

Welding School Guide

A guide to the essential components necessary to create a complete welding education facility and curriculum



Development of a Welding School

A GUIDE TO THE ESSENTIAL COMPONENTS NECESSARY TO CREATE A COMPLETE WELDING EDUCATION FACILITY AND CURRICULUM



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WELDING EDUCATION FOR EVERY STUDENT LEVEL

Lincoln Electric is built on a more than 100-year legacy of welding education. Any institution of learning must recognize different levels of student education. A welding education may be focused on students, tradesmen or management-level personnel, each requiring a more advanced curriculum and setting.

● BASIC ▲ INTERMEDIATE ■ ADVANCED LEVELS

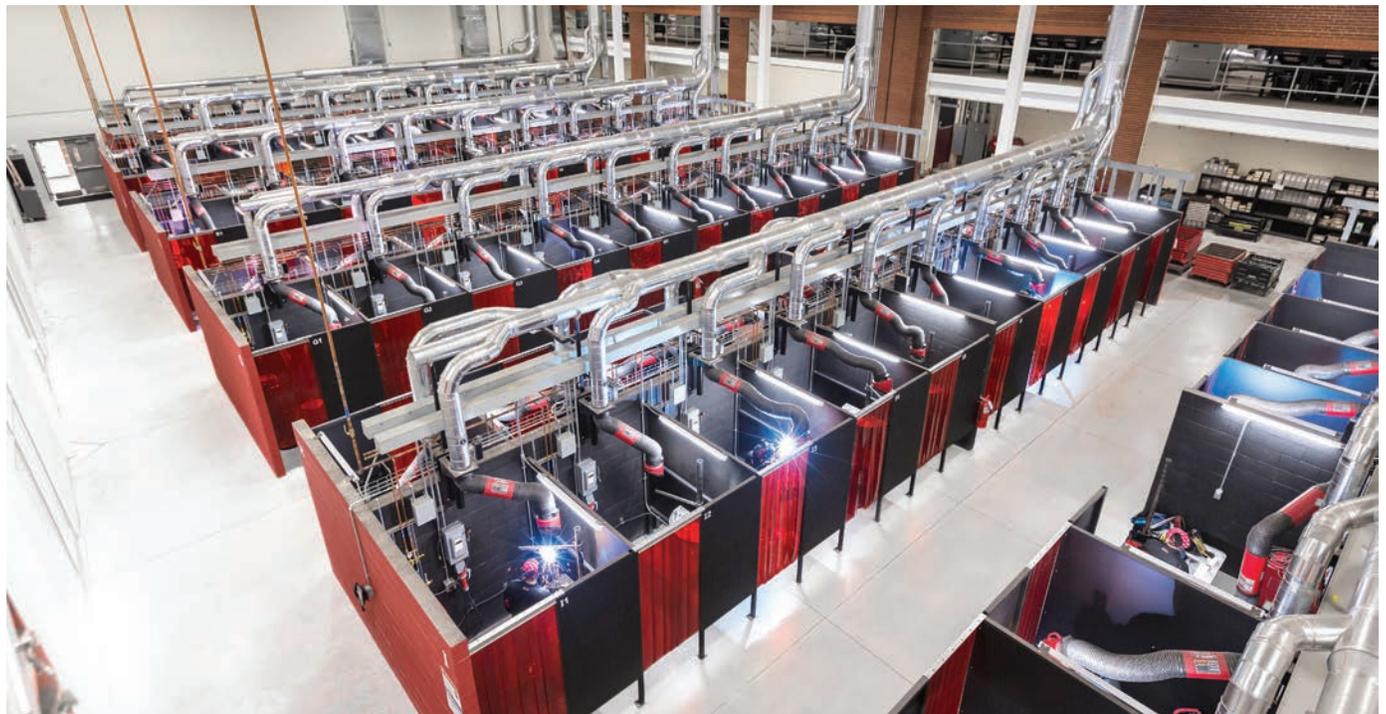
Throughout this Welding School Guide, Lincoln Electric identifies Basic, Intermediate and Advanced levels of education, which are based on recommendations from its own welding school curriculum. Look for the color-coded designations to identify which education level is most appropriate. Regardless of where you are or where you want to go, Lincoln Electric provides options for every level of student that will enable them to reach their goals.

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(NOTE: No color coding indicates All Education Levels)

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PREFACE

Competition in the welding industry is growing worldwide. The goal for the welding industry operating within this dynamic market should not be to survive — but to thrive. In order to thrive, the welding workforce must offer much more than competent welders. This Welding School Guide will provide the essential instructions, critical insights and vital information necessary to develop a welding school that will produce welding professionals who will thrive in the decades to come.

1. INTRODUCTION

The challenges facing today's welding industry are no different than any other modern business segment. The success of the welding industry for the foreseeable future is reliant upon its ability to adapt to change. Successful ventures in any industry have learned to identify market changes, prepare for those changes and continue to adapt, rather than rest on a once-proven model.

Likewise, the modern welding school must consider that its product is — the welding student. How well prepared the student is for the new challenges of the market determines their value in the marketplace — which should be the ultimate measure of a welding school's success.

1.1 TODAY'S WELDING MARKET CHALLENGES

The task that faces the welding industry for the foreseeable future is a dynamic combination of an aging workforce, technological advances, the introduction of new materials and the emergence of a global economy. While identifying these powerful movements occurring within the industry is the first step, preparing a dynamic workforce for the welding industry is the largest challenge that education faces today.

Today's welding education programs must stay current with the continuing maturity of the welding industry while offering students the skills needed as new career pathways evolve. Analysis of the welding industry indicates different types of welders are in demand. These welders include fabrication, heavy fabrication, manufacturing, automotive, pipeline and automation. There is also a growing need for more weld inspectors, quality assurance managers, welding engineering technologists and other essential personnel who support the industry.

The questions facing the welding industry become: What is the best way to prepare students seeking a career in welding? What skills are critical? What are acceptable levels of welding proficiencies by the industry? What skills should be taught at different levels of education? What are the entry-level skills in today's marketplace? To answer these questions, it is essential to also understand that in order to compete on a global scale, future welders and their employers will not be prepared for the new economic realities if they are merely trained to weld. Developing entry-level welders who are adept at repetitive welds in a shop setting is essential, but

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there must be an effort made to prepare students entering the welding industry with a deeper, richer education that goes far beyond the skillful joining of two pieces of metal.

Transforming the welding workforce to meet long-term goals and compete worldwide starts with the design of the educational facility and the alignment of the teaching curriculum. Today's welding curricula must be nimble and capable of incorporating the very latest technologies and market trends. The welding field is evolving into a diverse group of disciplines. Educating personnel with very specialized knowledge, as well as providing the required training, is the only way to ensure the workforce entering the market is prepared for success.

1.2 TYPES OF FACILITIES

There are many different types of facilities that contribute to the welding workforce. Many existing welding education/training programs are outdated and there is no one-size-fits-all approach for preparing someone heading into the modern welding market.

The public and private sector, technical trade schools, community colleges and even private companies' training facilities must embrace the integration of learning labs, weld theory and case studies. This blended education is more likely to develop a professional who can meet the demands of the modern marketplace.

Welding education programs should have areas that can incorporate the technology used in distinct disciplines of welding and metal fabrication. A general welding program can include classrooms, welding booths, robotics, CNC plasma cutting, real-world applications, inspection and fabrication areas. Although this is not an exhaustive list, it does provide an example of the complexity of a modern welding program.

1.3 DOCUMENT INTENTIONS

This Welding School Guide encourages a broader scope approach to a welding education by outlining the considerations necessary to build a successful welding program for the future. It will help in the preparation of curriculum development as well as make specific recommendations for the facility layout.

With a shift to an integrated education model, there are many considerations that will influence the type of welding school you build. From the time it takes to have initial discussions about funding or securing property to hiring educators and turning on the lights, a new facility can take up to two years to develop. The objective is to build the right school.



Figure 1-1: State-of-the-Art Classrooms Combine a Traditional Setting with Advanced Technology and Distance Learning Capability



Figure 1-2: Automated Technology is a Growing Area of Welding Education

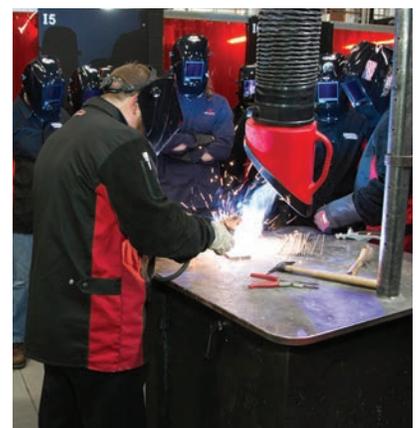


Figure 1-3: Hands-On Demonstration Areas are Critical to the Learning Process

1.4 INSTRUCTIONAL AND LABORATORY AREAS

This guide makes recommendations for the instructional and lab areas for development as part of a new facility and emphasizes classrooms situated to optimize learning. These specialized spaces include CNC plasma cutting, the latest robotic welding technology, fabrication, welding booths, faculty offices, storage, and accommodations for student meeting and leisure areas. This guide takes essential factors into consideration, such as climate-controlled areas, lab training access and placement of classrooms away from high-decibel lab areas, as well as the location of restrooms.

1.5 THE WELDING CURRICULUM

Instituting a consistent curriculum is the guiding light for any welding program. The curriculum is the backbone of the program and it should lead the decisions that impact space, lab areas, equipment and classrooms. Career pathways should guide the welding education at the secondary level, allowing the school to define the curriculum while providing students experience within different industry opportunities. Defining pathways is a tool for articulating programs between secondary and post-secondary institutions. This is a significant decision based on the type of welding employed within a school's geographic area.

Incorporating different levels of welding education is critical for success. Each of the levels could include elements or a combination of career pathways.

Career pathway options could include:

- » Automotive/ Transportation
- » General Fabrication
- » Heavy Fabrication
- » Maintenance & Repair
- » Offshore
- » Pipeline
- » Pipe Mill
- » Power Generation & Process
- » Liquefied Natural Gas
- » Nuclear
- » Pressure Vessel
- » Thermal Energy
- » Wind Power
- » Shipbuilding
- » Structural

A **production welding pathway** includes the development of specific skills that are used by local industry and may serve as a potential employment pipeline within a certain geographic region where the program is based. Having a production welding program can also benefit the student by developing basic skills that will allow them to transfer to an advanced welding program, where they may further hone their skills and reach additional levels of welding certification.

The **manufacturing and engineering pathway** utilizes skills development for part of the program, while applying manufacturing and engineering principles in the curriculum. The program's main objective is to develop an individual who has basic welding skills to apply to metal fabrication and quality assurance. When students complete this initial level of training, they should have the qualifications needed

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to continue their education at advanced training centers and colleges that offer Welding Engineering Technology programs.

The **automation pathway** is relatively new to the welding industry, necessitated by the greater prevalence of robotics and CNC in manufacturing. The demand for automation will continue to increase. The number of new welders with skills in robotics and CNC is not well defined, but the need has increased significantly the last 10 years. The industry recognizes that welders will make good robotic welders, but good robotic operators will not necessarily make the best robotic welders. To be successful in welding, robotic welders require a foundation of skills and knowledge. This pathway includes theory and skill development in welding, coupled with robotic and CNC programming to develop the next generation of high-tech advanced welders.



