

The Welding Industry:



Trends and Challenges in Education and Training

 **Weld-Ed**

National Center for Welding Education and Training

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Executive Summary

The National Center for Welding Education and Training (Weld-Ed) is tasked with addressing the hiring and professional development needs of the welding industry by improving the quality of welding education and training. In support of this mission, Weld-Ed has undertaken research to determine the projected demand for welders to compare that need to the supply of workers entering the field. Previous research revealed that there is no national data collection effort to gather the numbers of those who successfully complete secondary career and technical education (CTE) programs.¹ The previous research also concluded that postsecondary data available from the Integrated Postsecondary Education Data System (IPEDS) was out of date and missing information about institutions that are known to have Welding/Welding Technology programs.

To provide insight into whether the educational system's output of completers of welding programs meets the projected demand for skilled workers, Weld-Ed commissioned additional research to:

- Describe the secondary and postsecondary school programs that teach Welding and Welding Technology;
- Report estimates of program enrollments in Welding and Welding Technology in secondary and postsecondary schools;
- Report estimates of program output as evidenced by counts of program completions in Welding and Welding Technology from secondary and postsecondary schools; and
- Report estimates of completers of registered apprenticeship programs for welding and related trades.

In support of these objectives, JBS conducted quantitative and qualitative research. JBS conducted Internet research to gather qualitative information about how Welding/Welding Technology education programs are administered in the U.S. Welders and welding technicians learn their trade in a variety of ways through secondary CTE programs; postsecondary programs at community colleges, technical schools, and universities; military training; on-the-job training; and registered apprenticeships. The focus of this report is to provide insights into the Welding/Welding Technology programs taught in secondary and postsecondary institutions and schools. In addition, the report describes the registered apprenticeships programs that teach welding either directly or for six trades for which welding is an important skill.²

The report also provides quantitative estimates of students who are enrolled in and who complete these programs. The estimates of program enrollees and completers are based on data collected from federal and state agencies supplemented by a survey of institutions that provide welding instruction. A comparison of the number of student enrollments to completions provides an indication of the growth or decline of a program's size, and is an indicator of the numbers of students in the pipeline of future workers. Survey results from a randomly selected sample of institutions known to offer Welding programs show an estimated 52,800 completed secondary programs and 32,600 completed postsecondary programs. The U.S. Bureau of Labor Statistics (BLS) reports a projected national demand or average annual openings for 72,000 *Welders, Cutters, Solderers,*

¹*The Welding Industry: A National Perspective on Workforce Trends and Challenges.* <http://www.weld-ed.org/NR/rdonlyres/F75C7675-0F14-4492-9969-0F3C63F02AFD/4572/TheWeldingIndustryNationalreport.pdf>

²Office of Apprenticeship, U.S. Department of Labor

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and Brazers and an additional 9,000 *Welding, Soldering, Brazing Machine Setters, Operators and Tenders* for the period from 2006-2016.³ However, several issues that arose during the research phase of this project indicate that nationally-aggregated program completer data represent a pool of individuals with a variety of sets of skills and education levels, complicating comparison with national demand figures.

For example, there is no national standard for program requirements for welding and welding technology, and there is no core set of knowledge and skills that defines what should be taught in a welding program. Consequently, programs vary widely in content and the length of training required for successful completion, and they tend to provide students with the training needed to apply welding skills in the dominant industries in the geographic region. Because there are several levels of welding education, simple counts of program enrollments and completers provide an oversimplified picture of the supply of workers. These issues should be considered when comparing the supply of and demand for welders.

In addition to the national estimates, this report provides estimates for the four states in which Weld-Ed partner schools operate (North Dakota, Ohio, Pennsylvania, and Texas) and additional information about registered apprenticeship programs for *Welders, Cutters, Solderers, and Brazers*.

Next Steps/Recommendations

The research undertaken to develop this report revealed the challenges in collecting data that present an accurate picture of the supply of qualified welders. Due to variations in education and training programs, the welding industry would benefit from the development of national accreditation standards for Welding/Welding Technology programs. The development of a core set of knowledge and skills used throughout the U.S. would provide confidence that program completers have a set of skills which qualify them to be an entry-level welder.

As the report indicates, there are very few reported apprenticeship programs in Welding/Welding Technology, though apprenticeship is frequently utilized in occupations which use welding as a skill. Developing registered apprenticeship standards and programs would be a potential strategy for enhancing the numbers of qualified entry-level welders.

Research findings also show that there are no available sources of completer data which compare in value to the output of an annual survey. An annual survey of secondary and postsecondary schools would provide an ongoing measure of program offerings and outputs which would be especially helpful in identifying new welding programs and schools as well as programs that are no longer offered.

The findings in this document are intended to serve as a resource for educational policy makers, program planners and developers, and career development counselors and facilitators to guide and enhance workforce development activities in the welding industry.

³ Bureau of Labor Statistics, Employment Projections Program: <http://data.bls.gov/oep/servlet/oep.noeted.servlet.ActionServlet>

I. Introduction

A. Weld-Ed Consortium

Weld-Ed is a dynamic partnership between business and industry, community and technical colleges, universities, the American Welding Society (AWS), and government. The mission of Weld-Ed is to improve the quality, quantity, and availability of welding technicians through advancement of educational curricula and instructor professional development. To accomplish this mission, the staff and partners work collaboratively on the development of new and improved curricula in all areas of the materials joining industry. In addition, faculty and instructors are provided continuing education opportunities throughout the academic year and in the summer months. New programs, specifically designed to train the next generation of workers and to upgrade the skills of existing workers, are being developed. The intended result of these efforts is to ensure that there is a sufficient supply of workers with the right skills to meet employers' needs.

B. Weld-Ed National Skill Panel

With funding from the National Science Foundation, Weld-Ed convened the Weld-Ed National Skill Panel to coordinate research on local and national workplace needs. The Weld-Ed National Skill Panel, in partnership with AWS, has undertaken an initiative to strengthen the welding industry through workforce development efforts. Workforce development focuses on identifying employer demand for skilled workers, recruitment and retention efforts, and workforce preparation as evidenced by education and training objectives and outcomes. In support of this effort, the Weld-Ed National Skill Panel has commissioned reports to analyze labor market data to show the demand for welders and related occupations and to show the supply of those trained to enter the field.

C. About this Report

In 2008, JBS International, Inc. (JBS) prepared two reports in support of the Weld-Ed National Skill Panel's initiative: [The Welding Industry: A National Perspective on Workforce Trends and Challenges](http://www.weld-ed.org/NR/rdonlyres/F75C7675-0F14-4492-9969-0F3C63F02AFD/4572/TheWeldingIndustrynationalreport.pdf)⁴ provides a national perspective on the demand for welders and [The Welding Industry: A Regional Perspective on Workforce Trends and Challenges](http://www.weld-ed.org/NR/rdonlyres/F75C7675-0F14-4492-9969-0F3C63F02AFD/4573/TheWeldingIndustryregionallocal-report.pdf)⁵ focuses on the regions surrounding Weld-Ed's educational partners. These reports address the employer demand for welders by providing relevant labor market information from existing national and state data resources. They identify the occupational outlook for five Standard Occupational Classification (SOC) occupations related to the four welding occupations identified by Weld-Ed: *Welder*, *Welding Technician*, *Welding Inspector*, and *Welding Engineer*. Additionally, the reports provide wage distributions of workers in the industry, concentrations of industries that employ welders, and education program completer data from IPEDS. The research conducted in support of these reports revealed insufficient national and state data resources to identify accurate estimates of Welding/Welding Technology program completers.

⁴ <http://www.weld-ed.org/NR/rdonlyres/F75C7675-0F14-4492-9969-0F3C63F02AFD/4572/TheWeldingIndustrynationalreport.pdf>

⁵ <http://www.weld-ed.org/NR/rdonlyres/F75C7675-0F14-4492-9969-0F3C63F02AFD/4573/TheWeldingIndustryregionallocal-report.pdf>

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AWS expressed a need for data collection that would establish a baseline of the number of students enrolled in welding programs and the number of completers in the most recent and current program years. To facilitate the data collection effort AWS provided access to a directory of schools that teach Welding and Welding Technology. The database of information includes: school location, contact information, and estimates of program capacity evidenced by the number of booths available at the school and the number of shifts or sessions available. The database does not include the number of students enrolled or the number of students who successfully complete a program of study.

This report seeks to expand on the initial supply-side research and provide AWS with data gathered from a survey of welding education institutions as well as information from the federal and state agencies that collect and produce registered apprenticeship information. A potential outcome of this effort would also be to establish a methodology of collecting such information in the future.

This report will support Weld-Ed and AWS workforce development initiatives by:

- Describing the secondary and postsecondary school programs that teach Welding and Welding Technology;
- Reporting the program enrollments in Welding and Welding Technology in secondary and postsecondary schools;
- Reporting program output by counts of program completions in Welding and Welding Technology from secondary and postsecondary schools; and
- Reporting completers of apprenticeship programs for welding and related trades.

The findings in this document are intended to serve as a resource for educational policy makers, program planners and developers, and career development counselors and facilitators to guide and enhance workforce development activities in the welding industry.

II. Welding Education and Training Programs

A. Secondary Welding Programs

Career and Technical Education

*CTE is a planned program of courses and learning experiences that begins with exploration of career options, supports basic academic and life skills, and enables achievement of high academic standards, leadership, preparation for industry-defined work, and advanced and continuing education.*⁶

*At the high school level, CTE is provided in three main settings: comprehensive high schools, full-time CTE high schools, and area or regional CTE schools serving multiple high schools. Comprehensive high schools typically have an academic focus, but also offer CTE either on or off site, the latter often at an area CTE school. Full-time CTE high schools emphasize CTE, but also offer academic course-work; students typically spend their entire school day at the school. Area CTE schools provide CTE part time to students who receive all or most of their academic instruction at their home high school. These schools may also serve postsecondary and adult students.*⁷

Career Clusters and Welding Programs

The U.S. Department of Education Office of Vocational and Adult Education (OVAE) administers and coordinates CTE programs under the Carl D. Perkins Career and Technical Education Act of 2006 (Perkins IV). To support states in their efforts to develop and implement CTE programs, OVAE and the National Association for State Directors of Career Technical Education Consortium recognize 16 career clusters that may be used as an organizing tool for curriculum and instruction design.⁸ The 16 career clusters are occupational categories with industry-validated knowledge and skill statements that define what students need to know and be able to do in order to succeed in a chosen field. Within each of the clusters, programs of study (also called “career pathways”) have been developed, which outline sequences of academic, career, and technical courses and training that begin as early as ninth grade and lead to progressively higher levels of education and higher-skilled positions in specific industries or occupations.⁹

Though the national career clusters serve as an organizing tool, states are individually responsible for curriculum design and instruction. As such, there is considerable variety to how welding is taught at the secondary level across the country as states design and offer CTE programs of study tailored to the industries that are vital to the region. For example, Iowa, a state heavily reliant on agriculture, offers welding as part of the Agricultural Production and Agricultural Mechanics programs.¹⁰ In such cases, welding may be taught as a course that is part of a broader program of study.

An occupational program consists of one or more courses, designed to provide the student with sufficient knowledge and skills to perform in a specific occupation.¹¹ In other words, in addition to getting the necessary academic credits needed to graduate, the student takes classes that

⁶ <http://www.k12.wa.us/careerteched>

⁷ National Center for Education Statistics, *Career and Technical Education in the United States: 1990 to 2005*. <http://nces.ed.gov/pubs2008/2008035.pdf>

⁸ See Table 13 in Appendix B for a complete list of the 16 National Career Clusters.

⁹ <http://www.ed.gov/about/offices/list/ovae/pi/cte/factsh/career-clstrs-prgrms-study-fs080528qa-kc.doc>

¹⁰ http://www.iowa.gov/educate/index.php?option=com_content&view=article&id=263&Itemid=1423

¹¹ <http://nces.ed.gov/ipeds/glossary/index.asp?searchtype=definitionraw&keyword=program&Search=Search>

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focus on a specific occupational area. The occupational area can be broad (e.g. construction or manufacturing), or more focused (e.g. carpenter, boilermaker, welder).

The following list illustrates the varying ways in which welding may be taught at the secondary level across the country.

- *Program within major cluster—e.g. Alabama*

In Alabama, the Manufacturing cluster is made up of four programs: Drafting Design Technology, Industrial Maintenance Technology, Precision Machining Technology, and Welding Technology.¹² The Welding Technology Program includes 10 courses ranging from Introduction to Welding Technology Level I to Advanced Gas Tungsten Arc Welding (GTAW) for Ferrous and Nonferrous Metals Level II.

