1 Purpose and Scope

This supplement provides the requirements for welding and brazing operations performed at Jefferson Lab by employees, users, and temporary contract labor under Jefferson Lab direction as well as welding and brazing operations performed by outside organizations (e.g. subcontractors and user institutions). All revisions to this supplement must be approved by the Welding Technical Committee. This document shall not be provided in whole or in part to outside organizations for the purposes of welding and/or brazing operations. The welding/brazing operations considered include the following:

- Design and specification of welded or brazed connections
- Classification of weld or braze joint
- Qualification of welding and brazing personnel
- Qualification and specification of welding and brazing procedures
- Qualification of welding and brazing examiners and inspectors
- Performance of welding or brazing for new construction, repair, or alteration of a system or structure
- Material control
- Documentation

NOTE: Safety requirements for welders and brazers are provided in ES&H Manual Chapter 6122 *Hot Work (Welding, Cutting, Brazing, and Grinding) Safety Program*. These safety requirements apply to all welds and brazes, both Code and Low Risk.

1.1 Applicability

The requirements of this supplement apply to all groups and individuals at Jefferson Lab that perform or contract welding and brazing operations, repairs, or alterations to the following:

- All pressure systems except those listed in ES&H Manual Chapter 6151, *Pressure and Vacuum Systems Safety Program* Section 2.1 and Part 2:8.1.1 of the Pressure and Vacuum Systems Safety Supplement.
- All structures supporting loads greater than 100 lb. at any height AND having a RC>1.
- All structures supporting any load at heights greater than 6 ft. AND having a RC>1.
- All material handling equipment (MHE) supporting loads greater than 100 lb. or any load at a height of 6 ft. or more.
- All buildings or structures (such as mezzanines or detector stands) for human occupancy.
- Any welded components when assessed in their final configuration under appropriate normal and off-normal operating conditions that have a mitigated risk code greater than 1 (see ES&H Manual Chapter 3210 *Appendix T3 Risk Code Assessment*).

See also Appendix C, Welding and Brazing Supplement Requirements Applicability flowchart.

1.2 Exceptions

Welded and brazed connections employed on the following systems and components are excepted from the requirements of this supplement:

- All pressure systems and components listed in ES&H Manual Chapter 6151, *Pressure and Vacuum Systems Safety Program*, Section 2.1 and Part 2:8.1.1 of the Pressure and Vacuum Systems Safety Supplement.
- All unmodified UL listed equipment.
- Unmodified ASME pressure vessels (e.g. a stamp such as "U" or "UM", etc.).
- Modified or repaired ASME pressure vessels provided the alteration or repair is performed by an agency authorized by the National Board of Boiler Inspectors (e.g. and agency holding an "R" stamp).

Appeals for further explicit exceptions shall be directed to the Welding Technical Committee for consideration.

1.3 General Statements

Jefferson Science Associates LLC (JSA) functions as an Owner/Operator/User under the ASME Pressure Codes and applicable structural welding Codes in its capacity as the management and operating contractor of Jefferson Lab for the U.S. Department of Energy under Contract No. DE-ACO5-06OR23177; assuming all liability as the legal entity responsible for compliance in accordance with its Federal Contract. As such, JSA/JLAB has the overall responsibility for Code compliance and establishment of requirements for design, construction, examination, inspection, testing, operation, maintenance, alteration, and repair of welded structures, components, and systems.

As Owner/Operator/User, JSA/JLAB will assign specific responsibilities and duties to its employees acting in their capacity as employees of the Owner/Operator/User; specifically as the Jefferson Lab Responsible Engineer (the RE) and Jefferson Lab inspector.

1.3.1 Use of Subcontractors

The RE (or designee under the supervision of the RE) shall serve as Subcontracting Officer's Technical Representative (SOTR) for any work contracted to organizations other than Jefferson Lab (i.e. subcontractors). (See exception below.) The contract shall clearly state the specific Code functions assumed by the subcontracting agency. The RE shall take reasonable measures to ensure that these functions and the related requirements of the Code are fulfilled.

The RE may be an employee of an outside organization provided that he/she is qualified as given in subsequent sections and clearly identified in the contract. In such cases, the RE shall not serve as the SOTR.

2 Acronyms and Definitions

The following acronyms and definitions are general terms relevant to the welding industry and are provided for informational purposes only. Not all terms listed are referenced within this supplement.

2.1 Acronyms

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASNT	American Society of Nondestructive Testing
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BPQ	Brazer Performance Qualification
BPS	Braze Procedure Specification
BPVC	Boiler & Pressure Vessel Code
CMTR	Certified Mill Test Report
COC	Certificate of Conformance (or Compliance)
CWI	Certified Welding Inspector (certified by AWS)
DA	Jefferson Lab Design Authority
GTAW	Gas Tungsten Arc Welding
IBC	International Building Code
JSA	Jefferson Science Associates, LLC
MAWP	Maximum Allowable Working Pressure
MHE	Material Handling Equipment
NBIC	National Board Inspection Code
NDE	Non-destructive examination
NDT	Non-destructive test
PQR	Procedure Qualification Record
QA	Quality Assurance
QC	Quality Control
RC	Unmitigated Risk Code
RE	Responsible Engineer
SMAW	Shielded Metal Arc Welding
SOTR	Subcontracting Officers Technical Representative
SOW	Statement of work
THA	Task Hazard Analysis
UL	Underwriters Laboratory
WPQ	Welder/Operator Performance Qualification
WPS	Welding Procedure Specification

