**EDD-7
ELECTRIC CHARGE POINT METER
TEST RESULTS**

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ABSTRACT

The results of tests evaluating the electric switching portion of the EDD-7 Electric Charge Point Meter (ECPM) are presented. The ECPM is a modified parking meter that allows the purchase of 120 or 240 volt electric power. The ECPM is designed to make electricity available at any vehicle parking location. The test results indicate that the ECPM operated without failure thru a series of over current and ground fault tests at three different test temperatures. The magnitude of current required to trip the over current protection circuitry varied with temperature while the performance of the ground fault interruption circuitry did not change significantly with the test temperature.

SUMMARY

An EDD-7 Electric Charge Point Meter (ECPM) was tested at the INEL Electric Vehicle Battery Laboratory. The tests were designed to evaluate the safety and ruggedness of the electric switching portion of the ECPM. The test matrix included the following:

1. Meter Timer Tests
2. Receptacle Cover Tests
3. Timer Knob Tests
4. Over Current Tests
5. Ground Fault Interruption Tests
6. Temperature Tests

The principal results and conclusions of the tests are as follows:

1. The ECPM's basic safety features operated without failure for all tests.
2. The trip point of the over current protection circuitry varied with the test temperature.
3. Test temperature had no significant effect on the trip times of the over current circuitry.
4. The trip point of the ECPM's ground fault interruption circuitry was $3.7 \text{ mA} \pm 0.1 \text{ mA}$ for all three test temperatures.
5. The speed of the GFI circuitry was not significantly effected by test temperature.

EDD-7 ELECTRIC CHARGE POINT METER TEST RESULTS

INTRODUCTION

The EDD-7 Electric Charge Point Meter (ECPM) is a coin operated electric power dispensing device manufactured by EHV Corporation of Manhattan, Kansas. It is designed to supply electricity for the charging of electric vehicles at parking locations. This report covers the tests performed on a pre-production ECPM by the INEL Electric Vehicle Battery Laboratory. The tests evaluated the safety and ruggedness of the electronic switching portion of the ECPM.

DEVICE DESCRIPTION

The EDD-7 Electric Charge Point Meter (ECPM) is a coin operated switch that allows the user to purchase either 120 or 240 VAC 50/60 Hz electric power via an electronic timer (see Figure 1). A commercially available parking meter, manufactured by P.O.M. of Russellville, Arkansas, is utilized for the coin collection and electronic timing functions. The electronic timer connects the 120 volt NEMA 5-20 receptacle and the 120/240 volt NEMA 14-50 receptacle (see Figure 2) on the ECPM to electric service for a predetermined amount of time depending upon the number and respective values of coins placed into the meter. The ECPM is designed to supply electricity for charging electric vehicle batteries at any parking location. Because the general public will be operating this device, it must be extremely safe and tolerant to abuse. The ECPM unit supplied to EG&G for testing is a pre-production model and does not utilize all the external safety features that will be found on the production unit. For example, the production unit will feature a non-ferrous case to enclose the power electronics, and it will be equipped with water management gaskets. Because these safety items were omitted on the ECPM test unit, INEL tests were restricted to the evaluation of the safety and ruggedness of the electric switching portion of the unit.

In utilizing the P.O.M. parking meter in the ECPM, several electrical modifications have been made. Further, as improvements and upgrade functions are added to the charge station, further integration will be made between the P.O.M. parking meter and the EHV Corp. power unit. An obvious modification to the P.O.M. parking meter is the addition of four light emitting diodes (LEDs). The LEDs indicate the status of the ECPM. The first LED is labeled "POWER" and is illuminated when electric power is applied to the meter. The second LED is labeled "CHARGE" and indicates when the meter is supplying electricity to its receptacles. The third LED is labeled "VEHICLE FAILURE" and illuminates when the ECPM's ground fault interruption (GFI) or over current circuitry disconnects power to the receptacles. The fourth LED is labeled "METER FAILURE" and indicates when the internal circuitry of the ECPM has failed. The ECPM has a self evaluation algorithm that checks four items: the ground fault circuitry, the over current protection circuitry of the NEMA 5-20

Figure 1. Overall view of EDD-7 parking meter.

Figure 2. NEMA 14-50 (top) and 5-20 (bottom) receptacles.

receptacle, the over current protection circuitry of the NEMA 14-50 receptacle, and finally the voltage level at the contactor output. If any of these tests result in an "ERROR" the "METER FAILURE" LED will illuminate.

The ECPM's switching electronics connect the line input power to the NEMA 5-20 receptacle (rated at 20 amps) and the NEMA 14-50 receptacle (rated at 50 amps) via a contactor manufactured by ABB (see Appendix B for data sheets). The ECPM's short circuit and ground fault interruption capabilities are accomplished in the switching electronics. These features are designed to protect the equipment connected to the ECPM and the meter's operator. Another feature of the electronics is the monitoring of the receptacle cover and timer knob. Disturbing either of these devices on the ECPM causes interruption of power to the receptacles for approximately 6 seconds. This delay assures that the ECPM's contactor cannot be rapidly cycled during meter operation. If the overcurrent protection or the ground fault interruption circuitry disconnects the power from the ECPM to a load, the meter can be reset by turning the timer knob or opening the receptacle cover. For a detailed description of the ECPM's switching circuitry and specifications see Appendix A.

As was stated earlier in this report, the ECPM tested at the INEL Battery Laboratory was a preproduction unit. All questions concerning the latest version of the EDD-7 ECPM should be directed to EHV Corp.

TESTS PERFORMED

The tests performed at the INEL Electric Vehicle Battery Laboratory can be divided into 6 main sections:

1. Meter Timer Tests
2. Receptacle Cover Tests
3. Timer Knob Tests
4. Over Current Tests
5. Ground Fault Interruption Tests
6. Temperature Tests

The remainder of this section explains and illustrates the various tests listed above.

Due to time constraints, life cycle testing of the ECPM was not included in the testing procedure. To compensate for this omission, data sheets describing the ABB contactor are presented in Appendix B.

Meter Timer Tests¹

These tests involved purchasing electricity from the ECPM with a U.S. nickel and dime. The purpose of the tests was to determine the exact amount of time the ECPM delivers power when given each respective coin. See Figure 3 for the block diagram of the setup used for these tests.

Figure 3. Test set up for testing.

Receptacle Cover Tests¹

These tests involved opening the receptacle cover door while the ECPM was in operation. The tests considered three situations: when the NEMA 5-20 receptacle was under load, when the NEMA 14-50 receptacle was under load, and when neither receptacle was under load. The purpose of the tests was to determine if the ECPM interrupts power to the receptacles when the cover is disturbed. See Figure 3 for the block diagram of the setup used for these tests.

