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# Purpose:

### The purpose of this user guide is to provide instructions for Laser Technicians in the process and procedures necessary of Laser Welding.

# Responsibilities

### The Welding Supervisor and Manufacturing Engineers are responsible for maintaining this procedure, TA1080 and 41319 for continual suitability to all Laser Welding Processes.

### The Welding Supervisor and Weld Technicians are responsible for adhering to and effectively carrying out this procedure.

# Affected Department / Product Group / Support Group

### Departments: Manufacturing

### Product Groups: N.A.

### Functional Support Groups: Welding

# Associated Documents

### ISO 900

### Quality System Manual

### Quality Assurance Manual

### AWS Specifications: C7.4, A2.4, A3.0M, D17.1

### QAM 10 Improvement

### QAM 7.1.5 Monitoring and Measuring Resources

### QAM 8.7 Control of Nonconforming Outputs

### QA102 Visual Inspection Master

### QA1075 Preventive Maintenance Users Guide

### QC050 Analysis of Equipment Malfunction

### TA01 Nonconforming Material Control

### TA25 Laser Weld Technician Qualification Program

### TA27 Laser Weld Lab

### TA33 Laser Welding Process Map

### TA015 Laser Welder Verification

### TA036 Weld Penetration Test Datasheet

### TA081 Nonconforming Material

### TA140 Laser Weld Technician Qualification Record

### TA141 Laser Weld Inspector Qualification Record

### TA1051 Heated Ultrasonic Cleaning

### TA1061 General Workmanship Cleaning

### TA1243 Weld Measurement Users Guide

### TA1256 Argon Welding Shield Gas Delivery System User Guide

### PE04 Annual Eye Test Process

### PE1020 Lockout Tagout

### EN10 New Equipment Procurement Process

### EN1041 DPA and Chemical Etching Users Guide

### EN1087 Laser Welding Design Practices

### TA1080 Laser Welding Process and Operating Guide for General Electric Products

### 41319 Laser Welding Process and Operating Guide for PWR Products

# Safety Considerations

## Eye Protection

### Laser welding uses a focused beam of light to achieve very precise welds. The major hazard of this powerful beam is to the eyes, which can be blinded when hit with the beam. Special eye protection must be used, and care must be taken with any reflective surfaces since both the original and reflected beam are extremely dangerous. For additional information, refer to the manufacturer’s equipment operating manual.

## Electrical Hazards

### The laser power supply output can reach potentially lethal voltage levels. Do not perform any maintenance on or inside the laser power cabinet without following “PE1020 – Lockout/Tagout.” For additional information, refer to the manufacturer’s equipment operating manual.

### After powering down the laser, allow a two minute period for the high voltage capacitors to fully discharge before the laser power cabinet doors can be opened. Before working on anything powered by these capacitors, confirm a zero energy state has been achieved by checking with an electrical meter.

### When re-energizing equipment is necessary to troubleshoot, test or position the equipment, temporarily remove the lockout or tagout devices. This applies only for the time required to perform the task.

#### For power-on testing, whenever possible, use the procedures called out in the manufacturer’s users/operating manual.

# Laser Weld Specification

## Weld Penetration Specification

### Unless otherwise called out on the engineering or released drawing, all laser welds at PCB will be considered Class C seal welds. A class C laser weld is defined in AWS C7.4 as a “non-critical weldment whose failure would not affect the efficiency of the system or endanger personnel”. A seal weld as defined in AWS A3.0M is “any weld intended primarily to provide a specific degree of tightness against leakage.” As such there is no specific penetration requirement for these welds.

#### For seal butt welds, the welding department will attempt to get weld penetrations within the targets below. The following weld target uses the smaller material thickness of the two mating parts.

##### For material thickness between .000” - .019”, weld penetration will be 40-140% of the thinner material.

##### For material thickness between .020”-.049”, weld penetration will be 30-130% of the thinner material.

##### For material thickness .050” and larger, the weld penetration will be 20-85% of the thinner material.

##### The above weld penetrations over 100% of the thinner material are acceptable only as long the weld penetration does not break through the thicker material and send weld spatter into the sensor.

