XRC Controller

Robotic Arc Welding Manual for
Kobelco AL350

Part Number 145958-1

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SECTION 1

INTRODUCTION

1.1 Scope of this Document

This manual contains information regarding the aluminum welding system manufactured by Motoman, Inc. of West Carrollton, Ohio. It includes procedures for proper use, operation, and maintenance of the welding system. The manual is divided into the following sections:

SECTION 1 – INTRODUCTION

Provides general information regarding this manual, descriptions of the welding system and its components, technical specifications, installation, a list of reference documents, and customer service information.

SECTION 2 – SAFETY

Describes the conventions used to identify precautionary text throughout this manual. The section also contains a list of general cautions and warnings that apply to many of the procedures described in this manual.

SECTION 3 – THEORY OF OPERATION

Provides general principles of aluminum welding. The discussion identifies specific problems and requirements, how the welding system works, and how it addresses the specific requirements of aluminum welding.

SECTION 4 – OPERATION

Provides instructions for the proper use and operation of the aluminum welding system. Instructions provided include procedures to prepare the system for use, controls and indicators, and instructions for creating arc taper enhanced conditions.

SECTION 5 – TROUBLESHOOTING

The information provided in this section helps the user identify and remedy problems found during operation and welding.

SECTION 6 – CALIBRATION

Provides instructions for the calibration of the aluminum welding system appear in this section. These instructions relate specifically to the calibration of the Kobelco welder and wire feed unit.

APPENDICES

Appendix A - Spare Parts/Consumable Parts
Appendix B - Diagrams
Appendix C - Calibration Forms
Appendix D - SENSARC AL350 Technical Report
Appendix E - Modifying the AL-350 for Semi-automatic Operation
Appendix F - Vendor Manuals
1.2 **System Configuration**

The aluminum welding system is an integrated package of tools and components designed to meet the specific requirements of aluminum welding. System configuration is shown in Figure 1-1.

![Typical Aluminum Welding System Diagram](image)

*Figure 1-1  Typical Aluminum Welding System*
The system includes the following components and optional equipment

- Motoman robot manipulator (UP6, UP20) and XRC controller
- Welding equipment, including the following:
  - Kobelco SENSARC® AL350 welding power source, with wire feeder
  - Water-cooled Motoman Tough Gun torch, with voltage sensing lead
  - Wire Spool Dereeler Kit
  - 30 KVA Transformer

Options for the aluminum welding system include:

- Water circulator
- Nozzle cleaner
- Bulk wire delivery package

The XRC controls the operation of the aluminum welding system. It coordinates the operation of the various system components. The XRC executes instruction sequences provided in a job file. As the XRC steps through the series of instructions, it directs the movement of the torch, controls the positioner, and operates the welding power supply.

The robot moves the welding torch and supply lines through a series of programmed steps. The XRC controls the speed, direction, and position of the robot as it moves from point to point.

The XRC communicates weld signals through a cable to an interface board (XEW02) mounted in the welder cabinet. The XRC sends the AL-350 analog voltages for amperage, voltage, and penetration control, along with a signal to energize the contactor to weld. The Kobelco AL-350 communicates to the XRC when the arc is established, when there is a fault condition, or when the wire is stuck to the puddle. The gas solenoid is wired to an output to allow pre- and post-purge capability.

A handheld remote control unit is also provided with the AL-350, which allows remote control of the welder for hand welding applications. Appendix E contains instructions for modifying the AL-350 for use with a remote control unit.

1.3 System Components

In the following paragraphs you will find brief descriptions of each of the aluminum welding system components. Figure 1-1 shows a typical system layout.

1.3.1 XRC Controller

The XRC provides the following basic functions:

- Power ON
- Job creation
- Playback
- Process control
- Power OFF
From the XRC operator's panel you can perform the following tasks:

- Turn on servo power
- Select cycle mode
- Start and hold automatic operation

In addition, the XRC provides the following capabilities:

- Connection to external devices through the XRC RS232 serial interface port
- Input/output signal processing

Included with the XRC is a YASNAC XRC programming pendant which is used to operate the manipulator and teach the robot series of motions and operations. Use the programming pendant to perform the following tasks:

- Input and edit motion data
- Input and edit process data

The XRC also monitors the status of the system components. Various safety features of the aluminum welding system and the associated cell operate through the XRC. Under emergency conditions the XRC controls the shutdown of the system.

The XRC is equipped with enhanced welding software functions designed to control heat flow when welding aluminum. These functions can be activated and used for MIG welding applications.

### 1.3.2 Kobelco Sensarc AL-350 Power Supply

The Kobelco Sensarc AL-350 is a variable polarity (AC-pulsed) gas metal arc welding power source designed to permit control of the penetration of aluminum welding and burn-through. Use of reverse polarity, electrode positive (DCEP) [and occasionally straight polarity, electrode negative (DCEN)] is common in the welding industry. However, when welding thin materials, reverse polarity welding often results in burn-through and sound joints are hard to obtain, which impedes productivity. Straight polarity welding produces extremely shallow penetration, which prevents burn-through, but insufficient penetration often occurs, which limits applications.

The Kobelco power source alternately repeats the DCEP pulse current and the DCEN current to weld thin materials. Controlling the ratio of these two polar currents enables the free selection of penetration depth at the same setting as the wire feed rate.

### 1.3.3 Wire Feeding System

The Kobelco Sensarc wire feed system is controlled by the power supply and consists of the following components:

- Kobelco 4-roll wire feeder
- Torch adapter block
CAUTION!
The spool holder on the robot arm is only rated for 16 lb. aluminum spools. Do not mount steel wire spools on the upper arm or damage to equipment may result.

- Mounting bracket and spool holder
- Motoman Water-cooled Tough Gun Torch, with voltage sensing wire

The system handles 3/64" and 1/16" aluminum wire.

1.3.4 Robot
The aluminum welding system includes either a SK6 or SK16 Motoman industrial robot. Each of these uses a six-axis manipulator.

The UP6 manipulator has a payload of 6 Kg (13.2 lb). The UP6 robot features a 1,373 mm (54.06 in) reach, and has a relative positioning accuracy of ±0.08 mm (±0.003 in).

The UP20 manipulator has a payload of 20 Kg (44.1 lb). The UP20 robot features a 1658 mm (65.28 in) reach, and has a relative positioning accuracy of ±0.08 mm (±0.003 in).

Each robot can reach below its own base, and can travel in an arc approximately 340° around the base. These robots can be floor, wall (UP6 must have brakes if wall mounted), or ceiling mounted. Motoman UP-Series robots use brushless AC motors with absolute position encoders. A combination of capacitance and lithium batteries in both robot and XRC encoder assemblies protects program position data for up to a year without power. The life expectancy for the lithium battery is approximately three years.

Power for the robot manipulator is supplied through the XRC. A 4.5 KVA isolation transformer converts the 230/460 V delta input to a 208 V wye output.

Refer to your Motoman robot manipulator manual for more information.

1.3.5 Water Circulator
The water circulator supplies cooling water to the Motoman torch. This unit can supply coolant to the welding torch from up to 25 to 30 feet away. The water circulator motor and pump are enclosed in a hood. The bronze water pump is a rotary gear type with a stainless steel shaft. The pump discharge has a safety relief valve that bypasses the welding torch when discharge back pressure exceeds a predetermined setting.

1.3.6 Work Cell
A complete system typically includes certain work cell components. These components are not properly part of the aluminum welding system, but rather related items supplied separately. Some of these items are safety mats, interlocks, arc screens, fencing, and positioners. The number and type of components required depend on your specific application.
### 1.4 Equipment and Component Specifications

Specifications for the aluminum welding system and its components are listed in Table 1-1. Additional information is provided in the various vendor manuals supplied with the system.

**Table 1-1 Equipment and Component Specifications**

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<tr>
<td><strong>Power Requirements</strong></td>
<td>Generally pure Argon&lt;br&gt;12.8A at 230V AC, 3 Phase 6.3A at 460V AC, 3 Phase 60.0A at 200V AC, 3 Phase, 50/60 Hz., input cable 14 mm² (#6AWG), input line variations ±10 % (for all line voltages)</td>
</tr>
<tr>
<td><strong>Operating Environment</strong></td>
<td>0 - 40 °C&lt;br&gt;20 - 80 % (non-condensing)&lt;br&gt;Less than 0.5 G&lt;br&gt;Free from corrosive gases or liquids, explosive gases, and excessive electrical noise</td>
</tr>
<tr>
<td><strong>Kobelco Sensarc AL-350</strong></td>
<td>350A at 60%&lt;br&gt;270A at 100%</td>
</tr>
<tr>
<td><strong>Sensarc Wire Feed Unit</strong></td>
<td>Max. 16 m/min (529 ipm)&lt;br&gt;1.2 mmØ - 1.6 mmØ (3/64 inch – 1/16 inch)</td>
</tr>
<tr>
<td><strong>Motoman Tough Gun Torch</strong></td>
<td>450A - CO₂&lt;br&gt;400A - AR, AR/O₂, AR/CO₂&lt;br&gt;(based on the following:&lt;br&gt;Power supply output U=14+0.05xI&lt;br&gt;Water flow 0.9 l/min minimum&lt;br&gt;Watercooler rating of 1900 W&lt;br&gt;at 2 l/min at 22 °C ambient)</td>
</tr>
<tr>
<td><strong>Square D 30 KVA Transformer</strong></td>
<td>480/460V, 3-phase&lt;br&gt;208V, 3-phase</td>
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<tr>
<td><strong>Water Circulator</strong></td>
<td>115V AC (230V AC optional), 50/60 Hz&lt;br&gt;3 Gal.&lt;br&gt;Continuous operation for at least three hours at full rated current.&lt;br&gt;Duty cycle is based on a coolant temperature rise of 37 °C (66 °F) above a 23 °C (74 °F) ambient.</td>
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</table>
1.5 **Installation**

The Motoman aluminum welding system is shipped with the torch and wire feeder installed on the robot. Standard installation instructions (for robot, XRC, work cell, and common base) are located in the system manual shipped with your particular system. The instructions provided here are specific to the installation of the aluminum welding system. Refer to Figure 1-1 for a typical aluminum welding system interconnection diagram.

1.5.1 **Installing Power and Grounding the System**

**CAUTION!**

*Supply voltage must be within the range shown in Table 1-1. Exceeding this range could damage equipment.*

The aluminum welding system uses a 30 KVA transformer to "step down" the 480/460V supply voltage from the plant main power supply to the 208 V input needed for the Kobelco welding power supply. Below are instructions for installing power from the transformer to the power supply. Detailed instructions for grounding your World system (including the positioner and earth ground) are located in the system manual provided with your particular system.

**NOTE:** Stepdown transformers (such as Square D transformers) usually have primary taps ± 5 for adjusting to primary voltages. If 400-volt input is either high or low, use the primary tap to select the nearest actual voltage used.

1. Ensure main power is disconnected at main power distribution box.
2. Power input terminals and ground terminal are located behind access panel on the right side of the power supply. Remove top cover and right access panel.
3. Insert 3-phase input cables and grounding cable (Item J, Figure 1-1) from transformer through access hole in rear panel of power supply.

4. Install input power and grounding cables, as shown in Figure 1-2.

![Figure 1-2 Installing Input Power](image-url)
1.5.2 Connecting the Welding Cables

The location and length of the welding cables are very important to the optimum performance of the Kobelco aluminum welding system. Keep welding cables as short as possible and as close together as possible. If possible, tie weld cables together and split apart at last possible point. Do not coil excess cable, as this will affect performance.

1. Connect the (+) welding power cable (Item D, Figure 1-1) from the positive terminal on the welding power source to the power plug adapter on the front of the wire feeder (see Figure 1-3).

2. Connect (-) welding power cable (Item M, Figure 1-1) from the negative terminal on the welding power source to the positioner (see Figure 1-3).

1.5.3 Connecting the Voltage Detection Cables

The Kobelco power source requires the use of two voltage sensing cables, one to monitor the voltage at the torch and one to monitor the voltage at the work. It is important to connect the voltage detection cables correctly, as the power supply uses feedback from the cables to control the output current, voltage, and arc condition. Incorrect placement will result in open circuit voltage to the torch, no arc at wire (wire will curl), or bad welds.

The Motoman Tough Gun torch is shipped with a positive voltage detection wire already installed in the torch block, as close to the arc voltage as possible. The other end of this 18-gauge wire protrudes from the rear of the torch.

1. To finish installing the torch voltage detection, connect the feeder cable (Item H, Figure 1-1) from the wire feed connection on the power source to the connection on the rear of the wire feeder (see Figure 1-3). Connect the 18-gauge wire (gray/green with Nichifu connector) from the power source cable to the 18-gauge voltage detection wire protruding from the rear of the torch. Run the torch voltage detection cable as close to the wire feed power cable as possible.
2. Connect the negative voltage detection cable (Item L, Figure 1-1), to the positioner, as close to the work as possible (see Figure 1-3). This location should have the same weld potential as the welding circuit. Run this cable as close to the positioner power cable as possible. **Do not connect this cable to the same point as the weld ground.**

### 1.5.4 Connecting Welder to the XRC

1. Connect the Weldco control cable (Item K, Figure 1-1) from the power source to the panel on the right side of the XRC.

2. Connect the inch/reverse cable (Item C, Figure 1-1) from the power source to the panel on the right side of the XRC.

### 1.5.5 Connecting the Water and Gas Hoses

The aluminum welding system uses a water circulator to cool the torch barrel and improve tip life. Fill water circulator with antifreeze mixed with distilled water.

**CAUTION!**

*Use only the antifreeze provided by Motoman. Automotive antifreeze contains stop-leak additives that will clog the small torch water-cooling ports and damage the gaskets in the pump.*

Two water hoses (one red and one blue) are already connected to the rear of the torch.

1. Connect blue WATER-OUT hose (Item A, Figure 1-1) from the torch to the connection on the water circulator marked WATER-OUT.

2. Connect red WATER-IN hose (Item B, Figure 1-1) from the torch to the connection on the water circulator marked WATER-IN.

3. Connect the gas hose (Item E, Figure 1-1) from the torch to the gas supply.

### 1.6 Reference to Other Documentation

For additional information refer to the following:

- Motoman UP6 Manipulator Manual (P/N 142104-1)
- Motoman UP20 Manipulator Manual (P/N 144342-1)
- Motoman Operator's Manual for Arc Welding (P/N 142098-1)
- Tregaskiss Tough Gun Technical Guide for Water-Cooled Robotic Quick-Change MIG Guns

### 1.7 Customer Service Information

If you are in need of technical assistance, contact the Motoman service staff at (937) 847-3200. Please have the following information ready before you call:

- Robot Type (UP6, UP20, etc.)
- System Number (located on the cover page of this manual)
- Robot Serial Number (located on the back side of the robot arm)
- Application Type (palletizing, welding, handling, etc.)
SECTION 2
SAFETY

2.1 Introduction

It is the purchaser’s responsibility to ensure that all local, county, state, and national codes, regulations, rules, or laws relating to safety and safe operating conditions for each installation are met and followed.

We suggest that you obtain and review a copy of the ANSI/RIA National Safety Standard for Industrial Robots and Robot Systems. This information can be obtained from the Robotic Industries Association by requesting ANSI/RIA R15.06. The address is as follows:

Robotic Industries Association
900 Victors Way
P.O. Box 3724
Ann Arbor, Michigan 48106
TEL: (734) 994-6088
FAX: (734) 994-3338

Ultimately, the best safeguard is trained personnel. The user is responsible for providing personnel who are adequately trained to operate, program, and maintain the robot cell. The robot must not be operated by personnel who have not been trained!

We recommend that all personnel who intend to operate, program, repair, or use the robot system be trained in an approved Motoman training course and become familiar with the proper operation of the system.

This safety section addresses the following:

- Standard Conventions (Section 2.2)
- General Safeguarding Tips (Section 2.3)
- Mechanical Safety Devices (Section 2.4)
- Installation Safety (Section 2.5)
- Programming Safety (Section 2.6)
- Operation Safety (Section 2.7)
- Maintenance Safety (Section 2.8)
2.2 Standard Conventions

This manual includes information essential to the safety of personnel and equipment. As you read through this manual, be alert to the four signal words:

- DANGER
- WARNING
- CAUTION
- NOTE

Pay particular attention to the information provided under these headings which are defined below (in descending order of severity).

⚠️ DANGER!

Information appearing under the DANGER caption concerns the protection of personnel from the immediate and imminent hazards that, if not avoided, will result in immediate, serious personal injury or loss of life in addition to equipment damage.

⚠️ WARNING!

Information appearing under the WARNING caption concerns the protection of personnel and equipment from potential hazards that can result in personal injury or loss of life in addition to equipment damage.

⚠️ CAUTION!

Information appearing under the CAUTION caption concerns the protection of personnel and equipment, software, and data from hazards that can result in minor personal injury or equipment damage.

NOTE: Information appearing in a NOTE caption provides additional information which is helpful in understanding the item being explained.
2.3 General Safeguarding Tips

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. All personnel involved with the operation of the equipment must understand potential dangers of operation. General safeguarding tips are as follows:

- Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation of this robot, the operator's manuals, the system equipment, and options and accessories should be permitted to operate this robot system.

- Do not enter the robot cell while it is in automatic operation. Programmers must have the teach pendant when they enter the robot cell.

- Improper connections can damage the robot. All connections must be made within the standard voltage and current ratings of the robot I/O (Inputs and Outputs).

- The robot must be placed in Emergency Stop (E-STOP) mode whenever it is not in use.

- In accordance with ANSI/RIA R15.06, section 6.13.4 and 6.13.5, use lockout/tagout procedures during equipment maintenance. Refer also to Section 1910.147 (29CFR, Part 1910), Occupational Safety and Health Standards for General Industry (OSHA).

2.4 Mechanical Safety Devices

The safe operation of the robot, positioner, auxiliary equipment, and system is ultimately the user's responsibility. The conditions under which the equipment will be operated safely should be reviewed by the user. The user must be aware of the various national codes, ANSI/RIA R15.06 safety standards, and other local codes that may pertain to the installation and use of industrial equipment. Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location. The following safety measures are available:

- Safety fences and barriers
- Light curtains
- Door interlocks
- Safety mats
- Floor markings
- Warning lights

Check all safety equipment frequently for proper operation. Repair or replace any non-functioning safety equipment immediately.
2.5 Installation Safety

Safe installation is essential for protection of people and equipment. The following suggestions are intended to supplement, but not replace, existing federal, local, and state laws and regulations. Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location. Installation tips are as follows:

- Be sure that only qualified personnel familiar with national codes, local codes, and ANSI/RIA R15.06 safety standards are permitted to install the equipment.
- Identify the work envelope of each robot with floor markings, signs, and barriers.
- Position all controllers outside the robot work envelope.
- Whenever possible, install safety fences to protect against unauthorized entry into the work envelope.
- Eliminate areas where personnel might get trapped between a moving robot and other equipment (pinch points).
- Provide sufficient room inside the workcell to permit safe teaching and maintenance procedures.

2.6 Programming Safety

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. All personnel involved with the operation of the equipment must understand potential dangers of operation. Programming tips are as follows:

- Any modifications to PART 1 of the XRC controller PLC can cause severe personal injury or death, as well as damage to the robot! Do not make any modifications to PART 1. Making any changes without the written permission of Motoman will VOID YOUR WARRANTY!
- Some operations require standard passwords and some require special passwords. Special passwords are for Motoman use only. YOUR WARRANTY WILL BE VOID if you use these special passwords.
- Back up all programs and jobs onto a floppy disk whenever program changes are made. To avoid loss of information, programs, or jobs, a backup must always be made before any service procedures are done and before any changes are made to options, accessories, or equipment.
- The concurrent I/O (Input and Output) function allows the customer to modify the internal ladder inputs and outputs for maximum robot performance. Great care must be taken when making these modifications. Double-check all modifications under every mode of robot operation to ensure that you have not created hazards or dangerous situations that may damage the robot or other parts of the system.
- Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation, manuals, electrical design, and equipment interconnections of this robot should be permitted to operate the system.
• Inspect the robot and work envelope to be sure no potentially hazardous conditions exist. Be sure the area is clean and free of water, oil, debris, etc.

• Be sure that all safeguards are in place.

• Check the E-STOP button on the teach pendant for proper operation before programming.

• Carry the teach pendant with you when you enter the workcell.

• Be sure that only the person holding the teach pendant enters the workcell.

• Test any new or modified program at low speed for at least one full cycle.

2.7 Operation Safety

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. All personnel involved with the operation of the equipment must understand potential dangers of operation. Operation tips are as follows:

• Be sure that only trained personnel familiar with the operation of this robot, the operator's manuals, the system equipment, and options and accessories are permitted to operate this robot system.

• Check all safety equipment for proper operation. Repair or replace any non-functioning safety equipment immediately.

• Inspect the robot and work envelope to ensure no potentially hazardous conditions exist. Be sure the area is clean and free of water, oil, debris, etc.

• Ensure that all safeguards are in place.

• Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation, manuals, electrical design, and equipment interconnections of this robot should be permitted to operate the system.

• Do not enter the robot cell while it is in automatic operation. Programmers must have the teach pendant when they enter the cell.

• The robot must be placed in Emergency Stop (E-STOP) mode whenever it is not in use.

• This equipment has multiple sources of electrical supply. Electrical interconnections are made between the controller, external servo box, and other equipment. Disconnect and lockout/tagout all electrical circuits before making any modifications or connections.

