TL-508B
WELD HEAD

USER MANUAL

990-111 REV H

Revision Record

Revision	EO	Date	Basis of Revision
A	18455	08/00	Production release.
B	19146	01/02	Added Unitek Peco logo.
C	21776	05/08	Updated to Miyachi Unitek Logo and added CAUTION information.
D	42860	10/13	Updated to Miyachi America name and logo.
E	43207	03/15	Updated technical information. Updated to Amada Miyachi America name and logo.
F	43866	08/15	Updated to Amada Miyachi America format.
G	45853	04/20	Update Company Name (Amada Weld Tech) + Model Names
H	47210	01/24	Update Manual Title

FOREWORD

Thank you for purchasing an Amada Weld Tech TL-508B Weld Head.

Upon receipt of your equipment, please thoroughly inspect it for shipping damage before its installation. Should there be any damage, please immediately contact the shipping company to file a claim, and notify us at:

Amada Weld Tech Inc.
1820 South Myrtle Ave.
Monrovia, California 91016
Phone: **(626) 303-5676**
FAX: **(626) 358-8048**
E-mail: **info@amadaweldtech.com**

The purpose of this manual is to supply operating, maintenance and service personnel with the information needed to properly and safely operate and service the Amada Weld Tech TL-508B Weld Head.

We have made every effort to ensure that the information in this manual is accurate and adequate. Should questions arise, or if you have suggestions for improvement of this manual, please contact us at the above location/numbers. The contents of this manual are subject to change without notice.

Amada Weld Tech is not responsible for any loss or injury due to improper use of this product.

This Manual covers the following Weld Head models:

Original Model Name		Current Model Name	Basic Part Number
508A	→	TL-508B	2-190-xx

SAFETY NOTES

This instruction manual describes how to operate, maintain and service the TL-508B Weld Head, and provides instructions relating to its SAFE use. A separate manual provides similar information for the Power Supply used in conjunction with the Weld Head. Procedures described in these manuals MUST be performed, as detailed, by QUALIFIED and TRAINED personnel.

For SAFETY, and to effectively take advantage of the full capabilities of the Weld Head and Power Supply, please read these instruction manuals before attempting to use them.

Procedures other than those described in these manuals or not performed as prescribed in them, may expose personnel to electrical, burn, or crushing hazards.

After reading these manuals, retain them for future reference when any questions arise regarding the proper and SAFE operation of the Weld Head and Power Supply.

Please note the following conventions used in this manual:

WARNING: Comments marked this way warn the reader of actions which, if not followed, might result in immediate death or serious injury.

CAUTION: Comments marked this way warn the reader of actions which, if not followed, might result in either damage to the equipment, or injury to the individual if subject to long-term exposure to the indicated hazard.

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GENERAL TERMS AND CONDITIONS FOR THE SALE OF GOODS

1. Applicability.

(a) These terms and conditions of sale (these "**Terms**") are the only terms which govern the sale of the goods ("**Goods**") by Amada Weld Tech Inc. ("**Seller**") to the buyer identified in the Sales Quotation and/or Acknowledgment (as each defined below) to which these Terms are attached or incorporated by reference ("**Buyer**"). Notwithstanding anything herein to the contrary, if a written contract signed by authorized representatives of both parties is in existence covering the sale of the Goods covered hereby, the terms and conditions of said contract shall prevail to the extent they are inconsistent with these Terms.

(b) The accompanying quotation of sale (the "**Sales Quotation**") provided to Buyer, and/or sales order acknowledgement ("**Acknowledgement**") and these Terms (collectively, this "**Agreement**") comprise the entire agreement between the parties, and supersede all prior or contemporaneous understandings, agreements, negotiations, representations and warranties, and communications, both written and oral. For clarification, after the Acknowledgement is received by Buyer, the order for Goods is binding and cannot be cancelled by Buyer for any reason and the full purchase price amount set forth in the Acknowledgement shall be due and payable by Buyer to Seller pursuant to the payment schedule set forth in the Acknowledgement unless otherwise agreed to in writing by Seller. All terms and conditions contained in any prior or contemporaneous oral or written communication which are different from, or in addition to, the terms and conditions in this Agreement are hereby rejected and shall not be binding on Seller, whether or not they would materially alter this Agreement. These Terms prevail over any of Buyer's terms and conditions of purchase regardless whether or when Buyer has submitted its purchase order or such terms. Fulfillment of Buyer's order does not constitute acceptance of any of Buyer's terms and conditions and does not serve to modify or amend these Terms. Notwithstanding anything herein to the contrary, all orders for Goods must be for a minimum purchase price of $100 or such orders will be rejected by Seller.

2. Delivery.

(a) The Goods will be delivered within a reasonable time after Seller provides Buyer the Acknowledgment, subject to availability of finished Goods. Seller will endeavor to meet delivery schedules requested by Buyer, but in no event shall Seller incur any liability, consequential or otherwise, for any delays or failure to deliver as a result of ceasing to manufacture any product or any Force Majeure Event. Delivery schedules set forth in the Acknowledgment are Seller's good faith estimate on the basis of current schedules. In no event shall Seller be liable for special or consequential damages resulting from failure to meet requested delivery schedules.

(b) Unless otherwise agreed in writing by the parties in the Acknowledgement, Seller shall deliver the Goods to Seller's plant in Monrovia, CA, USA (the "**Shipping Point**") using Seller's standard methods for packaging and shipping such Goods. Buyer shall take delivery of the Goods within three (3) days of Seller's written notice that the Goods have been delivered to the Shipping Point. Buyer shall be responsible for all loading costs (including freight and insurance costs) and provide equipment and labor reasonably suited for receipt of the Goods at the Shipping Point. Seller shall not be liable for any delays, loss or damage in transit.

(c) Seller may, in its sole discretion, without liability or penalty, make partial shipments of Goods to Buyer, if applicable. Each shipment will constitute a separate sale, and Buyer shall pay for the units shipped whether such shipment is in whole or partial fulfillment of Buyer's purchase order.

(d) If for any reason Buyer fails to accept delivery of any of the Goods on the date fixed pursuant to Seller's notice that the Goods have been delivered at the Shipping Point, or if Seller is unable to deliver the Goods at the Shipping Point on such date because Buyer has not provided appropriate instructions, documents, licenses or authorizations: (i) risk of loss to the Goods shall pass to Buyer; (ii) the Goods shall be deemed to have been delivered; and (iii) Seller, at its option, may store the Goods until Buyer picks them up, whereupon Buyer shall be liable for all related costs and expenses (including, without limitation, storage and insurance).

3. Non-delivery.

(a) The quantity of any installment of Goods as recorded by Seller on dispatch from Seller's place of business is conclusive evidence of the quantity received by Buyer on delivery unless Buyer can provide conclusive evidence proving the contrary.

(b) Seller shall not be liable for any non-delivery of Goods (even if caused by Seller's negligence) unless Buyer gives written notice to Seller of the non-delivery within three (3) days of the date when the Goods would in the ordinary course of events have been received.

(c) Any liability of Seller for non-delivery of the Goods shall be limited to (in Seller's sole discretion) replacing the Goods within a reasonable time or adjusting the invoice respecting such Goods to reflect the actual quantity delivered.

4. Shipping Terms. Unless indicated otherwise in the Acknowledgment, Delivery shall be made EXW (Incoterms 2010), Shipping Point, including without limitation, freight and insurance costs. If no delivery terms are specified on the Acknowledgement, the method of shipping will be in the sole discretion of Seller. Unless directed in writing otherwise by Buyer, full invoice value will be declared for all shipments.

5. Title and Risk of Loss. Title and risk of loss passes to Buyer upon delivery of the Goods at the Shipping Point. As collateral security for the payment of the purchase price of the Goods, Buyer hereby grants to Seller a lien on and security interest in and to all of the right, title and interest of Buyer in, to and under the Goods, wherever located, and whether now existing or hereafter arising or acquired from time to time, and in all accessions thereto and replacements or modifications thereof, as well as all proceeds (including insurance proceeds) of the foregoing. The security interest granted under this provision constitutes a purchase money security interest under the California Commercial Code.

6. Amendment and Modification. These Terms may only be amended or modified in a writing which specifically states that it amends these Terms and is signed by an authorized representative of each party.

7. Inspection and Rejection of Nonconforming Goods.

(a) Buyer shall inspect the Goods within two (2) days of receipt ("**Inspection Period**"). Buyer will be deemed to have accepted the Goods unless it notifies Seller in writing of any Nonconforming Goods during the Inspection Period and furnishes such written evidence or other documentation as required by Seller. "**Nonconforming Goods**" means only the following: (i) product shipped is different than identified in Buyer's Acknowledgement; or (ii) product's label or packaging incorrectly identifies its contents. Notwithstanding the foregoing, for shipped Goods that require field installation, the "re-verification" terms in the Acknowledgement shall apply and for custom installations, the inspection and verification shall take place at Buyer's site immediately after the installation is completed.

(b) Seller will only accept Nonconforming Goods that are returned under Seller's Return Material Authorization procedures then in effect ("**RMA**"). Buyer shall obtain a RMA number from Seller prior to returning any Nonconforming Goods and return the Nonconforming Goods prepaid and insured to Seller at 1820 South Myrtle Avenue, Monrovia, CA 91016 or to such other location as designated in writing by Seller for the examination to take place there. If Seller reasonably verifies Buyer's claim that the Goods are Nonconforming Goods and that the nonconformance did not developed by use from Buyer, Seller shall, in its sole discretion, (i) replace such Nonconforming Goods with conforming Goods, or (ii) credit or refund the Price for such Nonconforming Goods pursuant to the terms set forth herein. Notwithstanding the foregoing, the only remedy for Nonconforming Goods that are custom systems is repair (not refund or replacement). No returns for Nonconforming Goods are allowed after thirty (30) days from the original shipping date.

(c) Buyer acknowledges and agrees that the remedies set forth in Section 7(a) are Buyer's exclusive remedies for the delivery of Nonconforming Goods. Except as provided under Section 7(a) and Section 14, all sales of Goods to Buyer are made on a one-way basis and Buyer has no right to return Goods purchased under this Agreement to Seller.

8. Price.

(a) Buyer shall purchase the Goods from Seller at the prices (the "**Prices**") set forth in Seller's published catalogue literature in force as of the date of the Sales Quotation. However, the Prices shown in such catalogue literature or any other publication are subject to change without notice. Unless specifically stated to the contrary in the Sales Quotation, quoted Prices and discounts are firm for thirty (30) days from the date of the Sales Quotation. Unless otherwise stated, prices are quoted EXW (Incoterms 2010), Shipping Point. Unless otherwise stated in the Acknowledgement, if the Prices should be increased by Seller before delivery of the Goods to a carrier for shipment to Buyer, then these Terms shall be construed as if the increased prices were originally inserted herein, and Buyer shall be billed by Seller on the basis of such increased prices.

(b) All Prices are exclusive of all sales, use and excise taxes, and any other similar taxes, duties and charges of any kind imposed by any governmental authority on any amounts payable by Buyer. Buyer shall be responsible for all such charges, costs and taxes (present or future); provided, that, Buyer shall not be responsible for any taxes imposed on, or with respect to, Seller's income, revenues, gross receipts, personnel or real or personal property or other assets.

9. Payment Terms.

(a) Unless otherwise provided in the Acknowledgement, if Buyer has approved credit with Seller, Buyer shall pay all invoiced amounts due to Seller within thirty (30) days from the date of Seller's invoice. If Seller does not have Buyer's financial information and has not provided pre-approved credit terms for Buyer, the payment must be made in cash with order or C.O.D. in US dollars. If Buyer has approved credit terms, the payment may be made by cash with order, wire transfer of immediately available funds, or check in US dollars. Certain products require a down payment. Any payment terms other than set forth above will be identified in the Acknowledgement. Notwithstanding anything herein to the contrary, all prepaid deposits and down payments are non-refundable. If a deposit is not received when due, Seller reserves the right to postpone manufacturing of Goods until payment is received. Seller will not be responsible for shipment delays due to deposit payment delays.

(b) In Seller's sole discretion, Seller may access Buyer interest on all late payments at the lesser of the rate of 1.5% per month or the highest rate permissible under applicable law, calculated daily and compounded monthly. Buyer shall reimburse Seller for all costs incurred in collecting any late payments, including, without limitation, attorneys' fees. In addition to all other remedies available under these Terms or at law (which Seller does not waive by the exercise of any rights hereunder), Seller shall be entitled to suspend the delivery of any Goods if Buyer fails to pay any amounts when due hereunder and such failure continues for ten (10) days following written notice thereof.

(c) Buyer shall not withhold payment of any amounts due and payable by reason of any set-off of any claim or dispute with Seller, whether relating to Seller's breach, bankruptcy or otherwise.

10. Intellectual Property; Software License.

(a) To the extent that any Goods provided under this Agreement contains software, whether pre-installed, embedded, in read only memory, or found on any other media or other form ("**Software**"), such Software and accompanying documentation are licensed to Buyer, not sold and shall remain the sole and exclusive property of Seller or third party licensors of Seller. Seller grants Buyer a non-exclusive license to use the Software solely as provided in and in connection with the use of the Goods in which such Software is contained and in accordance with any applicable user documentation provided with such Goods and subject to the provisions of this Agreement. Certain of Seller's Goods may include third party software such as computer operating systems. Licenses to such third party software are subject to the terms and conditions of any applicable third party software license agreements. Unless identified in the Acknowledgement, no license is granted by Seller with respect to such third party software products that may be provided with the Goods (if any). Seller makes no warranties regarding any third party software that may accompany the Goods or otherwise and such software is explicitly included in the definition of Third Party Products below.

(b) Buyer shall not copy, modify, or disassemble, or permit others to copy, modify, or disassemble, the Software, nor may Buyer modify, adapt, translate, reverse assemble, decompile, or otherwise attempt to derive source code from the Software. Buyer shall not transfer possession of the Software except as part of, or with, the Goods, and each such transfer shall be subject to the restrictions contained herein. Buyer may not sublicense, rent, loan, assign or otherwise transfer the Software or documentation, and Buyer shall retain on all copies of the Software and documentation all copyright and other proprietary notices or legends appearing therein or thereon. Seller may terminate this license upon written notice for any violation of any of the terms of this license

or any material breach of any provision of this Agreement. Buyer shall immediately discontinue use of the Software upon any termination of this license or Agreement. This license shall terminate upon any termination of the Agreement.