Figure 1-4: Robotics Cutting Table

2. CHARACTERISTICS OF A WELDING EDUCATION PROGRAM

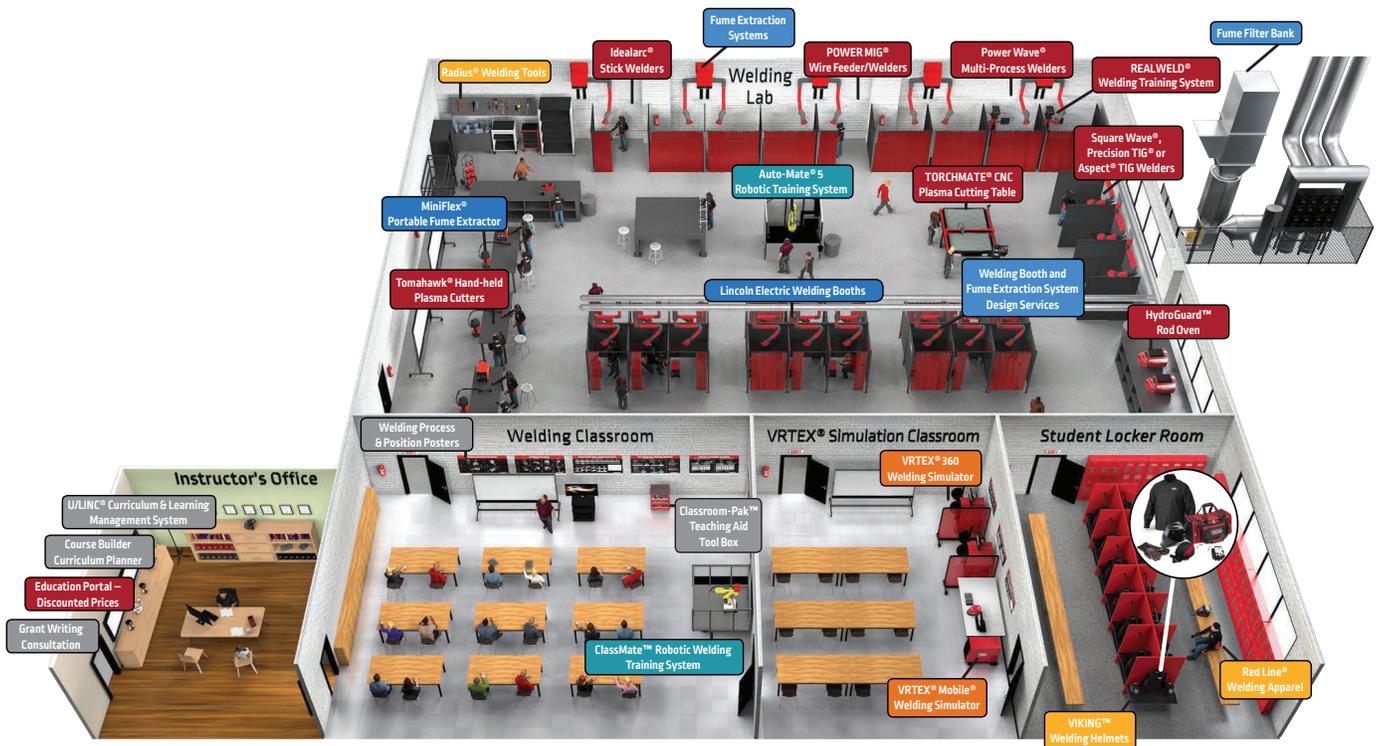


Figure 2-1: The Modern Weld School is Made up of Specialized Areas Designed for Distinct Learning Experiences

2.1 ELEMENTS NEEDED

The elements required for developing a welding education program are extensive. Lincoln Electric believes attention to the smallest details for each element is essential for the development of a program that can sustain the highest level of success for students.

The following are recommendations that must be weighed with the local and state ordinances, as well as OSHA compliance.

2.1.1 CLASSROOM(S)

Ideally, the classroom space (see Figure 2-2) should be 30 ft (9.1 m) x 30 ft (9.1 m) with a minimum ceiling height of 12 ft (3.7 m). Positioned adjacent to the lab area, the classroom should accommodate a predetermined number of students based on the school size and curriculum (most ranging between 12–24 students). Extra-wide double doors, up to 48-in (1.2 m) wide, provides access for moving multiple teaching aids into the learning environment. Bringing new and old tools into the classroom will enrich the learning experience.

Section 2 | Characteristics of a Welding Education Program

It is essential to create a controlled classroom environment that is comfortable, shielded from outside distractions and promotes full student concentration. The classroom (see Figure 2-2) should be completely insulated from laboratory noise. There should be ample ambient light entering the room and adjustable interior lighting levels to enhance the use of visual aids. This space should have independent climate control and sufficient wall space for posters and other visual learning aids.

The modern classroom should be capable of sustaining distance learning, including access to Wi-Fi and hardwiring for standard electrical power and internet access. Locating the 20-amp circuits up front will accommodate robotics and other teaching aids. Allocation for a Virtual Reality Arc Welding Simulator (VRTEX® 360) will require a dedicated 6 ft (1.8 m) x 8 ft (2.4 m) space. Speakers should be placed at ceiling height and angled down to the center of the room.

The instructor's workstation should provide a hub for all digital activity with desktop interface, space for classwork, a laptop computer, podium, AV projector and Interactive Project Camera. Specific instruction should be posted regarding fire exits, evacuation and storm shelter procedures. A landline phone, instructional whiteboards and a dedicated classroom printer should be located at the front of the room.

Student desks/chairs should be on wheels for enhanced flexibility. The first row of desks should be 10 ft (3 m) from the front wall, which will allow the placement of advanced trainers, such as the VRTEX® or REALWELD®, in the classroom, while providing adequate room for teaching aids that the instructor may bring in for discussion.

Position a large table for classroom supplies in a centrally located portion of the room. Include space for storage of audiovisual equipment, samples, reference texts, etc.

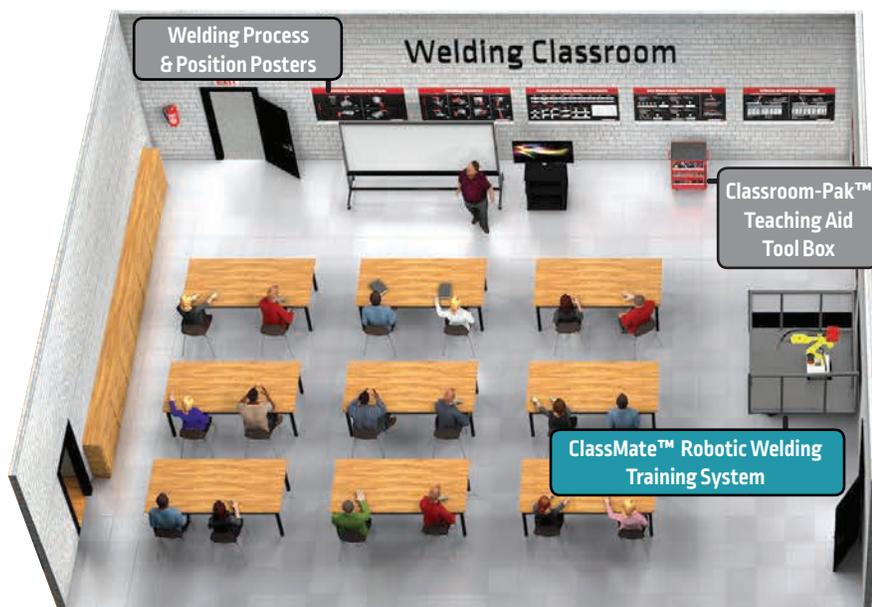


Figure 2-2: The Ideal Classroom Provides a Comfortable Learning Environment that Combines Flexible Seating for Students with Instructor Demonstration and Virtual Training Spaces

2.1.2 WELDING LABORATORY

A laboratory is for learning, not just training, and this space should be designed to enhance the students' education by creating a comfortable setting that optimizes space while providing safe, efficient student access (see Figure 2-3) to the required tools, materials and designated training booths.

Use the American Welding Society (AWS) recommendation of a minimum of 100 ft² (9.3 m²) of laboratory floor space per individual as a good general planning figure. At the outset, the architect/planner should take into account state recommendations for minimum square footage per individual. While they vary from state to state, factors of 75 ft² (7.0 m²) to 150 ft² (13.9 m²) of workspace per individual and a minimum of 400 ft² (37.2 m²) to 800 ft² (74.3 m²) for material storage are generally accepted requirements for this particular size area and the subjects to be taught. Floor dimensions of 40 ft (12.2 m) x 85 ft (25.9 m) are reasonably close to the normally accepted length to width proportions of 2 to 1. The minimum ceiling height should be 16 ft (4.9 m). The minimum ceiling height should account for the additional vertical space required for piping, lighting, ductwork and fume mitigation. The physical apparatus necessary for fume mitigation should be added to the recommended 16 ft (4.9 m) height. A utility door should be large enough [14 ft (4.3 m) x 14 ft (4.3 m)] to accommodate bulky materials, equipment and projects. Both male and female locker rooms with showers may be needed in case students need to attend other classes after welding. The locker rooms, including sanitary bathroom facilities, should be located to allow for quick, easy student access from the lab area.



Figure 2-3: The Ideal Welding Lab Combines Accessibility to Individual Welding Booths, Demonstration Tables, Coupon Access, Essential Tools and Equipment

Section 2 | Characteristics of a Welding Education Program

Institutional growth should be anticipated. The ability to adapt and reorganize to accommodate additional enrollment, new equipment or unplanned shop activities without going below space-per-individual minimums is critical to ensure future success for the school.

The entire laboratory should be wired for emergency shut-down capability. Where a hazard exists around machines, the power equipment should be placed so that welding personnel are not in the line of danger. Equipment should be enclosed in a safety zone painted on the floor. While a minimum width of 6 ft (1.8 m) is recommended for aisles, up to 10 ft (3.0 m) should be considered for aisles located where the largest materials are being handled. Aisles should be provided between benches, machines, and in areas in front of tool cabinets and storage lockers. Non-skid surfaces should be applied to the floor in the area around machines to minimize the risk of slipping. To minimize noise, dust and dirt, grind areas should be located away from weld booths.

2.1.3 THE WELDING BOOTH

The minimum recommended size of a welding booth is 5 ft (1.5 m) x 5 ft (1.5 m), with an optimal area size of 8 ft (2.4 m) x 8 ft (2.4 m) planned for general purpose welding booths. An area of 10 ft (3.1 m) x 10 ft (3.1 m) should be set aside for pipe welding booths. Welding booths should be constructed of fire-resistant material, with at least a 12 in (30 cm) gap between the floor and booth walls to permit air circulation. All four sides of the welding booth should provide welding personnel and others in the area with complete protection from harmful ultraviolet light and hot sparks.



Figure 2-4A: Welding Booth

Considerations when configuring a welding booth:

- » Will the power source be inside the booth?
- » Will the power source be elevated off the floor?
- » Size of welding/tacking table: minimum of 12 in (30.5 cm) x 24 in (61 cm)
- » Will the booth be used for project-based learning?
- » Use of curtains to view student activity without interrupting the student.
- » Ability to integrate technology into the booth (Ethernet connectivity).
- » Access to storage lockers in booth.