2.2 Definitions

Alteration	Any work performed on an existing system, fixture, or structure that changes or has the potential to change any aspect of the design specification or fluid service; this includes changes to the structural supports for piping or vessels or attachments to structures.
Applicable Code	National or International Consensus Code determined by the RE as the most relevant code for construction or post construction.
ASME Pressure Vessel	Any vessel designed and fabricated in compliance with ASME BPVC bearing an ASME Code stamp (e.g. a U stamp for a Section VIII Div 1 vessel).
Below the Hook Lifting Device	Lifting fixture attached below the hook of a crane that can act independently from the crane, lift, or trolley.
Code of Record	Code (including edition and/or year) determined as most applicable by the responsible engineer.
Employee of Jefferson Lab	Individual employed by Jefferson Lab. For the purposes of this supplement this includes temporary contract laborers.
Fixture	Assembly, typically purpose built, that temporarily supports a load. Often a fixture will allow motion of and access to a load for maintenance and/or assembly purposes. Detector assembly stands are an example.
Listed Material	Any material with an accepted published specification, such as ASTM B209 for aluminum alloy sheet and plate.
May	Indicates an action that is permitted but not required with regard to the welding program.
National Consensus Code or Standard	Any standard or modification thereof that (1) has been adopted and promulgated by a nationally recognized standards-producing organization under mandated procedures and (2) has been designated as such by the US Department of Labor.
Outside Organization	Organization, agency employer, etc. other than Jefferson Lab. This includes other laboratories, user institutions, and subcontractors.
P.E.	Professional Engineer (also PE)
Peer Review	A formal review of the design, construction, or other aspect of a component, system, or structure, performed by at least one other RE not associated with the project and not a member of the same group as the RE. Peer reviews may also be conducted by qualified individuals (e.g. professional engineers with applicable experience) not employed by Jefferson Lab.

Pressure system	A Pressure system shall be defined as any combination of vessels, piping, instrumentation (e.g. gauges), and/or equipment (e.g. pumps or compressors) either containing a fluid under internal pressure or exposed to external fluid pressure. Note that vacuum systems are a subclass of pressure systems.
Pressure vessel	A container that contains a fluid under internal or external pressure not used for the sole purpose of conveying fluid from one point to another.
Repair	Any work performed on an existing system, fixture, or structure that does not change the fluid service or any aspect of the original design specifications. This includes MAWP or design pressure and maximum and minimum design temperatures or structural loading. Work not expressly considered an alteration shall be considered a repair.
Responsible Engineer	Individual responsible for the design, fabrication, documentation, of Code weld joints. For pressure systems and components this individual shall be a Jefferson Lab Design Authority. The qualifications of these individuals are given in Section 4.1.
Shall	Indicates an action that is required or mandatory with regard to the welding and brazing program.
Should	Indicates an action that is considered good practice in most cases but, is not considered mandatory. In some cases, such action may not be appropriate.
Technical Review	A review performed by a responsible engineer(s) (or others similarly qualified such as a P.E.) not responsible for the pressure system, fixture, or structure.
Testing	Direct measurement of or determination of the properties of a component or material. The test object may be destroyed or rendered unusable by such measurements.
Weld/Braze Process	Process by which a weld or braze is performed such as GTAW, SMAW, torch braze, etc.
Weld/Braze Examination	The observation, by suitable technique, of whatever portions of components, joints, and other elements that are exposed to such observation either before, during, or after manufacture, fabrication, assembly, erection, inspection, or testing. This examination may include verification of the applicable requirements for materials, components, dimensions, joint preparation, alignment, welding or joining, supports, assembly, and erection. Examinations are performed without damaging the test object.
Weld/Braze Examiner	Qualified and authorized Individual responsible for performing welding/brazing examinations. See Section 4.4 and Section 5.7 for more detail.

Weld/Braze Inspection	Denotes the activities, performed by a Welding Inspector, to verify that all required examinations and tests have been completed, and to ensure that all the documentation for material, fabrication, and examination conforms to the requirements of the applicable Code and the engineering design.
Weld/Braze Inspector	Qualified and authorized Individual responsible for performing welding and brazing inspections. See Section 4.2 and Section 5.6 for more detail.
Weld/Braze Type	Geometry of weld or braze such as butt, square groove, vee groove, fillet, lap, etc.

3 Requirements

Appendix A - Minimum Welding/Brazing Requirements Table provides a summary of the requirements described in this Supplement.

3.1 Welding and Brazing Performed by Outside Organizations

If a welded or brazed connection is not exempt from the requirements of this supplement then the weld or braze shall be considered a "Code" weld or braze.

A RE shall be identified for each Code weld and/or braze joint. The RE shall assume responsibility for the design and fabrication of these welds and/or brazes. The RE shall be an employee of Jefferson Lab or other organization qualified as required in Section 4.1.

In cases where a national consensus Code can be directly applied, the outside organization performing a weld and/or braze operation(s) shall meet the full requirements of the applicable Code. This shall be documented and this documentation shall be made available to Jefferson Lab for filing in the appropriate database. No further requirements of the Welding and Brazing Supplement apply.

Where a national consensus Code cannot be directly applied, a Jefferson Lab RE shall ensure that the requirements of this Supplement and the engineering designs are met. Each instance where national consensus Codes cannot be directly applied shall be documented. The engineering design and/or contract shall clearly specify the individual and organization responsible for the welding and/or brazing operations.

Additional requirements for welding and brazing operations performed, by outside organizations, on pressure components are given in the Pressure and Vacuum Systems Safety Supplement.

3.2 Weld and Braze Classification and Code Determination

If a welded or brazed connection is not exempt from the requirements of this supplement as outlined in Section 1.2, then the weld or braze shall be considered a "Code" weld or braze. A weld or braze joint exempt from the requirements of this supplement shall be considered "Low Risk". The requirements, responsibilities, and qualifications given in this supplement are optional for Low Risk welds and brazes.

Earlier versions of this supplement employed a three category or "class" system. These classes were A, B, and C. These classes have been replaced by the "Code", "Low Risk" categories. The following table summarizes these changes:

Old Category or Class	New Category
Class A Class B	Code
Class C	Low Risk

Legacy drawings, sketches, specifications, etc. may still be used with the interpretation that class A and B welds and brazes shall now be treated as Code welds and brazes.

When a weld or braze is determined to be a "Code" weld, the responsible engineer shall determine the most applicable Code and edition of that Code for design, repair, alteration, and construction. This Code shall be the designated Code of Record for the weld or braze joint and shall be included in the classification. The applicable codes are:

- Pressure components:
  - Pressure piping and components shall be constructed according to the most applicable ASME B31 piping code.
  - Pressure vessels shall be constructed according to the most applicable Division of the ASME Boiler and Pressure Vessel Code.
  - Alterations and repairs: See the Pressure and Vacuum Systems Safety Supplement.
- Structural welds:
  - The design of welded or brazed joints in structures shall meet the requirements of the most applicable local, state, federal or international building code. Where building codes do not apply AWS Codes shall be used to the greatest extent possible.
- Fixtures:
  - Below the hook lifting fixtures shall be constructed to ASME B30.20.
  - Welded and brazed connections on all other fixtures shall be designed using the most applicable AWS Code.