(c) All patents, trademarks, copyrights or other intellectual property rights embodied in the Goods, including without limitation the Software, are owned by Seller and its licensors. Seller and its licensors retain all right, title and interest in such intellectual property rights. Except as expressly set forth herein, no license rights or ownership in or to any of the foregoing is granted or transferred hereunder, either directly or by implication. ALL RIGHTS RESERVED.

(d) If Buyer is the United States Government or any agency thereof, each of the components of the Software and user documentation are a "commercial item," and "computer software" as those terms are defined at 48 C.F.R. 2.101, consisting of "commercial computer software" and "commercial computer software documentation," as such terms are used in 48 C.F.R. 12.212. Consistent with 48 C.F.R. 12.212 and 48 C.F.R. 227.7202-1 through 227.7202-4, all United States government Buyers acquire only those rights in the Software and user documentation that are specified in this Agreement.

11. Installation and Other Services. Seller shall provide installation services ("**Installation Services**") to Buyer if set forth in the Acknowledgment. If Installation Services are provided for in the Acknowledgement, Buyer will prepare the location for the installation consistent with Buyer's written specifications and Buyer will install necessary system cable and assemble any necessary equipment or hardware not provided by Seller, unless agreed otherwise in writing by the parties. For Goods that will be operated on or in connection with Buyer supplied hardware or software, Buyer is responsible for ensuring that its hardware and software conform with Seller minimum hardware and software requirements as made available to Buyer. Seller shall provide other field services, such as maintenance visits and field repairs (the "**Other Services**" and together with the Installation Services, the "**Services**") if set forth in the Acknowledgement.

12. Limited Warranty.

(a) Subject to the exceptions and upon the conditions set forth herein, Seller warrants to Buyer that for a period of one (1) year from the date of shipment ("**Warranty Period**"), that such Goods will be free from material defects in material and workmanship.

(b) Notwithstanding the foregoing and anything herein to the contrary, the warranty set forth in this Section 12 shall be superseded and replaced in its entirety with the warranty set forth on **Exhibit A** hereto if the Goods being purchased are specialty products, which include, without limitation, laser products, fiber markers, custom systems, workstations, Seller-installed products, non-catalogue products and other custom-made items (each a "**Specialty Product**").

(c) **EXCEPT FOR THE WARRANTY SET FORTH IN SECTION 12(A), SELLER MAKES NO WARRANTY WHATSOEVER WITH RESPECT TO THE GOODS (INCLUDING ANY SOFTWARE) OR SERVICES, INCLUDING ANY (a) WARRANTY OF MERCHANTABILITY; (b) WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE; (c) WARRANTY OF TITLE; OR (d) WARRANTY AGAINST INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS OF A THIRD PARTY; WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE.**

(d) Products manufactured by a third party and third party software ("**Third Party Product**") may constitute, contain, be contained in, incorporated into, attached to or packaged together with, the Goods. Third Party Products are not covered by the warranty in Section 12(a). For the avoidance of doubt, **SELLER MAKES NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO ANY THIRD PARTY PRODUCT, INCLUDING ANY (a) WARRANTY OF MERCHANTABILITY; (b) WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE; (c) WARRANTY OF TITLE; OR (d) WARRANTY AGAINST INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS OF A THIRD PARTY; WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE.** Notwithstanding the foregoing, in the event of the failure of any Third Party Product, Seller will assist (within reason) Buyer (at Buyer's sole expense) in obtaining, from the respective third party, any (if any) adjustment that is available under such third party's warranty.

(e) Seller shall not be liable for a breach of the warranty set forth in Section 12(a) unless: (i) Buyer gives written notice of the defect, reasonably described, to Seller within five (5) days of the time when Buyer discovers or ought to have discovered the defect and such notice is received by Seller during the Warranty Period; (ii) Seller is given a reasonable opportunity after receiving the notice to examine such Goods; (iii) Buyer (if requested to do so by Seller) returns such Goods (prepaid and insured to Seller at 1820 South Myrtle Avenue, Monrovia, CA 91016or to such other location as designated in writing by Seller) to Seller pursuant to Seller's RMA procedures and Buyer obtains a RMA number from Seller prior to returning such Goods for the examination to take place; and (iii) Seller reasonably verifies Buyer's claim that the Goods are defective and that the defect developed under normal and proper use.

(f) Seller shall not be liable for a breach of the warranty set forth in Section 12(a) if: (i) Buyer makes any further use of such Goods after giving such notice; (ii) the defect arises because Buyer failed to follow Seller's oral or written instructions as to the storage, installation, commissioning, use or maintenance of the Goods; (iii) Buyer alters or repairs such Goods without the prior written consent of Seller; or (iv) repairs or modifications are made by persons other than Seller's own service personnel, or an authorized representative's personnel, unless such repairs are made with the written consent of Seller in accordance with procedures outlined by Seller.

(g) All expendables such as electrodes are warranted only for defect in material and workmanship which are apparent upon receipt by Buyer. The foregoing warranty is negated after the initial use.

(h) Subject to Section 12(e) and Section 12(f) above, with respect to any such Goods during the Warranty Period, Seller shall, in its sole discretion, either: (i) repair or replace such Goods (or the defective part) or (ii) credit or refund the price of such Goods at the pro rata contract rate, provided that, if Seller so requests, Buyer shall, at Buyer's expense, return such Goods to Seller.

(i) **THE REMEDIES SET FORTH IN SECTION 12(H) SHALL BE BUYER'S SOLE AND EXCLUSIVE REMEDY AND SELLER'S ENTIRE LIABILITY FOR ANY BREACH OF THE LIMITED WARRANTY SET FORTH IN SECTION 12(A).** Representations and warranties made by any person, including representatives of Seller, which are inconsistent or in conflict with the terms of this warranty, as set forth above, shall not be binding upon Seller.

13. Limitation of Liability.

(a) **IN NO EVENT SHALL SELLER BE LIABLE FOR ANY CONSEQUENTIAL, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR PUNITIVE DAMAGES, LOST PROFITS OR REVENUES OR DIMINUTION IN VALUE, LOSS OF INFORMATION OR DATA, OR PERSONAL INJURY OR DEATH ARISING IN ANY WAY OUT OF THE MANUFACTURE, SALE, USE, OR INABILITY TO USE ANY GOODS, SOFTWARE OR SERVICE, ORARISING OUT OF OR RELATING TO ANY BREACH OF THESE TERMS, WHETHER OR NOT THE POSSIBILITY OF SUCH DAMAGES HAS BEEN DISCLOSED IN ADVANCE BY BUYER OR COULD HAVE BEEN REASONABLY FORESEEN BY BUYER, REGARDLESS OF THE LEGAL OR EQUITABLE THEORY (CONTRACT, TORT OR OTHERWISE) UPON WHICH THE CLAIM IS BASED, AND NOTWITHSTANDING THE FAILURE OF ANY AGREED OR OTHER REMEDY OF ITS ESSENTIAL PURPOSE.**

(b) **IN NO EVENT SHALL SELLER'S AGGREGATE LIABILITY ARISING OUT OF OR RELATED TO THIS AGREEMENT, WHETHER ARISING OUT OF OR RELATED TO BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE) OR OTHERWISE, EXCEED THE TOTAL OF THE AMOUNTS PAID TO SELLER FOR THE GOODS SOLD HEREUNDER.**

(c) **ALL WARRANTIES SET FORTH HEREIN, DIRECT OR IMPLIED, ARE VOIDED IF THE INITIAL INSTALLATION AND START-UP OF THE SUBJECT GOOD IS NOT SUPERVISED BY AN AUTHORIZED REPRESENTATIVE OF SELLER. AFTER INSTALLATION, ANY RE-ALIGNMENT, RE-CLEANING, OR RE-CALIBRATION, PROVIDED THEY ARE NOT RELATED TO A PROVEN DEFECT IN MATERIALS OR WORKMANSHIP, SHALL BE PERFORMED BY AN AUTHORIZED REPRESENTATIVE OF SELLERAT THE CURRENT SERVICE RATES.**

(d) **WHERE GOODS ARE SUBJECT TO A MOVE TO ANOTHER LOCATION AFTER THE ORIGINAL INSTALLATION HAS BEEN MADE, THE WARRANTY MAY BE MAINTAINED ONLY IF SUPERVISED BY AN AUTHORIZED REPRESENTATIVE OF SELLER. SELLER, FOR A SERVICE CHARGE, WILL ARRANGE FOR AND SUPERVISE THE DISCONNECTION, TRANSPORTATION, REINSTALLATION AND START-UP OF THE EQUIPMENT. CLAIMS FOR DAMAGE IN SHIPMENT ARE THE RESPONSIBILITY OF BUYER AND SHALL BE FILED PROMPTLY WITH THE TRANSPORTATION COMPANY.**

14. Return Goods Policy. Seller's products may be returned to Seller for credit within sixty (60) days of shipment subject to the following conditions.

(a) In order to return products for credit, Buyer must obtain a RMA number from Seller. Upon receipt, it must be executed by an authorized person and then returned with the Goods. Goods returned to Seller without a RMA will be returned at Buyer's expense.

(b) Goods are to be returned to Seller at 1820 South Myrtle Avenue, Monrovia, CA 91016 with Freight Prepaid. Seller will not accept collect shipments.

(c) Restocking fees will be assessed in accordance with the following schedules: (i) Goods returned within the first thirty (30) days from shipment date will be restocked less twenty percent (20%) of the amount billed on the original invoice. (ii) Goods returned over thirty (30) days of shipment but less than sixty (60) days will be restocked less thirty percent (30%) of the amount billed on the original invoice. (iii) No returns are allowed after sixty (60) days from the original shipping date.

(d) The restocking fees set forth above are the minimum fees. If a returned Good requires rework to restore it to a saleable condition, further charges will be assessed. Seller's quality assurance department will document the condition of the Goods when received by Seller and report their findings to Buyer.

(e) **Notwithstanding the foregoing provisions of this Section 14, the following Goods cannot be returned, are not eligible for any credit and cannot be restocked: (i) custom or modified products and (ii) any expendable product(s) that have been used.**

15. Compliance with Law and Indemnification. Buyer shall comply with all applicable laws, regulations and ordinances. Buyer shall maintain in effect all the licenses, permissions, authorizations, consents and permits that it needs to carry out its obligations under this Agreement. Buyer shall comply with all export and import laws of all countries involved in the sale of the Goods under this Agreement or any resale of the Goods by Buyer. Goods, Services and technical data delivered by Seller shall be subject to U.S. export controls. Buyer shall, and shall cause its customers to, obtain all licenses, permits and approvals required by any government and shall comply with all applicable laws, rules, policies and procedures of the applicable government and other competent authorities. Buyer will indemnify and hold Seller harmless for any violation or alleged violation by Buyer of such laws, rules, policies or procedures. Buyer shall not transmit, export or re-export, directly or indirectly, separately or as part of any system, the Goods or any technical data (including processes and Services) received from Seller, without first obtaining any license required by the applicable government, including without limitation, the U.S. government. Buyer also certifies that none of the Goods or technical data supplied by Seller under this Agreement will be sold or otherwise transferred to, or made available for use by or for, any entity that is engaged in the design, development, production or use of nuclear, biological or chemical weapons or missile technology. No Buyer information will be deemed "technical data" unless Buyer specifically identifies it to Seller as such. Buyer assumes all responsibility for shipments of Goods requiring any government import clearance. Seller may terminate this Agreement if any governmental authority imposes antidumping or countervailing duties or any other penalties on Goods. For all international shipments, Seller requires that all required Export Control documentations, including Form BIS-711 Statement by Ultimate Consignee and Purchases, are submitted by Buyer along with the purchase order. Seller reserves the right to postpone shipment until all documentations are completed and submitted to Seller. Seller will not be responsible for shipment delays due to non-compliance by Buyer of the foregoing two sentences.

16. Termination. In addition to any remedies that may be provided under these Terms, Seller may terminate this Agreement with immediate effect upon written notice to Buyer, if Buyer: (i) fails to pay any amount when due under this Agreement and such failure continues for ten (10) days after Buyer's receipt of written notice of nonpayment; (ii) has not otherwise performed or complied with any of these Terms, in whole or in part; or (iii) becomes insolvent, files a petition for bankruptcy or commences or has commenced against it proceedings relating to bankruptcy, receivership, reorganization or assignment for the benefit of creditors.

17. Waiver. No waiver by Seller of any of the provisions of this Agreement is effective unless explicitly set forth in writing and signed by Seller. No failure to exercise, or delay in exercising, any rights, remedy, power or privilege arising from this Agreement operates or may be construed as a waiver thereof. No single or partial exercise of any right, remedy, power or privilege hereunder precludes any other or further exercise thereof or the exercise of any other right, remedy, power or privilege.

18. Confidential Information. All non-public, confidential or proprietary information of Seller, including, but not limited to, specifications, samples, patterns, designs, plans, drawings, documents, data, business operations, customer lists, pricing, discounts or rebates, disclosed by Seller to Buyer, whether disclosed orally or disclosed or accessed in written, electronic or other form or media, and whether or not marked, designated or otherwise identified as "confidential," in connection with this Agreement is confidential, solely for the use of performing this Agreement and may not be disclosed or copied unless authorized in advance by Seller in writing. Upon Seller's request, Buyer shall promptly return all documents and other materials received from Seller. Seller shall be entitled to injunctive relief for any violation of this Section 18. This Section 18 does not apply to information that is: (a) in the public domain through no fault of Buyer; (b) known to Buyer at the time of disclosure without restriction as evidenced by its records; or (c) rightfully obtained by Buyer on a non-confidential basis from a third party.

