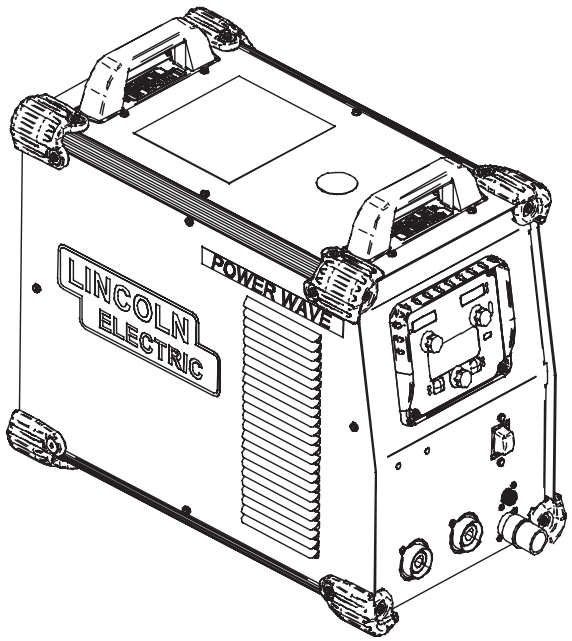
POWER WAVE® VERIFICATION AND CALIBRATION PROCEDURES

NOTE: This manual will cover most of the troubleshooting and repair procedures for the code numbers listed. Some variances may exist when troubleshooting/repairing later code numbers.

SERVICE MANUAL

K4171-1 Power Wave Calibration Kit



Need Help? Call 1.888.935.3877
to talk to a Service Representative

Hours of Operation:
8:00 AM to 6:00 PM (ET) Mon. thru Fri.

After hours?
Use "Ask the Experts" at lincolnelectric.com
A Lincoln Service Representative will contact you no later than the following business day.

For Service outside the USA:
Email: globalservice@lincolnelectric.com

SVM251 | Issue Date 14-Sep

THE LINCOLN ELECTRIC COMPANY
22801 St. Clair Avenue • Cleveland, OH • 44117-1199 • U.S.A.
Phone: +1.216.481.8100 • www.lincolnelectric.com

SAFETY DEPENDS ON YOU

Service and repair should be performed by only Lincoln Electric Factory Trained Personnel. Unauthorized repairs performed on this equipment may result in danger to the technician and machine operator and will invalidate your factory warranty. For your safety and to avoid Electrical Shock, please observe all safety notes and precautions detailed throughout this manual.

⚠ WARNING

This statement appears where the information must be followed exactly to avoid serious personal injury or loss of life.

⚠ CAUTION

This statement appears where the information must be followed to avoid minor personal injury or damage to this equipment.

KEEP YOUR HEAD OUT OF THE FUMES.

DON'T get too close to the arc. Use corrective lenses if necessary to stay a reasonable distance away from the arc.

READ and obey the Material Safety Data Sheet (MSDS) and the warning label that appears on all containers of welding materials.

USE ENOUGH VENTILATION or exhaust at the arc, or both, to keep the fumes and gases from your breathing zone and the general area.

IN A LARGE ROOM OR OUTDOORS, natural ventilation may be adequate if you keep your head out of the fumes (See below).

USE NATURAL DRAFTS or fans to keep the fumes away from your face.

If you develop unusual symptoms, see your supervisor. Perhaps the welding atmosphere and ventilation system should be checked.

WEAR CORRECT EYE, EAR & BODY PROTECTION

PROTECT your eyes and face with welding helmet properly fitted and with proper grade of filter plate (See ANSI Z49.1).

PROTECT your body from welding spatter and arc flash with protective clothing including woolen clothing, flame-proof apron and gloves, leather leggings, and high boots.

PROTECT others from splatter, flash, and glare with protective screens or barriers.

IN SOME AREAS, protection from noise may be appropriate.

BE SURE protective equipment is in good condition.

Also, wear safety glasses in work area AT ALL TIMES.

SPECIAL SITUATIONS

DO NOT WELD OR CUT containers or materials which previously had been in contact with hazardous substances unless they are properly cleaned. This is extremely dangerous.

DO NOT WELD OR CUT painted or plated parts unless special precautions with ventilation have been taken. They can release highly toxic fumes or gases.

Additional precautionary measures

PROTECT compressed gas cylinders from excessive heat, mechanical shocks, and arcs; fasten cylinders so they cannot fall.

BE SURE cylinders are never grounded or part of an electrical circuit.

REMOVE all potential fire hazards from welding area.

ALWAYS HAVE FIRE FIGHTING EQUIPMENT READY FOR IMMEDIATE USE AND KNOW HOW TO USE IT.

SECTION A: WARNINGS

CALIFORNIA PROPOSITION 65 WARNINGS

Diesel Engines

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

Gasoline Engines

The engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

ARC WELDING CAN BE HAZARDOUS. PROTECT YOURSELF AND OTHERS FROM POSSIBLE SERIOUS INJURY OR DEATH. KEEP CHILDREN AWAY. PACEMAKER WEARERS SHOULD CONSULT WITH THEIR DOCTOR BEFORE OPERATING.

Read and understand the following safety highlights. For additional safety information, it is strongly recommended that you purchase a copy of "Safety in Welding & Cutting - ANSI Standard Z49.1" from the American Welding Society, P.O. Box 351040, Miami, Florida 33135 or CSA Standard W117.2-1974. A Free copy of "Arc Welding Safety" booklet E205 is available from the Lincoln Electric Company, 22801 St. Clair Avenue, Cleveland, Ohio 44117-1199.

BE SURE THAT ALL INSTALLATION, OPERATION, MAINTENANCE AND REPAIR PROCEDURES ARE PERFORMED ONLY BY QUALIFIED INDIVIDUALS.

FOR ENGINE POWERED EQUIPMENT.

1.a. Turn the engine off before troubleshooting and maintenance work unless the maintenance work requires it to be running.

1.b. Operate engines in open, well-ventilated areas or vent the engine exhaust fumes outdoors.

1.c. Do not add the fuel near an open flame welding arc or when the engine is running. Stop the engine and allow it to cool before refueling to prevent spilled fuel from vaporizing on contact with hot engine parts and igniting. Do not spill fuel when filling tank. If fuel is spilled, wipe it up and do not start engine until fumes have been eliminated.

1.d. Keep all equipment safety guards, covers and devices in position and in good repair.Keep hands, hair, clothing and tools away from V-belts, gears, fans and all other moving parts when starting, operating or repairing equipment.

1.e. In some cases it may be necessary to remove safety guards to perform required maintenance. Remove guards only when necessary and replace them when the maintenance requiring their removal is complete. Always use the greatest care when working near moving parts.

1.f. Do not put your hands near the engine fan. Do not attempt to override the governor or idler by pushing on the throttle control rods while the engine is running.

1.g. To prevent accidentally starting gasoline engines while turning the engine or welding generator during maintenance work, disconnect the spark plug wires, distributor cap or magneto wire as appropriate.

1.h. To avoid scalding, do not remove the radiator pressure cap when the engine is hot.

ELECTRIC AND MAGNETIC FIELDS MAY BE DANGEROUS

2.a. Electric current flowing through any conductor causes localized Electric and Magnetic Fields (EMF). Welding current creates EMF fields around welding cables and welding machines

2.b. EMF fields may interfere with some pacemakers, and welders having a pacemaker should consult their physician before welding.

2.c. Exposure to EMF fields in welding may have other health effects which are now not known.

2.d. All welders should use the following procedures in order to minimize exposure to EMF fields from the welding circuit:

- 2.d.1. Route the electrode and work cables together - Secure them with tape when possible.
- 2.d.2. Never coil the electrode lead around your body.
- 2.d.3. Do not place your body between the electrode and work cables. If the electrode cable is on your right side, the work cable should also be on your right side.
- 2.d.4. Connect the work cable to the workpiece as close as possible to the area being welded.
- 2.d.5. Do not work next to welding power source.

ELECTRIC SHOCK CAN KILL.

3.a. The electrode and work (or ground) circuits are electrically "hot" when the welder is on. Do not touch these "hot" parts with your bare skin or wet clothing. Wear dry, hole-free gloves to insulate hands.

3.b. Insulate yourself from work and ground using dry insulation. Make certain the insulation is large enough to cover your full area of physical contact with work and ground.

In addition to the normal safety precautions, if welding must be performed under electrically hazardous conditions (in damp locations or while wearing wet clothing; on metal structures such as floors, gratings or scaffolds; when in cramped positions such as sitting, kneeling or lying, if there is a high risk of unavoidable or accidental contact with the workpiece or ground) use the following equipment:

- Semiautomatic DC Constant Voltage (Wire) Welder.
- DC Manual (Stick) Welder.
- AC Welder with Reduced Voltage Control.

3.c. In semiautomatic or automatic wire welding, the electrode, electrode reel, welding head, nozzle or semiautomatic welding gun are also electrically "hot".