#### For seal fillet welds, a minimum of .006” weld penetration should be targeted for connector or connector adaptor to housing welds. Welds that hold other parts of the sensor together should target a minimum of .010” weld penetration. Exceptions shall be made for extremely small parts with mating part cross sections less than .015”.

### If a Product Engineer creates an engineering drawing showing targeted weld penetrations, the Manufacturing Engineer will create weld samples as close to the targets as possible and present them to the Product Engineer for evaluation. Once the product engineer approves the penetration samples, the engineering drawing will be updated to reflect the agreed upon penetration range. The engineering drawing will then be released. Welding will be responsible to meet the weld penetration specifications on released drawings only. Welds with penetration requirements will be considered Class B welds. A class B laser weld is defined in AWS C7.4 as a “semi critical weldment whose failure would reduce the overall efficiency of the system, but loss of the system or endangerment of personnel would not be experienced.” See Section XII.C.

### Because PCB’s sensors can be very sensitive to heat (i.e. solder reflow and connector glass cracking) certain welds may be excluded from the preceding penetration targets. NOTE: The welding manufacturing engineer in consultation with design engineering and other manufacturing engineers shall be the sole authority in making this determination.

## Other Weld Specifications

### Porosity

#### Porosity voids are most commonly seen towards the bottom of our weld melts.

#### For welds with documented penetration requirements, the diameter of the porosity bubble must not be any larger than 50 percent of the weld penetration depth (reference AWS C7.4). Porosity bubbles should be a minimum of 2 times the size of the larger bubble apart. If 2 porosity bubbles are closer than 2 times the size of the larger bubble apart, the largest distance between the outsides of the bubbles must not be any larger than 50 percent of the weld penetration depth. This porosity will be measured at initial weld schedule validation and any subsequent process control checks.

#### There is no porosity specification for seal welds. The amount of acceptable porosity in a specific seal weld is determined by the welding manufacturing engineer.

### Tack welds

#### Unless otherwise called out on the drawing or router, tack welds will be considered a non-structural, non-sealing weld and will not require penetration checks or visual inspections. Unless defined in the router or drawing, the weld schedule/program will define the number of tacks and the position of the tacks.

#### Unless otherwise specified in the product drawing or router, a tack weld callout on the drawing or router will allow the operator to create a series of tack welds (also known as a run).

#### Production operators will be allowed to add tack welds as they see fit to any part and in any quantity and pattern so long as a final weld is done to cover the tack welds before the part is submitted for inspection.

##### In this case the tack welds do not need to be visually inspected and can be covered up with a weld without any intermediate cleaning operation.

##### These tack welds do not need to be documented in any written job instruction (i.e. routers, drawings, procedures, etc.)

### Titanium Top Connectors Weld (Typically SVS Sensors)

#### Unless not called out on the router, all Titanium top connectors must be welded in the Glove Box.

#### All other Titanium joints are welded as per router steps.

#### The weld manufacturing engineer, in consultation with design engineering and other manufacturing engineers, shall be the sole authority in determining whether a Titanium weld joint needs to be welded in the Glove Box.

# Weld Schedules/Program Creation and Validation

## Weld Schedule/Program Penetration Requirements

### Laser welds with penetration requirements specified on the product drawing will be done by either direct measurement or validation by analysis.

### **Weld Validation by Direct Measurement**

#### Engineering will obtain the parts to be welded for each weld and weld machine to be validated. Only the metal pieces to be welded will be used- these do not need to have the elements, connectors or electronics/wiring in them.

#### At the welding engineers discretion, heat sensitive paint, solder, etc will be applied to surface that will have heat sensitive components.

#### Manufacturing engineering or the weld technician will decide on the preliminary weld settings. This process may involve multiple trials. While developing the program, the weld technician may adjust the weld parameters as needed. The preliminary weld schedule/program will be saved on the laser welder’s local computer.

#### The weld technician will complete all the welds on the parts required for testing and submit them back to manufacturing engineering. Manufacturing engineering will have welding inspector visually inspect the welds per QA102.