- *Plan of study within pathway—e.g. Colorado*

In Colorado, the Manufacturing Cluster includes 6 pathways: Production/Process Technology; Manufacturing Production; Maintenance, Installation & Repair; Quality Assurance; Health, Safety & Environmental Assurance; and Logistics & Inventory Control. Welding and Soldering is a plan of study within the Production/Process Technology pathway.¹³

- *Program of study—e.g. Pennsylvania*

Pennsylvania offers 20 CTE programs of study including Welding Technology / Welder (CIP 48.0508).¹⁴ The program of study includes 13 technical units of study ranging from Principles of Welding in grade 10 to Manual Air Carbon Arc Cutting (CAC-A) in grade 12.¹⁵

- *Skill/course in non-welding focused program/pathway—e.g. Iowa*

In Iowa, welding skills are listed in the Content Standards and Benchmarks for Agricultural Production and Agricultural Mechanics. Iowa also offers an Introduction to Welding course in its Manufacturing Program.¹⁶

- *Welding not taught—e.g. Rhode Island*

"There are no organized welding classes being taught within the high schools in [Rhode Island] that I am aware of. It is possible that some students may receive instruction in welding techniques as a supplement to their occupational career and technical subject instruction, i.e., in an auto mechanics class or an auto body class or a machine shop class, but, nothing that could be classified as organized continuous instruction."¹⁷

For additional information about how welding is taught at the secondary level in each state see Table 12 in Appendix B for a complete list of states' secondary CTE Web sites.

¹² <http://alex.state.al.us/browseallStand.php?section=g>

¹³ http://www.coloradostateplan.com/default_cluster.htm

¹⁴ CIP stands for the Classification of Instructional Programs which provides a taxonomy to support the accurate tracking, assessment and reporting of fields of study and program completions activity. 48.0508 represents the program Welding Technology/Welder in the Career Cluster: Manufacturing.

¹⁵ http://www.pde.state.pa.us/career_edu/lib/career_edu/Welding_Introduction.pdf

¹⁶ http://www.iowa.gov/educate/index.php?option=com_content&view=article&id=263&Itemid=1423

¹⁷ Williams, Paul. "RE: Secondary School Welding Program Data Request." Email message. 4.3.2009

Welding Program Enrollment and Completer Data

To obtain information about program capacity we initially contacted the CTE directors in each state and the District of Columbia requesting data about program enrollments and completers for the Program Year (PY) 2007-2008. We received 34 responses.¹⁸ The responses indicate that in addition to variations in how welding is taught in each state, there are variations in how enrollment and completer data are collected. Variations include:

- *Level*—some states collect data only at the Career Cluster level, some states collect data at the program level, and some collect data at the course level.
- *Grade Participation*—some states offer CTE to students in grades 9-12 and some states offer CTE to only grades 10-12 or 11-12.
- *Completers*—some states consider ‘completers’ to include all students who have completed the course requirements; for other states, ‘completers’ are students who have logged 240 hours in a welding program and have graduated.
- *Enrollment/Completion*—some states provided only enrollment data.
- *Years Available*—some states have not yet collected 2008-2009 enrollment data.

Due to the discrepancies between states in the ways that data are collected and the ways welding programs are taught, data collected at the state level cannot be aggregated to the national level. Therefore, the data collection method was modified to include a random sample survey of secondary schools found in the AWS Welding School Locator database. A simple random sample of 1,227 secondary institutions was drawn to allow for rapid data collection. The planned sample was of sufficient size to allow for a confidence interval of plus or minus 1.6% at the 95% confidence level overall. 91 schools were identified as no longer offering welding. Interviews were completed with 603 secondary schools with a response rate of 53%. Of the 603 secondary institutions surveyed, 486 indicated that welding is taught as a program of study. Enrollment and completer data were gathered only for schools in which Welding/Welding Technology is taught as a program of study. Each respondent was asked to report the program enrollments and completers for the PY 2007-2008. The response data was weighted to provide estimates of enrollment and completer data for the overall population of 2,439 secondary institutions.¹⁹

The data collected includes the number of students enrolled in Welding/Welding Technology programs (enrollments) and the number of students who have successfully completed all requirements of those programs (completers). The enrollment figures include all students enrolled for all grade levels. Enrollment figures were obtained to provide an estimate of those in the ‘pipeline’ to fill jobs that require a knowledge and skill of welding and welding techniques. The completer estimates provide more specific labor supply estimates of potential new entrants into the workforce.

The following table shows the responses and weighted estimates from the survey questions: “How many students (all grades) were enrolled in program(s) for the 2007-2008 school year?” and “How many 12th grade or senior students are enrolled in the Welding/Welding Technology program for the 2008-2009 school year?” Data are broken out to identify the level of award and have been rounded to the nearest ten.

¹⁸ See Table 14 in Appendix B for state data responses.

¹⁹ See Section IV for a complete description of the survey methodology.

Table 1. 2007-2008 Welding/Welding Technology Secondary Enrollment

Weighted Enrolled Estimates		
	PY 2007-2008 all grades	PY 2008-2009 12th grade
By Award:		
Diploma	39,150	15,140
Associates	1320	980
Bachelors	0	0
Graduate	0	0
Short-term Certificate	18,940	6390
Long-term Certificate	22,030	9730
Other	19,430	6400
Total	100,870	38,640

Source: JBS Survey of Welding Institutions

Recalling that this response was obtained only from institutions indicating that Welding/Welding Technology was taught as a program of study, and that enrollment may include students in all grades, we see that the estimate of program enrollments nationwide exceeds 100,000 students. This figure taken alone would indicate that there is an adequate number of students in the pipeline to meet the estimated demand. Enrollment in the 12th grade is slightly more than a third of the three-grade estimate providing support that students are not dropping out of the programs. What those numbers do not show is the quality of content of the programs to adequately prepare entry-level welders and welding technicians.

The following table shows the responses and weighted estimates from the survey question: ‘How many students completed the Welding/Welding Technology program for the 2007-2008 school year?’ Data are broken out to identify the level of award.

Table 2. 2007-2008 Welding/Welding Technology Secondary Completers

Weighted Program Completer Estimates	
By Award:	
Diploma	19,370
Associates	840
Bachelors	0
Graduate	0
Short-term Certificate	7,170
Long-term Certificate	13,320
Other	9,700
Total	50,400

Source: JBS Survey of Welding Institutions

Responses regarding secondary completers indicate that an estimated 50,400 students successfully completed the requirements for a Welding/Welding Technology program nationwide. Of that number, over 800 were awarded an Associates Degree due to dual enrollment or a program associated with a 2-year college. What the data cannot tell us is whether the program completers entered the workforce, went on to further their education, or entered the military. Also of note: the estimated number of completers for PY 2007-2008 (50,400) is significantly larger than the estimated number of 12th grade students enrolled in Welding/Welding Technology programs in PY2008-2009 (38,640). The numbers for 12th grade enrollments would indicate an anticipated decrease in the number of completers expected for PY 2008-2009.

B. Secondary Welding in Weld-Ed Partner School Regions

This section provides detailed secondary welding program descriptions and available enrollment and completer data for the four states—North Dakota, Ohio, Pennsylvania, and Texas—in which Weld-Ed partner schools are located. The directors of CTE were contacted to gather information about how Welding/Welding Technology programs are administered and to collect the available enrollment and completer data.²⁰ Data were also collected from the survey of schools found in the AWS School Locator Directory. The discrepancies between the data illustrate differences in the ways states teach welding and the ways in which they collect enrollment and completer data.

North Dakota Secondary Welding Program

Program Description

North Dakota CTE is grouped by nine program areas: Agriculture Education; Business and Office Technology; Career Development; Family and Consumer Services; Health Careers; Information Technology; Marketing Education; Technology Education; and Trades, Industrial, and Technical. The Welding Technology program is one of 14 secondary programs contained within Technology, Education, and Trades. It consists of two courses: Welding Technology I and Welding Technology II. Course descriptions are as follows:

Welding Technology I introduces students to a career in welding. The course begins covering various types of metal welding, brazing, flame cutting, properties of metals, blueprint reading, electrical principles, welding symbols and mechanical drawing. Emphasis on applied academics, professional development, leadership, and organizational skills are integrated throughout the curriculum. Welding Technology I is a prerequisite course to Welding Technology II.

Welding Technology II provides advanced training in the various welding applications in preparation for college welding programs or entering employment. The course will adhere to American Welding Society standards in welding processes. Continued emphasis will be placed on applied academics, professional development, leadership, and organizational skills.²¹

The complete North Dakota Welding Content Standards document may be found at <http://www.nd.gov/cte/services/standards/docs/welding06.pdf>.

²⁰ See Table 14 in Appendix B for state responses.

²¹ Welding Technology: Secondary Programs. <http://www.nd.gov/cte/programs/trades-industry/secondary/welding.html#programs>

Data

To estimate PY 2007-2008 enrollment and completion data for North Dakota secondary schools, data from 9 randomly selected sample schools were weighted to represent all 33 North Dakota secondary schools in the database. The average number of students enrolled is 29 (confidence interval is from 18 to 41). This yields a total estimated enrollment of **748**. The average number of students who completed welding programs is 10 (confidence interval is from 4 to 16). This yields an estimated completer total of **260** students. Since the number of schools interviewed at the state level is small, these estimates have wide confidence intervals (the actual result is estimated to be within the numbers in the interval with a 95% confidence level). The estimates, therefore, must be used with caution until complete survey results become available in Fall 2009.

Ohio Secondary Welding Program

Program Description

Ohio CTE is grouped by 16 career fields: Agricultural and Environmental Systems, Arts and Communication, Business and Administrative Services, Construction Technologies, Education and Training, Engineering and Science Technologies, Finance Career Field, Government and Public Administration, Health Science, Hospitality and Tourism, Human Services, Information Technology, Law and Public Safety, Manufacturing Technologies, Marketing, and Transportation Systems.

The Welding and Cutting Program is contained in the Manufacturing Technologies Career Field which encompasses “technical and professional level careers in planning, managing, and performing the processing of materials into intermediate or final products and related professional and technical support activities.”²²

The Welding and Cutting Program includes the following units:

- Safety
- Materials Science, Inspection and Testing
- Engineering Drawings
- Welding Fabrication
- Oxyfuel Brazing and Soldering
- Shielded Metal Arc Welding (SMAW)
- Thermal Cutting
- Gas Metal Arc Welding (GMAW)
- Flux Core Arc Welding (FCAW)
- Gas Tungsten Arc Welding (GTAW)
- Advanced Welding Systems

Data

To estimate PY 2007-2008 enrollment and completion data for Ohio secondary schools, data from 28 randomly selected sample schools were weighted to represent all 144 Ohio secondary schools in the database. The average number of students enrolled is 85 (confidence interval is from 3 to 168). This yields a total estimated enrollment of **10126**. The average number of students who completed welding programs is 70 (confidence interval is from -10 to 150). This

²² The Ohio Manufacturing Technologies Technical Content Standards may be found at <http://www.ode.state.oh.us/GD/Templates/Pages/ODE/ODEPrimary.aspx?page=2&TopicID=1759&TopicRelationID=1775>.

yields an estimated completer total of **8311** students. Since the number of schools interviewed at the state level is small, these estimates have wide confidence intervals (the actual result is estimated to be within the numbers in the interval with a 95% confidence level). The estimates, therefore, must be used with caution until complete survey results become available in Fall 2009.

Pennsylvania Secondary Welding Program

Program Description

Pennsylvania offers 20 CTE programs of study including Welding Technology/Welder. The program provides students the opportunity to “learn safety practices and types and uses of electrodes and welding rods; properties of metals; blueprint reading; electrical principles; welding symbols and mechanical drawing; use of equipment for testing welds by ultrasonic methods and destruction and hardness testing; use of manuals and specification charts; use of portable grinders and chemical baths for surface cleaning; positioning and clamping; and welding standards established by the American Welding Society, American Society of Mechanical Engineers and American Bureau of Ships.”²³

The Secondary Competency Task List outlines core competencies covered by the program:²⁴

- Occupational Operation and Safety
- Principles of Welding
- Welding, Drawing, and Weld Symbol Interpretation
- Visual Examination, Inspection, and Testing
- Shielded Metal Arc Welding (SMAW)
- Gas Metal Arc Welding (GMAW)
- Flux Cored Arc Welding (FCAW)
- Gas Tungsten Arc Welding (GTAW)
- Manual Oxyfuel Gas Cutting (OFC)
- Mechanized Oxyfuel Gas Cutting (OFC)
- Manual Plasma Arc Cutting (PAC)
- Manual Air Carbon Arc Cutting (CAC-A)
- Brazing and Soldering

Data

To estimate PY 2007-2008 enrollment and completion data for Pennsylvania secondary schools, data from 25 randomly selected sample schools survey were weighted to represent all 128 Pennsylvania secondary schools in the database. The average number of students enrolled is 47 (confidence interval is from 35 to 58). This yields a total estimated enrollment of **4086**. The average number of students who completed welding programs is 23 (confidence interval is from 16 to 31). This yields an estimated completer total of **1900** students. Since the number of schools interviewed at the state level is small, these estimates have wide confidence intervals (the actual result is estimated to be within the numbers in the interval with a 95% confidence level). The estimates, therefore, must be used with caution until complete survey results become available in Fall 2009.