19. Force Majeure. Seller shall not be liable or responsible to Buyer, nor be deemed to have defaulted or breached this Agreement, for any failure or delay in fulfilling or performing any term of this Agreement when and to the extent such failure or delay is caused by or results from acts or circumstances beyond the reasonable control of Seller including, without limitation, acts of God, flood, fire, earthquake, explosion, governmental actions, war, invasion or hostilities (whether war is declared or not), terrorist threats or acts, riot, or other civil unrest, national emergency, revolution, insurrection, epidemic, lock-outs, strikes or other labor disputes (whether or not relating to either party's workforce), or restraints or delays affecting carriers or inability or delay in obtaining supplies of adequate or suitable materials, materials or telecommunication breakdown or power outage (each a "**Force Majeure Event**"), provided that, if the event in question continues for a continuous period in excess of thirty (30) days, Buyer shall be entitled to give notice in writing to Seller to terminate this Agreement.

20. Assignment. Buyer shall not assign any of its rights or delegate any of its obligations under this Agreement without the prior written consent of Seller. Any purported assignment or delegation in violation of this Section 20 is null and void. No assignment or delegation relieves Buyer of any of its obligations under this Agreement.

21. Relationship of the Parties. The relationship between the parties is that of independent contractors. Nothing contained in this Agreement shall be construed as creating any agency, partnership, joint venture or other form of joint enterprise, employment or fiduciary relationship between the parties, and neither party shall have authority to contract for or bind the other party in any manner whatsoever.

22. No Third-Party Beneficiaries. This Agreement is for the sole benefit of the parties hereto and their respective successors and permitted assigns and nothing herein, express or implied, is intended to or shall confer upon any other person or entity any legal or equitable right, benefit or remedy of any nature whatsoever under or by reason of these Terms.

23. Governing Law. All matters arising out of or relating to this Agreement is governed by and construed in accordance with the internal laws of the State of California without giving effect to any choice or conflict of law provision or rule (whether of the State of California or any other jurisdiction) that would cause the application of the laws of any jurisdiction other than those of the State of California.

24. Dispute Resolution.

(a) If Buyer is an entity formed under the laws of the United States of America, or any of its states, districts or territories ("**U.S. Law**"), then any dispute, legal suit, action or proceeding arising out of or relating to this Agreement shall be adjudicated and decided in the federal courts of the United States of America or the courts of the State of California in each case located in the City of Los Angeles and County of Los Angeles, California and each party irrevocably submits to the exclusive and personal jurisdiction of such courts in any such dispute, suit, action or proceeding.

(b) If Buyer is an entity formed under the laws of any country, state, district or territory other than U.S. Law, then the parties irrevocably agree that any dispute, legal suit, action or proceeding arising out of or relating to this Agreement shall be submitted to the International Court of Arbitration of the International Chamber of Commerce ("**ICC**") and shall be finally settled under the Rules of Arbitration of the ICC. The place and location of the arbitration shall be in Los Angeles, California, pursuant to the ICC's Rules of Arbitration and shall be finally settled in accordance with said rules. The arbitration shall be conducted before a panel of three arbitrators. Each party shall select one arbitrator and the two arbitrators so selected shall select the third arbitrator, who shall act as presiding arbitrator. Notwithstanding the foregoing, if the matter under dispute is $500,000 or less, there shall only be one arbitrator who shall be mutually selected by both parties. If the party-selected arbitrators are unable to agree upon the third arbitrator, if either party fails to select an arbitrator, or in the case that only one arbitrator is required and the parties are unable to agree, then the International Court of Arbitration shall choose the arbitrator. The language to be used in the arbitral proceeding shall be English. The arbitrator(s) shall have no authority to issue an award that is contrary to the express terms of this Agreement or the laws of the State of California or applicable US Federal Law, and the award may be vacated or corrected on appeal to a court of competent jurisdiction for any such error. The arbitrator(s) shall be specifically empowered to allocate between the parties the costs of arbitration, as well as reasonable attorneys' fees and costs, in such equitable manner as the arbitrator(s) may determine. The arbitrator(s) shall have the authority to determine issues of arbitrability and to award compensatory damages, but they shall not have authority to award punitive or exemplary damages. Judgment upon the award so rendered may be entered in any court having jurisdiction or application may be made to such court for judicial acceptance of any award and an order of enforcement, as the case may be. In no event shall a demand for arbitration be made after the date when institution of a legal or equitable proceeding based upon such claim, dispute or other matter in question would be barred by the applicable statute of limitations. Notwithstanding the foregoing, either party shall have the right, without waiving any right or remedy available to such party under this Agreement or otherwise, to seek and obtain from any court of competent jurisdiction any interim or provisional relief that is necessary or desirable to protect the rights or property of such party, pending the selection of the arbitrator(s) hereunder or pending the arbitrator(s)' determination of any dispute, controversy or claim hereunder.

25. Notices. All notices, request, consents, claims, demands, waivers and other communications hereunder (each, a "**Notice**") shall be in writing and addressed to the parties at the addresses set forth on the face of the Acknowledgement or to such other address that may be designated by the receiving party in writing. All Notices shall be delivered by personal delivery, nationally recognized overnight courier (with all fees pre-paid), facsimile (with confirmation of transmission) or certified or registered mail (in each case, return receipt requested, postage prepaid). Except as otherwise provided in this Agreement, a Notice is effective only (a) upon receipt of the receiving party, upon confirmation of delivery by nationally recognized overnight courier or upon forty-eight (48) hours after being sent by certified or registered mail (as applicable), and (b) if the party giving the Notice has complied with the requirements of this Section 25.

26. Severability. If any term or provision of this Agreement is invalid, illegal or unenforceable in any jurisdiction, such invalidity, illegality or unenforceability shall not affect any other term or provision of this Agreement or invalidate or render unenforceable such term or provision in any other jurisdiction.

27. Survival. Provisions of these Terms which by their nature should apply beyond their terms will remain in force after any termination or expiration of this Order including, but not limited to, the following provisions: Compliance with Laws, Confidentiality, Governing Law, Dispute Resolution, Survival, and the restrictions on Software in Sections 10(b), (c) and (d).

CHAPTER 1
DESCRIPTION

Section I: Features

Features

The TL-508B Weld Head, herein called the Weld Head, meets the needs of high-quality battery pack manufacturers. Its primary application is the welding of thin interconnecting tabs for a variety of battery technologies. The Weld Head is actuated by the patented EZ-AIR technology which brings a superior level of repeatability and functionality to force control.

The Weld Head has the following features:

- Compact design for bench top and automated use
- Includes stand and base plate assembly
- Weld head can be adjusted vertically on the stand
- Easy set up and maintenance
- Easy force adjustment with fine resolution
- Secure force setting with locking screw
- EZ-AIR prevents overforce
- EZ-Clean valve permits quick and easy electrode dressing
- Precise down speed control reduces impact force and eliminates damage to fragile battery cells
- L-shaped electrode holders with dual clamping screws uses 1.5 mm electrode rod (ES0250M) for fine positioning on small cells
- Fine electrode gap setting in a true horizontal plane
- Convenient adjustment of electrode gap, from 0 to 10 mm
- Independent control over each electrode force
- Ultra-flexible 4 gauge weld cable replaces conventional lamination type flexures
- High speed operation with advanced cylinder and slide combination

Section II: Major Components

Reference Publications

In addition to this manual, you will also have to refer to the manual provided with your power supply. If you need additional copies of any of these manuals, they can be procured from Amada Weld Tech.

Major Components

Figure 1-1 shows the major components of the unit. The function of each item is described below. The following figures and paragraphs describe the detail parts, controls, and indicators normally associated with operation.

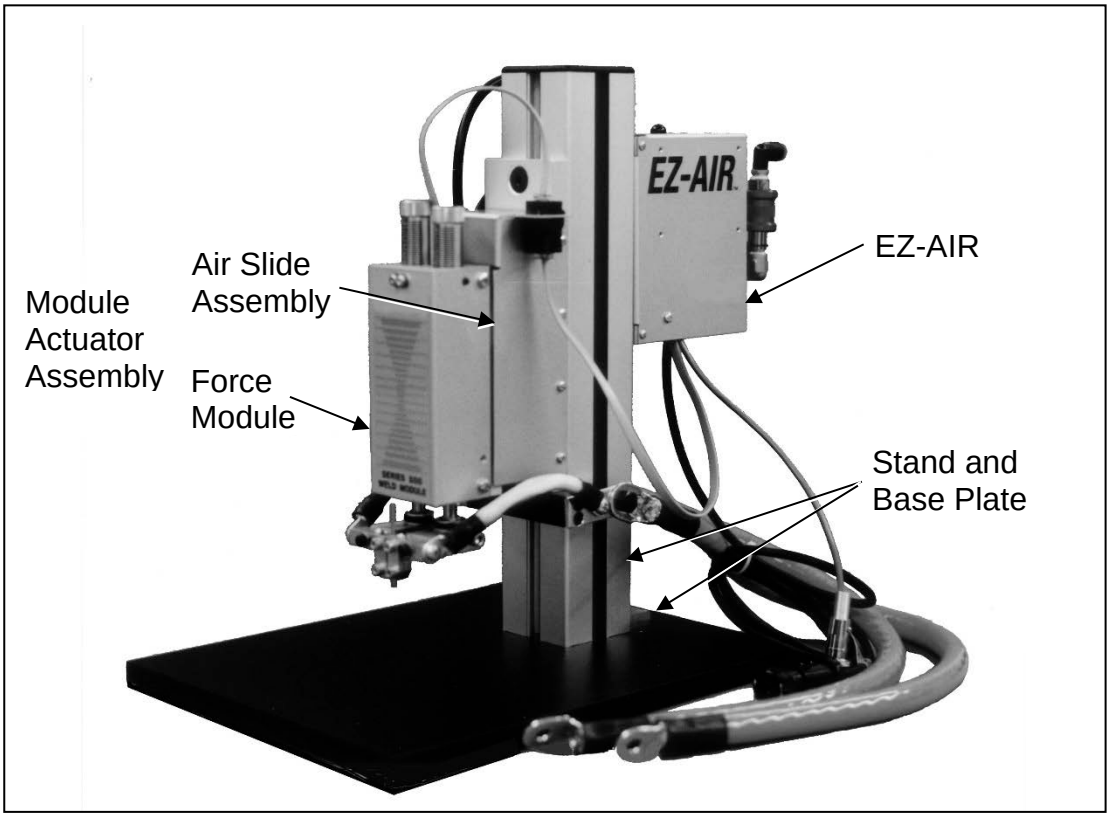

Figure 1-1. TL-508B Weld Head, Major Components

EZ-AIR. The EZ-AIR provides the pneumatic force to control the weld head. Upon receiving the down-stroke signal, the EZ-AIR moves the weld module down to the welding surface and maintains the pre-set pressure until the completion of the welding cycle (including squeeze and weld hold period). At that time the pneumatic pressure is released and the weld module returns to its up position.

Stand and Base Plate. The stand provides rigid mounting for the Force Module, Air Slide Assembly, and EZ-AIR, and permits vertical adjustment of the Module Actuator Assembly. The base plate provides a rigid surface for welding and will allow the mounting of part fixtures or jigs.

Air Slide Assembly. This assembly consists of a combination slide and twin pneumatic cylinders. Its function is to provide actuation of the Force Module.

Force Module. The Force Module is the main part of the Weld Head and controls the amount of force applied during the welding operation. The module has two independently adjustable force setting tubes, which compress individual force springs for each electrode assembly. The module contains an optical firing switch that senses when the set force is reached on each electrode. When this occurs, a firing signal is applied to the EZ-AIR which, in turn, provides the firing signal to the power supply.

NOTE: The Air Slide Assembly and Force Module are referred to, collectively, as the Module Actuator Assembly

Module Actuator Assembly Components and Controls

Figure 1-2 shows the Module Actuator Assembly components and controls, as described in the following paragraphs. Chapter 3, Operating Instructions, provides specific means of adjusting the controls.

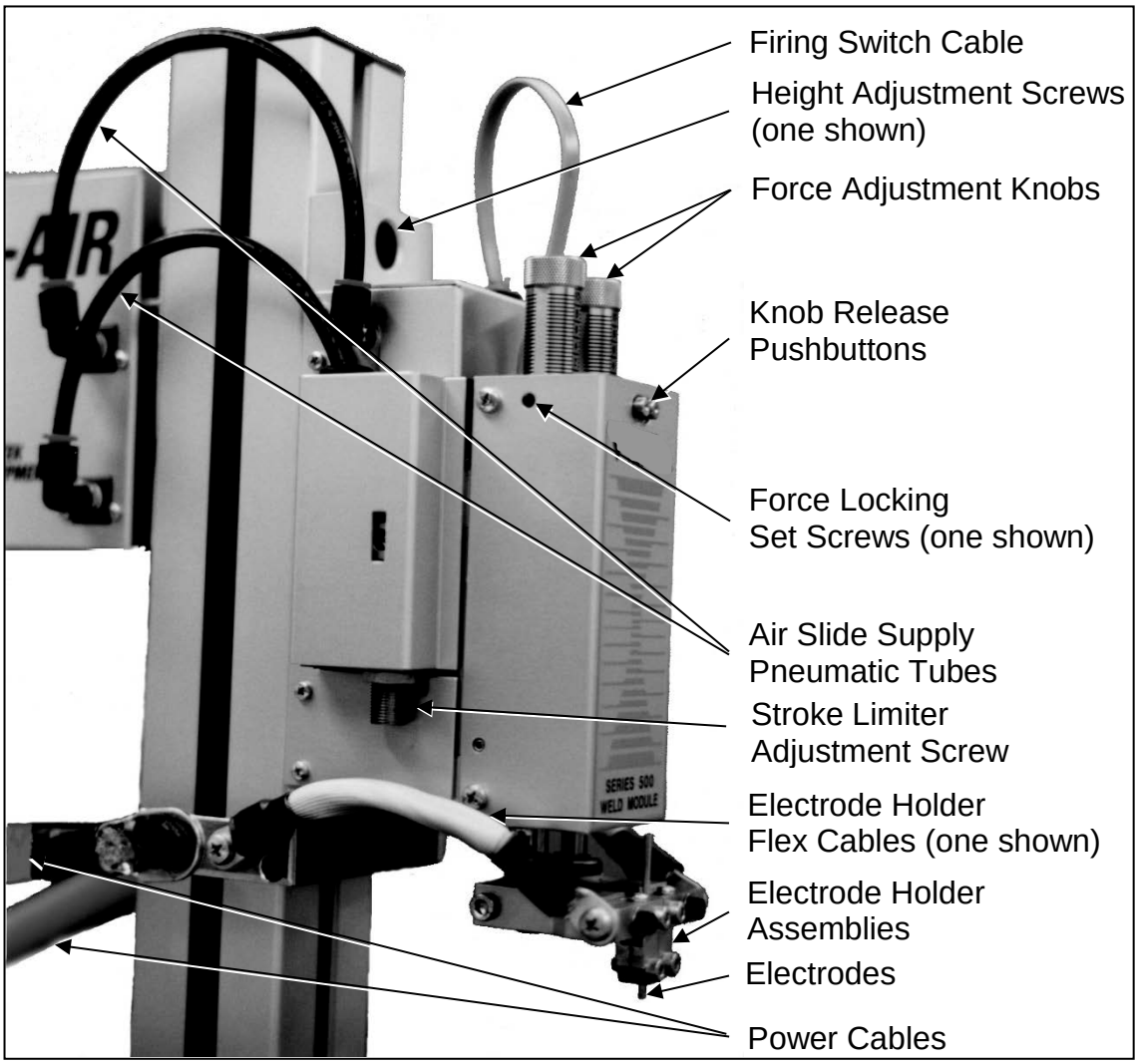

Figure 1-2. Module Actuator Assembly Components and Controls

Firing Switch Cable. This cable takes the firing signal from the Force Module to the EZ-AIR, when the force has been met on each electrode.