#### For sealed assemblies, the welding engineer will conduct the appropriate leak test based on the product’s router and/or drawing.

#### For titanium parts that require a connector pull test on the routing, a connector weld strength test will be completed on 2 parts. If the connector strength does not match the specification, repeat steps a-d until an acceptable value is achieved. For externally threaded parts, follow the connector weld strength verification described below. For internally 10-32 threaded parts, torque test to a minimum of 30 in-lbs.

#### The manufacturing engineer will have at least 1 of these parts sectioned and each weld location will be measured for penetration in 2 places and compared to the specification. DPA samples are created per TA27.

#### If excessive porosity (greater than 10% of the weld volume) is seen, this will be evaluated by product and manufacturing engineering and disposition will be determined.

#### If the measured weld penetrations for a specific part location are within specification, the weld schedule/program for that weld location will be accepted and stored on the machines local drive.

#### If the weld penetration for a specific part location is outside of specification, this process will be repeated until an acceptable weld penetration in that area is achieved.

#### The weld validation report will be stored on the network at R:\Engineering\Welding\Weld\_Penetration\_Log\01-DPA-Log. This report will include the weld parameters and the date and revision of the weld schedule/program used.

### **Weld Validation by Analysis**

### Validation of weld by analysis will be acceptable if all of the following conditions are met:

#### Material class number (as defined in AWS D17.1) is identical to a qualified weld schedule/program.

#### Welding power parameters (watts and Joules) are within +/- 5% of a qualified weld schedule/program.

#### Welding linear or rotary speed (ipm or rpm) is within +/- 5% of a qualified weld schedule/program.

#### Welding pulse rate (Hz) and pulse width (ms) are identical to the qualified weld schedule/program.

#### Same angle between the weld joint and the laser head as a qualified weld schedule.

#### Same joint geometry as a qualified weld schedule/program.

#### Material thickness at the joint is within +/- 30 % of a qualified schedule/program.

#### There are no customer requirements for specific weld penetrations.

## Weld Schedule/Program for Seal Weld Requirements

### Seal weld schedules may be derived based on the actual penetration measurements of weld samples, analysis to actual measurements of similar welds or historical weld schedules of similar welds. The welding manufacturing engineer shall be the sole authority making the determination as to whether a weld schedule can be qualified by analysis. The welding manufacturing engineer may authorize individual welding technicians to develop weld schedules for seal welds based on his knowledge of the product and the experience and skill of the welding technician.

## Deterioration of Welds and Requalification of Weld Schedules

### When the weld schedule/program is determined to be the root cause of a QC or MDR or production quality issue, or if an ECO makes significant changes to the welding of existing parts, the weld schedule/program will need to be revalidated. Production will be immediately stopped for this model on all affected weld machines. Manufacturing engineering will have the affected weld schedule/program either removed from the approved directory and have it placed in the hold directory or deactivated so that it cannot be run. The welding manufacturing engineer will then follow the appropriate weld schedule/program validation procedure (above).

## Weld Schedule/Program Storage and Backup

### All weld schedules, motion programs and any associated program libraries will be backed up to the network on a minimum of a monthly basis.

### Using the network to store the welding programs is not sufficient to meet the above requirement.

### Equipment without servo motion programs will store their weld schedules, fixture notes, etc. in a database on the network.

## Adjustments to Weld Schedules

### Rofin/Glovebox - In order to compensate for low or high power meter readings, the technician may adjust volume percent up to +/- 2% or milliseconds up to +/- 0.4.

### JK450 (Depew) and JK745 - The technician may adjust volume percent as needed to achieve programmed watts / joules.

### JK450 (NC) and IPG lasers – The machines automatically compensate for laser power fluctuations and no adjustment to the weld schedule is allowed.

### Minor changes to seal weld schedules can also be authorized by the welding manufacturing engineer and revision notes must be clearly kept in the program note files.

## Weld Schedule/Program Notes for Program Product

### Customer contracts may require a customer approval prior to changing or modifying a weld schedule. Program notes should be added to these specific weld schedules, notifying the welding technician that “customer approval of any changes is required.” This notification can also be added to the welding router step. Revision notes and any other customer requirements should be clearly kept in the program note files.

