Subject:	Effective Date:	Initiated by:
General Welding & Brazing Requirements	Feb. 26, 2013	Associate Laboratory Director for Engineering and Infrastructure
	Supersedes: Rev. 1, dated February 13, 2009	**Approved:** Director

Management System:	03.00 Engineering
Management System Owner:	Associate Laboratory Director for Engineering and Infrastructure
Management Process:	03.04 Engineering Programs and Processes
Process Owner:	Associate Laboratory Director for Engineering and Infrastructure
Sub-process:	03.04.01 Welding Program
Sub-process Owner:	Head, Fabrication and Operations
Subject Matter Expert (SME):	Head, Fabrication and Operations; Construction Manager; Welding Engineer

Applicability

The purpose of this procedure is to provide the requirements for all welding and torch brazing performed at the Laboratory, either by PPPL personnel or by subcontractors. It also addresses ASME Section IX Code qualification requirements for controlled atmosphere brazing procedures and personnel, when required. This procedure does not apply to code stamped welding. A certificate holder will be subcontracted to perform welding on code stamped vessels, if necessary. Development, management, and oversight of the PPPL welding and brazing program is the responsibility of the Fabrication and Operations Division.

Introduction

This procedure provides the requirements for welding and torch brazing. It also provides requirements for qualification of procedures and personnel to perform controlled atmosphere brazing, when ASME Section IX qualifications are specified by the cognizant individual or applicable code, per EM-004. It includes the development and qualification of welding and brazing procedures, the qualification of welders, brazers, and welding operators, the performance of welding and brazing, maintenance of weld and braze records, and weld inspection criteria. Personnel should consult the Mechanical Engineering Standards (http://www.pppl.gov/eshis/EngStds.html) for additional information regarding code applicability and requirements for specific types of welds.

When PPPL subcontracts with an Engineering firm to provide design and installation work including welding, the contract engineering signature approvals for calculations and for

drawings shall be acceptable for use unless otherwise specified by the Fabrication and Operations Division Head.

All welding and brazing activities must be performed in accordance with the safety requirements of ESHD-5008 Section 9 chapter 15. This chapter establishes compliance with ANSI Z49.1 "Safety in Welding, Cutting, and Allied Processes."

Definitions can be found in Attachment 1.

Reference Documents

ASME Section IX, Welding and Brazing Qualifications.
AWS D1.1 Structural Welding Code-Steel
QA-004 PPPL Site Inspection Program
PPPL Procedure ENG-038 Welding Materials Control
PPPL Procedure EM-004 Controlled Atmosphere Brazing
ESHD-5008 Section 9 chapter 15 Welding, Cutting, and other Hot Work
ANSI Z49.1 Safety in Welding, Cutting, and Allied Processes

Procedure

This procedure is presented in the following sections:

A. Welding and Brazing Program Organization and Responsibilities
B. Welding and Brazing Fabrication Process
C. Welding and Brazing Procedure Development and Qualification
D. Welder/Brazer Performance Qualification Testing
E. Orbital Welding Operator Qualification
F. Records and Files
G. Training

A. Welding and Brazing Program Organization and Responsibilities

Responsibility	Action
Fabrication & Operations Head	1. Designates engineer(s) as PPPL Welding Engineer
Welding Engineer	2. Develops welding and brazing procedure specifications per Section C of this procedure, supervises Procedure Qualification Record (PQR) qualification, and supervises welder, welding operator and brazer qualifications.
Fabrication & Operations Head	3. Reviews and approves written procedures for welding and brazing qualified by Section C of this procedure.

Welding Engineer	4.	Approves personnel qualified by Sections D & E of this procedure.
	5.	Issues and updates procedures and personnel qualification records, and associated lists.
	6.	Assures compliance with requirements of this and related procedures.
	7.	Reviews contractor procedures and personnel qualifications for conformance with requirements of this and related procedures.
Welding Engineer	8.	Reviews and approves drawings that show welding or brazing requirements to assure that the proper symbols and welding information are on the drawings, unless exempted by the RLM and Welding Engineer, using Attachment 5.