The RE shall make every reasonable effort to ensure full compliance (regarding design, construction, and inspection) with a national consensus Code. However, when no consensus Code can be **DIRECTLY APPLIED** because of geometry, specialized material, etc., the RE shall employ equivalent measures. In such cases, special requirements for design (see Section 3.14), weld/braze procedure specification and qualification (Section 3.7), and/or welder/brazer performance qualification (Section 3.8) shall be considered by the RE and required where applicable. For the case of unlisted (special) material(s), see Section 3.13.

Weld classifications are further summarized in Appendix B Weld Classification Tables.

3.2.1 Code Edition (Code of Record)

The Code of Record for welded or brazed joints on alterations or new construction shall be the version (Code year) of the most applicable Code (listed in Section 6.1) in effect 6 months prior to the time the design is initiated or the original contract date. A later version may be selected at the discretion of the RE. Applicable codes may be construction codes (e.g. ASME B31, AWS, IBC, etc.), or post construction (repair) Codes (e.g. ASME PCC-2, or NBIC Part 3). See Pressure and Vacuum Systems Safety Supplement for further guidance.

Appeals to use other Codes or versions shall be directed to the Welding Technical Committee. Requests for further guidance shall be likewise directed.

3.3 Documentation

All weld/braze related documentation for pressure systems and components shall be filed as required in the Pressure and Vacuum Systems Safety Supplement.

Documentation associated with non-pressure system work shall either reside within Document Control, or be controlled within the group of the RE and/or the group for which the work was performed. This documentation shall be made available to all groups and individuals with a legitimate need within a reasonable time period.

3.4 Analysis of Welds and Brazes

The RE shall ensure that all analyses required by Code, the engineering design, and sound engineering judgment, are performed and documented as follows:

- For pressure systems and components:
  - Design and analyses shall meet the requirements given in the Pressure and Vacuum Systems Safety Supplement.
- For structures and fixtures:
  - Design and analyses shall meet the requirements of the selected applicable Code.
- Below the hook lifting devices:
  - Design and analyses shall meet the requirements of ASME B30.20.
- When national consensus codes cannot be directly applied:
  - The RE shall use equivalent measures (see Section 3.14).
  - Analyses of pressure components shall be peer reviewed.
- Analysis of all components where national consensus codes can be directly applied shall be technically reviewed.

The RE shall determine the extent and nature of the analyses required for a given weld or braze design but in all cases shall meet the level of safety afforded by the Codes.

3.5 Drawings and Sketches

A drawing or sketch, signed by a RE, is required for all Code welds and brazes. The drawing, sketch, or some other form of specification shall indicate the following (general notes are acceptable):

- Each code weld/braze
- Type and process if required
- Filler metal specification if required
- Base metal specification

3.5.1 Symbols

All Code welds and brazes shall be represented by the symbols given in ANSI/AWS 2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.

3.5.2 Specifications

Written specifications shall address materials, inspection and examination or other requirements. This information shall be written on the assembly drawings or other documents referenced by the drawing in absence of formal specification(s) (e.g., statement of work, design parameter form, etc.). These specifications shall include:

- Applicable Code
- For pressure components:
  - Design pressures/temperatures
  - Leak/Test pressure and method
  - Sensitive Leak test specification (if applicable)
- For lifting devices and fixtures:
  - Design loads (lifting devices and fixtures)
  - Test load requirements
- Cold shock (if applicable)
- Examination requirements and methods
- Inspections required
- Other applicable NDE

The RE shall determine which of the above specifications are applicable and to the extent that they apply.

3.6 Design Parameter Form

The RE shall complete the Design Parameter Form for code welds and brazes or provide the specifications from Section 3.5.2 on a drawing, specification, or other document that includes

applicable drawing numbers, weld specifications, and any required examination and testing to be performed.

3.7 Procedure Specifications and Qualifications

Jefferson Lab shall develop welding and brazing procedures for all welding and brazing operations performed by Jefferson Lab employees. All welding or brazing procedures, WPSs or BPSs, qualified by Jefferson Lab shall only be used by Jefferson Lab personnel.

The use of prequalified and standard procedure specifications is allowed within the limits of the most applicable Code. Prequalified procedures shall be used to create formal Jefferson Lab approved procedures only. These procedures shall be stamped by the Jefferson Lab designated QA/CI Inspector and filed appropriately in DocuShare.

Copies of all WPS and BPS shall be appropriately filed in DocuShare for Lab-wide use. Each certified PQR shall be secured with its WPS at a central location maintained by the QA/CI Department.

3.7.1 Welds

Procedure qualification requirements for welds on pressure components including the preparation of Welding Procedure Specifications (WPS) and Procedure Qualification Records (PQR) shall meet the rules given in Articles II and XII of the ASME BPV Code, Section IX. For pressure piping, there are some modified requirements defined in each applicable ASME B31 piping code that take precedence over Section IX, e.g. ASME B31.3 ¶ 328.2.1.

Where ASME pressure codes are not applicable, either an ASME or AWS WPS shall be used.

3.7.2 Brazes

Procedure qualification requirements shall be as given in the most applicable ASME code for all Code brazes regardless of the application. Brazes on structural components shall be performed using procedures qualified to Section IX of the ASME BPVC. Qualified brazing procedures are not required for brazes performed on components using one of the following codes, categories and conditions:

- ASME B31.3 Category D with a maximum design temperature of 200F.
- ASME B31.9 all cases

3.8 Welder and Brazer Performance Qualifications

3.8.1 Jefferson Lab Employees

Welding and brazing of Code joints performed by Jefferson Lab employees (and contract employees) shall comply with ASME BPVC Section IX or AWS Code (see Section 1.2 for exceptions). All welders and brazers of Code welds shall be qualified as required by these Codes. Note that ASME qualification requirements are usually more comprehensive than AWS and thus may provide qualification under both Codes. Individual welder and brazer qualifications and all testing related to these qualifications shall be approved by the Jefferson Lab designated QA/CI Inspector.