To enhance the flexibility of equipment being utilized in the booths and considering efficiencies and current draws, weld booths should have access to a power source delivering a minimum of your welding equipment requirements. The power input will be determined by the power sources used and the school curriculum. It is

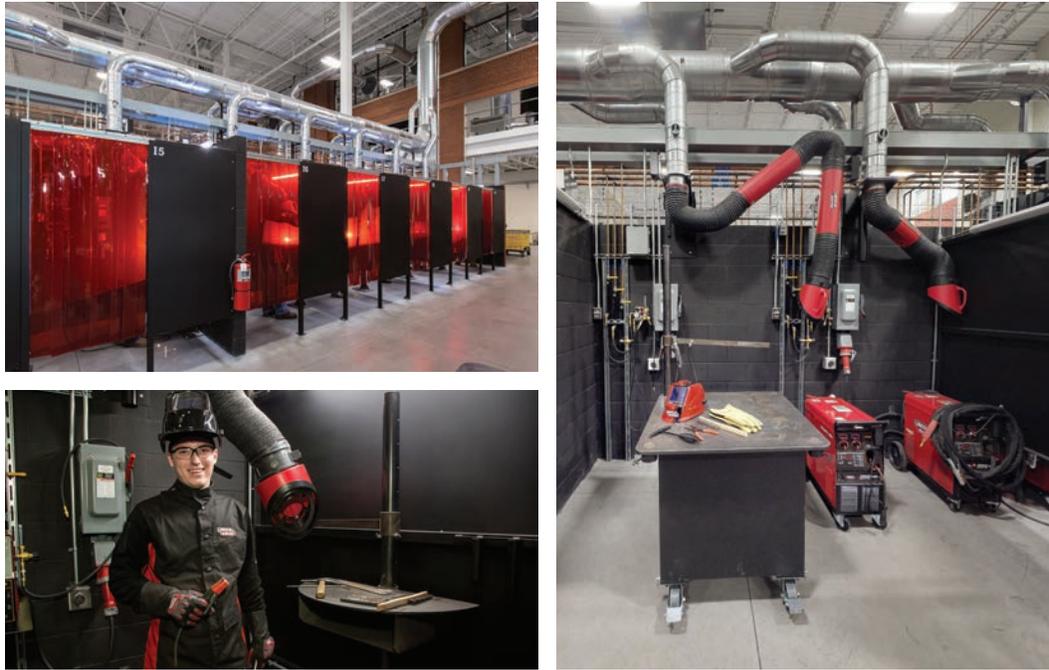


Figure 2-4B: The Ideal Welding Booth Should Be 8 ft (2.4 m) x 8 ft (2.4 m) with Access to Essential Power, Tools, Table and Exhaust Removal

recommended that the power source be located in the welding booth (see Figure 2-4B), which will allow the student to make adjustments without having to leave the booth. Adequate lighting and 110-volt power should be available in every booth. Each booth should have a 2 ft (0.6 m) to 3 ft (0.9 m) wide weld table, which should only be used for tacking, and a floor-mounted, adjustable, telescoping weld arm for securing materials (see Figure 2-4.2) to be welded out. Special consideration should be given to the added safety/convenience of counter-balance models.

Telescoping fume extraction arms (see Figure 2-4B) are recommended to ensure proper positioning for efficient plume removal.

To increase efficiency, tools and supplies should be located in close proximity to designated work areas. Storage for essential items such as Personal Protective Equipment (PPE), tool cribs and coupons/scrap, as well as consumables, rod ovens, tips, nozzles, expendables, etc., should be located near weld booths.

Machines should be positioned to allow for cleaning and convenient access around each base. Cabinets should fit flush to walls or be trimmed to fit flush for ease of floor maintenance. Bases for cabinets and benches should provide toe space for worker comfort and safety.

Instructors should have a designated work and grading area in the laboratory with close proximity to a minimum 72 in (0.9 m) x 40 in (1.0 m) whiteboard. A minimum of one 10 ft (3.1 m) x 10 ft (3.1 m) demonstration area should be available for every 20 welding personnel potentially occupying the laboratory at one time.

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Hot and cold running water, with suitable drinking fountains in the laboratory, and convenient sanitary restrooms are necessities. Always check local/state minimum requirements for restroom ratios per student. Washing facilities of either the half-round or trough-type sink are essential and should be adequate to accommodate one quarter of the welding personnel simultaneously. Location of the washing facilities should be as near the lab exit door as feasible. The need for convenient access to drinking fountains is highly desirable. Due to airborne contaminants within the lab environment, drinking fountains should be located outside the lab. Check local/state health code requirements to ensure compliance. Lincoln Electric recommends drinking fountains be located in an adjacent hallway or in close proximity to the weld lab. A safety shower and eye wash station should also be located within each laboratory area. Check on local/state minimum requirements to ensure compliance for student-to-station ratios. Proper floor drainage should be considered during installation of safety shower and eye wash stations.

The full scope of the lab's capabilities will dictate the extent of the specialized tools needed (e.g., fabrication, etc.). Work areas for tools such as wet or vertical band saws and drill presses should be located in areas denoted by high-impact floor markings.

Quench tanks (see Figure 2-5) are an essential part of any weld laboratory. Accommodations should be made to design the necessary drain and filtration systems required wherever quench tanks are located throughout the lab.

2.1.4 TOOL STORAGE

The location of storage areas for task-specific tools (e.g., grinders, gauges, acid, etc.) is critical to maintaining optimal use of student laboratory time. Tool storage areas with limited access provide for the convenient checking of tools for each process, which will conserve welding personnel time while helping them associate proper tool selection with a particular activity. Space beneath benches and tables provides for immediate storage of hardware, small amounts of raw stock or even small projects. Never store anything flammable beneath benches or tables.



Figure 2-5: Placement of a Quench Tank Near Grinding Stations is Important for Efficiency and Safety. Areas Where Materials are Cut Should be Located With Easy Access by Instructor.

OTHER TOOLS TO CONSIDER

- » Metal processing (Iron worker)
- » Vertical band saw
- » Horizontal band saw
- » Shop press
- » Sheet metal brake
- » Notcher
- » Track cutting table
- » Pipe profiler
- » Polishing area
- » Grinders
- » Bench vices
- » Files

2.1.5 METAL STORAGE

A locked/secured environment located in close proximity to the lab should be use for metal storage. Depending on regional climate, exterior storage may be a viable option. Access to the outside and a path to receive material should be considered as large flatbed trucks or tractor trailers will be needed to deliver and restock materials. These vehicles will need facility access and be able to maneuver around the school exterior. Metal generally comes in 20 ft (6.1 m) to 24 ft (7.3 m) pieces, and will need to be handled in an appropriate manner. Structural steel and steel sheets can be very heavy, requiring the assistance of an overhead crane or fork truck to provide safe maneuverability.



2.1.6 CNC PLASMA CUTTING

The CNC Plasma Cutting operation may be located on the lab floor or set off with its own designated room adjacent to the lab. Accommodations must be made for transporting and storing large steel plates and disposing scraps generated during lab work.

The space should contain a 5 ft (1.5 m) x 10 ft (3.0 m) cutting table, a source of water to easily fill the water table and drains in the floor for safe and convenient disposal of excess and contaminated water. Depending on local and state codes, wastewater may be considered hazardous and require special handling. Careful consideration should be paid to the location of the computer assigned to controlling the table operations.

NOTE: If there is no water table, you will need a fume extraction hood or a downdraft system under the table.

Adequate space should be allocated to provide student access to observing all activity on the table. Consideration should be given for space to accommodate students representing either a full or partial classroom size (minimum 10, no more than 20).

2.1.7 THERMAL CUTTING AREA

An open-style or booth-style thermal cutting area is required. Effort should be made to create a multifunctional thermal cutting area that combines plasma and oxy-cutting processes. The more functions a booth or cutting space can offer, the more efficient the space will become for



Figure 2-6: CNC Plasma Cutting Table

Section 2 | Characteristics of a Welding Education Program

students and overall lab use.

To provide flexibility for the thermal cutting station, standard power and gas access should be located in close proximity to the work area (see Figure 2-7). Thermal cutting stations may be featured in a booth setting for instruction, as well as out in the open for fabrication of larger pieces.

Cutting fuels should be provided in the booth for welding while alternative fuels, such as propane or natural gas, should be available for cutting.

Oxyacetylene cutting and oxy-fuel welding areas should be clearly defined, but thought should be given to developing a multi-functional space that can accommodate other functions when not in use. These areas could be used in the event that booth space becomes limited in the welding lab.

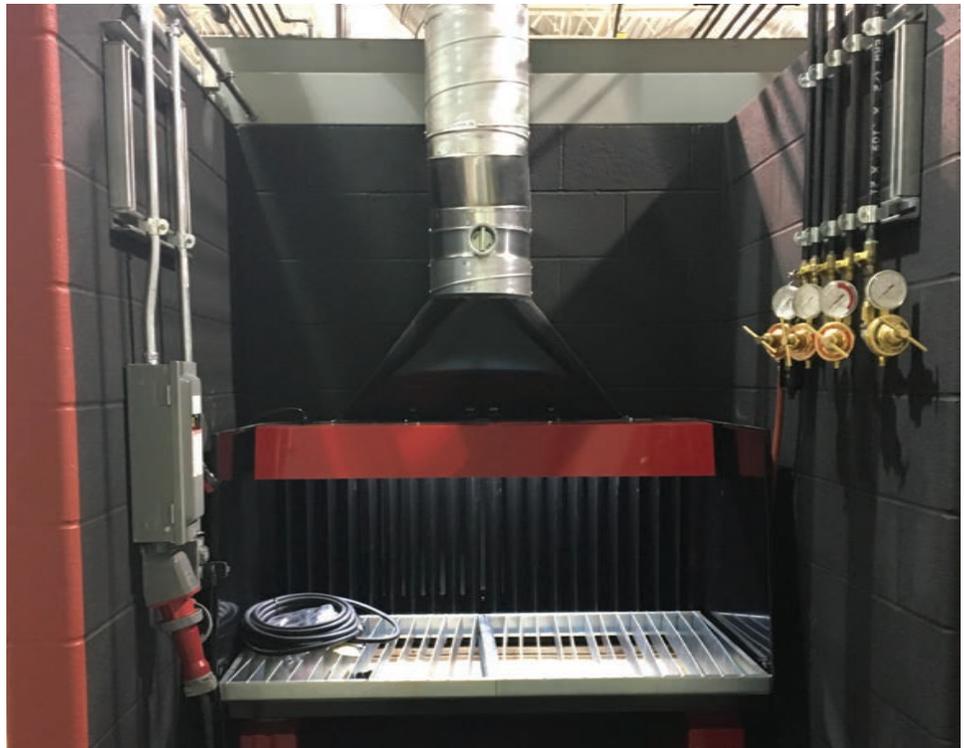


Figure 2-7: The Ideal Cutting Table Setup Includes Easy Access to Power, Gas, Essential Tools and Exhaust Removal

▲ ■ 2.1.8 ALTERNATIVE FUELS

Alternative fuels are a classification of flammable gases other than acetylene that can be used in oxy-fuel metal fabrication processes such as cutting, brazing and heating. Alternative fuels cannot be used for welding. Commonly used alternative fuels include liquid petroleum (LP) gases such as propane and propylene, natural gas (methane) and occasionally hydrogen.

Although steel can be cut very well with acetylene, welding schools should expose students to a wide variety of different gases and equipment that are commercially available and useful to perform various industry processes. For instance, LP gases have higher overall BTUs than acetylene and, with properly designed torches and tips, are more efficient in cutting steel. In addition, alternative fuels are preferred over acetylene in heavy heating applications because of the higher BTUs and the safety and stability versus acetylene.



