Clinton
INSTRUMENT COMPANY

Model HF-15A High Frequency Spark Tester
Instruction Manual

HF-15AC/BD-12 shown with optional X3A Horn/Light Tower

Clinton Instrument Company

295 East Main Street
Clinton, CT 06413 USA
Telephone: 860.669.7548 Fax: 860.669.3825
www.clintoninstrument.com

MODEL HF-15A

Digital High Frequency Sine Wave Spark Tester

- ≫ 3 kHz high frequency spark testing
- ≫ Versatile control configurations & communication options
- ≫ Test voltages 500v to 15KV rms
- ≫ Digital voltage and fault count displays
- ≫ Wide range of electrode styles
- ≫ CE approved

HF-15AC/BD-12 with optional X3A Horn/Light Tower

All-in-one configuration

The HF-15A, Clinton's versatile Digital High Frequency Sine Wave Spark Tester, will fit almost anywhere on the wire line. It combines all the power of the Clinton 3kHz design with digital circuitry that simplifies setup, use, and calibration.

The HF-15A can work either as a standalone spark tester or as part of a fully process-controlled quality system. It is built in three configurations:

≫HF-15AC all-in-one spark tester

≫HF-15AR spark tester and remote 19" ARC display located up to 200 feet away

≫HF-15AR spark tester, without display, that receives and responds to digital commands from a PLC or computer

When equipped with a 2" long bead chain electrode, the spark tester meets UL and CSA spark test standards for a wide variety of small products moving as fast as 3333 FPM; longer electrodes are available for faster line speeds. Other electrode designs are available for a wide range of product sizes and shapes.

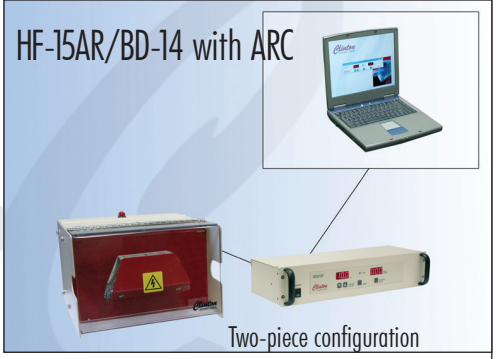
Digital test voltage and fault count displays are vivid and easy to read. For operator protection, a safety interlock switch removes high voltage when the electrode cover is lifted.

Wiring and setup are done externally-- there is no need to open up the unit. Membrane switches on the display panel allow the operator to configure the spark tester for respooling or extrusion modes or to set the length of time that process control relay contacts are energized after a fault occurs. The form C relay contacts are accessible on a rear panel connector for easy wiring to external alarms, lights or machinery that are to be controlled by the spark tester.

The HF-15A is equipped with an RS-485 serial interface that can receive and respond to digital commands. Spark tester voltage can be set or verified, the fault count and interlock status can be monitored, and many other tasks can be performed by computer or PLC.

HF-15AR/BR1A controlled by PLC or computer

HF-15AC/BD-22S



HF-15AR/BD-14 with ARC

Two-piece configuration

(Computer shown in photos not included nor offered by CIC.)

Clinton INSTRUMENT COMPANY

HF-15A SPECIFICATIONS

Voltage Test Range	approx. 500 volts to 15KV rms. Min. test voltage varies on electrode design.
Voltage Display	red 3-digit 14.2mm high LED display, accuracy 2% of reading.
Test Frequency	1000 to 3500 Hz, depending on load capacitance.
Output Power	4 ma. resistive, 40 ma. capacitive.
Fault Indication	red 3-digit 14.2mm high LED display; amber indicating light.
Fault Resolution	variable with electrode length to comply with UL fault resolution requirements, which specify detection of faults no farther than 24 inches apart at any wire line speed.
Detection Sensitivity	Mode 1 per British Standard BS EN 50356 Mode 2 per NEMA Standard WC 56
Operating Modes	Continuous HV/Remove Voltage on Fault, Momentary Process Control/Latch until Reset.
Process Control	Relay form "C" contacts rated 1 amp max @ 240VAC, 2 amps max @120VAC, for both NO and NC circuits. Front panel or external reset. In non-latch modes, closure time is adjustable in 10 millisecond increments from 50 milliseconds to 2-1/2 seconds.
Power Requirements	100 or 120VAC, 2 amps, 200 or 240VAC 1 amp (selectable), 49-61 Hz.
Communications	Analog (optional) Profibus (optional) Ethernet (optional)

HF-15A ELECTRODES

Bead Chain Assemblies:

BD-12	Bead Chain Assembly 1" Product Diameter, 2" along wire line.
BD-13	Bead Chain Assembly 1" Product Diameter, 3" along wire line.
BD-14	Bead Chain Assembly 1" Product Diameter, 4" along wire line.
BD-15	Bead Chain Assembly 1" Product Diameter, 5" along wire line.
BD-22S	Bead Chain Assembly 2" Product Diameter, 2" along wire line.

Brush Assemblies:

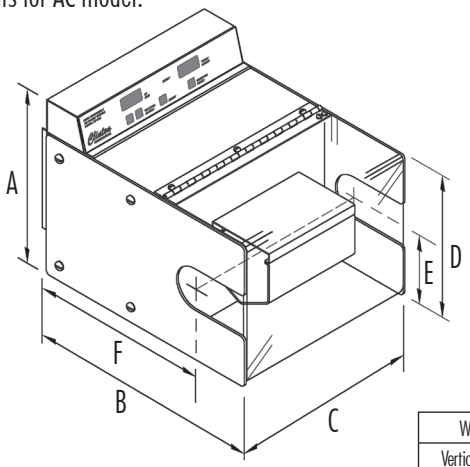
BR-1A	Brush Assembly Phosphor Bronze 1" Product Diameter.
BR-1ALZ	Brush Assembly Phosphor Bronze 1" Product Diameter, 10KV max.
BR-3A	Brush Assembly Phosphor Bronze 3" Product Diameter.
BR-3ALZ	Brush Assembly Phosphor Bronze 3" Product Diameter, 10KV max.
BRTC-6LZ	Brush Assembly Tape Cable 6", 10KV max.
BRTC-12LZ	Brush Assembly Tape Cable 12",10KVmax.
FB-12	Fiberlite Brush Assembly.

Roller Assemblies:

R-46	Roller Assembly .2" (6 mm) max. Product Thickness, 6" (152 mm) Product Width.

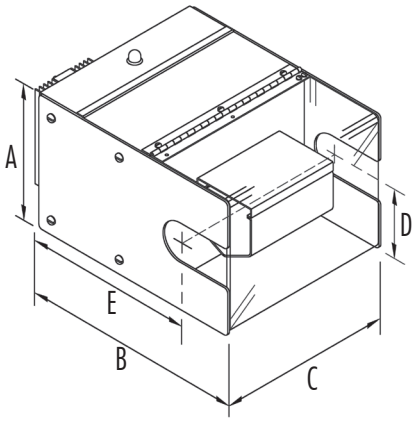
Please consult factory for help in choosing equipment for specific applications.

Measurements for AC model.

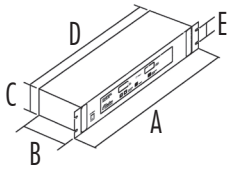


	A	B	C	D	Wireline Center E Vertical	Wireline Center F Horizontal
BD-12, 13, 14, BR-1A, BR-1ALZ, FB-12	9.5" [241 mm]	13.9" [353 mm]	11.5" [293 mm]	7.5" [190 mm]	3.8" [95 mm]	10.0" [254 mm]
BD-22S	10.5" [266 mm]	15.4" [292 mm]	11.6" [294 mm]	8.5" [216 mm]	4.3" [109 mm]	11.0" [279 mm]
BD-15	11.4" [290 mm]	16.3" [414 mm]	12.5" [318 mm]	9.4" [240 mm]	4.8" [120 mm]	11.5" [290 mm]
BR-3A, BR-3ALZ	11.4" [290 mm]	17.8" [452 mm]	13.5" [344 mm]	9.4" [240 mm]	Call Factory for Details	
BRTC-6	11.5" [293 mm]	19.1" [292 mm]	12.5" [318 mm]	9.6" [244 mm]	Call Factory for Details	

Measurements for models AR with optional ARC.



ARC display dimensions.



