curriculum Profile (TCP).



Material Joining Technology Program Profile

Page	Unit	
16	1	Introduction to Materials Joining Technology
17	2	Arc Welding Processes
20	3	Non-Arc Welding Processes
24	4	Physics of Welding
26	5	Heat Flow
27	6	Metallurgical Background
30	7	Welding Metallurgy
31	8	Design
36	9	Testing and Inspection
40	10	Safety

Material Joining Technology Competency Chart

At the end of the secondary program (12) and associate degree (AD) each competency is coded: I = Introductory; P = Proficient; R = Reinforce. In addition, the business, industry, and labor partnership (BIL) validated each competency: BIL: E = Essential; R = Recommended

Material Joining Technology (Emerging Technology Elective)		12	AD	BIL
Unit 1 Introduction to Materials Joining Technology				
1.1	Define welding engineers and material joining technicians	P	R	E
1.2	Describe the background related to materials joining	P	R	E
1.3	Classify the categories of welding and joining processes	P	R	E
Unit 2 Arc Welding Processes				
2.1	Contrast the classification of arc welding processes and describe how they fit in all fusion welding processes	P	R	E
2.2	Explain the shielded metal arc welding process and its uses	P	R	E
2.2	Explain the shielded metal arc welding process and its uses	P	R	E
2.3	Explain the gas metal arc welding process and its uses	P	R	E
2.4	Explain the flux cored arc welding process and its uses	P	R	E
2.5	Explain the submerged arc welding process and its uses	P	R	E
2.6	Explain the gas tungsten arc welding process and its uses	P	R	E
2.7	Explain the plasma arc welding process and its uses	P	R	E
2.8	Explain the electroslag (ES) and electrogas (EG) welding process and its uses	P	R	R
2.9	Explain the arc stud welding process and its uses	P	R	R
2.10	Develop an automated Arc Welding procedure for the manufacture of a real part (e.g. pacemaker body, bellows, etc.)	P	R	E
Unit 3 Non-Arc Welding Processes				
3.1	Summarize the non-arc welding processes	P	R	E
3.2	Explain the resistance welding process	P	R	E
3.3	Explain the oxy-fuel gas welding processes	P	R	R
3.4	Explain the thermit welding process	P	R	R
3.5	Explain the solid state bonding processes	P	R	R
3.6	Explain the high energy density fusion welding processes	P	R	E
3.7	Explain the brazing and soldering processes	P	R	E
3.8	Explain the processes used for joining of plastics	P	R	E
3.9	Explain adhesive bonding of parts	P	R	E
3.10	Develop a manual welding procedure for the bonding of thermoplastic parts using a hot air gun	P	R	E
3.11	Develop a resistance weldability “Lobe Curve” using a virtual on-line resistance welding machine	P	R	E

Unit 4 Physics of Welding				
4.1	Explain the concept of welding heat input	P	R	E
4.2	Describe the characteristics of the welding arc	P	R	E
4.3	Describe the physics of metal transfer	P	R	E
4.4	Describe the physics of the arc welding power sources	P	R	E
4.5	Describe the physics of arc blow	P	R	E
Unit 5 Heat Flow				
5.1	Describe heat flow in welds	P	R	E
5.2	Describe how heat flow affects the temperature profile around a weld	I	P	E
5.3	Develop a thermal profile around a moving weld	I	P	E
Unit 6 Metallurgical Background				
6.1	Define phases of matter and phase changes during solidification	P	R	E
6.2	Explain the common crystal structures in metallic materials	P	R	E
6.3	Explain imperfection in crystal structure	I	P	E
6.4	Define phase changes and phase diagrams	I	P	E
6.5	Define phase changes of eutectoid steels	I	P	E
6.6	Explain tie line	I	P	E
6.7	Explain transformation strengthening	I	P	E
6.8	Explain deformation strengthening	I	P	E
6.9	Explain precipitation strengthening	I	P	E
Unit 7 Welding Metallurgy				
7.1	Define weld regions	P	R	E
7.2	Define fusion and unmixed zones	I	P	E
7.3	Define the partially melted zone	I	P	E
7.4	Define the heat affected zone	I	P	E
7.5	Define the base metal zone	I	P	E
Unit 8 Design				
8.1	Explain mechanical properties of materials	P	R	E
8.2	Explain fatigue properties of materials	I	P	E
8.3	Explain fracture toughness properties of materials	I	P	E
8.4	Explain hardness properties of materials	P	R	E
8.5	Explain creep testing of materials	I	P	R
8.6	Explain other physical properties	P	R	R
8.7	Explain weld joint design	P	R	E
8.8	Explain the use of codes and standards	P	R	E
8.9	Explain the use of codes and standards in weldment joint design	P	R	E
8.10	Explain the use of welding symbols to communicate weld design	P	R	E
8.11	Explain residual stresses and distortion in weldments	I	P	E