Welding and brazing qualifications, including the preparation of Welding/Brazing Performance Qualifications (WPQs/BPQs), for pressure piping are given in Articles III and XIII of the ASME BPV Code, Section IX. Similar rules given in AWS construction codes (e.g.; AWS D1.1, AWS D1.2, AWS D1.6) may also apply provided they are the same or stricter than the ASME requirements or where the ASME requirements are not applicable (e.g. structural welds).

A qualification shall be revoked by the QA/CI Inspector for lack of use of the welding process in a six month period or repeated poor performance as required by ASME and AWS Codes.

All records of certified WPQs/BPQs shall be appropriately filed in DocuShare by the QA/CI Inspector for Lab-wide use. Each WPQ/BPQ shall be secured with its actual test results at a central location maintained by the QA/CI Department and shall be accessible for review.

3.8.2 Employees of Outside Organizations

Welders and brazers employed by outside organizations shall be qualified as required by the most applicable Code.

3.9 Weld/Braze Examination

Weld and braze examinations shall be performed where required by the applicable code or engineering design. The RE shall determine the extent and nature of examination and documentation of examination required. These examinations shall be performed by qualified personnel (see Section 4.4) according to a written procedure. Welding and brazing performed by Jefferson Lab employees shall be examined by personnel approved by the Jefferson Lab designated QA/CI Inspector.

Examinations shall verify the following (as applicable):

- Material certifications
- Welder/brazer qualifications
- Procedure qualifications

- Fit up, joint preparation, alignment, dimensions, preheat, and machine configuration
- In processes acceptability (e.g. root pass)
- Post weld heat treatment
- Weld and/or braze acceptability
- Specific requirements of the engineering design

Examinations performed by Jefferson Lab employees shall follow "Procedure Number NDT-PQ-100 Written Practice for the Qualification and Certification of NDT Personnel" and complete the appropriate documentation, In-Process Visual Examination Checklist or Final Visual Examination Checklist.

3.9.1 Documentation

Certified examinations consist of NDE, material handling load tests, and pressure/leak tests. Records of these exams showing dates, examiner and results shall be documented. This documentation shall be forwarded to the RE for filing in the appropriate database. Jefferson Lab examiners shall complete the appropriate documentation and forward this to the RE.

3.10 Weld or Braze Inspection

The RE shall determine the extent of required inspection and ensure that inspections are performed when required by the applicable code and/or the engineering design. Inspections shall be performed by individuals qualified as given in Section 4.2.

Inspectors of welding and brazing performed by Jefferson Lab employees shall be approved by the Jefferson Lab designated QA/CI Inspector. Inspectors of contract welding and brazing performed by outside organizations shall be approved by the QA/CI Inspector and shall be qualified as given in Section 4.2.

Weld and braze inspections shall review and verify the following (as applicable):

- Material certifications
- Welder/brazer/examiner qualifications
- Procedure qualifications
- Quality programs for all organizations
- Fit up, joint preparation, alignment, dimensions, preheat, and machine configuration
- In processes acceptability (e.g. root pass)
- Post weld heat treatment
- Weld and/or braze acceptability
- Overall documentation
- Specific requirements of the engineering design

3.11 Weld/Braze Traceability

Weld/braze traceability for pressure components shall be as required in the Pressure and Vacuum Systems Safety Supplement and the engineering design. For all other weld/braze joints traceability shall be as required by the applicable code and the engineering design. This can be accomplished using a log sheet, marking a welding/brazing assembly drawing ("weld map"), or stenciling/marking the welder/brazer name or identification number near the weld on the actual assembly.

3.12 Material Control

3.12.1 Receipt Inspection of Materials

Upon receipt of materials to be used for welding, the welding supervisor or designee shall inspect the documents to ensure that all welding consumables, base metals, welding gases, and electrodes conform to specification or to drawings.

3.12.2 Filler Metal Storage

Filler metal materials shall be separated by base metal and alloy, as indicated by stamping or tags, while stored in a dedicated cabinet controlled by the welding supervisor. These items shall also be identified by heat and lot numbers to the extent practicable. Shield Metal Arc Welding (SMAW) electrodes should be kept dry and locked in their original packaging. Low hydrogen electrodes purchased in hermetically sealed containers shall be stored in a locked cabinet until the container is opened and then in a locked oven held at 250 F or above until used. Any electrodes removed from the oven for less than four hours can be returned and must remain in storage for a minimum of four hours before being used. Any electrodes removed for a time exceeding four hours shall be properly disposed.

3.12.3 Control

Welding consumables shall be available only through the welding supervisor. Any unused welding rods or electrodes shall be returned into a locked consumables container.

3.12.4 Material Conformance and Certifications

3.12.4.1 Base Metal

For base metal forms (e.g., plates, heads, castings, etc.), either a certified test report (material test report or "mill certification") or certificate of compliance is required according to the applicable code or the engineering specification for structural joints. These documents shall list the specification designation, the grade, type and class (if applicable) of the base metal. Steel of

unknown specification may be used, for structural supports, where allowed by Code (cf. ASME B31.9 ¶ 921.1.1 or B31.3 ¶ 321.1.4).

Piping components shall be "listed" according to product form specifications or "unlisted" according to published specifications that include the information given in ASME B31.3, ¶ 323.1.2. Material supplier invoice information may be substituted for material certifications provided both product form and material specifications are noted.

Testing, performed by outside organizations (certified and approved for conducting such tests), calibrated portable testing equipment, or other suitable test and measurement equipment may be used to supplement knowledge of the base metal specification. Where CMTRs, COCs, and other documentation are not available, these tests may be relied upon entirely provided sound engineering judgment is applied (e.g. reduced allowable stress). For assistance, contact the QA/CI Inspector.

3.12.4.2 Filler Metal

Welding and brazing Filler Metal shall be certified either by including the AWS specification and classification on the packaging or affixing its alloy designation stamped or tagged to each rod. Shipping containers of new material must also bear the heat and lot numbers. Older material can be used provided it is properly identified. All packaging shall be traceable to the original manufacturer's records.