A	19.0"
B	5.8"
C	3.5"
D	17.0"
E	1.8"

	A	B	C	Wireline Center D Vertical	Wireline Center E Horizontal
BD-12, 13, 14, BR-1A, BR-1ALZ, FB-12	7.5" [190 mm]	13.9" [353 mm]	11.5" [293 mm]	3.8" [95 mm]	10.0" [254 mm]
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BRTC-6	9.6" [244 mm]	19.1" [292 mm]	12.5" [318 mm]	Call Factory for Details	

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Declaration of Conformity

Manufacturer: .....The Clinton Instrument Company
Address: .....295 East Main Street
Clinton, CT USA 06413

Herewith declares that

The High Frequency Sine Wave Spark Tester
type HF-15AC/AR

is in conformity with the provisions of the following EEC directives:

89/236/EEC
73/23/EED

Conforms with the emissions requirements of EN 61326:1998:

CISPR16:1998 .....Class A, Conducted Emissions, 150 kHz to 30 MHz
EN 55011:1998 .....Class A, Radiated Emissions, 150 kHz to 1GHz
IEC 61000-3-2:2001 .....Harmonics
IEC 61000-3-3:1999 .....Flicker

Conforms with the immunity requirements of EN 61326:1998:

IEC 1000-4-2:1995 .....Electrostatic Discharge
IEC 1000-4-3:1997 .....Radiated Immunity
IEC 1000-4-4:1995 .....EFT/Burst, Power and I/O Leads
IEC 1000-4-5:1995 .....Surge Immunity, Power Leads
IEC 1000-4-6:1996 .....Conducted Immunity, Power and I/O Leads
IEC 1000-4-11:1994 .....Voltage Dips and Interrupts

Conforms to the safety requirements of EN61010.

Clinton, CT USA June 2004

Marianne Szreders
President

Ted P. Lane
Chief Engineer

Table of Contents

Safety

Safety Symbols

The symbols depicted below are safety symbols placed on spark test equipment. It is important to understand the meaning of each.

Caution symbol. Caution- refer to the manual to protect against damage to the equipment or to avoid personal injury.

Risk of electric shock symbol.

Earth ground symbol.

Environmental Conditions

The spark tester is designed to be safe under the following conditions:

- Indoor use.
- Altitude to 2000m.
- Temperatures from 5ºC to 40ºC.
- Humidity to 80% R.H. at 31ºC, decreasing linearly to 50% R.H. at 40ºC

The Clinton Instrument Company certifies that this equipment met its published specifications at the time of shipment. Clinton further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology to the extent allowed by the Institute's calibration facility. For customer service or technical assistance with this equipment, please contact:

The Clinton Instrument Company
295 East Main Street, Clinton, CT 06413 USA
Telephone: 860-669-7548 Fax: 860-669-3825
Website: www.clintoninstrument.com
Email: support@clintoninstrument.com

Avoid the Risk of Fire!

Every time your wire line stops, be sure that the HV in the electrode goes off. If the HV remains ON while your wire line is stationary, the wire insulation within the electrode will heat and there is a danger of combustion. Refer to the table in "Installation" labelled "Terminal Block connections," under HV Enable on how to safely install your spark tester.

Caution: Pacemaker Warning

Clinton Instrument Company strongly advises any individual using a pacemaker or other such medical device to avoid operating or being in the vicinity of spark testers. Current studies indicate that such medical devices can malfunction in the presence of electrical and magnetic fields. When a fault occurs in the electrode of a Clinton spark tester, both high and low frequency electromagnetic fields are generated. The strengths of these emissions are unknown, since they depend on test voltage and other variables. The danger is greater when a customer does not ground the inner conductors of a test product. While Clinton cautions its customers to ground the test product for safety reasons, many times this warning is ignored. In this situation, both the spark tester and the entire length of the wire line will radiate these emissions. There is also a serious risk of electrical shock if an individual comes into contact with an ungrounded test product.
email: support@clintoninstrument.com.

Electrical Shock Hazard From Production Line Spark Testers

by Henry H. Clinton

The commonly accepted maximum values of 60Hz. current passing through the human adult body which permit a subject to let go of electrodes are nine milliamperes for males and six milliamperes for females. At 3000 Hz. this value increases to about 22 milliamperes for men and 15 milliamperes for women, DC currents do not present the same let-go problems, but a subject can readily let go at a level of 60 milliamperes. A continuous 60 Hz. current above 18 milliamperes stops breathing for the duration of the shock only. Ventricular fibrillation may occur above a level of 67 milliamperes. The reaction current level of 60 Hz. is about .5 milliamperes. Above this level a muscular reaction can occur which can cause a secondary accident. The DC and 3kHz. levels are probably considerably higher. Capacitor discharge energy of 50 Joules (watt-seconds) is regarded as hazardous.

Clinton DC spark testers are current limited to 5 milliamperes or less. Three kiloHertz spark testers are limited to 4 milliamperes or less, and 60 Hz. types to 7 milliamperes. Impulse spark testers can deliver a maximum charge of about .2 Joules 248 times per second. All these spark testers have current outputs above the reaction level, but none above the let-go threshold level. Because of the possibility of secondary accidents caused by muscular reactions, operators should be protected against accidental shock. Electrodes are supplied with interlock switches, and these should not be disabled. The conductor under test should be grounded. If an operator must inspect the product by touching its surface while it is being spark tested, he should be electrically insulated from his environment, and any possible cause of a secondary accident caused by reaction should be eliminated.

For references, see: Dalziel, Ogden, Abbot, "Effect of Frequency on Let-Go Currents," Transactions of A.I.E.E., Volume 62, December 1943, and Dalziel, "Electric Shock Hazard," I.E.E.E., Spectrum, February 1972.

Installation

CAUTION:

The installation procedures listed below are to be performed by qualified service personnel only. Failure to follow these procedures may result in danger to personnel and equipment damage.

Unpacking

HF-15AC Package

HF-15AR with ARC Package

Remove the spark tester from the carton. Retain the packing material in the event that the unit is returned for calibration or service at some future time.

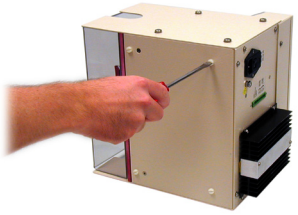
The following items are packed with the spark tester:

1. A power cord (additional power cord provided with ARC).
2. A green terminal block connector for process control connections. After it is wired, it will plug into the terminal block on the back of the spark tester.
3. An instruction manual.
4. An RS-485 connector (included with HF-15AC, HF-15AR & ARC).
5. RS-485 connecting cables (if ordered separately for HF-15AC, HF-15AR with ARC).
6. Rack Mount Kit (for ARC)

Site Preparation

Select a suitable location for the spark tester.

The HF-15A Spark Tester is designed for use in a fixed location, permanently connected to its power source. The unit may be mounted on a table or on a Clinton floor stand and should be placed at wire line height and within easy reach of the operator. For detailed dimensions of the spark tester, please see the specification sheet.



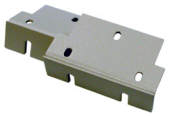
To mount the unit on a horizontal surface:

With a screwdriver, remove the (4) plastic feet from the tapped inserts in the bottom of the spark tester chassis. Insert (4) M-6 screws through the mounting surface into the (4) tapped inserts. Be sure the screws do not extend into the chassis more than 1/2 inch (12mm).

To install the unit on a Clinton floor stand:

Assemble the floor stand as shown in the drawings at the back of this manual. Secure the tripod base of the floor stand to the shop floor using 1/2" (12mm) bolts and washers. Remove the (4) plastic feet from the tapped inserts on the bottom of the spark tester chassis, as shown on the previous page. Mount the spark tester to the stand by feeding (4) M-6 screws supplied with the floor stand through the bottom of the floor stand plate and into the (4) tapped inserts in the bottom of the spark tester.

ARC Remote Display Assembly (if purchased):



Customers that have purchased the ARC may wish to install it in a rack or panel as far as 200 feet away from the HF-15AR spark tester. First install the rack mount kit supplied with the remote display, using the 6 screws provided. Then install the power cord that is provided with the unit. RS-485 cables for connection between the HF-15AR and a computer or PLC must be purchased separately.

Locate the safety ground terminal on the back panel of the ARC Remote Display. Remove the outer nut and the crimp terminal. Crimp a 16 ga. (1, 29 mm2, 1, 31 cross section) stranded insulated wire (preferably green with a yellow stripe) to the crimp terminal. Fasten this to the safety ground terminal and secure with the keps nut. Connect the other end to a safety ground system in accordance with EN 60204-1:1993, Section 5.2, Table 1.

Provide for ventilation of the Test Module

As with any apparatus producing a spark or electrical corona, the HF-15A Spark Tester produces ozone in the electrode region. While ozone reverts harmlessly to oxygen within a few minutes, an external air extraction system is recommended and should operate whenever the spark tester is in use. The exhaust of the external air extraction system should be discharged either outdoors or into some area well away from workers.