3.d. Always be sure the work cable makes a good electrical connection with the metal being welded. The connection should be as close as possible to the area being welded.

3.e. Ground the work or metal to be welded to a good electrical (earth) ground.

3.f. Maintain the electrode holder, work clamp, welding cable and welding machine in good, safe operating condition. Replace damaged insulation.

3.g. Never dip the electrode in water for cooling.

3.h. Never simultaneously touch electrically "hot" parts of electrode holders connected to two welders because voltage between the two can be the total of the open circuit voltage of both welders.

3.i. When working above floor level, use a safety belt to protect yourself from a fall should you get a shock.

3.j. Also see Items 6.c. and 8.

ARC RAYS CAN BURN.

4.a. Use a shield with the proper filter and cover plates to protect your eyes from sparks and the rays of the arc when welding or observing open arc welding. Headshield and filter lens should conform to ANSI Z87. I standards.

4.b. Use suitable clothing made from durable flame-resistant material to protect your skin and that of your helpers from the arc rays.

4.c. Protect other nearby personnel with suitable, non-flammable screening and/or warn them not to watch the arc nor expose themselves to the arc rays or to hot spatter or metal.

FUMES AND GASES CAN BE DANGEROUS.

5.a. Welding may produce fumes and gases hazardous to health. Avoid breathing these fumes and gases. When welding, keep your head out of the fume. Use enough ventilation and/or exhaust at the arc to keep fumes and gases away from the breathing zone. **When welding with electrodes which require special ventilation such as stainless or hard facing (see instructions on container or MSDS) or on lead or cadmium plated steel and other metals or coatings which produce highly toxic fumes, keep exposure as low as possible and within applicable OSHA PEL and ACGIH TLV limits using local exhaust or mechanical ventilation. In confined spaces or in some circumstances, outdoors, a respirator may be required. Additional precautions are also required when welding on galvanized steel.**

5. b. The operation of welding fume control equipment is affected by various factors including proper use and positioning of the equipment, maintenance of the equipment and the specific welding procedure and application involved. Worker exposure level should be checked upon installation and periodically thereafter to be certain it is within applicable OSHA PEL and ACGIH TLV limits.

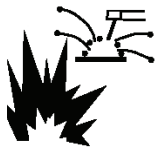
5.c. Do not weld in locations near chlorinated hydrocarbon vapors coming from degreasing, cleaning or spraying operations. The heat and rays of the arc can react with solvent vapors to form phosgene, a highly toxic gas, and other irritating products.

5.d. Shielding gases used for arc welding can displace air and cause injury or death. Always use enough ventilation, especially in confined areas, to insure breathing air is safe.

5.e. Read and understand the manufacturer's instructions for this equipment and the consumables to be used, including the material safety data sheet (MSDS) and follow your employer's safety practices. MSDS forms are available from your welding distributor or from the manufacturer.

5.f. Also see item 1.b.

WELDING AND CUTTING SPARKS CAN CAUSE FIRE OR EXPLOSION.



6.a. Remove fire hazards from the welding area. If this is not possible, cover them to prevent the welding sparks from starting a fire. Remember that welding sparks and hot materials from welding can easily go through small cracks and openings to adjacent areas. Avoid welding near hydraulic lines. Have a fire extinguisher readily available.

6.b. Where compressed gases are to be used at the job site, special precautions should be used to prevent hazardous situations. Refer to "Safety in Welding and Cutting" (ANSI Standard Z49.1) and the operating information for the equipment being used.

6.c. When not welding, make certain no part of the electrode circuit is touching the work or ground. Accidental contact can cause overheating and create a fire hazard.

6.d. Do not heat, cut or weld tanks, drums or containers until the proper steps have been taken to insure that such procedures will not cause flammable or toxic vapors from substances inside. They can cause an explosion even though they have been "cleaned". For information, purchase "Recommended Safe Practices for the Preparation for Welding and Cutting of Containers and Piping That Have Held Hazardous Substances", AWS F4.1 from the American Welding Society (see address above).

6.e. Vent hollow castings or containers before heating, cutting or welding. They may explode.

6.f. Sparks and spatter are thrown from the welding arc. Wear oil free protective garments such as leather gloves, heavy shirt, cuffless trousers, high shoes and a cap over your hair. Wear ear plugs when welding out of position or in confined places. Always wear safety glasses with side shields when in a welding area.

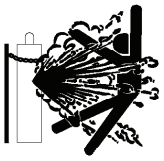
6.g. Connect the work cable to the work as close to the welding area as practical. Work cables connected to the building framework or other locations away from the welding area increase the possibility of the welding current passing through lifting chains, crane cables or other alternate circuits. This can create fire hazards or overheat lifting chains or cables until they fail.

6.h. Also see item 1.c.

6.I. Read and follow NFPA 51B " Standard for Fire Prevention During Welding, Cutting and Other Hot Work", available from NFPA, 1 Batterymarch Park, PO box 9101, Quincy, Ma 022690-9101.

6.j. Do not use a welding power source for pipe thawing.

CYLINDER MAY EXPLODE IF DAMAGED.



7.a. Use only compressed gas cylinders containing the correct shielding gas for the process used and properly operating regulators designed for the gas and pressure used. All hoses, fittings, etc. should be suitable for the application and maintained in good condition.

7.b. Always keep cylinders in an upright position securely chained to an undercarriage or fixed support.

7.c. Cylinders should be located:

- Away from areas where they may be struck or subjected to physical damage.
- A safe distance from arc welding or cutting operations and any other source of heat, sparks, or flame.

7.d. Never allow the electrode, electrode holder or any other electrically "hot" parts to touch a cylinder.

7.e. Keep your head and face away from the cylinder valve outlet when opening the cylinder valve.

7.f. Valve protection caps should always be in place and hand tight except when the cylinder is in use or connected for use.

7.g. Read and follow the instructions on compressed gas cylinders, associated equipment, and CGA publication P-I, "Precautions for Safe Handling of Compressed Gases in Cylinders," available from the Compressed Gas Association 1235 Jefferson Davis Highway, Arlington, VA 22202.

FOR ELECTRICALLY POWERED EQUIPMENT.

8.a. Turn off input power using the disconnect switch at the fuse box before working on the equipment.

8.b. Install equipment in accordance with the U.S. National Electrical Code, all local codes and the manufacturer's recommendations.

8.c. Ground the equipment in accordance with the U.S. National Electrical Code and the manufacturer's recommendations.

Refer to http://www.lincolnelectric.com/safety for additional safety information.

Welding Safety Interactive Web Guide for mobile devices

ELECTROMAGNETIC COMPATABILITY (EMC)

CONFORMANCE

Products displaying the CE mark are in conformity with European Community Council Directive of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility (89/336/EEC). It was manufactured in conformity with a national standard that implements a harmonized standard: EN 60974-10 Electromagnetic Compatibility (EMC) Product Standard for Arc Welding Equipment. It is for use with other Lincoln Electric equipment. It is designed for industrial and professional use.

INTRODUCTION

All electrical equipment generates small amounts of electromagnetic emission. Electrical emission may be transmitted through power lines or radiated through space, similar to a radio transmitter. When emissions are received by other equipment, electrical interference may result. Electrical emissions may affect many kinds of electrical equipment; other nearby welding equipment, radio and TV reception, numerical controlled machines, telephone systems, computers, etc. Be aware that interference may result and extra precautions may be required when a welding power source is used in a domestic establishment.

INSTALLATION AND USE

The user is responsible for installing and using the welding equipment according to the manufacturer's instructions. If electromagnetic disturbances are detected then it shall be the responsibility of the user of the welding equipment to resolve the situation with the technical assistance of the manufacturer. In some cases this remedial action may be as simple as earthing (grounding) the welding circuit, see Note. In other cases it could involve construction of an electromagnetic screen enclosing the power source and the work complete with associated input filters. In all cases electromagnetic disturbances must be reduced to the point where they are no longer troublesome.

Note: The welding circuit may or may not be earthed for safety reasons according to national codes. Changing the earthing arrangements should only be authorized by a person who is competent to access whether the changes will increase the risk of injury, e.g., by allowing parallel welding current return paths which may damage the earth circuits of other equipment.

ASSESSMENT OF AREA

Before installing welding equipment the user shall make an assessment of potential electromagnetic problems in the surrounding area. The following shall be taken into account:

a. other supply cables, control cables, signaling and telephone cables; above, below and adjacent to the welding equipment;

b. radio and television transmitters and receivers;

c. computer and other control equipment;

d. safety critical equipment, e.g., guarding of industrial equipment;

e. the health of the people around, e.g., the use of pacemakers and hearing aids;

f. equipment used for calibration or measurement

g. the immunity of other equipment in the environment. The user shall ensure that other equipment being used in the environment is compatible. This may require additional protection measures;

h. the time of day that welding or other activities are to be carried out.

The size of the surrounding area to be considered will depend on the structure of the building and other activities that are taking place. The surrounding area may extend beyond the boundaries of the premises.