Height Adjustment Screws. Allen head screws that allow vertical adjustment of the Module Actuator Assembly on the mounting post. This allows the user to set the welding stroke of the electrodes to the parts for the welding operation. The bottom screw is not visible in figure 1-2.

Force Adjustment Knobs. These thumbscrews provide for independent adjustment of the weld force on each electrode. The numeric scale and fine lines provide an approximate indication of force settings. The numbers do not directly relate to a given force and serve as a numeric indicator only. Chapter 3 provides specific cross-reference data.

Knob Release Pushbuttons. The two spring-loaded release buttons, one for each force adjustment knob, must be pressed in order to turn the force adjustment knobs. The buttons hold the force adjustment knobs in place during welding to ensure that force does not change due to vibration.

Force Locking Set Screws. Two set screws, one for each force adjustment knob, protects against unauthorized operator adjustment of the force adjustment knobs.

CAUTION: Each set screw must be loosened prior to pressing the force adjustment pushbutton and adjusting the force adjustment knob.

Air Slide Supply Pneumatic Tubes. The tubes connect the air supply from the EZ-AIR to the Air Slide Assembly.

Stroke Limiter Adjustment Screw. This screw is factory adjusted for a one-inch maximum electrode stroke. It can be adjusted for a shorter stroke if desired.

CAUTION: Before making adjustment, loosen the locking nut on the screw. Re-tighten the nut after adjustment is completed.

NOTE: Do not use the stroke limiter as a downstop. Its only use is that of restricting the overall stroke of the electrode to one inch.

Electrode Holder Flex Cables. These cables carry the welding energy from the bus bars to the electrode holder assemblies.

Electrode Holder Assemblies. The electrode holder assemblies hold two 1.5 mm diameter electrode rods and provide horizontal gap adjustment of the electrodes to suit the application.

Electrodes. Two 1.5 mm diameter electrode rods are provided in the Ship Kit.

CAUTION

Do ***not*** modify the electrode holders or attach additional mechanisms to the moving parts of the head. Doing so may hurt welding performance, damage the head, and ***void the warranty***.

Power Cables. These cables provide the electrical connection between the power supply and the Weld Head and conduct the welding energy to the bus bar.

EZ-AIR Components, Controls, and Indicators

Figure 1-3 shows the EZ-AIR components, controls, and indicators as described in the following paragraphs. Chapter 3, Operating Instructions, provides specific means of adjusting the controls.

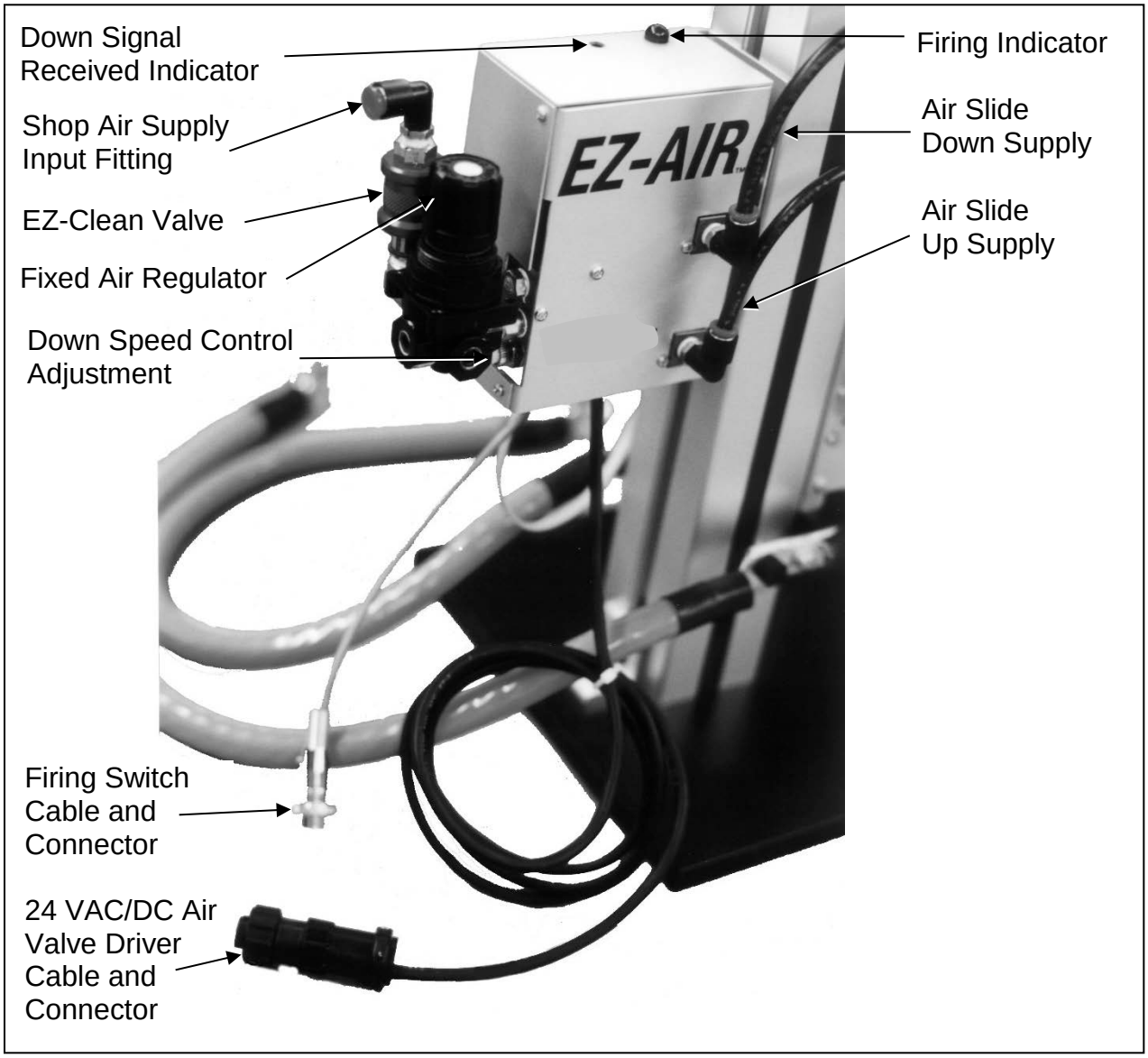

Figure 1-3. EZ-AIR Components, Controls, and Indicators

Firing Indicator. A green indicator that lights when the firing switch closes and stays lit until the end of the weld cycle. Thus, if a malfunction occurs, the operator can determine whether a firing signal is present.

Air Slide Down Supply. Male elbow fitting, ¼ inch OD tube to c inch male NPT brass. Connects controlled compressed air to weld head air cylinder top port.

Air Slide Up Supply. Male elbow fitting, ¼ inch OD tube to c inch male NPT brass. Connects controlled compressed air to weld head air cylinder bottom port.

24 VAC/DC Air Valve Driver Cable and Connector. Conducts 24 volt solenoid drive power from the power supply to the EZ-AIR.

Firing Switch Cable and Connector. Two-conductor male plug to connect firing signal to the power supply.

Down Speed Control Valve Adjustment. Operator adjustment that allows setting of the down speed of the Force Module to reduce part impact pressure.

Fixed Air Regulator. Controls pressure of air from shop air source into EZ-AIR. Regulator is factory set for 78 psi (538 kPa) and does not require any user adjustment.

EZ-Clean Valve. Allows bleeding of input air supply to permit dressing of electrodes.

Shop Air Supply Input Fitting. ¼ inch O.D. tube fitting for connecting shop compressed air to EZ-AIR. Shop air supply must be 85 – 130 psi (586 – 897 kPa).

Down Signal Received Indicator. An amber indicator, visible through an inspection port in the EZ-AIR cover, that lights when the initialization signal is received from the power supply, and stays lit until the pre-set force has been reached. If a problem occurs, the operator can determine whether the start signal is being received from the power supply.

Section III: Sequence of Operation

As shown in figure 1-4, there are five components involved in operation of the system: Operator; Footswitch (1 level or 2 level), Power Supply, Weld Head, Parts

General Overview:

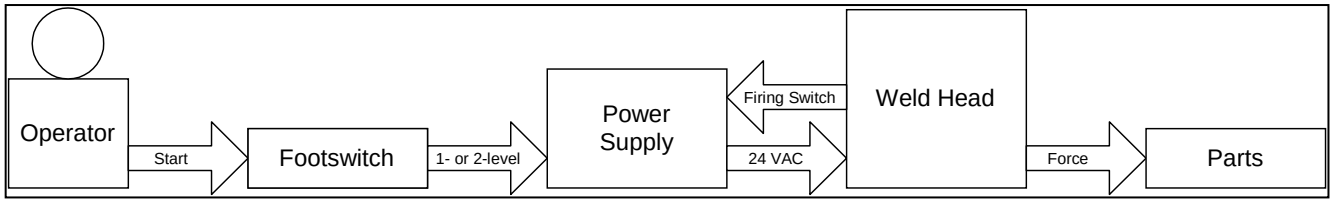

Figure 1-4. Welding Operations Components

The operator initializes the weld sequence by depressing the footwitch, which provides a start signal to the power supply. The power supply sends a 24 VAC/DC signal to the EZ-AIR, which triggers the valve to actuate the Slide and Cylinder Assembly and drive the Force Module downward. Once the set force has built up on both electrodes, the Force Module initiates a firing switch signal, sending it to the EZ-AIR. The EZ-AIR then closes two valves to lock the movement of the cylinder in the Valve and Cylinder Assembly. Simultaneously, the EZ-AIR sends the firing switch signal to the power supply to initiate the weld sequence. At the end of the weld sequence the EZ-AIR opens the valves to allow the slide to return the force module to its home position. A new operation can now begin.

There is a slight difference in sequence between a system running with a one-level or two-level footswitch, explained below:

Two-Level Foot Switch Operation

A weld sequence begins when the operator presses the foot switch to the first position. This sends a signal to the power supply, which begins the weld sequence by sending a signal to the EZ-AIR. (The operation of the EZ-AIR is described in more detail below.) The EZ-AIR moves the weld head electrodes to the welding surfaces. When the pre-set squeeze force is obtained, the Force Module sends a signal back to the EZ-AIR, which sustains that squeeze force. The operator can now check the items to be welded to verify proper placement. If satisfied with the placement, the operator presses the foot switch to the second position, and the power supply provides the complete pre-programmed weld cycle from squeeze through hold. (If unsatisfied, the operator needs only to release the foot switch, and the electrodes will rise, allowing realignment of the weld pieces.)

One Level Foot Switch Operation

The one-level foot switch operation works as above, but the entire sequence is actuated with the pressing of the foot switch. There is no pause to allow the operator to check the proper placement of the parts. This operation can be slightly faster but provides less control if part fixtures are not used.

Note: Most power supplies have a function called “footswitch weld abort.” If this function is turned on, the operator can abort the operation at any time in the sequence before the force is reached if postioning is incorrect. If the function is turned off, the operation cannot be terminated, but will continue through its completion.

Operation of the EZ-AIR

EZ-AIR uses a single four-way solenoid valve to direct air between the down solenoid valve and the up solenoid valve (figure 1-5), as described below.

Initial Air Applied. Upon initial application of air (whether or not power is applied), air pressure is applied through the four-way solenoid valve and the up solenoid valve to the lower chamber of the cylinder, driving the piston up. Air is exhausted through the four-way solenoid valve.

Down Stroke. During the electrode down stroke, air pressure is directed to the upper chamber of the cylinder, forcing the piston down. Waste air exhausts from the lower chamber through the up solenoid valve and the four-way solenoid valve.

Constant Force. When the electrode reaches weld force, the up and down solenoid valves close and air is trapped in both the upper and lower chambers of the cylinder. Weld force remains constant as the air cylinder piston cannot move. The four-way solenoid valve also switches to its off position, reversing the air connections to the up and down solenoid valves.

Up Stroke. At the completion of the weld, the up and down solenoid valves open. This causes the application of air pressure to the lower chamber of the cylinder, returning the piston to its up position.