Figure 2-8: Rod Oven



Figure 2-9: Storage for Pipe Material

2.1.9 ELECTRODE & CONSUMABLE STORAGE

A storage area for boxes of consumables, TIG wire, etc., should be designated near the welding laboratory (see Figure 2-10). Once cartons containing consumables have been opened, consider close proximity for rod ovens (see Figure 2-8) and other appropriate storage containers in order to maintain the integrity of the low-hydrogen consumables. Rod ovens are not recommended for cellulosic-type electrodes. Depending on the size of the lab, multiple areas may need to be created for consumable storage that can be accessed by the students in the lab. An alternate bulk storage space should be located away from the immediate welding area.

2.1.10 DEMONSTRATION AREA

Located in close proximity to the welding booths, the demonstration area should be 20 ft (6.1 m) x 20 ft (6.1 m) and capable of easily accommodating the movement of any size material necessary for process demonstrations.

NOTE: Weld demonstrations for a group of students should NOT be performed in a weld booth.



Figure 2-10: Electrode Storage

Section 2 | Characteristics of a Welding Education Program

For a student to observe a weld being performed, they must be in close proximity to the steel demo table (see Figure 2-11). It is important that students have space to gather around the table. Consider groups of **5-7 students** as ideal to ensure each student is positioned at the edge of the table and their view is not obstructed. The demo area should include a 6 ft (1.8 m) x 4 ft (1.2 m) whiteboard and room for instructional posters.

Welding labs today are equipping the demonstration area with microphones and cameras so that the demonstration can be seen by all. Today's cameras have the ability to show the arc with great clarity and should be considered if possible.



Figure 2-11: A Demo Table in the Lab Should Provide Observation Points with Clear Visibility for Students

2.1.11 GRINDING AREA

The most important aspect to consider for the grinding area is that it is enclosed and minimizes noise reaching the students on the lab floor. The grinding area (see Figure 2-12) should be comprised of grinding stations based on the average classroom size. A 7:1 ratio of students to grinding stations is recommended. Access to an outdoor grinding area is considered optimal whenever regional climates permit.

Grinding stations can include a two-wheel bench grinder, wire wheel grinder, drum sander and tables with vices for hand grinders. In the hand grinding area, there should be dividers to protect students in adjacent areas.

A school's welding curriculum may have different training levels. Lincoln Electric recognizes these levels as **Basic**, **Intermediate** and **Advanced**. The essential equipment necessary within the grinding station will be defined by the level of the welding curriculum.

A **Basic welding program** that teaches structural steel, but does not offer an advanced pipe or exotic material program, has a base starting point for the grinding station consisting of (1) wire wheel, (1) drum/belt sander, (2) tables with vices and (2) hand grinders.

An **Intermediate and Advanced welding program** will require a separate area designated for pipe and exotic material grinding. Each station should offer (1) vice stand for filing, (1) bench grinder, (1) wire brush, (1) hand grinder and (1) drum/belt sander. The 7:1 classroom ratio to determine number of grinding stations should be used for either Basic or Comprehensive programs. The use of a drum/belt sander greatly reduces noise and provides a safe metal preparation experience for students.



Figure 2-12: The Ideal Grinding Station Offers Easy Access to a Quench Tank with Adequate Dust Control

2.1.12 INSTRUCTOR OFFICE

This is an independent office located with convenient access from the classroom, laboratory and facility corridor. Activities in the classroom and laboratory should be visible from the instructor's office. The office window space should be designed to provide maximum vision to all areas along with proper ultraviolet light protection. Recommendations for the instructor's office size are at least 120 ft² (11.2 m²) of floor space per instructor [size 10 ft (3.1 m) x 12 ft (3.7 m)]. The office should be designed with at least one 3 ft (0.9 m) wide door, tile or carpet flooring cover, and an acoustical ceiling with fluorescent lighting. For instructional use and laboratory safety, the office should have a telephone. Each office should have room for file cabinets, desks, a bench with storage underneath for weld supplies, a shelf for boots, and room for two chairs for counseling welding personnel.

Section 2 | Characteristics of a Welding Education Program

2.1.13 INSTRUCTOR WORK ZONE IN WELD LABORATORY

This space is the instructor's base of operations in the lab. Instructors should have a designated work and grading area in the laboratory with close proximity to a minimum 3 ft (0.9 m) x 6 ft (1.8 m) whiteboard. A minimum of one 20 ft (6.1 m) x 20 ft (6.1 m) demonstration area (see Figure 2-13) should be available for every 20 welding personnel potentially occupying the laboratory at one time.

The instructor work zone should have a steel table with drawers for storage, podium, comfortable stool, adjustable task lighting and phone access. It is essential to provide an adjacent area designated for submitting student assignments and coupons for grading. A quench tank should be accessible to the instructor work zone and it should have fresh water access, floor drains and compressed air availability.



Figure 2-13: Instructor Work Zone in Weld Laboratory

■ 2.1.14 PIPE WELDING AREA

The pipe welding area (see Figure 2-14) should be large enough to accommodate large pieces of pipe while remaining functional for the students working within the booths. The recommended allocation of booth space is 10 ft (3.0 m) x 10 ft (3.0 m) with an overhead minimum clearance of 12 ft (3.7 m) to 16 ft (4.9 m) in order to allow for maneuvering of large pipe segments. In each pipe-welding booth, there should be electricity for grinders and space designated for the power source.

Once a decision is made whether to use engine drive welders, the power source, which will be placed outside the building structure, should have leads directed into each of the pipe welding booths.

If the school allows outside students to use their own engine drive welders for certifications at the school, whether it is for the American Petroleum Institute (API) or the American Society of Mechanical Engineers (ASME), students will often choose to use their own equipment. This will require suitable parking (three to five spaces are recommended), be allocated to position these vehicles in close proximity to the lab exterior wall, where leads may be passed through the wall and into the designated interior booths.

It is essential to have a designated demonstration space set up in the pipe welding area. In order to teach specific joint fit-out utilizing large sections of pipe, the area should provide ample space to maneuver the pipe sections and allow students to have an unobstructed view of the demonstration area.

NOTE: Weld demonstrations for a group of students should NOT be performed in a weld booth.



Figure 2-14: Pipe Welding Area

For a student to observe a weld being performed, they must be in close proximity to the steel demo table (see Figure 2-11). It is important that students have space to gather around the table. Consider groups of 5-7 students as ideal to ensure each student is positioned at the edge of the table and their view is not obstructed. The demo area should include a 6 ft (1.8 m) x 8 ft (2.4 m) whiteboard and room for instructional posters.

The demonstration space in the pipe welding area should have storage areas for student coupons and room for rod ovens. The pipe welding demonstration space should be located in close proximity to the grinding area.

2.1.15 BATHROOMS WITH LOCKERS

It is important to have enough bathrooms centrally located that can accommodate the number of students and staff in the facility at any one time. Give specific consideration to local and state requirements for bathroom ratios based on occupants or other factors. Bathrooms should be designated for public use with additional facilities for lab use. Be aware of the time that may be taken away from student learning if restrooms are located too far from classrooms or lab areas.

Secure lockers (see Figure 3-5) should be provided for daily student use. The lockers may be located in a designated locker room or situated within general spaces, such as adjacent hallways. Restrooms and lockers need to be provided for male and female students. Lockers should be large enough to hold student tools, equipment, backpacks, boots and jackets.

Section 2 | Characteristics of a Welding Education Program

2.116 GAS CYLINDER STORAGE

Storage will be needed for both fuel gases and weld shielding gases. Due to the potential hazards associated with use of welding industrial gases, it is critical to recognize OSHA, local, state and governmental guidelines when addressing gas cylinder storage.*

Cylinders shall be stored (see Figure 2-15) where they will not be exposed to physical damage, tampering, or subject to temperatures which would raise the contents above 125°F (52°C). Check for overhead combustibles such as overhead lines and piping, suspended ceiling materials, etc., when considering storage location. The storage location should be well ventilated to avoid the accumulation of hazardous gases in the event of cylinder leakage.

Cylinders shall be stored away from elevators, stairs or gangways in assigned places where cylinders will not be knocked over or damaged by passing or falling objects. Cylinders shall be secured in storage to prevent falling. Cylinders in storage shall be separated from flammable and combustible liquids and from easily ignited materials such as wood, paper, packaging materials, oil and grease by at least 20 ft (6.1 m) or by a noncombustible barrier at least 5 ft (1.6 m) high having a fire resistance of at least one-half hour.

Oxy-fuel pipelines must be equipped with approved dry or hydraulic flashback arrestors installed in accordance with NFPA-51.

General considerations for gas cylinder storage should recognize that contractors will be delivering and storing welding industrial gases at a designated area that should not interrupt students in class or the lab. Gas storage for full and empty bottles should be located outside the main building in a secured structure, cage or fenced-in area. Acetylene and other flammable gases should be stored separately.



Figure 2-15: Inert Gas Cylinder Storage

*Per: ANSI Z49.1, Part II—Specific Processes, 10.8.2 Cylinder Storage

Red rings, tags, or other denotation of empty bottles (see Figure 2-16) should be standardized to avoid time lost in locating full bottles. Any gas cylinder that will be used in a 24-hour period is considered “in-use.” Gas cylinders with no planned use in a 24-hour period should be stored as indicated above.

NOTE: Rings or tags will often be provided by gas suppliers.

Depending on the size of the school and the number of booths housed in the facility, it may be advantageous to consider bulk gas storage. Bulk industrial gas tanks, containing gas for cutting and welding, should be situated outside the main building. Bulk gas should be piped into a gas mixer, located within the facility, to regulate and appropriately mix gases.

Generally, facilities with more than 25-30 welding/cutting booths should consider bulk gas installations. Gas distribution systems can be designed for large facilities, but the number of cylinders and the space required can become impractical.

Conservatively, each station should be sized as follows:

- » 50 SCFH shielding gas for gas metal arc welding (GMAW)
- » 25 SCFH for gas tungsten arc welding (GTAW)
- » Oxy-fuel cutting and brazing stations should be sized for up to 200 SCFH oxygen and 40 SCFH fuel gas at each station
- » Heavy heating applications will require flow capacities of up to 1000 SCFH for oxygen and up to 400 SCFH fuel gas at each station

The gas supplier should determine the size and location of the bulk system. Decisions will be based on monthly gas consumption and availability of bulk gas replenishment.

If bulk gas systems are used, appropriately sized gas blenders should be used to ensure sufficient welding flow rates to each booth. Always check with local and state authorities, including your safety office and gas supplier, for any potential regulations that may apply.

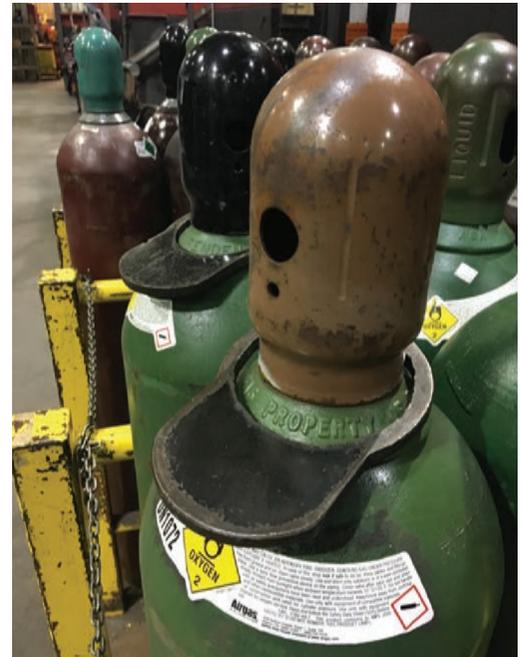


Figure 2-16: Gas Cylinder Tags Easily Denote Status

Section 2 | Characteristics of a Welding Education Program

2.1.17 FUME EXTRACTION

Adequate ventilation should be provided for all welding, cutting, brazing and related operations. Enough adequate ventilation should be provided so personnel exposure to hazardous concentrations of airborne contaminants are maintained below the allowable limits specified by the authority having jurisdiction.