• All modifications made to the controller will change the way the robot operates and can cause severe personal injury or death, as well as damage the robot. This includes controller parameters, ladder parts 1 and 2, and I/O (Input and Output) modifications. Check and test all changes at slow speed.
2.8 Maintenance Safety

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. All personnel involved with the operation of the equipment must understand potential dangers of operation. Maintenance tips are as follows:

• Do not perform any maintenance procedures before reading and understanding the proper procedures in the appropriate manual.

• Check all safety equipment for proper operation. Repair or replace any non-functioning safety equipment immediately.

• Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation, manuals, electrical design, and equipment interconnections of this robot should be permitted to operate the system.

• Back up all your programs and jobs onto a floppy disk whenever program changes are made. A backup must always be made before any servicing or changes are made to options, accessories, or equipment to avoid loss of information, programs, or jobs.

• Do not enter the robot cell while it is in automatic operation. Programmers must have the teach pendant when they enter the cell.

• The robot must be placed in Emergency Stop (E-STOP) mode whenever it is not in use.

• Be sure all safeguards are in place.

• Use proper replacement parts.

• This equipment has multiple sources of electrical supply. Electrical interconnections are made between the controller, external servo box, and other equipment. Disconnect and lockout/tagout all electrical circuits before making any modifications or connections.

• All modifications made to the controller will change the way the robot operates and can cause severe personal injury or death, as well as damage the robot. This includes controller parameters, ladder parts 1 and 2, and I/O (Input and Output) modifications. Check and test all changes at slow speed.

• Improper connections can damage the robot. All connections must be made within the standard voltage and current ratings of the robot I/O (Inputs and Outputs).
SECTION 3

THEORY OF OPERATION

This section covers the theory of operation of the overall aluminum welding system and specifically discussing the following items:

- Gas metal arc welding (GMAW) applications;
- Properties of aluminum and the effects these properties have on the welding process;
- Features of the aluminum welding system that address specific problems or concerns involved in the welding process;
- The Kobelco dual inverter, AC GMAW power source and wire feed system.

3.1 General System Operation

The Kobelco Sensarc AL 350 is a spray pulse machine designed to transfer one droplet of metal across the arc with each pulse cycle. The frequency of pulsing is determined by constant monitoring of actual arc conditions rather than programmable pulse conditions. The result of this constant monitoring of the conditions of the droplets and arc – combined with a voltage sensing wire that constantly monitors welding voltage across the contact tip and base metal – is current waveform control.

Waveform control ensures efficient arc-start and arc-end. At the end of a weld, the power source controls the current according to the gradually reducing wire speed. When the arc becomes longer than the determined length, the power source interrupts current and waits until the next short circuit. When the next short circuit occurs, the current is turned on again to break the bridge. This procedure is repeated until the wire stops and prevents a droplet from growing at the wire end.

Spatter generation frequently occurs when arc strikes just after the droplet, causing a short circuit to the molten pool, or at the moment droplet transfer in completed and the arc restrikes. In either case, the strong force at the moment of the arc striking, which blows off the droplet or molten pool, is the main cause of spatter. To lower the amount of spatter, the Kobelco lowers the welding current at the moment the droplet causes a momentary short circuit to the molten pool or at the moment the arc restrikes.

The AL350 provides AC current for MIG welding. Most MIG welding is done DCEP (reverse polarity) which provides deep penetration into the workpiece. DCEN (straight polarity) provides higher deposition, but the bead is convex and does not penetrate the base metal. The AL350 has penetration control which varies the ratio of DCEN to DCEP polarity. This capability allows welding thinner materials (down to 1.0 mm), extended gap conditions (about 1 x thickness), and higher travel speeds without burn through. (Refer to paragraph 3.2.2 for more details on AC pulsed MIG metal transfer.)

The Kobelco Sensarc receives welding current, voltage, and penetration control commands between zero and 14 volts from the robot control panel, and according to the control command, automatically adjusts welding current, voltage, and penetration. Refer to Figure 3-1 for a schematic of the robot interface inputs and outputs.
.3.2 Gas Metal Arc Welding

The gas-metal arc welding process establishes an arc between a continuously fed filler metal electrode and the weld pool. To accomplish this, the electrode must feed into the arc at a rate equal to that at which the electrode melts. The heat from the arc melts the surface of the base metal and the end of the electrode. The molten metal from the electrode transfers through the arc to the work piece where it becomes deposited weld metal. Under ideal conditions, the length of the arc between the tip of the electrode and the weld pool remains constant.
An envelope of externally supplied inert gas or gas mixture shields the arc. The shielding gas surrounds the arc area to protect it from atmospheric contamination. Figure 3-2 illustrates the gas-metal arc welding (GMAW) process. The GMAW system automatically maintains the welding arc, feeds the electrode wire into the arc, and controls the travel and guidance of the welding torch.

![Diagram of Gas-Metal Arc Welding](image)

**Figure 3-2  Gas-Metal Arc Welding**

### 3.2.1 The Consumable Electrode Welding Arc

The main function of the arc is to produce the heat required for the welding process. The arc also produces a bright light, noise, and ionic bombardment which removes oxides from the surface of the base metal. The consumable electrode welding arc is a sustained, high current, low voltage, electrical discharge through a highly conductive plasma. It produces enough thermal energy to join metals by fusion.

Figure 3-3 shows the welding arc. The arc appears at the gap between the tip of the melting electrode and the molten pool of the work piece. The welding system continuously feeds the electrode into the arc. Heat from the arc melts the tip of the electrode as it enters the arc. Molten metal from the electrode transfers across the gap to the work piece. As the metal solidifies, it becomes the deposited weld metal.

The consumable electrode welding arc is a column of electrically and thermally excited atoms, and ionized metal vapors from the electrode material known as plasma. The plasma operates at temperatures of approximately 6000 °C (10,000 °F). It conducts current at levels ranging from about 20 amps to over 500 amps, and has a voltage drop of between 10 to 50 volts. The relation of potential (volts) to current (amps) is roughly linear, except at the lowest current levels where an inverse relation exists.

The length of the arc affects the arc voltage. A short length arc, approximately equal to one diameter of the electrode, has the lowest voltage. The medium length arc occurs at the medium voltage range. The long arc has a length equal to about five times the diameter of the electrode. It also has the highest voltage. A long arc tends to become uncontrollable and does not deposit metal. If the gap is too long, the arc goes out. Use a higher current to sustain a longer arc. If the gap is too short, the arc shorts out. Excessive arc voltage can cause the arc to climb to the contact tip, and transfer from the work piece to the tip.
Figure 3-3 Consumable Electrode Welding Arc

Arc atmosphere also has an affect on arc voltage. Different gases or gas mixtures cause arc voltage levels to change. A voltage increase based on the shielding atmosphere produces a hotter arc. This increases the thermal energy in the arc, which increases the electrode melt-off rate slightly. When welding with aluminum, this can happen when the atmosphere is changed from an argon atmosphere to one using an argon-helium or argon-helium-oxygen mix. The Kobelco power supply is designed to use pure argon gas.

The two factors that most determine good quality welding and high productivity welding are penetration into the base metal and electrode melt-off rate. Both penetration and melt-off rate are affected by the following:

- Current polarity and arc atmosphere
- Current level
- Melting point of the material being welded
- Size of the electrode wire
- Electrode extension

The polarity of the current flowing through the arc and the gas atmosphere determine where the point of maximum heat occurs. In most gas-metal arc welding applications the point of maximum heat occurs at the work piece. This results in deeper penetration and reduced electrode melt-off.

Penetration and melt-off rate are related to the welding current level. Although the relationship is not linear, penetration and melt-off rate increase as welding current increases. This reflects the relationship between current level and thermal energy.

Of the factors effecting melt-off rates, the most important is the melting point of the metal or metals that make up the electrode. Aluminum has a particularly low melting point, which results in a higher melt-off rate.
Another factor that affects the melt-off rate is the size of the electrode. As the diameter of the electrode decreases, its current density increases. Current density is the welding current divided by the cross-sectional area of the electrode wire. At the same welding current, a small electrode has a higher current density than a larger wire. Both the melt-off rate and depth of penetration increase as current density increases.

The amount of electrode extension also affects the melt-off rate. The electrode extension is the length of the electrode between the tip and the arc. Heat is generated due to the electrode extension's resistance to the flow of current. As the length of the extension increases, so does its resistance and consequently the amount of heat generated. This results in a higher melt-off rate. The melt-off rate depends on both electrode extension and welding current, since these two factors are interrelated.

The heat generated in the electrode extension also has a preheating effect on the electrode wire. Preheating the electrode increases the deposition rate. Too much preheating, however, reduces the penetration of the arc. Since the amount of heat generated in the extension can be quite high, it can cause the electrode wire to lose its stiffness. This can make wire feeding more difficult.

In the arc welding process, successful operation requires a stable arc. To maintain a stable sustained arc, the melting rate of the electrode must equal the feed rate of the electrode into the arc. We have seen that there are many factors that affect the electrode melt-off rate. The purpose of the aluminum welding system is to balance these various factors and optimize the welding process.

### 3.2.2 Metal Transfer Across the Arc

A number of forces interact to cause the transfer of metal across the arc. Under varying conditions, the amount, rate of transfer, and pattern of the transferred metal changes. The transferred metal can range from small droplets, less than the diameter of the electrode, to droplets much larger in diameter than the electrode. The forces that control the transfer of molten metal across the arc gap are the following:

- Surface tension
- Plasma jet
- Gravity
- Electromagnetic force

The surface tension of a liquid causes the surface to contract to the smallest possible area. It tends to hold the droplet on the end of the melting electrode regardless of the weld position. In this manner, it works against the transfer of metal. Surface tension also holds the molten metal in the weld pool when welding in the vertical and overhead positions.

A plasma jet flows from the tip of the electrode to the base metal along the center of the arc column. This jet accelerates the drops of molten metal in flight towards the work piece. Under certain conditions, the plasma jet can interfere with the transfer of liquid metal across the arc gap.

The effects of gravity, to some extent, depend on the welding position. Earth's gravity tends to detach the drop of liquid metal downward from a horizontal or vertical position. It tends to hold the drop on the electrode when welding in the overhead position. Earth's gravity has a noticeable effect only when welding at lower current levels.

Electromagnetic force creates the pinch effect force, which helps to transfer metal across the arc gap. The flow of current through the electrode creates an
Electromagnetic field. Electromagnetic forces act on the drop of molten metal to help detach it from the tip of the electrode. As the drop begins to separate from the electrode, the pinch force pushes the drop away from the electrode and increases the rate of separation. At higher currents, electromagnetic forces within the drop of metal cause it to become elongated. This gives the drop stiffness, and projects it in line with the electrode regardless of the welding position. The mode of metal transfer is related to the following:

- Type of metal
- Arc atmosphere
- Welding position
- Welding current
- Current density
- Heat input
- Size, type, and polarity of electrode
- Characteristics of power source

The four major types of metal transfer are:

- Spray transfer
- Globular transfer
- Short-circuit transfer
- Pulsed-spray metal transfer

In addition to the types of metal transfer listed above, there are intermediate modes that occur in the transition zones between two major types. In these transition zones, both types of transfer can occur simultaneously.

Globular transfer is not used for aluminum arc welding applications. Of the remaining transfer modes, pulsed-spray metal transfer is the type most commonly used. It accounts for as much as 95% of aluminum welding applications. The spray transfer mode is used in most of the remaining applications. Short-circuit transfer is rarely used.

**Spray Transfer**

Spray transfer is a very smooth mode of metal transfer from the electrode to the molten weld pool. Figure 3-4 illustrates the spray metal transfer mode. Spray transfer occurs in an inert gas atmosphere, typically using a shielding gas with a minimum of 80% argon. This transfer mode occurs at relatively high current densities. Each different size of electrode requires a specific minimum current level. The use of helium in the shielding gas reduces the current level at which spray transfer occurs.

Molten metal droplets that form in this transfer mode are smaller than the diameter of the electrode. As current increases, the size of the droplets decreases. An increase in current level also causes droplets to form and transfer at a higher rate. Because of the high current densities involved, the electromagnetic forces have the most effect on this mode of transfer. The pinch force on the tip of the electrode limits the size of the metal droplets. As a result, only small droplets form, and transfer rates are relatively high. The deposition rate and efficiency of spray transfer mode are relatively high. The arc is smooth, stable, and stiff, and produces a weld bead that has a nice appearance and good wash into the sides of the weld.
The weld process in spray transfer mode, generates a large amount of heat. This creates a large weld pool with good penetration. However, it also makes the weld pool hard to control. In normal applications, this limits the use of spray transfer to flat or horizontal welding positions and prevents its use when welding thin materials.

**Short-Circuiting Transfer**

The short-circuiting transfer mode is occasionally used for aluminum welding, generally in thin metal or out-of-position welding applications. It is a low energy mode of metal transfer. Figure 3-5 illustrates short-circuiting transfer mode.
In short-circuiting transfer, the melting tip of the electrode is supported by the cathode jet and can grow to 1 1/2 times the diameter of the electrode (see Figure 3-6). The electrode feeds into the arc at such a high rate that the molten tip comes in contact with the weld pool. This causes a short circuit between the electrode and weld pool. It also causes the weld arc to extinguish.

As the electrode comes into contact with the weld pool, the high current density causes the electrode to act as a fuse and literally explode. The surface tension of the weld pool draws the molten metal at the tip of the electrode into the pool. The electrode separates from the weld pool and re-establishes the arc. This entire cycle repeats at random frequency, but occurs so rapidly that it is not apparent.

The short-circuiting transfer mode allows all-position welding, and the welding of thin materials. It uses a constant voltage power source that can provide the proper rate of current increase needed to maintain a stable arc during the short circuit. This process produces a small, easily controlled weld pool. However, it can cause cold lap defects and undercutting if weld parameters are not properly set. This metal transfer mode also produces a small amount of spatter.

**Pulsed-Spray Metal Transfer**

The pulsed-spray metal transfer mode was introduced to overcome the limitations of other metal transfer modes. Figure 3-7 illustrates this process. The pulsed-spray transfer mode requires a special pulsing power source. The welding current supplied by this power source varies between high (peak) and low (background) levels (see Figure 3-8). The peak current occurs at a point above the transition current, and supplies extra energy to transfer metal across the arc gap. The background current has enough energy to sustain a stable arc, but not enough to transfer the metal droplets. Theoretically, one drop of metal transfers across the arc gap at the peak of each pulse cycle. The liquid metal droplets formed in this process have a diameter approximately equal to that of the electrode. Metal transfer across the arc gap occurs at a fixed frequency.
**Figure 3-7  Pulsed Spray Transfer Mode**

The pulsed-spray transfer mode achieves spray transfer at a lower average current level. It uses an inert gas atmosphere, typically argon or an argon-helium mix. The pulsed-spray transfer mode operates at lower heat input levels. This produces a smaller, controllable weld pool that allows the welding of thin materials in all positions. It also allows the use of larger diameter electrodes than normal. It also reduces the amount of spatter produced. The result is a smooth weld with good physical characteristics and appearance.

**Figure 3-8  Pulsed-Spray Time Cycle**

When using pulsed-spray metal transfer, the aluminum welding system precisely regulates the variables that affect the welding process. The pulse peak current and peak current duration are matched to the background current (see Figure 3-8). By selecting the appropriate welding schedule, the system also matches the shape of the pulse waveform, duration of the peak pulse, and pulse frequency to the arc atmosphere and electrode feed rate for specific size and type of electrode.
The Kobelco pulse schedules have been optimized based on empirical data. On the front panel of the AL-350 is a switch for selecting the proper frequency for wire size (1.2 mm and 1.6 mm) and alloy (hard/5183,5356 or soft 4043,1100).

**AC-Pulsed MIG Metal Transfer**

Pulsed MIG welding has been conventionally used for MIG welding of aluminum alloys. However, when welding thin plate like aluminum (1-3 mm), burn-through often occurs and sound welds are difficult to obtain. To solve this problem, AC-pulsed MIG metal transfer was developed, which alternately repeats DCEP (electrode positive) pulse current (which produces deep penetration) and the DCEN (electrode negative) current, which produces shallow penetration. Controlling the ratio of these two polar currents enables the free selection of penetration depth at the same setting as the wire feed rate, a stable arc, and little to no metal spatter.

The main circuit in AC-pulsed MIG welding consists of two sets of inverters (see Figure 3-9). The primary inverter circuit controls the output current and the secondary inverter input changes the output polarity, resulting in the output of the AC waveform shown in Figure 3-10.

This arc phenomena is called current waveform control. Wave form control is divided into two periods: one in which a droplet at the end of the electrode is transferred to the molten pool, and the other in which the arc is generated and a droplet is formed at the end of the wire. These two periods are repeated anywhere from a few to well over one hundred times within one second.

During the DCEN current, heat is concentrated in the wire and starts to form the droplet (see Figure 3-11). Formation of the droplet is detected through the voltage sensing circuit. The power supply then switches to DCEP polarity to finish formation of the droplet and transfer (spray) it into the arc. Current is quickly reduced during transfer to reduce the force and spatter generated.
THEORY OF OPERATION

Figure 3-10 Current Waveform

Figure 3-11 Droplet Transfer in AC-pulsed MIG Welding
In the AC-pulsed welding method, which alternately repeats DCEP and DCEN processes, arc stability is not maintained by switching polarities alone, because the arc is extinguished as soon as the current direction changes. With aluminum alloys, 150 volts must be applied for a few microseconds at the moment the polarity changes to re-ignite the arc without fail. The pulse/switching frequency is dependent on the sensed arc voltage rather than a pre-programmed pulse frequency. This helps ensure that the arc is always operating at optimum efficiency. For a more detailed description of this process, refer to Appendix D.

3.3 Welding Aluminum and Aluminum Alloys

The following characteristics of aluminum affect the welding process:

- Aluminum oxide surface coating
- High thermal conductivity
- High thermal expansion coefficient
- Low melting temperature
- Absence of color change as temperature approaches the melting point

For automated applications using gas-metal arc welding, the absence of color change is not a great concern. The remaining characteristics, however, have a significant effect on the quality and strength of the resulting weld.

Aluminum is an active metal that reacts with oxygen in the air to produce a thin hard film of aluminum oxide on its surface. The melting point of aluminum oxide is almost three times that of pure aluminum. This aluminum oxide film tends to absorb moisture from the air, particularly as it becomes thicker. Moisture is a source of hydrogen which causes porosity in aluminum welds. Hydrogen enters the weld pool and mixes with the molten aluminum. As the aluminum solidifies, hydrogen may be trapped in the weld, making the aluminum porous and brittle. Other sources of hydrogen include the oxide and foreign materials on the electrodes and base metal, such as oil, dirt, anodizing, and paint.

It may be necessary to remove the aluminum oxide coating before welding. Otherwise, small particles of unmelted oxide trapped in the weld can cause reduced ductility, lack of fusion, and weld cracking. The aluminum oxide coating can be removed by mechanical, chemical, or electrical means. The oxide film starts to form immediately on exposure to air. This process occurs at a relatively slow rate, but welds made within 8 hours after cleaning give the best results.

Heat applied to aluminum conducts away from the arc at a rate that is three to five times greater than that of steel. Therefore, it takes more heat to initially fuse the weld to the base material. Welding thicker pieces may require preheating. However, heating at too high a temperature or for too long can weaken the weld joint. Using a high-speed process, such as gas-metal arc, with low heat input produces the best results.

When making longer welds or multiple welds on a part, the high heat conductivity will cause preheat in the joint. The preheat, combined with the low melting point of aluminum may require different weld parameters during the weld or on subsequent welds.
The high thermal conductivity of aluminum has one advantage. Since heat conducts away from the weld at a fast rate, the weld solidifies very quickly. This effect, along with surface tension, tends to hold the weld metal in place, and makes all-position welding practical.

The thermal expansion of aluminum is twice that of steel. In addition, aluminum welds decrease in volume by about 6% as they solidify. Uneven expansion or contraction as the metal melts and then solidifies can cause distortion and crater cracking. Careful attention must be given to match filler material to base alloy to prevent cracking. Also, considerable care must be taken to properly fill the crater at the ends of welds.
SECTION 4
OPERATION

This section identifies the controls and indicators used to operate the system under normal conditions. It also contains set-up instructions for preparing the aluminum welding system for operation, and includes instructions for setting up enhanced arc start files, using the slope up/down function, and a set of welding tips to help simplify the aluminum welding process.

4.1 Controls and Indicators

The Kobelco AL-350 provides constant voltage at the welding arc. Welding amperage varies depending on the rate of wire feed. This offers advantages when welding thinner materials, such as aluminum.

4.1.1 Power Source Settings

The controls for the power source are shown in Figure 4-1. The settings are listed in Table 4-1.

NOTE: Under normal circumstances, the Crater controls, shown below, are fully operational. However, when the Kobelco Power Source is used with a Motoman robot, Crater control becomes a function of the weld program controlled by the XRC.