8.12	Explain the development of welding procedures and weld qualifications	P	R	E
8.13	Design a welded structure	P	R	E
8.14	Evaluate a failed structure	P	R	E
Unit 9 Testing and Inspection				
9.1	Explain the factors considered in weld quality	P	R	E
9.2	Explain discontinuity and defect	P	R	E
9.3	Explain destructive weldment testing techniques	P	R	E
9.4	Explain weldability tests	I	P	R
9.5	Explain the need for nondestructive examination	P	R	E
9.6	Perform visual examination	P	R	E
9.7	Describe dye penetrant examination	P	R	E
9.8	Describe magnetic particle examination	P	R	E
9.9	Explain radiographic examination	I	P	E
9.10	Describe eddy current examination	P	R	R
9.11	Describe ultrasonic examination	P	R	E
9.12	Describe acoustic emission examination	P	R	R
9.13	Examine a weld structure	P	R	E
9.14	Appraise the quality of a welded part by non-destructive examination	P	R	E
Unit 10 Safety				
10.1	Describe the importance of safety training	P	R	E
10.2	Assess work area safety	P	R	E
10.3	Practice personal safety and select appropriate equipment	P	R	E
10.4	Describe fumes, gasses and toxic materials	P	R	E
10.5	Demonstrate gas storage safety	P	R	E
10.6	Demonstrate fire safety	P	R	E
10.7	Demonstrate electrical safety	P	R	E
10.8	Demonstrate radiation safety	P	R	E
10.9	Demonstrate proper ergonomic practices	P	R	E

MATERIALS JOINING TECHNOLOGY

Unit 1: Introduction to Materials Joining Technology

BIL: Essential

EDU:	12	AD
	P	R

Competency 1.1: Define welding engineers and material joining technicians

Key Indicators:

- 1.1.1 Describe the role of welding engineers and material joining technicians within industry.
- 1.1.2 Distinguish the differences between welding engineers, welding technicians, and welders.
- 1.1.3 Identify the industries currently employing welding engineers and material joining technicians.
- 1.1.4 Identify various welding career pathways in industry.

BIL: Essential

EDU:	12	AD
	P	R

Competency 1.2: Describe the background related to materials joining

Key Indicators:

- 1.2.1 Describe why materials joining is important to the world economy
- 1.2.2 Distinguish between joining and mechanical fastening processes
- 1.2.3 Define what materials are considered in material joining
- 1.2.4 Define the general categories of materials joining processes
- 1.2.5 Define the engineering and economic considerations needed to produce a manufactured part fit for its intended service.

BIL: Essential

EDU:	12	AD
	P	R

Competency 1.3: Classify the categories of welding and joining processes

Key Indicators:

- 1.3.1 Differentiate between fusion and non-fusion joining
- 1.3.2 Identify the various fusion joining processes
- 1.3.3 Identify the various non-fusion joining processes.
- 1.3.4 Recognize welding processes utilizing standard and nonstandard terms (e.g. American Welding Society [AWS] glossary)

Unit 2: Arc Welding Processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 2.1: Contrast the classification of arc welding processes and describe how they fit in all fusion welding processes

Key Indicators:

- 2.1.1 Recognize the fusion welding classification chart and where the arc welding processes fit into the chart
- 2.1.2 Describe the difference between the gas and flux based shielding systems in arc welding, and list the various types of flux and inert gases
- 2.1.3 Differentiate between consumable and non-consumable electrodes.

BIL: Essential

EDU:	12	AD
	P	R

Competency 2.2: Explain the shielded metal arc welding process and its uses

Key Indicators:

- 2.2.1 Describe the basics of the shielded metal arc welding (SMAW) process.
- 2.2.2 Classify the various types of SMAW electrodes
- 2.2.3 Describe the various components of the electrode and their function
- 2.2.4 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 2.3: Explain the gas metal arc welding process and its uses

Key Indicators:

- 2.3.1 Describe the basics of the gas metal arc welding (GMAW) process.
- 2.3.2 Describe the various components of the welding gun and the function of each part
- 2.3.3 Classify the various types of GMAW electrodes
- 2.3.4 Describe the various modes of metal transfer through the arc
- 2.3.5 Describe the effect of shielding gas on metal transfer
- 2.3.6 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 2.4: Explain the flux cored arc welding process and its uses**Key Indicators:**

- 2.4.1 Describe the basics of the flux cored arc welding (FCAW) process.
- 2.4.2 Describe the difference between the self shielded flux cored arc welding process and the gas shielded flux cored arc welding process
- 2.4.3 Classify the various types of FCAW electrodes
- 2.4.4 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 2.5 Explain the submerged arc welding process and its uses**Key Indicators:**

- 2.5.1 Describe the basics of the submerged arc welding (SAW) process.
- 2.5.2 Describe the various components of the welding torch (gun) and the function of each part
- 2.5.3 Classify the various types of SAW electrodes and fluxes.
- 2.5.4 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 2.6 Explain the gas tungsten arc welding process and its uses