Service plans are based on state and local ordinances. You need to have a service plan in place before doing any welding. Contact local officials regarding the disposal of used filters.

Arc welding is a safe occupation when sufficient measures are taken to protect the welder from potential hazards. The operation of welding fume control equipment is affected by various factors, including proper use and positioning of the equipment, maintenance of the equipment and the specific welding procedure and application. Worker exposure level should be checked upon installation and periodically thereafter to be certain it is within applicable OSHA PEL and ACGIH® TLV® limits.

Beyond the obvious importance of installing a reliable fume extraction system in a welding facility, it is important to recognize there is no single solution for safe fume extraction. Variables such as the facility's square footage, ceiling height, number of booths and types of booths will all need to be taken into consideration when choosing the fume extraction process.

There are self-contained and centralized fume extraction systems. For smaller schools with 10 or less booths, a self-contained system will be capable of handling safe fume extraction. For larger schools with more than 10 booths, a centralized system is essential to safely removing fumes from the workspace. Centralized fume extraction arms are eight inches in diameter and flexible enough to be situated in any position within the weld booth to readily extract the gas plume and keep the air mix fresh and safe within the booth.

Lincoln Electric offers consultation to welding schools to engineer a custom fume extraction system. With Lincoln Electric custom fume extraction systems, workspace air can be drawn into a filtration media, scrubbed clean and circulated back into the workspace. While safely cleaning the air within the workspace, this method also helps support efficient heating and cooling of the facility. Lincoln Electric offers a complete line of portable, stationary and engineered solutions for welding fume control.

Filter banks can be installed either inside or outside the facility. When designing from scratch or retrofitting a lab, the ductwork and filter banks must be considered. Inadequate planning for fume extraction systems can have a severe negative impact on the layout and functionality of the facility.



Figure 2-17: Centralized Fume Extraction Arms

General fabrication areas within the school may require additional attention for fume extraction that moves beyond zoned extraction. Lincoln Electric can provide the equipment for additional fume extraction based on a professional evaluation of the needs at the individual facility.

2.2 GENERAL CONSIDERATIONS

2.2.1 WHERE SHOULD THE WELDING SCHOOL BE LOCATED?

The welding school should be located on the main campus of the primary school and in proximity to allow for large trucks (see Figure 2-18) to deliver supplies needed to support welding activities. The welding school should not be set in an area of campus that seems inaccessible for students and staff. In addition, the welding lab should be placed strategically so noise levels do not distract other students within the school. When selecting a welding school location on campus, consider the following:



Figure 2-18: It is Critical to Consider How a Weld School Will Receive Materials

- » Locate close to the primary school
- » Situate to accommodate large delivery trucks
- » Allocate space to manage diverse materials
 - Racks to store raw material
 - Cranes to move materials
 - Buckets to hold cut materials
- » Consider noise levels

Section 2 | Characteristics of a Welding Education Program

NOTE: Many times, labs associated with Career and Technical Education are placed in areas that are removed from general learning environments. This arrangement can have an isolating effect on welding education, making it appear as secondary to academics conducted in the primary facility areas.

2.2.2 CLIMATE CONTROLS

Based on the size and configuration of the school, climate controls are critical to establishing a comfortable environment for students to learn while also maintaining temperature for welding equipment maintenance and the energy-efficient use of heating and cooling equipment.

Heating and cooling capacity should take into consideration the provision of a supply of fresh, clean incoming air. The laboratory heating system should automatically maintain a temperature of 68°F (20°C) measured 60 in (1.5 m) above the floor. The classroom and the office should be kept at 70°F (21°C) measured 30 in (762 mm) above the floor. A system of even heat distribution should be kept within 5% of these temperatures for student comfort and for the stability of equipment and stored materials.



2.2.3 FLOOR COVERING IN CLASSROOMS AND WELD AREA

Polished and stained concrete is an attractive and low-maintenance classroom flooring option gaining wide acceptance throughout the industry. Only concrete surfaces are acceptable for use on welding lab floors. Bright yellow safety markings on the classroom and lab floors should be used to designate work areas and provide safe movement throughout the facility.



Figure 2-19: Bright Yellow Safety Markings on the Floor Designate Work Areas

2.2.4 ELECTRICITY

Electrical power should be supplied with adequate voltage and amperage for each power source. Electrical service should be 208 volt, 230/240 volt, or 460/480 volt, single phase or three phase, and 60/50 cycle (60/50 Hz), alternating current. The primary service should never be less than 208 volts. Current capacity of 25-50% more than the known demand should be provided for expansion in the welding facility.

Electrical outlets for 110/120 volt service should be placed at convenient locations every 12 ft (3.7 m) and in every booth. Ground fault interrupters should be provided throughout the shop. The use of magnetic starters on all equipment is an additional

safety feature that gives a machine motor overload protection as well as low-voltage and no-voltage protection. After a power failure has been corrected, the machine will not start (even if it was running when the failure occurred) until the operator presses the start button.

A disconnect switch that can be locked out should be provided to cut off all power equipment, including power sources, in the shop. Panic switches

should be strategically located around the entire shop or laboratory and the locations known by all welding personnel. Switches should be wired to cut off power to every machine. Fused disconnect switches should be provided for each power source.



Figure 2-20: To Enhance Safety Within Welding Areas, All Electrical Outlets Should Have Covers.

2.2.5 APPROACH TO LEARNING

The question that any educational institution must ask itself is: What does our particular program wish to achieve? Sharing knowledge and unique insights are only a small percentage of educating. In the case of vocational programs, the physical hands-on lab work has always been a critical function of the welding school. Determining what ratio of classroom and lab time are allocated for a welding curriculum should reflect what goals the program wishes to achieve.

New welding technologies being deployed will continue to cause shifts in how we educate and train welders for tomorrow. Welding education programs can be categorized as weld training or weld educational facilities. Training facilities tend to focus more on the physical act of welding rather than the understanding of process theory. Educational facilities encourage a deeper understanding of the process and include more classroom time than traditional programs. With the expansion of new career pathways, the classroom will be utilized more than in the past. As an example, instructors in Automation would use classroom time to teach students how to program and manipulate CNC tables and robotic arms. Students would be able to program offline in virtual environments from their desks. This type of learning will greatly impact the design considerations of the classrooms and school.

2.2.6 CAREER PATHWAYS:

- | | | |
|------------------------------|------------------------------|-------------------|
| » Automotive/ Transportation | » Pipeline | » Pressure Vessel |
| » General Fabrication | » Pipe Mill | » Thermal Energy |
| » Heavy Fabrication | » Power Generation & Process | » Wind Power |
| » Maintenance & Repair | » LNG | » Shipbuilding |
| » Offshore | » Nuclear | » Structural |

Section 2 | Characteristics of a Welding Education Program

2.2.6.1 TRADITIONAL WELDING CLASSES

The traditional welding program has often utilized a model based on approximately 20% class time and 80% lab time. This often translates to a curriculum that is highly focused on training students to perform the various tasks associated with the welding vocation. This program has been successful in producing outstanding welders for a variety of tasks.

2.2.6.2 WELDING EDUCATION VS. TRAINING

As the modern educational process for a welding program has evolved, the model has changed to reflect more project-based learning, and much more attention is now spent on areas marginalized in previous welding curricula. The percentage of time spent in today's welding classroom has increased to 40% with approximately 60% of the time spent in the lab. This new distribution of class/lab time reflects a refined focus on topics, such as theory and new technological adaptations.

Today's evolving curriculum, while firmly planted in the welding industry, tends to provide a broader scope of education, which helps students understand broader aspects of industries such as advanced wave forms, GMAW, CNC plasma cutting and robotics. This curriculum creates a student who is prepared to step into new welding technologies as they emerge. It is an opportunity to prepare a student to adapt and evolve with changing industry demands and innovation.

▲ ■ 2.2.6.3 ADULT LEARNING AND CONTINUOUS EDUCATION

The growing popularity of adult learning and continuous education programs reflects the demands of a volatile economy that does not reward a stagnant workforce or a lack of innovation. Professionals in every vocation are returning to the classroom and lab to refresh and retool existing skillsets and to create new opportunities for themselves to be successful five years down the road.

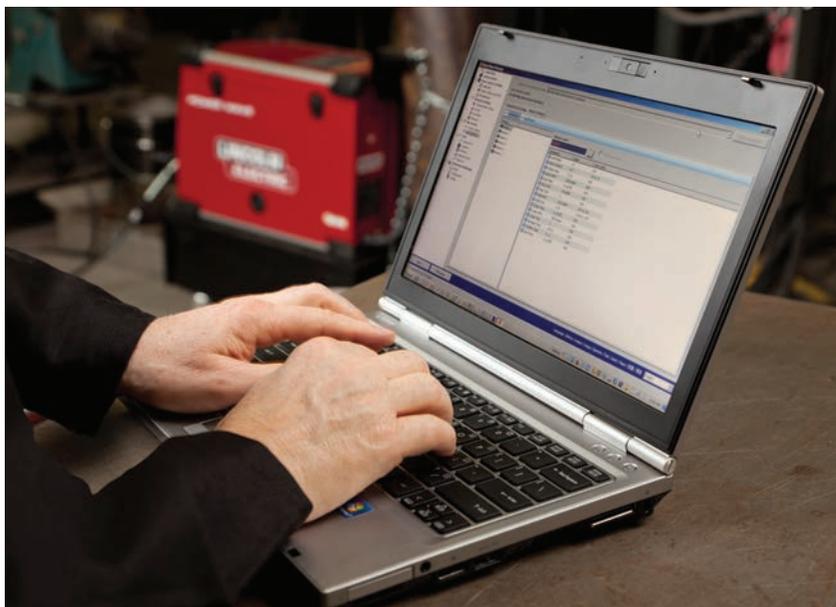


Figure 2-21: Today's Evolving Curriculum Provides a Broader Scope of Education to Help Students Understand Critical Aspects of Project Management, Time Allocation, Team Communication and Material Budgets.

These programs require particular planning for the facility space, equipment and staffing necessary to offer evening hours of operation. Ample parking spaces will be needed for an influx of evening students while daytime students may still be in the building or using the facilities. Consideration should be paid to creating flexible interior spaces with movable walls to accommodate different-sized evening classes, guest lectures, club meetings, and community or recruitment events.

The opportunity to host catered events will positively enhance the profile and perception of the school. These events are easier to host when a space is allocated for a fully functional kitchenette with stainless steel sinks, refrigeration and storage.

2.2.6.4 TYPES OF CONTENT DELIVERY METHODS

Existing and emerging technology offers myriad options for delivering essential information as part of the student curriculum. Access to the internet and the wealth of digital resources available within it make wireless access throughout the entire facility a necessity.

2.2.6.5 USE OF TECHNOLOGY

It seems the only constant besides the changing landscape of the industry may be the constant evolution of technology as a tool for teaching, as well as a tool for new welding applications. Introducing cameras into demonstration areas with a feed into the classroom for viewing is an effective way to integrate technology between the classroom and the lab.