![Figure 4-1 Control Panel on the Kobelco Power Source](image-url)
Table 4-1  Control Panel Settings

<table>
<thead>
<tr>
<th>Control</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>POWER</td>
<td>Turns power Off/On. When programming robot, make sure switch is in the On position.</td>
</tr>
<tr>
<td>GAS FLOW</td>
<td>Set to FLOW to purge gas; set to AUTO for automatic gas control. Checks the gas flow rate.</td>
</tr>
<tr>
<td>CRATER</td>
<td>Always set to Off; On is disabled in system which uses robot controller.</td>
</tr>
<tr>
<td>WIRE DIAMETER</td>
<td>Set to Ø 1.2mm (3/64') or Ø 1.6mm (1/16').</td>
</tr>
<tr>
<td>WIRE TYPE</td>
<td>Set to HARD (5183,5356) or SOFT (1100,4043).</td>
</tr>
<tr>
<td>CRATER CURRENT, VOLTAGE, and PENETRATION</td>
<td>Disabled in system which uses robot controller.</td>
</tr>
<tr>
<td>MOTOR TORQUE LIMITER</td>
<td>Adjusts motor torque to prevent bird nesting. Turn knob clockwise for hard aluminum and counterclockwise for soft aluminum.</td>
</tr>
</tbody>
</table>

4.1.2 Circuit Board Controls

Kobelco power source has an automatic burn back or "wire sharpening" circuit, located inside the power source on printed circuit board CVA2 (see Figure 4-2).
The CVA2 board contains a circuit that minimizes the ball left on the end of the wire at the end of a weld. Minimizing the ball improves arc starting on the following weld. If a ball forms on the wire, something in the weld program is defeating this circuit and adjustments must be made. CVA2 adjustment controls are listed in Table 4-2.

**Table 4-2  CVA2 Printed Circuit Board Controls**

<table>
<thead>
<tr>
<th>Control</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>JP1 (turns preflow on or off)</td>
<td>Set JP1 to YES to perform preflow for 0.5 seconds.</td>
</tr>
<tr>
<td>VR2 (adjusts run-in speed)</td>
<td>Turn control to adjust speed from minimum (1.3 m/min) to maximum (4.4 m/min).</td>
</tr>
<tr>
<td>VR7 (adjusts size of ball at burnback)</td>
<td>Turn clockwise to increase burn back time and increase size of ball; turn counterclockwise to decrease burn back time and decrease size of ball.</td>
</tr>
<tr>
<td>SW1001 (adjusts pulse duration for wire type, wire diameter, and feed rate)</td>
<td>Adjust the pulse duration to one of 10 different settings. The switch is factory-set at 5 (0 msec, standard) and all other settings (0 through 9) are the amount of difference (negative 1.25 to positive 1) from the standard. <strong>Do not change the pulse duration unnecessarily.</strong></td>
</tr>
<tr>
<td>VR9 (adjusts wire feed rate)</td>
<td>160 (+0/-1) rpm (AWELD = 14.00 Volts)</td>
</tr>
</tbody>
</table>
4.2 **Adjusting Feed Roll Tension**

1. Release the wire feed pressure handle and open the pressure arm (see Figure 4-3).
2. Adjust pressure handle to the recommended setting for wire type and size (see Figure 4-3).
3. Guide the wire through the center wire guide and into the torch.
4. Close the pressure arm and close the pressure handle.
5. Using the programming pendant, inch wire to the tip of the torch until it extends about 10 mm from the end of the tip.

![Diagram of adjusting feed roll tension](image)
4.3  Tips for Successful Aluminum Welding

4.3.1 Machine Settings

1. Use the soft setting for 4000 and 1000 series wire and the hard setting for 5000 series wire. These settings effect the peak current and pulse frequency and can cause arc instability if not set properly.

2. The AL350 can weld with 3/64 in. (1.2 mm) or 1/16 in. (1.6 mm) wire diameters. This setting also effects peak current and pulse frequency. The AL350 is not compatible with .035 in (1.0 mm) diameter wire.

3. The motor torque limiter setting prevents birds nests in the feeder. Use the chart on the Kobelco front panel as a guide for initial setting. Initially, set the motor torque limiter low and if a feed error occurs, increase the setting slightly. If a birds nest occurs, then reduce the setting slightly. Cancel the feed error by pressing the inch key on the programming pendant or cycling power on the welder. Do not inch wire when there is a feed fault. Inching acts like an override and may cause a birds nest if there is indeed a feed problem. Excessive tripping of this feed fault may indicate a worn tip or liner, but don’t change either hastily.

4. The gas purge switch checks gas purge. The crater switch and knobs for crater settings are not active for robotic use.

4.3.2 Penetration Command

1. Do not set Analog #3 less than 1.0 volt as the small ratio of straight polarity can cause arc instability. Most applications use penetration values in the 3-7 volt range. A 14.0 volt value will give 60% straight polarity which might cause some arc instability.

2. Penetration control is advantageous for welding material 1-2 mm thick, maintaining optimal welding gap conditions, and maintaining fillet profile at high speeds.

3. Set the amperage command to get the desired size weld and then add the penetration command to reduce the penetration. The amperage may need to be fine tuned for weld size and arc voltage is adjusted for desired arc length.

4. The power source meter reads average amperage. Therefore, when the penetration command (percentage of DCEN polarity) is increased, the meter will decrease even though wire feed remains constant.

4.3.3 Amperage Command

1. The XRC is set-up to send a 0-14 volt analog reference to the welder, depending on what amperage is present in the Arc Start File. This amperage-to-analog ratio is set-up as a table in the Welder Condition File. This data varies depending on wire size and type. Refer to Section 4 in the Operator's Manual for Arc Welding for more information on these files.
4.3.4 Voltage Command

1. The AL350 is a synergic welder with a preset voltage value for any given amperage command. This is referred to as Unified mode in the Welder Condition File. Instead of entering direct voltage values like 24.0 volts, enter the voltage as a percentage of the welder's preset voltage.

2. For any given amperage setting, the preset voltage value can be selected by entering 100% arc voltage. The arc length can be trimmed by decreasing or increasing from this value. Most applications range between 90%-100% arc voltage settings.

3. The AL350 is designed as a spray pulse machine. It adjusts the current to spray one droplet across the arc at a time. The arc length should be adjusted to the point before spatter occurs. For higher speeds, the arc can be adjusted where fine spatter occurs. Adjusting the arc length too low will cause arc instability and inconsistent performance.

4.3.5 Bead Profile

1. Using a push angle (10-20 degrees) will help flatten the profile of the aluminum bead. Aluminum welding requires more push angle than steel welding.

2. Increase amperage to flatten the weld bead. Weld current has a pronounced effect on weld profile while arc voltage has a reduced effect. This is opposite of what is usually encountered when welding with steel. If the bead shape is convex, try adding more current rather than arc voltage.

3. Heat flow has a pronounced effect on bead contour. If the contour changes from one weld to the next, check if there is a difference in mass between the parts or if the joint is adjacent to fixtures. Always allow parts to cool thoroughly between welds. If the part retains heat from a previous weld, the bead contour can be affected.

4.3.6 Black Soot

1. Increasing the amount of push angle can help reduce the amount of soot left behind on the edge of the weld. The 5000 series wire is more prone to producing soot on the weld.

2. Contaminated shielding gas can cause soot or porosity and may be the result of pin hole leaks upstream.

3. Oil contamination can create soot, lack of fusion, and porosity. Even light coatings can have an effect. Heavy oxide buildup can also cause bad welds.

4.3.7 Wire Feed

1. The torch is connected to the feeder with an adapter block. It is very important that the liner extend a few inches beyond the back of the torch and close to the feed rolls. This system was designed so a single liner is continuous from drive roll to contact tip.

2. While plastic liners are recommended for aluminum wire, the plastic next to the contact tip can melt. The outside of Tregaskiss liners have been wound with steel to help prevent this. A plastic Hobart liner with a short steel liner crimped on the end can also be used. If the Hobart liner is used, cut the steel tip to 1 or 2 inches long. This will allow the plastic portion to extend through the bend in the torch barrel. A Tregaskiss liner retainer will be required to anchor the Hobart liner into the back of the Tregaskiss torch. Refer to Appendix A for a list of consumables and part numbers.
3. Inconsistent welds can often be traced back to wire feeding problems. Some sources of inconsistent feeding might include a worn contact tip, dirty liner, lack of water cooling, or worn drive rolls.

4. The ceramic drive rolls supplied with the feeder provide electrical insulation from the wire. Do not substitute drive rolls made of conductive material.

**4.3.8 Voltage Sensing**

1. The AL350 does not have a programmable pulse, it uses information sensed at the arc through the voltage sensing leads and reacts in real time. It is very important that these voltage sensing leads be properly connected and some simple precaution followed:
2. Don't coil the weld leads! This will add inductance and contribute to arc instability.
3. Do use a replacement torch from Tregaskiss with the voltage sensing lead attached to the torch block (18 gauge wire extending from rear handle of torch).
4. Don't connect the negative voltage sensing lead to the weld ground point! The flow of welding current can create a voltage drop which will be sensed by the welder.
5. Do connect the negative voltage to a point at the same potential as the weld circuit, such as the fixture or positioner frame. Connect it as close to the arc as possible as bearings and bolting details can create voltage drop.
6. Keep the voltage sensing lead adjacent to the weld lead for as long a distance as possible (wire tie to lead).
7. Keep the positive and negative weld leads adjacent to each other for as long a distance as possible. Refer to the Kobelco Operators manual in Appendix E for more information.

**4.3.9 Contact tips**

1. Popular advice is to size the contact tip as small as possible in order to provide good electrical contact between the wire and the tip. However, the high arc-on time with robotic welding can cause increased friction and seizing in smaller tips. Therefore, using the .052 contact tip instead of the 3/64 contact tip may result in longer tip life.
2. If tips are failing at arc starts, change the parameters in the Arc Start file. The AL350 is designed to reduce the ball on the wire at arc off. If a ball forms at arc off, then adjust parameters in the Arc End file.
3. If an arc failure occurs in the tip, observe the back and front end of the tip. Aluminum deposits at the back of the tip indicate the wire is shaving somewhere in the feed system. Deposits in the front of the tip indicate spatter may interfere with feeding and arc length or stick-out distance needs to be increased.
4. Because the aluminum wire is soft, hard alloy or extended life contact tips have not been found to significantly increase tip life.

**4.4 Using Enhanced Files and Weld Slope Function**

Enhanced arc files (see Figure 4-4) and the slope up/down function (see Figure 4-5) are separate functions which can be used individually or together to program ramping weld parameters. Standard arc start files store parameter settings and initiate the arc with a single instruction. The standard arc start configuration for steel provides an amperage and voltage setting and a "dwell" time after arc start to
allow a puddle to build before the torch begins to travel. The standard arc start configuration contains 48 arc start and 12 arc end files. An enhanced arc start file for aluminum allows a second set of weld parameters which can "dwell" a specified time or distance from the start point. The enhanced configuration contains 48 arc start files and 12 arc end files.

![Enhanced Arc Condition](image1)

**Figure 4-4 Enhanced Arc Condition**

![Slope Up/Down Function](image2)

**Figure 4-5 Slope Up/Down Function**

The slope up/down function will taper the weld analogs from the initial value to another over a specified distance. Two instructions are provided: one to slope away from a programmed point and another to begin sloping when approaching a programmed point. The instruction contains the final weld parameters and the distance which determines the angle or rate of slope. The parameters set before the instruction determine if the slope is up or down.
4.4.1 Setting Up Enhanced Arc Files

The enhanced arc start condition files allow you to pause and/or travel with the starting conditions and allows you to set analogs 3 and 4. The Kobelco power source uses analog 3 to set the penetration control. Figure 4-6 shows an enhanced arc start file and Figure 4-7 is a signal timing chart that illustrates the difference between the "pause" and the "distance" start settings.

```
ARC START CONDITION FILE (ENHANCED)
COND NO. : 99
COMM
(STARTING CONDITION) :
CURRENT : 150A
VOLTAGE : 99%
ANALOG OUTPUT 3 CMD : 0.00V
ANALOG OUTPUT 4 CMD : 0.00V
ROBOT PAUSE TIME : 0.10sec
ROBOT MOVE DISTANCE : 10.0mm
(MAIN CONDITION)
CURRENT : 120A
VOLTAGE : 97%
ANALOG OUTPUT 3 CMD : 3.00V
ANALOG OUTPUT 4 CMD : 0.00V
SPEED
RETRY OFF/ON
MODE REPLAY
```

*Figure 4-6 Enhanced Arc Start File*
The standard arc end file configuration provides a single set of parameters for crater fill along with a dwell timer, as well as a single step parameter at the end. The enhanced arc end files provide two step parameters and two dwell timers. These are advantageous when filling craters during aluminum welding.

NOTE: Aluminum welding systems are shipped with enhanced files as standard.
### 4.4.2 Setting Up Slope Up/Down Files

The Slope Up/Down function consists of two instructions: ARCCTS and ARCCTE. The ARCCTS instruction tapers parameters away from a programmed point, as shown in Figure 4-8. Place it after a MOV command and the parameters will taper to the set values over the specified distance. If a "0" value is entered for distance, then it will taper the entire distance to the next MOV position.

The ARCCTE instruction uses the same settings as ARCCTS, but tapers toward a programmed point, as shown in Figure 4-9. Place this instruction prior to a MOV command and the taper will begin at the specified distance away from the approach point.

```plaintext
MOVL V=80 (Point A)
ARCCTS AC=150 AV=16.0 DIS=100
MOVL V=80 (Point B)
```

![Figure 4-8 ARCCTS (Slope from Start) Instruction](image)

**Figure 4-8  ARCCTS (Slope from Start) Instruction**
4.4.3 Sample Jobs

Combining enhanced files and slope functions allows you to use complicated current files with minimum programmed points and are useful when welding the part profiles shown in Figure 4-10. To use the slope up/down function, combine the ARCCTS and ARCCTE instructions at a programmed point so the current slopes away from the step (ARCCTS) and then tapers in the opposite direction as it approaches the next step (ARCCTE). The ARCCTS instruction executes first. Make sure there is enough distance between the two points to execute both tapers. A few sample jobs that demonstrate use of these functions are shown below.

Figure 4-9 ARCCTE (Slope to End) Instruction

Figure 4-10 Part Profiles
**Sample #1 - Outside Corner Joint**

This joint is welded vertically and down. Use the penetration command (AN3) to reduce melt-through on inside of corner (see Figure 4-11).

MOVJ VJ=100.00

ARCON ASF#(1)

105 amps, 100% volts, 0.02 seconds
80 amps, 96% volts, 9.00 volts AN3

ARCCTE AN3=13.00 DIS=160.0

value to 13.00 volts starting 160 mm

MOVL V=85

TIMER T=0.02

ARCOF

MOVJ VJ=50.00

MOVJ VJ=50.00

(Arc Start with File #1)

Start conditions with 0.02 second dwell

Main conditions for weld

Taper Analog #3 (penetration) from set

from next step (about 200 mm from start point).

Speed shown in inches/minute.

Very short timer to allow puddle to catch up.

Straight arc off without any crater conditions.

**Figure 4-11  Outside Corner Joint**
Sample #2 - Lap Joint with 1T Gap

In this job, weave motion is used to improve cosmetics. The conditions are changed in the middle of the weld to illustrate the effects of parameters on cosmetics (see Figure 4-12).

MOVJ VJ=50.00
ARCON ASF#(2)

- 70 amps, 100% volts, 5.00 mm
- 55 amps, 96% volts, 14.00 volts AN3

WVON WEV#(1)

- Start conditions for first 5 mm of travel
- Main conditions for weld

MOVJ VJ=50.00
ARCCUR AC=53
MOVL V=9
ARCOF AEF#(2)

- 65 amps, 98% volts, 2.5 AN3, 0.3 sec
- 55 amps, 98% volts, 2.5 AN3, 0.4 sec

WVOF

- Step change in current at _ way point.
- Narrower bead from increased speed.

MOVJ VJ=50.00
MOVL V=13
ARCCUR AC=53
WVON WEV#(1)

Figure 4-12 Lap Joint with 1T Gap
**Sample #3 - Lap Joint**

Weld this joint at high speed with no gap (see Figure 4-13).

MOVJ VJ=50.00

ARCON ASF#(3)

- 160 amps, 95% volts, 5.00 mm  
  Start conditions for first 5 mm of travel
- 140 amps, 94% volts, 0.00 volts AN3  
  Main conditions for weld

MOVL V=70

ARCOF AEF#(3)

- 60 amps, 100% volts, 8.0 AN3, 0.1 sec  
  First step of crater fill condition
- 40 amps, 100% volts, 8.0 AN3, 0.1 sec  
  Last step of crater fill condition

MOVJ VJ=50.00

MOVJ VJ=50.00

**Figure 4-13  Lap Joint**
Sample #4 - Tee Joint

This job weaves in direction of travel for “layered penny” cosmetics (see Figure 4-14).

MOVJ VJ=50.00

ARCON ASF#(5)

150 amps, 100% volts, 5.00 mm
100 amps, 95% volts, 7.00 volts AN3

Start conditions for first 5 mm of travel
Main conditions for weld

REFP 1

Reference Point 1 is taught a few inches above the arc on position on the vertical wall.

REFP 2

Reference Point 2 is taught straight out from the arc on point (90 degrees from the joint). The elevation to arc on point does not matter.

WVON WEV#(2)

Weave Advance angle is altered to 90 from 0 to oscillate in direction of travel. Weave angle is set to 0 to weave flat.

MOVL V=45

WVOF

ARCOF AEF#(5)

60 amps, 100% volts, 8.0 AN3, 0.1 sec
40 amps, 100% volts, 8.0 AN3, 0.1 sec

First step of crater fill condition
Last step of crater fill condition

MOVJ VJ=50.00

Figure 4-14   Tee Joint
**Sample #5 - Stitchback**

The following job illustrates a way to terminate the weld. The weld crater is filled with back stepping (or stitchback) to prevent large depression (see Figure 4-15).

MOVJ VJ=50.00
MOVJ VJ=50.00
ARCON ASF#(10)

- 175 amps, 99% volts, 5.00 mm
- 150 amps, 98% volts, 0.00 volts AN3

MOVL V=26
TIMER T=1.50
ARCCTE AC=60 DIS=10.0

MOVL V=22
ARCOF AEF#(10)

- 60 amps, 100% volts, 8.0 AN3, 0.1 sec
- 40 amps, 100% volts, 8.0 AN3, 0.3 sec

MOVJ VJ=50.00
MOVJ VJ=50.00
END

Start conditions for first 5 mm of travel
Main conditions for weld
Point programmed at end of weld bead.
Long timer (1.5 sec) to fill large crater.
Taper instruction to reduce current over 10.0 mm.
Point in reverse direction about 15.0 mm.
ARCOF conditions occur in weld not crater. This reduces the depression in the crater common when using higher amperages. Cold lap at the end of the weld and crater cracking are also reduced.
First step of crater fill condition
Last step of crater fill condition

---

**Figure 4-15  Stitchback**
NOTES
SECTION 5
TROUBLESHOOTING

5.1 Troubleshooting Procedures

Table 5-1 lists the error indicators on the Kobelco power supply and provides brief instructions for locating the cause of the error. It also identifies common problems that occur during aluminum welding. When troubleshooting welding problems, refer to the schematic shown in Figure 5-1 to locate robot/welder interface connections.

To troubleshoot your system, identify the type of problem and look for it in the PROBLEM column. Next to this column is a list of probable causes. For each probable cause, one or more remedies is suggested. Be aware that sometimes more than one problem can occur at the same time. After identifying and resolving a problem, test the system thoroughly to make sure no other problems exist. A list of spare parts is located in Appendix A.

WARNING!
When an error indicator illuminates on the Kobelco power source (except HEAT or FEED), turn OFF the Kobelco Power Switch and cut off power at the main disconnect. Be sure to wait at least two minutes before opening power supply cabinet.