METHODS OF REDUCING EMISSIONS

Mains Supply

Welding equipment should be connected to the mains supply according to the manufacturer's recommendations. If interference occurs, it may be necessary to take additional precautions such as filtering of the mains supply. Consideration should be given to shielding the supply cable of permanently installed welding equipment, in metallic conduit or equivalent. Shielding should be electrically continuous throughout its length. The shielding should be connected to the welding power source so that good electrical contact is maintained between the conduit and the welding power source enclosure.

Maintenance of the Welding Equipment

The welding equipment should be routinely maintained according to the manufacturer's recommendations. All access and service doors and covers should be closed and properly fastened when the welding equipment is in operation. The welding equipment should not be modified in any way except for those changes and adjustments covered in the manufacturers instructions. In particular, the spark gaps of arc striking and stabilizing devices should be adjusted and maintained according to the manufacturer's recommendations.

Welding Cables

The welding cables should be kept as short as possible and should be positioned close together, running at or close to floor level.

Equipotential Bonding

Bonding of all metallic components in the welding installation and adjacent to it should be considered. However, metallic components bonded to the work piece will increase the risk that the operator could receive a shock by touching these metallic components and the electrode at the same time. The operator should be insulated from all such bonded metallic components.

Earthing of the Workpiece

Where the workpiece is not bonded to earth for electrical safety, not connected to earth because of its size and position, e.g., ships hull or building steelwork, a connection bonding the workpiece to earth may reduce emissions in some, but not all instances. Care should be taken to prevent the earthing of the work piece increasing the risk of injury to users, or damage to other electrical equipment. Where necessary, the connection of the workpiece to earth should be made by a direct connection to the work piece, but in some countries where direct connection is not permitted, the bonding should be achieved by suitable capacitance, selected according to national regulations.

Screening and Shielding

Selective screening and shielding of other cables and equipment in the surrounding area may alleviate problems of interference. Screening of the entire welding installation may be considered for special applications.

[1] Portions of the preceding text are contained in EN 60974-10: "Electromagnetic Compatibility (EMC) product standard for arc welding equipment."

As a rule of thumb, for many mild steel electrode, if the air is visibly clear and you are comfortable, then the ventilation is generally adequate for your work. The most accurate way to determine if the worker exposure does not exceed the applicable exposure limit for compounds in the fumes and gases is to have an industrial hygienist take and analyze a sample of the air you are breathing. This is particularly important if you are welding with stainless, hardfacing or Special Ventilation products. All Lincoln MSDS have a maximum fume guideline number. If exposure to total fume is kept below that number, exposure to all fume from the electrode (not coatings or plating on the work) will be below the TLV.

There are steps that you can take to identify hazardous substances in your welding environment. Read the product label and material safety data sheet for the electrode posted in the work place or in the electrode or flux container to see what fumes can be reasonably expected from use of the product and to determine if special ventilation is needed. Secondly, know what the base metal is and determine if there is any paint, plating, or coating that could expose you to toxic fumes and/or gases. Remove it from the metal being welded, if possible. If you start to feel uncomfortable, dizzy or nauseous, there is a possibility that you are being overexposed to fumes and gases, or suffering from oxygen deficiency. Stop welding and get some fresh air immediately. Notify your supervisor and co-workers so the situation can be corrected and other workers can avoid the hazard. Be sure you are following these safe practices, the consumable labeling and MSDS to improve the ventilation in your area. Do not continue welding until the situation has been corrected.

NOTE: The MSDS for all Lincoln consumables is available on Lincoln's web-site: www.lincolnelectric.com

Before we turn to the methods available to control welding fume exposure, you should understand a few basic terms:

Natural Ventilation is the movement of air through the workplace caused by natural forces. Outside, this is usually the wind. Inside, this may be the flow of air through open windows and doors.

Mechanical Ventilation is the movement of air through the workplace caused by an electrical device such as a portable fan or permanently mounted fan in the ceiling or wall.

Source Extraction (Local Exhaust) is a mechanical device used to capture welding fume at or near the arc and filter contaminants out of the air.

The ventilation or exhaust needed for your application depends upon many factors such as:

- Workspace volume
- Workspace configuration
- Number of welders
- Welding process and current
- Consumables used (mild steel, hardfacing, stainless, etc.)
- Allowable levels (TLV, PEL, etc.)
- Material welded (including paint or plating)
- Natural airflow

Your work area has adequate ventilation when there is enough ventilation and/or exhaust to control worker exposure to hazardous materials in the welding fumes and gases so the applicable limits for those materials is not exceeded. See chart of TLV and PEL for Typical Electrode Ingredients, the OSHA PEL (Permissible Exposure Limit), and the recommended guideline, the ACGIH TLV (Threshold Limit Value), for many compounds found in welding fume.

Ventilation

There are many methods which can be selected by the user to provide adequate ventilation for the specific application. The following section provides general information which may be helpful in evaluating what type of ventilation equipment may be suitable for your application. When ventilation equipment is installed, you should confirm worker exposure is controlled within applicable OSHA PEL and/or ACGIH TLV. According to OSHA regulations, when welding and cutting (mild steels), natural ventilation is usually considered sufficient to meet requirements, provided that:

1. The room or welding area contains at least 10,000 cubic feet (about 22' x 22' x 22') for each welder.
2. The ceiling height is not less than 16 feet.
3. Cross ventilation is not blocked by partitions, equipment, or other structural barriers.
4. Welding is not done in a conned space.

Spaces that do not meet these requirements should be equipped with mechanical ventilating equipment that exhausts at least 2000 CFM of air for each welder, except where local exhaust hoods or booths, or air-line respirators are used.

Important Safety Note:

When welding with electrodes which require special ventilation such as stainless or hardfacing (see instructions on container or MSDS) or on lead or cadmium plated steel and other metals or coatings which produce hazardous fumes, keep exposure as low as possible and below exposure limit values (PEL and TLV) for materials in the fume using local exhaust or mechanical ventilation. In conned spaces or in some circumstances, for example outdoors, a respirator may be required if exposure cannot be controlled to the PEL or TLV. (See MSDS and chart of TLV and PEL for Typical Electrode Ingredients.) Additional precautions are also required when welding on galvanized steel.

BIBLIOGRAPHY AND SUGGESTED READING

ANSI Z87.1, Practice for Occupational and Educational Eye and Face Protection, American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

Arc Welding and Your Health: A Handbook of Health Information for Welding. Published by The American Industrial Hygiene Association, 2700 Prosperity Avenue, Suite 250, Fairfax, VA 22031-4319.

NFPA Standard 51B, Cutting and Welding Processes, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9146, Quincy, MA 02269-9959.

OSHA General Industry Standard 29 CFR 1910 Subpart Q. OSHA Hazard Communication Standard 29 CFR 1910.1200. Available from the Occupational Safety and Health Administration at http://www.osha.org or contact your local OSHA office.

The following publications are published by The American Welding Society, P.O. Box 351040, Miami, Florida 33135. AWS publications may be purchased from the American Welding society at http://www.aws.org or by contacting the AWS at 800-443-9353.

ANSI, Standard Z49.1, Safety in Welding, Cutting and Allied Processes. Z49.1 is now available for download at no charge at http://www.lincolnelectric.com/community/safety/ or at the AWS website http://www.aws.org.

AWS F1.1, Method for Sampling Airborne Particulates Generated by Welding and Allied Processes.

AWS F1.2, Laboratory Method for Measuring Fume Generation Rates and Total Fume Emission of Welding and Allied Processes.

AWS F1.3, Evaluating Contaminants in the Welding Environment: A Strategic Sampling Guide.

AWS F1.5, Methods for Sampling and Analyzing Gases from Welding and Allied Processes.

AWS F3.2, Ventilation Guide for Welding Fume Control.

AWS F4.1, Recommended Safe Practices for the Preparation for Welding and Cutting of Containers and Piping That Have Held Hazardous Substances.

AWS SHF, Safety and Health Facts Sheets. Available free of charge from the AWS website at http://www.aws.org.

LISTED BELOW ARE SOME TYPICAL INGREDIENTS IN WELDING ELECTRODES AND THEIR TLV (ACGIH) GUIDELINES AND PEL (OSHA) EXPOSURE LIMITS

INGREDIENTS	CAS No.	TLV mg/m3	PEL mg/m3
Aluminum and/or aluminum alloys (as Al)*****	7429-90-5	10	15
Aluminum oxide and/or Bauxite*****	1344-28-1	10	5**
Barium compounds (as Ba)*****	513-77-9	****	****
Chromium and chromium alloys or compounds (as Cr)*****	7440-47-3	0.5(b)	.005(b)
Fluorides (as F)	7789-75-5	2.5	2.5
Iron	7439-89-6	10*	10*
Limestone and/or calcium carbonate	1317-65-3	10	15
Lithium compounds (as Li)	554-13-2	10*	10*
Magnesite	1309-48-4	10	15
Magnesium and/or magnesium alloys and compounds (as Mg)	7439-95-4	10*	10*
Manganese and/or manganese alloys and compounds (as Mn)*****	7439-96-5	0.2	5.0(c)
Mineral silicates	1332-58-7	5**	5**
Molybdenum alloys (as Mo)	7439-98-7	10	10
Nickel*****	7440-02-0	1.5	1
Silicates and other binders	1344-09-8	10*	10*
Silicon and/or silicon alloys and compounds (as Si)	7440-21-3	10*	10*
Strontium compounds (as Sr)	1633-05-2	10*	10*
Zirconium alloys and compounds (as Zr)	12004-83-0	5	5

Supplemental Information:

(*) Not listed. Nuisance value maximum is 10 milligrams per cubic meter. PEL value for iron oxide is 10 milligrams per cubic meter. TLV value for iron oxide is 5 milligrams per cubic meter.