Wiring Requirements

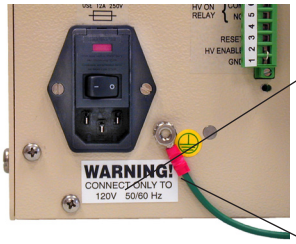
Install an external disconnecting device

Install an external switch or circuit breaker in close proximity to the spark tester and within easy reach of the operator. The switch or circuit breaker must meet the relevant requirements of IEC 947-1 and IEC 947-3 and should be marked as the disconnecting device for the equipment. The rating of the circuit breaker or fuse should be no greater than 5 amperes.

Caution: be sure the external disconnecting device is OFF and locked out before continuing.

Mains Power

Note the spark tester's operating voltage, which is marked on a label beneath



the ON/OFF switch on the back panel. If it does not match the power line voltage you will be using to energize the spark tester, you must change the spark tester's operating voltage. To do so, see the section entitled, "Changing the Spark Tester's Operating Voltage."

Ground the Spark Tester

Locate the ground stud on the back panel of the spark tester. Remove the outer nut and crimp terminal. Crimp a 16 ga. (1, 29 mm^2, 1, 31 cross section) stranded insulated wire (preferably green with a yellow stripe) to the crimp terminal. Fasten this to the ground stud and secure with the keps nut. Connect the other end to a safety ground system in accordance with EN 60204-1:1993, Section 5.2, Table 1.

X3A Horn/Light Tower

Customers who have purchased an X3A Horn/Light Tower should proceed to the X3A Horn/Light Tower section below for X3A installation and operating instructions. When you have completed the X3A installation, disregard the "Terminal Block Wiring (no X3A)" instructions following and skip to the section entitled, "Connecting the HF-15AR to ARC."

If you do not have an X3A, skip to the section entitled, "Terminal Block Wiring (no X3A)" and begin wiring the HF-15A spark tester.

X3A Horn/Light Tower

Unpacking

Remove the following items from the carton:

1. X3A Horn/Light Tower with mounting plate. Note: If the X3A was ordered for the BD-22 electrode, the carton should contain the BD-22 mounting plate (part #91243).
2. Power Cord (part #03780)
3. A 4 conductor cable, with a 9-pin terminal block connector on one end and a 10-pin connector on the other.

Installation

1. Decide which side of the spark tester you wish to mount the X3A. Note that you may have to remove the small plate from the X3A chassis and secure it to the opposite side so that the green X3A terminal block is accessible from the spark tester back panel. Mount the X3A using the mounting plate and the (4) bolts that attach the end guard to the spark tester, as shown in the picture to the left.
2. Make sure the spark tester is off before wiring to the X3A.

3. Locate the 10-pin green terminal block on the back of the X3A and the 9-pin terminal block on the back of the spark tester. The X3A is supplied with a 4 conductor cable. The 10-pin connector will plug into the X3A terminal block and the 9-pin connector will connect to the spark tester terminal block. Prior to inserting them, pins 1-5 of the 10-pin connector should be wired to accessory equipment with 22 guage or larger, stripped back 1/4" (6mm) and fed into the green terminal block connector at the proper pin numbers, as described on the following page. Pins 1-3 of the 9-pin connector should be wired as shown on the following page.

4. When wiring the two units, notice that pins 8-5 on the spark tester are now being used to communicate with the X3A. The functions of pins 8-5 on the spark tester have now been transferred to pins 5-1 on the X3A terminal block. When the wiring is complete, plug in the power cords to both X3A and the spark tester.

X3A to Spark Tester Connections

X3A Horn/Light Tower Terminal Block Connections					Spark Tester Terminal Block Connections				
Conductor	Designation		Terminal Block Connections	Pin No.	Pin No.	Terminal Block Connections	Designation		Conductor
4-conductor cable supplied with X3A (22 gauge or higher)	FAULT RELAY	COM	To Spark Tester: Wire pins 10-7 to spark tester pins 8-5 on the spark tester terminal block connector	10	9	Not Used	FAULT RELAY	NC	
		NO		9	8	To X3A: Wire pins 8-5 to X3A pins 10-7 on X3A terminal block connector		COM	4-conductor cable supplied with X3A (22 gauge or higher)
	HV ON RELAY	COM		8	7			NO	
		NO		7	6		HV ON RELAY	COM	
Not Used				6	5			NO	
(3) 22 ga. stranded conductors rated 250V, less than 10 meters in length, contained in a common insulating sheath	FAULT RELAY	NC	Process Control: To activate external lights, alarms or relays* when a fault occurs, wire them between dry relay contact pins 5,4 & 3. If the Lch function is ON (set on the front panel), the dry relay contacts will remain closed until the RESET button is pressed or when pins 1&3 are closed by remote switch or relay. If the Lch function is OFF, the dry relay contacts will return to normal state after the interval known as the PCd (Process Control Duration, set on the front panel) has elapsed.	5	4	Not Used			
		COM		4	3	External Reset: To reset the spark tester fault relay with an external switch, wire a momentary switch** between pins 1&3. When these contacts close, the fault relay will return to a normal state. The interval that the contacts are closed must exceed 50 ms. HV Enable: **CAUTION:** For HV on the electrode, install a normally closed switch or relay contact** between pins 1&2. This switch or relay should open automatically when the wireline stop switch is activated or be opened manually by the system operator when the line stops. **FAILURE TO DO SO COULD RESULT IN A FIRE HAZARD.** If the HV remains ON in the electrode when your line is stationary, the wire insulation in the electrode will heat and there is a danger of combustion.	RESET	(3) 22 ga. stranded conductors rated 250V, less than 10 meters in length, contained in a common insulating sheath
		NO		3	2			HV ENABLE	
22 ga. stranded conductors rated 250V, less than 10 meters in length, contained in a common insulating sheath	HV ON RELAY	COM	HV ON Indication: Dry relay contact pins 1&2 will close when the test voltage exceeds 500v. For an indication that HV is ON in the electrode, wire a lamp or auxiliary device* here.	2	1			GND	
		NO		1					

*When connecting auxiliary equipment to dry relay contacts pins 1, 2, 3, 4, or 5, observe maximum ratings of 120VAC at 2 amps or 240VAC at 1 amp.

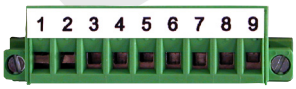
**Switches and relays connected to pins 1,2, & 3 should be suitable for 24V low current applications.

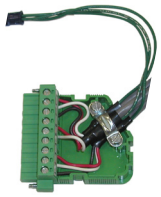
X3A Operation

X3A Horn/Light Tower will respond to faults depending on how your spark tester is configured. Please see the chart below. for the X3A response:

Spark Tester Configuration	X3A Response to Fault in Electrode
Lch on rUF on PCd nA	Red HV On Lamp will go off. Audible alarm will sound, and Yellow Fault Light will flash until the spark tester reset button is pressed.
Lch off rUF on PCd 2.00 sec	Red HV On Lamp will go off. Audible alarm will sound, and Yellow Fault Light will flash for length of PCd (Process Control Duration) - 2.00 seconds in this case.
Lch on rUF off PCd nA	Red HV On Lamp will stay on. Audible alarm will sound, and Yellow Fault Light will flash until the spark tester reset button is pushed.
Lch off rUF off PCd 2.00 sec	Red HV On Lamp will stay on. Audible alarm will sound, and Yellow Fault Light will flash only for length of PCd.

Terminal Block Wiring (no X3A installed)



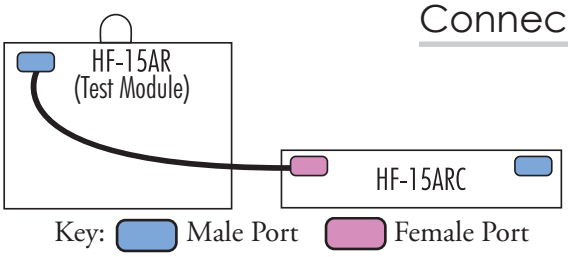


Refer to the table below for information on pin functions. Locate the green terminal block on the back of the spark tester and its companion green terminal block connector that came with the unit.

Conductors connecting auxiliary equipment, relays and switches should be shielded 22 gauge or larger and should be stripped back ¼" (6mm) and fed into the green terminal block connector at the proper pin number. Shields from conductors connecting auxiliary equipment should be grounded to the safety ground terminal.