²³ Pennsylvania Welding Technology/Welder Program of Study. http://www.pde.state.pa.us/career_edu/lib/career_edu/Welding_Introduction.pdf

²⁴ http://www.pde.state.pa.us/career_edu/lib/career_edu/welding_template.pdf

²⁵ Catalog of Career and Technical Education Courses. <http://ritter.tea.state.tx.us/cte/catalog/catalog.html>

Texas Secondary Welding Program

Program Description

Texas offers CTE programs grouped by the 16 national career clusters.²⁵ Within the manufacturing cluster, the following programs of study are available: Health, Safety and Environmental Assurance, Logistics & Inventory Control, Maintenance, Installation & Repair, Manufacturing Production Process Development, Production, and Quality Assurance. Welding or Welding Technology is not listed as its own program of study under manufacturing. Rather, welding skills are taught in several manufacturing career related courses including:

- Introduction to Precision Metals Manufacturing Careers
- Metal Trades I and II
- Quality Control II
- Sheet Metal I
- WBL/Metal Technology Systems
- Welding I and II

Welding is also taught as part of the Agriculture, Food, and Natural Resources Cluster in two courses:

- Introduction to Agricultural Mechanics
- Agricultural Mechanics II

Data

To estimate PY 2007-2008 enrollment and completion data for Texas secondary schools, data from 82 randomly selected sample schools were weighted to represent all 414 Texas secondary schools in the database. The average number of students enrolled is 57 (confidence interval is from 47 to 67). This yields a total estimated enrollment of **13455**. The average number of students who completed welding programs is 29 (confidence interval is from 22 to 36). This yields an estimated completer total of **6579** students. Since the number of schools interviewed at the state level is small, these estimates have wide confidence intervals (the actual result is estimated to be within the numbers in the interval with a 95% confidence level). The estimates, therefore, must be used with caution until complete survey results become available in Fall 2009.

C. Postsecondary Welding Programs

*CTE spans secondary, postsecondary, and adult education levels. At the postsecondary level, career education is linked to preparation for employment in specific occupations or careers, although postsecondary credentials in career fields may also lead to further education.*²⁶

For the purposes of this study, postsecondary institutions include technical institutes (welding academies and centers of industry and technology), two-year degree granting institutions (community colleges) and four-year degree granting institutions (colleges and universities), and private institutions (private welding schools). These institutions grant postsecondary awards ranging from short-term certificates to bachelor's degrees. The following list provides three sample illustrations of award types and programs that grant the awards from a geographically diverse selection of postsecondary institutions.

²⁶ National Center for Education Statistics, *Career and Technical Education in the United States: 1990 to 2005*, <http://nces.ed.gov/pubs2008/2008035.pdf>

²⁷ <http://www.sheltonstate.edu/content.aspx?PageID=211>

- *Certificates—e.g., Shelton State Community College (Alabama)*

Award(s) Available: Certificate (54-55 Semester Hours) and Short-term Certificate (25 Semester Hours). The Welding Technology program is designed to establish welding skills necessary for entry-level job placements and enhance the skills of experienced welders in the various arc welding processes used by industry. The program also provides welder certification training for experienced welders as well as for beginning students.²⁷

- *Associates Degree—e.g., The University of Montana College of Technology (Montana)*

Award(s) Available: Welding Technology Associate of Applied Science Degree (4 semesters) and Certificate (2 semesters). “Welding students develop skills in six different welding processes—oxyacetylene, shielded metal arc, gas metal arc, flux core arc, submerged arc, and gas tungsten arc welding. They study the design and fabrication of jigs and related fixtures and learn how to test for, inspect, and repair defective welds. In addition, students study metallurgy and understand how the heating and cooling cycles of welding affect the properties of metals. Welding technology students have the opportunity to become certified to American Welding Society specifications and receive documentation stating qualifications.”²⁸

- *Bachelor’s Degree—e.g. Weber State University (Utah)*

Award(s) Available: Bachelor of Science (BS) Manufacturing Engineering Technology-Welding Emphasis. “This program [offers] a full four-year B.S. degree with an emphasis in Welding Engineering Technology. The program has six main areas of study: Welding and Manufacturing, Design and Structural, Metallurgical, Quality Assurance, Electrical, and Management.”²⁹

Welding Program Enrollment and Completer Data

The following preliminary postsecondary awards data come from IPEDS 2007 institutional characteristics and program completers. Completion counts are for July 1, 2006 through June 30, 2007. Program data in the IPEDS survey is collected using the Classification of Instructional Programs (CIP) taxonomy. The data covers completers counts reported under CIP codes: 48.0508 (Welding Technology/Welder), 46.0503 (Plumbing Technology/Plumber), and 47.0302 (Heavy Equipment Maintenance Technology/Technician) and excludes Puerto Rico and American Samoa.

Table 3. 2006-2007 Welding/Welding Technology IPEDS Completer Data

US Totals	Award Types				
	Less Than 2	Associates	Less Than 4	BA/BS	Total
	12,016	1,026	254	15	13,311

Source: IPEDS

There are discrepancies between the number of postsecondary institutions reported in the IPEDS database and the AWS School Locator database. For example, the IPEDS database identifies 46 postsecondary institutions that teach welding in Texas while the AWS School locator database

²⁸ <http://www.cte.umt.edu/industrialtech/welding>

²⁹ <http://weber.edu/COAST/welding.html>

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identifies 66. The most recent data from the IPEDS survey represents program completers from the PY 2006-2007. To allow the reported data to be consistent with secondary data collection methods, the postsecondary enrollment and completer data was derived from a survey of a random sample of postsecondary schools selected from the AWS School Locator database.

A simple random sample of 492 postsecondary institutions was drawn to allow for rapid data collection. The planned sample was of sufficient size to allow for a confidence interval of plus or minus 1.6% at the 95% confidence level overall. Interviews were completed with 259 postsecondary schools in the sample with a response rate of 56%. Of the 259 postsecondary institutions surveyed, 226 indicated that welding is taught as a program of study. Enrollment and completer data were gathered only for schools in which Welding/Welding Technology is taught as a program of study. Each respondent was asked to report the program enrollments and completers for the PY 2007-2008. The response data was weighted to provide estimates of enrollment and completer data for the overall population of 954 postsecondary institutions.³⁰

The following table shows the responses and weighted estimates from the survey questions: “How many students (all grades) were enrolled in program(s) for the 2007-2008 school year?” and “How many 12th grade or senior students are enrolled in the Welding/Welding Technology program for the 2008-2009 school year?” Data are broken out to identify the level of award and have been rounded to the nearest ten.

Table 4. 2007-2008 Welding/Welding Technology Postsecondary Enrollment and Completer Data

Weighted Enrolled		Weighted Completed	
By Award:		By Degree:	
Diploma	12,970	Diploma	7,250
Associates	44,610	Associates	14,960
Bachelors	1,040	Bachelors	380
Graduate	0	Graduate	0
Short-term Certification	19,670	Short-term Certification	6,670
Long-term Certification	10,420	Long-term Certification	6,560
Other	300	Other	150
Total	89,030		35,970

Source: JBS Survey of Welding Institutions

Weighted responses from the institutions in the sample show that nearly 36,000 successfully completed the requirements of postsecondary Welding/Welding Technology. This number is significantly higher than the 13,300 reported under the IPEDS data survey despite the different reporting periods.³¹ Based on the previous research, the discrepancy is most likely due to program completers reported under different CIP codes in the IPEDS survey or low response rates.

³⁰ See Section IV for a complete description of the survey methodology.

³¹ IPEDS - PY 2006-2007; Survey Reporting period PY 2007-2008

Of the number of completers estimated from the survey, approximately 42% were awarded an Associates Degree. Short-term and Long-term Certificate awards were evenly distributed at just under 20% of the awards reported. Data estimates of degrees conferred at the Bachelors level was 380. None of the institutions in the sample reported conferring graduate level degrees. The numbers of enrollees in postsecondary programs suggests that there is a good supply of students in the pipeline of potential workers.

D. Postsecondary Welding in Weld-Ed Partner School Regions

This section provides postsecondary welding program descriptions and available completer data for the four states—North Dakota, Ohio, Pennsylvania, and Texas—in which Weld-Ed partner schools are located. Note the variance in program content which provides insights into how welding programs are customized to fit the employer needs in the region.

North Dakota Postsecondary Welding Programs

There are six postsecondary institutions that offer welding programs in North Dakota in the AWS School Locator Database. They comprise 2-year, 4-year, and private institutions and offer a range of awards including Certificate, Diploma, and Associate Degree. The following description provides an overview of the Welding Technology program at the North Dakota State College of Science (NDSCS), the Weld-Ed partner school in North Dakota.

NDSCS offers a certificate, diploma, or Associate of Applied Science degree in Welding Technology. “The Welding curriculums are designed to provide students experience in welding as it pertains to assembly, manufacturing, energy and construction. This program provides education and training in common welding, robotics, CNC plasma cutting, CNC press brake operations, inspection, print reading, fabrication, pipe and plate welding, automated manufacturing, human relations, communications and other aspects of general education. Recent placement has been 100 percent.”³²

Data

To estimate PY 2007-2008 enrollment and completion data for North Dakota postsecondary schools, data from 5 randomly selected sample schools were weighted to represent all 6 North Dakota postsecondary schools in the database. The average number of students enrolled is 190 (confidence interval is from -263 to 643). This yields a total estimated enrollment of **684**. The average number of students who completed welding programs is 180 (confidence interval is from -276 to 636). This yields an estimated completer total of **648** students. Since the number of schools interviewed at the state level is small, these estimates have wide confidence intervals (the actual result is estimated to be within the numbers in the interval with a 95% confidence level). The estimates, therefore, must be used with caution until complete survey results become available in Fall 2009.

Ohio Postsecondary Welding Programs

There are 25 postsecondary institutions that offer welding programs in Ohio in the AWS School Locator Database. They comprise 2-year, 4-year, private, and technical institutions and offer a range of awards including: Short-Term Technical Certificate, One-Year Technical Certificate, Associate Degree, Bachelor of Science, Master of Science, and Doctor of Philosophy. The following descriptions provide overviews of the welding programs at Lorain County Community College and the Ohio State University, the Weld-Ed partner schools in Ohio.

³² <http://www.ndscs.nodak.edu/departments/techservdean/welding.jsp>

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The educational partner in Northeast Ohio, Lorain County Community College, offers a 2-year Associate of Applied Science in Welding Technology requiring 66 credit hours. "The Welding Technology Program is designed to provide students with the knowledge, skills, and behaviors necessary for the competent performance as a welding technician. The welding technician is the liaison between the welding engineer and the welder. The program is based on the occupational analyses and needs of the maintenance and fabrication welding industries. Employment opportunities exist in a variety of industries such as steel, construction, fabrication, pipelines, and others. Students who excel in the program may be qualified to take certain welding certification tests. Lorain County Community College has articulation agreements with colleges and universities including programs offered by Lorain County Community College's University Partnership."³³ Lorain County Community College also offers Short-Term and One-Year Technical Certificates in Welding.

The Ohio State University (OSU), the educational partner in Central Ohio, offers Welding Engineering Bachelor of Science, Master of Science, and Doctor of Philosophy programs. "The Welding Engineering Program at the Ohio State University is designed to train welding engineers to meet the challenges of manufacturing for the 21st century. The welding engineer is concerned with all of the activities related to the design, production, performance, and maintenance of welded products. Interest is primarily in the manufactured or fabricated product, including material selection, manufacturing methods, tooling, operator training, quality control, performance evaluation, sales, and service. The broad range of welded products with which welding engineers deal includes structures, such as bridges and buildings; pressure vessels and heat exchangers, such as nuclear systems, boilers, chemical processing equipment, storage vessels, and transmission and distribution piping; transportation vehicles for water, land, air, and space travel; and production and processing machines of all types."³⁴

Data

To estimate PY 2007-2008 enrollment and completion data for Ohio postsecondary schools, data from 8 randomly selected sample schools were weighted to represent all 40 Ohio postsecondary schools in the database. The average number of students enrolled is 73 (confidence interval is from 1240 to 663). This yields a total estimated enrollment of **1830**. The average number of students who completed welding programs is 45 (confidence interval is from 15 to 75). This yields an estimated completer total of **1130** students. Since the number of schools interviewed at the state level is small, these estimates have wide confidence intervals (the actual result is estimated to be within the numbers in the interval with a 95% confidence level). The estimates, therefore, must be used with caution until complete survey results become available in Fall 2009.