3.12.4.3 Welding Gases

Certification of welding gases shall be made available from the vendor upon request

3.13 Unlisted Materials

The use of unlisted materials shall be avoided whenever reasonably possible. Jefferson Lab is a research facility, however, and use of such materials is often required to perform this research. Welding or brazing with unlisted base or filler metals may be allowed provided a WPS or BPS is developed. This procedure shall conform as much as possible to the requirements of the most applicable Code (e.g. ASME BPVC Section IX for pressure components). The RE shall determine by suitable research and/or testing, the relevant physical properties of the material(s). Limitations or other effects (e.g. reduced fracture toughness, reduced temper, etc.) shall be noted on the WPS or BPS as applicable. These limitations shall be considered by the engineering design.

Procedures using unlisted materials and used by Jefferson Lab employees shall be approved by the Jefferson Lab designated QA/CI Inspector.

Welders and brazers of these joints shall qualify to the specialized WPS or BPS as required by the applicable Code.

Procedures for use by employees of organizations other than Jefferson Lab shall be reviewed by a Jefferson Lab RE. In all such cases, the Jefferson Lab RE shall ensure that all requirements of the engineering design are met and employ sound engineering judgment.

3.14 Equivalent Measures

Equivalent measures shall be used to ensure a level of safety equal to or greater than that required by applicable Codes. These measures shall be taken for each weld or braze that cannot be designed, performed, examined/inspected etc. in full Code compliance. Because of the unique nature of each joint geometry, it is not possible to give detailed requirements for these *equivalent measures.* The general requirements for equivalent measures (also known as equivalency) shall be as follows:

- Documentation for each weld/braze joint where Codes cannot be directly applied:
  - Reason why the engineering design requires that each weld or braze joint cannot fully comply with the selected Code of Record.
  - Specific Code requirements which cannot be met.
  - Calculations as required by Code and the engineering design.
  - Specifications for special examinations or inspections if applicable.
- Measures taken to ensure a level of safety equal to or greater than that required by the most applicable Code. These measures can include:
  - Extensive detailed analysis
  - Protective barriers
  - Secondary containment
  - Specialized testing
- Equivalent measures for pressure components shall be as given in the Pressure and Vacuum Systems Safety Supplement.
- A peer review of each weld/braze joint where Codes cannot be directly applied shall be performed.

The above requirements, including peer reviews, apply to any component constructed by Jefferson Lab or agencies other than Jefferson Lab.

The RE is encouraged to consult other REs for assistance, guidance and arbitration.

3.15 Cutting and Burning

When cutting and/or burning is used to size components for the fabrication of pressure components or structural elements the RE shall be informed. Cutting and burning may have a

detrimental effect on the microstructure of the heat affected zone. This may affect the base metal or weld quality in an unacceptable fashion.

4 Qualifications

4.1 Responsible Engineer (RE)

The qualifications and experience of the RE depends on the complexity, application, and criticality of the weld/braze joint. For the design of Code welds/brazes on pressure components, the responsible engineer shall have applicable experience and extended knowledge of the applicable ASME Codes. Similarly for structures, the RE shall have familiarity with relevant nationally recognized Codes (e.g. IBC) or manuals (e.g. American Institute of Steel Construction, *Steel Construction Manual*).

4.1.1 Jefferson Lab Employees

The RE shall also meet one of following requirements to provide the engineering design of Code welds/brazes:

- Completion of an engineering degree, requiring four or more years of full-time study, plus a minimum of five years of experience in the design of pressure components or structures.
- Professional engineering registration, and experience in the design of pressure components or structures.
- Completion of an engineering associates degree, requiring at least two years full-time study, plus a minimum of 10 years of experience in the design of pressure systems or structures.
- 15 years of experience in the design of pressure components or structures.
- Approval of the Jefferson Lab Engineering Manager or person of a higher organizational level.

An RE responsible for the construction of pressure components shall be a qualified Design Authority as defined and required in the Pressure and Vacuum Systems Safety Supplement.

4.1.2 Employees of Outside Organizations

The responsible engineer shall meet the following requirements to provide the engineering design of Code welds/brazes:

- Professional engineering registration, and experience in the design of pressure components or structures.

4.2 Welding Inspector

For all Code welding and brazing, the Welding Inspector shall be the Jefferson Lab designated CWI ESH&Q QA/CI Inspector (or his designated alternate), an employee of an engineering or scientific organization experienced in welding inspection, or of a recognized insurance or

inspection company acting as Jefferson Lab's agent. The inspector shall be independent from all aspects of the design, manufacturing, erection, testing, or examination processes. Jefferson Lab welding/brazing inspectors shall be qualified as follows:

- Jefferson Lab designated CWI or alternate
  - CWI or senior CWI, possessing a valid certificate as defined by AWS QC1, with at least 5 years of experience.
- Inspectors employed by outside organizations to inspect welds or brazes performed by Jefferson Lab employees
  - CWI or senior CWI, possessing a valid certificate as defined by AWS QC1, with at least 5 years of experience.
- Inspectors employed by outside organizations to inspect welds or brazes performed by outside organizations shall be qualified as given by the code of construction or post construction.

4.3 Welder/Brazer

Welders and brazers of pressure equipment either working at or employed by Jefferson Lab shall maintain the following training and qualifications:

- SAF 130A (Pressure System Safety Awareness)
- SAF 150 (Welding Safety).
- Shall maintain qualifications detailed by the DA and line management for the appropriate welding and brazing procedures and processes.
  - SAF 150GTA – Automatic Gas Tungsten Arc Welding
  - SAF 150FC – FCAW Flux Core Arc Welding
  - SAF 150GM – Gas Metal Arc Welding
  - SAF 150GT – Gas Tungsten Arc Welding
  - SAF 150SM – Shielded Metal Arc Welding (SMAW)
  - SAF 150OX – Oxygen Fuel Welding/Brazing
- Shall have knowledge of their individual qualifications.
- Shall meet additional or superseding qualifications given in ASME Codes of construction or post construction (e.g. ASME BPVC Section IX and ASME B31.3. ¶ 333).

Welders and brazers of pressure equipment fabricated off site for use at Jefferson Lab shall be qualified as required in the specified ASME Code of Record. These qualifications shall meet the requirements of ASME BPVC Section IX (except where superseded by the Code of Record or the engineering design) with regard to WPS/PQR, WPQ/BPQ, and documentation. These qualifications shall be detailed in a SOW where appropriate. Where ASME Codes are not applicable, procedures, welders, and brazers shall be qualified as given in Pressure and Vacuum

Systems Safety Supplement. This shall be detailed and documented as required by a SOW where welding or brazing is to be performed by agencies other than Jefferson Lab.