Key Indicators:

- 2.6.1 Describe the basics of the gas tungsten arc welding (GTAW) process.
- 2.6.2 Describe the various components of the welding torch and the function of each part
- 2.6.3 Classify the various types of electrodes
- 2.6.4 Explain the effect of shielding gas, current polarity, and electrode tip geometry
- 2.6.5 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 2.7 Explain the plasma arc welding process and its uses

Key Indicators:

- 2.7.1 Describe the basics of the plasma arc welding (PAW) process.
- 2.7.2 Describe the various components of the welding torch and the function of each part
- 2.7.3 Explain the characteristics of transferred arc and non-transferred arc systems
- 2.7.4 Explain keyhole welding mode.
- 2.7.5 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Recommended

EDU:	12	AD
	P	R

Competency 2.8: Explain the electroslag (ES) and electrogas (EG) welding process and its uses

Key Indicators:

- 2.8.1 Describe the basics of the electroslag and electrogas arc welding processes.
- 2.8.2 Describe the various components of the welding gun and the function of each part
- 2.8.3 Describe the electrode and flux combination.
- 2.8.4 List the advantages, quality issues and limitations in relation to other arc welding processes

BIL: Recommended

EDU:	12	AD
	P	R

Competency 2.9 Explain the arc stud welding process and its uses

Key Indicators:

- 2.9.1 Describe the basics of the arc stud welding processes.
- 2.9.2 Describe the various components of the stud gun and the function of each part
- 2.9.3 List the advantages, quality issues and limitations in relation to other welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 2.10 Develop an automated Arc Welding procedure for the manufacture of a real part (e.g. pacemaker body, bellows, etc.)

Key Indicators:

- 2.10.1 Prepare an automated turning table for part manipulation
- 2.10.2 Construct a GTAW arc welding system for part welding
- 2.10.3 Perform welds with various welding current levels
- 2.10.4 Analyze weld quality and heat input
- 2.10.5 Prepare a written report describing the best welding procedure for part manufacture.

Unit 3: Non-Arc Welding Processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 3.1 Summarize the non-arc welding processes

Key Indicators:

- 3.1.1 List the non-arc welding processes
- 3.1.2 Explain where the non-arc welding processes fit into the fusion welding chart
- 3.1.3 Explain why the non-arc welding processes are different from the arc welding processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 3.2 Explain the resistance welding process

Key Indicators:

- 3.2.1 Explain the resistance welding (RW) processes including essential parameters for spot, seam, and projection welding
- 3.2.2 Describe electrode design
- 3.2.3 Identify the Lobe Curve Weldability concept for resistance spot welding (RSW)
- 3.2.4 List the advantages, quality issues and limitations in relation to other joining processes

BIL: Recommended

EDU:	12	AD
	P	R

Competency 3.3 Explain the oxy-fuel gas welding processes

Key Indicators:

- 3.3.1 Explain the oxy-fuel gas welding equipment
- 3.3.2 Explain the differences of neutral, reducing and oxidizing flames
- 3.3.3 List the advantages, quality issues and limitations in relation to other joining processes

BIL: Recommended

EDU:	12	AD
	P	R

Competency 3.4 Explain the thermit welding process

Key Indicators:

- 3.4.1 Explain the thermit chemical reaction and consumables
- 3.4.2 Identify the uses of thermit welding
- 3.4.3 Compare thermit welding process to other joining processes

BIL: Recommended

EDU:	12	AD
	P	R

Competency 3.5 Explain the solid state bonding processes

Key Indicators:

- 3.5.1 List the solid state bonding processes and explain where they fit in relation to the welding process chart
- 3.5.2 Explain the various types of solid state bonding processes (friction welding (FRW) solid state, diffusion welding, etc.)
- 3.5.3 Explain the diffusion welding (DFW) process.
- 3.5.4 Explain the ultrasonic welding (USW) process
- 3.5.5 Explain the explosion welding (EXW) process
- 3.5.6 Explain the friction stir welding (FSW) process
- 3.5.7 Compare solid state bonding to other joining processes

BIL: Essential

EDU:	12	AD
	P	R

Competency 3.6 Explain the high energy density fusion welding processes

Key Indicators:

- 3.6.1 Explain the laser and electron beam welding processes.
- 3.6.2 Explain beam focusing
- 3.6.3 Explain keyhole welding mode
- 3.6.4 Explain how these processes can be used
- 3.6.5 Explain advantages and limitations of laser welding and electron beam welding

BIL: Essential

EDU:	12	AD
	P	R

Competency 3.7 Explain the brazing and soldering processes

Key Indicators:

- 3.7.1 Explain the differences between the brazing and soldering processes and where they fit in the welding chart
- 3.7.2 Explain the advantages and limitations of brazing and soldering
- 3.7.3 List the various heat sources used in brazing and soldering