Timer Knob Tests¹

These tests involved rotating the timer knob while the ECPM was in operation. One set of tests evaluated the situation in which no additional coins were placed in the meter. The other tests consider the situation where additional coins were inserted in the meter. The purpose of the tests was to determine if the ECPM interrupts power to the receptacles when the timer knob was rotated, and to determine the duration in seconds of the interruption. See Figure 3 for the block diagram of the setup used for these tests.

Over Current Tests¹

These tests involved applying resistive loads to the ECPM that cause the over current circuitry to interrupt power to the receptacles. Over load conditions were repeated for 1.05, 1.2, 1.5 and 2.0 times the magnitude of the current that caused the circuit to be disconnected. The tests were repeated for the four different ways resistive loads can be applied to the ECPM thru the NEMA 5-20 and the NEMA 14-50 receptacle. A final test was performed to determine the magnitude of current available from both receptacles operating at the same time. The purpose of these tests was to determine if the ECPM reacts appropriately to loads that draw currents beyond the device's specifications. See Figure 3 for the setup used for these tests.

Ground Fault Interruption Tests¹

These tests involved applying loads to the ECPM that result in ground faults. The first tests required the application of various resistive loads between the X and the ground terminal of the NEMA 14-50 receptacle. After the minimum magnitude of current that caused a GFI was determined, fault currents 1.05, 1.5, 2.0, 5.0, 10.0, 20.0, 50.0, and 100.0 times that original current were applied. The purpose of these tests was to determine the length of time required for the ECPM's GFI circuitry to open the contactor when each of the above mentioned faults are applied. A second set of tests involved a ground fault current being generated thru various capacitors. The purpose of these tests was to determine the amount of capacitance the ECPM's GFI circuitry tolerates before tripping. See Figure 4 for the setup used in these tests. For the capacitor GFI tests, the decade resistor box was removed, and the various capacitors were placed between the "X" and ground terminals of the NEMA 14-50 receptacle. The data acquisition system was removed from the test circuit because the ground fault was to occur across a purely capacitive load. No current or voltage measurements were needed to obtain the desired results.

Temperature Tests¹

These tests involved performing all the tests described in this section at two other temperatures: $60 \pm 2^\circ\text{C}$ and $-20 \pm 2^\circ\text{C}$. The initial set of tests were performed at the ambient temperature of the Battery Laboratory, which was $23 \pm 2^\circ\text{C}$. The purpose of these tests was to determine if extreme temperatures effect the performance of the ECPM.

Figure 4. Setup for ground fault interruption tests.

DATA ACQUISITION

The data acquisition system utilized for all tests that were a function of time was an Industrial Computer Source Model AI08 A/D converter placed in an IBM PC. The AI08 is a 12-bit successive approximation A/D converter that was driven by control software written in BASIC. The program allowed data acquisition at various rates. For the Meter Timer Tests the data acquisition rate was 40 samples per second (S/sec). For the Receptacle Cover Tests and the Timer Knob Tests, the data acquisition rate was 1000 S/sec. Finally, for the Over Current Tests and Ground Fault Interruption Tests the sampling rate was 4000 S/sec. In these tests two channels of the AI08 were used, one to monitor voltage and the other to monitor current. Because two of the AI08's channels were used, the sampling rate per channel is half of the overall system sampling rate.

TEST RESULTS

This section presents the test results for room temperature tests, the high temperature tests, and the low temperature tests simultaneously. Detailed test results are presented in the "Discussion of Results" section.

Meter Timer Tests

The various lengths of time the ECPM delivered power after receiving U.S. nickels and dimes is summarized in Table 1.

Table 1. Meter Timer Test Results.

Coin	Length of Power Delivery (secs)		
	60°C	23°C	-20°C
U.S. nickel	172.9	173.3	172.7
U.S. dime	352.3	354.4	351.6

Receptacle Cover Tests

Opening the receptacle cover and then closing it immediately while the ECPM was delivering power to its receptacles resulted in an interruption of power to the receptacles in all the Receptacle Cover Tests. Table 2 gives the length of time of the interruption of power for each of the different test situations.

Table 2. Receptacle Cover Test Results.

Situation	Length of Power Interruption (secs)		
	60°C	23°C	-20°C
No load	5.5	5.9	5.6
25 amps from NEMA 14-50	5.4	10.8	5.7
10 amps from NEMA 14-50	5.6	10.8	5.8

Timer Knob Tests

Two types of Timer Knob Tests were performed on the ECPM. One set involved rotating the timer knob with no additional money placed in the meter, and for the other set of tests a nickel was placed in the corresponding coin slot before the timer knob was rotated. Rotating the timer knob in both these cases while the ECPM was delivering power to its receptacles resulted in an interruption of power by the ECPM. Table 3 gives the length of the interruption of power in seconds for the tests in which no additional money was placed in the meter. Table 4 gives the length of the interruption of power in seconds for the tests in which a nickel was placed in the meter before rotating the timer knob.

Table 3. Timer Knob Test Results/No Additional Coin.

Situation	Length of Power Interruption (secs)		
	60°C	23°C	-20°C
No load	10.5	5.6	5.8
25 amps from NEMA 14-50	5.3	5.4	5.8
10 amps from NEMA 5-20	10.6	5.7	5.8

Table 4. Timer Knob Test Results/Additional Coin.

Situation	Length of Power Interruption (secs)		
	60°C	23°C	-20°C
No load	10.5	11.2	5.8
25 amps from NEMA 14-50	5.5	5.7	5.8
10 amps from NEMA 5-20	5.5	11.2	6.0

Over Current Tests

The tests evaluating the over current circuitry of the ECPM looked at the four different ways the unit could deliver electric power to a load: the 120 volt circuit of the NEMA 5-20 receptacle, the 240 volt circuit (X-Y) of the NEMA 14-50 receptacle, and the two 120 volt circuits (X-W and Y-W)

of the NEMA 14-50 receptacle. Table 5 gives the measured trip point in amps for each of these circuits at the three different test temperatures.

Table 5. Over Current Trip Points.

Temp (°C)	Trip Current (amps)			
	NEMA 5-20	NEMA 14-50 X-Y	NEMA 14-50 X-W	NEMA 14-50 Y-W
60	21	56	64	62
23	23	62	72	69
-20	29	72	85	82

After establishing the trip point of each circuit, resistive loads that result in various multiples of the trip currents were applied. Tables 6, 7, and 8 give the amount of time required for the over current circuitry to disconnect power when drawing the various multiples of the trip currents shown in Table 5. These three tables give the results obtained at the three respective test temperatures.

Table 6. Over Current Trip Times at 60°C.

Trip Current Multiplier	Trip Times (secs)			
	NEMA 5-20	NEMA 14-50 X-Y	NEMA 14-50 X-W	NEMA 14-50 Y-W
1.05	.549	.416	.559	.790
1.20	.442	.303	.463	.500
1.50	.364	.251	.458	.384
2.00	.328	.260	.519	.434

Table 7. Over Current Trip Times at 23°C.