(**) As respirable dust.

(*****) Subject to the reporting requirements of Sections 311, 312, and 313 of the Emergency Planning and Community Right-to-Know Act of 1986 and of 40CFR 370 and 372.

(b) The PEL for chromium (VI) is .005 milligrams per cubic meter as an 8 hour time weighted average. The TLV for water-soluble chromium (VI) is 0.05 milligrams per cubic meter. The TLV for insoluble chromium (VI) is 0.01 milligrams per cubic meter.

c) Values are for manganese fume. STEL (Short Term Exposure Limit) is 3.0 milligrams per cubic meter. OSHA PEL is a ceiling value.

(****) There is no listed value for insoluble barium compounds. The TLV for soluble barium compounds is 0.5 mg/m3.

TLV and PEL values are as of April 2006. Always check Material Safety Data Sheet (MSDS) with product or on the Lincoln Electric website at http://www.lincolnelectric.com

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POWER WAVE VERIFICATION AND CALIBRATION PROCEDURES

⚠ WARNING

Service and repair should be performed only by Lincoln Electric factory trained personnel. Unauthorized repairs performed on this equipment may result in danger to the technician or machine operator and will invalidate your factory warranty. For your safety and to avoid electrical shock, please observe all safety notes and precautions detailed throughout this manual.

If for any reason you do not understand the test procedures or are unable to perform the test/repairs safely, contact the Lincoln Electric Service Department for electrical troubleshooting assistance before you proceed. Call 1-888-935-3877.

TEST DESCRIPTION

This procedure will aid the technician in the verification and calibration of a Power Wave power source. The verification procedure should be performed first. If the verification procedure indicates a significant error in the accuracy of either the voltage or current feedback, the calibration procedure is recommended.

MATERIALS NEEDED

PC with Power Wave Manager loaded. (This utility can be downloaded from http://www.powerwavesoftware.com).
Serial or Ethernet Cable
Load Bank (K1530-1)
Certified Calibrated Current Probe or Current Meter and (Shunt)
Certified Calibrated Voltage Meter (Fluke 355)
10K Low Pass Filter (M25303-1) (M25303-1 included in K4171-1)
Power Wave (Equipped with optional User Interface or connected to an Arclink compatible feeder)
Weld Cable (Minimum 2/0, >10ft. in length)

POWER WAVE VERIFICATION AND CALIBRATION PROCEDURES *(continued)*

POWER WAVE CALIBRATION TIPS AND RECOMMENDATIONS

CALIBRATION GUIDELINES

The Power Wave output voltage and current are calibrated at the factory. Generally speaking, the machine calibration will not need adjustment. However, if the weld performance changes or the ***Verification Procedure*** reveals a problem, perform the ***Power Wave Calibration Procedure***.

The calibration procedure itself requires the use of a grid (Resistive Load Bank) and certified actual meters for voltage and current. The accuracy of the calibration will be directly affected by the accuracy of the measuring equipment you use. See ***Measurement Accuracy Of Voltage Calibration Equipment*** and ***Special Considerations For The Measurement Of AC Waveforms***. **For best results always use a DC test mode for calibration**, even if the machine is capable of producing AC. This provides the most stable output and induces the least amount of noise related error in the calibration test equipment.

NOTE: It is possible to verify AC and/or pulsed output waveforms with the proper measurement equipment following the guidelines discussed later in this procedure.

GENERAL CALIBRATION TIPS

Always take a SnapShot prior to adjusting the calibration. This records the present calibration settings as well as other detailed information for future reference.

NOTE: The calibration settings of some newer vintage machines are saved during the final test sequence at the factory. For these machines, the factory defaults for voltage and current calibration can be restored with the Power Wave Manager software utility.

Always use the recommended test modes for calibration. Output modes designed for welding contain special thresholds and logic to deal with real world events (shorts circuits, arc outages and everything in between). This special logic can affect their "performance" into a static load.

Always use a high quality calibrated meter.

Always question meter accuracy or set up when a large deviation is present. Calibration seldom drifts substantially. If the machine performance has not changed, suspect interference, signal attenuation or improper location / application of the metering equipment.

NEVER use the same meter to simultaneously measure current and voltage. Internal meter "crosstalk" can affect the accuracy of some meter readings.

TIPS FOR CURRENT CALIBRATION

Select the proper equipment. Current can be measured using either an inductive style (clamp on) meter or a traditional shunt and millivolt meter. Using the latter may require a conversion factor unless the millivolt meter is specifically scaled to the shunt.

Locate the meter a minimum of 5ft (1.5m) from the power source. Theoretically, the current flow is the same anywhere in a closed loop path, but it is good practice keep the meter away from the power source to reduce the likelihood of electrical interference.

Avoid very short cables. While output cable inductance has little effect on DC current calibration or measurement accuracy of the Power Wave, it does have a smoothing effect on the output current waveform. Reduced output ripple may improve the susceptibility and therefore accuracy of external metering equipment. Even with minimal cable lengths (10ft), the output current in a DC test mode is extremely stable and relatively easy to measure.

TIPS FOR VOLTAGE CALIBRATION

Be certain the voltmeter used for calibration is monitoring at the same location as the Power Wave (i.e. studs, remotely at the load, etc.). Although test modes typically default to the output studs, it is good practice to use the Power Wave Manager utility to calibrate since it displays the actual sense lead location in the calibration window. See ***Measurement Accuracy Of Voltage Calibration Equipment*** for additional information.

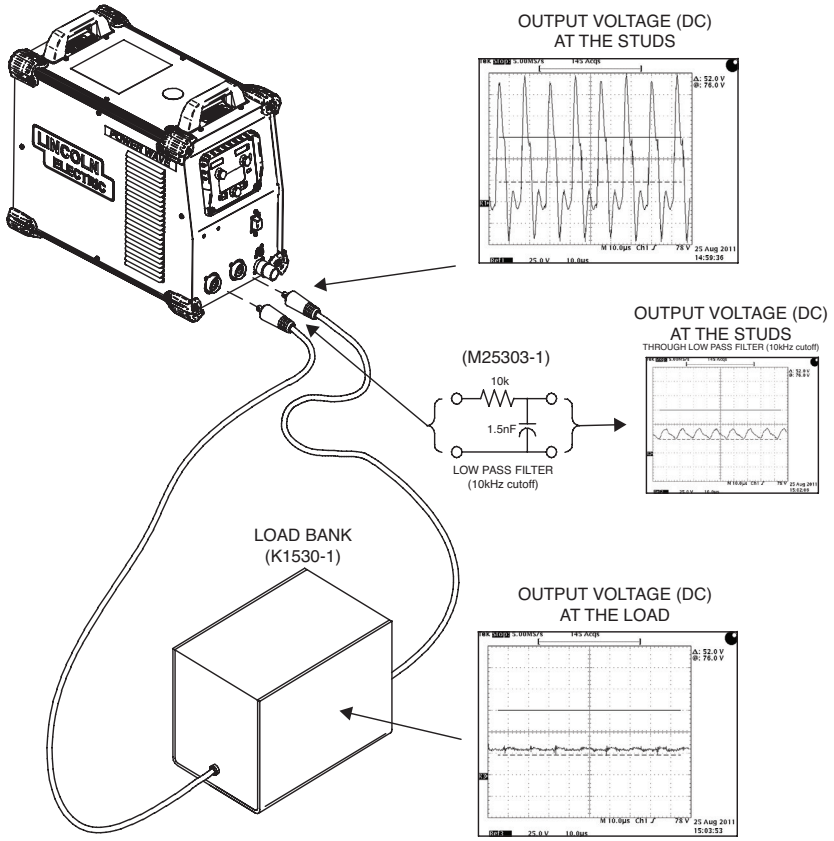
Calibrate at the output studs whenever possible. Each Power Wave is factory tested to verify the maximum difference between any combination of voltage monitoring locations (studs, remote sense leads, etc) is less than 0.5V. By design, calibration of the output stud voltage ensures the accuracy of all sensing locations.

Special filtering may be required for accurate measurement of the stud voltage. The output voltage waveform at the studs can be vastly different than the voltage waveform at the load. This is primarily due to the inductive reactance of the weld cables. See ***Measurement Accuracy Of Voltage Calibration Equipment*** for additional information.