Pennsylvania Postsecondary Welding Programs

There are 10 postsecondary institutions that offer welding programs in Pennsylvania in the AWS School Locator Database. They comprise 2-year, 4-year, and private institutions and offer a range of awards including Certificate, Associate Degree, and Bachelor of Science. The following description provides an overview of the welding program at the Pennsylvania College of Technology, the Weld-Ed partner school in Pennsylvania.

³³ <http://www.lorainccc.edu/Academic+Programs/Associates+Degree+and+Certificate+Programs/wt.htm>

³⁴ http://www-iwse.eng.ohio-state.edu/programs_welding.cfm, http://www-iwse.eng.ohio-state.edu/programs_welding_bs.cfm

The Pennsylvania College of Technology offers a Welding Certificate, a Welding Technology Associate of Applied Science, and a Welding & Fabrication Engineering Technology Bachelor of Science degree. "The certificate curriculum offers practical skills, training, and welding with theory and practice in oxy-fuel welding, inert gas shielded metal arc welding, flux-core arc welding, shielded metal arc welding, non-destructive testing and quality assurance, and CNC plasma cutting. The associate [degree program] curriculum offers practical skills and theory in welding, quality assurance, welding design, robotic welding, CNC plasma cutting, non-destructive testing, plus the mathematics and language skills necessary to mature to a technical or management career in the welding and fabrication industries. The bachelor's degree program is structured to support welding and joining operations where engineers pass plans and projects to mid-management personnel who must carry out the planning, organization and delivery of manufacturing projects."³⁵

Data

To estimate PY 2007-2008 enrollment and completion data for Pennsylvania postsecondary schools, data from 3 randomly selected sample schools were weighted to represent all 17 Pennsylvania postsecondary schools in the database. The average number of students enrolled is 140 (confidence interval is from -204 to 484). This yields a total estimated enrollment of **2380**. The average number of students who completed welding programs is 120 (confidence interval is from -138 to 378). This yields an estimated completer total of **2040** students. Since the number of schools interviewed at the state level is small, these estimates have wide confidence intervals (the actual result is estimated to be within the numbers in the interval with a 95% confidence level). The estimates, therefore, must be used with caution until complete survey results become available in Fall 2009.

Texas Postsecondary Welding Programs

There are 66 postsecondary institutions that offer welding programs in Texas in the AWS School Locator Database. They comprise 2-year, 4-year, and private institutions and offer a range of awards including Certificate and Associate Degree. The following description provides an overview of the welding program at Texas State Technical College (TSTC) Waco, the Weld-Ed partner school in Texas.

TSTC Waco offers a one-year certificate program in Combination Welding and a two-year Associate of Applied Science degree in Welding Technology. "The welding programs at Texas State Technical College emphasize the development of real, hands-on welding, layout, and fitting skills. In addition to 180 ventilated arc welding stations and 20 oxy-acetylene stations, Welding Technology offers Combination Welding students instruction on plasma torches for oxy-acetylene and air carbon arc cutting. The one-year Combination Welding program focuses on the skills and knowledge required for the welder qualification test for the American Welding Society, Section IX of the American Society of Mechanical Engineers Code and the American Petroleum Institute. In addition to the Certificate of Completion, Welding Technology offers advanced exit points for specialized skill development."³⁶

Data

To estimate PY 2007-2008 enrollment and completion data for Texas postsecondary schools, data from 22 randomly selected sample schools were weighted to represent all 95 Texas postsecondary schools in the database. The average number of students enrolled is 162 (confidence interval

³⁵ <http://www.pct.edu/schools/iet/weld>

³⁶ <http://www.waco.tstc.edu/wlt/index.php>

³⁷ We contacted SAC states to fill in data for the missing states, but many states use different methodologies so comparison with OA data is not always possible.

is from 60 to 263). This yields a total estimated enrollment of **13257**. The average number of students who completed welding programs is 56 (confidence interval is from 26 to 86). This yields an estimated completer total of **4603** students. Since the number of schools interviewed at the state level is small, these estimates have wide confidence intervals (the actual result is estimated to be within the numbers in the interval with a 95% confidence level). The estimates, therefore, must be used with caution until complete survey results become available in Fall 2009.

E. Registered Apprenticeship

Registered apprenticeship is a combination of on-the-job training and related classroom instruction in which workers learn the practical and theoretical aspects of a highly skilled occupation. The registered apprenticeship system, established in 1937 with the National Apprenticeship Act, provides a framework for this form of training. Registered apprenticeship programs can be a partnership of business and organized labor as the primary operators of programs, or implemented by employers or employer associations. These employers or groups of employers and unions design, organize, manage, and finance registered apprenticeship programs under a set of standards, which include an on-the-job training outline, related classroom instruction curriculum, and the operating procedures.

Apprenticeship programs are registered with the U.S. Department of Labor's Office of Apprenticeship (OA) or an OA recognized State Apprenticeship Agency (SAA) often called State Apprenticeship Councils (SAC). The OA administers apprenticeship programs in 23 Bureau of Apprenticeship and Training (BAT) states, and oversees SACs which perform these functions in 27 SAC states, the District of Columbia, Puerto Rico, and the Virgin Islands.

The OA maintains the Registered Apprenticeship Partners Information Data System (RAPIDS) to collect information about apprenticeship programs. The OA collects completer data from the BAT states. SAC states voluntarily submit their completer data, so in some cases data from these states is missing.³⁷ All apprenticeable occupations are assigned a RAPIDS classification code to facilitate standardization of data collection.

The following table provides information about the apprenticeships that fit within the SOC classification for Welders, Welding Machine Operators, and Welding Inspectors. The table also lists the term length of training in hours, the type of training (Time-Based, Competency-Based, or a Hybrid), and the RAPIDS code.³⁸

³⁸ For more information on the three approaches to apprenticeship program completion see <http://www.doleta.gov/OA/CircularsFY05.cfm> and http://www.doleta.gov/OA/pdf/Three_Approaches_Apprenticeship_Program_Completion.pdf.

Table 5. Welding Apprenticeships

Weld-Ed Title	SOC Occupation	Registered Apprenticeship			
		Occupational Title	Term	Type of Training	RAPIDS Code
Welder	<i>Welders, Cutters, Solderers, and Brazers (51-4121)</i>	Welder, Arc	8000	Time-Based	620
		Welder, Combination	6000	Time-Based	622
		Lead Burner	8000	Time-Based	274
		Welderfitter	8000	Time-Based	627
	<i>Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders (51-4122)</i>	Welding Machine Oper, Arc	6000	Time-Based	945
Welding Technician	<i>Engineering Technicians, Except Drafters, All Other (17-3029)</i>	Welding Technician	8000	Time-Based	498
		Non-Destructive Tester	4000	Comp-Based	1010CB
		Laboratory Asst, Metallurgical	4000	Time-Based	621

Source: U.S. Department of Labor List of Officially Recognized Apprenticeshipable Occupations³⁹

There is only one apprenticeship occupational title associated with *Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders (51-4122)*—Welding Machine Operator, Arc. This is not a commonly apprenticed occupation; for 2008, OA reported two completers.

Three apprenticeship titles are associated with *Engineering Technicians, Except Drafters, All Other (17-3029)*. Again, there are few registered apprenticeships for this occupation: two completers for 2008.

Non-Destructive Testers are classified as *Engineering Technicians, Except Drafters, All Other (17-3029)*. A recent OA Bulletin is available for the occupation of Non-Destructive tester.⁴⁰ This Bulletin details the learning topics and types of non-destructive testing. Non-Destructive testing apprentices will receive Radiographic Technician training which may contribute to AWS's Radiographic Interpreter certification.

Registered apprenticeship is more frequently utilized for the occupation *Welders, Cutters, Solderers, and Brazers (51-4121)*. The table below reports completer totals for all occupational titles associated with SOC 51-4121.

³⁹ <http://www.doleta.gov/oa/bul08/apprenticeshipable%20occupations.xls>

⁴⁰ <http://www.doleta.gov/OA/BulletinsFY05.cfm>

Table 6. Welding Registered Apprenticeship Completers 2008

State	Welders, Cutters, Solderers and Brazers 51-4121	State	Welders, Cutters, Solderers and Brazers 51-4121
Alabama (BAT)	0	Montana (SAC)	0
Alaska (BAT)	0	Nebraska (BAT)	0
Arizona (SAC)	0	Nevada (SAC)	0
Arkansas (BAT)	0	New Hampshire (BAT)	15
California (BAT)	6	New Jersey (BAT)	0
Colorado (BAT)	1	New Mexico (SAC)	NA
Connecticut (SAC) ⁴¹	0	New York (SAC)	0
Delaware (SAC)	NA	North Carolina (SAC)	NA
Florida (SAC)	7	North Dakota (BAT)	0
Georgia (BAT)	0	Ohio (SAC)	3
Hawaii (SAC)	7	Oklahoma (BAT)	1
Idaho (BAT)	1	Oregon (SAC) ⁴²	0
Illinois (BAT)	0	Pennsylvania (SAC)	2
Indiana (BAT)	1	Rhode Island (SAC)	0
Iowa (BAT)	6	South Carolina (BAT)	3
Kansas (SAC)	NA	South Dakota (BAT)	0
Kentucky (SAC)	5	Tennessee (BAT)	12
Louisiana (SAC)	0	Texas (BAT)	0
Maine (SAC) ⁴³	NA	Utah (BAT)	0
Maryland (SAC) ⁴⁴	NA	Vermont (SAC)	NA
Massachusetts (SAC)	0	Virginia (SAC)	8
Michigan (BAT)	1	Washington (SAC)	8
Minnesota (SAC)	0	West Virginia (BAT)	6
Mississippi (BAT)	18	Wisconsin (SAC) ⁴⁵	0
Missouri (BAT)	72	Wyoming (BAT)	0
Total			183

Source: Office of Apprenticeship, U.S. Department of Labor
 NA – data not available

The table above indicates a total of 183 apprenticeship completers in 2008. The table also illustrates that many states do not offer apprenticeships in ‘welding’ occupations.

⁴¹ We contacted the Connecticut Department of Labor by email and phone. They reported that there are currently no registered welding apprenticeships in Connecticut.

⁴² Reported via email by Oregon Bureau of Labor Statistics.

⁴³ We contacted the Maine Department of Labor via email. They did not have this data available, but reported 57 completers, 58 cancelled, and 8 currently active since 1989.

⁴⁴ We contacted the Maryland Apprenticeship and Training Program by phone. They report 28 completers of the occupation Welder, Combination and 3 completers of Welding Technician since the inception of the program.

⁴⁵ See http://dwd.wisconsin.gov/apprenticeship/pdf/cancellation_completion_rates_bytrade.pdf, page 41.

Related Occupations

To varying degrees, welding is a skill applied in more than 25 trades or occupations.⁴⁶ As such, AWS requested apprenticeship data be collected for four main occupations in which welding is a critical component: Boilermakers, Millwrights, Pipefitters, and Ironworkers. Boilermakers, Millwrights, and Pipefitters align with the SOC titles *Boilermakers; Millwrights and Plumbers, Pipefitters, and Steamfitters*, respectively. Ironworker is not an SOC occupation title. To identify the ironworker occupations that use welding, we searched the term 'weld' using O*NET Online. The results showed three occupations similar to ironworkers among the top ten highest Relevance Scores: *Structural Metal Fabricators and Fitters, Sheet Metal Workers, and Structural Iron and Steel Workers*. The table below reports 2008 apprenticeship completers by state for these six identified occupations.

Table 7. Related Trades Apprenticeship Completers 2008

Apprenticeship Completers 2008						
	Boiler- makers	Plumbers, Pipefitters, and Steamfitters	Sheet Metal Workers	Structural Iron and Steel Workers	Mill- wrights	Structural Metal Fabricators and Fitters
Alabama (BAT)	0	39	15	22	3	0
Alaska (BAT)	0	31	11	2	5	0
Arizona (SAC)	14	29	16	10	7	0
Arkansas (BAT)	0	80	5	0	0	0
California (BAT)	0	182	128	51	26	40
Colorado (BAT)	0	104	19	33	0	0
Connecticut (SAC) ⁴⁷	NA	NA	NA	NA	NA	NA
Delaware (SAC)	NA	NA	NA	NA	NA	NA
Florida (SAC)	188	263	48	39	8	0
Georgia (BAT)	0	55	18	18	15	0
Hawaii (SAC)	0	17	1	0	5	0
Idaho (BAT)	0	15	17	3	6	0
Illinois (BAT)	153	263	98	107	26	0
Indiana (BAT)	2	249	53	95	32	0
Iowa (BAT)	0	57	43	38	8	0
Kansas (SAC)	NA	NA	NA	NA	NA	NA
Kentucky (SAC)	0	15	0	0	3	0
Louisiana (SAC)	0	1	0	0	0	0
Maine (SAC)	NA	NA	NA	NA	NA	NA
Maryland (SAC) ⁴⁸	NA	NA	NA	NA	NA	NA
Massachusetts (SAC)	0	2	0	0	0	0

(Table 7 continued on next page)

⁴⁶ American Welding Society, *Vision for the Welding Industry*.