Trip Current Multiplier	Trip Times (secs)			
	NEMA 5-20	NEMA 14-50 X-Y	NEMA 14-50 X-W	NEMA 14-50 Y-W
1.05	.616	.436	.785	.554
1.20	.461	.309	.469	.443
1.50	.370	.262	.387	.370
2.00	.326	.246	.428	.400

Table 8. Over Current Trip Times at -20°C.

Trip Current Multiplier	Trip Times (secs)			
	NEMA 5-20	NEMA 14-50 X-Y	NEMA 14-50 X-W	NEMA 14-50 Y-W
1.05	.603	.409	.687	.770
1.20	.460	.318	.536	.562
1.50	.369	.262	.410	.403
2.00	.336	.259	.353	.354

The final evaluation of the over current protection circuitry involved connecting a load to each of the ECPM's receptacles at the same time to determine the magnitude of current allowable from the combination before a trip occurred. The load connected to the NEMA 5-20 receptacle required 13 amps continuously. The 240 volt circuit of the NEMA 14-50 receptacle was connected to the Alber BCT-30 to determine the combination trip point. Table 9 displays the results of this test at the three test temperatures.

Table 9. Over Current Trip Point for Both Receptacles in Operation.

Temperature (°C)	Trip Point (amps)
60	39
23	45
-20	63

Ground Fault Interruption Tests

The first step in evaluating the ground fault interruption circuitry of the ECPM was to determine the minimum magnitude of current thru the X and ground terminals of the NEMA 14-50 receptacle that results in a disconnection of power. To achieve the resistive loads required for these tests, a decade resistor box was used. Table 10 gives the measured trip points of the GFI circuitry in milliamps for the three test temperatures.

Table 10. Trip Points of the GFI Circuitry.

Temperature (°C)	Trip Point (mA)
60	3.8
23	3.7
-20	3.6

After establishing the magnitude of current that caused the GFI circuitry to trip, the decade resistor box was adjusted to cause ground faults of various multiples of the trip points shown in Table 10. From these tests the GFI circuitry trip time was recorded. Each step was performed three times and an average time was calculated. Table 11 gives the average trip times for the various magnitudes of trip current for the three test temperatures.

Table 11. Average GFI Trip Times.

	Average Trip Times (secs)		
Trip Current Multiplier	60°C	23°C	-20°C
1.05	.642	.684	.598
1.50	.360	.383	.380
2.00	.320	.325	.328
5.00	.273	.289	.294
10.00	.264	.281	.285
20.00	.258	.275	.275
50.00	.254	.269	.273
100.00	.201	.229	.233

The final step in the GFI tests was to determine the amount of capacitance the GFI circuit could tolerate without tripping. The capacitive load was placed across the X and ground terminals of the NEMA 14-50 receptacle. The load was switched "ON" for one second and then switched "OFF" and discharged thru a resistor, this process was repeated ten times. The result of this test was the same at all three test temperatures, the GFI circuitry tripped when a 0.055 microfarad capacitor was utilized in the test circuit. The trip occurred the first time that the 0.055 microfarad capacitor was switched "ON" between the "X" and ground terminal of the NEMA 14-50 receptacle, while the GFI tolerated a 0.047 microFarad capacitor being switched "ON" and "OFF" ten times.

DISCUSSION OF RESULTS

Meter Timer Tests

The reason for the Meter Timer Tests was to determine if the ECPM's timer allowed for the approximately 6 second delay between the time money is inserted into the meter and power is available at the meter's two receptacles. A U.S. nickel should give 180 seconds of electricity and the U.S. dime should give 360 seconds of electricity according to the claim on the ECPM's head. The results show that the short delay is included in the amount of time purchased with each respective coin (see Table 1). Changing the test temperature had no noticeable effect on the timing circuitry.

Receptacle Cover and Timer Knob Tests

Because the results of these two different sets of tests are very similar, they are discussed at the same time. The reason for these tests was to determine if the ECPM would disconnect power to its receptacles under various load conditions when the receptacle cover or timer knob was disturbed. The ECPM disconnected the power as expected in all the tests. The length of the delay before the power was again available at the receptacle varied from test to test (see Table 2, Table 3, and Table 4). The delays were either approximately 5.5 seconds or 11 seconds, indicating that occasionally the ECPM's self evaluation circuitry runs thru its algorithm twice before the power is returned to the receptacles. Assuming that the higher delay times (between 10 and 12 seconds) represent the ECPM running thru its self evaluation algorithm twice, the calculated average time of a single self evaluation is 5.55 seconds.

The reason the ECPM occasionally ran through its self-evaluation cycle twice was the result of the unit being reactivated in the latter part of the internal testing cycle. No repeatable pattern of this behavior is seen in the test results because the reactivation occurred randomly. Basically, the ECPM was double checking the situation to assure that power could be safely returned to the receptacles.

Over Current Tests

The Over Current Tests were intended to determine the magnitude of current needed to trip (trip currents) the ECPM's various circuits and the length of time required for a disconnection of power at multiples of these trip currents. The interesting results of the Over Current Tests was the effect the test temperature had on the trip currents of the ECPM's over current protection circuitry. Figure 5 illustrates this by graphing the data from Table 5. The 80 degree C temperature swing between the high and low test temperatures caused the trip point to increase by 20 amps or more for the two 120 volt (X-W and Y-W) circuits of the ECPM's NEMA 14-50 receptacle. All the trip points are rather high considering that the NEMA 5-20 is rated at 20 amps continuous and the NEMA 14-50 is rated at 50 amps continuous.

The trip times of the ECPM's over current circuitry showed no significant dependence upon the test temperature.

The over-current tests in which both receptacles supplied current to loads at the same time (see Table 9) also illustrate the effect of test temperature on over-current trip point. While both receptacles would not be utilized at the same time in the intended use of the ECPM, it was possible (as the test results show) to receive power from both at the same time. In this situation, the over-current circuitry operated as expected in limiting the total current at all three test temperatures.

Ground Fault Interruption Tests

The trip current of the ground fault circuit interruption was within 0.1 mA of 3.7 mA at all three test temperatures (see Table 10). The specifications of the ECPM given in Appendix A, Page V, indicate that the ECPM's GFI is to trip at a current less than 6 mA. The 3.7 mA trip current is within this specification. The average trip times of the GFI were not significantly effected by test temperature. Figure 6 illustrates the three sets of average trip times listed in Table 11. This plot shows that the trip times decrease rapidly during the first four ground-fault tests, and then level off through the remaining tests.

Figure 5. Electric Charge Point Meter currents-versus-temperature.

Figure 6. Average ground-fault interruption trip times.