4.4 Welding and Brazing Examiner

Examiners shall have training and experience commensurate with the needs of the specific examinations as determined by the specified Code, engineering design, and the RE. Qualification records of the examiners showing dates and results shall be made available for review. All examiners that are Jefferson Lab employees shall be approved by the Jefferson Lab designated QA/CI Inspector.

Visual examiners employed by Jefferson Lab or other agency shall have at least one of the following qualifications (specific to the specified examination process):

- Shall be qualified to ASNT SNT-TC-1A ACCP Level II.
- Shall meet the requirements of Jefferson Lab procedure NDT-PQ-100.

Note: Specific visual examiner requirements are given in the "Quality Assurance Training and Certification for Visual Examiners Procedure" and "Procedure Number NDT-PQ-100 Written Practice for the Qualification and Certification of NDT Personnel" filed in DocuShare.

5 Responsibilities

5.1 Division Heads

Each Division Head is responsible for ensuring that all groups within their division meet the requirements of this program. Responsibilities include establishing and maintaining policies for documentation, and assigning supervisors responsible for the design, fabrication, testing, and examination of in-house welds and brazes.

5.2 Pressure Systems Committee

- Arbitrate contested reviews of equivalent measures when ASME Pressure Codes or related requirements of this supplement cannot be directly applied.
- Any decision shall be directed to the QA/CI Inspector for evaluation of possible impacts and modifications to Jefferson Lab welding operations.

5.3 Welding Technical Committee

- Arbitrate contested reviews of equivalent measures when National Consensus Codes (other than ASME Pressure Codes) or related requirements of this supplement cannot be directly applied.
- Any decision shall be directed to the QA/CI Inspector for evaluation of possible impacts and modifications to Jefferson Lab welding operations.

5.4 Environmental, Safety, Health, and Quality (ESH&Q) Division

The ESH&Q Division is responsible for providing oversight and support to the site-wide welding program through the designated QA/CI Inspector. Responsibilities include:

- Support, oversee and/or supervise, as needed, the Jefferson Lab Code inspector.
- Support and/or oversee contracted inspectors, examiners, or welders as required by contract or engineering design.
- Review quality programs of outside organizations as required in accordance with the Jefferson Lab Approved Vendor Program and maintain the approve vendor list.
- Provide inspection as required by Codes or by engineering requirements.
- Approve and monitor vendor sub-contracts for certifications and qualifications for welders, examiners and inspectors as required by contract or engineering design.
- Ensure Jefferson Lab welder, brazer, and examiner qualifications are current and appropriate.
- QA/CI Inspector will provide final acceptance inspection for welding personnel qualification test coupons.
- QA/CI Inspector will provide final acceptance inspection for purchased custom

fabricated welded items as required by contract or engineering design.
- Monitor current requirements and certifications necessary for examination and inspection personnel.
- Establish and maintain a welding documentation database.
- Provide access to the welding database, standard forms, procedures, and qualifications.

5.5 Supervisors

Supervisors of engineers, designers, examiners, welders, and brazers must be cognizant of the requirements provided in this supplement. Respective supervisors shall be responsible for ensuring the engineers, examiners, welders, and brazers under their purview are qualified to perform their tasks. They shall verify, through the QA/CI Inspector, certification and qualifications of examiners, welders and brazers for specific tasks.

For welding and brazing performed on site by Jefferson Lab employees, the supervisor of the welder/brazer shall ensure that:

- All materials are handled in accordance with this program.
- The inspector and/or examiner are contacted as required by this program.
- An appropriate welding/brazing specification exists and has been assigned for the work to be done.
- The Design Parameter Form or a Fabrication Traveler has been developed that contains as a minimum the required testing and nondestructive examination (NDE) requirements given by the responsible engineer.
- The welder/brazer has attained and maintained all applicable qualifications.
- The welding supervisor shall ensure, through the QA/CI Inspector, that procedures have been qualified and the welder/brazer has been qualified to those procedures.
- The welding supervisor shall ensure that the welder/brazer maintains his/her qualifications as required to complete shop workloads.

5.6 Responsible Engineers

NOTE: The responsible engineer may delegate design duties but not his/her responsibilities.

Responsible engineers of welded or brazed assemblies of any type must be cognizant of the requirements provided in this program. For contracted work, this person is often the Subcontracting Officer's Technical Representative (SOTR). The responsible engineer may be a qualified employee of an outside organization.

Responsible engineers shall assume the following responsibilities:

- Determine the **most** applicable Code and edition of that Code that a given weld or braze

joint must comply with.
- Determine the extent of analysis required each weld/braze.
- Determine and assign the appropriate welding/brazing specification to each weld/braze as required by this program.
- Ensure any required analysis is complete.
- Ensure all the correct applicable information (e.g. design loads not given in a specification, materials, part numbers, vendor information, testing, American National Standards Institute (ANSI) and/or American Welding Society (AWS) symbols, specifications, etc.) and instructions are called out on the drawings.
- Ensure that the design has been appropriately reviewed.
- Ensure that the requirements of any sub-contracted work includes adherence to nationally recognized construction codes.
- The responsible engineer ensures that examinations/inspections required by the applicable code and the engineering design are performed and documented. The RE shall employ sound engineering judgment to determine the nature and extent of examination and inspection.

See also Appendix C Responsible Engineer (RE) Requirements flowchart. Additional responsibilities for cases of welding/brazing operations performed by outside organizations are given in Section 3.1.

5.7 Welders/Brazers

Welders/Brazers must be knowledgeable of their qualifications and expectations with regard to their welding activities.

- Shall maintain qualifications detailed by the RE and line management for the appropriate welding and brazing procedures and processes.
- Shall have knowledge of their individual qualifications.
- Shall perform their tasks in a safe manner consistent with ES&H Manual Chapter 6122 *Hot Work (i.e. Welding, Cutting Brazing, and Grinding) Safety Program*.
- Shall ensure that they are qualified in accordance with the applicable code prior to performing welding or brazing.