⁴⁷ We contacted the Connecticut Department of Labor by email and phone. They reported that completer data is not publicly available.

⁴⁸ This data was not available using Standard Occupational Classification titles.

Table 7. Related Trades Apprenticeship Completers 2008

Apprenticeship Completers 2008						
	Boiler-makers	Plumbers, Pipefitters, and Steamfitters	Sheet Metal Workers	Structural Iron and Steel Workers	Mill-wrights	Structural Metal Fabricators and Fitters
Michigan (BAT) ⁴⁹	0	94	35	20	51	0
Minnesota (SAC)	0	0	8	0	0	0
Mississippi (BAT)	3	36	10	0	1	0
Missouri (BAT)	0	268	75	92	21	0
Montana (SAC)	1	0	0	0	0	0
Nebraska (BAT)	0	21	11	15	0	0
Nevada (SAC)	0	115	40	31	3	1
New Hampshire (BAT)	0	86	7	0	0	0
New Jersey (BAT)	9	219	55	25	1	0
New Mexico (SAC)	NA	NA	NA	NA	NA	NA
New York (SAC)	0	1	8	6	0	0
North Carolina (SAC)	NA	NA	NA	NA	NA	NA
North Dakota (BAT)	0	21	5	0	5	0
Ohio (SAC)	0	257	99	100	53	0
Oklahoma (BAT)	0	22	20	7	0	37
Oregon (SAC) ⁵⁰	0	140	49	55	6	0
Pennsylvania (SAC)	48	191	63	55	24	0
Rhode Island (SAC)	0	56	5	0	0	0
South Carolina (BAT)	0	0	2	0	0	0
South Dakota (BAT)	0	18	0	0	0	0
Tennessee (BAT)	0	33	24	26	6	4
Texas (BAT)	0	127	38	50	33	0
Utah (BAT)	0	33	25	6	0	0
Vermont (SAC)	NA	NA	NA	NA	NA	NA
Virginia (SAC)	16	23	16	5	3	3
Washington (SAC)	0	25	11	0	0	0
West Virginia (BAT)	0	32	32	12	0	0
Wisconsin (SAC)	0	5	0	0	0	0
Wyoming (BAT)	0	2	3	1	0	1
Total	434	3227	1113	924	351	86

Source: Office of Apprenticeship, U.S. Department of Labor
 NA – data not available

⁴⁹ For additional Michigan apprenticeship enrollment and completer data see: http://www.michigan.gov/documents/michigan_apprenticeship_enrollment_table_57135_7.htm.

⁵⁰ Oregon Bureau of Labor Statistics reported via email that currently Oregon does not have dedicated welding apprenticeship programs.

The totals indicate that registered apprenticeship programs for the six related trades are generating thousands of completers or journey workers every year. These counts should not be taken as indicators of an oversupply of welders since these new entrants to the workforce would most likely fill the projected openings for occupations in their respective occupational fields.

Information about apprenticeship opportunities has been provided to present the potential of registered apprenticeship as an alternative to more traditional forms of education. All the trades, except *Structural Metal Fabricators and Fitters*, report more apprenticeship completers than *Welding, Soldering, and Brazing Workers* in 2008. *Plumbers, Pipefitters and Steamfitters* has a comparable total employment with *Welding, Soldering, and Brazing Workers*, but more than 17 times as many apprenticeship completers, suggesting that apprenticeship is used as a training method for *Plumbers, Pipefitters, and Steamfitters* at a much higher rate.⁵¹ Further research could be directed at explaining why apprenticeship is utilized less frequently for welders, and if apprenticeship should have a greater role in the training of welders in the future.

F. Registered Apprenticeship in Weld-Ed Partner School Regions

This section provides registered apprenticeship data for states in which Weld-Ed partner schools operate: Ohio, Pennsylvania, Texas, and North Dakota. In the following tables, counties that did not report any completers for welding or any of the six identified occupations are not listed.

North Dakota

The following table displays North Dakota apprenticeship completers by county for three related trades. No apprenticeship completers were reported for *Boilermakers; Structural Iron and Steel Workers; Structural Metal Fabricators and Fitters; and Welders, Cutters, Solderers, and Brazers*.

Table 8. North Dakota 2008 Apprenticeship Completers

County	Plumbers, Pipefitters, and Steamfitters	Sheet Metal Workers	Millwrights
Burleigh	4	0	3
Cass	8	5	2
Ward	9	0	0
State Total	21	5	5

Source: Office of Apprenticeship, U.S. Department of Labor

⁵¹ BLS reports that 462,000 workers were employed as *Welding, Soldering, and Brazing Workers* in 2006 and 502,000 were employed as *Plumbers, Pipefitters, and Steamfitters*. 3,227 completers compared with 183.

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Ohio

The table below contains 2008 apprenticeship completers by Ohio county. Northern Ohio counties are highlighted in **green**, Central Ohio counties in **yellow**. No apprenticeship completers were reported for *Boilermakers and Structural Metal Fabricators and Fitters*.

Table 9. Ohio 2008 Apprenticeship Completers

County	Plumbers, Pipefitters, and Steamfitters	Sheet Metal Workers	Structural Iron and Steel Workers	Mill-wrights	Welders, Cutters, Solderers, and Brazers
Allen	4	0	0	0	0
Ashland	1	0	0	0	0
Butler	0	0	0	13	0
Cuyahoga	44	20	10	0	0
Defiance	0	0	0	3	0
Erie	0	0	0		1
Franklin	39	22	9	14	0
Guernsey	5	0	0	0	0
Hamilton	67	10	20	0	0
Hancock	0	0	0	7	0
Huron	6	0	0	0	0
Lucas	2	0	29	1	0
Mahoning	16	7	10	0	0
Montgomery	11	10	12	2	0
Pickaway	0	0	0	0	2
Richland	0	0	0	2	0
Scioto	31	0	0	0	0
Stark	5	13	10	0	0
Summit	9	0	0	5	0
Trumbull	3	0	0	1	0
Warren	0	6	0	0	0
Washington	1	00	0	0	0
Wood	13	9	0	5	0
Wyandot	0	2	0	0	0
State Total	257	99	100	53	3

Source: Office of Apprenticeship, U.S. Department of Labor

Pennsylvania

The following table displays Pennsylvania apprenticeship completers by county. No apprenticeship completers were reported for *Structural Metal Fabricators and Fitters*.

Table 10. Pennsylvania 2008 Apprenticeship Completers

County	Boiler-makers	Plumbers, Pipefitters, and Steamfitters	Sheet Metal Workers	Structural Iron and Steel Workers	Mill-wrights	Welders, Cutters, Solderers, and Brazers
Allegheny	48	15	20	17	7	0
Beaver	0	17	0	0	0	0
Berks	0	6	10	0	0	0
Bucks	0	7	0	0	0	1
Cambria	0	1	0	0	0	0
Chester	0	2	0	0	0	0
Clearfield	0	7	0	2	0	0
Dauphin	0	6	5	8	5	0
Delaware	0	8	0	0	0	0
Erie	0	0	0	0	0	1
Lancaster	0	1	3	0	0	0
Lebanon	0	0	0	0	5	0
Lehigh	0	5	9	0	1	0
Luzerne	0	2	1	0	0	0
Mercer	0	0	0	0	2	0
Montgomery	0	84	10	0	0	0
Philadelphia	0	2	0	28	3	0
Snyder	0	0	1	0	0	0
Tioga	0	22	0	0	0	0
Westmoreland	0	6	4	0	0	0
York	0	0	0	0	1	0
State Total	48	191	63	55	24	2

Source: Office of Apprenticeship, U.S. Department of Labor

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Texas

McLennan County is highlighted because it is in the Heart of Texas region. Bosque, Falls Freestone, Hill, and Limestone counties, the other counties in the Heart of Texas region, did not report apprenticeship completers for these occupations. No apprenticeship completers were reported for *Boilermakers and Structural Metal Fabricators and Fitters*.

Table 11. Texas 2008 Apprenticeship Completers

County	Plumbers, Pipefitters, and Steamfitters	Sheet Metal Workers	Structural Iron and Steel Workers	Mill-wrights	Welders, Cutters, Solderers, and Brazers
Bastrop	0	0	0	0	2
Bexar	10	21	7	0	0
Dallam	16	0	0	0	0
El Paso	2	0	1	0	0
Harris	49	0	0	31	0
Lubbock	2	1	0	0	0
McLennan	8	0	0	0	0
Nueces	5	0	0	0	0
Potter	7	0	0	0	0
Tarrant	8	10	31	2	0
Tom Green	1	0	0	0	0
Travis	16	4	11	0	0
Walker	0	0	0	0	10
Wichita	3	2	0	0	0
State Total	127	38	50	33	12

Source: Office of Apprenticeship, U.S. Department of Labor

III. Conclusions

This report focuses on the education and apprenticeship programs that prepare future workers for welding and/or welding technology occupations. It provides qualitative information about secondary, postsecondary, and apprenticeship programs and quantitative estimates of program enrollees and completers. The research conducted to describe education at the secondary and postsecondary level provided some interesting insights. A major finding is the variance in content and length of training required for successful completion of a program of study at secondary and postsecondary institutions. Individual states have curriculum requirement standards that apply to the delivery of CTE, but there is no national standard. (This fact would support the need and desirability of developing accreditation standards for welding and welding technology programs.) Also, given the many different types of welding processes: shielded metal arc welding, gas metal arc welding, gas tungsten arc welding, to name a few, there is no core set of knowledge and skills that define what should be taught in a welding program. Programs vary in the focus and amount of time spent on these subjects.

Another interesting finding from the Internet research and supported by the survey responses is that programs tend to provide students with the training needed to apply welding skills in the dominant industries in the geographic region. This is true for occupationally specific welding programs as well as for instances where welding is taught as part of another broader program. For example, Ohio, a state with high industry concentrations in Fabricated Metals and Machinery Manufacturing, includes welding instruction in the Manufacturing Technology program.⁵² This is especially notable at the secondary level. Of the 603 secondary institutions responding to the survey, 232 indicated that Welding/Welding Technology is taught as a part of another program. Those program titles vary widely, but tend to include agricultural machinery repair, automotive repair, industrial processes, machining and metals, and structural work.⁵³ Note that enrollment and completer data were not collected for such programs.

Simple counts of program enrollments and completers do not provide an accurate picture of the supply of workers. When respondents were asked “Will completers of the program be qualified as entry-level Welders, Welding Technicians, Welding Engineers, or Other” 91% of the secondary institutions responded that program completers would qualify as an entry-level welder; 4%, as a welding technician; and 5% responded ‘Other.’ The responses for postsecondary institutions indicated that 84% would qualify as entry-level welder; about 2% welding engineer; 12 % welding technician; and 2 % ‘Other.’ These responses would reduce the total estimated supply accordingly.

Finally, registered apprenticeship programs have a documented history of success in providing skilled workers for the trades. There are very few reported programs in the welding and welding technology fields. Developing registered apprenticeship standards and programs would be a potential strategy for enhancing the numbers of qualified workers.

The challenges presented to the research team to identify resources of data, collect existing enrollment and completer numbers, and analyze the results are not easily overcome. The findings show that there are no existent sources of data to replicate a process of collecting information about

⁵² The Welding Industry: Workforce Trends and Challenges; <http://www.weld-ed.org/NR/rdonlyres/F75C7675-0F14-4492-9969-0F3C63F02AFD/4573/TheWeldingIndustryregionallocalreport.pdf>

⁵³ See Table 17 in Appendix D for additional detail.

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the future supply of workers other than to conduct an annual survey. The AWS School Locator database of institutions provided a valuable resource for the survey effort, but it does not contain a 'universe' of schools. Comparison of the institutions included in the AWS database to the institutions in the IPEDS survey and to other sources of information about welding schools showed that the number of institutions by type differed. Additional research to identify and add schools that offer welding instruction to the AWS database would improve future survey efforts.

Data collected through the survey provides a baseline of enrollment and completer information. Annual data collection would provide an ongoing measure of program offerings and outputs. Of the 982 institutions surveyed, 120 secondary schools and 91 postsecondary schools indicate that they no longer offer a welding program. An annual data collection would be useful to identify new programs as well as programs that are no longer offered.