Underwriters Laboratory (UL) tests were not performed at the INEL Battery Laboratory (due to time and financial limitations), and no conclusions were drawn about the ability of the EDD-7 ECPM meeting the requirements of the UL Standards (Reference 2). Discussions with EHV Corp. indicated that UL will be testing an EDD-7 ECPM for certification/approval. Modifications to the EHV electronics were being made to ensure the product would meet or exceed all UL requirements.

CONCLUSION

The ECPM is a modified parking meter that allows the purchase of 120 or 240 volt electric power. The ECPM is designed to make electricity available at any vehicle parking location. The test results indicate that the ECPM operated without failure through a series of over current and ground fault tests at three different test temperatures. The magnitude of current required to trip the over current protection circuitry varied with temperature while the performance of the ground fault interruption circuitry did not change significantly with the test temperature.

Tests were performed on the Meter to determine if the ECPM's timer allowed for the approximately 6 second delay between the time money is inserted into the meter and power is available at the meter's two receptacles. A U.S. nickel should give 180 seconds of electricity and the U.S. dime should give 360 seconds of electricity according to the claim on the ECPM's head. The results show that the short delay is included in the amount of time purchased with each respective coin. Changing the test temperature had no noticeable effect on the timing circuitry.

Receptacle Cover and Timer Knob Tests were conducted to determine if the ECPM would disconnect power to its receptacles under various load conditions when the receptacle cover or timer knob was disturbed. The ECPM disconnected the power as expected in all the tests. The length of the delay before the power was again available at the receptacle varied from test to test. The delays were either approximately 5.5 seconds or 11 seconds, indicating that occasionally the ECPM's self evaluation circuitry runs through its algorithm twice before the power is returned to the receptacles. Assuming that the higher delay times (between 10 and 12 seconds) represent the ECPM running through its self evaluation algorithm twice, the calculated average time of a single self evaluation is 5.55 seconds.

The reason the ECPM occasionally ran through its self-evaluation cycle twice was the result of the unit being reactivated in the latter part of the internal testing cycle. No repeatable pattern of this behavior is seen in the test results because the reactivation occurred randomly. Basically, the ECPM was double checking the situation to assure that power could be safely returned to the receptacles.

The Over Current Tests were intended to determine the magnitude of current needed to trip (trip currents) the ECPM's various circuits and the length of time required for a disconnection of power at multiples of these trip currents. The interesting results of the Over Current Tests was the effect the test temperature had on the trip currents of the ECPM's over current protection circuitry. The 80 degree C temperature swing between the high and low test temperatures caused the trip point to increase by 20 amps or more for the two 120 volt (X-W and Y-W) circuits of the ECPM's NEMA 14-50 receptacle. All the trip points are rather high considering that the NEMA 5-20 is rated at 20 amps continuous and the NEMA 14-50 is rated at 50 amps continuous.

The trip times of the ECPM's over current circuitry showed no significant dependence upon the test temperature.

The over-current tests in which both receptacles supplied current to loads at the same time also illustrate the effect of test temperature on over-current trip point. While both receptacles would not be utilized at the same time in the intended use of the ECPM, it was possible (as the test results show) to receive power from both at the same time. In this situation, the over-current circuitry operated as expected in limiting the total current at all three test temperatures.

The trip current of the ground fault circuit interruption was within 0.1 mA of 3.7 mA at all three test temperatures. The specifications of the ECPM given in Appendix A, Page V, indicate that the ECPM's GFI is to trip at a current less than 6 mA. The 3.7 mA trip current is within this specification. The average trip times of the GFI were not significantly effected by test temperature. The data indicates that the trip times decrease rapidly during the first four ground-fault tests, and then level off through the remaining tests.

Underwriters Laboratory (UL) tests were not performed at the INEL Battery Laboratory and no conclusions were drawn about the ability of the EDD-7 ECPM meeting the requirements of the UL Standards (Reference 2). Discussions with EHV Corp. indicated that UL will be testing an EDD-7 ECPM for certification/approval. Modifications to the EHV electronics were being made to ensure the product would meet or exceed all UL requirements.

The principal results and conclusions of the tests are as follows:

1. The ECPM's basic safety features operated without failure for all tests.
2. The trip point of the over current protection circuitry varied with the test temperature.
3. Test temperature had no significant effect on the trip times of the over current circuitry.
4. The trip point of the ECPM's ground fault interruption circuitry was $3.7 \text{ mA} \pm 0.1 \text{ mA}$ for all three test temperatures.

REFERENCES

1. Electric and Hybrid Vehicle Program Test Plan for Testing of the EDD-7 Electric Charge Point Meter.
2. Underwriters Laboratory, Inc., "UL Standard 943 for Safety Ground-Fault Circuit (Interrupters), Second Edition, 1985.

APPENDIX A

ELECTRIC CHARGE POINT METER MANUAL

EDD-7

ELECTRIC CHARGE POINT METER

EDD-7
ELECTRIC CHARGE POINT METER

This manual is provided to

EG&G Idaho
765 Lindsay Avenue
Idaho Falls, Idaho 83415-1650

in partial fulfillment of
U.S. D.O.E. Order Number
C 92 630714

by

EHV
Suite 105
1640 Fairchild Ave
Manhattan, Kansas 66502
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Scope of this Manual

This document provides information on how to install and operate the EDD-7 charge point meter manufactured by the EHV Corporation.

It is not intended to be used as a repair manual. Should the need for repair occur, contact:

EHV
Suite 105
1640 Fairchild Ave
Manhattan, Kansas 66502
VOX: 913-537-4850
FAX: 913-537-0179

Introduction

The EDD-7 charge point meter is intended to be installed in an environment as might be encountered in parking garages and curbside locations. Its intended use is as a source of electricity to recharge the batteries in electric vehicles. A coin operated timer connects the receptacle(s) to the power service for a period dependent upon the value of the coin, the number of coins and the time-per-value programmed into the timer.

The EDD-7 requires a single phase 120/240 Volt 50/60 Hz power source. Since the EDD-7 operates as a smart switch, the Voltage characteristics at the receptacles is equal to that supplied. Depending on the receptacles provided, units which can switch currents up to 100 Amperes are available.

Safety features include Ground Fault Interruption, over-current protection, and a design which precludes insertion and removal of connectors with power applied.

Options include a debit-card system for activating the meter and several connector/receptacle arrangements.

The remainder of this manual will address the prototype unit manufactured by EHV for the Department of Energy and shipped to EG&G Idaho.