Never place the meter on or near the power source or weld cables. Any reasonable separation distance will reduce the likelihood of electrical interference.

POWER WAVE VERIFICATION AND CALIBRATION PROCEDURES *(continued)*

Figure F.1 – Waveform voltage readings



MEASUREMENT ACCURACY OF VOLTAGE CALIBRATION EQUIPMENT

The noise susceptibility of traditional digital and analog meters has long been a concern when measuring the output voltage of Power Wave equipment, especially when measuring directly at the output studs. The primary reason is the power source provides very little output inductance at conventional load operating points. Although this performance characteristic is desirable for high speed waveform manipulation, it can result in significant voltage transients at the output studs of the machine. Transients appear on the studs at each output cycle (40-120 kHz), but do not appear at the load because of its resistive nature. See Figure F.1. This is why the closer the meter is to the load the less susceptible it appears to "inverter noise."

⚠ CAUTION

It is critical that the voltmeter used for calibration or procedure verification is monitoring the same location as the Power Wave (i.e. studs, remotely at the load, etc.).

Typically voltage calibration is performed directly at the output studs. Since most voltmeters are not equipped to process high speed transients, the standard calibration procedure for DC output recommends a "heavily filtered" high quality meter. In practice, a simple low pass filter with a 10 kHz cutoff frequency is sufficient to accurately measure DC voltage without significantly attenuating reference measurements of AC or pulse output waveforms as seen Figure F.1.

POWER WAVE VERIFICATION AND CALIBRATION PROCEDURES *(continued)*

SPECIAL CONSIDERATIONS FOR THE MEASUREMENT OF AC WAVEFORMS

Some Power Wave equipment has the ability to produce AC output waveforms. Unlike conventional power sources, these machines can produce a nearly infinite combination of complex waveshapes including sine, triangular and square waves. Each with varying amounts of wave balance and offset. This flexibility places a high demand on the requirements of external monitoring equipment.

The following recommendations should be considered when measuring the AC output of a Power Wave power source for calibration or procedure verification purposes.

Select a true RMS meter with a high crest factor. Crest factor is the peak to RMS ratio of the output waveform. As such, the crest factor rating is also a measure of how well a meter can process transient waveforms. A minimum crest factor of 6 has traditionally been recommended, however, with proper transient filtering (f_{cutoff} = 10kHz) (Low Pass Filter M25303-1) favorable results have been achieved with meters having a crest factor as low as 2. See ***Measurement Accuracy of Voltage Calibration Equipment*** for additional information about filtering.

Always select the "AC + DC" option when measuring AC waveforms. Offset, imbalanced or irregular waveforms contain a DC component for both current and voltage. To accurately measure them, the meter must have an AC + DC option. For best results, use this setting to measure all AC outputs (both current and voltage) for balanced, unbalanced or offset waveforms.

NOTE: It is possible to verify balanced AC outputs with no offset using a True RMS meter without the AC + DC function, provided the crest factor and filtering requirements are met.

Avoid heavily filtered meters. Low pass filters with cutoff frequencies less than 9kHz can attenuate the output waveform and result in inaccurate measurements.

Always use a DC test mode for calibration. This provides the most stable output and induces the least amount of noise related error in the calibration test equipment. For AC machines calibrate using DC+ and then verify DC- and AC outputs.

Always calibrate machines individually. If machines are part of a parallel group, disconnect them from each other prior to calibration.

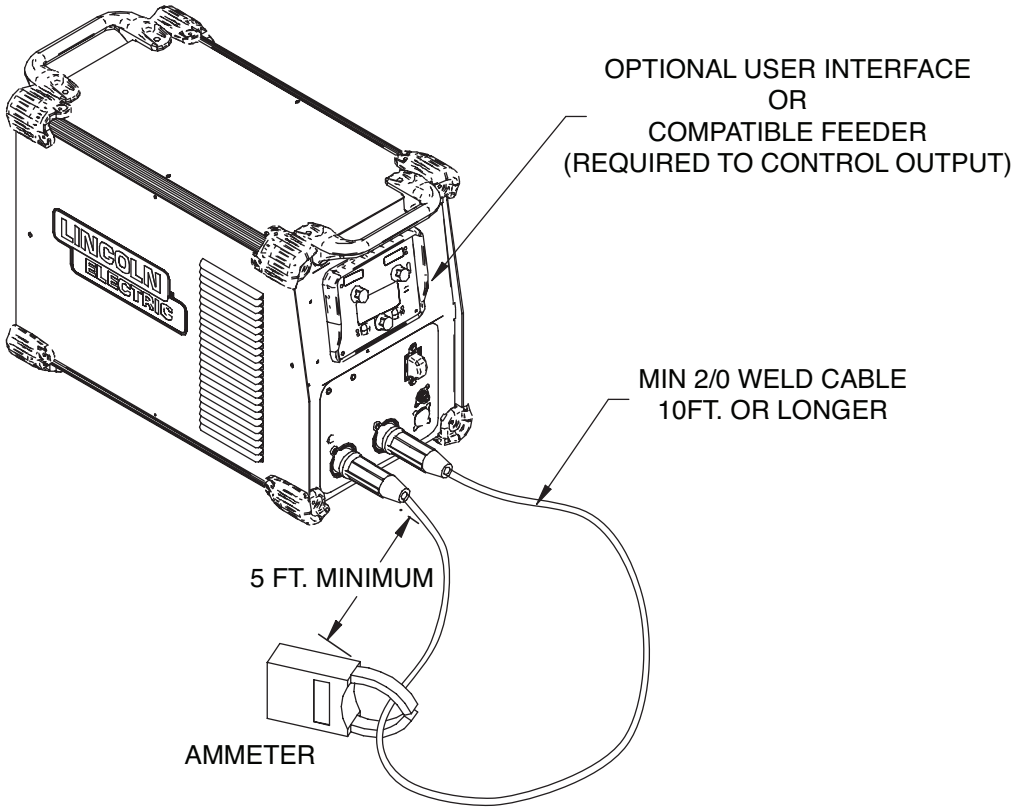
Always question meter accuracy when a large deviation is present. Calibration seldom drifts substantially. If the machine performance has not changed, suspect interference or signal attenuation in the metering equipment.

⚠ CAUTION

It is critical that the voltmeter used for calibration or procedure verification is monitoring the same location as the Power Wave (i.e. studs, remotely at the load, etc.). Failure to do so can result in a significant voltage measurement error. When in doubt, use the calibration window in the Power Wave Manager utility to monitor the actual sense lead location.

POWER WAVE VERIFICATION AND CALIBRATION PROCEDURES *(continued)*

Figure F.2 – Current verification setup



VERIFICATION PROCEDURE

TEST DESCRIPTION

The verification procedure is intended to verify the general accuracy of the voltage and current feedback of Power Wave equipment.

NOTE: If the verification procedure indicates a significant error in the accuracy of either the voltage or current feedback, calibration is recommended.

MATERIAL NEEDED

Power Wave (Equipped with optional user interface or connected to an ArcLink compatible feeder)
Weld Cable (Minimum 2/0, >10Ft. in length)
Ammeter (Inductive or shunt style)
Voltmeter (M25303-1 Low Pass Filter Recommended)

SETUP

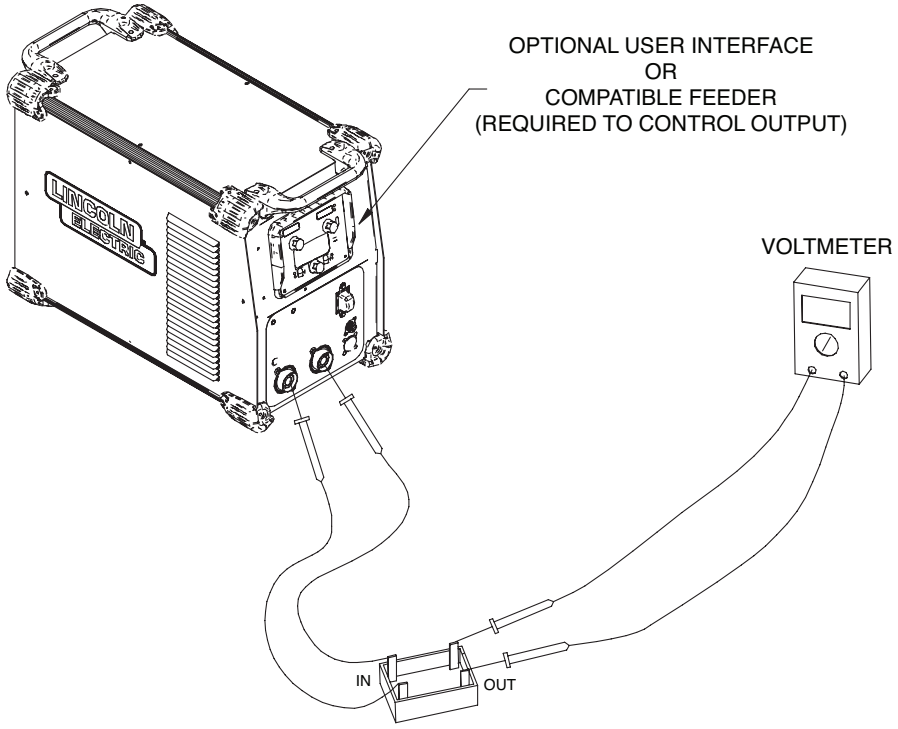
1. Prepare the equipment for testing by connecting the optional user interface/compatible feeder to the Power Wave power source.
2. Attach the weld cable across the output studs (short circuit) with an ammeter configured to measure the output current through the cable. For accurate testing the ammeter must be positioned at least five feet from the output studs. See Figure F.2.
3. Carefully apply the correct input power to the power source. Wait for the system to initialize and then access the test modes via the user interface.