Terminal Block Connections	Pin No.	Designation	Conductor
Process Control: To activate external lights, alarms or relays* when a fault occurs, wire them between dry relay contact pins 9,8 & 7. If the Lch function is ON (set on the front panel), the dry relay contacts will remain closed until the RESET button is pressed or when pins 1&3 are closed by remote switch or relay. If the Lch function is OFF, the dry relay contacts will return to normal state after the interval known as the PCd (Process Control Duration, set on the front panel) has elapsed.	9	NC	(3) 22 ga. stranded conductors rated 250V, less than 10 meters in length, contained in a common insulating sheath
	8	COM	
	7	NO	
HV ON Indication: Dry relay contact pins 1&2 will close when the test voltage exceeds 500v. For an indication that HV is ON in the electrode, wire a lamp or auxiliary device* here.	6	COM	
	5	NO	
	4	not used	
External Reset: To reset the spark tester fault relay with an external switch, wire a momentary switch** between pins 1&3. When these contacts close, the fault relay will return to a normal state. The interval that the contacts are closed must exceed 50 ms. HV Enable: **CAUTION:** For HV on the electrode, install a normally closed switch or relay contact** between pins 1&2. This switch or relay should open automatically when the wireline stop switch is activated or be opened manually by the system operator when the line stops. **FAILURE TO DO SO COULD RESULT IN A FIRE HAZARD.** If the HV remains ON in the electrode when your line is stationary, the wire insulation in the electrode will heat and there is a danger of combustion.	3	RESET	(3) 22 ga. stranded conductors
	2	HV ENABLE	
	1	GND	
When connecting auxiliary equipment to dry relay contact pins 5, 6, 7, 8 or 9, observe maximum ratings of 120VAC at 2 amps, 240VAC at 1 amp. **Switches and relays connected to pins 1,2, & 3 should be suitable for 24V low current applications.			

Connecting the HF-15AR to the ARC



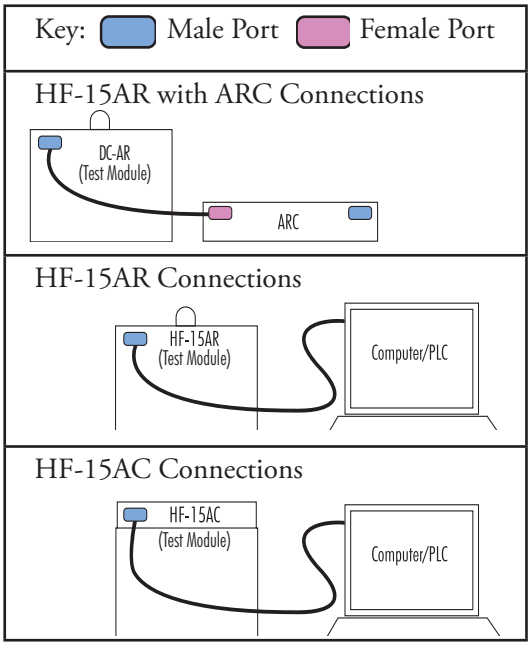
The HF-15AR with ARC Remote Display can be used as a standalone spark tester, the two modules located up to 200' apart. On the back of the ARC Remote Display there are two RS-485 ports. Connect the female port labeled "To test module," located on the left hand side, to the male port on the HF-15AR electrode labeled "RS-485 port" with an RS-485 connecting cable.

Connecting the RS-485 Interface

Models HF-15AC and HF-15AR with ARC Remote Display are each equipped with an RS-485 serial interface so that the spark tester can receive commands and exchange information with a PLC or computer. Programming and control of voltage settings, which can be done manually on the HF-15AC display or on the ARC remote display, can also be done through this interface. Control display buttons are not disabled when the serial interface is in use.

If your computer has only an RS-232 serial port, the RS-485 from the spark tester must be converted to RS-232. There are many RS-485 to RS-232 converters available. Contact the factory for more information on these converters. NOTE: most adapters require a converter cable from the adapter to the spark tester. It is highly recommended that the converter cable be shielded.

Connect RS-485 cables as follows:



RS-485 Connections for the HF-15AR with ARC

On the back of the ARC Remote Display there are two RS-485 ports. Connect the male port of the ARC labeled "RS-485 port," located on the right hand side, to a PLC or computer with an RS-485 cable.

RS-485 Connections for the HF-15AR

Connect the female end of the RS-485 cable to the male RS-485 port labeled "RS-485 port," located on the left rear of the test module. Attach the other end of the RS-485 cable to the appropriate RS-485 port on the computer or PLC.

RS-485 Connections for the HF-15AC

Connect the female end of the RS-485 cable to the male port labeled "RS-485 port," located on the left rear of the test module. Attach the other end of the RS-485 cable to the appropriate RS-485 port on the computer or PLC.

For information on the RS-485 interface, contact the factory.

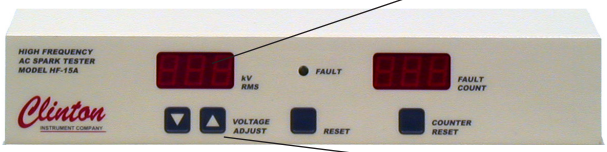
Prepare your Product for Testing

- Insure that the product to be tested is dry as it enters the spark test electrode. A continuous film or sheath of water on the product can provide an effective electrical path to the nearest grounded point. Surface leakage can trigger a false count in the spark tester. Efficient air wipes that can adequately dry the product before it enters the electrode are available from Clinton.
- Ground the product conductor(s). This is a safety precaution as well as a requirement of most spark test specifications. Please see the paper, "Grounding of Conductors During the Spark Test," included in this manual.
- Position the product in the center of the electrode, through the safety end guards. Be sure it will remain centered as it is being drawn through the electrode assembly. Lateral wire vibration which may be imperceptible can cause phantom faults to register on the spark tester. Properly positioned guides installed at entry to and exit from the electrode can eliminate this condition.

Spark Tester Controls

ON/OFF Power Switch

This switch is located on the rear panel of the spark tester.



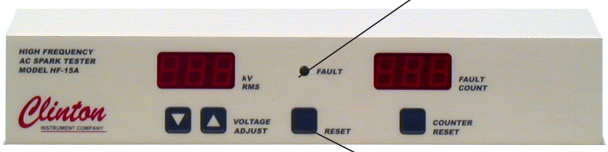
Voltmeter

The voltmeter indicates the voltage at the electrode. When the output voltage is adjusted to 1.0 KV, the voltmeter will read 1.0. A reading of 10.2 indicates that the voltage at the electrode is 10.2 KV rms.

VOLTAGE ADJUST buttons

The spark test voltage may be adjusted from 0 to 15,000 volts in 100 volt increments by pressing the up and down VOLTAGE ADJUST arrow buttons under the voltmeter. Press and hold a button to increase the speed at which you change the voltage setting.

The test voltage can be turned OFF or ON from a remote location if: (1) the power switch is ON; (2) there is a remote switch connected between Pins 1 & 2 of the terminal block that is located on the back of the unit.

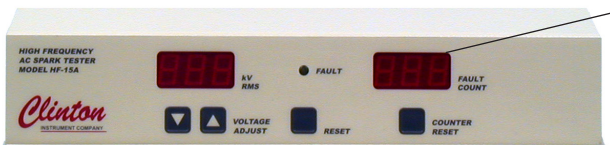


FAULT light

The FAULT light will illuminate in response to a single pinhole fault in the electrode. It also indicates that the process control relay contacts are in fault condition, activating any accessories that are connected. If the Lch (Latch on Fault) function is ON, the FAULT light can be turned OFF in 2 ways: (1) by pressing the RESET button below it; or (2) closing a momentary remote switch or relay contacts wired between Pins 1 & 3 of the green rear panel terminal block. Simultaneously, the fault counter relay contacts will reset to normal position. If the Lch function is OFF, the FAULT light will go OFF automatically and the fault relay will return to the normal state after an interval known as the Process Control Duration (PCd, which is programmed on the front panel) has elapsed.

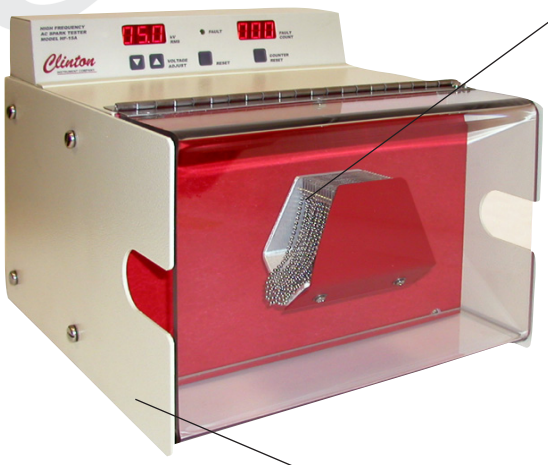
RESET button

If the Lch (Latch on Fault) function is ON, the RESET button will return the fault relay contacts to their normal state and turn OFF the FAULT light. The RESET button will have no effect on the number of faults registered on the fault counter.