The facility should have room to expand and be able to accommodate the use of new technologies, from forms of distance learning to the implementation of new welding equipment and processes. Each facility should have its own resource center that offers a traditional library setting with computer access and quiet areas for study.



Figure 2-22: Live Camera Operation, Overhead Multimedia

Section 2 | Characteristics of a Welding Education Program

Advanced Training Equipment (clockwise from top left) VRTEX® 360+; ClassMate® Educational Welding Robot; REALWELD® System; and Engage Workstation



Figure 2-23: VRTEX® 360+



Figure 2-24: ClassMate® Educational Welding Robot



Figure 2-25: REALWELD® System



Figure 2-26: Engage Workstation

2.6.7 ADVANCED LEARNING AREAS



Figure 2-27: The Lincoln Electric VRTEX® 360 Virtual Reality Welding Simulator

▲ ■ 2.6.7.1 VRTEX® 360 LAB

The VRTEX® 360 is a best-in-class, advanced-level welding training system. It is an engaging, easy-to-use training tool, designed to provide a full-featured, expandable platform. The VRTEX® is a practical tool for basic-to-advanced welding training and educational evaluation by instructors.

Features:

- » Supports all out of position welds
 - Dedicated welding gun and retractable stinger
 - Flexible and adjustable welding stand
- » Supports tee joint, flat plate, groove joint, 6 in diameter schedule 40 pipe, 2 in diameter XXS pipe and lap joint

Section 2 | Characteristics of a Welding Education Program

The VRTEX® 360 can be utilized to prepare students for their time in the welding booth or to specifically address student deficiencies. Lincoln Electric regularly updates the available data on VRTEX® 360 use. Check the Lincoln Electric website or contact your Lincoln Electric representative to ensure you have the very latest data and recommendations.

▲ ■ 2.6.71.1 CLIMATE CONTROLLED

Operating the VRTEX® 360 unit generates heat. In order to ensure comfort for the operator and the surrounding area, the unit should be placed in a climate-controlled space.

▲ ■ 2.6.71.2 AVOIDING HIGH FREQUENCIES (GTAW)

The VRTEX® 360 can be affected by the high frequencies created by gas tungsten arc welding (GTAW), also known as tungsten inert gas (TIG) welding. All VRTEX® 360 units should be located away from designated GTAW operational areas.

▲ ■ 2.6.71.3 ACCESSIBLE BY STUDENTS

Several VRTEX® 360 units should be located in the lab. Consideration should be paid to details concerning student accessibility during off hours and without instructors on site. It is critical students be allowed the greatest extent of accessibility to the VRTEX® 360 unit and other educational assets within the school.

▲ ■ 2.6.72 REALWELD®

REALWELD® monitoring technology allows instructors to evaluate student time spent in the weld booth. The REALWELD® system does not need to be in every weld booth and may be allocated to a designated demonstration booth. Adding a REALWELD® Advanced Trainer to your welding program can help improve training results. Using the system's "Arc OFF" mode, students can practice, troubleshoot and master welding techniques while reducing program material costs, including welding plate, electrode or wire and shielding gas. With audio coaching and instructor review of objective scores on five welding parameters, student training time and comprehension are enhanced.

▲ ■ 2.6.72.1 REALWELD® BOOTH LOCATION

The REALWELD® booth should be recognized as a training booth. In order to avoid removing an operational weld booth from student training access, the REALWELD® booth should not be assembled within an operational welding booth.



Figure 2-28: REALWELD® Station

■ 2.6.73 DEVELOPING AN ATF & UTILIZING NONDESTRUCTIVE AND DESTRUCTIVE TESTING

Nondestructive Testing (NDT) and Destructive Testing (DT) spaces are essential for students being evaluated for welding techniques. If a dedicated lab space is not available for this testing, space must be allocated with the appropriate equipment to accommodate testing needs. The NDT and DT testing space can often be shared with other functions within the welding lab.

■ 2.6.74 EXPERIENTIAL LEARNING

Experiential learning is a process through which students develop knowledge, skills and values from direct experiences outside a traditional academic setting. While experiential learning applies knowledge from the classroom, its effectiveness in teaching today's welders is based on solving problems encountered in the lab and with hands-on experience. The goal is to provide an experience that replicates real-world situations and challenges.



Figure 2-29: Project-Based Learning is Critical for a Complete Welding Education

2.6.75 TEACHING PROJECT-BASED LEARNING

Project-based learning (see Figure 2-29) is emerging as the preferred teaching method for new welders entering the market. Project-based learning is considered a far more “real-world” approach to problem solving that reflects what students will encounter once they enter the workforce. With project-based learning, students gain knowledge and skills by working for an extended period of time to investigate and respond to an engaging and complex question, problem or challenge. This process also prepares students for roles that move beyond the primary task of welding and into more management and specialty areas.



3.0 CHECKLISTS: DEDICATED STUDENT LEARNING AREAS

Designated areas within the welding school facility should provide students with an environment that fosters learning outside the classroom and welding booth. This space should offer quiet and controlled noise levels as well as group meeting space for discussions and collaborative projects. Special attention should be paid to accommodating technological tools such as Wi-Fi access, computer/monitor stations, online learning and options for charging cell phones and other electronic devices.

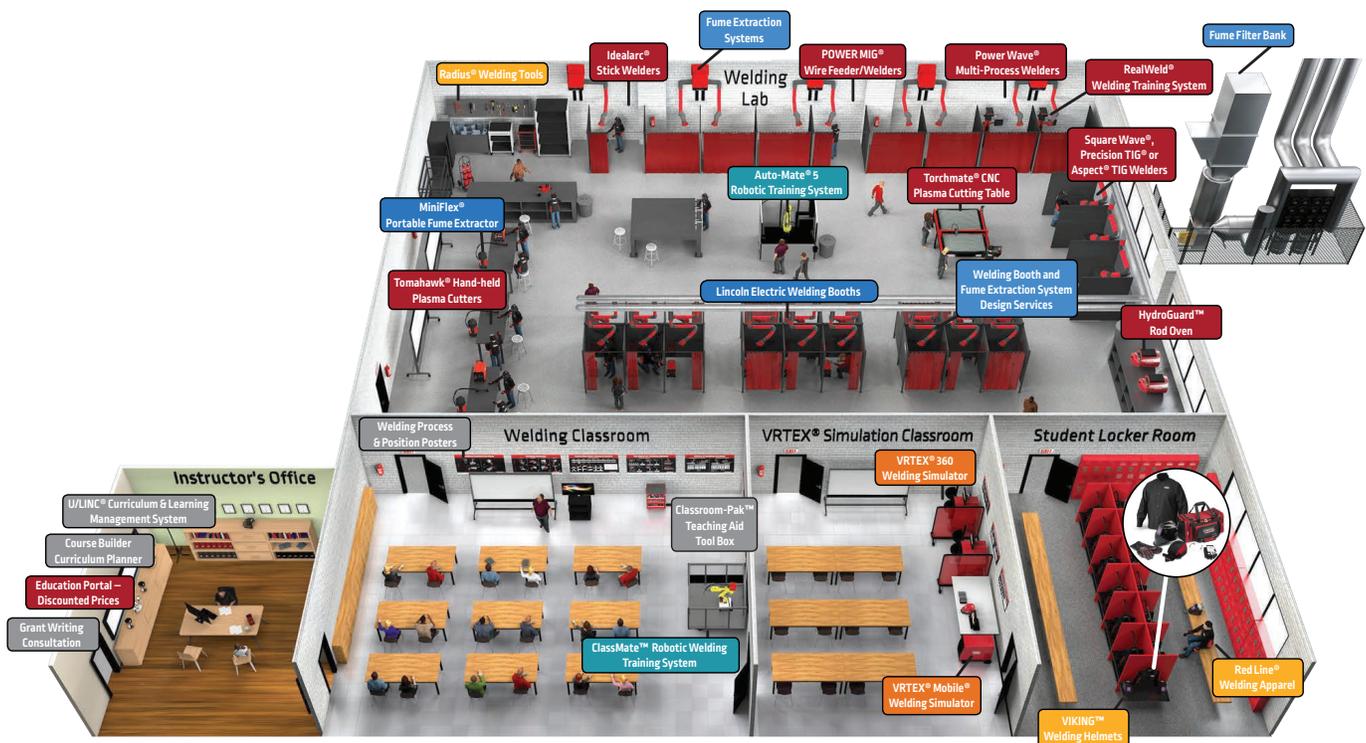


Figure 3-1: The Components for an Ideal Classroom

Section 3 | Checklists

3.1 CLASSROOM DESIGN

- Classroom design (Page 13, 14)
- Student-to-teacher ratio
- Extending student-to-teacher ratio
- Classroom dimension (Page 13, 14, 15)
- Entryways (Page 13, 15)
- Controlled environment (Page 14)
- Noise reduction (Page 14, 29)
- Lighting (Page 14, 23, 24)
- Climate control (Page 9, 14, 33, 36)
- Landline phone (Page 14)
- Whiteboards (Page 14, 17, 24)
- Audio speakers (Page 14)
- Class-accessed printer (Page 14)
- Front row (Page 14)
- Use of multi-media
- Desks and tables on wheels (Page 14)
- Storage areas (Page 9, 14, 19)
- Instructor desk/work area (Page 14, 23)
- Table for classroom supplies (Page 14)
- Projector (Page 14)
- Wi-Fi (Page 14, 39)
- Internet (Page 14, 33)
- VRTEX® (Page 3, 14, 34, 35, 36)
- REALWELD® (Page 34)



Figure 3-2: Large Double-Door Entryway



Figure 3-3: Flexible Learning Spaces in the Classroom Provide Desks and Chairs on Wheels



Figure 3-4: REALWELD® System

3.2 WELDING LABORATORY

- Minimum floor space (Page 15)
- Minimum per-student workspace (Page 18)
- Ceiling height (Page 15, 28)
- Utility doors (Page 13)
- Locker rooms (Page 15, 25)
- Emergency shut-down capability (Page 16)
- Power equipment placement (Page 16, 31)
- Safety floor markings (Page 18, 30)
- Aisle sizes (Page 16)
- Non-skid surfaces (Page 16)
- Grind-area location (Page 22, 23)
- Demonstration area (Page 8, 7, 21, 22, 24, 25, 33, 36)
- Instructor office (Page 23)
- Gas cylinder storage (Page 26, 27)
- Bathrooms with lockers (Page 15, 25)
- Electricity (Page 24, 30)
- Nondestructive testing (Page 37)
- Destructive Testing (Page 37)



Figure 3-5: Secure Locker Rooms



Figure 3-6: Demonstration Area with Good Student Visibility

Section 3 | Checklists

3.3 WELDING BOOTH

- Power source inside and outside (Page 16, 24, 30, 31)
- Optimal size: general and pipe (Page 16)
- Air circulation (Page 16)
- Fume extraction (Page 17, 19, 28)
- Whiteboard (Page 17, 24)
- Size of tacking table (Page 16, 17)
- Pole with table and weld arm (Page 17)
- Quench tanks (Page 18)
- Ease to install and remove equipment (Page 16, 17)
- Gas lines/bottles in booth (Page 20, 26)
- Choosing bulk or bottle gas (Page 26, 27)
- Ethernet connectivity (Page 16)