This report attempts to inform the process undertaken by the Weld-Ed National Skills Panel to identify the education and training programs that prepare welders and welding technicians, and the numbers of students in the welding supply pipeline. The enrollment and completer figures extrapolated from the survey sample provide estimates of program enrollments and completers for PY 2007-2008 at a national level and at the state level for the Weld-Ed partner school regions. When the survey has been completed for all institutions found in the AWS School Locator database, anticipated in early Fall 2009, additional data will become available for sub-state levels.

IV. Methodology

Weld-Ed commissioned this report to provide insight into whether the educational system is providing sufficient numbers of trained welders to meet the projected demand for skilled workers. The goal of this report and its findings is to provide the welding industry with information that can guide workforce development activities, but also to contribute to the development of a methodology for collecting such information in the future. The research presented in this report comes from qualitative information about education programs and apprenticeship obtained through Internet research; quantitative data provided by federal and state government agencies; and the output and analysis of the JBS Survey of Welding Institutions. Different strategies were utilized to research and collect data for the secondary, post-secondary, and apprenticeship programs. In each section, special focus was given to the Weld-Ed partner school states: North Dakota, Ohio, Pennsylvania, and Texas. The JBS Survey of Welding Institutions provides enrollment and completer data using a statistics-based survey methodology.

Secondary

At the secondary level, welding is taught as part of state CTE programs. We contacted state CTE directors to see how each state taught welding and to learn if enrollment and completer data were available. Using the National Association of State Directors of Career Technical Education (NAS-DCTE) Consortium Web site (<http://www.careertech.org/>), we identified contact information for each state director and a Web site for each state's secondary CTE program. Each state's CTE Web site was reviewed to identify contact information for staff associated either with welding programs directly or with manufacturing or trade and industrial education. We emailed all 50 state directors and relevant program staff requesting enrollments for PY 2007-2008 and PY 2008-09 and completers for PY 2007-2008. The responses indicate that there are variations in how welding is taught in each state, as well as variations in how enrollment and completer data are collected. Due to the discrepancies between states in the ways that data are collected and the variety of approaches states take to provide secondary welding education, data collected at the state level cannot be aggregated to the national level. Therefore, the data collection method was modified to include a random sample survey of secondary schools found in the AWS Welding School Locator database. We identified the following challenges in researching secondary welding programs:

- No centralized source at either the national or state level for program information
- No standard definition or criteria for program completers
- No standard course of study with measurable objectives for Welding Program outcomes
- Inconsistent requirements for Career and Technical Education Programs of Study
- Freedom of Information Act and cost requirements for some data requests

Postsecondary

The U.S. Department of Education, National Center for Education Statistics (NCES) conducts an annual data collection effort for postsecondary education institutions in the U.S. The survey includes a reporting of program completers as evidenced by certificates and degrees awarded by public and private institutions. Programs of study for Welding Technology/Welder are reported

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under the CIP code 48.0508.⁵⁴ We obtained the data collected under IPEDS survey to find the number of program completers. Availability of the final data set from the IPEDS lags about 15 months behind the end of a program year. It is anticipated that the data for PY 2007- 2008 will be available in September 2009.

Due to the time lag and the potential variance in how institutions report program completer data, we used enrollment and completer data derived from schools via a phone survey of postsecondary welding institutions listed in the AWS Welding School Locator database. The primary challenges in collecting postsecondary data were:

- IPEDS survey data is delayed and missing schools and programs.
- IPEDS survey does not provide enrollment data.

Apprenticeship

To understand welding apprenticeship and how welding is used in apprenticeable trades, we began by researching the trades related to welding in the Occupational Outlook Handbook. We consulted OA's list of apprenticeable occupations to determine the apprenticeship titles coded to welding SOC codes. We searched the OA and state apprenticeship agency Web sites for Bulletins, Standards and other documents which provide detail on the skills taught in welding apprenticeships. We also examined the Web site of the largest union apprenticeship programs for welding and related trades.

The OA provided an Excel file with completers of registered apprenticeships organized by location and SOC code. We sorted for the relevant SOC and organized the data by state. For the partner school states, we sorted the data by county and SOC. We called and emailed the SAC states that had not submitted completer data to the OA. Some of the challenges to the research effort included:

- The absence of a single data source for enrollments and completers.
- SAC data not centralized, data collected from states with variations in methodology.
- Some program completer data is not clearly defined by year or any given timeframe. (e.g. cumulative completer totals)
- Freedom of Information Act and cost requirements for some data requests.

JBS Survey of Welding Institutions

In order to provide Weld-Ed with information to use in its efforts to impact policy and improve the information available about CTE program output, Weld-Ed and its partners needed to develop a strategy that would ensure the availability of data needed for program planning now and in the future. They decided to employ the services of professional statisticians at JBS International, Inc. to conduct a survey of welding educational institutions.

JBS received a data set of the Welding School Locator Database from Weld-Ed with 3,526 welding institutions. The database listed educational institutions along with attributes such as contact information and school type. The cases were reviewed for missing data on school type and secondary/postsecondary status was added. Since the survey was restricted to U.S. institutions offering welding instruction, international schools and suppliers of welding equipment and curricula were removed from the data set. This resulted in a final data set of 3,469 institutions.

⁵⁴ Welding is also taught as a component Heavy Equipment Maintenance Technology/Technician (47.0302), and Plumbing Technology/Plumber (46.0503).

A simple random sample of 1,750 institutions was drawn to allow for rapid data collection. The planned sample was of sufficient size to allow for a confidence interval of +/-1.6% at the 95% confidence level overall. The size of the sample also allowed for data to be reported out by secondary vs. postsecondary school status, with confidence intervals of 5% or better. A total of 1,238 Secondary and 512 Post Secondary schools were included in the sample.

Data was collected over a 1.5 month period beginning in May and ending in June of 2009. During data collection, duplicate records were identified in the random sample, reducing the total sample to 1,719, of which 492 were postsecondary institutions and 1,227 were Secondary institutions. Interviews were completed with 982 schools, 120 (12.2%) of which were found to no longer offered welding. These schools were identified as follows: 91 were secondary schools and 29 were postsecondary schools.

Of the remaining 862 schools which offered welding, 603 were secondary schools (response rate with data for random sample 53%) and 259 were postsecondary schools (response rate with data for random sample 56%).

It should be noted that the refusal rate was very low (only 16 schools total refused to complete the survey). The primary reason for non-response was that schools had let out for the summer by the time they were called.

Interviewers and senior project staff checked data as it was received to ensure that numbers were plausible. Where needed, interviewers re-called schools to confirm questionable data.

Booths, shifts, enrollment capacity, enrolled students, and completing students were checked to ensure internal consistency (e.g., that enrollment capacity did not appear unreasonable given the number of booths and shifts, that enrolled students and completing students did not greatly exceed enrollment capacity).

Although data was clean for the most part, it should be noted that there were about 80 cases for 2007- 2008 enrollment and completion data, which had data that looked wrong, specifically in the 2007- 2008 completers column. The problem was that the number of enrolled and completers was identical, and the number of expected completers for the following year was substantially lower, leading data reviewers to suspect that the respondents gave the number of students successfully completing whatever courses they were enrolled in, rather than the whole program. This data was set to "missing" so that it would not artificially inflate the number of 2007- 2008 completers.

Data was imported into SAS for analysis, and frequencies, percentages, means, and sums were computed as appropriate for both the raw completed sample and for the sample weighted up to the overall population of 3,393 unique institutions in the locator database of which 954 are postsecondary and 2,439 are secondary institutions.

To ensure consistency between the surveyors and the schools being surveyed, JBS defined the types of educational awards for the survey of educational institutions.

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Appendix A: Educational Awards Definition

Diploma: Refers to a document received upon completion of required education or training. For purposes of this survey, a diploma will represent the award given for the completion of high school requirements.

Certificate: An award granted for the successful completion of a program of study. Certificates typically require the equivalent of less than two academic years of full-time college-level study, with some requiring less than one full-time equivalent year. These certificates are usually awarded in a career education field and may cover the same coursework as an associate's degree, but without the general education requirements.

- *A short-term certificate* requires the completion of at least 30 and up to 59 credit hours.
- *A long-term certificate* requires completion of at least 60 credit hours.

Associate's degree: A degree granted for the successful completion of a program of study, usually requiring the equivalent of at least two but less than four full-time academic years of college-level study.

Bachelor's degree: A degree granted for the successful completion of a baccalaureate (Bachelor's degree) program of studies, usually requiring the equivalent of at least four but not more than five full-time academic years of college-level study.

Appendix B: Additional Secondary Welding Program Information

Table 12. State Sources of Secondary Career and Technical Education Information

State	Secondary CTE Web Site
Alabama	http://www.alcareertech.org
Alaska	http://www.eed.state.ak.us/tls/cte
Arizona	http://www.ade.state.az.us/cte
Arkansas	http://dwe.arkansas.gov
California	http://www.cde.ca.gov/ci/ct
Colorado	http://www.coloradostateplan.com/index.htm
Connecticut	http://www.sde.ct.gov/sde/cwp/view.asp?a=2678&Q=320802
Delaware	http://www.doe.k12.de.us/infosuites/ddoe/aboutdoe/workgroups/cte.shtml
District of Columbia	http://www.k12.dc.us/dcps/programs/program16.htm
Florida	http://www.fldoe.org/workforce
Georgia	http://www.gadoe.org/ci_cta.aspx
Hawaii	http://www.hawaii.edu/cte
Idaho	http://www.pte.idaho.gov
Illinois	http://www.isbe.state.il.us/career/default.htm
Indiana	http://www.doe.in.gov/octe
Iowa	http://www.iowa.gov/educate/index.php?option=com_content&task=view&id=1246&Itemid=2132
Kansas	http://www.ksde.org/Default.aspx?tabid=249
Kentucky	http://kytech.ky.gov
Louisiana	http://www.doe.state.la.us/lde/family/510.html
Maine	http://www.maine.gov/education/it/index.shtml
Maryland	http://www.marylandpublicschools.org/MSDE/divisions/careertech
Massachusetts	http://www.doe.mass.edu/cte
Michigan	http://www.michigan.gov/mde/0,1607,7-140-6530_2629---,00.html
Minnesota	http://www.grantsplus.mnscu.edu/Perkins/PerkinsIII.html
Mississippi	http://www.mde.k12.ms.us/vocational/OVTE

(Table 12 continued on next page)

Table 12. State Sources of Secondary Career and Technical Education Information

State	Secondary CTE Web Site
Missouri	http://www.dese.mo.gov/divcareered
Montana	http://www.mus.edu/wd
Nebraska	http://www.nde.state.ne.us/NCE
Nevada	http://www.doe.nv.gov/CTE.htm
New Hampshire	http://www.ed.state.nh.us/education/doe/organization/adultlearning/careerdevelopment.htm
New Jersey	http://www.nj.gov/education/voc
New Mexico	http://ped.state.nm.us/CTWEB/index.html
New York	http://www.emsc.nysed.gov/cte
North Carolina	http://www.dpi.state.nc.us/cte
North Dakota	http://www.nd.gov/cte
Ohio	http://www.ode.state.oh.us/GD/Templates/Pages/ODE/ODEPrimary.aspx?page=2&TopicRelationID=2
Oklahoma	http://www.okcareertech.org
Oregon	http://www.ode.state.or.us/search/results/?id=151
Pennsylvania	http://www.pde.state.pa.us/career_edu/site/default.asp
Rhode Island	http://www.ride.ri.gov/cte
South Carolina	http://www.ed.sc.gov/agency/standards-and-learning/career-and-technology-education/index.html
South Dakota	http://doe.sd.gov/octe/index.asp
Tennessee	http://www.state.tn.us/education/cte
Texas	http://www.tea.state.tx.us/cte/index.html
Utah	http://www.usoe.k12.ut.us/ate/newate.htm
Vermont	http://www.state.vt.us/educ/new/html/pgm_teched.html
Virginia	http://www.pen.k12.va.us/VDOE/Instruction/CTE
Washington	http://www.k12.wa.us/careertech
West Virginia	http://careertech.k12.wv.us
Wisconsin	http://www.dpi.wisconsin.gov/cte/index.html
Wyoming	http://www.k12.wy.us/tcd.asp

Source: http://www.careertech.org/state_profile

Table 13. 16 Career Clusters and Descriptions

Agriculture, Food & Natural Resources	The production, processing, marketing, distribution, financing, and development of agricultural commodities and resources including food, fiber, wood products, natural resources, horticulture, and other plant and animal products/resources.
Architecture & Construction	Careers in designing, planning, managing, building and maintaining the built environment.
Arts, A/V Technology & Communications	Designing, producing, exhibiting, performing, writing, and publishing multimedia content including visual and performing arts and design, journalism, and entertainment services.
Business Management & Administration	Business Management and Administration careers encompass planning, organizing, directing and evaluating business functions essential to efficient and productive business operations. Business Management and Administration career opportunities are available in every sector of the economy.
Education & Training	Planning, managing and providing education and training services, and related learning support services.
Finance	Planning, services for financial and investment planning, banking, insurance, and business financial management.
Government and Public Administration	Executing governmental functions to include Governance; National Security; Foreign Service; Planning; Revenue and Taxation; Regulation; and Management and Administration at the local, state, and federal levels.
Health Science	Planning, managing, and providing therapeutic services, diagnostic services, health informatics, support services, and biotechnology research and development.
Hospitality & Tourism	Hospitality & Tourism encompasses the management, marketing and operations of restaurants and other foodservices, lodging, attractions, recreation events and travel related services.
Human Services	Preparing individuals for employment in career pathways that relate to families and human needs.
Information Technology	Building Linkages in IT Occupations Framework: For Entry Level, Technical, and Professional Careers Related to the Design, Development, Support and Management of Hardware, Software, Multimedia, and Systems Integration Services.
Law, Public Safety, Corrections & Security	Planning, managing, and providing legal, public safety, protective services and homeland security, including professional and technical support services.
Manufacturing	Planning, managing and performing the processing of materials into intermediate or final products and related professional and technical support activities such as production planning and control, maintenance and manufacturing/process engineering.
Marketing	Planning, managing, and performing marketing activities to reach organizational objectives.
Science, Technology, Engineering & Mathematics	Planning, managing, and providing scientific research and professional and technical services (e.g., physical science, social science, engineering) including laboratory and testing services, and research and development services.
Transportation, Distribution & Logistics	Planning, management, and movement of people, materials, and goods by road, pipeline, air, rail and water and related professional and technical support services such as transportation infrastructure planning and management, logistics services, mobile equipment and facility maintenance.