Fault Counter

The 3-digit fault counter registers a count each time a pinhole fault is detected in the electrode. Press the COUNTER RESET button to reset the number of faults on the counter to 0.



Bead Chain Electrode

When the spark tester power is ON and the clear protective cover is down, the test voltage set on the spark tester front panel is applied to the product under test as it runs through the electrode. 1", 2", and 3" bead chain electrodes are available. Other electrodes are available. Please contact factory for details.

Clear Protective Cover

The clear cover protects the operator from coming into contact with the energized electrode.

Safety Interlock switch

This switch turns OFF the high voltage in the electrode when the clear protective cover is lifted. Do not attempt to defeat the safety interlock switch.

Safety end guards

Metal end guards on each end of the high voltage test module prevent the operator from reaching into the energized electrode. The test product should be centered in the electrode to avoid damage to the product.

Front Panel Programming

1. All-in-one spark tester: Turn OFF the ON/OFF power switch, located on the back panel. Press and hold in the RESET button while turning ON the ON/OFF power switch on the back panel.

   Two-piece spark tester: Leave the test module power switch ON and turn OFF the power switch on the ARC front panel. Press and hold in the RESET button on the ARC front panel while turning ON the ON/OFF power switch on the ARC back panel.

2. The voltmeter and fault counter will read: CON SYS (Configure System), indicating that you can now configure the spark test system. Release the RESET button.

3. The first of 4 functions (Lch, rUF, PCd, or ELE), described in the table on the following page, will be displayed on the fault counter. The selected option for that function will be displayed on the voltmeter.

4. Press an up or down VOLTAGE ADJUST button to choose a different option for that function.

5. To program the next function, press the COUNTER RESET button, and it will display on the fault counter. The selected option for this function will display on the voltmeter. Press a VOLTAGE ADJUST up or down arrow button to select a different option for that function.

6. Repeat this sequence for all 4 available functions.

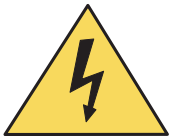
7. When you have made your choices for each of the 4 functions, press the RESET button and they will be accepted and saved by the system. The system will immediately begin to function according to the new system configuration with the voltage at the last preset value.

Function	Function Description	Option	Option Description
Lch	Relay Latches when a fault occurs	ON	When a fault occurs in the electrode, the process control relay (pins 7,8, &9) latches in fault mode until manual or remote reset.
		OFF	When a fault occurs in the electrode, the process control relay (pins 7, 8, &9) closes momentarily, returning to normal position after the PCD (process control duration) interval has elapsed.
rUF	Remove Voltage on Fault (This is only available when Lch is ON.)	ON	When a fault occurs, the voltage in the electrode will be removed until manual or remote reset.
		OFF	When a fault occurs, the voltage in the electrode will stay ON.
		nA	The Remove Voltage on Fault funtion is not available if the Lch function (Relay Latch on Fault) is OFF.
PCd	Process Control Duration	numeric value 50 ms. to 2-1/2 sec.	The Process Control Duration (PCd) operates only when the Lch funtion (Latch on Fault) is OFF. It is an interval that begins when a fault is detected in the electrode and it determines the length of time the fault relay contacts remain closed, energizing any auxiliary equipment connected to those contacts. The PCd may be set for lengths from 50ms. to 2-1/2 sec. Many alarms and lights require a signal of at least one second in length before responding; the fault relay contact closure time should be set to the duration needed to activate accessories connected to the relay. If a second arc should occur in the electrode before the Process Control Duration has elapsed, the contacts remain closed until that interval has ended.
		nA	The Process Control Duration does not apply if the Lch function (Relay Latch on Fault) is ON.
ELE	Electrode Length along the Wire Line	number 1,2,3,4,5	Choose a value of 1,2,3,4 or 5. This represents a 1", 2", 3", 4" or 5" long electrode length along the wire line (the horizontal dimension of the electrode that will cover your test product).
dFn			Display firmware version number
EFn			Test Module firmware version number

Testing Your Product

CAUTION: During installation, the spark tester was programmed to report and respond to faults in specific ways. Internal settings must not be changed except by qualified personnel.

1. Thread your product through the bead chain electrode. Be sure the wire is centered in the electrode.
2. Verify that the product conductor(s) are grounded. If this is not the case, do not proceed. Contact service personnel to review the spark tester installation.
3. Turn ON the external disconnecting device to bring power to the spark tester.
4. Turn the spark tester (and ARC, if you have one) power switch(es) ON. Push the front panel RESET button and the COUNTER RESET button, if necessary, so that both the voltmeter and fault counter 0.
5. Start the wire line. Press the VOLTAGE ADJUST up arrow button until the voltmeter indicates the desired test voltage value.



6. **CAUTION:** Do not touch the wire while it is being tested.
7. The spark tester will operate in accordance with the settings selected during "Installation" and "Front Panel Programming." See the table on the following page for spark test modes that are available.

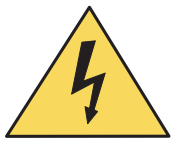
CAUTION: When the spark tester is operated with bare wire in the electrode for an extended length of time, i.e., several minutes or longer, damage to the equipment may result. This condition should be avoided, either by switching the spark tester OFF manually or by a zero speed switch operated by the machinery. Similarly, if the HV remains ON in the electrode while your wire line is stationary, the product insulation within the electrode will heat and there is a **danger of combustion.** Refer to the table "Terminal Block Connections" in the Installation section of this manual on how to safely install your spark tester.

Spark Tester Modes

Below are the sample settings for different spark test modes:

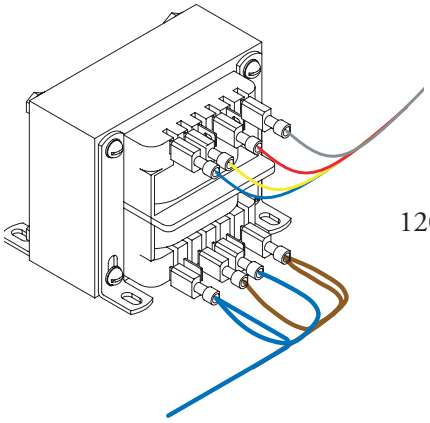
Spark Tester Function	Display Programming	Terminal Block Connections
Extruder Mode: When a fault occurs, the relay closes momentarily for an interval between .05 seconds and 2.5 seconds (known as the PCd), activating auxiliary devices for that interval. The relay then automatically returns to normal state and the fault light goes OFF. Voltage on the electrode stays ON.	Lch off rUF N/A PCd a value between .05 and 2.5 seconds ELE 1, 2, or 3	Jumper between Pins 1 & 2 Auxiliary devices on 7, 8, & 9
Respooler Mode, High Voltage OFF: When a fault occurs, the relay latches, the fault light goes on, auxiliary devices are activated, and voltage on the electrode is removed until the front panel RESET button is pressed.	Lch on rUF on PCd N/A ELE 1, 2, or 3	Jumper between Pins 1 & 2 Auxiliary devices on 7, 8, & 9
Respooler Mode, High Voltage ON: When a fault occurs, the relay latches, the fault light goes ON, and auxiliary devices are activated until the front panel RESET button is pressed. Voltage on the electrode stays ON.	Lch on rUF off PCd N/A ELE 1, 2, or 3	Jumper between Pins 1 & 2 Auxiliary devices on 7, 8, & 9
External RESET: When a fault occurs, the relay latches, the fault light goes on, auxiliary devices are activated, and voltage on the electrode is removed until a remote reset switch is pressed.	Lch on rUF on or off PCd N/A ELE 1, 2, or 3	Jumper between Pins 1 & 2 Remote switch between Pins 1 & 3
Remote ON/OFF HV:		Remove the jumper between Pins 1 & 2 and wire a remote ON/OFF switch here.
HV ON Indication:		Wire an external lamp or auxiliary device on pins 5 & 6. Pins 5 & 6 will close when voltage on the electrode exceeds 500v, activating this circuit.