CURRENT VERIFICATION (SHORT CIRCUIT)

1. Using the optional user interface or compatible feeder, select **Mode 200** (constant current). See Figure F.2.
2. Using the optional user interface or compatible feeder, set the output level to about 1/2 of the rated output of the power source or a minimum of 200 amps. See Figure F.2.
3. Turn the output ON and compare the current displayed on the user interface to the value displayed on the ammeter. See Figure F.2.
4. Turn the output OFF. See Figure F.2.
5. Remove the weld cable connected across the output studs (open the short circuit path). See Figure F.2.

POWER WAVE VERIFICATION AND CALIBRATION PROCEDURES *(continued)*

Figure F.3 – Voltage verification setup



VOLTAGE VERIFICATION (OPEN CIRCUIT)

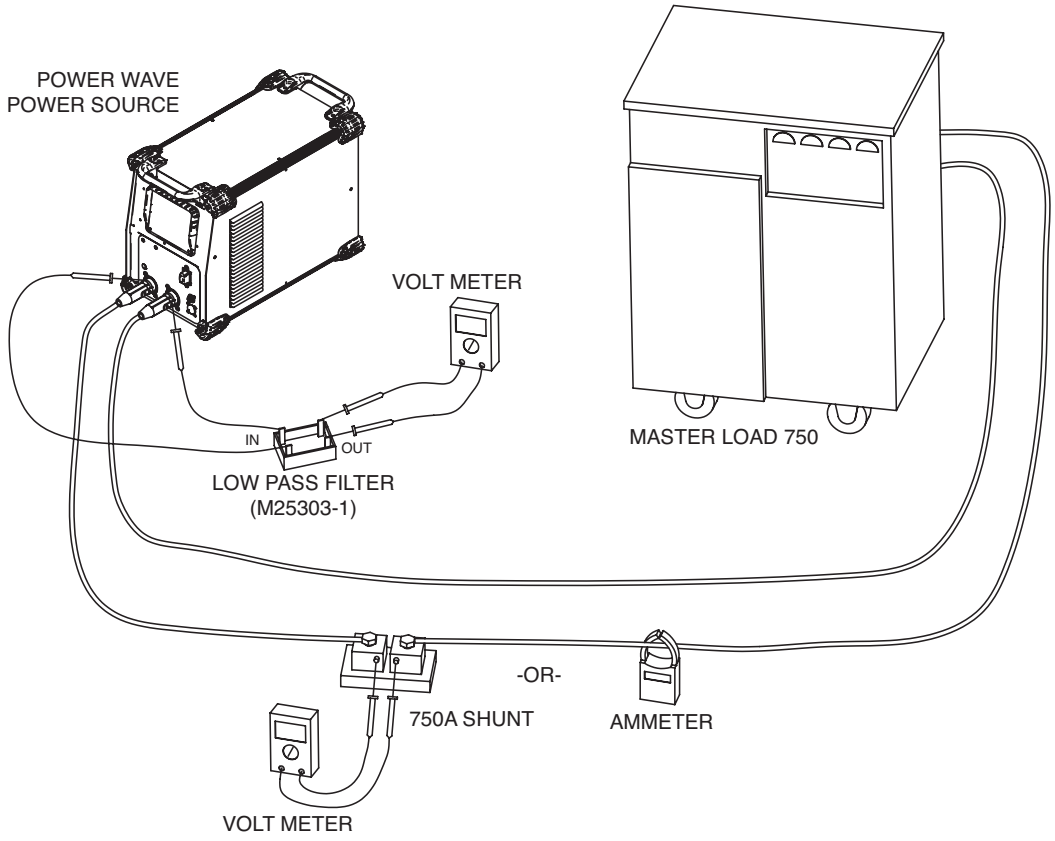
1. Attach the voltmeter across the output studs.

NOTE: High speed voltage transients associated with the Power Wave output can adversely affect the accuracy of some metering equipment. The M25303-1 low pass filter is strongly recommended between the meter and the power source to reduce this effect.

2. Using the optional user interface or compatible feeder, select **Mode 212** (OCV test). See Figure F.3.
3. Using the optional user interface or compatible feeder, set the output level to 30V. See Figure F.3.
4. Turn the output ON and compare the voltage displayed on the feeder/UI to the value displayed on the external voltmeter. See Figure F.3.
5. Turn the output OFF. See Figure F.3.

POWER WAVE VERIFICATION AND CALIBRATION PROCEDURES *(continued)*

Figure F.4 – Calibration setup



CALIBRATION PROCEDURE

⚠ CAUTION

Please read and be familiar with the contents of the *Power Wave Calibration Tips And Recommendations*, *Measurement Accuracy Of Voltage Calibration Equipment* and *Special Considerations For The Measurement Of AC Waveforms* sections before attempting this calibration procedure.

1. Remove input power to the power wave power source.
2. Carefully connect power wave power source output cables to the load bank. See Figure F.4.
3. Connect the 10K low pass filter (M25303-1) input across electrode + and work – studs then connect calibrated voltmeter across the low pass filter output. See Figure F.4.
4. Connect calibrated shunt with a millivolt meter in line with electrode cable or use clamp-on ammeter to measure current. See Figure F.4.
5. Using a serial or ethernet cable, connect the PC to the power source.
6. Carefully apply input power to the power wave power source to be calibrated.
7. Using the PC, launch Power Wave Manager utility and establish connection with the machine. See ***Figure F.5***.
8. Using the Power Wave Manager utility, navigate to the 'Calibration' page and select the DC+ output mode. See ***Figure F.6***.
9. Using the Power Wave Manager utility, set the 'Amperage Setpoint' from ***Table F.1*** for the power source being calibrated. See ***Figure F.7***.
10. Using the Power Wave Manager utility, select 'Turn Output ON. See ***Figure F.7***.
11. Adjust load bank switches until external voltage meter agrees with the voltage list in Table F.1 for the power source being calibrated.

NOTE: Voltage sense locations should be "Studs".

12. Using the Power Wave Manager utility, adjust the '+' and '–' 'Amperage Adjust' icons as necessary, until external current measurement matches the 'Output amperage' displayed on the 'Calibration' page. See ***Figure F.8***.
13. Using the Power Wave Manager utility, adjust the '+' and '–' 'Voltage Adjust' icons as necessary, until the 'Output Voltage' displayed on the 'Calibration' page matches the external voltage meter. See ***Figure F.9***.
14. Repeat steps 12 and 13 until both voltage and current measurements agree with values displayed in Power Wave Manager for 'Output amperage' and 'Output voltage'. See ***Figure F.10***.

POWER WAVE VERIFICATION AND CALIBRATION PROCEDURES *(continued)*

Table F.1 – Power Wave calibration recommended nominal loads

MACHINE	CURRENT	VOLTAGE
POWER WAVE C300	200A	24V
POWER WAVE S350 / R350	200A	32V
POWER WAVE 355M	300A	32V
POWER WAVE I400	300A	32V
POWER WAVE 455M	300A	32V
POWER WAVE S500 / R600	300A	32V
POWER WAVE 655R	300A	32V
POWER WAVE S700	600A	32V
POWER WAVE AC/DC 1000	600A	32V
POWER WAVE AC/DC 1000SD	600A	32V

NOTE: The recommended loads are based on the factory calibration procedure, however, due to the precise full range control of the Power Wave's output, deviation from this value will not create significant error.

15. Using the Power Wave Manager utility, select 'Turn output OFF'. See ***Figure F.11***.
16. Turn output ON and verify that calibration settings are correct. If voltage and current measurements do not agree with the values displayed in Powerwave Manager, repeat the calibration procedure. If the problem persists contact the Lincoln Electric Service Department at 1-877-837-8145.
17. Remove input power to the power wave power source.
18. Disconnect the serial or ethernet cables from the machine.
19. Disconnect the output cables from load bank and power source.