Specifications

Appearance

Shape: See Figure 1
Color: Jaguar green

Connections

Output: #1: NEMA 5-20 / 115 VAC
#2: NEMA 14-50 / 115-0-115
Input: Screw operated box terminals

Voltages (Input/Output)

Magnitudes: 115-0-115VAC
Frequency: 50/60Hz
Shape: Sine
Distortion: None added

Current (Input/Output)

Maximum: NEMA 5-20: >20 Amperes
NEMA 14-50: >60 Amperes
Shape: Determined by load
Distortion: None added at receptacles
Standby: Less than 20 milliAmperes
Charging: Less than 35 milliAmperes added to Load
GFCI: Class A, less than 6 milliAmperes
Leakage: Less than 1 milliAmpere 115V terminals to any other terminal when output is off.

Control Head Display:

7-segment, 4 character Liquid Crystal, indicating time remaining and other information, protected by clear plastic bezel
Currency: U.S. nickel, dime, quarter
Rates: Programmable with programming fixture
Vault: Holds accepted coins, unlocks with key, coins held in removable container
Retention: Secured to Power Unit with access to mounting fixture only through same and locked Vault area.

Power Unit

Receptacle(s): #1: NEMA 5-20 / 115 VAC
#2: NEMA 14-50 / 115-0-115
Access: Through front door, secured by screws. Required only for installation and repair.
Retention: Lock screw through support pipe. Screw accessible only through Access door.
Connections: Four wires (115-0-115, case) through center of support pipe.

Environmental

Temperature: -40F to 160F, -40C to 70C
Light: Not dependent upon light for operation, nor damaged by direct sunlight

Life Expectancy Switching:

200,000 on/off cycles at full load

Characteristics of the EDD-7 Evaluation Unit

The Evaluation Unit (EU) has been supplied with standard National Electrical Manufacturer's Association (NEMA) receptacles, styles NEMA 5-20 and 14-50. Two angle plug which will mate with these receptacle have also been provided, although these would normally be supplied by the user and attached to his vehicle.

The EU is shown in Figures 1 and 2, from the left side and from the front, mounted upon a support pipe and disk suitable for use in a laboratory setting. Figure 1 depicts the EU with the vehicle's power cord attached to the receptacle and the connector cover closed. Figure 2 contains similar views with the connector cover open. The 50 Ampere plug is shown. The 20 Ampere receptacle is almost covered by the large plug, but may be partially seen just below and behind the cord and installed plug.

The timer unit is activated by placing coins (U.S. 5, 10, and/or 25 cent pieces) in the appropriate slots provided and rotating the knob clockwise and releasing. The knob is directly below the time display at the top of the EU.

Since this unit is a pre-production unit used to investigate potential production problems and options, there are some differences between it and a production model. A partial, although possibly not complete list of these differences follow:

- A. The power electronics is enclosed in a steel case fabricated by welding and machining. Production units will use a non-ferrous case manufactured by casting.
- B. The power unit's door is retained by ordinary slotted (straight-blade) screws rather than the tamper-resistant screws used on production units.
- C. The battery "charger" circuitry which allows the timer's internal battery to last for years is not connected.
- D. Certain environmental hardening items, such as water management gaskets have been omitted.
- E. Some of the warning and information labels have not been applied.

Figure 1 Complete electric charge point unit shown supported by test stand with vehicle cord in place and connector cover closed.

Figure 2 Electric charge point unit shown on test stand with 50 Ampere vehicle charge cord in place and connector cover open.

In addition to the differences listed above, certain internal differences also are present. These include:

- F. Certain plug-connector components will be replaced by hard-soldered connections.
- G. The relationship between the length of time an overcurrent of a given magnitude will be allowed without shut-down occurring may yet be modified.
- H. Some hardware, both internal and external retained with screws and nuts will be secured with more permanent methods such as rivets.
- I. A flange which prevents the support pipe from passing into the power enclosure when the retaining screw is removed will be added.

Set-Up

Support Coupling

Refer to Figure 3. After unpacking both the base and the EU, place the EU vertically on its base so as to mate the support pipe with the threaded coupling in the base. The EU may then be rotated such that the right-hand threads engage between the two components. Continue to tighten until the junction is tight. Use only unassisted hand torque, being careful to avoid damaging the threads in either part when the threads first start to mate.

Alternately, the EU can be placed on its back on a surface such as a table with the support pipe end projecting over the table's edge. Then the support base can be placed against the support pipe's threaded end and the base "spun" into place.

CAUTION: Do NOT at anytime support the unit by the timer head portion of the EU. Doing so may crack the castings.

Electrical Connections

The only tools required to connect the meter after the service wires have been prepared is a single straight-blade screwdriver of blade width as large as possible, but not exceeding .3 inch.

NOTE: If the receptacle cover wire which keeps the cover from swinging free has been removed, please install a light cord or wire through the lock holes. This keeps the cover from swinging freely in the following steps.

Referring to Figure 4, remove the 8 screws identified. These hold the power electronics into the enclosure. Care should be exercised as the last removal is being made to assure that the power electronics assembly does not fall forward and out of the unit.

After all 8 screws have been removed, tilt the power electronics unit forward as shown in Figure 5. The timer control cord will be attached to the power electronics unit. It should be disconnected. There are two connectors that must be disengaged. One is located at the bottom of the exposed printed circuit board and the other is located against the back of the panel near the top. Both connectors have a button/lever which when depressed allows easy removal of the receptacle from the plug.

NOTE: notice the positioning of the wire which runs between the two connectors so that it may be re-installed similarly later.

After the connectors have been disengaged, set the panel and cover unit with its associated power electronics aside.

Figure 3 To assemble meter on support base, locate threaded end over threaded coupling in base and rotate meter until right-hand threaded joint is tight.

Figure 4 To connect service feed, the front panel must be removed. Remove the 8 marked screws, being careful to restrain the panel from falling away from the meter body as the last screw is extracted. See Figure 5.

Figure 5 As the panel is pulled from the enclosure, release the two plugs at the points shown. Both have a push-down lever to disengage the lock. Note location of smaller wire and plug so it may be positioned similarly during assembly.

The EU requires four service wires. One of these will be the "case ground", another the neutral, and the remaining two are the 120 Volt legs which have 240 Volts between them. Wire gauge and insulation materials suitable for the load currents should be used. Stranded wire will greatly aid in the connection process as the increased flexibility makes the process much easier.

See Figure 6. The four wires should be pushed into the enclosure from the support base until they can be pulled through the enclosure panel hole, allowing 6 to 8 inches extra. They should be routed out of the notch in the support base.

Each of the four wires should be stripped so that 1/2 inch of conductor is exposed.

Referring to Figure 7, the four wires will be connected as shown with the corresponding retaining screws identified as #1 through #4. Screws #2 through #4 should be turned counter clockwise such that the contactor's cable insertion cavities are sufficiently clear for the wires chosen.

Connection of the case ground should be made first. Holding the power electronics unit near the enclosure opening and the protruding wires, release screw #1 until the case ground wire can be inserted into the terminal. Tighten terminal #1.

Connect the remaining three conductors, positioning the neutral in the center contactor conductor cavity. Tighten the related screws.