Changing the Operating Voltage

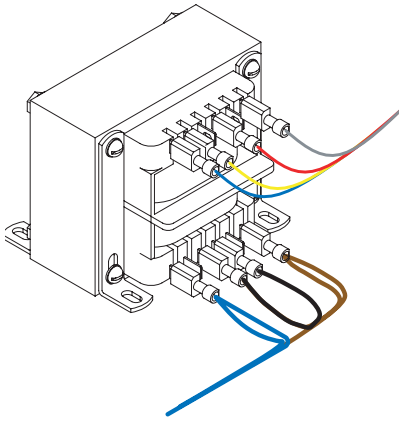


CAUTION: The procedure listed below is to be performed by qualified service personnel only. Failure to follow this procedure may result in danger to personnel and equipment damage.

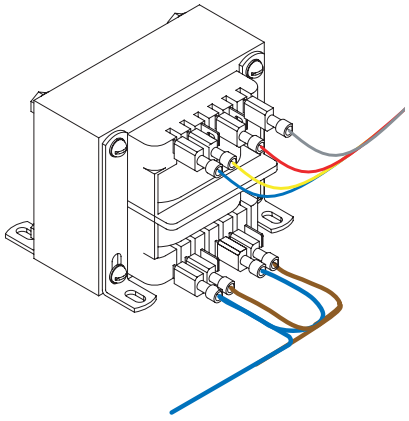
1. Turn OFF the spark tester.
2. Be sure the external disconnecting device is OFF and locked out before continuing.
3. Remove the back panel to expose the mains power transformer.
4. Rearrange the transformer jumper connections to the correct test voltage as shown in the drawings to the left.
5. Reattach the back panel and change the operating voltage displayed on the back panel label near the ON/OFF switch.
6. Change the fuse inside the ON/OFF power switch. At operating voltages of 100 or 120V, use a 2 Amp 250VAC 5x20mm low breaking time delay fuse, CIC part number 02606. If the spark tester operating voltage is 200 or 240V, use a 1 Amp 250AC 5x20mm low breaking time delay fuse, CIC part number 02603. This fuse is located in the ON/OFF power switch and is accessible with a flathead screwdriver as shown in the Maintenance section of this manual.



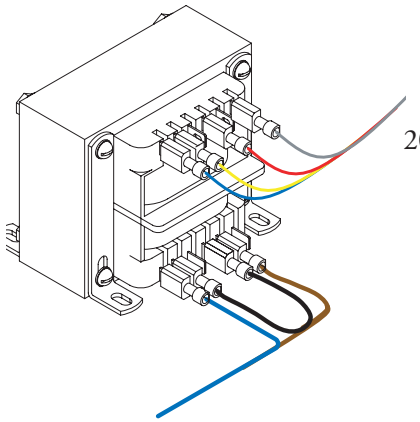
120V



240V



100V



200V

Calibration

The Spark Tester may be reasonably expected to retain its accuracy for a period of one year from the date of calibration under conditions of normal use.

CAUTION: The calibration procedures listed below are to be performed by qualified service personnel experienced in high voltage safety procedures only. Failure to follow these procedures may result in danger to personnel and equipment.

A Clinton HF-CAL High Frequency Calibration System or an accurately calibrated Electrostatic Voltmeter (EVM) is required for this procedure.

HF-CAL Calibration Procedure

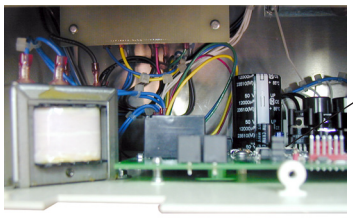
1. Connect the HF-CAL as described in the HF-CAL manual.
2. Turn ON the HF-CAL meter to the VOLTS AC position (V~) (First Position).
3. Turn ON the spark tester and press the VOLTAGE ADJUST arrow buttons until the voltmeter reads 3.00. Record the voltage reading on the HF-CAL meter. Multiply this reading by 100 to get the actual high voltage reading and record. Repeat this step for all required test voltages.
4. Compare your HF-CAL readings with the HF-15A voltmeter readings and verify that the spark tester readings are within factory specifications (2% of the reading).
5. If the readings are within tolerance, turn OFF the spark tester and disconnect the HF-CAL.
6. If the readings are not within tolerance, do not disconnect the HF-CAL. Proceed to the "Recalibration" section.

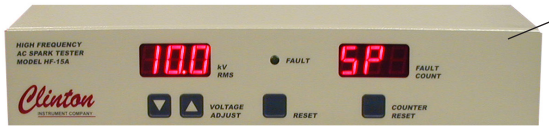
EVM Calibration Procedure

The EVM has a mirrored area to assist in eliminating errors in reading. The correct way to read the meter is to move the viewing position (your eye) until the reflection of the needle in the mirror is directly behind the needle itself, and observe the needle position on the scale. This eliminates any parallax error that might result from viewing the meter at a slight angle.

1. Before connecting to the EVM, turn ON the spark tester and adjust the voltage to 0 using the VOLTAGE ADJUST down arrow button. Turn OFF the spark tester.
2. With the power OFF, zero to EVM. Clip the HV lead from the EVM to the electrode of the spark tester. Use high voltage insulated wire.
3. Connect the ground terminal of the EVM to ground. Set the EVM range switch to the 20kV range.
4. Turn the spark tester ON. Using the VOLTAGE ADJUST buttons, slowly increase the voltage until the EVM reads the exact test voltage at which the spark tester is most often used (for example, 3KV, 5KV, 7.5KV, etc.); record the HF-15A voltmeter reading at each of these points.
5. Compare the Voltmeter readings to the EVM true voltages. If the spark tester voltage readings are within factory specifications (within 2% of the EVM reading), turn OFF the spark tester and disconnect the EVM from the spark tester and GND.
6. If the readings are not within tolerance, do not disconnect the EVM. Proceed to the "Recalibration" section.

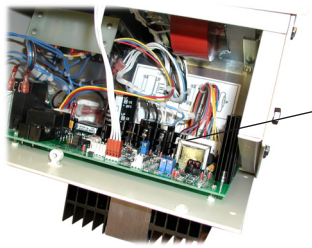
Recalibration

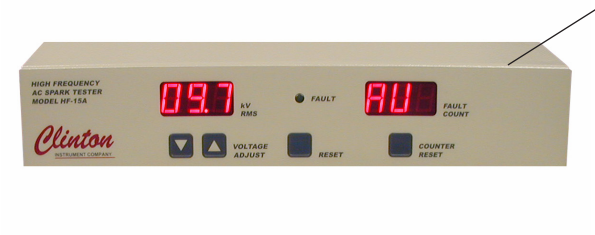




7. Using the VOLTAGE ADJUST arrow buttons, adjust the voltage to 10.0KV RMS. Turn OFF the spark tester.
8. Remove the two screws holding the display panel to the back of the spark tester chassis. Slide the display unit off and rest on top of the spark tester chassis. Do not disconnect the cable on the display.
9. Look straight down into the back of the spark tester at the test module PC board. Locate the calibration jumper JMP1 which covers the two left pins of the three-pin terminal labelled CAL ENABLE.
10. Move JMP1 to the right so that it covers the two right pins of the three-pin terminal labelled CAL ENABLE.
11. Turn ON the spark tester. The voltmeter & counter will display the following:

    This readout indicates that the spark tester is at a Set Point of 10KV rms.





12. Locate the calibration potentiometer R8, which can be found in the center of the test module PC board. Adjust R8 with a small plastic screw driver until the EVM or HF-CAL reads 10KV.

13. Press the COUNTER RESET button. The spark tester voltmeter & counter will display the following:

    This readout indicates the spark tester's Actual Voltage (AU).

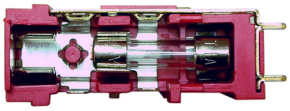
14. Press a VOLTAGE ADJUST arrow button just once to adjust the voltage readout toward 10.0 KV. Every time you press a VOLTAGE ADJUST button, you will see the FAULT light flash, and after a few seconds, the voltage readout will reflect the change. Repeat this step until the AU (actual voltage) displayed on the spark tester voltmeter matches the EVM or HF-CAL voltage reading.

15. Turn OFF the spark tester. Remove the JMP1 calibration jumper and return it to its original position on the PC board.

16. Return to steps 1 through 6 of "EVM Calibration Procedure" or "HF-CAL Calibration Procedure" to take calibration readings.