POWER WAVE VERIFICATION AND CALIBRATION PROCEDURES *(continued)*

Figure F.5 – Connection page

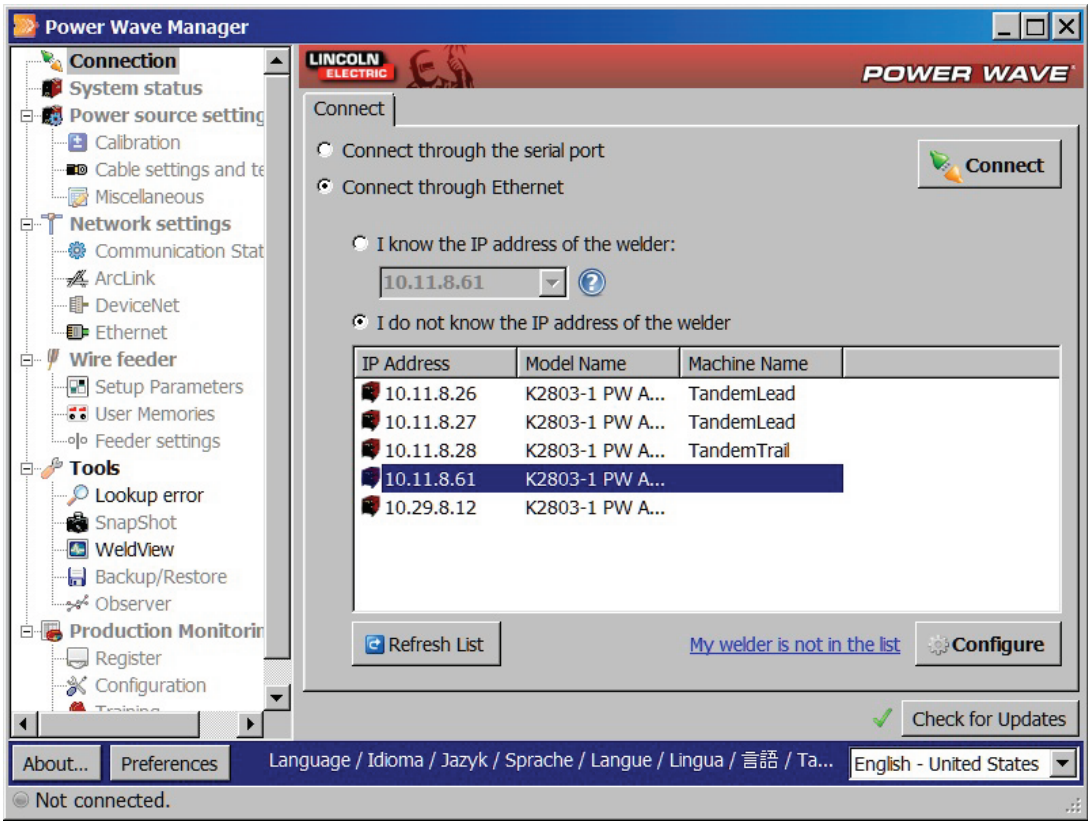
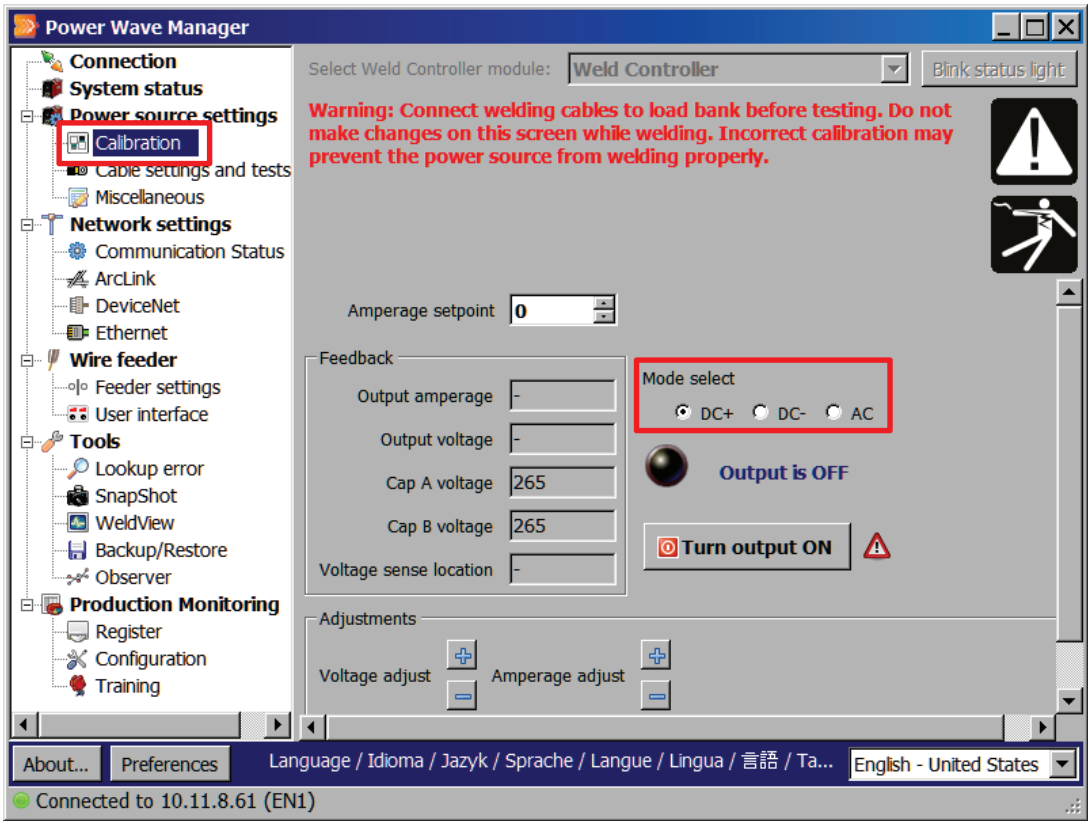


Figure F.6 – DC output mode selection



POWER WAVE VERIFICATION AND CALIBRATION PROCEDURES *(continued)*

Figure F.7 – Amperage setpoint

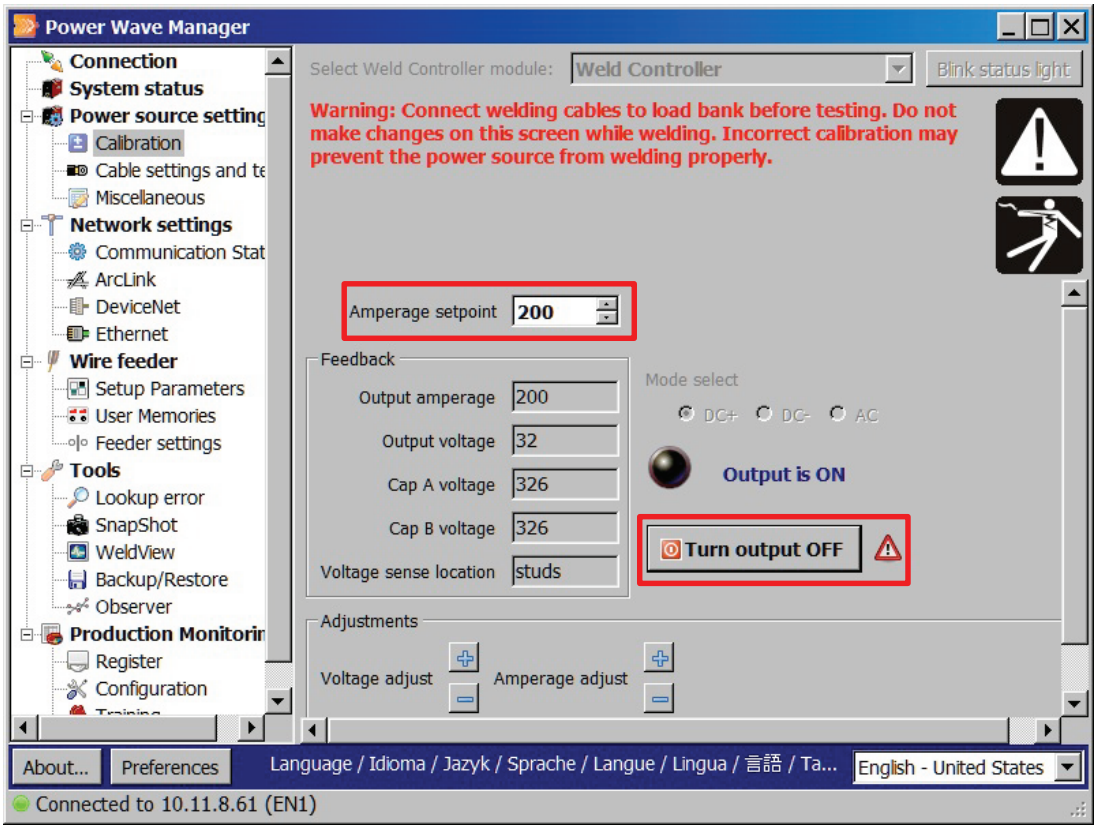
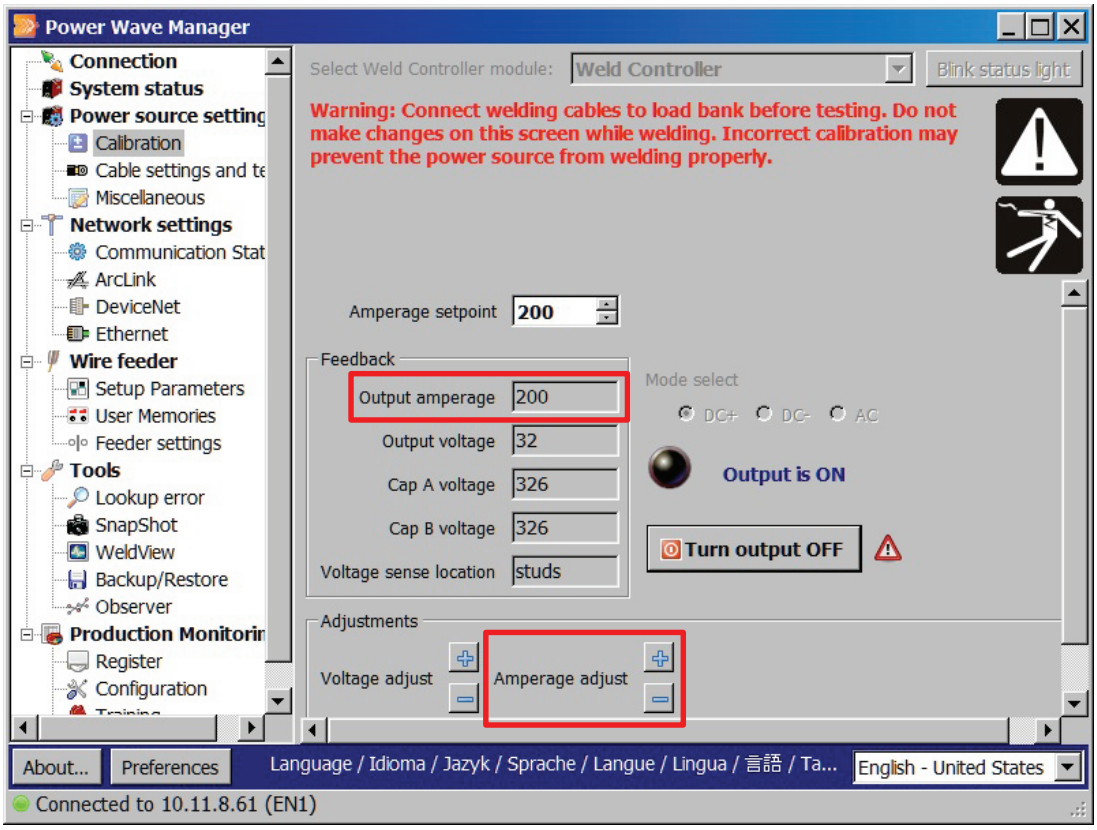