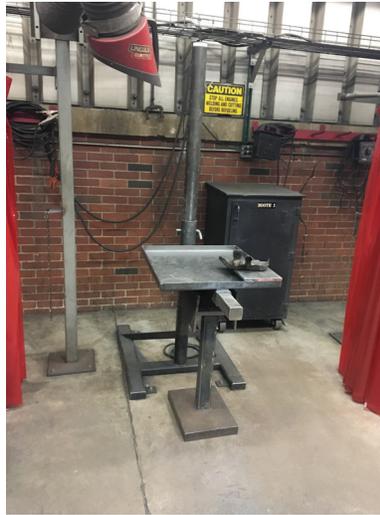


Figure 3-7: Booth Setup with Pole, Clamp, Exhaust



Figure 3-8: Booth with Safety Curtain Closed



Figure 3-9: Portable Gas Tank Set



Figure 3-10: Demonstration Table with Weld Arm Setup

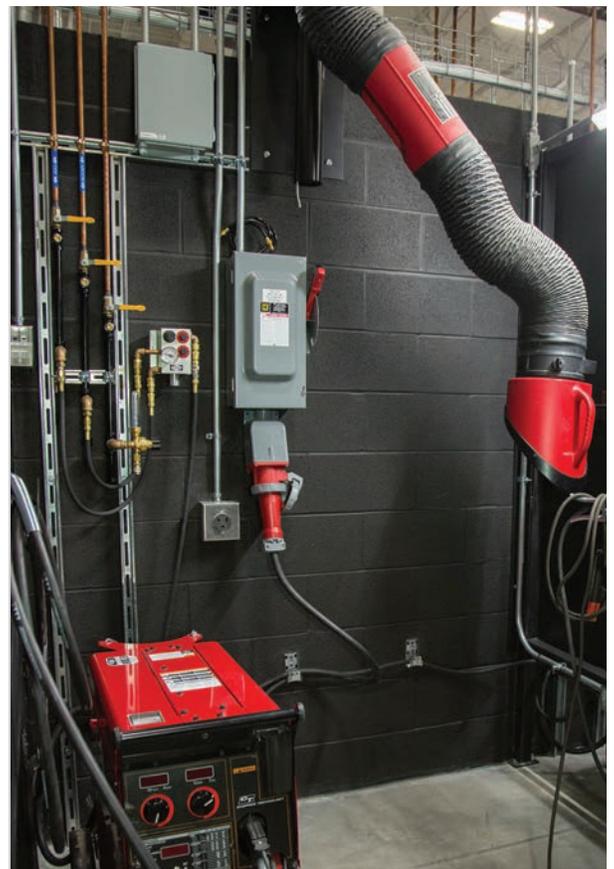


Figure 3-11: Booth Setup for Shielding Gas Lines with Mixer

3.4 STORAGE OF WELDING SUPPLIES & GEAR

- Electrodes and consumables (Page 17, 21)
- Weld coupons (Page 17, 24, 25)
- Tool storage (Page 18)
- Metal storage (Page 19)
- CNC plasma cutting (Page 8, 19)
- Climate controlled (Page 19)
- General storage (Page 15)



Figure 3-12: Convenient Coupon Access is Essential for Efficiency and Safety

3.5 PIPE WELDING BOOTHS

- Use of hoist (Page 43)
- Electrical power (Page 14, 30)
- Power source location (Page 16, 24)
- Demonstration area (Page 17, 21, 22, 24)
- Pipe welding (Page 16, 24, 35)
- Power sources (Page 16, 31)
- Welding area (Page 24, 25)
- Ideal for 5-7 students (Page 25)
- Combined with some storage (Page 24)

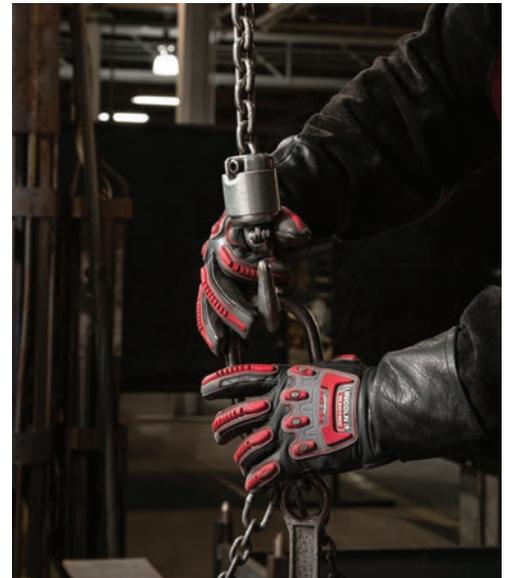


Figure 3-13: A Forklift or Manual Crane Will Be Necessary to Move Heavy Materials



Figure 3-14: The Complete Weld School Layout Combines Classroom, Lab, Locker Room, Controlled Study Space and Advanced Learning Areas

Section 3 | Checklists

3.6 MATERIAL PREPARATION

- Campus designation and common areas (Page 29)
- Grinders (Page 18, 22, 23, 24)
- Tools needed (Page 18)
- Other tools to consider (Page 18)
 - Metal processing (Iron Worker)
 - 6 in (12.2 cm) wide x 1 in (2.5 cm) thick capacity
 - Vertical band saw
 - Horizontal band saw
 - Press
 - Bender
 - Notcher
 - Track cutting table
 - Pipe profiler
 - Polishing area
 - Bench vices
 - Files

3.7 THERMAL CUTTING

- Power sources and gas lines outside (Page 24, 26, 27, 28)
- Cutting table with removable pan (Page 19)
- Location: student demonstration area (Page 22)
- Alternative fuels (Page 20)



Figure 3-15: Common Areas Should Be Designed to Encourage Student Interaction, Provide Space for Downtime and Offer an Optional Space to Host Larger Events



Figure 3-16: Track Cutting Table

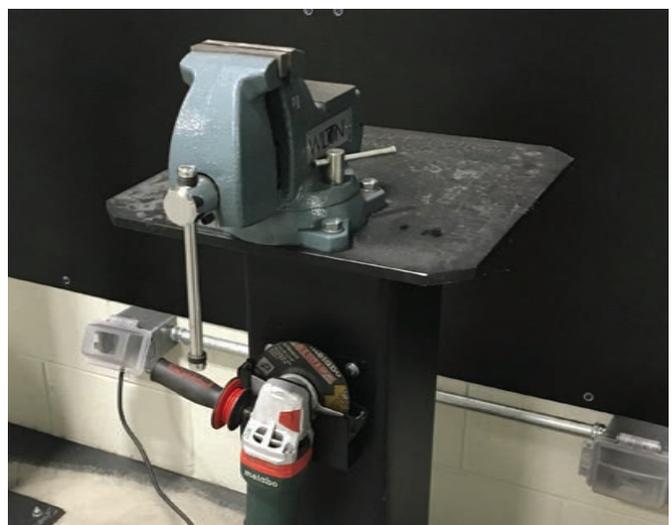


Figure 3-17: Grinders and Bench Vices

CONCLUSION

This Welding School Guide provides the initial building blocks and guidance to establish a facility capable of educating students at several different levels of curricula. There is no one-size-fits-all approach to educating welders. Welding facilities must embrace the integration of advanced technology, computer labs, weld theory and case studies to create a more comprehensive welding professional who can meet the demands of the modern global marketplace.

With the industry's largest team of field sales engineers, Lincoln Electric is not simply committed to exceptional quality and service every day, but the continued development of the welding profession. This Welding School Guide represents the worldwide knowledge and experience of Lincoln Electric, accumulated over more than 100 years as the welding industry's leader in design, innovation and service. Lincoln Electric's reputation as a welding educator is a legacy built over a century-long commitment to the development of the welding profession.

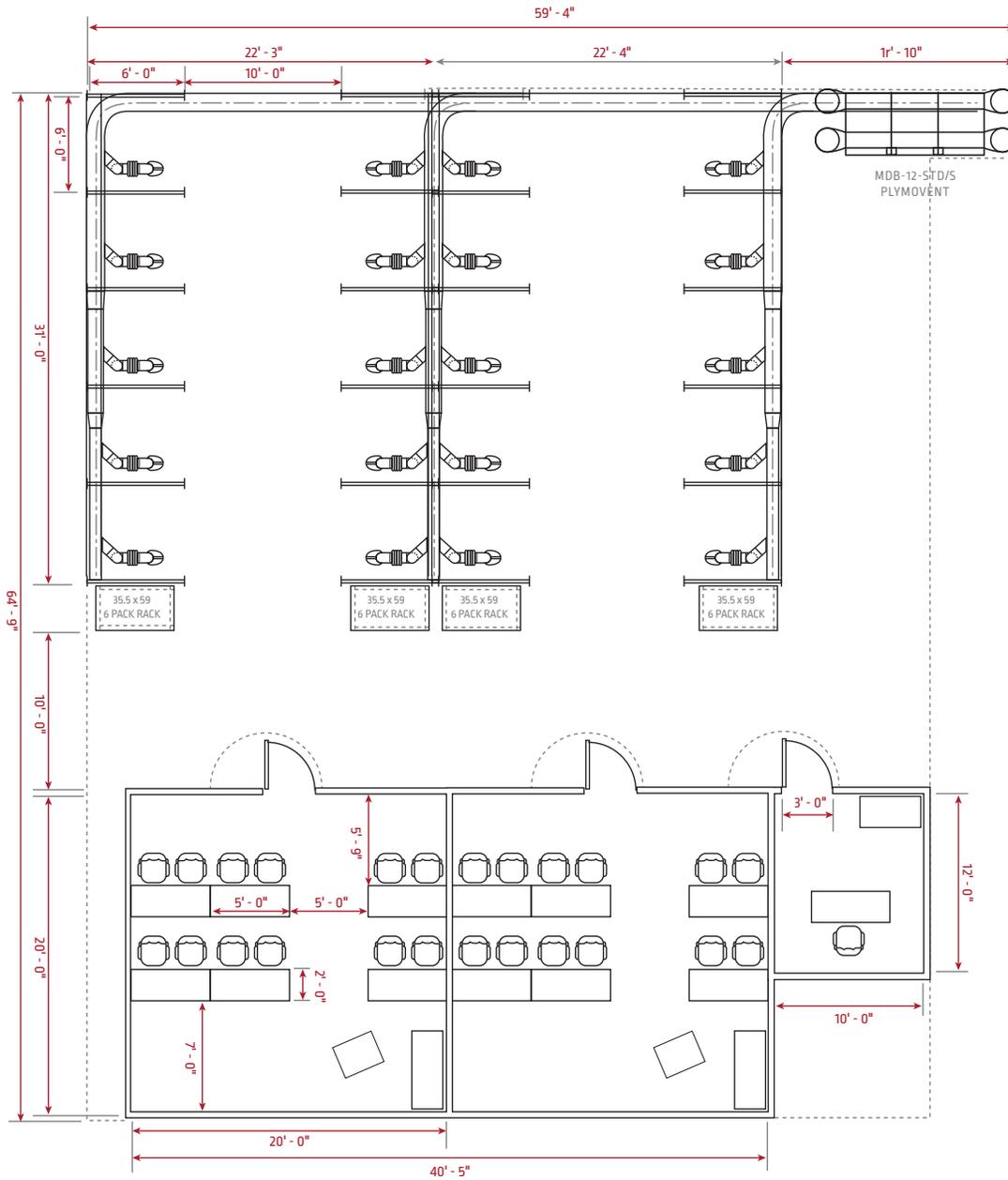
Growing worldwide competition in the welding industry means a dynamic marketplace will demand welding professionals who are equally more dynamic in their approach to planning, problem solving and executing the welding craft amid a growing diversity of settings and new materials.

While this comprehensive Welding School Guide provides a baseline for establishing a welding education facility, the Lincoln Electric Education website (education.lincolnelectric.com) should be considered as a resource for additional information, continued insights and specialized assistance for every aspect of building, maintaining and expanding a welding school.