Table 5-1 Troubleshooting Chart

<table>
<thead>
<tr>
<th>Problem</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>POWER lamp does not illuminate.</td>
<td>POWER switch is defective.</td>
<td>Replace POWER switch.</td>
</tr>
<tr>
<td></td>
<td>Fuse F1 or F2 is blown.</td>
<td>Replace fuses.</td>
</tr>
<tr>
<td></td>
<td>The lamp is burned out.</td>
<td>Replace lamp.</td>
</tr>
<tr>
<td></td>
<td>The input cable is defective.</td>
<td>Replace cable.</td>
</tr>
<tr>
<td>Fan does not rotate.</td>
<td>Fan is wired incorrectly.</td>
<td>Rewire fan.</td>
</tr>
<tr>
<td></td>
<td>Fan is defective.</td>
<td>Replace fan.</td>
</tr>
<tr>
<td>INV lamp illuminates</td>
<td>Current overload through inverter transistor.</td>
<td>Turn the power OFF and then ON again. If the error recurs, call Motoman Service Department.</td>
</tr>
<tr>
<td>CURRENT lamp illuminates</td>
<td>This lamp illuminates if a current exceeding the power supply rating runs through the load for more than 2 seconds.</td>
<td>Turn the power OFF.</td>
</tr>
<tr>
<td></td>
<td>Torch tip is shorting to base metal.</td>
<td>Check for a short circuit between the weld tip and the base metal.</td>
</tr>
<tr>
<td></td>
<td>There is a short between output cables.</td>
<td>Turn power OFF and check for a short between output cables.</td>
</tr>
<tr>
<td>Problem</td>
<td>Probable Cause</td>
<td>Remedy</td>
</tr>
<tr>
<td>---------</td>
<td>---------------</td>
<td>--------</td>
</tr>
<tr>
<td>INPUT lamp illuminates</td>
<td>Supply voltage exceeds 200 V or open phase is occurring. Fuses F1 or F2 (on front panel) are blown. If fuses aren't blown, measure primary voltage for each phase to determine if one is missing.</td>
<td>Turn power OFF and check that input voltage is 200 V ± 10% or if open phase has occurred. Replace blown fuse and perform a trial weld. If F1 or F2 blows again, call Motoman Service Department. If one phase is missing, recover missing phase. Check connection. (200V AC ±10% CN200) (220V AC ±10% CN220)</td>
</tr>
<tr>
<td>HEAT lamp illuminates (Over Heat)</td>
<td>The welding power supply is exceeding its specified duty cycle. Air vent is blocked.</td>
<td>With the power ON, allow the power source to run until the internal temperature drops sufficiently. Make sure there is adequate clearance between air vent and other equipment that may obstruct air flow.</td>
</tr>
<tr>
<td>CABLE lamp illuminates</td>
<td>The wire feeder cable is shorted to other cables or ground. FU1 or FU2 (on CVA2) is blown.</td>
<td>Turn power OFF and check for contact between cables. Replace fuse(s).</td>
</tr>
<tr>
<td>REV lamp illuminates</td>
<td>REV supply voltage is out of range. If REV error occurs during welding, you will lose control of weld penetration.</td>
<td>Make sure torch and base metal cables are as close together and parallel as possible. If you can't weld at all during a REV error, call Motoman Service Department.</td>
</tr>
<tr>
<td>FEED lamp illuminates</td>
<td>Wire buckling (bird nest) prevention circuit is activated.</td>
<td>Inch wire slowly to clear alarm. Check the condition of the torch, tip, clean the Teflon liner, or take other measures to lower feeding resistance. Check Motor Torque Limiter setting and ensure it is not too low.</td>
</tr>
</tbody>
</table>
## Table 5-1 Troubleshooting - continued

<table>
<thead>
<tr>
<th>Problem</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire feed is erratic</td>
<td>Resistance inside conduit is too high.</td>
<td>Check the condition of the torch, clean the Teflon liner, and examine condition of tip to ensure it is not damaged.</td>
</tr>
<tr>
<td></td>
<td>Torch is overheating.</td>
<td>Adjust flow rate of water circulator.</td>
</tr>
<tr>
<td></td>
<td>Wire feed power is weak and erratic.</td>
<td>Ensure wire feed pressure lever is set appropriately.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check that drive feed rolls are not slippery or clogged with wire chips and oil.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check that drive roll is appropriate for wire size.</td>
</tr>
<tr>
<td>Arc does not establish</td>
<td>Arc voltage feedback is inappropriate.</td>
<td>Check that negative terminal of arc voltage detection cable is connected correctly. Refer to paragraph 1.5.2 and 1.5.3.</td>
</tr>
<tr>
<td></td>
<td>Voltage is not applied between contact tip and base metal.</td>
<td>Check that welding cables are connected correctly.</td>
</tr>
<tr>
<td></td>
<td>Weld wire is not feeding correctly.</td>
<td>See remedy under &quot;Wire feed is not smooth.&quot;</td>
</tr>
<tr>
<td>Arc stays at open circuit voltage</td>
<td>Positive voltage sensing cable is not connected properly.</td>
<td>Check that wires to feed motor are not loose. Check connection of cable between torch and feeder cable. Check connection at rear of torch (unthread cover on rear of torch to remove).</td>
</tr>
</tbody>
</table>
### Table 5-1 Troubleshooting - continued

<table>
<thead>
<tr>
<th>Problem</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arc start is erratic</td>
<td>Current is not flowing smoothly.</td>
<td>Check that no insulating material (e.g. coating) exists on surface of base metal.</td>
</tr>
<tr>
<td></td>
<td>Contact tip is wrong size, weld wire is not contacting top portion of tip, or weld wire is straight.</td>
<td>Check that base metal has fully contacted the fixture.</td>
</tr>
<tr>
<td></td>
<td>Arc voltage is too low. EN ratio is too high. Welding speed is too fast. Wire RUN-IN speed is too fast.</td>
<td>Use appropriate size tip, and make sure weld wire contacts top portion of tip. If weld wire is straight, adjust the curvature to 300 - 500 R using the straight roll.</td>
</tr>
<tr>
<td></td>
<td>Large droplets are formed at the wire tip, contacting base metal.</td>
<td>Increase voltage, decrease AN #3, or decrease weld and RUN-IN speed. Do not set AN #3 between 0.01 and 0.99 Volts.</td>
</tr>
<tr>
<td>Arc is erratic</td>
<td>Wire feed is incorrect.</td>
<td>See &quot;Wire feed is erratic.&quot;</td>
</tr>
<tr>
<td></td>
<td>Pulse condition has changed.</td>
<td>Weld cable is too long. Shorten cable as much as possible. Verify that weld cable is not coiled.</td>
</tr>
<tr>
<td></td>
<td>Arc voltage feedback is incorrect.</td>
<td>Verify that torch is not overheating. Check water flow pressure and cable connections.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verify that negative voltage detection cable and welding cable are wired and connected correctly. Make sure negative voltage detection cable is as close to weld cable as possible, but not connected at the same point.</td>
</tr>
</tbody>
</table>
### Table 5-1 Troubleshooting - continued

<table>
<thead>
<tr>
<th>Problem</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shielding gas is insufficient or doesn't flow.</td>
<td>Main valve for the gas cylinder is closed or incorrect pressure is supplied.</td>
<td>Check that gas valve is open and that pressure gauge reads correctly. Set switch to FLOW. If gas still doesn't flow, call Motoman Service Department.</td>
</tr>
<tr>
<td></td>
<td>Flow switch on front panel is not set to FLOW.</td>
<td></td>
</tr>
<tr>
<td>Burn back occurs</td>
<td>Arc length is too long.</td>
<td>Check welding speed and ensure it is not too slow and that arc voltage is not too high. Correct setting. See remedies under &quot;Wire feed is erratic.&quot;</td>
</tr>
<tr>
<td></td>
<td>Robot setting is wrong.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wire feed is erratic.</td>
<td></td>
</tr>
<tr>
<td>Burn-through occurs</td>
<td>Work piece accuracy is poor.</td>
<td>Check that gap is not too large and that it does not vary. Check that base metal is not distorted during welding. Ensure forward welding is used. Check welding current and arc voltage and ensure they are not too high. Increase penetration control (AN #3).</td>
</tr>
<tr>
<td></td>
<td>Welding conditions are not correct.</td>
<td></td>
</tr>
<tr>
<td>Puckering occurs (cathode spot is below molten pool; cleaning action is not appropriate)</td>
<td>Welding current is too high or current variation is too large. Arc voltage is too high. Gas shielding is insufficient or doesn't flow.</td>
<td>Check current level and variation and reduce, if necessary Check voltage and reduce, if necessary. See instructions under, &quot;Gas flow in insufficient and doesn't flow.&quot;</td>
</tr>
<tr>
<td>Problem</td>
<td>Probable Cause</td>
<td>Remedy</td>
</tr>
<tr>
<td>---------</td>
<td>----------------</td>
<td>--------</td>
</tr>
<tr>
<td>Blow holes and pits are formed when welding.</td>
<td>Insufficient shielding.</td>
<td>Ensure that prepurge and post purge are performed for shielding gas.</td>
</tr>
<tr>
<td></td>
<td>Parts or wire is contaminated.</td>
<td>Ensure the distance between the nozzle and the base metal is not too large.</td>
</tr>
<tr>
<td></td>
<td>Parameters are not set correctly.</td>
<td>Verify that the gas flow rate is adjusted correctly.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Make sure parts are free of oil. Change wire spool.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increase torch push (lead) angle to decrease arc voltage.</td>
</tr>
<tr>
<td>Penetration is insufficient</td>
<td>Welding conditions are not correct.</td>
<td>Check that arc start conditions and main welding conditions are set separately. (Do not increase EN ratio excessively for arc start when welding aluminum.)</td>
</tr>
<tr>
<td></td>
<td>Weld joint characteristics are not correct.</td>
<td>Check welding target positions when welding materials with greatly different heat capacity and conductivity.</td>
</tr>
</tbody>
</table>
Figure 5-1  YRI-II Interface PC Board Schematic
SECTION 6
CALIBRATION AND REPAIR

This section provides the instructions for calibrating and performing routine maintenance on the aluminum welding system. We recommend the system be calibrated periodically to ensure optimal performance. The wire feed speed is critical for efficient operation of the aluminum welding system. For normal operation, calibrate the wire feeder for a maximum speed of 160 RPM, with an AWELD setting of 14.00 volts.

6.1 Tools and Equipment

Refer to Table 6-1 for a list of tools and equipment required to calibrate the aluminum welding system. If you do not have the tools specified, substitute tools of equal or greater capacity and accuracy.

<table>
<thead>
<tr>
<th>Tool or Equipment</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital multimeter</td>
<td>Fluke Model 87 or 8062A (or equivalent)</td>
</tr>
<tr>
<td>Digital tachometer</td>
<td>0.1 RPM resolution</td>
</tr>
<tr>
<td>Resistance welding load bank</td>
<td>Capable of handling full power source load</td>
</tr>
<tr>
<td>(optional)</td>
<td></td>
</tr>
<tr>
<td>Small calibration screwdriver</td>
<td>For adjusting small test points</td>
</tr>
<tr>
<td>Micro test clip leads</td>
<td>For connection to small test points</td>
</tr>
<tr>
<td>Digital RMS ammeter</td>
<td>Yokogawa Model 2343-04 (or equivalent)</td>
</tr>
</tbody>
</table>

6.2 Calibration Setup

1. Set up the following test job:
   
   AWELD = 14.00
   VWELD = 14.00
   AOUT#3 = 14.00
   TIMER T = 120
   END

   This job will check the MEW-02 board output and scale calibration. No adjustments on analog channels are required.

2. Set the power source controls to the following positions:
   
   a) Power to OFF
   b) Motor Current Limiter at 3.0
   c) Wire Type to SOFT.
   d) Crater to OFF.
   e) Gas Flow to AUTO.
f) Wire Diameter to 1.2 mm.
g) Crater Current, Crater Voltage and Penetration to mid-range.

3. Make sure the torch cable is installed on the power source positive terminal.
4. Make sure the work cable is installed on the power source negative terminal.
5. Make sure the wire feeder is connected to the front power source receptacle CON2.
6. Make certain that the work voltage sensing lead is connected to CON1.
7. Make sure that the work voltage sensing lead is connected to the work and that the torch sensing lead is connected to wire #205 on the wire feeder connection.
8. Make sure that the voltage sensing lead is connected inside the torch.
9. Loosen the feed roll tension. Make sure there is no wire in the feeder. Disconnect all welding cables from the power source.

6.3 Kobelco Power Source Calibration

During calibration of the Kobelco AL-350 Power Source, record all measurements on the test record in Appendix C. When initial calibration is complete, perform a weld test to confirm settings are accurate. Finally, check wire stick sensing to ensure this function is operating correctly.

6.3.1 Initial Calibration Procedures

1. Remove the top of the AL-350 to gain access to the main CVA2 printed circuit board and the interface board. Also remove the access panel on the right side of the power source. Refer to Figure 6-1 for location of boards and main input power.

DANGER!

Use extreme caution when working with live electrical components. Do not work alone. Contact with live electrical circuits can cause serious injury or death.

2. At the main power input, confirm 200 volt ±10% three phase at the input to the welder.
3. Measure and log the input voltage on the chart provided in Appendix C. Record line-to-line voltage of each phase and line to neutral voltages.
4. Turn on the XRC, and run the test job.
Figure 6-1 Location of PC Boards and Power Input

DANGER!

Robots can move unexpectedly. Unexpected robot movement can cause serious injury or death.

The following is a quick test of I/O functions and initial installation check.

5. Turn on the Inch Forward output command and observe that the wire feeder rolls are turning correctly to feed forward. The speed will accelerate after a few seconds and then stabilize. Record on the test report that the feed motor is turning in the forward direction.

6. Turn on Inch Reverse output command and observe that the wire feeder rolls are turning correctly to feed reverse. The speed will accelerate after a few seconds and then stabilize. Record on the test report that the feed motor is turning in the reverse direction.

7. Turn on the Purge/Gas output and observe that the gas valve on the feeder energizes. Record function test.

8. At connector CN507 on the interface board, measure the VWELD command from the robot at CN507-1(+) and CN507-2(-). Refer to Figure 6-2 for location of connectors and test points. Record this value on the test report. This voltage should be 14.00 ±.02 volts DC.

9. Measure the scaled analog VWELD command at CN501-1 (+) and test point CH44 on the main PC board. The voltage should be 10.00 ±.2 volts DC. Record this value.
10. At connector CN507 measure the AWELD command from the robot at CN507-3 (+) and CN507-4 (-). The voltage should be 14.00 ±.02 volts. Record this value.

11. Measure the scaled AWELD command at connector CN501-2 to test point CH44 on the main PC board. The voltage should be 10.75 ±.25 volts. Record this value.

12. At connector CN509 measure the Penetration Command from the robot. Measure CN509-1(+) to CN509-2 (-). This voltage should be 14.00 ±.02 Volts DC. Record this value.

13. Measure the scaled Penetration Command at connector CN509-3 (+) to test point CH44 on the main PC board. This value should be 9.75 ±.20 volts. Record this value.

14. Make certain the wire feeder pressure rolls are loosened so they do not feed wire. Set Jumper JP2 to YES on the main PC board and set the Crater Current Dial on the front panel to its fully clockwise position and turn on the wire inch output of the robot. The wire feeder drive rolls will turn.
**DANGER!**

*When testing the power source calibration, welding potential will be applied to the output terminals. Do not work alone. Contact with live electrical circuits can cause serious injury or death.*

15. Using a precision tachometer, set the feed roll speed using Pot VR9 (pot is located near IC 7N) on the CVA2 to obtain 160 +0, -1 RPM. This represents 17.5 m/min (689 IPM) feed rate. Record this value.

16. Record motor voltage value at CN511-2 and CN511-4.

17. Reset the jumper JP2 to **NO** after the test is completed.

18. While inching, insert a soft large nylon tie-wrap into the feed roll gears. The Motor Buckling alarm lamp on the front of the power source should illuminate and feed roll rotation stop. Remove the tie wrap and press the inch button again. The alarm should clear and the feed roll should turn. Record function.

19. Check the inch forward rate. The factory default inch setting is 4 m/min (158 IPM), but may be adjusted from near “0” to 8 m/min if necessary. Note inch speed RPM (35 RPM ± 3) and record in chart.

20. Check the inch reverse rate. It should be the same as inch forward, due to only a relay reversal of polarity. Observe that the rate is the same (-35 RPM ± 3) and record. Record voltage at CN511-2 to CN511-4.

**NOTE:** The following adjustments have been set to factory default settings. Do not change the factory default setting unless directed by factory personnel to do so.

**CAUTION!**

*Do not change any other controls on the main PC board, particularly those marked with red sealer or marker.*

21. Adjust run-in speed. The factory default run-in speed is set to 1.3 m/min (51.2 IPM) but can be adjusted to a maximum of 4.4 m/min (173.7 IPM) with adjustment of VR2 on the main PC board CVA2. This pot is located toward the front of the power source on the right side near IC 2A. 1.3 m/min = 11±2 RPM.

22. Adjust burn back. At shipment the burn back pot adjustment VR7 is set fully CCW to its minimum. Adjusting VR7 CW increases the burn back time and will increase the ball size during burn back. Observe and record that VR7 is set fully CCW.

23. Adjust preflow set time. Jumper JP1 is factory set to “NO” to provide gas flow at the same time as arc on command. If necessary, JP1 can be set to “Yes” to give a fixed pre-flow of 0.5 seconds. Record that JP1 is set to “NO.”
24. Adjust arc failure time settings. Pot VR1 on PC board YRI (Yaskawa Interface) sets the arc failure time. The arc failure time is set to 1.0 seconds after the start of a weld or 0.6 seconds during a weld. The delay at the start of welding can be changed from 0.5 to 2.0 seconds by adjusting VR1 on the Yaskawa interface PC board YRI. If, however, there is a overload, input error, or other serious inverter condition, the power source will shut down immediately. Record that VR1 is set to mid range.

25. Adjust inch forward wire feed. Pot VR3 on PC Board YRI sets inch speed. The factory inch setting is mid scale at 4 m/min (158 IPM), but may be adjusted from near “0” to 8 m/min if necessary. Default speed in 35±2 RPM for 4 m/min.

**CAUTION!**

*Do not change the default setting of SW1001 unless directed by factory personnel.*

26. The factory default setting of SW1001 is switch position #5. Each step clockwise (CW) increased pulse 0.25 milliseconds and each step in the CCW direction reduced the pulse time by 0.25 ms. Record the default setting and insure it is set to position #5.

### 6.3.2 Weld Testing

Actual weld tests confirm proper settings in the XRC and calibration of the Kobelco AL-350. The following settings are typical for soft 4043 alloy 3/64" diameter aluminum wire and argon gas. Make certain all cables are connected.

1. Set up the following weld table in the XRC controller or confirm that it has been set up correctly. The following setup information is for 3/64" diameter 4043 aluminum wire. Set the power source external switch for soft wire.

<table>
<thead>
<tr>
<th>Amps</th>
<th>Robot Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>69</td>
<td>2.75</td>
</tr>
<tr>
<td>100</td>
<td>3.88</td>
</tr>
<tr>
<td>131</td>
<td>5.00</td>
</tr>
<tr>
<td>150</td>
<td>5.88</td>
</tr>
<tr>
<td>175</td>
<td>7.00</td>
</tr>
<tr>
<td>200</td>
<td>7.88</td>
</tr>
<tr>
<td>238</td>
<td>9.38</td>
</tr>
<tr>
<td>263</td>
<td>10.25</td>
</tr>
</tbody>
</table>

2. Set up the following voltage table in % units:

<table>
<thead>
<tr>
<th>Volts %</th>
<th>Robot Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>88%</td>
<td>3.00</td>
</tr>
<tr>
<td>100%</td>
<td>7.00</td>
</tr>
<tr>
<td>112%</td>
<td>11.0</td>
</tr>
</tbody>
</table>

3. The following data is for the third analog channel or Polarity Change. Generally a value of “0” represents no polarity change (all Reverse Polarity - 100% electrode positive) and 14.00 indicates a value of 58% Straight Polarity.

<table>
<thead>
<tr>
<th>Polarity</th>
<th>Robot Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14.00</td>
<td>14.00</td>
</tr>
</tbody>
</table>

(normal range is 1.0 - 4% to 12.00 at 40%, 14.00=58%)
4. Set the following amperage conditions in the job or load the test job for the Kobelco into the XRC.
   
a) **Weld condition #1** – Set 150 amps in job, 100% voltage, “0” Penetration, 90 CM/min travel, bead on plate with slight 5 degree push angle and 5/8” wire stick out. Use 3/16” aluminum plate. Run bead on plate and check the actual analog command settings in the diagnostic section. The volts should be VWELD=7.00, Amps AWELD=6.29, and Penetration AOUT #3 of 0.0 volts. Record actual amps and volts displayed on the power source meters and the wire feed speed motor shaft RPM during welding. Record the diagnostic analog values.

b) Actual conditions should be 160 Amps ± 15 amps, 20.6 volts ±0.3, and motor RPM of 62 ±1 (7.67 meter/minute, or 302 IPM).

c) **Weld Condition #2** – Set 150 amps, 100% volts, Penetration Control of 7.00 and travel speed of 70 CM/Minute and run the weld. Record actual volts, amps, and Motor speed on the test report.

d) The actual amps should be 124 amps ± 15, 19.0 ± 1 volts, and 62 ± 1 RPM motor speed.

e) Record the actual command signal given in the diagnostic screen. These should be: volts 7.00, amps 6.29, and Aout #3 or penetration of 7.00.

### 6.3.3 Checking Wire Stick Sensing

Wire stick sensing is controlled by the robot MEW-02 board, which applies approximately 11 volts to the output terminals of the welding power source. When this voltage drops due to a “wire stick” condition of less than 500 ohms, the robot detects wire sticking. To check wire stick sensing, proceed as follows:

1. Apply an alligator clip between the weld wire and the work. Switch the robot from Teach to Play. A wire stick warning should be displayed. Remove clip and alarm will reset.

   **NOTE:** The power source voltmeter will display approximately 5 volts ±2 volts on the meter without a wire stick and “0” with a stick.

2. If wire stick occurs during actual welding, turn off the power source. An arc failure alarm will be given immediately and the robot will attempt to re-strike.
APPENDIX A

SPARE PARTS/CONSUMABLE PARTS

Included here is a list of the various components of the aluminum welding system and the engineering drawing number which contains the corresponding parts listing. These drawings appear in Appendix B. Also included is a list of consumable parts and part numbers for the Kobelco AL-350 Welding Power Supply and the RF202YAM Wire Feed Unit. Also included is an assembly drawing of the power supply, an electrical connection diagram, and a detailed view of the connectors on the robot interface board.