This next step may require some patience, depending upon the wires selected to supply power and their flexibility. The power electronics panel should be returned to the position shown in Figure 5 and the timer control cable re-connected with the smaller wire repositioned to its pre-disconnection state.

Figure 6 Feed the four service connections through the support pipe from the support base so that they emerge through the enclosure opening as shown. The wire disconnected in Figure 5 is NOT shown. The service wires should pass through the notch in the support base.

Figure 7 Connection of service feed to meter. Connection #1 should be made first to avoid conflict with the wires terminating on the contactor. #2, #3, and #4 on the contactor poles may be made in any convenient order. Note that only a small part of the enclosure body is shown.

Then the wired panel is worked back into the enclosure opening. This is best done by starting with the panel somewhat high and slowly lowering it to force the service wires down into the pipe. The wires could also be pulled slightly from the support base.

Once the panel is in place, the 8 retaining screws should be started into their respective threads. After all 8 are started, they may be tightened. Because of the close fit, it is advisable to work all 8 screws together rather than tightening one fully, then the next, etc.

Installation is now complete.

Operation

Initial Testing

When the EU is received and with no AC power supplied, the timer unit battery should cause the time display to be 00:00 and the panel on the reverse side should alternate between gray/silver and red. If this is not the case, either the timer battery is exhausted or the timer needs to be reset. The latter usually is required only when the battery has been changed. Instructions on battery replacement may be found in the "Timer Battery Failure" section.

1. With the timing unit operating, rotate the timer knob clockwise. The display should show: ----.
2. Release the timer knob and insert a nickel into the 5 cent slot. Then rotate the timer knob as far clockwise as it will go and release it. The display must show 00:03, indicating 03 minutes and 00 hours. The display on the reverse side should now show only gray/silver.
3. As the minutes pass, the display should change to 00:02, then 00:01 and then return to 00:00. When the latter display occurs, the rear panel should again alternate between gray/silver and red.
4. Apply AC power to the meter. The green Light Emitting Diode (LED) must light, indicating that power is available. The red LED next to METER FAIL must first show a steady output, then begin to blink, and finally extinguish.
5. Repeat step 2 above. After approximately 6 seconds the red POWER LED should light and the contactor must be heard to close.
6. Before 3 minutes pass and time expires, rotate the timer knob again, but without any money in a slot. The contactor should be heard to release and the POWER LED should extinguish.
7. Release the timer knob and approximately 6 seconds after the remaining time is displayed the POWER LED must again light and the contactor again heard to close.
8. If time has expired, insert another coin, rotate the timer knob and release so that at least a full minute remains on the meter before the next test step.
9. With the POWER LED lit, open the receptacle cover, removing any restraining materials in the lock holes. The POWER LED should immediately extinguish and the contactor heard to release.
10. Close the cover and after approximately 6 seconds POWER should again light and the contactor heard to pull in.

11. Wait until the time returns to 00:00 and the POWER LED should extinguish and the contactor heard to release.

Use

If all the preceding tests have passed, the unit should be ready to use.

Theory of Operation

The EDD-7 is, fundamentally, a "smart" switch controlled by a timer. The switch connects the receptacles to the service power mains which enter the unit through the support pole.

The timer accepts the U.S. coins nickel, dime and quarter. After inserting the coin(s) in the appropriate slot(s) and cycling the meter knob, the timer directs the power electronics contained in the lower portion of the unit to close the contactor and supply Voltage to the receptacles. This command remains for a period of time that is directly proportional to the total value of the coins inserted and the pre-programmed currency value-to-time constant programmed in the meter. The supplied meter has a constant of 36 seconds per cent or 3 minutes per nickel.

The "smart" nature of the EDD-7 relates to its safety features. Although the timer unit may direct the contactor to close, a number of conditions must be met before closure will occur.

First and foremost is the need for the Voltage to be applied, for it is the service main Voltage that is used to activate the contactor.

Once service Voltage is present, whether the timer requests contact closure or not, the power electronics unit commences a self-test mode. In this state 4 tests are performed and all must be passed before contact closure would be possible. The first test passes a small current through the Ground Fault Interruption (GFI) coil and a check is performed to see that the GFI circuitry reacts as if a GFI fault had taken place. (More details on the GFI may be found later in this section.)

Next a small current is supplied to the over-current sensing circuitry that monitors the smaller receptacle and one leg of the high current receptacle. Again, the fault detecting circuitry output is monitored to assure that an apparent fault was detected.

Third, over-current sensing circuitry that monitors the remaining high Voltage leg of the high current receptacle is tested in a fashion identical to the previous test.

Finally, the Voltage level at the contactor output is checked. This should be zero unless the contactor or its control circuitry failed or power is being supplied externally to the receptacles. If the contactor is closed due to a failure, whether electrical or mechanical, the EDD-7 has no way of forcing the receptacle Voltage to zero. However, as indicated below, the failure will be notified to the user.

The four tests just described are separated by brief periods when no tests are performed. The test evaluation circuitry internal to the EDD-7 requires that four "errors" are shown as a consequence of the tests and that those "errors" are separated by the absence of any error condition. If, after the tests are all completed, the error counter indicates exactly four error conditions had been detected, the "METER FAIL" device is set in the no-failure mode. If more or less than four failure events were detected, the same unit is set to the failure condition.

If the failure mode had been set, the circuitry that enables the contactor drive is blocked, thereby not allowing a request to activate the contactor to reach the contactor coil. Additionally, the METER FAIL LED on the timer face is made to blink to alert the user, or potential user, that the meter has failed internally. When power is first applied or when it is re-applied, the failure mode is always set to assure that the meter circuitry is tested whenever the timer is requesting contactor closure.

Two additional conditions must be met, even if all the tests pass, before contactor closure will be allowed if the timer is requesting closure. The first is that the receptacle cover must be closed. In fact, any time the cover is open, contactor control Voltage is removed. This assures that connection plugs will never be inserted into a receptacle or removed from a receptacle with Voltage available.

The final condition which must be met for contactor closure is concerned with available Voltage to operate the EDD-7. Whenever the internal Voltage supply begins to fail, the meter-fail mode is forced to occur, which will cause the contactor to release.

As supplied, the EDD-7 EU has two receptacle: a NEMA 5-20 20 Ampere unit and a NEMA 14-50 50 Ampere unit. The two receptacles are placed in close proximity to each other, making it difficult to use both simultaneously. Simultaneous use will reduce the maximum currents available from each.

All load currents are intended, following standard electrical practice, to flow between the small flat blade and the larger blade terminal on the NEMA 5-20. On the NEMA 14-50, currents are expected to flow between any of the flat blades such that the Kirchhoff sum of those currents is zero at any time.

Any currents flowing through one of the blades, but without a corresponding reverse direction current flowing through another is not allowed. The most likely source of currents that do not satisfy this condition would be improperly operating equipment.