# Laser Equipment Qualification and Capability

## Equipment Qualification

### Effective 1/1/12, new equipment will be qualified per procedure EN10. Validation for equipment purchased prior to 1/1/12 is substantiated by customer PPM data. Evidence of product meeting quality standards is in lieu of documented qualification records.

## Equipment Capability

### Welding equipment shall be capable of producing welds that meet the acceptance criteria called out in QA102. Welding equipment shall not be used without needed repairs or adjustments when a welding operator or welding engineer has a concern about the capability of the equipment to operate satisfactorily. The welding equipment shall be capable of maintaining weld quality and consistency.

## Equipment Requalification

### When the weld machine is determined to be the root cause of a QC or MDR or production quality issue, the weld machine will need to be revalidated. Production will immediately stop on the affected weld machine(s). The weld machine will be repaired to fix the root cause of the quality issue. Based on the problem with the weld machine, the manufacturing engineer will create and record an equipment requalification plan. Only after the weld machine has successfully completed this requalification plan, will it be placed back into production.

# Part Cleaning and Subsequent Handling

### The following cleaning and handling requirements are for parts made of all material types, including titanium and titanium alloys.

## Parts Cleaning

### It is essential for good welding that the part, especially the weld joint and area surrounding the weld joint, be extremely clean prior to welding. This cleaning requirement is for parts of all material types, including Titanium. Parts will cleaned by the assembly technicians per TA1051 and/or TA1061 prior to being sent to the welding area.

## Part Storage

### Clean parts will be loaded into covered ESD boxes, nitrogen cabinets or ovens by the assembly technicians. Parts that are too large for the standard ESD boxes will have the critical welding surfaces protected by appropriate means.

### Because parts are stored in enclosed units (boxes, ovens, cabinets) prior to welding, there is no requirement for the maximum amount of time allowed between the cleaning process and the welding process.

## Post Cleaning Handling

### Parts will not be handled with dirty hands or gloves. The welding technicians should refrain from using hand lotions. Gloves or finger cots are not required for this operation. If possible, bare fingers should not come in contact with the areas to be welded.

## Suspect Dirty Parts

### If for any reason it is believed that the parts are dirty in the box or the parts gets contaminated outside the box, these parts are to be sent back to the assembly area for re-cleaning.

### Parts that were not cleaned properly by the assembly technicians should be given to the Production Manager or the welding manufacturing engineer for possible issuance of a quality alert or MDR.

# Job Procurement and Welding the Parts

### **Reference TA33 for Laser Welding Process Map**

## Job Procurement

### The weld technicians pickup jobs from the incoming material rack located outside the laser welding room. Job priorities are determined by jobs on the “hot” shelf, if applicable, and the order of incoming parts (First in - first out). The welding room Supervisor, or designee, may make adjustments based on welding labor efficiency, product lead-time and/or verbal requests from the assembly areas.

## Welding the Parts – Open Workstations

### Load the proper weld program, using the appropriate method, for the weld machine being used. If no program or tooling exists for the job, contact the welding room supervisor, designee or weld manufacturing engineer.

### If necessary, assemble the parts per print, router note, or weld program instruction. Visually check the tightness and fit of the parts being welded. If the fit of the parts seems too loose (gap too large), contact the welding room supervisor, designee or weld manufacturing engineer.

### Install the required collets and/ or fixtures. The fixture/collets needed are called out in the beginning of each program. Visually check fixturing/collets for any signs of wear, damage, or contamination. If the collet/fixture is dirty and has excess contamination, follow TA1061 Process G to clean the surfaces – especially those coming into contact with a welded part. Inspection of the fixture surfaces under a scope is not required. If fixtures/collets appear worn, damaged or the identification is illegible, contact welding room supervisor, designee or weld manufacturing engineer.

### Mount the part(s) into the tooling/fixture(s). When alignment marks are on the parts to be welded, align the 2 marks so that they are in line.