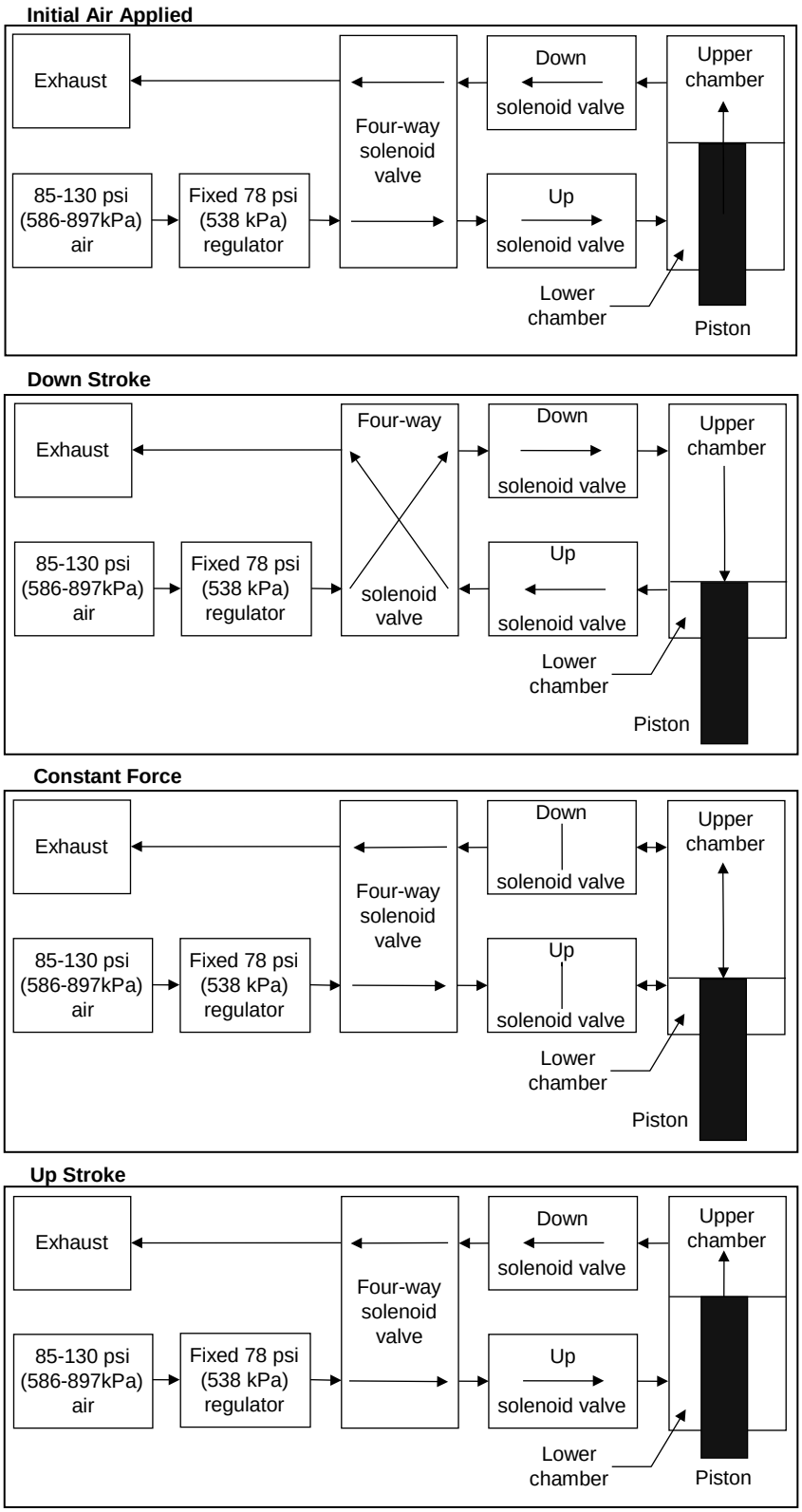

Figure 1-5. EZ-AIR Sequence of Operation

CHAPTER 2
GETTING STARTED

Section I: Planning for Installation

The Weld Head comes fully assembled from the shipping box. The only installation requirements are planning the work space, installing the electrodes, and connecting the unit to the appropriate power supply with the cables provided in the Ship Kit.

Space Requirements

An outline drawing of the Weld Head is included in Appendix A. Additional space must be allowed for the power supply. The specific dimensions of the Weld Head are:

Width:	10.0 in. (25.4 mm)
Depth	17.25 in. (43.82 mm)
Height	15.0 in. (38.1 mm) maximum
Weight	21 lb. (10 kg)

Power Requirements

The Weld Head requires 24 VAC/DC -5%/+10%, ½A, which may be available from the power supply. In addition, the weld head requires welding current from the power supply. Refer to the power supply user's manuals for power requirements of that unit.

Compressed Air Requirements

The EZ-AIR requires a 1/8 inch F'NPT fitting connected to a shop air source of 85–130 psi (586–897 kPa). It is recommended that an auto drain air filter with a 5-micron element (Amada Weld Tech Part Number 10-373-01, catalog number ADAF) be placed in the air line.

CAUTION: A shop air compressor using synthetic oil will cause damage to the EZ-AIR. Petroleum-based oil only is recommended.

Section II: Weld Head Set-up

Unpacking

Unpack the Weld Head from its shipping box and verify that all components of the Ship Kit, shown in table 2-1 are present. The Weld Head comes from the shipping box completely assembled except for the electrodes. They are installed and adjusted in accordance with directions given in Chapter 3, Operating Instructions.

NOTE: Carefully put the packing materials back in the packing boxes and store for future shipping.

Table 2-1. Components of Ship Kit

Item	Component	Amada Weld Tech Part Number	Qty
1	Bolt, hex head, M8-1.25 x 16 mm	160-048	2
2	Brochure, accessories	991-161	1
3	Cable assy, 2/0	4-35386-01	2
4	Electrode, 1.5 mm	4-35686-01	2
5	Fitting, ¼ in. tube, 1/8 in. M'NPT	325-185	1
6	Gauge, electrode adjustment	4-35675-01	1
7	Hex key set	770-034	1
8	Installation drawing	4-35684-01	1
9	Nut, hex, M8-1.25	465-206	2
10	Polishing disk	4-04688-01	1
11	Screw, cap, socket head, M8x1.25	625-893	2
12	Ship Kit drawing	4-35714-01	1
13	Terminal ring, #6	700-103	2
14	Tubing, plastic, ¼-in. dia. OD	050-138	6 ft
15	User's manual	990-111	1
16	Washer, Flat, 5/16	755-044	4
17	Wrench, Allen, 5 mm, short	770-027	1
18	Wrench, Allen, 5 mm, ball	770-042	1

Installation

Installation consists of setting the assembled Weld Head on the work bench, connecting the power and signal cables, and connecting the shop air pneumatic tubing. See figure 2-1.

Pneumatic Connection

The Ship Kit contains a fitting for shop air (item 5) with a 1/8 in. M'NPT thread. Connect the fitting to the shop air fitting.

NOTE: The pneumatic tubing end cuts must be smooth and square. We recommend using an SMC TKA-1 tube cutter. Do not use pliers, wire nippers or scissors.

Cut the pneumatic tubing in the Ship Kit (item 14) to the appropriate length and using the push-in fittings, connect the shop air pneumatic tubing to the Weld Head air supply input.

NOTE: Be sure the tubing is pushed in all of the way to prevent leakage.

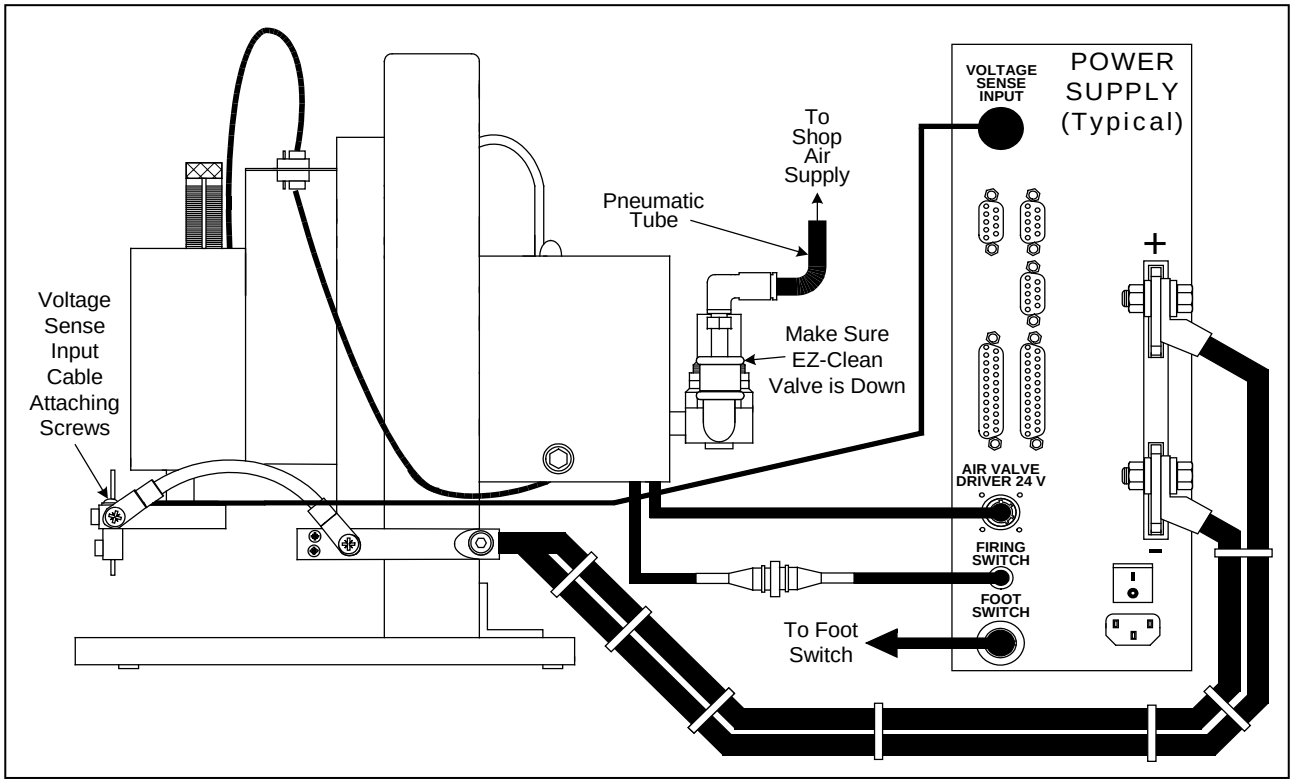

Figure 2-1. Weld Head Installation Connections

NOTE: Be sure the EZ-Clean (red) valve is in the down position. Power and Signal Connections

1 Connect the 24 VAC/DC air valve driver cable to a 24 VAC or 24 VDC power source. (All current models of Amada Weld Tech power supplies have 24 VAC or 24 VDC available on the rear of the power supply.)

2 Connect the firing switch cable connector to the firing switch connector on the power supply.

3 Locate the power supply voltage sense input cable. If it is equipped with any termination (other than with # 6 terminal rings), remove those terminations, and crimp the # 6 terminal rings from the Ship Kit (item 13) to the two wires. Attach the two wires to the top of the electrode holder assemblies with the screws already installed on the assemblies.

4 Connect the welding cables (item 3) in the Ship Kit between the power supply and the Weld Head. Route the cables parallel to each other and secure them together to prevent inductive loss. The cables are attached to the power supply with the two bolts (item 1), four washers (item 16), and two nuts (item 9) from the Ship Kit. The cables are attached to the Weld Head with the two cap screws (item 11).

5 Connect the foot switch cable to the power supply.

6 We recommend the use of 50 to 150ms “squeeze time,” if that program feature exists on your power supply.

CHAPTER 3
OPERATING INSTRUCTIONS

Section I: Operating Precautions

General Operator Safety

Always wear safety glasses any time you are operating the Weld Head.

Never wear loose clothing or jewelry when operating the Weld Head. It could be caught in the mechanism.

Before operating a Weld Head, read both this manual and the manual on the power supply. Particularly note the specific hazards associated with those components.

Section II: Preparing for Operation

Pre-Operational Checks

Before operating the equipment, verify that the power and compressed air connections are made to the Weld Head, as described in Chapter 2, Getting Started, and to the power supply, as described in its manual. Verify that all pneumatic connections are secure and that there are no air leaks.

Verify that the Weld Head and power supply are properly connected.

Pre-Operational Adjustments

Pre-operational adjustments include the electrode height, electrode gap, force adjustment, and weld head height on the weld head; and down speed control valve adjustment on the EZ-AIR.

Electrode Height

Install, if necessary, two electrodes (item 4) from the Ship Kit. Verify, and adjust if necessary, the electrodes in the electrode holders. Each electrode should extend 1/4-inch below its holder. The Ship Kit contains a gauge (item 6) for making the adjustment. See figure 3-1. Note that the gauge has a hole for convenient attachment to the Weld Head so that it is not misplaced.

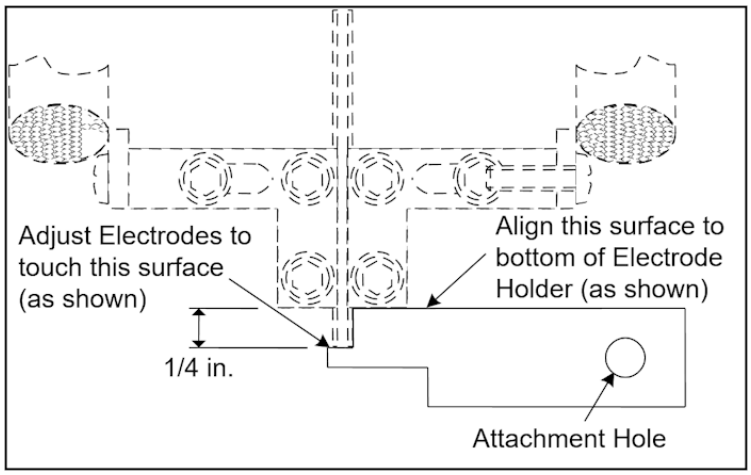

Figure 3-1. Use of Electrode Adjustment Gauge

To adjust the height of each electrode, loosen the two screws (figure 3-2) that secure the electrode, make the adjustment, and re-tighten the screws

Electrode Gap

Verify, and adjust if necessary, the electrode gap (the space between the electrodes) for your specific needs. The gap is adjustable to a maximum of 10 mm (0.0394 inch). A good starting point for most applications is a 1.5 mm gap.