B. Welding & Brazing Fabrication Process

Responsibility	**Action**	
Cog Individual / Welding Engineer	1.	Specifies the welding and brazing requirements, QC hold points, and the acceptance criteria. The acceptance criteria are defined in the applicable code, unless otherwise specified.
Drafting	2.	Documents the welding and brazing design on controlled drawings, including the materials to be joined, joint types and sizes, process(es) or procedures to be used, inspection and testing requirements and acceptance criteria.
Welding Engineer	3.	Furnishes qualified Welding or Brazing Procedure or develops a new one and has it qualified, per Section C of this procedure.

Weld Supervisor	4.	Checks drawings for Welding Engineer's approval, or exemption by the RLM and Welding Engineer, using Attachment 5. If neither signature is provided, consults the Cognizant Individual regarding need for approval by Welding Engineer.
	5.	Selects qualified welder or brazer, and signs and issues a weld/braze work record, to document joining process usage.
Welder/Brazer	6.	Obtains Hot Flame Permit from ESU and arranges fire watch, if required.
ESU	7.	Verifies welder's status by checking the authorized welder/brazer list prior to issuing Hot Flame Permit (per Section F.3. below).
Welder/Brazer	8.	Performs the welding and/or brazing fabrication in accordance with the WPS or BPS, and supplemental instructions of the Weld/Braze Engineer, if necessary.
Welding Engineer / Weld Supervisor / Welder	9.	Maintains filler material control per Procedure ENG-038, to assure proper material is used during welding process and that weld rod is properly stored before use.
QC	10.	Provides weld inspection support, as requested, per QA-004, to requirements of para. 1 above.
Welding Engineer	11.	Assures compliance with requirements of this and related procedures

C. Welding and Brazing Procedure Development and Qualification

Responsibility		Action
Welding Engineer	1.	Develops Welding Procedure Specifications (WPS) and Brazing Procedure Specifications (BPS) per ASME Section IX for work performed by PPPL when required (see Attachment 2 or EM-004, as applicable). Stud welding and bellows welding are further addressed in Attachments 3 and 4, respectively.
	2.	Arranges with Weld Supervisor to provide welder/brazer for procedure qualifications.
	3.	Conducts procedure qualification test, provides supervision for the test, and documents the results and the parameters on Procedure Qualification Record (PQR) form and provides Welder Qualification Quarterly Reviews to the Training Office in Human Resources who will post the revised lists on the training website.
	4.	Assigns the WPS or BPS a unique number.
	5.	Visually examines test joint, transmits samples to Material Test Laboratory (MTL), and specifies test requirements.
	6.	Identifies the specimen with a unique number.
Material Test Lab (MTL)	7.	Conducts mechanical tests on specimens, as requested by the Welding Engineer. Test samples shall be retained for a minimum of six (6) months, after which they may be discarded.
Welding Engineer	8.	Reviews test data and samples and determines test results.
	9.	Completes and signs WPS/BPS.
Fabrication & Operations Division Head	10.	Signs the qualified WPS/BPS for final review and approval.

D. Welder/Brazer Performance Qualification Testing

Responsibility		Action
Weld Supervisor	1.	Issues a request for qualification to the PPPL Welding Engineer. The request shall include the process, materials, and position(s) to be qualified.
Welding Engineer	2.	Reviews with Fabrication & Operations Division Head.
	3.	Provides material and equipment required for qualification.
Cognizant Individual	4.	Provides any unique qualification materials.
Welding Engineer	5.	Provides instructions to welder/brazer and oversees qualification test to ASME Section IX or Attachment 3 requirements, as applicable.
Welder/Brazer	6.	Sets up and welds or brazes the specimen in the required position in accordance with the applicable WPS/BPS, and instructions provided by the Welding Engineer / Weld Supervisor.
	7.	Identifies the specimen with own unique number.
Welding Engineer	8.	Visually examines test joint, and transmits acceptable specimen(s) to Material Test Lab (MTL).
Material Test Lab	9.	Identifies specimen with unique number and conducts tests requested by the Welding Engineer, per ASME Section IX. Requirements for stud welding and bellows welding are further addressed in Attachments 3 and 4, respectively. Test samples shall be retained for a minimum of six (6) months, after which they may be discarded.
Welding Engineer	10.	Reviews test data and samples, and determines test results. If a test is acceptable, completes Steps 11-13 and 15. If test is not acceptable, additional training and/or practice shall be provided prior to further testing.