Whenever the current condition stated above is no longer satisfied and the size of the unbalance reaches approximately 6 milliAmperes, the GFI circuitry internal to the EU forces the contactor to be released, disconnecting all supplied power. Such an event also triggers the VEHICLE FAIL LED into blinking. This alerts a user that something in the vehicle has probably failed.

Similarly, attempts to draw more current from a given receptacle than it is rated for will cause an identical failure warning.

VEHICLE FAIL warnings are cleared whenever the cover is opened, the timer knob rotated or after the interruption of electrical power to the meter.

Although the NEMA 14-50 is "rated" at 50 Amperes, this rating is an assigned value and a receptacle with identical contact materials, but a different orientation to one blade has an assigned rating of 60 Amperes. The EU has been designed to handle 60 Amperes at the larger receptacle. The 14-50 was installed only because plugs are readily available for it.

When the EDD-7 is field installed, exposure to pranksters is unavoidable. There is an approximately 6 second delay in re-activating the contactor after turning the timer knob or raising the connector cover. This prevents unrestricted cycling of the contactor under potentially heavy loads and helps to extend meter life. It also may prevent a failure in external charging circuitry that handles high powers.

Furthermore, there are locking holes at the lower right-hand corner of the cover which will allow the user to insert a small personal lock and prevent the undesired removal of the plug of a charging vehicle.

Funds Collection

Coins collected by the meter are deposited in the coin vault immediately below the timer unit. Access to the coins is achieved using the supplied key in the lock located in the vault door. Inserting the key and rotating clockwise 90 degrees allows the door to drop forward against the retaining straps. The collection cup may then be removed and emptied. The process is reversed to re-install the coin collection parts.

Timer Battery Failure

The timer unit is powered from a 9 Volt alkaline battery. This battery will allow the timer to "remember" how much charge time remains after service power interruptions.

In production units a small charging circuit will effectively make the battery "float", thereby achieving a very long life. But the EU does NOT have the circuit activated and battery replacement may be required.

Battery replacement may be indicated by an absent time display or failure of any of the tests outlined in the initial test section.

To replace the battery, the timer protective cover is first removed. Insert the supplied key into the lock on the EU rear. Rotating the key about 45 degrees counter clockwise will allow the head cover to be slid to the left as viewed from the back and then pulled upward. Figure 8 shows head cover removal.

The timing head may be raised up a short distance and the cover for the 9 Volt battery removed. The location is shown in Figure 9.

If the timer cable will not allow the timer to be raised adequately, the cable will have to be disconnected. This may only be accomplished by opening the power electronics enclosure as shown in Figures 4 and 5, and disconnecting the large connector from the printed circuit board near the contactor. This will allow enough slack that the timer head may be raised sufficiently.

CAUTION: Remove AC power to the meter before opening the power electronics enclosure. Dangerous Voltages are present in the enclosure and disconnecting the timer head connector with power applied may damage circuitry.

After installing a new battery, and returning the timer head to its original position, perform the "Initial Testing" procedure up through Step 3. If the test steps do not pass, the timer may need to be reset. On the timer head front just below the metal plate listing the time-per-coin information, on the left edge of the face is a small black button. To reset the meter, depress the button for one second and then release it. After about 6 seconds during which some time information is displayed, normal operation should resume.

Re-assemble the EU by reversing the previous disassembly steps.

Figure 8 Access to the meter battery must be gained through the head. The key is inserted in the slot and rotated approximately 45 degrees and held. The display cover is then slid to the left and then upward, exposing the meter timer unit. The key may then be released and removed.

Figure 9 Details of the timer unit, indicating the location of the 9 Volt battery which powers the timer electronics.

APPENDIX B

MANUFACTURER'S DATA

ABB Line
Open Type w/Class 10 OLR

Horsepower & Voltage
[Maximum UL/CSA Ratings]

MOTOR HORSEPOWER				COMPLETE STARTER ¹⁾		STARTER COMPONENTS			
3-PHASE, 1800 RPM				CATALOG NUMBER	LIST PRICE	CONTACTORS ²⁾		OVERLOAD RELAYS ³⁾	
200V	230V	480V	575V			CATALOG NUMBER	LIST PRICE	CATALOG NUMBER	LIST PRICE
—	—	—	1/4	B9S-1C	\$ 104	B9C-1	\$ 52	T25DU0.4 (25-4)	\$ 42
—	—	1/4, 1/3	1/3	B9S-1D				T25DU0.63 (4-63)	
—	1/4	1/2	1/2	B9S-1E				T25DU1.0 (65-1)	
1/4, 1/3	1/3	3/4	3/4	B9S-1F				T25DU1.4 (1-1.4)	
—	1/2	—	1	B9S-1G				T25DU1.8 (1.3-1.8)	
1/2	—	1	1.5	B9S-1H				T25DU2.4 (1.7-2.4)	
3/4	3/4	1.5	2	B9S-1J				T25DU3.1 (2.2-3.1)	
—	1	2	—	B9S-1K				T25DU4.0 (2.8-4)	
1	—	—	3	B9S-1L				T25DU5.0 (3.5-4)	
1.5	1.5	3	5	B9S-1M				T25DU6.5 (4.5-6.5)	
2	2	5	—	B9S-1N				T25DU8.5 (6-8.5)	
—	—	—	7.5	B9S-1P				T25DU11 (7.5-11)	
3	3	7.5	10	B12S-1P	108	B12C-1	56	T25DU11 (7.5-11)	68
5	5	10	15	B16S-1R	120	B16C-1	68	T25DU19 (13-19)	
—	7.5	15	20	B25S-1S	166	B25C-1	122	T25DU25 (18-25)	
7.5	10	20	25	B25S-1T				T25DU32 (24-32)	
10	—	—	30	B30S-1T	210	B30C-1	168	T25DU32 (24-32)	
15	15	25, 30	40	B50S-1C	288	B50C-1	220	T75DU42 (29-42)	
—	—	40	50	B50S-1D				T75DU52 (36-52)	
20	20	50	—	B63S-1E	316	B63C-1	248	T75DU63 (45-63)	
—	25	—	—	B63S-1F				T75DU80 (60-80)	
—	—	—	60	B75S-1E	368	B75C-1	275	T75DU63 (45-63)	
25	30	60	—	B75S-1F				T75DU80 (60-80)	
—	—	—	75	EH110S-1A	510	EH110C-1	320	T135DU90 (65-90)	110
30	40	75	100	EH110S-1B				T135110 (80-110)	
40	50	100	125	EH145S-1A	875	EH145C-1	600	T200DU135 (100-135)	150
50	60	125	150	EH160S-1B	1070	EH160C-1	920	T200DU150 (110-150)	
60	75	150	200	EH170S-1D	1300	EH170C-1	1150	T200DU200 (150-200)	
75	100	200	250	EH250S-1J	1796	EH250C-1	1300	T25J-CT5 (172-252)	496
100	—	250	300	EH270S-1K	1925	EH270C-1	1400	T25K-CT5.5 (220-320)	525
125	125, 150	300	400	EH450S-1L	2324	EH450C-1	1700	T25L-CT6 (284-407)	624
150	200	400	500	EH550S-1M	3724	EH550C-1	3100	T25M-CT6 (342-520)	
200	250	500	600	EH700S-1M	5564	EH700C-1	4800	T25M-CT6.5 (516-780)	764
250	300	600	700	EH800S-1M	5764	EH800C-1	5000	T25M-CT7 (645-975)	

* The overload relays for EH450 - EH800 starters include an interposing control relay for contactor operation. To select desired coil voltage for this relay, substitute the * in the catalog number with the desired coil suffix code found in the Coil Voltage Selection chart.