To adjust the electrode gap, loosen the screw (figure 3-2) that secures each electrode holder, make the adjustment, and re-tighten the screw.

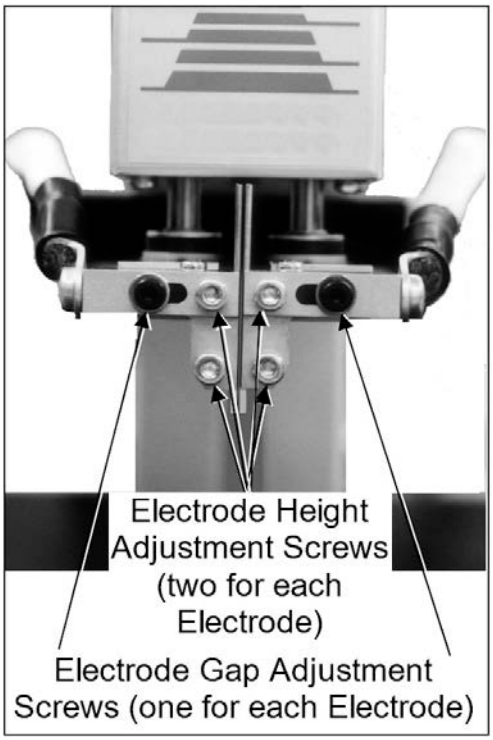

Figure 3-2. Electrode Adjustment Screws

Force Adjustment

The force adjustment knobs allow the selection of separate weld forces for each electrode to produce equal size weld nuggets. The method of selecting force for each electrode is identical, so only one is described.

Refer to figure 3-3, and perform the following steps:

CAUTION: Before making adjustment, loosen the force locking set screw. **NOTE:** When unit is shipped from the factory, the set screw is not tightened against the force adjustment knob, so you will not initially need to loosen it.

However, it is held in place by thread locking compound, so when you do tighten it you will feel resistance from the compound. Do not interpret this as the screw being tightened to the force adjustment knob.

1 Loosen the force locking set screw.

2 Press and hold in the knob release pushbutton.

3 Refer to figure 3-4 to determine the equivalent force adjustment knob setting for the desired electrode force.

NOTE: The actual electrode force is affected by the down speed control adjustment (figure 1-3). A faster down speed setting results in a higher electrode force; a slower down speed setting results in a lower electrode force. For an exact weld force, we recommend that you use a separate force gauge (Amada Weld Tech Part Number FG20)

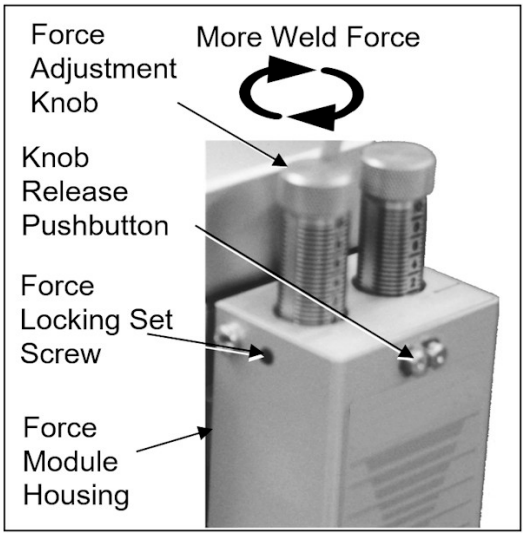

Figure 3-3 Weld Force Adjustment

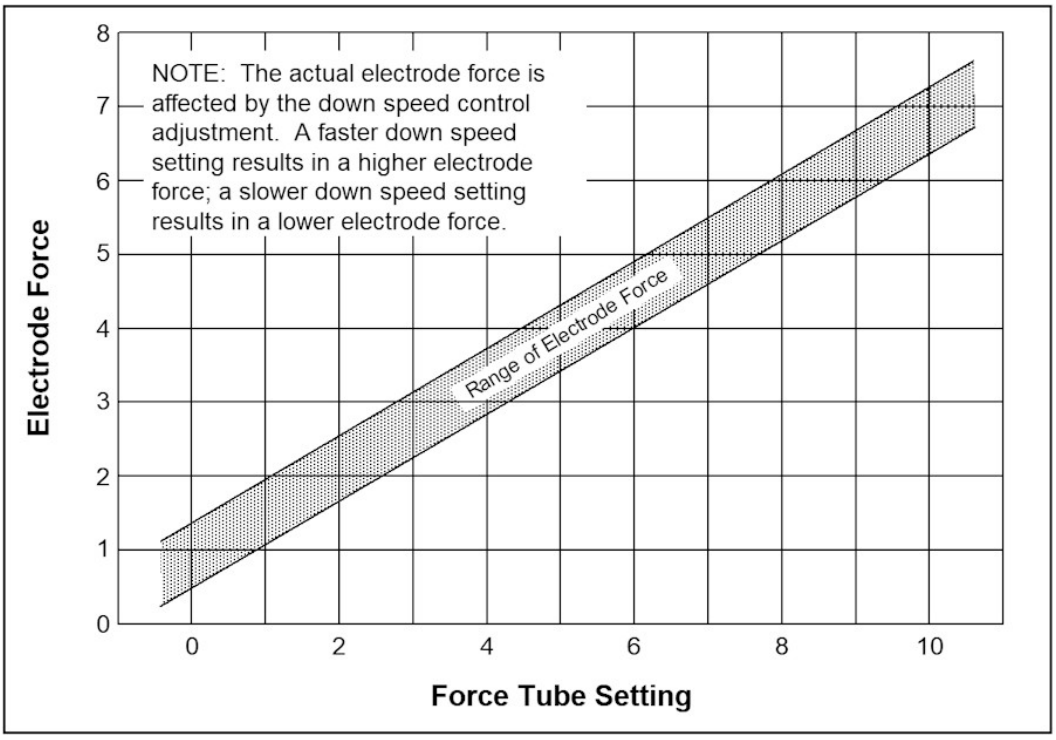

Figure 3-4. Electrode Force Adjustment Range

4 Turn the force adjustment knob until the desired force graduation mark is flush with the Force Module Housing surface, as in the examples shown in figure 3-5.

5 Release the knob release pushbutton.

NOTE: The adjustment knobs must be set so that the numbers face the front. This will assure that the flats on the shafts are on the side that will be secured with the force locking set screw. When the unit is shipped from the factory, the set screw is held in place by thread locking compound. Do not interpret the resistance from the compound as an indication that the screw is tightened to the force adjustment knob.

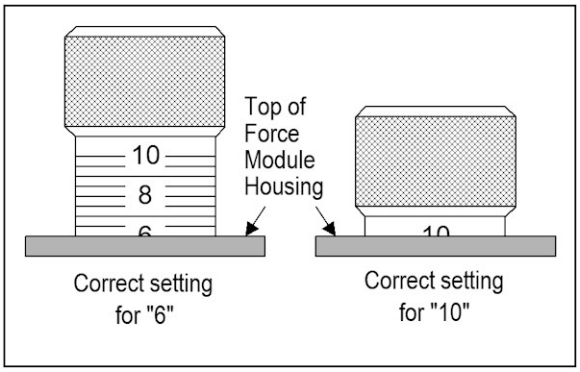

Figure 3-5. Proper Adjustments of Weld Force Adjustment Knobs

6 Re-tighten the force locking set screw to prevent unintentional adjustments.

Module Actuator Assembly Height

To adjust the height of the Module Actuator Assembly, loosen the two Height Adjustment Screws (figure 1-2), adjust the height, and re-tighten the screws. A hex key set (item 7) and two 5 mm wrenches (items 17 and 18) are provided in the Ship Kit for these adjustments. Items 17 and 18 will be particularly useful for adjusting the bottom screw (not visible in figure 1-2). To do this, the Module Actuator Assembly must be pushed up. This will occur automatically when air is applied, or it can be done manually.

EZ-AIR Down Speed Control Valve Adjuster

To adjust the EZ-AIR Down Speed Control Valve Adjuster, perform the following steps:

NOTE: The equipment has to be operating before this adjustment can be made.

1 If the red EZ-Clean valve is in the purge position (up), push it all the way down.

2 Set the power supply so that the Weld Head can operate without performing a weld. For instance, on an Amada Weld Tech power supply, set the WELD/NO WELD switch to NO WELD.

3 Press the foot switch several times to operate the Weld Head and observe the down speed.

4 Set the Down Speed Control Valve Adjuster (figure 1-3) to provide an acceptable welding speed.

NOTE: Excessive electrode down speed causes excessive impact force on the parts. Electrodes should contact parts in a controlled manner. Most Amada Weld Tech power supplies have programmable squeeze time that allows force to stabilize prior to firing. A squeeze time setting between 50 and 150ms is recommended.

Turning the Equipment On

To apply power to the unit, follow the directions in the respective power supply manual.

Section III: Operation

Once set-up is completed, there are no separate steps required during Weld Head operation except that the EZ-Clean valve (figure 1-3) can be actuated to purge the air during electrode dressing. To do so, push the EZ-Clean (red) slide valve up. To restore pressure, slide the valve down. See Chapter 4 , User Maintenance, for electrode dressing instructions.

CHAPTER 4
USER MAINTENANCE

Section I: Precautions

General Operator Safety

WARNINGS

Always wear safety glasses any time you are operating the Weld Head.

Never wear loose clothing or jewelry when operating the weld head. It could be caught in the mechanism.

Before operating the Weld Head, read this manual and the power supply manual. Particularly note the specific hazards associated with those components.

Section II: Operator Maintenance

Preventive Maintenance

The only preventive maintenance required is occasional lubrication of the EZ-Clean valve, whenever necessary. The valve should only be lubricated with a petroleum or lithium based grease.

CAUTION: Do not use synthetic oil. It will damage the EZ-AIR.

Routine Maintenance

The only routine maintenance is dressing the electrode tips periodically to remove oxides and welding debris This is simplified by the EZ-Clean valve which, when pushed to the purge (up) position, automatically allows the weld head to lower without disturbing any of the settings. To dress the electrodes, perform the following steps:

1 Fold a piece of 600 grit silicon carbide disk (item 10 in the Shipping Kit) over a *flat, rigid backing* with the grit surface facing outward. The rigid backing will maintain the flatness of the electrode face during dressing.

2 Place the silicon carbide disk and backing beneath electrodes, and slide the EZ-Clean (red) valve up. The electrodes should contact with the disk with a force that is low enough to allow the disk to be moved without damaging its surface.

3 Gently pull the emery paper forward one or two inches (as shown below).

4 Clean the electrode face with a small cotton swab saturated in alcohol.

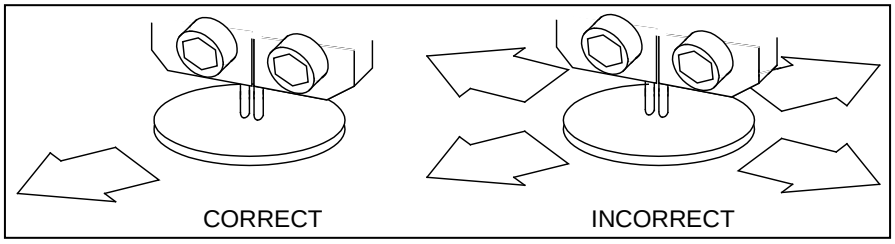

Figure 4-1. Dressing Electrodes

Corrective Maintenance

The only recommended user corrective maintenance is clearing foreign matter from the EZ-AIR that might jam a valve open. If the weld head fails to move up or down, refer to table 4-1 and perform the actions prescribed.

Table 4-1. Troubleshooting Table

NOTE: Table presumes all power and pneumatic connections are made and properly adjusted.

Fault	Check for:	Possible Cause	Action
Weld head does not move upward when air is first applied.		Problem with input shop air.	Verify correct input shop air pressure. See Chapter 2, Compressed Air Requirements.
		EZ-Clean valve is closed (in up position).	Open valve by pushing downward.
		Internal valve is stuck.	Contact company representative.
Weld head does not go downward when footswitch is pressed (first position for two-level foot switches).	Neither green firing indicator nor amber initialization signal received indicator light.	Problem exists in power supply, footswitch, or cable connections.	Check cable connections. Refer to appropriate power supply manual.
	Amber initialization signal received indicator is lit.	Internal valve is stuck.	Contact company representative.
		Down Speed Control valve is closed.	Turn valve counterclockwise to open.
Weld head moves downward too forcefully when footswitch is pressed (first position for two-level foot switches).		Down Speed Limiter valve requires adjustment.	Contact company representative.

Spare Parts

Table 4-2 lists the spare parts that we recommend that you have available for user maintenance. The quantities listed are those used in the assembly.

Table 4-2. Recommended Spare Parts List

Component	Amada Weld Tech Part Number	Qty
Bolt, hex head, M8-1.25 x 16 mm	160-048	2
Cable assy, 2/0	4-35386-01	2
Cable, weld	4-35674-01	2
Electrode set (2), 1.5 mm	ES0250M	1
Gauge, electrode adjustment	4-35675-01	1
L-block, electrode holder (right)	4-35644-01	1
L-block, electrode holder (left)	4-35644-02	1
Mounting block, electrode holder	4-35643-01	2
Nut, hex, M8-1.25	465-206	2
Polishing disk (package of 50)	PD	1
Screw, cap, socket head, M4x12mm	625-825	4
Screw, cap, socket head, M4x18mm	625-941	2
Screw, cap, socket head, M5x18mm	625-836	2
Screw, cap, socket head, M8x1.25	625-893	2
Screw, pan head, philips, M5x10, w/ nylok	625-948	4
Tubing, plastic, ¼-in. dia. OD	050-138	6 ft
Washer, flat, M4	755-318	2

Repair

If problems cannot be resolved using the above troubleshooting table, contact Amada Weld Tech at the address/telephone/fax shown in the Foreword.