Maintenance

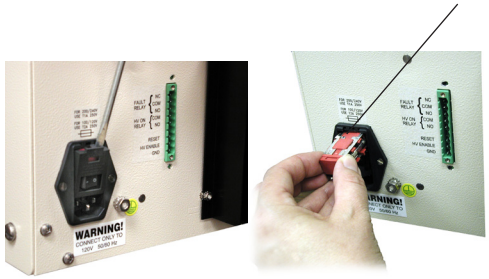
Fuses



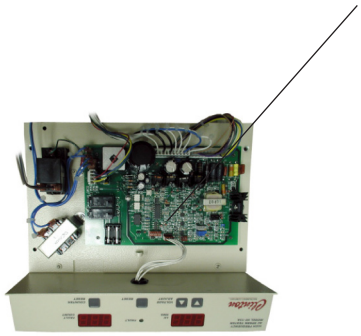
Fuse

The fuses in this equipment are not expected to fail in normal operation. Their failure may be an indication of equipment malfunction requiring qualified repair personnel.

There is one fuse associated with the spark tester's operating voltage, located in the ON/OFF power switch on the back panel of the unit. See the section entitled, "Changing the HF-15AC/AR Operation Voltage" when changing this fuse.



Two additional fuses that could be defective are found on the main printed circuit board, behind the back panel.



Periodic Inspection

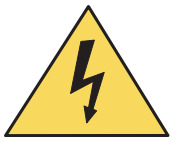
It is important to inspect the electrode and electrode mounting plate periodically for residue and wear.

Insulation and water deposits can reduce the effectiveness of the spark test. The red electrode mounting plate may be wiped with a clean, dry cloth. Bead chain assemblies contaminated with insulation residue should be removed from the high voltage test module and cleaned with a wire brush. Broken safety covers and mounting plates and electrode assemblies with worn brushes or missing beads should be replaced immediately.

The red electrode mounting plate, clear cover, and bead chain assemblies are subject to damage and contamination that is not always visible. They should be replaced if current leakage occurs.

Refer to the "Troubleshooting" section for assistance with electrical problems.

Troubleshooting



CAUTION: Troubleshooting is to be performed by qualified service personnel only. Failure to follow the procedures in this manual may result in danger to personnel and equipment damage.

Phantom faults are being indicated.

1. Lateral wire line vibration or water may be present. See "Installation" for information on drying, centering and restraining the product in the electrode.
2. The high voltage mounting plate may be contaminated with dirt or conductive material. Clean the mounting plate or replace.
3. Inspect proper grounding of inner conductor.
4. If, after 1,2,& 3 have been corrected, you still experience false counting due to a capacitive loading effect on your test product, turn switch SW2 on the main PCB (part number 91065) to the reduced sensitivity position (away from TP3 and toward R92). Note that your spark tester will now meet the NEMA Standard for sensitivity but not BS.

The voltmeter blinks 00.0.

1. The clear safety cover is open.
2. There is no switch or relay contact between Pins 1 & 2 (GND and HV ENABLE). Refer to the table in "Installation" labelled "Terminal Block Connections," under HV ENABLE.

After adjusting the voltage with product in the electrode, a lower voltage is displayed.

1. The spark tester may have reached the highest voltage possible for this product due to a capacitive loading effect from the test product. Consult the factory regarding your application.

Equipment at relay terminals COM and NO or NC is not activated when a fault occurs.

1. The PCd (Process Control Duration) value may be too short for the auxiliary equipment to recognize.
2. Check fuse on main pc board.

The spark tester controls are ON but the equipment does not function.

1. The high voltage test module interlock switch is not closed.

2. The terminal block connector is not plugged in.
3. F101 fuse is blown.
4. There is no switch or relay contact between Pins 1 & 2 (GND and HV ENABLE). Refer to the table in "Installation" labelled "Terminal Block Connections" under HV ENABLE.

Display shows "Err 001".

1. All-in one spark tester: This error message means that the display is unable to communicate with the test module. Contact Clinton Instrument and return unit for service.
2. Two-piece spark tester: Make sure that the interconnecting cable between the ARC remote display and the HF-15AR test module is secure and connected to the correct ports. If the cable is properly installed and the problem continues, contact Clinton Instrument and return the unit for service.

Replacement Parts

Note: Printed circuit boards are carefully constructed and calibrated at the factory. Components are not supplied for field repair of boards. Please return faulty circuit boards to the factory or to your Clinton sales representative for quick and inexpensive repair and calibration.

Part Number	Description
02606	2 amp low breaking time delay fuse, 5x20mm for 120V units
02603	1 amp low breaking time delay fuse, 5x20mm for 240V units
91088	Printed circuit board, display
A/AC Control Unit	Display unit complete for all-in-one spark tester
91061	Power entry module (ON/OFF Switch)
00465	Power transformer w/top mounted insulation barrier
91065	Printed circuit board, main for 15KV units
91065LZi	Printed circuit board, main, for 10KV units HF-15A, AR, & AC/BD-22LZ, BRTC-6LZ & BD-12LZ
91068	Assy Heat Sink
25002	Assy Bead Chain BD-12 w/trough & kydex cover
35002	Assy Bead Chain BD-12 no trough or kydex
20028	Assy Bead Chain BD-13 w/trough and kydex cover
35002 & 30050	Assy Bead Chain BD-13 no trough or kydex
91462I	Cover Clear Safety
91046	Hinge
91048	Electrode Mounting Plate for BD-12, BD-13, & BR-1A
50013	Assy Transformer High Voltage 15KV
10024	Asssy Transformer High Voltage 10KV Low Z
03004	Switch, Interlock
91069	Terminal Block Connector Kit (Green)
03780	Power Cord
91463	End Guard HF-15AC/AR/BD-12 and BD-13
91326	BD-22S Bead Chain Assembly
91112	Clear Cover BD-22

01554	Standoff-Ceramic
91113	BD-22 Electrode Mounting Plate
90819	Rubber Gasket for 01554
91111	BD-22 End Guard
BD-12V Replacement Parts	
91122-12V	Mounting Plate for Vertical Electrode
91491I	Cover Clear Safety
91065i-NEMA	Printed Circuit Board (This is a 91065i board with SW2 switch in the reduced sensitivity position away from the TP3 and toward the R92).
50302	Vertical Electrode Assembly and Plate
Optional Accessories	
FS-4	Floor Stand for HF-15A, 39-42” Adjustable wire line height
FS-4A	Floor Stand for HF-15AC with BR-3A or BRTC electrodes
838/3	High Speed Air Wipe, .020-.315” product dia.
688/3	Adjustable Orifice Air Wipe, .076-.472” product dia.
674/3	Adjustable Orifice Air Wipe, .188-.866” product dia.
HF-CAL	High Frequency Spark Tester Calibrator
AM, PM, PM-D, EM	Analog, Profibus, and Ethernet Communications Modules

Warranty

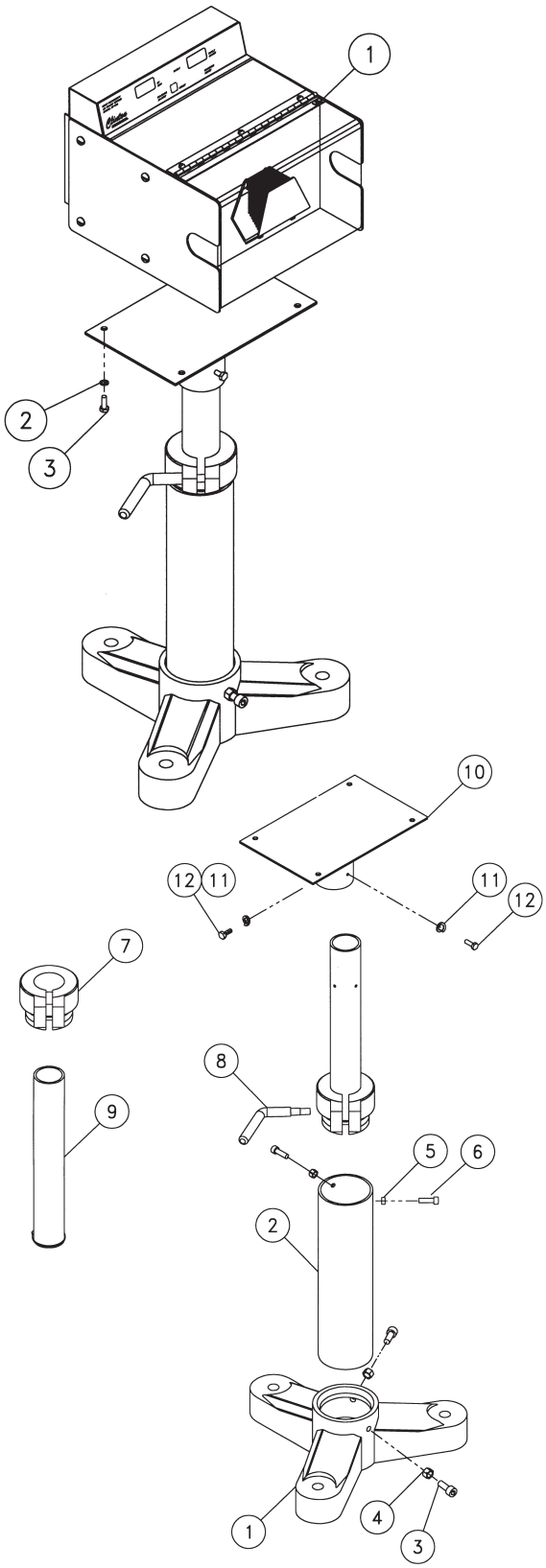
The information contained in this document is subject to change without notice. The Clinton Instrument Company makes no warranty of any kind with regard to this material, including, but not limited to, the implied warranties or merchantability and fitness for a particular purpose.