Table A-1 System Spare Parts List

<table>
<thead>
<tr>
<th>Item Name</th>
<th>Drawing Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum Welding System for SK Robot</td>
<td>137053</td>
</tr>
<tr>
<td>Power Source Kit</td>
<td>137067</td>
</tr>
<tr>
<td>Torch Kit</td>
<td>133522</td>
</tr>
<tr>
<td>Water Circulator</td>
<td>470158</td>
</tr>
<tr>
<td>Transformer, 30 KVA</td>
<td>479529</td>
</tr>
<tr>
<td>Wire Spool Dereeler Kit (Hobart)</td>
<td>374831A</td>
</tr>
</tbody>
</table>

Table A-2 System Consumable Parts List

<table>
<thead>
<tr>
<th>Item Name</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuses</td>
<td></td>
</tr>
<tr>
<td>PE-0505 5A-250V</td>
<td>138318-1</td>
</tr>
<tr>
<td>PE-0501 0.5A-250V</td>
<td>138316-1</td>
</tr>
<tr>
<td>PE-0502 1A-250V</td>
<td>138319-1</td>
</tr>
<tr>
<td>Torch Tips (from Tregaskiss)</td>
<td></td>
</tr>
<tr>
<td>3/64&quot; aluminum wire</td>
<td>403-1-364</td>
</tr>
<tr>
<td>1/16&quot; aluminum wire</td>
<td>403-1-1.8</td>
</tr>
<tr>
<td>Torch Liners</td>
<td></td>
</tr>
<tr>
<td>Hobart, 3/64 or 1/16</td>
<td>379529-5 (3/64),</td>
</tr>
<tr>
<td></td>
<td>379529-9 (1/16)</td>
</tr>
<tr>
<td>Tregaskiss Liner retainer</td>
<td>415-116-05</td>
</tr>
<tr>
<td></td>
<td>415-18</td>
</tr>
</tbody>
</table>
### Table A-3  AL350 Power Supply Unit Spare Parts List

<table>
<thead>
<tr>
<th>Item Name</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVA2 PC Board</td>
<td>138414-1</td>
</tr>
<tr>
<td>YRI Interface PC Board</td>
<td>138337-1</td>
</tr>
<tr>
<td>DRV-2 PC Board</td>
<td>138339-1</td>
</tr>
<tr>
<td>SDRV PC Board</td>
<td>138338-1</td>
</tr>
<tr>
<td>Q1-4 Transistor</td>
<td>138335-1</td>
</tr>
<tr>
<td>Q11-42 Transistor</td>
<td>138336-1</td>
</tr>
<tr>
<td>TRB1 Transistor</td>
<td>138333-1</td>
</tr>
<tr>
<td>DB1 Diode Module</td>
<td>138334-1</td>
</tr>
<tr>
<td>DD1-3 Diode Module</td>
<td>138331-1</td>
</tr>
<tr>
<td>DAS Diode Module</td>
<td>138332-1</td>
</tr>
<tr>
<td>DE2-5 Diode Module</td>
<td>138329-1</td>
</tr>
<tr>
<td>BD1-5 Diode Module</td>
<td>138330-1</td>
</tr>
<tr>
<td>MC1 Contactor</td>
<td>138327-1</td>
</tr>
<tr>
<td>FAN1,2 Fan</td>
<td>138328-1</td>
</tr>
<tr>
<td>SW1 Switch</td>
<td>138309-1</td>
</tr>
<tr>
<td>SW2-5 Switch</td>
<td>138326-1</td>
</tr>
<tr>
<td>PL1 Lamp</td>
<td>138297-1</td>
</tr>
<tr>
<td>A Ammeter</td>
<td>138324-1</td>
</tr>
<tr>
<td>V Voltmeter</td>
<td>138322-1</td>
</tr>
<tr>
<td>CON1 Connector</td>
<td>138323-1</td>
</tr>
<tr>
<td>CON2 Connector</td>
<td>138320-1</td>
</tr>
</tbody>
</table>

### Table A-4  RF202YAM Wire Feed Unit Parts/Consumable List

<table>
<thead>
<tr>
<th>Item Name</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Base Unit</td>
<td>PB351-0666</td>
</tr>
<tr>
<td>Motor Unit</td>
<td>PB351-0530</td>
</tr>
<tr>
<td>Pressure Bolt Unit</td>
<td>PB351-0667</td>
</tr>
<tr>
<td>Pressure Bolt</td>
<td>PB351-0676</td>
</tr>
<tr>
<td>Spring Seat</td>
<td>PB351-0529</td>
</tr>
<tr>
<td>Three Lobe Knob</td>
<td>TK40 (made by Imao)</td>
</tr>
<tr>
<td>Pressure Arm Unit</td>
<td>WFAA0070</td>
</tr>
<tr>
<td>Wire Straightener</td>
<td>PB351-0547</td>
</tr>
</tbody>
</table>

#### Consumable Parts

<table>
<thead>
<tr>
<th>Item Name</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>120V Feed Roller</td>
<td>PB351-0530</td>
</tr>
<tr>
<td>Center Wire Guide</td>
<td>PB351-0671</td>
</tr>
</tbody>
</table>
APPENDIX B
DIAGRAMS

This appendix contains a set of reference drawings for the aluminum welding system. The table below lists the drawings included.

<table>
<thead>
<tr>
<th>Item Name</th>
<th>Drawing Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Circulator</td>
<td>470158</td>
</tr>
<tr>
<td>Torch Kit</td>
<td>133522</td>
</tr>
<tr>
<td>Wire Spool Dereeler Kit</td>
<td>374831A</td>
</tr>
<tr>
<td>Power Source Kit</td>
<td>137067</td>
</tr>
<tr>
<td>Kobelco Power Source with Feeder</td>
<td>137536</td>
</tr>
<tr>
<td>Cable, Clutch Sense, XRC to Feeder</td>
<td>134023</td>
</tr>
<tr>
<td>Kobelco Power Cable</td>
<td>134024</td>
</tr>
<tr>
<td>30 KVA Transformer</td>
<td>479529</td>
</tr>
<tr>
<td>MEW02-2 Board</td>
<td>132120-1</td>
</tr>
<tr>
<td>Aluminum System Outline</td>
<td>137053</td>
</tr>
<tr>
<td>Motoman SK6 Robot</td>
<td>133523</td>
</tr>
<tr>
<td>Motoman SK16 Robot</td>
<td>133526</td>
</tr>
</tbody>
</table>
# APPENDIX C
## CALIBRATION RECORDS

### Record of Test Values

**Power Source Serial Number:**

**System Reference Number:**

1. Input Voltage Line to Line ______ ______ ______ (208 ±8V AC)
2. Input voltage line to ground ______ ______ ______ (120 ±5V AC)
3. VR7 set to CCW
4. VR2 set to Mid range
5. VR1 set to Mid range
6. VR8 set to Mid range
7. SW1001 Set to #5
8. Wire feeder feeds forward
9. Wire feeder feed reverse
10. Gas valve energizes
11. Voltage Sense Lead Resistance (205 to torch tip) ______ <.3 ohmΩ
12. Robot Controller VWELD Voltage at CN507-1 and CN507-2 ______ 14.00±.02
13. Scaled VWELD Command at CN501-1 to CH44 ______ 10.00±.25
14. Robot Controller AWELD voltage at CN507-3 and CN507-4 ______ 14.00±.02
15. Scaled AWELD Command at CN501-2 and CH44 ______ 10.75±.25
16. Robot Controller Penetration Volts at CN509-1 and CN509-2 ______ 14.00±.02
17. Scaled Penetration command at CN509-3 and CH44 ______ 9.80±.25
18. Wire Feed Speed RPM ______ 160 +0-1
19. Motor Volts CN511-2(+) to CN511-4(-) @ full speed ______ 22±2
20. Inch Forward Speed RPM (hold inch 3-4 sec. to stabilize) ______ 35±3
21. Inch Fwd Motor Volts at CN511-2(+) to CN511-4-4(-) ______ 5.5±2
22. Inch Reverse RPM (hold inch for 3-4 sec. minimum) ______ 35±3
23. Inch Reverse Motor Volts at CN511-2 (+) to CN511-4(-) ______ -5.5±2
24. Wire Buckling Test
25. Wire Stick Test
Weld Testing Setting #1
1. Weld Volts ______ 21±.2
2. Weld Amps ______ 160±15
3. Wire Feeder RPM ______ 62±2
4. Robot Diagnostic settings (VWELD, AWELD, AOUT#3)_____, _____, _____

Weld Testing Setting #2
1. Weld Volts ______ 19±1
2. Weld Amps ______ 123±15
3. Wire Feeder RPM ______ 62±2
4. Robot Diagnostic settings (VWELD, AWELD, AOUT#3)_____, _____, _____

Test Engineer: ___________________________ Date: ______________
Customer: _______________________________ Location: ______________
APPENDIX D
SENSARC AL350 TECHNICAL REPORT
1. Introduction

Aluminum alloys today are used in automobiles, rolling-stock, fishing vessels, chemical containers, construction, and other wide-ranging fields thanks to their superior properties, such as lightness, recyclability, and corrosion resistivity. Thus modern equipment for the welding of aluminum alloys has greatly been in demand.

MIG and TIG welding processes are the mainstream of aluminum-alloy welding. For the welding of thin plate joints, which normally causes difficulties, the TIG process is preferred for the reason that the arc can be stabilized using a weak welding current. However, the TIG process requires a longer time and expertise, and most importantly it is not adaptable to robotic operation because of the complexity of handling fillers and electrodes.

Industries trying for further reduction in product weights, such as the automotive industry, have been looking for the equipment that is capable of easily welding light-gage aluminum-alloy plates using the MIG process, which permits the high-efficient robotized welding operation.

Such welding equipment is now available from Kobe Steel. The newly developed SENSARC AL350 MIG Welding Power Source is designed for the easy welding of thin aluminum-alloy plates with perfectly controlled
eneration-being a MIG-process welder it is, of course, adaptable to the robotic operation. The following describes the details of the new welding equipment.

2. Object of the Development

In the MIG welding of aluminum alloys the DC welding current exceeding critical current with reverse polarity (wire-electrode positive, base metal negative; referred to as DCEP hereinafter) is employed. This method ensures stable spray transfer, base-metal cleaning, and deep penetration. While, pulsed MIG welding using the DCEP polarity has recently been widely employed, in which droplets are forcibly spray-transferred by pulsed current even in the low-range current below critical current.

The pulsed MIG welding results in excessively deep penetration, however, when applied to plates thinner than 2 mm or weld joints having gaps due to low precision, causing burn-through and other defects as shown in Figure 1. It has thus been difficult with this conventional method of welding to maintain the quality of weldments or robotize the operation.

Noting the differences in characteristics between DCEP pulsed welding and DC straight polarity (wire-electrode negative, base meal positive; referred to as DCEN hereinafter), we have solved the above-mentioned problems by combining only the advantages of DCEP and DCEN—see Figure 2. The result is an AC pulsed MIG welding power source, SENSARC AL350, in which the stable spray transfer and deep penetration

<table>
<thead>
<tr>
<th></th>
<th>DCEP Pulsed Welding</th>
<th>DCEN Welding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Droplet transfer</td>
<td>(Spray transfer)</td>
<td>(Globular transfer)</td>
</tr>
<tr>
<td>Bead shape &amp; penetration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wire melting speed</td>
<td>Almost identical to DCEP.</td>
<td>Over 1.5 times that of DCEP.</td>
</tr>
<tr>
<td>Cleaning action</td>
<td>Available.</td>
<td>Not available.</td>
</tr>
<tr>
<td>Defects caused with thin plates</td>
<td>Burn-through, undercuts.</td>
<td>Poor penetration, bulged beads.</td>
</tr>
<tr>
<td>Countermeasure</td>
<td>AC pulsed MIG welding with advantages of DCEP pulsed welding and DCEN welding combined.</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2 Polaritys & weld phenomena
utilized to forcibly transfer that droplet from the wire end to the base metal in synchronization with pulse current. This process further allows droplet transfer without any short-circuiting even at currents lower than the critical current, resulting in less spatter and sound arc stability.

In AC pulsed welding, which SENSARC AL350 performs, one droplet is transferred to the base metal without fail in synchronization with every AC cycle providing sound arc stability similar to the pulsed droplet transfer process in DCEP welding. This is achieved by optimizing DCEN currents and DCEP pulses so that droplets formed on the wire end during the DCEN period are separated by DCEP pulse currents as shown in Figure 8. Thus droplet transfers are made at regular intervals in synchronization with current frequencies, accomplishing an ideal AC-pulsed welding method with extremely less spatter.

In the AC-pulsed welding method, which alternately repeats DCEP and DCEN processes, arc stability cannot be maintained by the switching of polarities alone because the arc is extinguished as soon as the

---

**Figure 8** Droplet transfer in AC-pulsed MIG welding

---

**Figure 9** Relationship of plate thickness & max. allowable gap in flat lapped joints

---

**Figure 10** Example of welding flat lapped joints with different thickness

---

<table>
<thead>
<tr>
<th>Joint configuration</th>
<th>A5052 2.5mm thick</th>
<th>1.2mm-thick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding power source</td>
<td>SENSARC AL350</td>
<td>Conventional pulsed MIG</td>
</tr>
<tr>
<td>Wire</td>
<td>A518(1.2mm dia)</td>
<td>A518(1.2mm dia)</td>
</tr>
<tr>
<td>Shielding gas</td>
<td>Ar[20liters/min]</td>
<td>Ar[20liters/min]</td>
</tr>
<tr>
<td>Polarity</td>
<td>AC(polarity ratio:30%)</td>
<td>DCEP</td>
</tr>
<tr>
<td>Wire feed rate</td>
<td>7.0mm/min</td>
<td>7.0mm/min</td>
</tr>
<tr>
<td>Welding conditions</td>
<td>90A x 18V x 60cm/min</td>
<td>110A x 18V x 60cm/min</td>
</tr>
<tr>
<td>Bead appearance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penetration configguration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
shown in Figure 4. The main specifications of SENSARC AL350 are shown in Table 1.

3.2 Penetration Control

SENSARC AL350 controls penetration taking advantage of increase in the amount of wire melting and reduction in the depth of penetration during a DCEN welding as described earlier. The effects of polarity on the wire-melting rate, penetration, and bead shape are shown in Figure 5.

In AC-pulsed welding with the DCEN-to-DCEP conductivity ratio set at 1:1 and compared to DCEP pulsed welding, the wire-melting rate is 50 to 70% higher for the same current and current is 30 to 40% lower at the same wire-feed rate, reducing the heat input to the base metal.

Thus penetration is deeper and beads are flat in DCEP pulsed welding, whereas penetration is extremely shallow and beads are bulged in AC-pulsed welding involving 50% of DCEN welding.

SENSARC AL350 has a function that continuously varies the DCEN-to-DCEP conductivity ratio, which is the polarity ratio. The polarity ratio can be defined in the following formula — Figure 4 for the description of the parameters in the formula:

\[
\text{Polarity ratio} = \left( \frac{I_{\text{EN}} \times T_{\text{EN}}}{I_{\text{EN}} \times T_{\text{EN}} + I_{e} \times T_{e}} \right) \%
\]

Figure 6 shows how changes in the polarity ratio affect penetration and bead and cleaning widths. As can be seen in the figure, SENSARC AL350 permits the optimum selection of penetration depth ranging from very shallow to very deep while maintaining the cleaning action. The depth of penetration alone can thus be controlled with the wire-feed rate unchanged maintaining the same amount of deposited metal. This permits formation of beads most proper for the plate thickness or gap as shown in Figure 7.

With conventional equipment, undercuts are caused when current is reduced in order to prevent burn-through because the wire-feed rate is reduced at the same time decreasing the amount of deposited metal. On the other hand, increasing the wire-feed rate increases current and burn-through is caused with flared joints, for example, which require a large amount of deposited metal.

3.3 Stabilization of AC-pulsed Arc

In the commonly adapted DCEP pulsed welding, the molten droplet on the end of the electrode wire is squeezed by the electromagnetic pinch force generated when pulse current is applied. This phenomenon is
capabilities of DCEP pulsed welding and the higher wire melting and shallow penetration capabilities of DCEN welding are alternately repeated.

3. Features

Features of SENSARC AL350, of which the external view is shown in Photo 1, are described in this Section.

3.1 Design and Function

The main circuit is composed of two inverters—see Figure 3. The primary inverter circuit controls output current and the secondary inverter circuit alters output polarity, resulting in the output of the AC waveform.

<table>
<thead>
<tr>
<th>Item</th>
<th>Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated supply voltage</td>
<td>3-phase, 200/220V/110%</td>
</tr>
<tr>
<td>Supply frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Rated apparent power</td>
<td>18 kVA</td>
</tr>
<tr>
<td>Rated welding current</td>
<td>350A</td>
</tr>
<tr>
<td>Welding current</td>
<td>40 to 350A</td>
</tr>
<tr>
<td>Welding voltage</td>
<td>15 to 36V</td>
</tr>
<tr>
<td>Rated duty cycle</td>
<td>60%</td>
</tr>
<tr>
<td>Output polarity ratio</td>
<td>0 to 58%</td>
</tr>
<tr>
<td>Applicable wire diameter</td>
<td>1.2 or 1.6 mm dia.</td>
</tr>
<tr>
<td>Wire feed rate</td>
<td>0 to 16 m/min</td>
</tr>
<tr>
<td>External dimensions (W x H x D)</td>
<td>434 x 796 x 695 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>120 kg</td>
</tr>
</tbody>
</table>

Figure 3 Basic circuit diagram

Figure 4 Current waveform

Figure 5 Effects of polarity on penetration, bead shape, & wire melting rate
current direction changes. With aluminum alloys, a voltage of about 150V must be applied to re-ignite the arc without fail. SENSARC AL350 has a function to apply an ample pulse voltage needed for arc re-ignition for a few microseconds at the time of every polarity-change, permitting stable AC-pulsed arc welding without being interrupted by the extinguished arc.

4. Welding Tests

The results of typical welding tests using SENSARC AL350 and a conventional pulsed MIG welder are described.

4.1 Thin-plate Lapped Fillet Joint

As shown in Figure 9, SENSARC AL350 allowed welding of 1 mm-thick plates at a welding speed of 60 cm/min, which used not to be possible. With 2 mm-thick plates, a greater gap allowance was obtained and burn-through was not caused even when a gap as wide as the plate thickness was present.

4.2 Practical Joints

The results of comparative welding tests on three practical joints are shown in Figures 10 to 13. The advantages of SENSARC AL350 were fully demonstrated in these tests. Thin-plate joints of aluminum alloys, which used to forbid the use of pulsed MIG welding and require TIG welding, were successfully welded by SENSARC AL350 without causing burn-through.

<table>
<thead>
<tr>
<th>Joint configuration</th>
<th>AS5052 3.0mm-thick</th>
<th>Gap: 2.0mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding power source</td>
<td>SENSARC AL350</td>
<td>Conventional pulsed MIG</td>
</tr>
<tr>
<td>Wire</td>
<td>AS183 (1.2mm dia.)</td>
<td>AS183 (1.2mm dia.)</td>
</tr>
<tr>
<td>Shielding gas</td>
<td>Ar (20 liters/min)</td>
<td>Ar (20 liters/min)</td>
</tr>
<tr>
<td>Polarity</td>
<td>AC (polarity ratio: 25%)</td>
<td>DCEP</td>
</tr>
<tr>
<td>Wire feed rate</td>
<td>6.5m/min</td>
<td>6.5m/min</td>
</tr>
<tr>
<td>Welding conditions</td>
<td>105A x 19V x 50cm/min, 120A x 19V x 50cm/min</td>
<td></td>
</tr>
</tbody>
</table>

Figure 11 Example of welding flat flared joints with a gap

<table>
<thead>
<tr>
<th>Joint configuration</th>
<th>AS5052 1.5mm-thick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding power source</td>
<td>SENSARC AL350</td>
</tr>
<tr>
<td>Wire</td>
<td>AS183 (1.2mm dia.)</td>
</tr>
<tr>
<td>Shielding gas</td>
<td>Ar (20 liters/min)</td>
</tr>
<tr>
<td>Polarity</td>
<td>AC (polarity ratio: 25%)</td>
</tr>
<tr>
<td>Wire feed rate</td>
<td>6.5m/min</td>
</tr>
<tr>
<td>Welding conditions</td>
<td>90A x 17V x 70cm/min, 105A x 18V x 70cm/min</td>
</tr>
</tbody>
</table>

Figure 12 Example of welding flat butt joints with a gap
5. Advantages

Major advantages of using SENSARC AL350 are described.

5.1 Basic Features

SENSARC AL350, in which the newly developed waveform control technology is incorporated, has the following basic features:

1) Freely controllable penetration depth

The optimum penetration depth can freely be selected by adjusting the polarity ratio while keeping the same wire-feed rate — without canging

the setting of current. The feature permits sound penetration and beads while maintaining an appropriate amount of excess metal according to the joint being welded.

2) Stabilized AC-pulsed arc

Droplets are transferred at regular intervals in synchronization with AC frequencies, generating extremely less splatter. Furthermore, high voltage is applied to re-ignite the arc at the moment of every polarity-change in order to ensure the stability of AC-pulsed arcs without being interrupted by the extinguished arc.

5.2 Potential Improvements

The capability of SENSARC AL350 to allow shallow penetration should enable the following improvements in the welding of thin aluminum-alloy plates:

- The minimum weldable plate-thickness can be as thin as 1.0 mm, expanding the applicability of MIG welding to thinner plates.
- The wider allowable gap range permits to improve the welding quality of low-precision joints and boost yields in welding operations.
- Increased productivity and further labor-saving can be achieved in welding operations through easy robotization.

6. Conclusion

SENSARC AL350 is, compared to conventional pulsed MIG welding equipment, capable of extending the weldability range of thin aluminum-alloy plates. Thus a large portion of the welding of aluminum-alloy joints, which so far had to depend on inefficient and expertise-demanding TIG welding, may now be turned to efficient and easily controllable MIG welding.

SENSARC AL350 should well become instrumental in stabilizing welding quality, improving productivity, and advancing robotization in automotive, rolling stock, and other industries, where the welding of thin aluminum-alloy plates is ever more vital to make their products lighter.
APPENDIX E

MODIFYING THE AL350 FOR SEMI-AUTOMATIC OPERATION

E.1 Installation

The AL-350 power supply is shipped ready to operate with an XRC controller (automatic operation). However, you can also operate the welder using an optional handheld remote control unit (semi-automatic operation). The steps outlined below describe the modifications necessary to convert the AL-350 from automatic operation to semi-automatic operation.

1. Remove the top cover of the AL-350 power supply.
2. Two printed circuit boards, CVA2 and YRI, are located under the top cover of the AL-350 power supply (see Figure E-1).