APPENDIX A
SPECIFICATIONS

Table A-1. Specifications

ITEM	SPECIFICATION
Dimensions	Width: 10.0 in. (25.4 mm) Depth 17.25 in. (43.82 mm) Height 15.0 in. (38.1 mm) maximum
Weight	21 lb. (10 kg)
Power Requirements	24 VAC/DC -5% / +10%, ½A (from Power Supply)
Compressed air Requirements	85 – 130 psi (586 – 897 kPa) An auto drain air filter with a 5-micron element (Amada Weld Tech Part Number 10-373-01, catalog number ADAF) is recommended. **CAUTION:** Compressor supplying air must not be lubricated with synthetic oil.
Operating Environment	60 - 113ºF (15.5 - 45ºC) 93% Relative Humidity (maximum) at 104ºF (40ºC)
Weld Force	1 - 7 lb (0.5 – 3.2 kg) (each electrode)
Gap Adjustment	up to 0.0394 in. (10 mm)

Outline Drawing

(Dimensions are in inches)

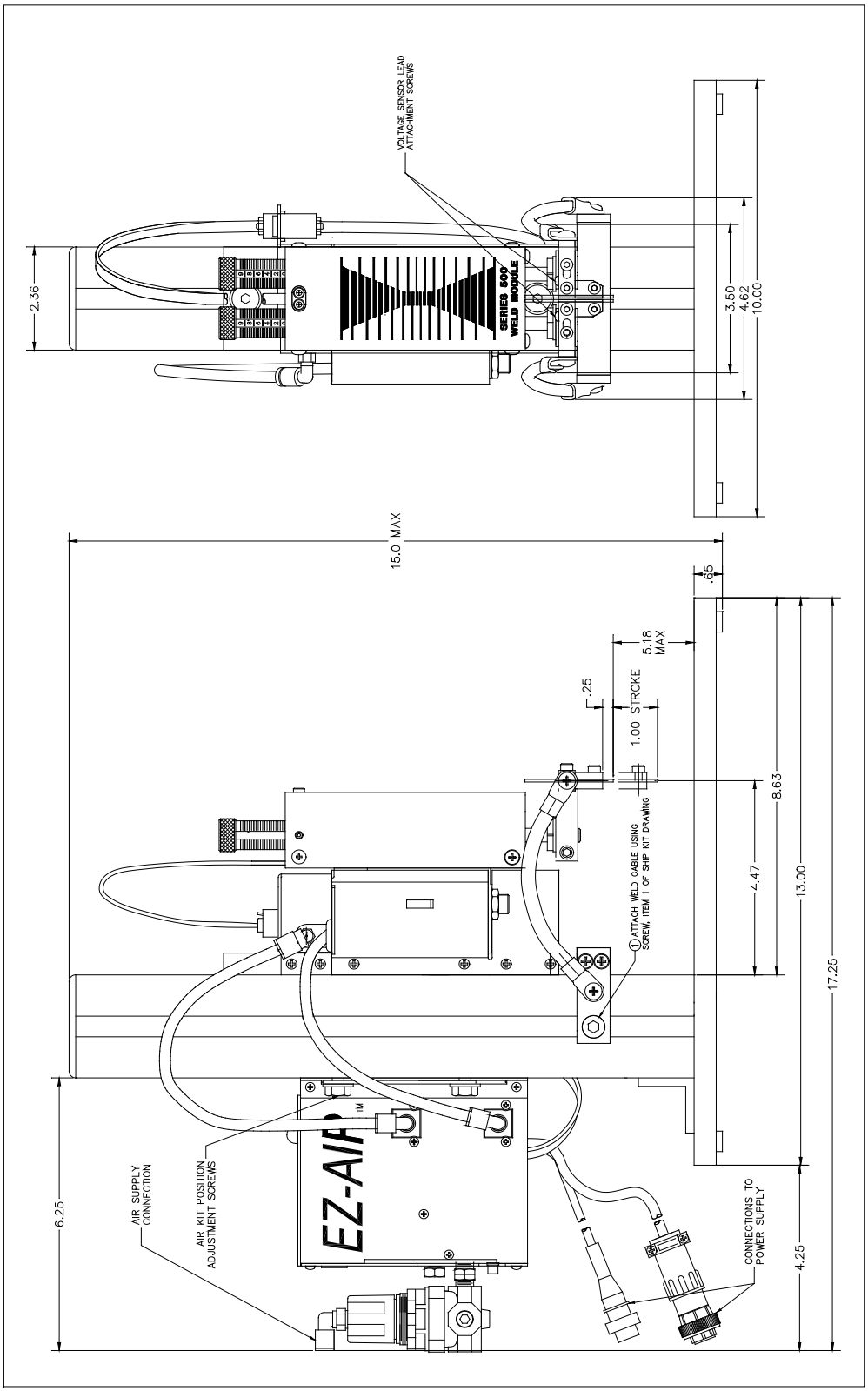

Figure A-1. Outline Drawing

APPENDIX B
THE BASICS OF RESISTANCE WELDING

Section I: General Data

Resistance Welding Parameters

Resistance welding heat is produced by passing electrical current through the parts for a fixed time period. The welding heat generated is a function of the magnitude of the weld current, the electrical resistance of the parts, the contact resistance between the parts, and the weld force applied to the parts. Sufficient weld force is required to contain the molten material produced during the weld. However, as the force is increased, the contact resistance decreases. Lower contact resistance requires additional weld current, voltage, or power to produce the heat required to form a weld.

1 The higher the weld force, the greater the weld current, voltage, power, or time required to produce a given weld. Low weld force usually results in lower bond strength. Increased weld force requires higher energy but usually results in a stronger bond. Weld Heat is proportional to the square of the welding current (I), the total electrical resistance (R_t), and the weld time (t) and is inversely proportional to the contact area (A). . Figure B-1 illustrates the effect of weld force on the parts.

Welding Parameter Interaction

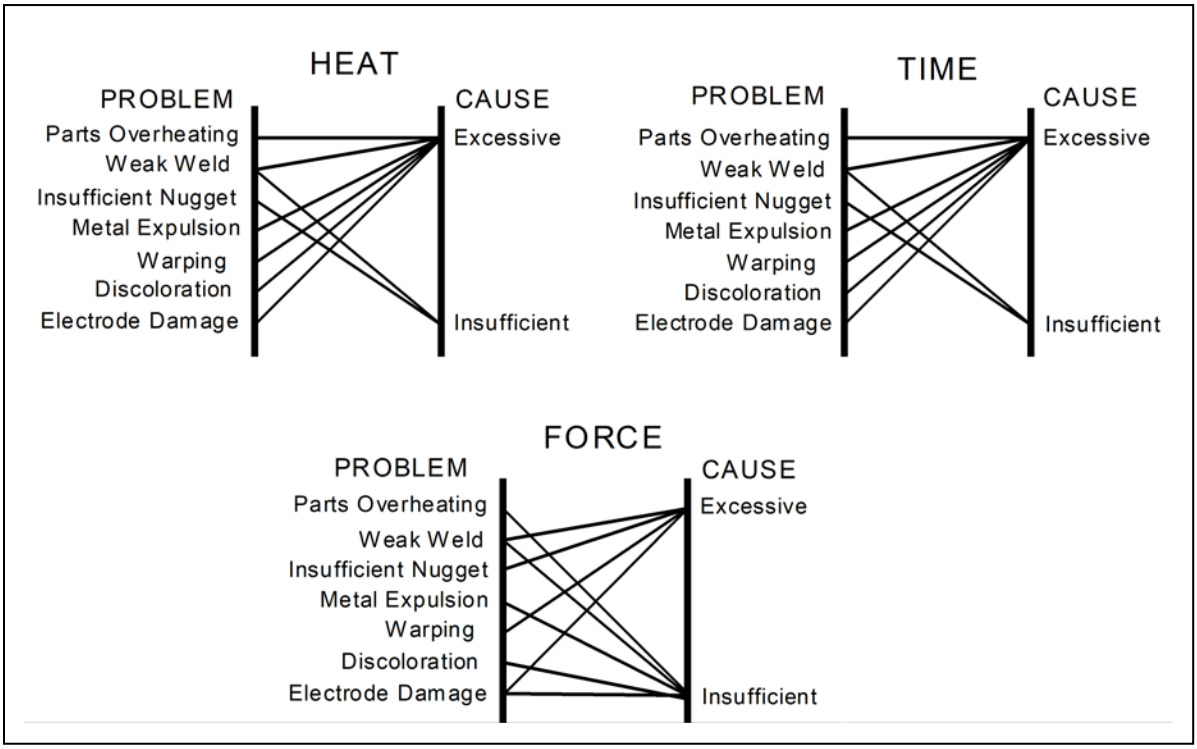

Figure B-1. Interaction of Welding Parameters

Electrode Selection

Correct electrode selection strongly influences how weld heat is generated in the weld area. In general, use conductive electrodes such as a RWMA-2 (Copper alloy) when welding electrically resistive parts such as nickel or steel so that the weld heat is generated by the electrical resistance of the parts and the contact resistance between the parts. Use resistive electrodes such as RWMA-13 (Tungsten) and RWMA-14 (Molybdenum) to weld conductive parts such as copper and gold because conductive parts do not generate much internal heat so the electrodes must provide external heat. Use the following Electrode Selection Table for selecting the proper electrode materials.

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Alumel	-2	Alumel	-2
Alumel	-2	Chromel	-2
Alumel	-2	Dumet	-2
Aluminum	-1	Aluminum	-1
Aluminum	-1	Aluminum Alloys	-1
Aluminum	-1	Cadmium Plating	-1
Aluminum	-1	Tinned Brass	-14
Aluminum	-1	Tinned Copper	-14
Aluminum	-1	Gold Plated Dumet	-2
Aluminum	-1	Gold Plated Kovar	-2
Aluminum	-1	Kovar	-2
Aluminum	-1	Magnesium	-1
Aluminum	-1	Cold Rolled Steel	-2
Aluminum	-1	Stainless Steel	-2
Beryllium Copper	-2	Beryllium Copper	-2
Beryllium Copper	-2	Brass	-2, -14
Beryllium Copper	-2	Copper	-14
Beryllium Copper	-2	Tinned Copper	-14
Beryllium Copper	-2	Nickel	-2

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Beryllium Copper	-2	Cold Rolled Steel	-2
Beryllium Copper	-2	Stainless Steel	-2
Brass	-2, -14	Brass	-2, -14
Brass	-2, -14	Tinned Brass	-14
Brass	-2, -14	Consil	-2
Brass	-2, -14	Constantan	-2
Brass	-2, -14	Copper	-14
Brass	-2, -14	Tinned Copper	-14
Brass	-2, -14	Dumet	-2
Brass	-2, -14	Nichrome	-2
Brass	-2, -14	Nickel	-2
Brass	-2, -14	NiSpan C	-2
Brass	-2, -14	Paliney 7	-2
Brass	-2, -14	Silver	-11, -14
Brass	-2, -14	Cold Rolled Steel	-2
Brass	-2, -14	Stainless Steel	-2
Bronze	-2, -11	Bronze	-2, -11
Bronze	-2, -11	Tinned Copper	-14
Bronze	-2, -11	Iron	-2
Bronze	-2, -11	Nichrome	-2
Bronze	-2, -11	Nickel	-2
Chromel	-2	Chromel	-2
Chromel	-2	Constantan	-2

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Chromel	-2	Copel	-2
Chromel	-2	Copper	-14
Chromel	-2	Tinned Copper	-14
Chromel	-2	Dumet	-2
Chromel	-2	Nichrome	-2
Chromel	-2	Cold Rolled Steel	-2
Consil	-2	Consil	-2
Consil	-2	Tinned Copper	-14
Consil	-2	Dumet	-2
Constantan	-2	Constantan	
Constantan	-2	Copper	-14
Constantan	-2	Tinned Copper	-14
Constantan	-2	Iron	-2
Constantan	-2	Nichrome	-2
Constantan	-2	Nickel	-2
Copper	-14	Copper	-14
Copper	-14	Dumet	-2
Copper	-14	Invar	-2
Copper	-14	Karme	-2
Copper	-14	Manganin	-2
Copper	-14	Nichrome	-2
Copper	-14	Nickel	-2
Copper	-14	Paliney 7	-2
Copper	-14	Silver	-11, -14
Copper	-14	Cold Rolled Steel	-2
Copper	-14	Stainless Steel	-2
Dumet	-2	Dumet	-2
Dumet	-2	Nichrome	-2
Dumet	-2	Nickel	-2
Dumet	-2	Platinum	-2
Dumet	-2	Cold Rolled Steel	-2
Evanohm	-14	Copper	-14

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Gold	-14	Gold	-14
Gold	-14	Kovar	-2
Hastalloy	-2	Titanium	-2
Inconel	-2	Inconel	-2
Inconel	-2	Kulgrid	-2
Invar	-2	Invar	-2
Iridium	-2	Iridium	-2
Iridium	-2	Platinum	-2
Iron	-2	Iron	-2
Karma	-2	Karma	-2
Karma	-2	Nickel	-2
Karma	-2	Platinum	-2
Kovar, Gold Plate	-2	Kovar, Gold Plate	-2
Kovar, Gold Plate	-2	Kulgrid	-2
Kovar, Gold Plate	-2	Nickel	-2
Kovar, Gold Plate	-2	Silver	-11, -14
Kovar, Gold Plate	-2	Stainless Steel	-2
Magnesium	-1	Magnesium	-1
Molybdenum	-2	Molybdenum	-2
Molybdenum	-2	Nickel	-2
Molybdenum	-2	Tungsten	-2
Nichrome	-2	Nichrome	-2
Nichrome	-2	Nickel	-2
Nichrome	-2	Cold Rolled Steel	-2
Nichrome	-2	Stainless Steel	-2
Nickel	-2	Nickel	-2
Nickel	-2	Cold Rolled Steel	-2
Nickel	-2	Stainless Steel	-2
Nickel	-2	Tantalum	-2
Nickel	-2	Tungsten	-2
Nickel Alloy	-2	Nickel Alloy	-2

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Nickel Alloy	-2	Tinned Brass	-14
Nickel Alloy	-2	Beryllium Copper	-2
Nickel Alloy	-2	Consil	-2
Nickel Alloy	-2	Tinned Copper	-14
Nickel Alloy	-2	Nichrome	-2
Nickel Alloy	-2	Nickel	-2
Nickel Alloy	-2	Cold Rolled Steel	-2
NiSpan C	-2	NiSpan C	-2
NiSpan C	-2	Cold Rolled Steel	-2
NiSpan C	-2	Stainless Steel	-2
Niobium	-2	Niobium	-2
Platinum	-2	Platinum	-2
Paliney 7	-2	Paliney 7	-2
Silver	-11, -14	Silver	-11, -14
Silver	-11, -14	Cadmium	-13

MATERIAL	ELECT RWMA TYPE	MATERIAL	ELECT RWMA TYPE
Silver	-11, -14	Cold Rolled Steel	-2
Silver	-11, -14	Stainless Steel	-2
Cold Rolled Steel	-2	Cold Rolled Steel	-2
Cold Rolled Steel	-2	Stainless Steel	-2
Cold Rolled Steel	-2	Tantalum	-2
Stainless Steel	-2	Stainless Steel	-2
Stainless Steel	-2	Tungsten	-2
Tantalum	-2	Tantalum	-2
Titanium	-2	Titanium	-2
Tungsten	-2	Tungsten	-2
Tungsten	-2	Henium	-2
Zinc	-14	Zinc	-14

Electrode Maintenance

Depending on use, periodic tip resurfacing is required to remove oxides and welding debris from electrodes. Cleaning of electrodes on the production line should be limited to use of #400-600 grit electrode polishing disks. For less critical applications, a file can be used to clean a badly damaged tip. However, after filing, polishing disks should then be used to ensure that the electrode faces are smooth. If this is not done, the rough surface of the electrode face will have a tendency to stick to the work piece.