BIL: Essential

EDU:	12	AD
	P	R

Competency 3.8 Explain the processes used for joining of plastics

Key Indicators:

- 3.8.1 Explain the different types of polymeric materials
- 3.8.2 Describe the processes used for plastic welding including: hot plate, hot gas, infrared, vibration, and ultrasonic
- 3.8.3 Explain the advantages and limitations of each process

BIL: Essential

EDU:	12	AD
	P	R

Competency 3.9 Explain adhesive bonding of parts

Key Indicators:

- 3.9.1 Explain the different types of adhesive materials (thermosets & thermoplastics)
- 3.9.2 Describe the benefits (problems) of the various modes
- 3.9.3 Describe adhesive selection criteria
- 3.9.4 Explain the advantages and limitations of adhesive bonding

BIL: Essential

EDU:	12	AD
	P	R

Competency 3.10 Develop a manual welding procedure for the bonding of thermoplastic parts using a hot air gun

Key Indicators:

- 3.10.1 Select a hot air gun for the bonding of three different plastics
- 3.10.2 Determine the welding parameters for welding the three plastics
- 3.10.3 Perform welds with the determined welding procedures
- 3.10.4 Analyze weld quality
- 3.10.5 Prepare a written report describing the best welding procedure for part manufacture

BIL: Essential

EDU:	12	AD
	P	R

Competency 3.11 Develop a resistance weldability “Lobe Curve” using a virtual on-line resistance welding machine

Key Indicators:

- 3.11.1 Examine the resistance welding press type welder by disassembling the machine
- 3.11.2 Document the various systems (cooling, mechanical, power) in the welding using written text and figures
- 3.11.3 Perform welds at a variety of weld currents and weld times using constant squeeze pressure
- 3.11.4 Analyze the effects of weld current and weld time on surface and internal expulsion
- 3.11.5 Analyze weld quality of actual RW weld samples
- 3.11.6 Develop the weldability “Lobe Curve” and prepare a written report describing the best welding procedure for part manufacture

Unit 4: Physics of Welding

BIL: Essential

EDU:	12	AD
	P	R

Competency 4.1 Explain the concept of welding heat input

Key Indicators:

- 4.1.1 Explain the concept of heat input from welding arcs
- 4.1.2 Explain Heat transfer efficiency
- 4.1.3 Explain melting efficiency
- 4.1.4 Describe other energy sources used for welding

BIL: Essential

EDU:	12	AD
	P	R

Competency 4.2 Describe the characteristics of the welding arc

Key Indicators:

- 4.2.1 Describe the conduction of current through the arc and the relationship of conducting

- particles to temperature
- 4.2.2 Describe the Cathode Drop, Anode Drop and Plasma regions
 - 4.2.3 Describe the importance of thermionic work function and ionization potential to arc establishment
 - 4.2.4 Describe the arc voltage-current characteristic curves for various arc welding processes
 - 4.2.5 Describe the effect of arc length and shielding gases on the arc voltage-current characteristic curve

BIL: Essential

EDU:	12	AD
	P	R

Competency 4.3: Describe the physics of metal transfer

Key Indicators:

- 4.3.1 Describe the metal transfer in various welding processes
- 4.3.2 Describe the pinch effect on molten droplet formation
- 4.3.3 Describe the transfer mode transition between short circuit, globular, and spray transfer with current
- 4.3.4 Describe the effects of wire feed rate on welding current
- 4.3.5 Describe pulsed arc transfer mode
- 4.3.6 Describe the effect of wire size on deposition rate and current ranges

BIL: Essential

EDU:	12	AD
	P	R

Competency 4.4: Describe the physics of the arc welding power sources

Key Indicators:

- 4.4.1 Using the power sources table, describe the different types of arc welding machines including AC, DC, Constant Current and Constant Voltage
- 4.4.2 Construct the machine voltage-current characteristic curves
- 4.4.3 Describe methods to convert input power to output power (e.g. inverters)
- 4.4.4 Describe the relationship between arc characteristics and machine characteristics and the stable arc position
- 4.4.5 Describe self regulation of arcs

BIL: Essential

EDU:	12	AD
	P	R

Competency 4.5: Describe the physics of arc blow

Key Indicators:

- 4.5.1 Describe conditions when arc blow occurs
- 4.5.2 List ways to reduce arc blow

Unit 5: Heat Flow

BIL: Essential

EDU:	12	AD
	P	R

Competency 5.1: Describe heat flow in welds

Key Indicators:

- 5.1.1 Describe conduction, convection and radiation heat transfer
- 5.1.2 Describe heat flow in the welding arc
- 5.1.3 Describe the effect of shielding gas on arc heat flow

BIL: Essential

EDU:	12	AD
	I	P

Competency 5.2: Describe how heat flow affects the temperature profile around a weld

Key Indicators:

- 5.2.1 Describe Fourier's law of heat flux
- 5.2.2 Describe conservation of energy as it applies to heat flow