Welding Engineer	11.	Completes a Welder Qualification Record (WQR) or Brazer Qualification Record (BQR).
	12.	Signs the WQR/BQR indicating approval.
	13.	Issues the WQR or BQR and an updated listing of qualified personnel, to the PPPL Weld Supervisors and Training Office in HR, and maintains originals in Fabrication & Operations Central Files.
	14.	Reviews welding and brazing procedures and personnel qualifications of subcontract employees and issues a list of qualified subcontract welders and brazers to ESU.
	15.	Assigns a unique metal stamp to each qualified welder/brazer for use in identifying welds/brazes performed by that individual.
Weld Supervisor	16.	Maintains welder/brazer to process qualification by assigning joining in that process in the time frame required, per ASME Section IX.
Welding Engineer	17.	Requalifies welder/brazer as required per ASME Section IX.

E. Orbital Welding Operator Qualification

Responsibility	**Action**	
Welding Engineer	1.	Provides instructions to welding operators and oversees qualification testing per ASME Section IX.
Welding Operator	2.	Sets up and welds test specimens in accordance with applicable WPS and instructions provided by Welding Engineer.
Welding Engineer	3.	Visually examines test weld, and reviews mechanical test data and samples, and determines test results.
	4.	Completes and signs welding operator qualification test record (WQR) indicating approval.
	5.	Issues WQR to PPPL Welding Supervisors and Training Office in HR, and maintains original in Fabrication & Operations Central Files.

F. Records and Files

Responsibility	Action
Welding Engineer	1. Maintains permanent records of all original Welding and Brazing Procedure Specifications (WPS and BPS), Procedure Qualification Records (PQR), completed Welding / Brazing Relief Authorization Requests and welder/brazer qualification records (WQR/BQR) in a controlled file
	2. Issues approved WPS/BPS, and welder/brazer/-welding operator qualification records to weld supervisors.
	3. Provides lists of authorized welders/brazers/welding operators to ESU, including qualified contractor personnel. Lists shall be updated whenever changed, or annually, as a minimum.
	4. Provides copies of all welder/brazer qualification records and original weld/braze filler metal issuance forms to Training in the Office of Human Resources for the purpose of updating the training database.
Training in the Office of Human Resources	5. Maintains personnel qualification records as necessary, and issues monthly reports of PPPL welder/ brazer/welding operator qualification continuity.

G. Training (Section Required for All Procedures)

Responsibility	Action
Head, FOM Division	1. Identifies the welders and brazers and assures that they read and understand the latest revision of this procedure within one month of it being approved.
Management System Owner or Designee	2. Notifies the Human Resources Training Office of the training so that they will be aware of the training requirements.

Attachments

1. Definitions
2. Welding/Brazing that Requires Qualified Procedures and Welders
3. Stud Welding Procedure and Welder Qualification
4. Bellows Welding Requirements.
5. Welding / Brazing Relief Authorization Request Form.
6. Welding and Brazing Notes on Fabrication Drawings

Definitions

Definition of specific terms appropriate to this procedure are:

1. Appointed

   Assigned specific responsibilities by the cognizant manager.

2. Automatic Welding

   Welding with equipment that performs the welding operation without adjustment of the controls by a welding operator.

3. Braze

   A joint produced by heating an assembly to suitable temperatures and by using a filler metal having a liquidus above 840°F, and below the solidus of the base materials. The filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

4. Cognizant Individual

   A member of the Engineering or scientific and research staff who has been placed in charge of a specific project, job, or task by senior management.

5. Designated

   Selected or assigned by the employer or the employer's representative as being qualified to perform specific duties.

6. Machine Welding

   Welding with equipment which performs the welding operation under the constant observation and control of a welding operator.

7. Manual Welding

   A welding operation performed and controlled completely by hand.