5.8 Inspectors

The Jefferson Lab designated QA/CI Inspector shall assume the following responsibilities:

- Perform welding and brazing inspections (and provide documentation) as required by RE and the engineering design.
- Maintain Jefferson Lab PQR, WPS, WPQ, etc. These documents shall be available for Jefferson Lab general use.
- Maintain records of welder, brazer, and procedure qualifications and testing related to

qualifications for review.
- Maintain qualifications as given in Section 4.2.
- Review quality programs of outside organizations as required in accordance with the Jefferson Lab Approved Vendor Program and maintain the approved vendor list.

All welding inspectors employed by outside organizations shall perform inspections as required by the engineering design and the applicable code.

Inspectors shall be responsible for ensuring the QA/QC documentation is in compliance with all requirements of the applicable code.

5.9 Examiners

Examiners and/or test personnel shall perform their function in concert with the inspector when required. Each welding group may have one or more personnel trained and certified as an examiner if deemed necessary by supervision and workload.

Specific requirements and duties of both inspectors and examiners are maintained and available for review within the ESH&Q Division.

6 References

6.1 Applicable External Standards

These standards are applicable in entirety, or in part, to this program.

6.1.1 Pressure Vessels

- ASME Boiler and Pressure Vessel Code (BPVC). This is the national consensus code is used as the standard for pressure vessel design, fabrication, testing, and inspection. The most frequently used sections of the ASME BPV Code as applied to pressure vessels at Jefferson Lab are:
  - Section II: Materials, Parts A, B, C, and D
  - Section V: Nondestructive Examination
  - Section VIII: Rules for Construction of Pressure Vessels, Divisions I & II
  - Section IX: Welding and Brazing Qualifications

6.1.2 Pressure Piping

- ASME Code for Pressure Piping B31. This is the national consensus code used as the standard for piping system design, fabrication, testing, and inspection at Jefferson Lab. Sections of B31 that apply to piping systems at Jefferson Lab include:
  - B31.1 Power Piping
  - B31.3 Process Piping
  - B31.5 Refrigeration Piping
  - B31.9 Building Services Piping
- ASME B31.3 Process Piping shall be used as the primary standard for Jefferson Lab piping systems. Other sections shall be applied as appropriate based on sound judgment of the responsible engineer/designer and proven practices in the respective field.
- ASME B31.9 Building Services Piping prescribes welding and brazing requirements of piping systems for building services including those in the building or within the property limits. This Code Section has rules for the piping in industrial, institutional, commercial and public buildings, and multi-unit residences, that do not require the range of sizes, pressures, and temperatures covered in B31.3.
- ASME BPV Code.

6.1.3 Structural

- AWS D1.1/D1.1M, Structural Welding Code—Steel
- AWS D1.2/D1.2M, Structural Welding Code—Aluminum
- AWS D1.6, Structural Welding Code—Stainless Steel
- AWS B2.1-X-XXX, Standard Welding Procedure Specifications
- AWS D1.3, Structural Welding Code—Sheet Steel

6.1.4 Material Handling

- ASME 30.20/ASME BTH-1, Below the Hook Lifting Devices
- ANSI/AWS D14.1, Specification for Welding of Industrial and Mill Cranes and other Material Handling Equipment

6.1.5 NDE Examiner Qualification

- ASNT Recommended Practice No. SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing
- Jefferson Lab Procedure Number NDT-PQ-100 Written Practice for the Qualification and Certification of NDT Personnel

6.1.6 Design

- ANSI/AWS A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination

6.2 Applicable Internal Standards

6.2.1 Jefferson Lab ES&H Manual

- ES&H Manual Chapter 3210 Appendix T3 Risk Code Assignment
- ES&H Manual Chapter 6122 Hot Work (i.e., Welding, Cutting Brazing, and Grinding) Safety Program
- ES&H Manual Chapter 6150 Compressed, Liquefied, and Solidified Gas Program
- ES&H Manual Chapter 6151 Pressure and Vacuum Systems Safety Program

7 Revision Summary

Note: All revisions to this Supplement must be approved by the Welding Technical Committee.

Revision 2.1– 01/12/16 – Minor edits, revised Table 1 Pressure/Vacuum System Weld Classification, defined responsibilities for the Pressure Systems Committee and the Welding Technical Committee

Revision 2.0– 11/06/15 – Periodic Review; changed categorization of welds from Class A, B, and C to Code and Low Risk; updated to incorporate the Pressure and Vacuum System Safety Supplement.

Revision 1.1 – 04/2011 – Content removed from ES&H Manual

Appendix A - Minimum Welding/Brazing Requirements Table

Weldment / Brazement Classification	**Code**	**Low Risk**
Former Weldment / Brazement Classification	*A/B*	*C*
Risk Code*	**2 through 4 (and 0 or 1 for MHE and buildings/structures for human occupancy)**	**0 or 1**
SAFETY REQUIREMENTS	ES&H Manual Chapter 6122, *Hot Work (i.e. Welding, Cutting, Brazing, and Grinding) Safety Program*	ES&H Manual Chapter 6122, *Hot Work (i.e. Welding, Cutting, Brazing, and Grinding) Safety Program*
PROCEDURE QUALIFICATION	ASME or meets minimum requirements of ASME for comparable procedures	None Required
WELDER/BRAZER QUALIFICATION	ASME or meets minimum requirements of ASME for comparable procedures	Optional***
INSPECTION & EXAMINATION	ASME for pressure vessels and pressure piping	Optional***
	100% visual examination** for all structural and MHE plus a load test for MHE (ref. ES&H Manual Chapter 6141 T6). Inspection per engineering documents.	
MATERIAL REQUIREMENTS	ASME for pressure vessels and piping	Optional***
	Material certifications per engineering documents for non-ASME	
ENGINEERING DOCUMENTATION	Signed drawings/sketches and analysis per applicable ASME Codes for pressure systems and nationally recognized codes for structures	Optional***
QA DOCUMENTATION	Inspection report verifying above requirements are met for pressure systems and only if specified for structural welding	Optional***

* Risk codes according to ES&H Manual Chapter 3210 Appendix T3 Risk Code Assignment, before implementation of above requirements.

** Additional examination is recommended for structural tubular welds requiring complete joint penetration.

*** The requirements, responsibilities and qualifications given in this supplement are optional for Low Risk welds and brazes.