BIL: Essential

EDU:	12	AD
	I	P

Competency 5.3 Develop a thermal profile around a moving weld

Key Indicators:

- 5.3.1 Examine the thermal profile from a moving arc weld provided in the thermal modeling tool
- 5.3.2 Prepare a virtual test sample by placing one with thermocouples in the plate.
- 5.3.3 Produce heating and cooling curves from the thermocouples when the weld profile moves across the plate.
- 5.3.4 Prepare a written report describing the thermal traces obtained.
- 5.3.5 Develop the thermal profile of a moving weld

Unit 6: Metallurgical Background

BIL: Essential

EDU:	12	AD
	P	R

Competency 6.1: Define phases of matter and phase changes during solidification

Key Indicators:

- 6.1.1 Describe the phases of matter
- 6.1.2 Describe the phase nucleation and growth in solidification
- 6.1.3 Describe the temperature time cooling curve for solidification of a pure metal

BIL: Essential

EDU:	12	AD
	P	R

Competency 6.2: Explain the common crystal structures in metallic materials

Key Indicators:

- 6.2.1 Draw a cubic, face centered cubic, body centered cubic and hexagonal close packed crystal structures
- 6.2.2 Describe what “close packed” means
- 6.2.3 Calculate the number of atoms per cell in the crystal structures illustrated above

BIL: Essential

EDU:	12	AD
	I	P

Competency 6.3: Explain imperfection in crystal structure

Key Indicators:

- 6.3.1 Define point line and surface imperfection in metal crystal structure
- 6.3.2 Illustrate the type of point imperfections and indicate their effect on material properties
- 6.3.3 Define edge and screw dislocations and illustrate their effect on material properties
- 6.3.4 Define grain boundaries

BIL: Essential

EDU:	12	AD
	I	P

Competency 6.4: Define phase changes and phase diagrams

Key Indicators:

- 6.4.1 Define allotropic phase changes as a function of temperature (use iron as an example)
- 6.4.2 Define the production of alloys by substitution and interstitial alloying
- 6.4.3 Define an equilibrium phase diagram for iron alloys
- 6.4.4 Define “Component” “Phase” and “Constituent”

BIL: Essential

EDU:	12	AD
	I	P

Competency 6.5: Define phase changes of eutectoid steels

Key Indicators:

- 6.5.1 Define the constituent structure when slowly cooling a eutectoid steel from austenite to pearlite
- 6.5.2 Define the constituent structure when rapidly cooling a eutectoid steel from austenite to martensite

BIL: Essential

EDU:	12	AD
	I	P

Competency 6.6: Explain tie line

Key Indicators:

- 6.6.1 Define the tie line concept for calculating percent of a phase in the two phase region of equilibrium diagrams
- 6.6.2 Calculate and show illustrations of the phases present in the two phase pro-eutectoid ferrite region

BIL: Essential

EDU:	12	AD
	I	P

Competency 6.7: Explain transformation strengthening

Key Indicators:

- 6.7.1 Define martensite structure
- 6.7.2 Define the continuous cooling curve and critical cooling rate
- 6.7.3 Compare structures and properties obtained with different cooling rates
- 6.7.4 Define tempering of martensite

BIL: Essential

EDU:	12	AD
	I	P

Competency 6.8: Explain deformation strengthening

Key Indicators:

- 6.8.1 Define cold work, and demonstrate increased strength with reduced ductility
- 6.8.2 Define annealing with recover, recrystallization and grain growth

BIL: Essential

EDU:	12	AD
	I	P

Competency 6.9: Explain precipitation strengthening

Key Indicators:

- 6.9.1 Define solution annealing
- 6.9.2 Define precipitation
- 6.9.3 Define overaging

Unit 7: Welding Metallurgy**BIL: Essential**

EDU:	12	AD
	P	R

Competency 7.1: Define weld regions**Key Indicators:**

- 7.1.1 Define composite zone
- 7.1.2 Define heat affected zone
- 7.1.3 Define base metal

BIL: Essential

EDU:	12	AD
	I	P

Competency 7.2: Define fusion and unmixed zones**Key Indicators:**

- 7.2.1 Define composite zone solidification describing epitaxial nucleation and growth
- 7.2.2 Define constitutional supercooling and its effect on dendrite morphology
- 7.2.3 Define competitive growth
- 7.2.4 Define composite zone hot cracking
- 7.2.5 Define the unmixed zone

BIL: Essential

EDU:	12	AD
	I	P

Competency 7.3: Define the partially melted zone**Key Indicators:**

- 7.3.1 Define the partially melted zone
- 7.3.2 Define non homogeneity liquation
- 7.3.3 Define constitutional liquation

BIL: Essential

EDU:	12	AD
	I	P

Competency 7.4: Define the heat affected zone

Key Indicators:

- 7.4.1 Define the heat affected zone
- 7.4.2 Define the thermal cycles associated with the heat affected zone
- 7.4.3 Define the HAZ differences between material with allotropic and non-allotropic transformations
- 7.4.4 Define HAZ effects on cold worked alloy
- 7.4.5 Define HAZ structure effect on precipitation strengthened alloys and effect of welding in the solution annealed and as aged conditions
- 7.4.6 Define the effect of cooling rate on HAZ structure in materials with allotropic transformations
- 7.4.7 Define cold cracking in the HAZ and preventative measures
- 7.4.8 List post weld heat treatment methods and their effects on the material properties of the heat affected zone

BIL: Essential

EDU:	12	AD
	I	P

Competency 7.5: Define the base metal zone

Key Indicators:

- 7.5.1 Define the base metal zone
- 7.5.2 Define Lamellar Tearing in the base metal and ways of prevention
- 7.5.3 Define the problems associated with multi-pass welds in HAZ and base metal reheat cracking

Unit 8: Design

BIL: Essential

EDU:	12	AD
	P	R

Competency 8.1: Explain mechanical properties of materials

Key Indicators:

- 8.1.1 Define the difference between structure sensitive properties and structure insensitive properties
- 8.1.2 Describe the tensile test and measure engineering properties like stress, strain, yield stress, ultimate tensile stress, elongation and modulus
- 8.1.3 Define elastic and plastic deformation
- 8.1.4 Describe the bend test

BIL: Essential

EDU:	12	AD
	I	P

Competency 8.2: Explain fatigue properties of materials**Key Indicators:**

- 8.2.1 Define fatigue and its effect on materials
- 8.2.2 Describe fatigue fracture appearance
- 8.2.3 Define the fatigue stress-number of cycles to failure (SN) curve
- 8.2.4 Describe the metallurgical and design factors that promote fatigue losses

BIL: Essential

EDU:	12	AD
	I	P

Competency 8.3: Explain fracture toughness properties of materials**Key Indicators:**

- 8.3.1 Describe fracture toughness and toughness testing
- 8.3.2 Describe the factors that effect fracture toughness
- 8.3.3 Describe Charpy Toughness Testing
- 8.3.4 Interpret the data obtained from Charpy toughness testing to define the ductile-brittle transition.
- 8.3.5 Describe the effect of discontinuities on toughness

BIL: Essential

EDU:	12	AD
	P	R

Competency 8.4: Explain hardness properties of materials

Key Indicators:

8.4.1 Describe hardness indentation testing

8.4.2 Describe the relationship between hardness and other material properties

BIL: Recommended

EDU:	12	AD
	I	P

Competency 8.5: Explain creep testing of materials**Key Indicators:**

8.5.1 Describe the creep stages in materials

8.5.2 Describe creep testing and creep testing machines

BIL: Recommended

EDU:	12	AD
	P	R

Competency 8.6: Explain other physical properties**Key Indicators:**

8.6.1 Describe physical properties in materials

8.6.2 Describe corrosion, optical, wear and nuclear properties of materials

BIL: Essential

EDU:	12	AD
	P	R

Competency 8.7: Explain weld joint design**Key Indicators:**

8.7.1 Describe the various joint designs used in weldments

8.7.2 Describe the various parts of the weld joint

8.7.3 Describe the various positions in which the weld joint can be welded

8.7.4 Describe the loading of joints

BIL: Essential

EDU:	12	AD
	P	R

Competency 8.8 Explain the use of codes and standards

Key Indicators:

- 8.8.1 Describe the differences between codes and standards
- 8.8.2 Describe the types of standards writing bodies
- 8.8.3 Describe what is covered by codes and standards

BIL: Essential

EDU:	12	AD
	P	R

Competency 8.9: Explain the use of codes and standards in weldment joint design

Key Indicators:

- 8.9.1 Describe pre-qualified joint designs and specifications
- 8.9.2 Describe the use of codes and standards in static loaded joints
- 8.9.3 Describe the use of codes and standards in dynamic loaded joints
- 8.9.4 Describe the use of codes and standards in welding economics

BIL: Essential

EDU:	12	AD
	P	R

Competency 8.10: Explain the use of welding symbols to communicate weld design

Key Indicators:

- 8.10.1 Describe the AWS welding symbol system
- 8.10.2 Demonstrate the application of welding symbols to weld joint design

BIL: Essential

EDU:	12	AD
	I	P

Competency 8.11: Explain residual stresses and distortion in weldments

Key Indicators:

- 8.11.1 Describe the formation of residual stresses
- 8.11.2 Illustrate the formation of weld residual stresses
- 8.11.3 Explain the residual stress effects on weldment function (e.g. distortion, fatigue limits, etc.)
- 8.11.4 Explain pre and post weld methods for residual stress reduction

BIL: Essential

EDU:	12	AD
	P	R

Competency 8.12: Explain the development of welding procedures and weld qualifications**Key Indicators:**