### Verify that the correct fiber cable is installed in the laser head. (400µM or 600 µM based on program specs)

### If required, adjust the angle of the laser head.

### For shaped parts (squares, rectangles, teardrops, etc.) adjust the rotary axis until the crosshairs are aligned with the part features.

### Focus the laser on the work piece by using the Z-axis until you can see the grain structure of the material.

### Align the laser beam with the weld joint. If the program notes say to favor one side of the weld, follow the notes. It is preferred that this is programmed to be done automatically, so make the manufacturing engineer aware of any such program. If necessary, change the fiber cable.

### Align the shield gas nozzle to the work piece. Proper nozzle positioning minimizes discolored welds.

### If necessary, adjust the air knife to prevent spatter from getting on the cover slide.

### If necessary, adjust the exhaust vents to remove the soot and smoke that will form during welding.

### When welding covers onto sensors, to insure good contact during the tacking program, apply pressure to the cover with a tool (screwdriver, fixture, tweezers, etc.).

### Run program and weld.

## Welding the Parts – In the Glovebox

### Place parts into glove box antechamber and evacuate 3 times (to prevent oxygen from entering the glovebox). If parts are coming out of a vacuum oven, the parts must be placed into the glovebox antechamber and the chamber evacuated with 15 minutes.

### From inside of glove box, remove items from antechamber.

### Confirm that chamber is at 0-10 ppm of oxygen and moisture (if reading reaches greater than 10 ppm, welding is not permitted until solution is determined and implemented).

### Allow any hot parts to cool to room temperature before proceeding.

### Follow numbers 1-9 and 13-14 of Section X.B Welding the Parts – Open workstations above, in order to complete welding.

# Visual Inspection and Handling of Defective Welds

## Visual Inspection

### A first piece sample for each setup will be inspected under a minimum 7x microscope by the operator to verify the setup is correct and the desired results have been achieved. In addition to the requirements of QA102, the operator will also look at the spacing between pulses, the pulse surface texture, etc. to make sure that the weld parameters appear correct for the model being produced.

### Unless called out in the router all welds will be visually inspected under a minimum 7X microscope per QA102. Visual inspection will only be performed by a qualified visual weld inspector.

### Unless otherwise noted on the router, welds should be inspected in the “as-welded condition”. No mechanical cleaning, sanding, or polishing should be done before the visual inspection. However, a light wiping of the surface dust on and around a weld (generated from the welding process) is allowed in order to inspect the weld.

### Unless instructed by the customer contract, never use visible dye penetrant to check weld integrity.

## In Process Correction

### If a work piece is found to be defective before it is submitted for inspection, the operator may reweld this part up to 2 times. The only exception to this rule is a discolored titanium weld. Discolored titanium or aluminum welds that fail the requirements of QA102 are considered scrap and may not be reworked, sand blasted, polished or cut apart.

### The parts should be allowed to cool between successive welds on the same joint. Before rewelding the part, the surfaces to be welded may be cleaned to remove any contaminants.

## 

## Handling of Defective Welds

### All defective parts will be segregated from the good pieces by placing them in a separate black ESD box. TA01/QAM 8.7 will be followed for material disposition.

### If a TA081 is generated for discolored titanium or aluminum welds that fail the requirements of QA102, it must clearly identify the units as scrap.

## Reworking Defective Weld Joints

### Unless the router indicates that customer requirements forbid rework of the weld joints, or a discolored titanium or aluminum weld that fails the requirements of QA102 is found, the following reworks are acceptable:

### Parts should be allowed to cool prior to performing any rework.

### Cracked weld joints may be reworked by rewelding the joints up to 2 times/joint for titanium parts and 4 times/joint for all other materials.

### Welds with holes or cracks that cannot be fixed by rewelding may be cut apart and rewelded up to 4 times/joint.

### Raised covers may be reseated or cut off and replaced.

### Discolored welds on materials other than titanium or aluminum may be cleaned up by sand blasting or polishing.

### All reworked parts must be visually inspected by a qualified visual inspector and must conform to QA102.

# Process Checks/Verifications

## Power Meter Check

### The purpose of the power meter check is to monitor the state of the flash lamps/diodes and adjust for wear of these components or replace them. In addition to this, the check also detects dirty cover slides and damaged fiber optic cables.