Appendix B – Weld Classification Tables

Table 1 Pressure/Vacuum System Weld Classification

	A (in^2)	P (psi)	CODE
Pressure Vessel	> 28.8	< -15, > 15	ASME B&PV
Pressure Vessel-Water	> 28.8	> 300	ASME B&PV
Pressure Piping, non-hazardous	—	≥ 15	ASME B31
Pressure/Vacuum Piping, hazardous*	—	any	ASME B31
Any Pressure System/Component Excluded from ASME Codes with a RC > 1**	—	≥ 0	Most applicable ASME or AWS
Any Pressure System/Component Excluded from ASME Codes with a RC ≤ 1**	—	≥ 0	Not required
Cat. 0 Vacuum Systems***	—	≤ 15	Not required
Cat. 1 Vacuum Systems***	> 33 AND V > $35ft^3$	≤ 15	Not required
Cat. 2 Vacuum Systems***	< 33 OR V < $35ft^3$	≤ 15	Not required
Cat. 2 Vacuum Systems***	> 33 AND V > $35ft^3$	≤ 15	Most applicable ASME OR AWS
Cat. 3 Vacuum Systems***	—	< 0, ≥ 15	Most applicable ASME

Where:

A largest internal cross sectional area

P maximum allowable external or internal differential pressure

V volume of vacuum system

Notes:

* Generally true for most process piping excluding cryogenic, flammable, damaging and toxic fluids (RE must consult applicable piping code). The minimum or maximum pressure thresholds may be different for other piping applications according to their applicable code.

** Risk Code shall be determined by a Responsible Engineer

*** Refer to *Pressure and Vacuum Systems Safety Supplement, Part 7: Vacuum Systems*

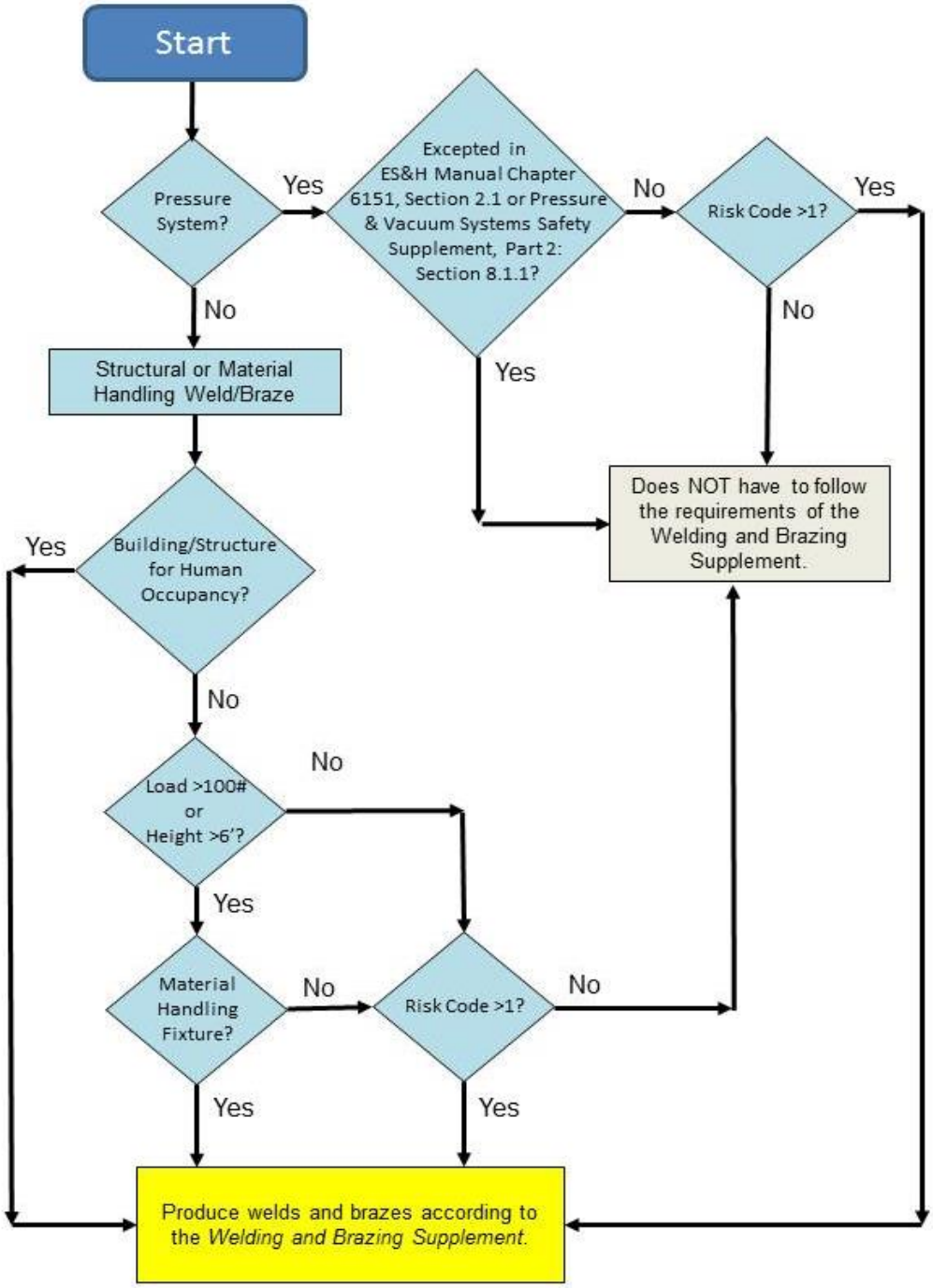
Table 2 Structural and Material Handling Weld Classification

	Load Height Above Floor	Weight Supported by Item/System	Risk Code	CODE
Load Bearing Structures	Any	>100 Lbs	**RC>1**	Yes
	>6 Ft	Any	**RC>1**	Yes
	Any	Any	**RC>1**	Yes
Material Handling Fixtures	Any	>100 Lbs	Any	Yes
	≥6 Ft	Any	Any	Yes
	Any	Any	**RC>1**	Yes
Building/Structures for Human Occupancy	Any	Any	Any	Yes

Note: These are general guidelines and a Task Hazard Analysis shall be performed for each case to verify the above classifications.

Appendix C – Requirements Flowcharts

Welding and Brazing Supplement Requirements Applicability



Responsible Engineer (RE) Requirements