- 8.12.1 Describe the basic steps in weld procedure qualification
- 8.12.2 Describe procedure qualification records
- 8.12.3 Describe welder qualifications
- 8.12.4 Describe the welding procedure specification
- 8.12.5 Describe the purpose of procedure qualification records (PQR), welding procedure specification. (WPS), welder performance qualification record (WPQR)

BIL: Essential

EDU:	12	AD
	P	R

Competency 8.13 Design a welded structure**Key Indicators:**

- 8.13.1 Define the various aspects involved in designing a structure including: mechanical and physical properties of materials, joint design, weld stresses and distortion, codes and standards
- 8.13.2 Select (from a list of examples or propose from your own experience) a useful device which can be manufactured with a welded construction.
- 8.13.3 Utilize proper design criteria to engineer this welded structure fit for service structure
- 8.13.4 Document the design project with engineering drawings and process procedure using isometric and orthographic drawings of the part complete with welding symbols.
- 8.13.5 Construct the welded structure with the most desirable welding process and material with cost justification

BIL: Essential

EDU:	12	AD
	P	R

Competency 8.14 Evaluate a failed structure

Key Indicators:

- 8.14.1 Describe the samples required from a failed aircraft structural component in order to evaluate the cause of failure.
- 8.14.2 Select the appropriate metallurgical and mechanical samples
- 8.14.3 Test the samples
- 8.14.4 Analyze data
- 8.14.5 Prepare a written report describing the cause of the failure, proper repair techniques, and primary design or material selection changes to avoid such failures in the future

Unit 9: Testing and Inspection

BIL: Essential

EDU:	12	AD
	P	R

Competency 9:1: Explain the factors considered in weld quality

Key Indicators:

- 9.1.2 Describe weld quality related to design, fabrication and operation
- 9.1.3 Describe visual weld examination in regard to: size, shape, contour and soundness

BIL: Essential

EDU:	12	AD
	P	R

Competency 9.2: Explain discontinuity and defect

Key Indicators:

- 9.2.1 Describe the differences between discontinuity and defect in a welded structure
- 9.2.2 Classify the occurrences of discontinuities
- 9.2.3 Define ways to reduce or eliminate each type of discontinuity

BIL: Essential

EDU:	12	AD
	P	R

Competency 9.3: Explain destructive weldment testing techniques

Key Indicators:

- 9.3.1 Describe how destructive test help reveal discontinuities
- 9.3.2 Describe tensile tests and test sample locations
- 9.3.3 Describe bend tests and sample selection
- 9.3.4 Describe fatigue tests and sample locations
- 9.3.5 Describe corrosion tests

BIL: Recommended

EDU:	12	AD
	I	P

Competency 9.4: Explain weldability tests

Key Indicators:

- 9.4.1 Describe weldability tests for hydrogen cracking
- 9.4.2 Describe weldability tests for Lamellar Tearing
- 9.4.3 Describe weldability tests for hot cracking
- 9.4.4 Describe weldability tests for hot ductility

BIL: Essential

EDU:	12	AD
	P	R

Competency 9.5: Explain the need for nondestructive examination

Key Indicators:

- 9.5.1 Describe the need for nondestructive testing techniques
- 9.5.2 List the type of NDE procedures that can be performed

BIL: Essential

EDU:	12	AD
	P	R

Competency 9.6: Perform visual examination

Key Indicators:

- 9.6.1 Describe visual examination techniques
- 9.6.2 Describe benefits and limitations of visual examination
- 9.6.3 Use the tools needed for visual examination

BIL: Essential

EDU:	12	AD
	P	R

Competency 9.7: Describe dye penetrant examination

Key Indicators:

- 9.7.1 Describe dye penetrant techniques
- 9.7.2 Describe benefits and limitations of dye penetrant
- 9.7.3 Describe the tools needed for dye penetrant

BIL: Essential

EDU:	12	AD
	P	R

Competency 9.8: Describe magnetic particle examination

Key Indicators:

- 9.8.1 Describe magnetic particle techniques
- 9.8.2 Describe benefits and limitations of magnetic particle
- 9.8.3 Describe the tools needed for magnetic particle

BIL: Essential

EDU:	12	AD
	I	P

Competency 9.9: Explain radiographic examination

Key Indicators:

- 9.9.1 Describe radiographic examination techniques
- 9.9.2 Describe benefits and limitations of radiographic examination
- 9.9.3 Describe the equipment needed for radiographic examination
- 9.9.4 Describe exposure enhancement
- 9.9.5 Examine radiographs

BIL: Recommended

EDU:	12	AD
	P	R

Competency 9.10: Describe eddy current examination

Key Indicators:

- 9.10.1 Describe eddy current examination techniques
- 9.10.2 Describe benefits and limitations of eddy current examination
- 9.10.3 Describe the equipment needed for eddy current examination

BIL: Essential

EDU:	12	AD
	P	R

Competency 9.11: Describe ultrasonic examination

Key Indicators:

- 9.11.1 Describe ultrasonic examination techniques
- 9.11.2 Describe benefits and limitations of ultrasonic examination
- 9.11.3 Describe the tools needed for ultrasonic examination

BIL: Recommended

EDU:	12	AD
	P	R

Competency 9.12: Describe acoustic emission examination

Key Indicators:

- 9.12.1 Describe acoustic emission examination techniques
- 9.12.2 Describe benefits and limitations of acoustic emission examination
- 9.12.3 Describe the equipment needed for acoustic emission examination

BIL: Essential

EDU:	12	AD
	P	R

Competency 9.13: Examine a weld structure

Key Indicators:

- 9.13.1 Define the various aspects involved in designing a structure including: mechanical and physical properties of materials, joint design, weld stresses and distortion, codes and standards
- 9.13.2 Utilize proper design criteria to engineer a welded structure fit for service.
- 9.13.3 Document the design project with engineering drawings and process procedure.
- 9.13.4 Construct the welded structure with the most desirable welding process and material with cost justification

BIL: Essential

EDU:	12	AD
	P	R

Competency 9.14 Appraise the quality of a welded part by non-destructive examination**Key Indicators:**

- 9.14.1 Select a welded part from a supply of parts. (This might be the part designed/built above, or representative parts from auto sales firm or junk yard etc.)
- 9.14.2 Determine a suitable non-destructive testing technique to be used to examine the part (visual, dye penetrant, magnetic particle, etc.)
- 9.14.3 Perform an inspection using one or more techniques
- 9.14.4 Prepare a written report describing the results of the NDE

Unit 10: Safety**BIL: Essential**

EDU:	12	AD
	P	R

Competency 10.1: Describe the importance of safety training**Key Indicators:**

- 10.1.1 Describe safety training importance
- 10.1.2 Describe safety warnings and material safety data sheets (MSDS)
- 10.1.3 Describe a variety of AWS safety and health materials
- 10.1.4 Review OSHA standards for workplace safety
- 10.1.5 Employ lock-out tag-out procedures

BIL: Essential

EDU:	12	AD
	P	R

Competency 10.2: Assess work area safety

Key Indicators:

- 10.2.1 Describe importance of general housekeeping and tripping hazards
- 10.2.2 Prepare for unexpected emergencies
- 10.2.3 Describe proper storage and handling of equipment
- 10.2.4 Describe protection from inhalation hazards
- 10.2.5 Identify workplace safety hazards and corrective actions

BIL: Essential

EDU:	12	AD
	P	R

Competency 10.3: Practice personal safety and select appropriate equipment

Key Indicators:

- 10.3.1 Describe protective clothing
- 10.3.2 Describe eye protection equipment
- 10.3.3 Employ proper lens shade selection for selected processes
- 10.3.4 Assess protection needs of other personnel
- 10.3.5 Demonstrate proper use of hearing protection

BIL: Essential

EDU:	12	AD
	P	R

Competency 10.4: Describe fumes, gasses and toxic materials

Key Indicators:

- 10.4.1 Describe fume generation and its dangers
- 10.4.2 Describe potential safety hazards with gasses
- 10.4.3 Describe the possibility of toxic materials
- 10.4.4 Describe ventilation and other means of protection
- 10.4.5 List methods used to measure fume exposure levels

BIL: Essential

EDU:	12	AD
	P	R

Competency 10.5: Demonstrate gas storage safety

Key Indicators:

- 10.5.1 Describe gas storage bottles and threads
- 10.5.2 Describe gas safety equipment
- 10.5.3 Demonstrate gas handling

BIL: Essential

EDU:	12	AD
	P	R

Competency 10.6: Demonstrate fire safety

Key Indicators:

- 10.6.1 Describe components needed to support a fire
- 10.6.2 Describe the classes of fire extinguishers
- 10.6.3 Describe welding conditions which may result in fires and the proper extinguishing techniques

BIL: Essential

EDU:	12	AD
	P	R

Competency 10.7: Demonstrate electrical safety

Key Indicators:

- 10.7.1 Describe sources of electrical shock
- 10.7.2 Describe electrical safety procedures

BIL: Essential

EDU:	12	AD
	P	R

Competency 10.8: Demonstrate radiation safety

Key Indicators:

10.8.1 Describe sources of radiation hazards

10.8.2 Describe radiation safety procedures

BIL: Essential

EDU:	12	AD
	P	R

Competency 10.9 Demonstrate proper ergonomic practices

Key Indicators:

10.9.1 Describe ergonomic hazards

10.9.2 Explain ergonomic corrective actions

10.9.3 Explain the relationship between ergonomics safety and cost

Materials Joining Technology TCP

Business Panel Participants:

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Dr. Dave Dickerson, Professor, Ohio State University

Chuck Drews, Honda of America

Christopher Hayes, Whirlpool

Richard McGuire, National Board of Boiler and Pressure Vessel Inspectors

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