### PCB has 2 types of laser welding machines: In one case, the machine automatically makes a power meter check every 4 hours. These machines then automatically adjust the laser output to compensate for any deterioration in laser output. The power meter check data may either be stored on the machine or on PCB’s network. If the data is not stored on PCB’s network, then the data must be backed up to the network once per month.

### The other type of machine requires a technician to make power meter checks. In this case the following procedure will be followed:

### The technician will perform at least two power meter verification checks per shift (at shift start up and after lunch) on the 600 µM fiber for all welders being used. If the 400 µM fiber is used, the technician will perform at least one power meter check per day. Reference the applicable (work site and machine) TA015 instructions for 400 µM power meter check frequency.

#### Press the “on/ready/off button once to turn the power meter on.

#### Press the button again and the display will say “Ready” and will show the meter temperature.

#### If the meter temperature is above 30 degrees C, cool down the meter by placing it in water or near the exhaust duct.

#### Hold the power meter centered under the cover glass, but not touching the cover glass. For the most accurate reading, the power meter should not be subjected to a direct strong airflow.

#### Run the power meter weld schedule/program.

#### About 10 seconds after exposure, an initial reading will appear on the display.

#### Wait about 20 more seconds for the final reading will be displayed and a beep will sound.

#### Record the reading on the TA015 check sheet.

### If between the normal maintenance schedules, the power meter reading is trending toward the lower tolerance, the Technician will first check the condition of the cover slide. If the cover slide is dirty it will be replaced and a new measurement is performed. These results are documented on the TA015 form. If the power meter is still towards the lower spec, the technician will change the flash lamps.

### When power meter wattage readings are outside of the tolerance range listed on TA015, and / or a noticeable difference in weld pattern is observed: The technician may adjust the laser per Section VII.E to ensure proper welds. Adjustment will be noted on a TA015 form.

### If at any time, any welder has a power meter reading that is out of tolerance, documented on TA015, the welder that is out of tolerance will be shut down until serviced and will not be allowed to operate until the power meter reading is within tolerance. At the discretion of manufacturing engineering, parts produced since the last acceptable power meter reading may be contained and a TA081 may be initiated.

### Power meter checks will be done by using a fixed set of parameters for pulse rate (hz), pulse width (ms), pulse height (%) and test duration for each laser. Because there is variation in the quality of flash lamps, the following procedure will be followed if a new set of flash lamps are installed:

#### The pulse height setting from the last power meter program will be reduced by 10% and gradually increased to achieve the target power for that laser and fiber combination.

#### The flash lamps will be allowed to burn in for four hours.

#### A new power meter reading will be done with the pulse height raised back up until the pulse height achieves the target power for that laser and fiber combination. That pulse height will be saved into the power meter program and used for all subsequent power meter checks for this set of flash lamps.

## Connector Weld Strength Verification

### Verify Titanium connector welds (1 out of every 10; minimum of 1 piece per job; if a failure occurs the lot must be tested 100%) for strength by performing a pull test as follows:

### Hold the transducer (e.g. using vice) making sure not to damage transducer components.

### Screw applicable connector onto fixture threads (10-32, 5-44, or M3 [metric]).

### Screw the hook (supplied with tester) onto the Chatillon Tester.

### Place hook around the fixture.

### Use the Chatillon Tester to apply a transverse load to connector (verify 10-32 connectors to 25#, 5-44 and M3 connectors to 15#).

### If possible, repair failed welds. Reference Section 0 and XI.D.

## Class B Welds

### Class B welds with weld penetration specifications on the drawings will have a production sampling plan designed to make sure that these requirements are met. The welding manufacturing engineer is responsible to make sure that this process is developed and implemented. Typically, an extra set of the parts being welded will be added to the product BOM. Instructions/steps for the sampling will be added to the product Router. The sample parts should be welded in the same setup as the rest of the production job and the welding operation should not be moved on and completed until confirmation that the sample meets the weld penetration specification.