8. Qualified

A person who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated his/her ability to solve or resolve problems or perform an operation relating to the subject matter and work.

9. Semiautomatic Arc Welding

Arc welding with equipment that controls only the filler metal feed. The advance of the welding arc is manually controlled.

10. Weld

A localized coalescence of metals produced by heating the materials to suitable temperatures, with or without the application of pressure.

11. Weld Supervisor

A person directly supervising welders and brazers and who is authorized to issue weld/braze authorizations and filler materials.

12. Welder/Brazer

One who performs a manual or semiautomatic welding or brazing operation, as applicable..

13. Welding Engineer

A designated engineer who develops welding and brazing procedure specifications, supervises weld and braze procedure qualifications, qualifies welders and brazers, and assures compliance with the PPPL welding and brazing program. A weld engineer writes, reviews, and signs procedures signifying that technical aspects of the welding process are adequate and comply with he PPPL welding and brazing program. He/she accepts responsibility for the welding/brazing in that procedure. He/she qualifies welders/brazers and weld operators at PPPL.

14. Welding Operator
One who operates machine or automatic welding equipment.

Welding/Torch Brazing that Requires Qualified Procedures and Personnel

1. All vacuum systems.

2. All crane welding including mobile cranes and access ladders and platforms. (NO EXCEPTIONS)

3. All lifting fixtures. (NO EXCEPTIONS)

4. All temporary fixtures to support, locate or position critical components. (NO EXCEPTIONS) (Note: critical components are described in the PPPL Lift Procedures Guidelines.)

5. All power bus supports or towers for PPPL devices. (NO EXCEPTIONS)

6. Any device or structure that is dynamic seismically designed. (NO EXCEPTIONS)

7. Any construction which the design documents call out the ASME Codes or the AWS Code for welding requirements. (NO EXCEPTIONS)

8. Any welding designated by the cognizant individual in the work documents requesting qualified welders, procedures and QC inspection.

Welding/Torch Brazing that Does Not Require Qualified Procedures and Personnel

Welding/brazing may be performed on items which are listed above, with the written authorization of the RLM. The requesting organization shall describe the type of work to be performed and submit to Fabrication and Operations for review on form in attachment 5.

Form A of attachment 5 should be used if the work falls into items listed above but have no significant risk involved as described on attachment 5, Form A.

Form B of attachment 5 should be used if the work does not fall into any of the items listed above but a waiver from the requirements is needed.

Stud Welding Procedure and Welder Qualification

A. Procedure Qualification

1. Stud welding procedures will be qualified according to base metal, stud metal, arc shield, and the type of equipment.

2. Procedure qualification will require ten studs to be welded to a base plate. Select five of these studs at random and subject them to hammer bending to 90 degrees from their original axis. The weld should not break or crack for this test. Any failure requires requalification. The remaining five studs shall be torqued to the values shown in Table 1. Any failure in these five studs requires requalification. The PPPL Welding Engineer or designee must be present during the testing.

3. For material other than P-1 or P-8, the PPPL Welding Engineer will provide torque values for testing.

4. Stud welding procedures shall be controlled in accordance with Section F of this procedure.

B. Welder Qualification

1. A welder must weld five studs that will pass the bend test as described in paragraph A 2 above. The studs shall be mid-range size for the equipment use.

2. A welder may shoot <u>one</u> extra stud if the individual deems one of the five test studs is unacceptable before they are subject to testing.

3. Failure of the weld in any one stud is cause for rejection and retesting.

4. Retesting is permitted immediately upon failure of the first test. Failure of the second test requires retraining before the welder can be retested.

5. After retraining, a welder must repeat a shoot of five studs that pass the bend test as described in (1) above. A welder may shoot <u>one</u> extra stud before testing begins, to replace any one the individual believes may be unacceptable.

6. Stud welder qualifications shall be documented and controlled in accordance with Section F of this procedure.

C. Field Requirements

1. Before any welding is done in the field, a welder must shoot two studs of each type and size to be used, to material of similar thickness, that pass the bend test. Test studs shall be shot in the position(s) to be welded in the field.