3. Disconnect connector CN1YR and from terminal CN1 on the CVA2 board and connect connector CN1 (see Figure E-2).
MODIFYING THE AL350 FOR SEMI-AUTOMATIC OPERATION

DISCONNECT THE CN1YR CONNECTOR ON TERMINAL CN1 AND CONNECT THE CN1 CONNECTOR TO THE CN1 TERMINAL.

Figure E-2  Location of CN1YR

4. Disconnect CN305 on the YRI board (see Figure E-3).

DISCONNECT THE CN305 CONNECTOR FROM THE CN305 TERMINAL

Figure E-3  Location of CN305
5. Disconnect CN5 on the CVA2 board, and replace it with CN305, which you just removed from the YRI board (see Figure E-4).

![Diagram of CVA2 board with CN5 and CN305 connections highlighted]

**Figure E-4  Location of CN5**

6. Disconnect CN11B and CN11A on CVA2 (see Figure E-5).

![Diagram of CVA2 board with CN11B and CN11A connections highlighted]

**Figure E-5  Location of CN11B and CN11A**
7. Disconnect CN101 from CN101B. These connectors are free-floating and located as shown in Figure E-6.

**Figure E-6 Location of CN101 and CN101B**

8. Disconnect CN101A on the CVA2 board, and connect CN101, which you just disconnected from CN101B (see Figure E-7).

**Figure E-7 Location CN101 and CN101A**
9. Disconnect connector CN32 from terminal CN308 on the YRI board (see Figure E-8).

10. Disconnect CN32YR from terminal CN32 on the CVA2 board and connect CN32, which you just removed from the YRI board (see Figure E-9).
11. Insert a #13 wire into the middle of connector CN3 on the CVA2 board (see Figure E-10).

12. Disconnect the reverse inching cable, which is connected to TB1 on the YRI board (see Figure E-11).

13. Connect the remote control pendant to the receptacle labeled “VOLTAGE DETECTOR” on the front cover (see Figure E-11). Remove the robot control cables and the reverse inching cable from the rear of the AL350.
MODIFYING THE AL350 FOR SEMI-AUTOMATIC OPERATION

REAR OF UNIT ROTATED 180°

REMOVE REVERSE INCHING CABLE CONNECTED TO TB1 ON THE PC BOARD YR1

REMOVE CONTROL CABLES

CONNECT REMOTE CONTROL BOX

Figure E-11 Connecting the Remote Control Unit
E.2 Operation

E.2.1 AL-350 Control Panel

**POWER**
This switch turns the power ON/OFF.

**GAS**
When set to FLOW, gas is supplied independent of the welding operation. This switch is used to check the flow rate of gas. When set to AUTO, gas is supplied only during welding.

**CRATER**
To control the welding operation with the remote control unit, set this switch to ON. This switch works in conjunction with CRATER CURRENT, CRATER VOLTAGE, and CRATER PENETRATION to control the welding operation.

**WIRE DIAMETER**
According to which diameter of wire to use, set this switch to 1.2 or 1.6.

**WIRE TYPE**
According to wire type is used, set this switch to HARD (when wire is 5000 series) or SOFT (when wire is 4000 or 1000 series).

**CRATER CURRENT, CRATER VOLTAGE, CRATER PENETRATION**
When the CRATER switch is turned ON, CRATER CURRENT, CRATER VOLTAGE, and CRATER PENETRATION can be used to set current, voltage and weld penetration for crater treatment. When the CRATER switch is turned OFF (as in automatic operation), these switches are disabled and do not have any influence on the welding operation.

E.2.2 Remote Control Panel

**WELDING CURRENT Control**
This is used to adjust welding current. Set this control to a proper welding current value.

**NOTE:** In reality, this control sets wire feed speed (wire melting rate). Welding current can also be changed with the PENETRATION control. Current scale on the remote control unit shows a guideline when the PENETRATION control is turned counter clockwise to the end (zero).

**VOLTAGE FINE Control**
The zero setting on the VOLTAGE FINE control indicates the welding current is adjusted to a standard value. When it is necessary to set welding voltage at a level higher or lower than the standard value, turn this control in the plus or minus direction.
MODIFYING THE AL350 FOR SEMI-AUTOMATIC OPERATION

**PENETRATION Control**
This control is used to adjust weld penetration. When set to zero, reversed polarity welding (wire positive; base metal negative) is executed, and weld penetration is deepest. Turning the control clockwise increases the ratio of straight polarity in AC welding, making weld penetration shallower. When set to 10 (60%), straight polarity welding (wire negative; base metal positive) is executed, and the weld penetration is shallowest.

**NOTE:** Turning the PENETRATION control clockwise decreases welding current. However, when the VOLTAGE FINE control is set at a constant value, the melting rate of wire does not change.

**E.2.3 Error Indicators**
If an error indicating lamp other than OVER HEAT lights up, turn OFF the POWER switch and then the switch on the distribution box. Be sure to turn the primary power source OFF and wait for more than 2 minutes before checking inside the welding power supply. Be careful not to touch hot parts in the welding power supply.

**INV**
This lamp lights up if an over-current flows through the inverter transistor in the welding power supply. If this error recurs when the power is turned ON again, immediately call a nearby KOBE STEEL sales office.

**OVER CURRENT**
This lamp lights up if a current exceeding the rating flows through the load for more than 2 seconds. Check for short-circuiting between a chip and base metal or between output cables.

**OVER HEAT**
This lamp lights up when the welding power supply is operated exceeding the specified service factor. With the power turned ON, wait until inside temperature of the welding power supply sufficiently drops.

**INPUT**
This lamp lights up if supply voltage of 200V AC input line exceeds the allowable limit or if open-phase occurs. Check whether input voltage is too high or too low, or whether open-phase occurred. The allowable range of supply voltage is ± 10%.

**NOTE:** It is necessary to connect connectors in the welding power supply according to the level of primary side supply voltage (200/220V AC). At shipment the connection is made for 200V AC.

**CABLE**
This lamp lights up if a cable leading to an external device such as wire feeder and remote control box is short-circuited with other cable (other signal line, power cable or grounding cable). Check for contact between cables. If fuse FUl (1 Amp, printed circuit board CVS) or FU2 (0.5 Amp, printed circuit board CVS) is blown, replace it with new one.
REV
This lamp lights up if REV supply voltage inside the welding power supply is out of proper range. If the REV error indicating lamp lights up weakly during welding operation, it becomes impossible to control weld penetration. Make wire torch side and base metal side power cables as parallel to each other as possible and as short as possible. If welding stopped due to REV error during operation, immediately call a nearby KOBE STEEL sales office.

NOTE: To recover from the error condition, turn the POWER switch OFF, and then, after checking the above explained items, ON again.

E.3 Inspection and Maintenance
For peak performance, the welding power supply needs to regularly be inspected and maintained.

NOTE: Be sure to turn the primary power source OFF and wait for more than 2 minutes before checking inside the welding power supply. Be careful not to touch hot parts in the welding power supply.

E.3.1 Daily Inspection/Maintenance
1. Check the surface of cables for crack, flaw or other defect.
2. Check part mounting screws and connectors for loosening.
3. Check cable connection for abnormal heating.
4. Check for abnormal vibration, noise or smell.
5. Check the surface of gas hose for crack, flaw or other defect.

E.3.2 Quarterly Inspection/Maintenance
To ensure the cooling of semiconductor elements such as transistor, remove the top and side covers, and remove dust sticking to cooling fin and fan.

E.3.3 Dielectric Strength Test and the Measurement of Insulation Resistance
This welding power supply uses transistors. If executed carelessly, the dielectric strength test or the measurement of insulation resistance may damage component parts. The dielectric strength test and the measurement of insulation resistance shall be executed observing the following precautions.

1. The test/measurement shall be executed on unit welding power supply, with input/output cables and wire feeder removed.
2. Short-circuit 3 input terminals as well as 2 output terminals.
3. Short-circuit the anode and cathode of primary side diode DBl as well as the collector and emitter of transistors Ql to Q4. Remove the case grounding terminal of capacitor C11.
4. Short-circuit the anode and cathode of secondary side diodes Dl and D2, the anode and cathode of diodes DDl to DD3 and BDl to BD4, and the collector and emitter of transistors Q11, Q42, and TRBl.
E.3.4 **Cleaning the Fan**

To clean the fan, remove the front panel, and remove dust sticking around the fan with a brush or lint-free cloth.

E.3.5 **Troubleshooting**

Be sure to turn the primary power source OFF and wait for more than 2 minutes before checking inside the welding power supply. Be careful not to touch hot parts in the welding power supply.

Probable error causes are listed in the table below. Investigate and remove the causes according to the table. If necessary, repair or replace defective part.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Probable Cause (or inspection point)</th>
</tr>
</thead>
</table>
| POWER lamp does not light. | POWER switch is defective.  
                                   | Fuse Fl or F2 is blown.  
                                   | The lamp is defective.  
                                   | The input cable is defective.  |
| Fan does not rotate. | Fan cable is wired incorrectly.  
                                   | The fan is defective.  |
| Gas is not supplied. | When the GAS switch is set to FLOW, gas does not flow. One of the following could be the problem:  
                                   | • Gas cylinder valve is not opened.  
                                   | • Gas hose is disconnected.  
                                   | • CON2 connection on wire feeder is loose.  
                                   | • Faston terminal connection (line 201C or 206) is loose.  
                                   | • Foreign matter is caught in the gas line solenoid valve  
                                   | • Fuse FU2 (0.5 A) of the solenoid valve for gas line is blown. (Replace after removing the cause.)  
                                   | • Wire breakage occurred on the cable (line No. 201C or 206) of wire feeder.  
                                   | Printed circuit board CYS seems defective.  |
| INCHING does not work | CURRENT volume is set to 0 (zero).  
Connection of CON2 of wire feeder is loose.  
Connection of CON1 of remote control box is loose.  
The INCHING switch on the remote control box is defective.  
Connection to the faston terminal (line No. 201A or 202) of wire feeder is loose.  
Wire breakage occurred on the cable (line No. 201A or 204) of wire feeder.  
Printed circuit board CVS seems defective. |
### Table E-1  AL350 Troubleshooting - continued

<table>
<thead>
<tr>
<th>Problem</th>
<th>Probable Cause (or inspection point)</th>
</tr>
</thead>
</table>
| Welding does not start (voltage is applied) | TORCH switch is defective.  
Connection of CON2 of wire feeder is loose.  
Connection to the faston terminal (line No. 201B or 204) of wire feeder is loose.  
Wire breakage occurred on the cable (line No. 201B or 240) of wire feeder.  
Connection of the (2-core) connector for TORCH switch on the wire feeder is loose.  
Wire breakage occurred on the TORCH switch cord wired in the torch.  
Printed circuit board CVs, DRV-II or SDRV is defective.  
Main transistor Q1 to Q4 or Q11 to Q42 is damaged.  
Fuse FO is blown. |
| Welding does not start (voltage is applied, but wire does not inch) | If wire can be inched using the INCH function, a possible cause could be one of the following:  
• (-) voltage detection cable is not connected to base metal  
• Connection of (-) voltage detection cable at the terminal of wire feeder is loose.  
• Connection to the faston terminal (line No. 207) of wire feeder is loose.  
• Connection of CON2 for wire feeder is loose.  
Printed circuit board CVS is defective. |
| Welding does not start (voltage is applied, wire inches, but no arc is generated) | Wire breakage occurred on the (+) voltage detection cable wired in the torch.  
Connection of (+) voltage detection cable at the terminal of wire feeder is loose.  
Connection of the faston terminal (line No. 205) of wire feeder is loose.  
Wire breakage occurred on the cable (line No. 205) for wire feeder.  
Connection of CON2 for wire feeder is loose.  
Printed circuit board CVS is defective. |
| CURRENT control does not work.                           | Pressure of feed roller is too low.  
Dirt choked the conduit.  
Torch is bent too sharply.  
The CURRENT control on the remote control box is  
defective.  
Printed circuit board CVS is defective. |
|---------------------------------------------------------|-----------------------------------------------------------------------------------|
APPENDIX F
VENDOR MANUALS

Kobelco SENSARC Wire Feed Unit – RF202YAM Instruction Manual
Kobelco SENSARC AL350 – RYU2 Instruction Manual
1. Specifications

1.1 Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>RF202YAM</td>
</tr>
<tr>
<td>Wire Feed Rate</td>
<td>Max. 16 m/min</td>
</tr>
<tr>
<td>Applicable Wire Dia.</td>
<td>1.2mmφ - 1.6mmφ</td>
</tr>
<tr>
<td>Weight</td>
<td>5 kg</td>
</tr>
</tbody>
</table>

2. Welding Preparation

2-1. Connection

Refer to the welding power supply instruction manual (separate volume) for connection details. When connection has been completed, check the items below in order.

2-2. Wire pressure control

Slots are provided for the pressure bolts as shown in Fig. 1. Generally, the top surface of the pressure handle is positioned at the level shown in Fig. 2. Consider this as a reference level.

2-3. Wire setting

When guiding the wire to the wire feed drive, release the pressure handle while pressure is adjusted, guide the wire to the outlet guide, and apply pressure. When setting the wire, be extremely careful not to injure your eyes with the wire tip.

Pressure adjustment

![Diagram of pressure adjustment](image)

Fig. 1 Pressure Control
2-4. Wire inching

Press the WIRE INCHING switch on the robot teaching pendant to feed the wire to the tip of torch. Stop the wire when it is about 10mm from the tip.

3. Handling Precautions

3-1. Wire feed path

If the wire path of the wire guide, feed roller, outlet guide, etc. is extremely contaminated by dust or oil, the torch liner becomes clogged easily, resulting in deteriorated wire feed performance. Always keep these parts clean.

3-2. Dust prevention

When not operating the unit for long periods, protect the unit from dust with a vinyl cover. Note that the unit connection part with the torch (connector front face) is particularly affected by dust and oil.
4. Parts Lists

[Note] Symbols A to C in the remarks column indicate the following.

A : Consumable parts
B : Semi-consumable parts ••• Those that may become worn or malfunction due to improper handling
C : General Parts •••••• Those that are not damaged by normal operation.

4-1. Wire feed unit (part code: WFAA0073)

<table>
<thead>
<tr>
<th>No.</th>
<th>Part Code</th>
<th>Part Name</th>
<th>Required Q'ty</th>
<th>Min. supply Q'ty</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PB351-0666</td>
<td>Pressure Base Unit</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>PB351-0530</td>
<td>Motor Unit</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>PB351-0667</td>
<td>Pressure Bolt Unit</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>WFAA0070</td>
<td>Pressure Arm Unit</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>11</td>
<td>PB351-0684</td>
<td>120 V feed roller</td>
<td>4</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>30</td>
<td>PB351-0547</td>
<td>Wire correction unit</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
</tbody>
</table>
### 4-2. Pressure base unit (part code: PB351-0666)

<table>
<thead>
<tr>
<th>No.</th>
<th>Part Code</th>
<th>Part Name</th>
<th>Required Q'ty</th>
<th>Min. supply Q'ty</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PB351-0669</td>
<td>Pressure base guide</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>10</td>
<td>PB351-0426</td>
<td>Double drive gear</td>
<td>2</td>
<td>2</td>
<td>B</td>
</tr>
<tr>
<td>13</td>
<td>PB351-0672</td>
<td>Feed roller shaft</td>
<td>2</td>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Deep slot ball bearing</td>
<td>4</td>
<td>4</td>
<td>C 6001ZZ (JIS B1512)</td>
</tr>
<tr>
<td>15</td>
<td>PB351-0673</td>
<td>Feed roller shaft spacer</td>
<td>4</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>16</td>
<td>PB351-0674</td>
<td>Drive shaft spacer</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>17</td>
<td>PB351-0675</td>
<td>Drive Gear</td>
<td>1</td>
<td>1</td>
<td>B</td>
</tr>
<tr>
<td>22</td>
<td>PB351-0405</td>
<td>Pressure axis</td>
<td>2</td>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>23</td>
<td>PB351-0576</td>
<td>Insulation bush</td>
<td>2</td>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>25</td>
<td>PB351-0670</td>
<td>Center wire guide bracket</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>26</td>
<td>PB351-0671</td>
<td>Center wire guide</td>
<td>1</td>
<td>1</td>
<td>A</td>
</tr>
</tbody>
</table>

### 4-3. Motor unit (part code: PB351-0530)

<table>
<thead>
<tr>
<th>No.</th>
<th>Part Code</th>
<th>Part Name</th>
<th>Required Q'ty</th>
<th>Min. supply Q'ty</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>PB351-0574</td>
<td>Motor insulation bush</td>
<td>2</td>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>28</td>
<td>PB351-0573</td>
<td>Motor speed reducer</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>29</td>
<td>PB351-1460</td>
<td>Motor insulation seat</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
</tbody>
</table>
### 4-4. Pressure bolt unit (part code: PB351-0667)

<table>
<thead>
<tr>
<th>No.</th>
<th>Part Code</th>
<th>Part Name</th>
<th>Required Q'ty</th>
<th>Min. supply Q'ty</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>PB351-0678</td>
<td>Pressure bolt</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>19</td>
<td>PB351-0529</td>
<td>Spring seat</td>
<td>2</td>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>20</td>
<td>PB351-0677</td>
<td>Pressure spring</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>Three Lobe/Knob</td>
<td>1</td>
<td>1</td>
<td>C TK40 made by Imao</td>
</tr>
</tbody>
</table>

### 4-5. Pressure arm unit (part code: WFAA0070)

<table>
<thead>
<tr>
<th>No.</th>
<th>Part Code</th>
<th>Part Name</th>
<th>Required Q'ty</th>
<th>Min. supply Q'ty</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>PB351-0678</td>
<td>Pressure arm</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>PB351-0679</td>
<td>Pressure roller unit connection shaft</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>PB351-0680</td>
<td>Connection shaft bush</td>
<td>2</td>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>6</td>
<td>PB351-0681</td>
<td>Pressure roller base 1</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>7</td>
<td>PB351-0682</td>
<td>Pressure roller base 2</td>
<td>1</td>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Deep slot ball bearing</td>
<td>4</td>
<td>4</td>
<td>C 608ZZ (JIS B1512)</td>
</tr>
<tr>
<td>9</td>
<td>PB351-0689</td>
<td>Pressure roller spacer</td>
<td>4</td>
<td>4</td>
<td>C</td>
</tr>
<tr>
<td>10</td>
<td>PB351-0426</td>
<td>Double drive gear</td>
<td>2</td>
<td>2</td>
<td>B</td>
</tr>
<tr>
<td>12</td>
<td>PB351-0683</td>
<td>Pressure roller shaft</td>
<td>2</td>
<td>2</td>
<td>C</td>
</tr>
</tbody>
</table>
Fig. 2 Wire feed unit (part code: WFAA0073)
SENSARC

WELDING POWER SUPPLY FOR ROBOT USE

AL350-RYU2

INSTRUCTION MANUAL

Read and understand this manual before installing, operating or servicing this equipment.

KOBE STEEL, LTD.

1-2, Mitsuya-cho Nakahara Toyohashi, Aichi, JAPAN
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Figure 1. Assembly
Figure 2. Electrical Connection
1. Safety Instructions

- Please read this manual carefully before operation.

- Cautions in this instruction manual will help you operate the unit safely and protect you from danger and the unit from damage.

- When you operate the unit incorrectly, various levels of danger and consequent damages could result. In this manual, those levels are categorized into the three levels shown below using respective safety alert symbols and signal words to give warnings.

<table>
<thead>
<tr>
<th>Safety Alert Symbol</th>
<th>Signal Words</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Triangle]</td>
<td>DANGER</td>
<td>An imminently hazardous situation which, if not avoided, will result in death or serious injuries.</td>
</tr>
<tr>
<td>![Triangle]</td>
<td>WARNING</td>
<td>A potentially hazardous situation which, if not avoided, could result in death or serious injuries.</td>
</tr>
<tr>
<td>![Triangle]</td>
<td>CAUTION</td>
<td>A potentially hazardous situation which, if not avoided, may result in minor or moderate injuries or only property damage.</td>
</tr>
</tbody>
</table>

- Serious injuries include blindness, burns (second and third degree), electric shock, broken bones, poisoning, among others which cause sequela, or require hospitalization or long-term outpatient treatment. Moderate injuries include burns, or electric shock which does not require hospitalization or long-term outpatient treatment. Property damage refers to extended damage which includes property breakage and equipment damage.
## 2. Safety Precautions

<table>
<thead>
<tr>
<th>WARNING</th>
<th>PROTECT YOURSELF AND OTHERS FROM POSSIBLE INJURIES OR DEATH.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Follow the warnings and precautions in this manual when using SENSARC. Otherwise, serious accidents resulting in death or serious injuries could occur.</td>
<td></td>
</tr>
<tr>
<td>• Keep personnel off the welding machine or welding work area.</td>
<td></td>
</tr>
<tr>
<td>• The welding machine generates a magnetic field during welding, which may cause a bad effect on some sensors and watches. Consequently a person who uses a pacemaker must not come near the welding machine or work area during welding without a doctor’s permission.</td>
<td></td>
</tr>
<tr>
<td>• To ensure safety, have all installation maintenance, inspection, and repair work performed by trained and qualified people who thoroughly understand the welding machine.</td>
<td></td>
</tr>
<tr>
<td>• To ensure safety, have the unit operated only by trained or qualified people who thoroughly understand the instructions in this manual and can operate the unit safely.</td>
<td></td>
</tr>
<tr>
<td>• Do not use the welding machine for other purposes than the arc welding specified in this instruction manual.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WARNING</th>
<th>ELECTRIC SHOCK can kill.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Do not touch live electrical parts, or fatal electric shock or burns could result.</td>
<td></td>
</tr>
<tr>
<td>When input power is on, the input circuit and internal parts of welding machine are electrified. Also, even when input power is off, the capacitor may still be charged. When the welder output is on, electrodes, base metal and metal parts which make contact with these areas are electrified.</td>
<td></td>
</tr>
<tr>
<td>• Never touch the &quot;electrified&quot; parts.</td>
<td></td>
</tr>
<tr>
<td>• Case of welding power source, base metal and jigs which are electrically connected to the base metal must be grounded according to laws and regulations.</td>
<td></td>
</tr>
<tr>
<td>• Installation, maintenance or inspection shall be started only after the input power is completely turned off using the disconnect switch of the distribution box. As the capacitor may not discharge immediately when the input power is cut, make sure that there is no charge before maintenance or inspection.</td>
<td></td>
</tr>
<tr>
<td>• Perform maintenance and inspection of the unit regularly. Repair or replace the damaged parts before use.</td>
<td></td>
</tr>
<tr>
<td>• Never use a cable with insufficient capacity, damaged or a bare conductor.</td>
<td></td>
</tr>
<tr>
<td>• Firmly tighten and insulate the cable connection.</td>
<td></td>
</tr>
<tr>
<td>• Connect the welding cable for the base metal as close as possible to the area being welded.</td>
<td></td>
</tr>
<tr>
<td>• Never operate without a housing or cover of the welding machine.</td>
<td></td>
</tr>
<tr>
<td>• Make sure to put the cover on the input and output terminals before use.</td>
<td></td>
</tr>
<tr>
<td>• Never use torn or wet gloves.</td>
<td></td>
</tr>
<tr>
<td>• Use a lifeline when working in a high place.</td>
<td></td>
</tr>
<tr>
<td>• Turn off all the power switches and input powers to all the units when not in use.</td>
<td></td>
</tr>
</tbody>
</table>
CAUTION  ARC RAYS can burn.