Source: <http://www.careerclusters.org/>

Table 14. State Provided Secondary Welding Program Completer/Enrollment Data

State	2007-2008 Enrollments	2007-2008 Completers	2008-2009 Enrollments	Notes
Alabama	n/a	n/a	n/a	Data not available
Alaska	—	—	—	No response
Arizona	—	—	—	No response
Arkansas	—	—	—	No response
California	6445	1052	n/a	Enrollment: grades 9-12, Completers: grade 12 graduates, The data represents an aggregate of students enrolled in three welding programs, Arc, Technical (MIG and TIG), and Combination.
Colorado	797	394	n/a	Welding 480508, grades 9-12, completers - all grades
Connecticut	—	—	—	No response
Delaware	74	28	n/a	Welding program enrollment and completers
DC	0	0	0	No welding programs
Florida	—	—	—	No response
Georgia	n/a	n/a	n/a	Cost associated with data request
Hawaii	—	—	—	No response
Idaho	936	108	781	The secondary enrollments represent 9 - 12 grade and the completers represent only those student that have completed a sequence of 4 classes (Welding I, Welding II, Welding III, and an internship). The completers could be in their junior or senior year.
Illinois	1432	n/a	n/a	480508 Welder/Welding Technologist
Indiana	1500	486	1666	Welding data, grades 9-12, completers - all grades
Iowa	—	—	—	No response
Kansas	257	175	102	2007-2008 data is based on 11th graders that took a minimum of three credits in the welding program's sequence and 12th graders that took a minimum of three courses. The 11th graders are under a new definition for concentrator and the 12th graders were allowed to complete under the old definition. There is a preliminary number of 102 concentrators (11th or 12th grade) for the program year 2008-2009.
Kentucky	2970	496	2636	WELDING (MANUFACTURING) [48.0508]
Louisiana	617	n/a	801	Welding, Spring 08 - Official 14th day; Spring 09 Preliminary 14th day

(Table 14 continued on next page)

Table 14. State Provided Secondary Welding Program Completer/Enrollment Data

State	2007-2008 Enrollments	2007-2008 Completers	2008-2009 Enrollments	Notes
Maine	294	264	n/a	Welding, grades 11-12
Maryland	389	156	n/a	Enrollment: grades 10-12, Completers: grade 12 graduates
Massachusetts	—	—	—	No response
Michigan	1904	727	n/a	9-12, (checking if completers = graduates)
Minnesota	2842	794	n/a	Welding Occupations (OE Code 172306), Participants = 100 hours in a welding program, Completer = 240 hours in a welding program and has graduated
Mississippi	—	—	—	No response
Missouri	1307	n/a	n/a	Welding Technology Enrollment
Montana	—	—	—	No response
Nebraska	n/a	n/a	n/a	Data is broken out by career cluster.
Nevada	768	125	806	Welding Programs and Ag Welding, 9-12, Terminal Completer: a student who earns a grade of a D or better in a Terminal course which is the ending course in a sequence of courses in a program area.
New Hampshire	—	—	—	No response
New Jersey	589	135	n/a	Welding, 9-12, Completers: students completing the sequence of courses for the program
New Mexico	n/a	n/a	n/a	New Mexico does not collect this level of data.
New York	n/a	n/a	n/a	Data not available at program level.
North Carolina	—	—	—	No response
North Dakota	597	197	603	Welding, 10 – 12
Ohio	1845	n/a	n/a	Welding, 11 – 12
Oklahoma	1220	677	n/a	Data represent secondary and adult enrollments and completers
Oregon	n/a	n/a	n/a	Oregon does not collect this level of data.
Pennsylvania	2053	506	n/a	480508, Grades 9-12 and adults in secondary programs
Rhode Island	0	0	0	No welding programs
South Carolina	2196	382	n/a	Welding Enrollment grades 9-12
South Dakota	—	—	—	No response

(Table 14 continued on next page)

Table 14. State Provided Secondary Welding Program Completer/Enrollment Data

State	2007-2008 Enrollments	2007-2008 Completers	2008-2009 Enrollments	Notes
Tennessee	—	—	—	No response
Texas	6008	n/a	5552	Completer = passed class, Total - 7 Welding related courses
Utah	—	—	—	No response
Vermont	98	n/a	138	Welding and Industrial Mechanics/Maintenance (with AWS welding), 11-12
Virginia	1455	n/a	1340	Welding I, Welding II, Welding
Washington	—	—	—	No response
West Virginia	—	—	—	No response
Wisconsin	3315	n/a	n/a	2008 WI CTE Concentrators Where Welding May be Part of Curriculum, 11-12
Wyoming	n/a	n/a	n/a	Data not available

Source: Email responses from state CTE representatives

Appendix C: Additional Registered Apprenticeship Information

Welding Apprenticeship Work Process Schedule

Work process schedules, parts of apprenticeship standards, outline the skills an apprentice would learn on-the-job in a given occupation. Currently, no national work process schedules for welding are publicly available. There are, however, state work process schedules. The content of work process schedules can vary, but the example from Maine below shows one way 8,000 hours of on-the-job training could be apportioned between different techniques and topics.⁵⁵

Table 15. Registered Apprenticeship Work Process Schedule (Maine)

Welder	
SOC: 51-4121.02	
Program Length: 8,000 hours	Hours
OXY-FUEL WELDING	120
OXY-FUEL BRAZING	480
SHIELDED METAL ARC WELDING (SMAW)	2000
GAS TUNGSTEN ARC WELDING (GTAW)	640
GAS METAL ARC WELDING (GMAW) - Semi automatic	640
TOOLS AND EQUIPMENT	640
FABRICATION AND ASSEMBLY	1980
RIGGING	500
MAINTENANCE PRACTICES	1000

Registered Apprenticeships for Six Trades by SOC Code

The table below reports the apprenticeable occupations associated with the six trades for which welding is an important skill. The table links specific apprenticeship titles to SOC occupations and illustrates term length, type of training, and RAPIDS code.

⁵⁵ See full Maine standards with competencies here http://www.maine.gov/labor/apprenticeship/apprenticeable_occupations/list.htm. See also this example registered in Oregon <http://online.onetcenter.org/link/summary/47-2011.00>.

Table 16. Registered Apprenticeships for Six Trades by SOC Code

SOC Occupation	Registered Apprenticeships			
	Occupational Title	Term	Type of Training	RAPIDS Code
<i>Boilermakers (47-2011)</i>	Boilerhouse Mechanic	6000	Time-Based	38
	Boilermaker Fitter	8000	Time-Based	39
	Boilermaker I	6000	Time-Based	40
	Boilermaker II	6000	Time-Based	41
	Coppersmith (Ship & Boat)	8000	Time-Based	91
<i>Plumbers, Pipefitters, and Steamfitters (47-2152)</i>	Gas-Main Fitter	8000	Time-Based	964
	Pipe Fitter - Sprinkler Fitter	8000	Time-Based	0414S
	Pipe Fitter (Const)	8000	Time-Based	414
	Pipe Fitter (Ship & Boat)	8000	Time-Based	412
	Steam Service Inspector	8000	Time-Based	460
	Plumber	8000	Time-Based	432
<i>Sheet Metal Workers (47-2211)</i>	Sheet Metal Worker	8000-10000	Hybrid	0510HY
	Sheet Metal Worker	8000	Time-Based	510
<i>Structural Iron and Steel Workers (47-2221)</i>	Assembler, Metal Building	4000	Time-Based	877
	Structural Ironworker	6000-8000	Hybrid	0669HY
	Structural Steel/Ironworker	6000	Time-Based	669
	Structural Steel/Ironworker	6000-8000	Hybrid	0669HY
	Tank Setter (Petrol Prod)	4000	Time-Based	558
<i>Millwrights (49-9044)</i>	Automated Equip Engr-Tech	8000	Time-Based	821
	Machine Erector	8000	Time-Based	293
	Millwright	5200-8000	Hybrid	0335HY
	Millwright	8000	Time-Based	335
<i>Structural Metal Fabricators and Fitters (51-2041)</i>	Fabricator-Assembler Metal Prod	8000	Time-Based	833
	Former, Hand (Any Ind)	4000	Time-Based	200
	Metal Fabricator	8000	Time-Based	325
	Ship Propeller Finisher	6000	Time-Based	611
	Fitter (Mach Shop)	4000	Time-Based	197
	Fitter I (Any Ind)	6000	Time-Based	189

Source: U.S. Department of Labor List of Officially Recognized Apprenticeable Occupations.⁵⁶

⁵⁶ <http://www.doleta.gov/oa/bul08/apprenticeable%20occupations.xls>

Use of Welding in Six Apprenticesable Trades

This section uses Apprenticeship Standards to describe what types of welding are being taught and used in six apprenticesable trades: *Boilermakers; Plumbers, Pipefitters, and Steamfitters; Sheet Metal Workers; Structural Iron and Steel Workers; Millwrights; and Structural Metal Fabricators and Fitters*. The information demonstrates the importance of welding in these trades and sheds light on the types of welding they use.

Boilermakers

Boilermakers and Boilermaker Mechanics make, install, and repair boilers, closed vats, and other large vessels or containers that hold liquids and gases. In addition to installing and maintaining boilers and other vessels, boilermakers also help erect and repair air pollution equipment, blast furnaces, water treatment plants, storage and process tanks, and smoke stacks. Boilermakers weld sections of boilers together, often using robotic welding systems or automated orbital welding machines. Boilermakers arc-weld pressure vessel structures and parts together. Their activities involve the inspection of welds and the use of welding equipment to make repairs. In sum, welding is an important skill for boilermakers.⁵⁷

Individuals with welding certifications or other welding training get priority in selection to boiler-maker apprenticeship programs.⁵⁸ The Boilermakers National Apprenticeship Program (BNAP) is a major boilermaker apprenticeship sponsored by the International Brotherhood of Boilermakers. In this program, boilermaker apprentices must complete 576 hours of classroom training to graduate, of which more than 163 hours are dedicated to welding classes and shop time. Another portion of the 576 hours is spent learning welding-related skills such as blueprint reading and layout. By examining the types of welding skills that boilermakers are taught in the classroom, we can see what they are likely to apply in the field. The following welding skills appear in the BNAP Classroom Training Schedules which function as the curriculum for the BNAP classroom hours:

- Welding Symbols
- Advanced Welding
- Vertical/Horizontal/Overhead Theory
- Vertical/Horizontal/Overhead
- Plate with/Backup strip
- Tungsten Inert Gas (TIG)/Metal Inert Gas (MIG) Theory
- Tungsten Inert Gas (TIG)/Metal Inert Gas (MIG) Processes (Tube/Plate)
- Orbital-Theory
- Tube (Walls/Elements, Etc.)-Theory⁵⁹

Based on the curriculum, boilermakers must possess significant welding knowledge and skills. They must understand welding theory and symbols, use several welding processes, and be able to weld in different positions.