2. Two consecutive studs must pass the bend test before welding will be permitted. There is no limit on the number of set-ups to obtain good welds. However, four attempts should be sufficient to establish the gun settings. If, after four attempts, good welds cannot be produced, the Weld Supervisor or the PPPL Welding Engineer should be contacted.

3. Settings should be rechecked every 50 studs by hammer bending one stud 90 degrees to its axis, on a separate sample piece.

Table 1: Minimum Torque Values

1/4 - 20	4.2 ft-lbs
5/16 - 18	8.6 ft-lbs
3/8 - 16	15 ft-lbs
7/16 - 14	24 ft-lbs
1/2 - 13	37 ft-lbs

The weld engineer shall provide values for any size not listed.

Bellows Welding Requirements

A. Prerequisite

Welder must be qualified in accordance with the applicable WPS for the base metal(s) and thickness of the bellows to be welded.

B. **Production Welding**

1. Welder to weld section of bellows. The welder will have to make the required heat sinks for the bellows.

2. Testing of welded bellows will include a visual examination using a 5 power magnifying loop and a helium leak check on a machine with a minimum sensitivity of 1 x 10-8 std. cc/sec. Any detectable crack or linear indication, or leak is cause for rejection of the test assembly.

FORM A: Welding / Brazing Relief Authorization Request for Small Projects

Project: _____ Date: _____
Drawing: _____ (If Applicable)
Description of Item: _____
Quantity: _____

With concurrence of the Responsible Line Manager this work does not require signed weld drawings if the welding to be accomplished meets all of the following conditions:

- Does not create an ES&H impact
- Does not involve tritium or other radioactive contaminated or activated equipment
  Does not impact multiple projects, systems or groups
- Is not part of a crane including mobile cranes and access ladders and platforms.
- Is not part of a lifting fixture and is not a temporary or permanent fixture to support, locate or position critical components. (Note: critical components are described in the PPPL Lift Procedures Guidelines.)
- Is not part of a power bus support or tower for PPPL devices.
- Is not a device or structure that is dynamic seismically designed.
- Is not any construction which the design documents call out the ASME Codes or the AWS Code for welding requirements.
- Does not involve electrical potentials > 50 volts
- Does not involve RF leakage > 5mW/cm^2
- Does not create significant schedule delay

Requestor:_____

RLM CONCURRENCE:_____Date:_____ _____

Weld Engineer Approval:_____Date: _____

Distribution: FO Files, _____, _____,
_____, _____

FORM B: Welding / Brazing Relief Authorization Request

Project: _____ Date: _____

Drawing: _____ (If Applicable)

Description of Item: _____

Quantity: _____

Exceptions requested and Reasons:

Requested by:_____

Welding Engineer's Disposition:

Approved:_____

Date:_____

Distribution: FOM Files, _____, _____,

_____, _____

Welding and Brazing Notes on Fabrication Drawings

The following are guidelines concerning standard drawing notes to be applied where welding and/or brazing is involved in the fabrication process. Typical welding-related notes that cover the major portion of components fabricated at PPPL should read as follows:

"Welding (and Brazing, if applicable) shall be performed in accordance with the requirements of (* insert code here). Welding (and Brazing, if applicable) performed onsite shall also meet the requirements of PPPL Procedure No. ENG-037. Visual weld inspection shall be performed in accordance with the acceptance criteria of
(* insert code here)"

Where * =

ASME B31.3 Category D (for weld joints in low pressure process and vacuum system piping and tubing)

AWS D1.1 Section 6 (for structural carbon and low alloy steel welding)

AWS D1.2 (for structural aluminum welding)

AWS D1.3 (for welding of structural sheet steel)

AWS D1.6 (for structural welding of austenitic stainless steel)

AWS D9.1 (for non-structural sheet metal welding)

ASME Section VIII Division 1 (for welding and brazing of pressure vessels)

ASME Section I (for welding and brazing of power boiler components)

ASME B31.1 (for welding and brazing of power piping)

ASME B31.9 (for welding and brazing of building services piping)

AWWA D100 (for welding of atmospheric storage tanks)