Weld Schedule Development

Developing a weld schedule is a methodical procedure, which consists of making sample welds and evaluating the results. The first weld should be made at low energy settings. Adjustments are then made to each of the welding parameters ***one at a time*** until a successful weld is made.

1 Install the correct electrodes in the electrode holders on the Weld Head. See the preceding table for electrode material recommendations.

2 Use a flat electrode face for most applications. Use a "domed" face if surface oxides are a problem. If either of the parts is a wire, the diameter of the electrode face should be equal to or greater than the diameter of the wire. If both parts are flat, the face should be at least one-half the diameter of the electrodes. Pencil point electrodes cause severe electrode sticking to the parts, unexplained explosions, and increase the weld heat substantially because of the reduced electrode-to-part contact area.

3 Use the Force Adjustment Knob on the Weld Head to set the Firing Force and adjust the EZ-AIR per the detailed instructions found in Chapter 3: Operating Instructions. Figure B-1 illustrates the effect of weld force on the parts.

4 Refer to the recommendations in Chapter 3, Operating Instructions, to make your first weld. Always observe safety precautions when welding and wear safety glasses.

5 Use pliers to peel the welded materials apart. A satisfactory weld will show residual material pulled from one material to the other. Tearing of base material around the weld nugget indicates a material failure NOT a weld failure. Excessive electrode sticking and/or "spitting" should define a weld as unsatisfactory and indicates that too much weld current, voltage, power, or time has been used.

6 If the parts pull apart easily or there is little or no residual material pulled, the weld is weak. Increase the weld time in 1ms increments. Increase weld current, voltage, or power if a satisfactory weld achieved using 10ms of weld time.

Note: Actual weld strength is a user-defined specification.

7 Polarity, as determined by the direction of weld current flow, can have a marked effect on the weld characteristics of some material combinations. This effect occurs when welding materials with large differences in resistivity, such as copper and nickel or when welding identical materials with thickness ratios greater than 4 to 1. The general rule is that the more resistive material or the thinner material should be placed against the negative (-) electrode. Polarity on the power supply can only be changed by reversing the weld cables.

Weld Strength Testing

Destructive tests should be performed on a random basis using actual manufacturing parts. Destructive tests made on spot welds include tension, tension-shear, peel, impact, twist, hardness, and macro-etch tests. Fatigue tests and radiography have also been used. Of these methods torsional shear is preferred for round wire and a 45-degree peel test for sheet stock.

Weld Strength Profiles

Creating a weld strength profile offers the user a scientific approach to determining the optimum set of welding parameters and then displaying these parameters in a graphical form.

1 Start at a low weld current, voltage, or power, making five or more welds, then perform pull tests for each weld. Calculate the average pull strength. Increase weld current, voltage, or power and repeat this procedure. Do not change the weld time, weld force, or electrode area.

2 Continue increasing weld current, voltage, or power until any unfavorable characteristic occurs, such as sticking or spitting.

3 Repeat steps 1 and 2 for different weld forces, then create a plot of part pull strength versus weld current, voltage, or power for different weld forces as shown in Figure B-2.

4 Repeat steps 1 through 3 using a different but fixed weld time.

Figure B-2 illustrates a typical weld strength profile. The 14 lb electrode force curve shows the highest pull strengths but the lowest tolerance to changes in weld current, voltage, or power. The 12 lb electrode force curve shows a small reduction in pull strength, but considerably more tolerance to changes in weld energy. Weld heat will vary as a result of material variations and electrode wear.

The 12 lb electrode force curve is preferred. It shows more tolerance to changes in weld current, voltage, or power and has nearly the same bond strength as the 14 lb electrode force curve.

A comparison of weld schedules for several different applications might show that they could be consolidated into one or two weld schedules. This would have obvious manufacturing advantages.

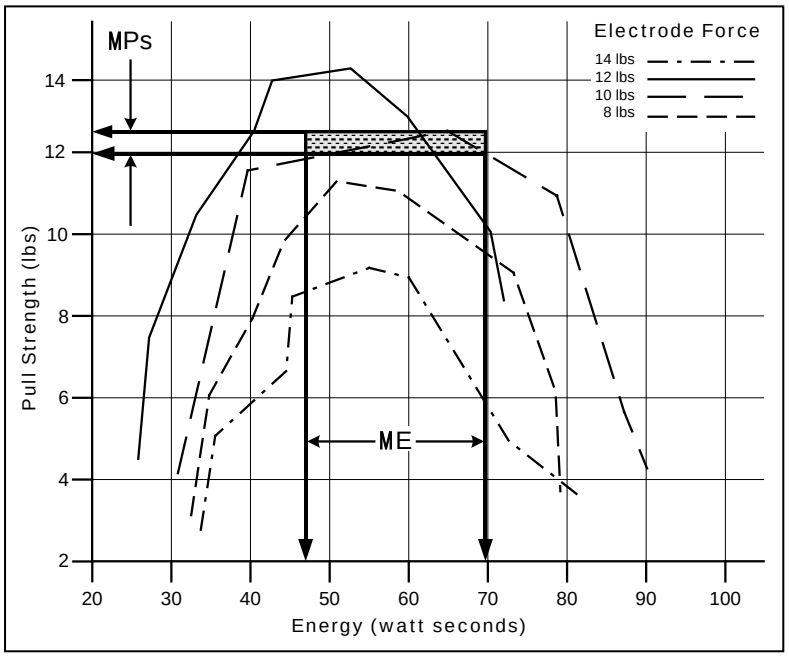

Figure B-2. Typical Weld Strength Profile Chart

Section II: Basic Principles of Resitance Welding For Battery Pack Manufacture.

Two requirements must be met in order to form a weld. First, the oxide layer covering the surface of the metals must be displaced. Second, the irregular surfaces must be brought into intimate contact with each other. Resistance welding uses a combination of heat, time and pressure. Electrode pressure is used to force the materials together and controls the resistance between the two. Heat is generated by the resistance of the work pieces to the flow of electricity. When the current flow stops and the electrode force is maintained, the weld or molten zone is cooled and solidifies. A nugget is formed.

Refer to figure B-3. At the beginning of the weld the relatively rough surfaces of the metals when forced together form peaks. On the peaks where the contact pressure is sufficiently high, the oxide layer breaks down, forming metal to metal bridges. The weld current is distributed over a large area as it passes through the bulk metal (R5 and R8 in the example). As the current approaches the interface (R6 and R7) it is forced to flow through the metallic bridges. This “necking” down increases the current density, generating enough heat to cause melting. As the bridges melt, the resistance of the molten metal becomes higher than that of the new remaining bridges and the current flow transfers from bridge to bridge. This process continues until the entire surface is molten or until the current flow stops and the electrodes rapidly cool the metal.

Note: In the example there is significantly less resistance in path R1, R3, R5, R4, and R2 for current to flow than in current flowing though into R6, R8 and R7. Therefore the majority of the welding current shunts across the tab in the example given.

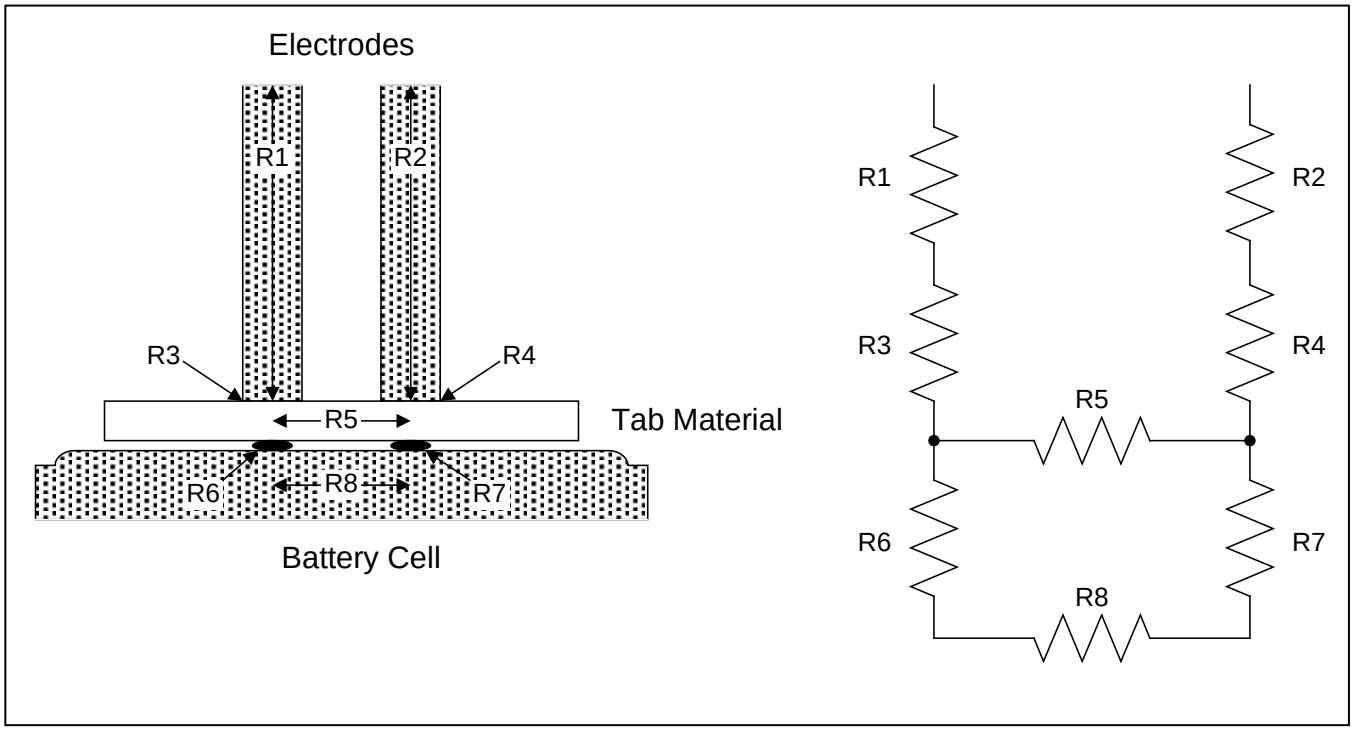

Figure B-3. Actual and Schematic Representation of Resistance Welding

Process Variables

Successful battery welding depends primarily on controlling four variables: materials, energy, time and force. Secondary factors include positioning, electrode diameter and shape, and finally operator training. Many users tend to focus on the energy and time variable to the exclusion of materials and the other secondary variables. Consistent positioning and good material and part design are vital to achieving a quality robust process.

Material Control

There are five main types of tab materials used in the battery industry:

- Pure nickel (Ni 200)
- Cold rolled steel (CRS)
- Ni plated CRS
- Ni plated CRS with brighteners
- Diffusion – annealed Ni plated CRS

Nickel 200 and cold rolled steel are easily welded, but nickel 200 is more expensive and cold rolled steel does not protect the material from oxide build up. Nickel plated steel is an obvious way to cut costs, but its use will not guarantee good results, particularly if brightening treatments are applied to either the tab or the cell.

Energy and Time Control

There are four main power supply technologies used for battery pack manufacture:

- Capacitor Discharge – open loop.
- AC (alternating current) – open loop.
- High Frequency Inverter – closed loop.
- Linear DC – closed loop.

In general all welding technologies are capable for battery pack manufacture. Capacitor discharge technology provides fast rise time and short weld time, which is ideal for many applications (repetition rates can be an issue for faster high-energy welds). AC or alternating current is a very flexible technology for many applications but lacks fine energy control and resolution of time control for more critical applications. Inverter and linear DC welding technology is preferred for critical applications that require the highest quality and repeatability. The closed loop feedback control can compensate for minor part and positional variables. A typical battery weld of 0.005" tab to cell will require between 1500 and 2100 amperes for 2-4 milliseconds.

Force Control

Force control is very important in the process as it controls resistance values R3, R6, R7, and R4. If too little force is applied Resistances R3 and R4 will be too high. This will cause the heat generated at these points to be high and will result in weld splash, electrode sticking and weak welds. If the force set is too high the resistances R6 and R7 will become too low. This will cause heat generation to be low and will result in weak welds. There needs to be enough force applied to minimize the contact resistances R3 and R4 while maintaining enough resistance at R6 and R7 to form sufficinet weld nuggets. A good starting point is 3-4 pounds force per electrode. Force may have to be adjusted for the positive and negative electrodes if polarity causes unequal nugget dimensions.

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