The Clinton Instrument Company shall not be liable for errors contained herein or for incidental damages in connection with the furnishing, performance, or use of this material.

We warrant to the original purchaser that the equipment described herein is free from defects in materials and workmanship for a period of one year from the date of invoice, our obligation under this warranty being limited to repair or replacement of the defective parts. This warranty does not apply to fuses, lamps, or any normally expendable parts. Any part appearing to have defects in material or workmanship, upon our examination only and as determined by us, and providing the equipment has not been subject to abuse, misuse, or alteration, will be repaired or replaced at no charge for materials and labor, either upon receipt of the defective part or equipment, transportation charges prepaid, at our plant or at the equipment location, as selected by us. No parts or equipment shall be returned without our prior permission. Any parts replaced under this warranty shall be warranted until the expiration date of the original warranty.

The warranties herein are in lieu of all other warranties, expressed or implied, and of all other obligations or liabilities on our part concerning this equipment.

FS-4 Floor Stand Assembly



Item No.	Item Description	Qty.
1	Test Module	1
2	6 mm Split Lock Washer	4
3	M6 x 16 Hexhead Screw	4

Item No.	Item Description	Qty.
1	Base	1
2	Outer Column	1
3	10-1.5 x 30 mm bolt	2
4	10-1.5 mm Hex Nut	2
5	8 x 1.25 mm Hex Nut	2
6	8-1.5 x 25 mm Bolt	2
7	Column Clamp	1
8	Handle	1
9	Inner Column	1
10	Test Module Mounting Plate	1
11	M6 Split Washer	2
12	M6 x 16 mm Bolt Hex	2

MEASURING & TESTING

clinton instrument company

Grounding of conductors during the spark test

by Henry Clinton

Nearly all industry-wide specifications for insulated wire and cable pertaining to in-line spark testing require the grounding or earthing of the conductors under test. It is the purpose of this discussion to examine the reasons for this and to define the conditions which allow for a safe and effective spark test when conductors are not grounded. Although this testing mode cannot be used to satisfy most industry specifications, it can be useful when quality must be strictly monitored and conductor grounding is inconvenient or impossible.

D-C spark testing

If a direct potential is used for spark testing, it is absolutely necessary to ground the conductor or conductors under test. In Fig. 1, C_g represents the capacitance of the product to ground, which could be in the range of 100 to 2,000 picofarads, depending on the size and length of the conductor.

If the conductor is not grounded, the potential on the conductor with respect to ground will rise when the first insulation fault passes through the electrode. This is because C_g charges towards the D-C test potential applied to the electrode through the arc.

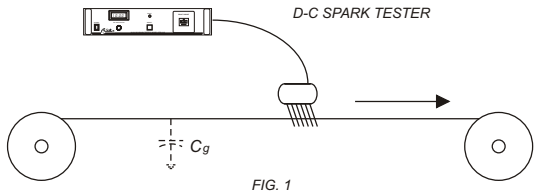


FIG. 1

If the conductor is not grounded but is initially at ground potential, when the first insulation defect passes through the electrode, an arc forms between the electrode and the conductor. The current flowing through this arc charges capacitance C_g, elevating the potential of the conductor by a value which is a function of arc time duration and the value of the current. After the defect or fault has completed its passage through the electrode, C_g retains this elevated potential, since C_g has no discharge path to ground. The effective test potential on the product insulation is now reduced by this retained conductor potential. If a second insulation flaw traverses the electrode, additional charging of C_g takes place, further reducing the effective test potential. Eventually the effective test potential falls below that required to cause an arc to occur on the passage of an insulation flaw, and all subsequent flaws will be undetected. Usually, current and traverse time are large enough to sully charge C_g on the passage of the first flaw, so it will be the only one detected.

Furthermore, the entire length of product is now charged to the test potential. If the operator accidentally comes into contact with the conductor or with a flawed insulation area anywhere along the wire line, C_g can discharge through his body to ground. If by coincidence a faulted insulation area is within the electrode, the maximum current output of the spark tester can also pass through his body. While this current , in the case of Clinton spark testers, is well below a dangerous level, the involuntary muscular reaction resulting from this event can itself cause a secondary accident.

It is thus apparent that from the dual standpoints of utility and safety the conductors of a product being spark tested with a D-C potential should be grounded.

A-C spark testing, general

If an A-C potential is used for the spark test, and the conductors are not grounded, the diagram in Fig. 2 applies.

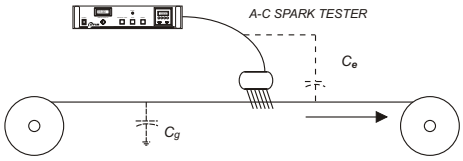
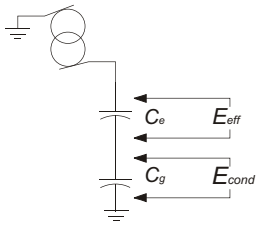


FIG. 2

Note that the electrode to product capacitance C_e is shown, and that C_e and C_g comprise a voltage divider which determines the A-C potential from conductors to ground, and also the effective test potential applied across the product insulation.



$$\frac{E_{eff}}{E_{cond}} = \frac{C_g}{C_e}$$

$$E_{cond} = E_{app} - E_{eff}$$

$$E_{eff} = \frac{C_g}{C_e\ C_g} E_{app}$$

If C_g is very large compared to C_e, Eeff is nearly equal to Eapp. For example, if C_e = 5pf and C_g - 1000pf, 99.5% of the applied test potential is impressed across the product insulation. If C_g is 100pf, however, the effective test voltage drops to 95% of the applied value.

Power mains frequency testing

When an insulation defect passes through the electrode, the arc which forms to the ungrounded conductor in effect connects the conductor to the electrode. If the spark tester operates at the

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mains frequency, the ungrounded conductor will be elevated to nearly the full test potential. If an operator comes into contact with a bare spot in the insulation at this time, current can flow through his body to ground. The maximum value of this current will be the maximum output level of the spark tester. For Clinton mains frequency spark testers this level is less than the " let-go" threshold and is not dangerous in itself However, as in the D-C case, the event is unexpected and unpleasant, and can lead to a secondary accident. From the standpoint of flaw detection, the detector circuitry must differentiate between normal electrode current and the new level when the arc connects C_g to the electrode, which is a small increment. As in the D-C case, grounding of the conductors under test is a practical necessity.

High Frequency spark testing

When the A-C test frequency is increased to 3Khz, two dramatic changes occur. First, because a short electrode is used, the capacitance to the conductor C_e is kept small. For a 2 in. electrode C_e might be typically 2 to 20pf, increasing with the applied potential. The other change is the low reactance of Cg, which allows the current to be conducted readily to ground through a capacitive path rather than by direct connection.

The ratio of C_g /C_e is usually high, so that nearly all of the applied test potential appears across the product insulation. When an insulation flaw passes through the electrode, current drawn from the spark tester increases sharply in this same ratio, subject to the current limiting characteristics of the test equipment. This means that flaws can be detected reliably. If required, C_g can be increased by passing a considerable length of the product close to the grounded surface.

Although the maximum resistive current which can be delivered by a Clinton 3Khz spark tester is well below the "let-go" threshold, a mild shock could still be experienced if an operator contacts a bare spot on the product while a second defect is in the electrode. For this reason the entire line should be provided with protective guards to prevent this.

The ratio of C_g/C_e can be experimentally determined by measuring Econd, the conductor to ground potential, with a high impedance A-C volt-meter or an oscilloscope.

$$\frac{C_g}{C_e} = \frac{E_{app} - E_{cond}}{E_{cond}}$$

Summary

Spark testing of ungrounded conductors is usually not permitted by industry-wide specifications, and is unsatisfactory in any event if D-C or A-C power mains frequency test potentials are used. A satisfactory test for quality control purposes can be made on ungrounded conductors at 3Khz, however, if proper precautions are followed.

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