Figure F.8 – Amperage adjust



POWER WAVE VERIFICATION AND CALIBRATION PROCEDURES *(continued)*

Figure F.9 – Voltage adjust

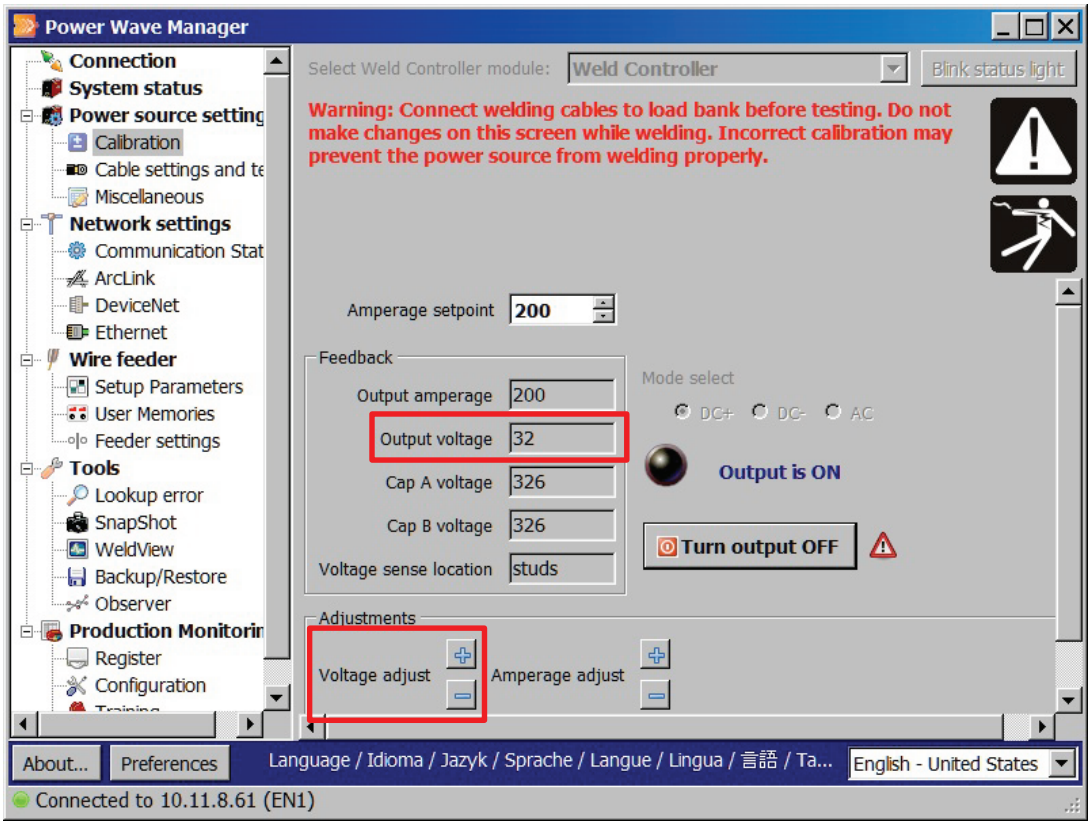
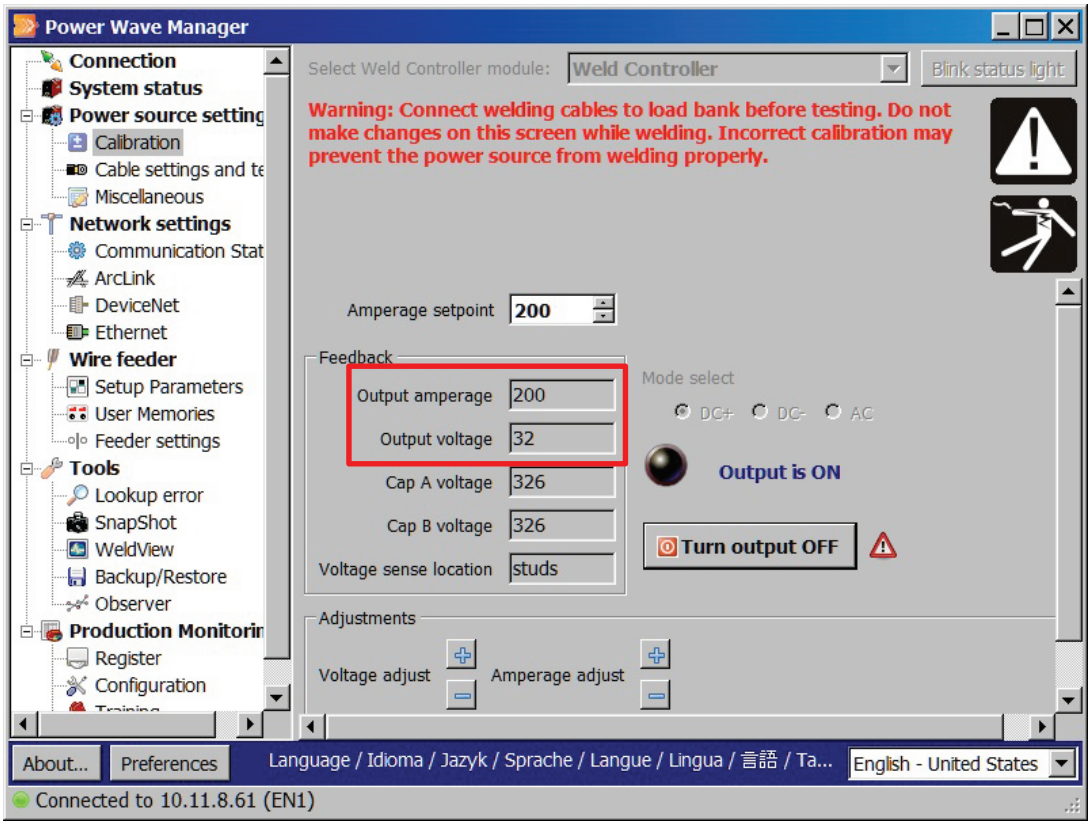


Figure F.10 – Output amperage and voltage



POWER WAVE VERIFICATION AND CALIBRATION PROCEDURES *(continued)*

Figure F.11 – Turn output OFF