Learn More at:
education.lincolnelectric.com

Appendix-A | Welding Education School Floor Diagrams



Welding Booths

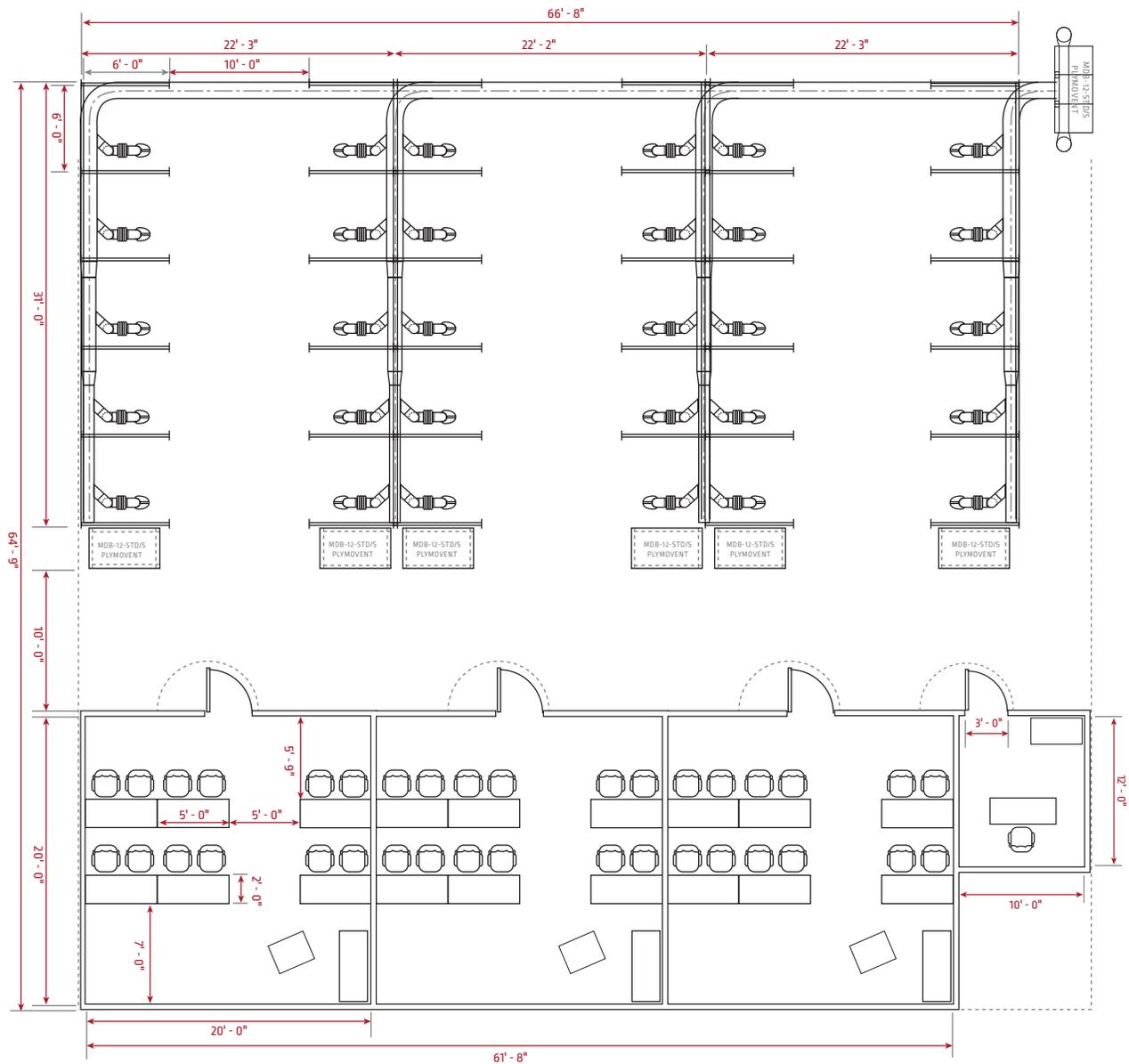
- » [4] Rows of [5] booths set side-by-side. Share side panels.
- » All panels are made from steel with 2 in [5 cm] x 2 in [5 cm] supports. Walls are painted black.
- » End panels are painted red on the outside, black on the inside.
- » Booth inside dimensions: 6 ft [1.8 m] x 6 ft [1.8 m].
- » Footprint: Approximately 3,850 ft² [357.7 m²], refer to dotted line.

Classrooms

- » [2] Classrooms.
- » Room size 20 ft [6 m] x 20 ft [6 m] inside, 12 seats.

Office

- » [1] Office
- » Room size 10 ft [3.04 m] x 12 ft [3.66 m] inside, door size 3 ft [0.92 m] width.



Welding Booths

- » [4] Rows of [5] booths set side-by-side. Share side panels.
- » All panels are made from steel with 2 in [5 cm] x 2 in [5 cm] supports. Walls are painted black.
- » End panels are painted red on the outside, black on the inside.
- » Booth inside dimensions: 6 ft [1.8 m] x 6 ft [1.8 m].
- » Footprint: Approximately 4,643 ft² [431.3 m²], refer to dotted line.

Classrooms

- » [3] Classrooms.
- » Room size 20 ft [6 m] x 20 ft [6 m] inside, 12 seats.

Office

- » [1] Office
- » Room size 10 ft [3.04 m] x 12 ft [3.66 m] inside, door size 3 ft [0.92 m] width.

SPECIFICATION FOR BID

(Provided At No Cost Upon Request)

Lincoln Electric Aspect 375™

Part # K3946-2 (Aspect 375™ Ready-Pak® Package)

The Lincoln Electric Aspect TIG 375 is a 375-amp, single- or three-phase, constant current power source for TIG and stick welding. It must have both AC and DC output with built-in high frequency and gas solenoid, plus Square/Triangle Wave output and pulsing capabilities. It must also have advanced TIG features, such as Auto-Balance™. The unit must have a 3-year warranty on parts and labor.

POWER SOURCE: Aspect 375

Technical specifications:

Input Power: 200-600V/ 1/3 phase 50/60 Hertz

Rated Output: 3 phase	330A/40% Duty Cycle
1 phase	240A/40% Duty Cycle

Power Source Must Also Have the Following Features / Included Accessories:

- » Output range of 2-375 both EP & EN
- » AC frequency range 40-400 Hz
- » Auto-Balance control for AC operation, with manual balance control 35-99% EN
- » Built-in advanced TIG pulsing and downslope controls
- » Water-cooled torch connections requiring no adapters – side mounted to keep the connections out of the way and protected
- » AC pulse frequency 0.1-25% output frequency setting in pulses per second
- » DC pulse frequency 0.1-2,000 pulses per second
- » AC wave shapes: Soft Square, Sine, Square, Triangle
- » Comes with Cool Arc 47 water cooler
- » 2 containers of coolant
- » Foot pedal
- » Gas regulator
- » Fan-As-Needed™ (F.A.N.™) cooling of transformer and other components
- » Potted PC board(s) for long life and environmental protection

SPECIFICATION FOR BID

(Provided At No Cost Upon Request)

Lincoln Electric POWER MIG® 210 MP

Part # K3963-1 (POWER MIG® 210 MP 120/230V)

The Lincoln Electric POWER MIG® 210 MP is a single-phase, combination power source and wire feeder unit. The unit must be a compact, lightweight CV/CC power source for MIG (GMAW) and stick (SMAW) welding. It must have continuous voltage giving it a wider voltage sweet spot across the welding range and more forgiving. The unit must have a 3-year warranty on parts and labor.

POWER SOURCE: Power MIG 210MP

Technical specifications:

Input Power: 120/230/1/60

Rated Output: 120V-100A/19V/40% Duty Cycle
230V-200A/24V/25% Duty Cycle

Power Source Must Also Have the Following Features / Included Accessories:

- » Max OCV 56V
- » Wire feed speed range 50-500 ipm
- » HxWxD (in) – 14 x 10.75 x 19
- » Net weight: 40 lbs

SPECIFICATION FOR BID

(Provided At No Cost Upon Request)

Lincoln Electric Power Wave® C300 Educational Ready-Pak® (K2774-4)

Part # K2774-4: Educational Ready-Pak® Model

The Power Wave® C300 is an advanced, compact, multi-process power source with an integrated Ready-Pak® wire feeder.

POWER SOURCE: Power Wave® C300

Technical specifications:

Input Power: 200-600V/ 1/3 phase 50/60 Hertz

Rated Output: 208-575V/ 1/3 phase 50/60 Hz
300A/29V/40% 3 phase
250A/27V/100% 1 phase

Must Also Have the Following Features / Included Accessories:

- » PowerConnect™ Technology (Patent-Pending) – Automatically adjusts to input power from 200-600V, 50 or 60 Hz, single phase or three phase
- » Tribrid™ Power Module – Exceptional welding performance with high power
- » Production Monitoring™ 2 – Track equipment usage, store weld data and configure fault limits to aid in production
- » Compact and durable case – IP23 rated to withstand harsh environments
- » K2734-2 understorage cart
- » K2951-2-6-45 Magnum® PRO Curve™ 300 gun package w/Magnum® PRO
- » Front end expendables
- » K2505-3 TIG Torch Twist Mate™ to stud adapter
- » K1782-12 PTA-17 Pro-Torch™ TIG Torch with Ultra-Flex™ cable, 12 ft (3.7 m), 1 pc.
- » K1622-1 Twist Mate™ Torch Adapter
- » KP508 parts kit for PTA-17 series torches
- » Harris® Flowmeter/Regulator & Hose
- » K870-2 Foot Amptrol™ with 12-Pin universal connector
- » K2374-1 stick electrode holder and cable (includes Twist Mate™ Connector)

SPECIFICATION FOR BID

(Provided At No Cost Upon Request)

Lincoln Electric Statiflex® 200-M

Part # K1654-2 & K1654-1 (Statiflex® 200-M)

The Lincoln Electric Statiflex® 200-M is a stationary, wall-mounted low vacuum system designed for extraction and filtration of welding fume. The unit must have a 1-year warranty on parts and labor (consumable items, 30-day warranty).

POWER SOURCE: Statiflex® 200-M

Technical specifications:

Input Power: 200-600V/ 1/3 phase 50/60 Hz

Rated Output: 208-575V/ 1/3 phase 50/60 Hz

300A/29V/40% 3 phase

250A/27V/100% 1 phase

Must Also Have the Following Features / Included Accessories:

- » Airflow of 735 CFM
- » Internal spark arrestor – Also functions as a pre-filter for larger-sized particulate
- » Filter status indicator – Visual guide to remaining filter life
- » Large filter capacity – 538 square feet
- » 3D-pleated filter design
- » Washable aluminum pre-filter

Items To Be Quoted

- » K1654-2 (Statiflex® 200-M Dual Base Unit) Qty - 6
- » K1654-1 (Statiflex® 200-M Single Base Unit) Qty - 2
- » K1655-3 (LTA 2.0 Extraction Arm) Qty - 14
- » K1657-2 (SF2400 Wall Mounting Bracket) Qty - 14
- » K1669-4 (Lamp Kit with Arc Sensor) Qty - 14
- » K1656-1 (SF 2400 Stationary Fan (1 HP)) Qty - 14
- » KP44-3545-15 (Liner)

Lincoln Electric's Commitment to Education

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Learn More at:

education.lincolnelectric.com

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