- Arc rays contain harmful ultraviolet and infrared rays which can cause inflamed eyes as well as burns.
- Spatters and slags can hurt eyes and cause burns.
- Noise may harm hearing.

- Use shielding equipment (eye protector) or welding face shield with sufficient shielding ability when welding or observing welding work.
- To protect your eyes from spatters and slags, wear eye protector.
- Install a suitable non-flammable screen around the welding site to protect others' eyes from the arc rays.
- Use leather safety gloves for welding, long-sleeved-clothing, leg covers and a leather apron to protect yourself.
- Use hearing protection equipment when the noise level is high.

CAUTION  FUMES AND GASES can be dangerous.

- Welding produces fumes and gases. Inhaling those fumes and gases could affect your health.
- Welding in a small confined area may cause lack of oxygen and result in suffocation.

- To prevent gas poisoning and suffocation, use ventilation equipment or effective respirator. Also have a trained supervisor observe the welding work.
- Do not weld in any place near where degreasing, cleaning or spraying operations are being carried out, since toxic gases will be generated.
- When welding coated steel sheets or plates such as galvanized, toxic fumes will be generated. Remove the coating before welding or wear respirator while welding.
### CAUTION

**CYCINDER may explode if damaged.**

- If a gas cylinder falls over, it may result in death or injuries.
- A gas cylinder contains high pressure gas. If improperly handled, explosion or high pressure gas blast may cause death or injuries.

- Handle gas cylinders according to the relevant laws and regulations.
- Do not expose a gas cylinder to high temperatures.
- Always keep cylinders in an upright position, securely chained or fixed in a dedicated stand.
- Never generate an arc across a gas cylinder. Also, do not allow a welding torch or electrode to touch a gas cylinder.
- Keep your head and face away from the cylinder valve outlet when opening it.
- Valve protection caps should always be in place except when the cylinder is in use.
- Use KOBE STEEL's or recommended gas regulators only.
- Read and follow the instructions on gas regulator before use.

---

### CAUTION

**WELDING SPARKS can cause fire or explosion.**

- Spatter or hot base metal just after welding may cause a fire.
- Incomplete connection of cable or contact in the base metal such as steel frame, may cause a fire through overheat.
- Generating an arc on a metal container for a flammable fluid such as gasoline may result in an explosion.
- Welding a sealed tank or pipe may cause an explosion.

- Do not weld in a place where spatters may reach flammable materials.
- Do not weld in an area with flammable gases near-by.
- Do not bring hot base metal close to inflammables.
- When welding on a ceiling, floor, or walls, fire may occur on the hidden side. Remove inflammables from the hidden side.
- Tighten the cable connection securely. Connect the welding cable on the base metal side as close as possible to where the base metal is being welded.
- Do not weld a gas pipe which still contains gas.
- Do not weld a sealed tank or pipe.
- Keep an extinguisher near the welding work area in case of fire.
<table>
<thead>
<tr>
<th>CAUTION</th>
<th>MOVING PARTS can injure.</th>
</tr>
</thead>
</table>

- Rotating parts such as the cooling fan of a welding power source or wire feed roller can catch fingers, hair, and clothing and consequently cause injuries.
- If you look into the nozzle of the welding torch while inching wire, you may get stabbed by the wire, sticking it into your face or eyes.
- When spooled wire becomes loose, the wire may jump out and can hurt you or other people nearby.

- Never operate welding machine without a housing or cover.
- Only a trained or qualified technician who understands the welding machine very well should remove the case and perform maintenance, inspection or repairs. Also put up fences around the welding machine to prevent unnecessary access.
- Never put hands, fingers, hair, or clothing too close to a rotating cooling fan or the wire feed roller.
- Keep your face away from the nozzle of the welding torch during wire inching.
- Make sure to fix the end of the wire to the wire end holder on the spool. When the spool rolled wire is in storage, transportation, or during installation in the wire feeder.
- When inserting spooled wire through the wire guide of the wire feeder, hold the wire securely so that it does not become loose.

3. Specifications

〈Welding power supply〉

<table>
<thead>
<tr>
<th>Model</th>
<th>AL350-RYU2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated input</td>
<td>18kVA</td>
</tr>
<tr>
<td>Rated input voltage</td>
<td>200VAC ± 10%</td>
</tr>
<tr>
<td>Phase•Frequency</td>
<td>3-phase•50/60Hz</td>
</tr>
<tr>
<td>Output current</td>
<td>40 to 350A</td>
</tr>
<tr>
<td>Output voltage</td>
<td>15 to 36V</td>
</tr>
<tr>
<td>No-load voltage</td>
<td>60V</td>
</tr>
<tr>
<td>Duty cycle</td>
<td>270amps at 100% 350amps at 60%</td>
</tr>
<tr>
<td>Outside dimensions</td>
<td>434mm(W)×796mm(H)×695mm(D)</td>
</tr>
<tr>
<td></td>
<td>(17in×31.3in×27.4in)</td>
</tr>
<tr>
<td>Mass</td>
<td>120kg (264 pounds)</td>
</tr>
</tbody>
</table>

〈Standard accessories〉

<table>
<thead>
<tr>
<th>Part name</th>
<th>Part No.</th>
<th>Specification</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>WPAC0022</td>
<td>for YASNAC</td>
<td>1</td>
</tr>
<tr>
<td>Fuse</td>
<td>PE-0505</td>
<td>5A-250V</td>
<td>1</td>
</tr>
<tr>
<td>Fuse</td>
<td>PE-0501</td>
<td>0.5A-250V</td>
<td>1</td>
</tr>
<tr>
<td>Fuse</td>
<td>PE-0502</td>
<td>1A-250V</td>
<td>1</td>
</tr>
</tbody>
</table>

〈Optional parts〉

<table>
<thead>
<tr>
<th>Part name</th>
<th>Shape</th>
<th>Part No.</th>
<th>Welding torch</th>
</tr>
</thead>
<tbody>
<tr>
<td>(+) voltage detection cable</td>
<td></td>
<td>PB351-0514</td>
<td>TOA SEIKI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PB351-0600</td>
<td>Other makers</td>
</tr>
</tbody>
</table>

The welding torches supplied by KOBE STEEL have built-in voltage detection cables. To use a torch from another manufacturer, it is necessary to connect voltage detection cables between the conductor of the torch and the control cable of the wire feeder.

Weld torches must have voltage sensing wiring.

For details, see the paragraph "Connecting the (+) voltage detection cable" in section 4-5.
4. Connecting to Power Source

4-1 Primary power requirements

<table>
<thead>
<tr>
<th>Voltage</th>
<th>200VAC, 50/60Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of phases</td>
<td>3-phase</td>
</tr>
<tr>
<td>Installed capacity</td>
<td>18kVA or more</td>
</tr>
<tr>
<td>Fuse capacity</td>
<td>60A</td>
</tr>
<tr>
<td>Input cable</td>
<td>14mm² or more (#6 AWG)</td>
</tr>
</tbody>
</table>

Allowable variation of supply voltage: ±10%

If other than 200V 3phase is used, a step-down transformer with at least 30% more capacity than power source KVA draw must be used.

CAUTION! : Supply voltage shall be within the range above.

If it exceeds this range and input to the equipment continually, this equipment may be damaged.

4-2 Installation location

To install AL350, select a place which is not humid or dusty, which is not exposed to direct sunlight or rain, and in which ambient temperature is in the range of -10 to 40 degrees C (14°F to 104°F). Then install AL350 on a firm and level floor.

Keep AL350 30cm (12 inch) or more away from wall or other welding machines.

4-3 Ventilation

During welding operation, a small amount of metal fumes, ozone and nitrogen oxide are generated which may be hazardous.

CAUTION! : FUMES AND GASES can be dangerous to your health.

Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area.
The above figure shows the standard connection diagram when AL350 is combined with wire feeder and torch.
4-4 Input wiring

**WARNING! : ELECTRIC SHOCK CAN KILL**

Disconnect all the input power with disconnect switch at the distribution box on breaker.

- Each welding power supply must have a fused distribution box or breaker of the capacity defined in 4-1.
- Make certain to tighten all connections.
- Ground the device with 14mm² (#6 AWG) or thicker grounding cable.
- Ground installation must conform to Art. 250 of NEC, NEPA 70.

Input terminals are located in the left side of AL350. Put the three input cables and one grounding cable into AL350 through the access hole on the upper left portion of the rear panel.
It is necessary to connect connectors in the welding power supply according to the level of primary side supply voltage (200/220 VAC). At shipment, the connection is made for 200 VAC.

(See Figure 1 "Assembly" and Figure 2 "Electrical Connection".)

1. For 200 VAC, connect between "CNC" and "CN200".
2. For 220 VAC, connect between "CNC" and "CN220".

For operating voltages higher than 200V 3-phase AC, use a step-down transformer with at least 30% larger capacity than welder. Secondary voltage to AL-350 must be 200V ±10%.

4.5 Secondary connections

Output terminals for power cables and connector for (-) voltage detection and connector for feeder cable are located on the lower front panel.

- (-)power cable (to base metal)
- (+)power cable (to torch)
- CON2 (from feeder)
- Feeder cable
- CON1 (from base metal)
- (-)voltage detection cable

Use power cable (Welding cables) greater than 60mm² (AWG #0).

Make wire power cables as parallel to each other as possible and as short as possible to reduce the inductance of power cable path. If the inductance is too high, welding become unstable.

Connect the (-) output terminal to base metal and (+) output terminal to wire feeder with power cables.
○ Connecting the (-) voltage detection cable and feeder cable

Two metal connectors are provided: CON1 and CON2. The former is for (-) voltage detection cable, and the latter for feeder cable.

The metal connectors (CON1 and CON2) provided on the front panel of the welding power supply are used to connect to (-) voltage detection cable and to feeder cable, respectively.

○ (-) voltage detection cable

Connect the "negative (-) voltage detection cable" to the base metal.

The cable shall be connected to a position as close to the arc as possible, such as the weld ground cable connection on the frame or positioner.

If connected too far from arc, the welding power supply may not operate properly. Omitting this cable will cause open circuit voltage and damage torch. Check the distance from the welding power supply. If the length of the cable needs to be sized for the installation. This cable should be as close to the arc as possible.
Connecting the (+) voltage detection cable

(+ ) voltage detection cable is an important signal line for accurately monitoring the condition of welding arc. It must be properly connected. If the cable is not connected, welding will not start.

The welding torches supplied by KOBE STEEL have built-in voltage detection cables. To use a torch from another manufacturer, it is necessary to connect voltage detection cables between the conductor of the torch and the control cable of the wire feeder.

(Use only welding torches with voltage detection cables capability.)

When a torch from TOA SEIKI is used, the voltage detection cable can be connected as follows.

For part No., see <Optional parts> (+) voltage detection line) in "3. Specifications".
Precautions when laying voltage detection cables

This welding power supply monitors welding voltage and uses its feedback to control the output current and voltage according to droplet transfer and arc condition at all times. And this control provides excellent workability. To use the welding power supply with its highly controlled performance, the voltage detection cable must be laid colectly. The point is that the feedback of the welding voltage must be rightly conducted to the power supply.

Requirements when laying voltage detection cables

This power source needs precise welding voltage that has generated from the arc.

a) Try not to detect the voltage drop generated by the electric resistor in the loop of the welding current. Connect the (+) voltage detection cable (one of seven core wires of the feeder cable) to the contact tip as near as possible.

![Diagram of welding cable and voltage detection cable](image)

b) Try to decrease the inductance of the voltage detection path to reduce the influence of inductive noise. Make an area which is enclosed by the (+) and (-) voltage detection cable (Area deiscribed as S in Figure below).

![Diagram of area S](image)
Example of laying (-) voltage detection cable

a) When using multiple welding stages
Connect the welding cable (base metal side) to each stage in order, and connect the (-) voltage detection cable to the last stage in the series to prevent detecting voltage drop occurring in the welding cable (base metal side).

b) When setting a base metal on a positioner which can not attach the welding cable directly to the base metal and have to use slip ring. Attach the voltage detection cable to the slip ring which is not used for the welding cable. (Try not to detect the voltage drop generated by the slip ring which is used for the welding cable for the base metal.)
c) When setting a robot on a slider and laying the feeder cable inside through cable carrier duct. Make that a (-) voltage detection cable close to a feeder cable and tie them by plastic fasteners with every 1 meter. Keep the (-) voltage detection cable and the feeder cable tied until they reach the manipulator. Then attach the (-) voltage detection cable to the base frame of manipulator. If this base frame and base metal have no electrically conduction, connect them by a cable (cable size AWG#12. nonflammable). (Make an area small which is enclosed by the (+) and (-) voltage detection cable.)
NOTE) For 4 rolls type feeder, connect motor cables to feeder cables marked different numbers.

Connection procedure for wire feeder with torch:

- Welding power source → Feeder Cable → Wire Feeder → Torch → Base metal

(-) voltage detection cable

(+), voltage detection cable
4-6 Connecting to a robot

This welding power supply includes the interface for MOTOMAN robots.

A control cable and a reverse inching cable are connected between this welding power supply and MOTOMAN controller.
Functions of the interface with YASNAC

- **CONNECTOR CONY1**

<table>
<thead>
<tr>
<th>Item</th>
<th>Pin No.</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Welding voltage command</td>
<td>A (+)</td>
<td>Allowable input resistance: approx. 10kohm input range: 0 to 14V. When approximately 7.0V is applied, welding voltage is automatically adjusted and output at a proper level which matched the welding current.</td>
</tr>
<tr>
<td></td>
<td>B (-)</td>
<td></td>
</tr>
<tr>
<td>(2) Welding current command</td>
<td>C (+)</td>
<td>Allowable input resistance: approx. 10kohm When 0 to 14V is input, welding current can be changed from 0A to the maximum level (the current corresponding to the wire feed rate of 17.5m/min(689ipm)).</td>
</tr>
<tr>
<td></td>
<td>D (-)</td>
<td></td>
</tr>
<tr>
<td>(3) Welding START signal input (Torch switch)</td>
<td>K</td>
<td>Start signal input.</td>
</tr>
<tr>
<td></td>
<td>L (O12)</td>
<td></td>
</tr>
<tr>
<td>(4) Forward wire inching</td>
<td>F</td>
<td>Forward inch wire when external contact is made. Feed rate can be adjusted with control VR3 on the printed circuit board YRI of the interface. At the shipment VR3 is adjusted to approx. 8m/min(315ipm)</td>
</tr>
<tr>
<td></td>
<td>G (O12)</td>
<td></td>
</tr>
<tr>
<td>(5) Wire stick signal connecting terminal</td>
<td>M (+)</td>
<td>A wire stick voltage from robot controller is applied to output term. (11 Volts DC) when resistance of ps is less than 500ohm. a &quot;wire stick&quot; is detected.</td>
</tr>
<tr>
<td></td>
<td>N (-)</td>
<td></td>
</tr>
<tr>
<td>(6) Welding current detection signal output</td>
<td>P</td>
<td>The contact makes approximately 0.1 second after welding current has started to flow, and breaks approximately 0.5 second after welding current has stopped</td>
</tr>
<tr>
<td></td>
<td>E (COM)</td>
<td></td>
</tr>
<tr>
<td>(7) Arc trouble signal output</td>
<td>R</td>
<td>①Detect the occurrence of arc stoppage while torch switch is turned ON. Detection of &quot;no arc&quot; makes the contact, the delay time is set to 1 second after starting welding or 0.6 second during welding. The delay time after starting welding can be adjusted to 0.5 to 2 seconds with VR1 on the printed circuit board YRI. Detected signal is held and reset when torch switch is turned OFF. When &quot;no arc&quot; is detected, wire feeding is stopped, and output voltage is shut off after specified delay time has elapsed.</td>
</tr>
<tr>
<td></td>
<td>E (COM)</td>
<td>②If the welding power source fails (INV over-current, overheat, input error, emergency stop, defective cable, etc.) the contact will make instantly.</td>
</tr>
<tr>
<td>(8) Penetration control command</td>
<td>H (+)</td>
<td>Allowable resistance: approx. 10kohm:input range: 0 to 14V. Weld penetration is reduced as the command voltage increases.</td>
</tr>
<tr>
<td></td>
<td>J (-)</td>
<td></td>
</tr>
</tbody>
</table>

**REVERSE INCHING CABLE**

Reverse inch wire when external contact is made.
Reverse feed rate is the same as forward feed rate.
Followings are the explanation of each control when the welding power supply is used with a robot.

(1) POWER

This switch is used to turn the power ON/OFF.

When teaching the robot, this switch should be turned ON.

(2) GAS

Set to "FLOW", when purge of gas is needed.

This switch is used to check the flow rate of gas.

When set to "AUTO", the gas is controlled by the robot.

(3) CRATER

Always set this to "OFF".

When combined with a robot, "ON" is disabled.

(At shipment, signal wire #13 from the CRATER switch to connection CN3 on P.C.B CVA2 is removed.)
(4) WIRE DIAMETER

According to which diameter of wire to use, set this switch to "ϕ1.2mm" (3/64") or "ϕ1.6mm" (1/16").

(5) WIRE TYPE

According to which type of wire material, set this switch to "HARD" or "SOFT". HARD is for hard aluminum (1100, 4043). SOFT is for soft aluminum (5183, 5356).

(6) CRATER CURRENT, CRATER VOLTAGE and CRATER PENETRATION

When used with a robot, these controls are disabled and do not have any influence on welding operation.

(7) MOTOR TORQUE LIMITTER

Compared with mild steel wire, aluminum wire is soft and tends to buckle (or birdnest) when feed force is too great, or torch has too much resistance, or liner is dirty. Even when buckling does not occur, the wire can kink in the torch, lowering the stability of the arc.

To reduce this problem, this welding power supply is designed such that the maximum output torque of the motor can be set and that when the limit is reached, the motor is stopped and the corresponding error lamp lights up. If set properly, the robot system will shut down prior to wire birdnesting. Because wire feeding force at the time of a birdnest is a function of wire diameter and material, it is necessary to properly adjust the MOTOR TORQUE LIMITTER knob provided on the front panel.

Turning the "buckling control" clockwise makes the feed motor less sensitive. Softer alloys will require lower settings. The values marked on the front panel show only guideline. Correctly adjust the value in the following manner.
1. Adjusting the pressure of feed roller

Adjust the pressure of feed roller to a proper level according to wire size and material. (For details, see the instruction manual for the wire feeder.)

2. Adjusting the MOTOR TORQUE knob

Adjust the MOTOR TORQUE knob at a lower value in the table shown on the front panel. Then, with the torch tip pushed against a stop, press the INCHING switch.

Then, if the error lamp lights up to stop the motor, slightly turn the control knob clockwise. And, with the torch tip pushed against a stop, press the INCHING switch again. By repeating this, set the control level to a position which is just below the position at which wire actually buckles.
6. Setting Controls on Printed Circuit Board CVA2

(See Figure 1 "Assembly").

(1) PRE-FLOW YES/NO change-over switch

At shipment, this switch is set to "NO".

When pre-flow is necessary, set jumper pin JPl of printed circuit board CVA2 to "YES". Then Pre-Flow is performed for approximately 0.5 second.

(2) Adjustment of RUN-IN speed

RUN-IN speed at starting welding operation is adjusted to 1.3 m/min (51.2ipm). The speed can be adjusted to max. 4.4 m/min (173.7ipm) with adjustment VR2 on printed circuit board CVA2.

(3) Adjustment of ball at Burn-Back

This is used to adjust the size of the "ball" which is generated on the wire tip when welding ends.

Adjust this with the setting of VR7 of printed circuit board CVA2. CW increase time and CCW decrease Burn-Back time to reduce the ball size.