## Monthly Weld Penetration Checks

### Welds from every machinewill be checked/verified via a weld penetration measurement on a monthly basis.

#### Weld penetration measurements are usable in terms of comparison with experimentally derived, historically accepted, and properly documented values and parameters (material, part, welder, welder settings, etc.). A monthly sample is cross sectioned and measured for each machine to verify penetration.

#### Weld samples will be prepared per EN1041 and analyzed per TA1243.

##### Identify (etch, tag, etc) the sample with the welding date and welder used.

##### If samples do not meet ranges listed on TA036 or the PM, notify welding manufacturing engineer to determine disposition and action taken as recorded on TA036.

#### NY Facility - Results are documented on Weld Penetration Test Data Sheet TA036.

#### NC Facility - Weld penetration test results will be recorded in the PM Database.

##### Each machine will have an entry.

##### The part numbers, machine parameters and depth will be reordered in the database.

##### Signing off the PM sheet will indicate the parts meet the specification.

### Weld penetration testing is always available and is used as much or as little as deemed appropriate by the weld room Supervisor, Engineering staff, and/or the Quality department. The weld room Supervisor, or designee, performs the test.

## Glove Box Confirmation Check

### The glovebox’s oxygen and moisture sensors will be calibrated on a yearly basis. If there are any concerns about the measured values of the oxygen or moisture, a glove box confirmation check can be done. The method used to confirm measured values is the Electric Light bulb Test.

### The “Electric Light Bulb Test”

#### Obtain an incandescent non-Halogen 25w light bulb and confirm the light bulb works by installing in a light socket and turning on.

#### Turn the light off, allow time to cool and carefully remove the bulb from light socket.

#### File or flame torch a hole through the glass of the bulb (being careful not to break the filament).

#### The bulb is then installed into a socket, located inside the glove box, and turned on.

#### If the filament burns out within 6 hours at the time of the test (same shift/day), the oxygen and moisture content is higher than 10 ppm, this is out of tolerance.

#### The Calibration System Leader should be contacted and QC050 should be filled out.

#### At that time, appropriate corrective action and any supporting documentation is recorded and filed with the QC050 record.

#### **NC Facility** - This test will be done every 6 months and recorded in the PM database.

# Continuous Improvement

### **Reference QAM 10**

## Daily Quality Review

### The welding inspector enters all welding rejects into the non-conforming database. These items are reviewed on a daily basis at the morning visual board meeting. Significant issues are addressed, including returns from the customer, and documented on the visual board task tracker.

## Issuance of Quality Alerts and MDRs

### Prior to welding, if a part is found to have defects (contamination, damage, etc) in or near the weld joint, this part will be reviewed with the welding manufacturing engineer. At the manufacturing engineer’s discretion, pictures of this defect may be taken and a quality alert may be issued to the assembly area. In cases that the quality alert is ineffective at reducing the defects, a MDR will be written.

## Continuous Improvement Meeting

### A welding continuous improvement meeting will be conducted regularly. Open tasks on the continuous improvement plan will be tracked and reviewed, including large continuous improvement tasks or items needing management help or buy-in.

## Resource Allocation

### When the welding department is running at greater than a 98.5% FTTQ, management may decide not to prioritize continuous improvement activities in welding in favor of other areas with worse FTTQ.

# Technician Qualification

### **Reference TA25 for the following qualification programs.**

## Weld Operator Qualification

### New welding technicians will be trained to this procedure and other customer specific welding procedures. The manufacturing supervisor is responsible for the training or assigning another qualified person to be trainer. On the job training will include the items identified in the Laser Welder Technician Qualification Record (TA140) for each laser machine used. To validate that the training is successful, the trainer will sign off that the items have been trained successfully. Once completed, the training record will be signed off by the manufacturing supervisor and welding engineer.

### It is the responsibility of the manufacturing supervisor to make sure PE04 for eye test examination is completed prior to the training record being signed off and qualification completed.

### Specific certification is not required for other weld conditions, such as different base metal forms, base metal groups, weld type/positions, and thickness. The job training and actual parts used for the sample test welds developed by PCB are adequate for operator qualification. PCB does not qualify based on test specimens.