⁵⁷ <http://www.bls.gov/oco/ocos221.htm>

⁵⁸ <http://www.bls.gov/oco/ocos221.htm>

⁵⁹ <http://bnap.com/process/class.htm>

Plumbers, Pipefitters, and Steamfitters

Plumbers, Pipefitters, and Steamfitters install, maintain, and repair many different types of pipe systems. Pipefitters assemble and secure pipes, tubes, fittings, and related equipment, according to specifications, by welding, brazing, cementing, soldering, and threading joints. They attach pipes to walls, structures, and fixtures, such as radiators or tanks, using brackets, clamps, tools or welding equipment. According to the Bureau of Labor Statistics, job opportunities for this occupation will be better for workers with welding experience.⁶⁰

By examining the Standards of Apprenticeship adopted by the Seattle Area Plumbers, Housing Plumbers, Pipefitters, HVAC/Refrigeration Mechanics, and Marine Pipefitters Apprenticeship Committee and approved by the Washington State Apprenticeship and Training Council, we can see the role of welding in an example of a Marine Pipefitter apprenticeship. In this apprenticeship, 500 of the 6,000 apprenticeship hours are spent on welding and burning.⁶¹

Sheet Metal Workers

Sheet Metal Workers make, install, and maintain heating, ventilation, and air-conditioning duct systems; roofs; siding; rain gutters; downspouts; skylights; restaurant equipment; outdoor signs; railroad cars; tailgates; customized precision equipment; and many other products made from metal sheets. They set up and operate fabricating machines to cut, bend, and straighten sheet metal; shape metal over anvils, blocks, or forms using hammers; operate soldering and welding equipment to join sheet metal parts; and inspect, assemble, and smooth seams and joints of burred surfaces.⁶² Welding is one of the methods sheet metal workers use to join metal pieces, and it is a significant skill for many sheet metal workers.

The Sheet Metal Workers' International Association and the Sheet Metal and Air Conditioning Contractor's National Association sponsor a four-year, 8,000-hour apprenticeship and a five-year, 10,000 hour apprenticeship. The Schedule of Work Experience and the Schedule of Related Instruction, parts of the Apprenticeship Standards, indicate what the apprentice will learn on-the-job and in the classroom. In both the 4-year and 5-year programs the apprentice will receive 500 hours of Welding work experience.⁶³ Topics for the 5th year Schedule of Related Instruction include:

- Shielded Metal Arc Welding (SMAW) Certificate
- Gas Metal Arc Welding (GMAW) Certification
- Gas Tungsten Arc Welding (GTAW) Certification
- Codes and Symbols
- Carbon Arc Brazing
- Orbital Welding

Structural Iron and Steel Workers

Structural and Reinforcing Iron and Metal Workers place and install iron or steel girders, columns, and other construction materials to form buildings, bridges, and other structures. They also position and secure steel bars or mesh in concrete forms in order to reinforce the concrete used in highways, buildings, bridges, tunnels, and other structures. The possession of welding skills makes a worker more qualified for employment as a structural iron and steel worker.⁶⁴

⁶⁰ <http://www.bls.gov/oco/ocos211.htm>

⁶¹ <http://www.lni.wa.gov/tradeliicensing/apprenticeship/files/standards/0115.pdf>

⁶² <http://www.bls.gov/oco/ocos214.htm>

⁶³ <http://www.doleta.gov/OA/bul01/Bul2001-11%20NGS-Sheet%20Metal%20Trades.pdf>

⁶⁴ <http://www.bls.gov/oco/ocos215.htm>

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Workers learn welding skills as part of structural iron and steel apprenticeships. The International Association of Bridge, Structural, Ornamental and Reinforcing Ironworkers sponsors a structural iron and steel worker apprenticeship with a three year program of 6,000 hours and a four-year program of 8,000 hours. 1200 hours of the 6,000-hour program are directed toward welding and 1600 hours of the 8,000-hour program are as well. Welding also occupies 110 hours of the 390-467 hour core curriculum of the classroom training. Particularly, apprentices will learn:

- Oxyacetylene welding
- Shielded Metal Arc Welding
- Flux Core Arc Welding
- Gas Tungsten Arc Welding
- Structure and Types of Metals and Welding Materials (within each type of welding).⁶⁵

Millwrights

Millwrights install, replace, dismantle, and repair machinery and heavy equipment used in power generation, including wind power, hydroelectric dams, and natural gas turbines, and in manufacturing plants, construction sites, and mining operations. Millwrights often use welding and soldering to assemble and repair machines. They work with hand and power tools, such as cutting torches, welding machines, hydraulic torque wrenches, hydraulic stud tensioners, soldering guns, and with metalworking equipment, including lathes and grinding machines. Workers with welding experience will be more competitive when seeking employment as millwrights.⁶⁶

The United Brotherhood of Carpenters and Joiners of America developed an apprenticeship program for millwrights. Their program has a core curriculum which describes the basic knowledge and skills all millwrights need. It also includes several curricula specialized to reflect the requirements of the particular industry in which the millwrights work. For example, there are specialized curricula for millwrights working in the aerospace industry, the automotive industry, and the food processing industry. The core curriculum for all apprentices includes these welding topics:

- Oxygen Acetylene Welding
- Basic Shielded Metal Arc Welding (SMAW)

The following welding topics appear in the various specialized curricula:

- Certified Shielded Metal Arc Welding (SMAW)
- Certified Gas Metal Arc Welding (GMAW)
- Certified Gas Tungsten Arc Welding (GTAW)
- Certified Welding Inspector
- Non Destructive Testing

Structural Metal Fabricators and Fitters

Structural Metal Fabricators make and assemble structural metal products such as frameworks or shells for machinery, ovens, iron staircases, tanks, stacks, and metal parts for buildings and bridges. Structural metal fabricators and fitters fabricate, lay out, position, align, and fit parts of structural metal products. They position, align, fit, and weld parts to form complete units or subunits, following blueprints and layout specifications, and using jigs, welding torches, and hand tools.

⁶⁵ http://www.doleta.gov/OA/bul06/Bulletin%202006-16_att3.pdf

⁶⁶ <http://www.bls.gov/oco/ocos190.htm>

To understand what apprentices in this occupation are being taught, we examined the Standards of Apprenticeship adopted by the Washington Structural Metal Fabricators' Apprenticeship Committee for Structural Steel and Ornamental Metal Fabricators. Of the 8,000 hours of work experience, 1,000 are dedicated to welding. Time is also invested in related skills such as Layout and Inspection.⁶⁷

⁶⁷ <http://www.lni.wa.gov/TradesLicensing/Apprenticeship/files/standards/0124.pdf>

Appendix D: Titles of Programs with a Welding Component

These programs, identified in the JBS Survey of Welding Institutions, teach welding, though welding is not their primary focus.

Table 17. Titles of Programs with a Welding Components

Program Titles	
Select Electronics Programs	General High School Course
3D Fine Arts	General High School Program
3D Fine Arts Program	General Metal
ABC Welding Agriscience	HVAC
AVAC	Heating and Air
Advance Manufacture Industry	Heating and Air Conditioning
Ag/Metal Fabrication	Heating and Air conditioning
Agricultural	Heating, Air Conditioning and Refrigeration
Agricultural Mechanics	Heating, Ventilation & Air Conditioning
Agricultural Construction	Heaving Equipment
Agricultural Education	Heavy Equipment mechanics
Agricultural Education Program	Heavy equipment
Agricultural Education and Leadership	High Mileage Vehicle
Agricultural Engineering	Home Mechanics
Agricultural Management	Horticulture
Agricultural Mechanics	Hot Metals
Agricultural Metal	Hot and Cold Metals
Agricultural Power	Industrial
Agricultural Program	Industrial Art Class
Agricultural Program NCCER certification	Industrial Arts
Agricultural Science	Industrial Education
Agricultural Science 322 (Metal Fabrication)	Industrial Education Technology
Agricultural Science, Mechanics, Animals, Crops and Soils	Industrial Electrical
Agricultural Sciences	Industrial Engineering

(Table 17 continued on next page)

Table 17. Titles of Programs with a Welding Components

Program Titles	
Agricultural Systems	Industrial Machine Maintenance
Agricultural Technology	Industrial Maintenance
Agricultural Welding	Industrial Maintenance Technology
Agricultural and Natural Resources	Industrial Manufacturing
Agricultural mechanics	Industrial Mechanics
Agriculture	Industrial Plant Maintenance
Agriculture Curriculum	Industrial System
Agriculture Diesel	Industrial Systems
Agriculture Education	Industrial Systems Technology
Agriculture Mechanics	Industrial Tech
Agriculture Mechanics (Advanced students)	Industrial Technology
Agriculture Metal Fabrication	Industrial Technology Program
Agriculture Metals	Industrial Type Training
Agriculture Program	Industrial technology
Agriculture Science	Intro to Agricultural Welding
Agriculture Science and Mechanics	Intro to Tech Prep Engineering Program
Agriculture Studies	Introduction to Agriculture
Agriculture Technology	Introduction to Metal
Air Conditioning/ Refrigeration	Introduction to Trade and Industry
Air Conditioning/Refrigeration	Introduction to Welding
Aircraft	Machine
Aircraft Maintenance	Machine II
Animal Science	Machine Technology
Animals and Agriculture	Machine Tool
Appliance Service	Machine Tool Operator Class
Architecture	Machine Tool Technology
Art	Machine Tooling
Artistic Welding	Machine Tools
Arts	Machine and Manufacturing Technology

(Table 17 continued on next page)

Table 17. Titles of Programs with a Welding Components

Program Titles	
Associate of Applied Science Degree	Machining
Auto	Machining Class
Auto Body	Machining Tool
Auto Mechanics	Maintenance
Auto Repair/Tech	Manufacture of technology
Auto Tech	Manufacturing
Auto Technician	Manufacturing Engineering
Auto Technology	Manufacturing and Engineering Technology
Auto mechanics	Marine Fabrication
Auto shops	Mechanical Engineer
Auto tech	Mechanical Engineering
Auto/Agriculture Education	Mechanical Engineering Technology
Autobody	Mechanical Technology
Autobody Repair	Mechanics
Autobody, plumbing, agriculture	Mechanized Agriculture
Autobody/Auto Tech	Metal Art
Automated Engineering Technology	Metal Fabrication
Automobile	Metal Fabrication/Welding
Automotive	Metal Preps (used for other classes that need welding)
Automotive	Metal Processes
Automotive	Metal Shop
Automotive (torch cutting)	Metal Technology
Automotive Autobody	Metal Trade
Automotive Mechanics	Metal Trades
Automotive Systems Technology	Metal Trades and Welding
Automotive Technology	Metal Working
Automotive Training	Metal working I Metal working
Automotive Welding	Metal working II
Automotive/Autobody	Metals
Automotive/Autobody Repair	Metals Manufacturing

(Table 17 continued on next page)

Table 17. Titles of Programs with a Welding Components

Program Titles	
Automotive/Sheet Metal	Metals Program
Automotives	Modern Industrial Technology
Aviation	Motor Sports Vehicle Technology
Aviation Maintenance	Motorcycle Service
Beginning Metals	Motorsports Technology
Body Program	Multi Craft
Body and Fender	Natural Gas Compression
Brick Masonry	Night welding
Building Construction	Ornamental Iron Work
CAREER TECH PROGRAM	Painting
Career Exploration	Petroleum Technology
Career and Technical Program	Pipe Fitting
Carpentry	Pipefitting Technology
Caterpillar	Plumbing
Civil Technology	Power Drive and General Technology
Collision Repair	Power Sports
Collision Repair Technology	Power and Energy
Combined Welding and Agricultural Ed	Process Technology
Construction	Production Design and Technology
Construction Corp. (NCCER) (Also a Prerequisite)	Production Systems
Construction Technology	ROP Ag. Welding
Crops and Soils	Related Welding
Design Drafting	Sculptural Welding
Diesel	Sculpture/Bachelor of Arts
Diesel Equipment Technology	Sheet Metal
Diesel Mechanics	Small Engines
Diesel Power Technology	Small Gas Engine
Diesel Technology	Steel Design
Diesel and heavy equipment technology	Super Mileage
Diesel. Autobody	Technical Industrial

(Table 17 continued on next page)

Table 17. Titles of Programs with a Welding Components

Program Titles	
Diesel/Heavy Equipment Technician	Technical System Management
Drafting	Technology Field
Electrical	Tool and Die
Electrician	Tool and Die Option
Electromechanical Technology	Tooling and Machining
Electronics	Trade and Industrial
Engineering	Transportation and Manufacturing
Engineering Technology	Umbralle Job Corps
Engines	University of MO, Art program
Farm Welding	Vocational Agricultural
Forestry	Welding Introduction
Forestry Management Technology	Welding and Fabrication
General Curriculum	Welding to Design (art)

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