At shipment, VR7 is set to fully CCW.
(4) Adjustment of pulse duration

Pulse condition (pulse current/pulse duration) during aluminum welding has been set property for each wire type (HARD/SOFT) and wire diameter and wire feed rate.
Besides, to get the optimum pulse condition in accordance with the wire brand or welding position, pulse duration can be adjusted finely by the rotary code switch SW1001 on P.C.B. CVA2.
Do not change the setting of SW1001 unnecessarily.

<table>
<thead>
<tr>
<th>Setting code of SW1001</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defference from standard pulse duration</td>
<td>-125</td>
<td>-1.0</td>
<td>-075</td>
<td>-0.5</td>
<td>-025</td>
<td>0</td>
<td>+025</td>
<td>+0.5</td>
<td>+075</td>
<td>+1.0</td>
</tr>
</tbody>
</table>

At shipment, SW1001 is set to code #5 and pulse duration is standard.

(5) Adjustment of wire feed rate

Adjust motor speed. whenever a welding power supply and a wire feed motor are combined newly. Motor speed can adjust by variable resister VR9 on printed circuit board CVA2.
Correctly adjust the motor speed in the following manners.

① Set jumper pin JP2 on P.C.B. CVA2 to "YES" and turn CRATER CURRENT dial on the front panel fully clockwise.
② Press the INCHING switch on remote control pendant of robot.
③ Measure motor revolution by teichometer and adjust the revolution to 160(+0/-5)rpm using variable resister VR9 on P.C.B. CVA2.
④ Set the jumper pin JP2 to "NO" after adjusting motor revolution.

NOTE: EXCEPTING ABOVE,
do not change setting of other switches and variable resistors on P.C.B. CVA2.
7. Precautions for Operation with Robot

7-1 Polarity of current, voltage and penetration control command
SENSARC receives welding current, voltage and penetration control command in the range from 0 to 14V from the robot control panel, and according to the control command, adjusts welding current, voltage and penetration. To connect to a welding machine, be sure that the polarity of welding current, voltage and penetration control command is "plus" (+).

7-2 Welding conditions
SENSARC automatically and unitarily adjusts welding voltage according to welding current.
When voltage command is set at a little higher level than the center value, welding voltage can be controlled at a proper level only by adjusting welding current control command.
Fine adjust welding voltage, taking welding conditions, such as joint geometry, the appearance of bead and welding speed, which are determined through weld examination.

Filler wire A5356

![Graph showing the relation between current command and welding current]
Penetration control command

AL350 receives penetration control command in addition to current and voltage commands, as welding conditions. When receives penetration control command in the range from 0 to 14 V, it can adjust weld penetration by changing operation mode from straight polarity welding to reversed polarity welding.

Note 1: When 0 V < command value < 14 V, command value is not proportional to the ratio of straight polarity. Therefore, setting in this range must be avoided. Be sure to set penetration control command to 0V or the range from 1 to 14V.

Note 2: Although the greater the penetration control command value the smaller the actual welding current, the melting rate (feed rate) of wire does not change when current command is kept at constant.
When penetration command is used with high current command, arc length is too short even if welding voltage command is set to high. Do not set current and penetration commands to value shown the UNSTABLE ARC area in the following figure.

Note 3: If the inductance of welding power cables is high value, the UNSTABLE ARC area extends. Make wire cables as parallel to each other as possible and as short as possible to reduce the inductance.
8. Error Conditions

If an error indicating lamp other than "HEAT" and "FEED" lights up, turn OFF the POWER switch and then turn off the distribution box.

WARNING! : ELECTRIC SHOCK CAN KILL.

Be sure to turn the primary power supply OFF and wait for more than 2 minutes before checking inside the welding power supply. Be careful not to touch hot parts in the welding power supply.

○ INV

This lamp lights if an over-current flows through the inverter transistor in the welding power supply. If this error recurs when the power is turned ON again, notify your Kobelco dealer.

○ CURRENT (OVER CURRENT)

This lamp lights up if a current exceeding the power supply rating through the load for more than 2 seconds.

Check for short-circuiting between the weld tip and base metal or between output cables.

○ HEAT (OVER HEAT)

This lamp lights up when the welding power supply is operated exceeding the specified duty cycle.

With the power turned ON, wait until inside temperature of the welding power supply drops sufficiently.

The figure below shows the relation between welding current and duty cycle.

- When used exceeding the duty cycle, the welder may be damaged. Always use within duty cycle.
INPUT

This lamp lights up if supply voltage of 200 VAC input line exceeds the allowable limit or if open-phase occurs. Check whether input voltage is too high or too low, or whether open-phase has occurred. The allowable range of supply is ±10%.

Normally when shipped, the welding power supply is connected for 200V. Both 200 and 220 VAC taps are provided. For details, refer to page 10 of this manual. If fuse F1, F2, F4 or F5 is blown, replace it with a new one.

CABLE

This lamp lights up if the wire feeder cable is shorted with other cables or ground.

Check for contact between cables. If fuse FU1 (1A, printed circuit board CVA2) or FU2 (0.5 A, printed circuit board CVA2) is blown, replace it with a new one.
This lamp lights up if REV supply voltage inside the welding power supply is out of proper range.

If the REV error indicating lamp lights up weakly during welding operation, it becomes impossible to control weld penetration. Make wire torch side and base metal side power cables as parallel to each other as possible and as short as possible.

- Wire the cables so as to minimize area S.
- Without looping, use proper length power cable.

If welding stopped due to REV error during operation, notify your Kobelco dealer.
WATER

Lights up if water pressure becomes too low while using a water cooled torch. (See "9. External Connection Terminal").

FEED

Lights up if the wire buckling (birdnest) prevention circuit works.
Check the condition of the torch or clean the Teflon liner in the torch or take other proper measures to lower feeding resistance.
Even when feeding resistance is low, this lamp may light up if the MOTOR TORQUE LIMITTER knob is set at too low of a value. Re-adjust the value to proper level. (See "(7) MOTOR TORQUE LIMITTER" in Section 5.)
This error can also be removed by turning the power switch OFF-then ON, or pressing the INCHING switch.

To recover the error condition, turn the POWER switch OFF and then, ON after determining the cause for error.
9. External Connection Terminal

Remove the top cover of the welding power supply, and you will see external connection terminals provided near to the rear panel.

- **WATER PRESSURE SW (1-2)**
  Used to protect a water cooled torch. For this, remove the jumper between terminals "1" and "2" and connect a pressure switch of water cooler.

- **GAS CHK (2-3)**
  Connect switch for external control of gas valve. When the contact closes, the gas valve energizes allowing gas to flow (to supply gas).

- **EMERGENCY STOP (2-4)**
  Used to stop the welding power supply with an external switch. The external switch shall have a normally closed contact (which breaks to stop the welding power supply). To connect the external switch to the terminal base, remove the jumper which short-circuits terminals "2" and "4".
CRATER (2-5)

Must not be used when combined with a robot.

CURRENT DETECT (6-7)

Do not use when power source is connected to robot.

AMMETER (8-9)

External ammeter connection. Signal level is 400 mA, 60 mV.

VOLT METER (10-11)

External voltmeter connection signal level is approximately 70 volt OCV (Open Circuit Voltage).

TORCH SW (12-13)

Do not use when power supply is connected to robot.

RESERVED (14-15)

Reserved terminals. Do not use and usually open these terminals.
10. Inspection and Maintenance

To improve reliability, the welding power supply needs to regularly be inspected and maintained.

WARNING! : ELECTRIC SHOCK CAN KILL. Do not contact electrically live circuits. Turn the primary power supply OFF and wait for more than 2 minutes before checking inside the welding power supply. Be careful not to touch hot parts in the welding power supply.

CAUTION! : MOVING PARTS can injure. Turn the primary power supply OFF before cleaning the fan.

10-1 Daily inspection/maintenance

(1) Check the surface of cables for crack, flaw or other defect.
(2) Check mounting screws and connectors for loosening.
(3) Check cable connection for overheating.
(4) Check for abnormal vibration, noise or smell.
(5) Check the surface of gas hose for crack, flaw or other defect.

10-2 Inspection/maintenance every 3 months

To ensure the cooling of semiconductor elements such as transistor, remove the top and side covers, and remove dust sticking to cooling fin and fan.

10-3 Dielectric strength test and the measurement of insulation resistance

This welding power supply uses many different semiconductors. The semiconductors may be damaged if tested using high voltage test or the measurement of insulation resistance. High voltage test and the insulation resistance measurement shall be done observing the following precautions.

(1) The test/measurement shall be executed on unit welding power supply, with input/output cables and wire feeder removed.
(2) Short-circuit 3 input terminals as well as 2 output terminals.
(3) Short-circuit the anode and cathode of primary side diode DB1 as well as the collector and emitter of transistors Q1 to Q4.
(4) Short-circuit the anode and cathode of diodes DD1 to DD3 and BD1 to BD5 as well as the collector and emitter of transistor Q11 to Q42 and TR1.
10-4 Cleaning the fan

To clean the fan, remove the front panel according to the figure below, and remove dust sticking around the fan with a brush or the like.

10-5 How to remove the fuses

To remove fuses F1 to F2, inset a tool (screwdriver, etc.) through the square hole on the top of the holder or through notched hole on the front face to push down the lever inside the holder.
WARNING! : ELECTRIC SHOCK CAN KILL.

Be sure to turn the primary power supply OFF and wait for more than 2 minutes before checking inside the welding power supply.

Be careful not to touch hot parts in the welding power supply.

Probable error causes are listed in the table below. Investigate and remove the causes as shown in the table. If necessary, repair or replace defective part.

<table>
<thead>
<tr>
<th>Event</th>
<th>Cause (or inspection point)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 POWER lamp does not light.</td>
<td>(1) POWER switch is defective.</td>
</tr>
<tr>
<td></td>
<td>(2) Fuse F1, F2, F4 or F5 is blown.</td>
</tr>
<tr>
<td></td>
<td>(3) The indicating lamp is defective.</td>
</tr>
<tr>
<td></td>
<td>(4) The input cable is defective.</td>
</tr>
<tr>
<td>2 Fan does not rotate.</td>
<td>Fan motor rotates during welding and 5 minutes after welding.</td>
</tr>
<tr>
<td></td>
<td>(1) Fan cable is wired incorrectly.</td>
</tr>
<tr>
<td></td>
<td>(2) The fan is defective.</td>
</tr>
<tr>
<td>3 Gas is not supplied.</td>
<td>(1) When setting the GAS switch of the welding power supply to &quot;FLOW&quot; does not supply gas all.</td>
</tr>
<tr>
<td></td>
<td>(a) Gas cylinder valve is not opened.</td>
</tr>
<tr>
<td></td>
<td>(b) Gas hose is disconnected.</td>
</tr>
<tr>
<td></td>
<td>(c) Connection of CON2 of wire feeder is loose.</td>
</tr>
<tr>
<td></td>
<td>(d) Connection to the gas solenoid is loose.</td>
</tr>
<tr>
<td></td>
<td>(e) Foreign matter is caught in the solenoid valve of gas line.</td>
</tr>
<tr>
<td></td>
<td>(f) Fuse FU2 (0.5 A) of the solenoid valve for gas line is blown. (If blown, replace after determining the cause.)</td>
</tr>
<tr>
<td></td>
<td>(g) Wire breakage occurred in the cable to the solenoid.</td>
</tr>
<tr>
<td></td>
<td>(2) When setting the GAS switch of the welding power supply to &quot;FLOW&quot; supplies gas</td>
</tr>
<tr>
<td></td>
<td>Printed circuit board CVA2 may be defective.</td>
</tr>
<tr>
<td>Event</td>
<td>Cause (or inspection point)</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4  INCHING does not work.</td>
<td>(1) Connection of CON2 of wire feeder is loose. (2) Connection to the faston terminal (line No. 201A or 202) of wire feeder is loose. (3) Wire breakage occurred in the cable (line No. 201A or 202) to wire feeder. (4) If &quot;F&quot; and &quot;G&quot; of the (cable side) connector CONY1 are not short-circuited when the connector for robot on the rear panel of the welding power supply is removed and robot INCHING switch is pressed ON, check on the robot side. (5) When short-circuited in above (4), check continuity between &quot;F&quot; of the connector and &quot;CN506-3&quot; of printed circuit board YRI as well as between &quot;G&quot; and &quot;CN506-4&quot;. If not continuous, check for wire breakage or loose connection on this path. (6) When continuous in above (5), relay LY1 on P.C.B. CVA2 may be defective. Replace LY1 by new ones. (7) When wire does not feed even in above (6), printed circuit board CVA2 or YRI may be defective.</td>
</tr>
<tr>
<td>5  Welding does not start (No-load voltage cannot be applied).</td>
<td>(1) Release feed roll on the wire feeder so as not to feed wire. Remove the connector for robot on the rear panel of the welding power supply, and short-circuit &quot;K&quot; and &quot;L&quot; of the connector for robot (on welding power supply side). When no-load voltage is present between them, check on the robot side.</td>
</tr>
<tr>
<td>Event</td>
<td>Cause (or inspection point)</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>5</td>
<td><strong>Welding does not start (No-load voltage cannot be applied).</strong></td>
</tr>
<tr>
<td>(2)</td>
<td>When no-load voltage is not present in above (1), turn the power OFF and check continuity between &quot;K&quot; of the connector and &quot;CN507-5&quot; of printed circuit board YRI as well as between &quot;L&quot; and &quot;CN507-6&quot;. If not continuous, check for wire breakage and loose connection on this path.</td>
</tr>
<tr>
<td>(3)</td>
<td>When continuous in above (2), printed circuit board CVA2, DRV-II or YRI may be defective, transistor Q1 to Q4 may be defective, or fuse FO may be blown.</td>
</tr>
<tr>
<td>6</td>
<td><strong>Welding does not start (No-load voltage present, but wire does not feed).</strong></td>
</tr>
<tr>
<td>(1)</td>
<td>When wire cannot be fed even with INCHING function. See item 4.</td>
</tr>
<tr>
<td>(2)</td>
<td>When wire is fed with INCHING function Remove remote control connector CON1, and check continuity between the base metal and pin 6 of CON1 (cable side). If not continuous, wire breakage may have occurred on (-) voltage detection cable, or its connection to the base metal may be loose.</td>
</tr>
<tr>
<td>(3)</td>
<td>When continuous in above (2), check continuity between pin 6 of feeder connector CON1 (on welding power supply side) and connector &quot;CN5-1&quot; of printed circuit board CVA2. If not continuous, printed circuit board YRI may be defective, or wire breakage or loose connection may have occurred on line &quot;PR&quot; or or &quot;V-&quot; in the welding power supply.</td>
</tr>
<tr>
<td>(4)</td>
<td>When continuous in above (3), printed circuit board CVA2 may be defective.</td>
</tr>
<tr>
<td>Event</td>
<td>Cause (or inspection point)</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------------</td>
</tr>
</tbody>
</table>
| 7 Welding does not start (Wire can be fed, but no arc is emitted). | (1) Remove remote control connector CON2, and check continuity between the welding contact tip and pin 5 of CON2 (cable side). If not continuous, wire breakage may have occurred on (+) voltage detection cable (line No. 205) which is connected to the torch and feeder cable.  
(2) When continuous in above (1), check continuity between pin 5 of feeder connector CON2 (on welding power supply side) and connector "CN5-3" of printed circuit board CVA2. If not continuous, printed circuit board YRI may be defective, or wire breakage or loose connection may have occurred on line No. 205 in the welding power supply.  
(3) When continuous in above (2), printed circuit board CVA2 may be defective. |
| 8 CURRENT control does not work. | (1) Pressure of feed roll is too low.  
(2) Dirt is clogging the conduit.  
(3) Torch is bent too sharply.  
(4) Remove the connector for robot on the rear panel of the welding power supply, and check voltage between "C" and "D" of the connector (on cable side). If the voltage between "C" and "D" does not change at all when current setting is changed on robot side, check on the robot side.  
(5) When voltage changes in above (4), check continuity between "C" of the connector and "CN507-3" of printed circuit board YRI as well as between "D" and "CN507-4". If not continuous, check these paths. When continuous, printed circuit board CVA2 or YRI may be defective. |
<table>
<thead>
<tr>
<th>Event</th>
<th>Cause (or inspection point)</th>
</tr>
</thead>
</table>
| 9 VOLTAGE control does not work. | (1) Check (1) to (3) in item 8.  
(2) Connection of (+) voltage detection cable is loose. (Check item (1) in 7.)  
(3) (-) voltage detection cable is not connected.  
(4) Remove the connector for robot on the rear panel of the welding power supply, and check voltage between "A" and "B" of the connector (on cable side). If the voltage between "A" and "B" does not change at all when current setting is changed on robot side, check on the robot side.  
(5) When voltage changes in above (4), check continuity between "A" of the connector and "CN507-1" of printed circuit board YRI as well as between "B" and "CN507-2". If not continuous, check these paths.  
When continuous, printed circuit board CVA2 or YRI may be defective. |
| 10 PENETRATION control does not work. | (1) Check (1) to (3) in item 8.  
(2) REV error indication lamp is lighting.  
(See item "REV" in "8. Error".)  
(3) Remove the connector for robot on the rear panel of the welding power supply, and check voltage between "H" and "J" of the connector (on cable side). If the voltage between "H" and "J" does not change at all when the setting of PENETRATION is changed on robot side, check on the robot side. |
<table>
<thead>
<tr>
<th>Event</th>
<th>Cause (or inspection point)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 PENETRATION control does not work.</td>
<td>(4) When voltage changes in above (3), check continuity between &quot;H&quot; of the connector and &quot;CN509-1&quot; of printed circuit board YRI as well as between &quot;J&quot; and &quot;CN509-2&quot;. If not continuous, check these paths. When continuous, printed circuit board CVA2 or YRI may be defective.</td>
</tr>
<tr>
<td>11 Arc is unstable.</td>
<td>(1) Welding voltage is too low or too high. (2) Tip is worn greatly. (3) Dirt is clogging the conduit. (4) Connection of (+) and (-) voltage detection cables are loose. (5) WIRE DIAMETER and WIRE TYPE switches are set to wrong position.</td>
</tr>
</tbody>
</table>
11. Parts List

To order repair parts, please inform the part name and part number to a nearby KOBE STEEL sales office.

Symbols in the "Symbol" column coincides with those used in the electrical connection diagram.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Part Name</th>
<th>Part Code No</th>
<th>Quantity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVA2</td>
<td>Printed circuit board</td>
<td>WPPC0065</td>
<td>1</td>
<td>Welding control, etc.</td>
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<tr>
<td>LED2</td>
<td>Printed circuit board</td>
<td>PB351-1146</td>
<td>1</td>
<td>Error indication</td>
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<tr>
<td>DRV-II</td>
<td>Printed circuit board</td>
<td>PB351-0280</td>
<td>1</td>
<td>Inverter driver</td>
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<tr>
<td>SDRV</td>
<td>Printed circuit board</td>
<td>PB351-0341</td>
<td>1</td>
<td>Inverter driver</td>
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<tr>
<td>TRO</td>
<td>Inverter transformer</td>
<td>PB351-0299</td>
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<td>Y37A11995</td>
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<tr>
<td>TRCD</td>
<td>Auxiliary transformer</td>
<td>PB351-1109</td>
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<td>TRSD</td>
<td>Drive transformer</td>
<td>PB351-1067</td>
<td>1</td>
<td>T8119B</td>
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<tr>
<td>LD1</td>
<td>D.C. reactor</td>
<td>PB351-0301</td>
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<td>Y37A11996-1</td>
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<tr>
<td>Q1～Q4</td>
<td>Transistor</td>
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<td>MG200H2CK1</td>
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<tr>
<td>Q11～Q42</td>
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<td>MG300Q1UK1</td>
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<td>Transistor</td>
<td>PB351-0360</td>
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<td>DB1</td>
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<tr>
<td>DD1～DD3</td>
<td>Diode module</td>
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<td>2F1100A-030</td>
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<td>DAS</td>
<td>Diode module</td>
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<tr>
<td>DE2～DE5</td>
<td>Diode module</td>
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<td>RM10TB-M</td>
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<tr>
<td>BD1～BD5</td>
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<td>Quantity</td>
<td>Remarks</td>
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<td>RH11～RH14</td>
<td>Resistor</td>
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<td>C1</td>
<td>Capacitor</td>
<td>PB351-0288</td>
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<td>RWA400LGSN-6800C</td>
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<td>CA13, CA14</td>
<td>Capacitor</td>
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<tr>
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<tr>
<td>CH1, CH2</td>
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<td>Z1～Z3</td>
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<td>ENCG471-14A</td>
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<td>SK1</td>
<td>Spark killer</td>
<td>PB351-0306</td>
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<td>XEB1201</td>
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<tr>
<td>MC1</td>
<td>Contactor</td>
<td>PB351-0307</td>
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<td>SC-2N.A.C200V</td>
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<tr>
<td>TH1, TH2</td>
<td>Thermal relay</td>
<td>PB351-0375</td>
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<td>TRS3-85BLR00</td>
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<td>SHT1</td>
<td>Shunt</td>
<td>PB351-1044</td>
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<td>5915PC-20T-B30-B00</td>
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<td>SW2～SW5</td>
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<td>Fuse</td>
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<td>Fuse</td>
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<td>CT1, CT2</td>
<td>Current transformer</td>
<td>PB351-0182</td>
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<td>HCS</td>
<td>Hall current detector</td>
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<td>NNC20CA(9V/600A, ±12V)</td>
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<tr>
<td>Symbol</td>
<td>Part Name</td>
<td>Part Code No</td>
<td>Quantity</td>
<td>Remarks</td>
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