### Once a welder is qualified on a specific machine, they are qualified to weld all production products on that specific machine.

### Existing weld operators will be deemed qualified if they have performed their job for 200 hours in the last calendar year. This will be documented by the Manufacturing Supervisor.

### A weld operator can become unqualified to weld on a specific machine or on all production equipment/product. If an operator’s quality of work begins to deteriorate, it is the responsibility of the manufacturing supervisor to consult with the welding engineer to determine if the weld operator has their qualified status removed and the subsequent course of action.

## Visual Weld Inspector Qualification

### New welding inspectors will be trained to this procedure and other customer specific welding procedures. The manufacturing supervisor is responsible for the training or assigning another qualified person to be trainer. On the job training will include the items identified in the Laser Welder Inspector Qualification Record (TA141). Once completed, the qualification record will be signed off by the manufacturing supervisor and welding engineer.

### It is the responsibility of the manufacturing supervisor to make sure PE04 for eye test examination is completed prior to the training record being signed off and qualification completed.

### Existing visual weld inspectors will be deemed qualified if they have performed their job for 40 hours in the last calendar year. This will be documented by the manufacturing supervisor.

### A weld visual inspector can become unqualified to visually inspect welded product. If an operator’s quality of work begins to deteriorate, it is the responsibility of the manufacturing supervisor to consult with the welding engineer to determine if the weld inspector has their qualified status removed and the subsequent course of action.

# Miscellaneous Topics

## Argon Shield Gas

### Argon Shield gas will be used to provide a protective atmosphere during welding. This will be provided either through off-axis, coaxial shield gas application or in a glovebox. The nozzle and diffuser that are used for off-axis, coaxial application are documented on drawing #55677 and #55678. Argon shield gas must meet or exceed the specifications called out on drawing #46264 for cryogenic dewars and drawing #62468 for bulk supply. Instructions on handling and changing argon dewars is contained in TA1256.

## Sanding of Triax Cubes

### The X-axis of the triax cubes will be sanded flat. Titanium cubes will be sanded with 240 grit sand paper and aluminum cubes will be sanded with 180 grit sandpaper. Sanding should be minimized and be just enough to achieve a flat surface.

## Maintenance

### All monitoring devices related to welding and inspection equipment and tools are controlled, calibrated and maintained per QAM 7.1.5.

### The Welding Site portion of the PCB Preventive Maintenance (PM) database specifies, describes, schedules, and tracks all welder preventative maintenance requirements. Reference QA1075.

### In NY, if a machine fails to operate as expected, an Express Maintenance Request will be submitted.

### After replacing or adjusting anything used to produce or transmit the laser beam, a visual inspection of a welded sample and a power meter must be done prior to restarting production.

### After replacing anything that is responsible for movement of the work piece or movement of the laser head, a visual inspection of a welded sample must be done prior to restarting production.

### The manufacturing engineer shall be notified of significant equipment reworks for evaluation if other testing is required prior to restarting production.

## Production Weld Joint Clearances

### Recommended production weld joint clearances are called out per EN1087.

### There may be many reasons to deviate from this guideline (i.e. capability of machined components, fitting together of components, etc). Regardless, the drawing tolerances will always specify the maximum weld joint clearance.

## Heat Treatment / Stress Relief

### PCB does not stress relieve welds or perform any heat treatment after welding.

## Back-up Materials

### Backup materials are not required because the laser beam is absorbed completely by the base materials.

## Filler Metal

### No filler metal will be used in laser welding at PCB Piezotronics.

## Run-on / Run-off Tabs

### PCB does not use run-on/ run-off tabs.

## Witness Lines/ Features

### PCB does not use witness lines or features in our laser welding.

## Test Specimens

### PCB does not use test specimens.

## Multi-pass and Subsequent Pass Welds

### PCB does not design or utilize multi-pass and subsequent pass welds.

## GTA Tack Welding

### PCB does not have a process for GTA tack welding.

## Bend Tests

### PCB does not perform bend tests on sample or production parts.

## Maskants

### PCB does not use maskants of any kind for the welding process.