CAUTION: The above ratings are based on average motor FLA. Actual FLA on the motor nameplate should be used for overload relay setting.

- (1) All catalog numbers include a 120V coil. To select other coil voltages, substitute the code from the Coil Voltage Selection chart for the first digit after the dash in the catalog number.
 (2) For motors with RPM greater or less than 1800 RPM, check full load amp rating on motor nameplate to ensure proper overload protection.

COIL VOLTAGE SELECTION CHART

Hz	VOLTS											
	12	24	48	110	120	125	208	220	240	277	380	440
60	F	G		1		B		2	C		3	4
50	N			1				J			3	
DC	U	Y	W	P		Q		R			T	

- NOTES:
 (1) For other voltages, consult factory.
 (2) 24VAC coils are not available for sizes EH450 - EH800.
 48VAC coils are not available for sizes EH450 - EH800.
 For these 24 & 48V applications, use an interposing control relay.
 (3) 12VDC coils are not available for EH450 - EH800.
 (4) DC coils not available for B12

3 Pole AC & DC Operated

3 POLE, A.C., Open

THERMAL CURRENT	MAXIMUM MOTOR HORSEPOWER RATINGS				AC OPERATED		DC OPERATED	
	200V	230V	480V	575V	CATALOG NUMBER	LIST PRICE	CATALOG NUMBER	LIST PRICE
21	2	2	5	7.5	B9C-1	\$ 52	BC9C-P	\$ 82
21	3	3	7.5	10	B12C-1	56	—	—
21	5	5	10	15	B16C-1	68	BC16C-P	98
33	7.5	10	20	25	B25C-1	122	BC25C-P	152
45	10	10	20	30	B30C-1	168	BC30C-P	198
65	15	15	40	50	B50C-1	220	BE50C-P	250
85	20	25	50	50	B63C-1	248	BE63C-P	318
105	25	30	60	60	B75C-1	275	BE75C-P	345
125	25	30	60	60	EH80C-1	300	EH80C-P	370
150	30	40	75	100	EH110C-1	320	EH110C-P	460
170	40	50	100	125	EH145C-1	600	EH145C-P	740
190	50	60	125	150	EH160C-1	920	EH160C-P	1090
230	60	75	150	200	EH170C-1	1150	EH170C-P	1320
300	75	100	200	250	EH250C-1	1300	EH250C-P	1490
350	100	100	250	250	EH270C-1	1400	EH270C-P	1590
525	125	150	350	400	EH450C-1	2200	EH450C-P	2440
600	150	200	400	500	EH550C-1	3100	EH550C-P	3430
715	200	250	500	600	EH700C-1	4800	EH700C-P	5130
900	250	300	600	700	EH800C-1	5000	EH800C-P	5330

COIL VOLTAGE SELECTION

All AC operated catalog numbers include a 120VAC coil. All DC operated catalog numbers include a 110VDC coil. To select other coil voltages, substitute the code from the Coil Voltage Selection chart for the first digit after the dash in the catalog number.

COIL VOLTAGE SELECTION CHART

Hz	VOLTS															
	12	24	48	110	120	125	208	220	240	277	380	440	480	500	600	
60		F	G		1		B		2	C		3	4		6	
50		N		1				J			3			5		
DC	U	Y	W	P		Q		R				T				

- NOTES: (1) For other voltages, consult factory.
 (2) 24VAC coils are not available for sizes EH450-EH800
 48VAC coils are not available for sizes EH450-EH800
 For these 24 & 48V applications, use an interposing control relay
 (3) 12VDC coils are not available for EH450-EH800
 (4) DC coils not available for B12

AUXILIARY CONTACTS AS STANDARD

TYPE	NUMBER OF CONTACTS
B9 - B25 (1)	1 N.O.
B30	2 N.O. & 2 N.C.
B50 - EH800	1 N.O. & 1 N.C.

Additional auxiliary contacts are available for all contactor sizes. See Accessories.

(1) B9 - B25 contactors can be supplied with 1 N.C. auxiliary contact as standard. Add suffix "01" after the coil voltage suffix. Price is the same.

	B9	B12	B16	B25	B30	B50	B63	B75
A.C. Rating Information								
NEMA Size	00	—	0	1	1P	2	—	3
NEMA cont. amp rating (thermal current)	9	—	18	27	36	45	—	90
NEMA maximum H.P. ratings (1 Phase)								
115VAC	1/3	—	1	2	3	3	—	—
230VAC	1	—	2	3	5	7.5	—	—
NEMA maximum H.P. ratings (3 Phase)								
200VAC	1.5	—	3	7.5	—	10	—	25
230VAC	1.5	—	3	7.5	—	15	—	30
480/575VAC	2	—	5	10	—	25	—	50
U.L. General Purpose Current (Thermal)	21	21	21	33	45	65	85	105
U.L. Max 3 Ph. Switching Motor Loads (AC3), Amps	9	11	17	28	32	52	65	80
U.L. maximum H.P. ratings (1 Phase)								
115 VAC	0.5	1	1.5	2	3	3	5	7.5
230 VAC	1	2	3	3	5	7.5	10	15
U.L. maximum H.P. ratings (3 Phase)								
200 - 208 VAC	2	3	5	7.5	10	15	20	25
220 - 240 VAC	2	3	5	10	10	15	25	30
440 - 480 VAC	5	7.5	10	20	20	40	50	60
550 - 600 VAC	7.5	10	15	25	30	50	50	60
Making capacity 600 VAC, (Amps)	300	300	300	350	400	600	800	800
Breaking capacity, 240 VAC (Amps)	200	200	200	315	380	720	720	720
Breaking capacity, 600 VAC (Amps)	120	120	120	210	290	600	600	600
Lighting Ballast and Incand., 600 VAC	—	15	—	—	30	60	75	85
Resistive Heating Applications, 600 VAC	—	15	—	—	30	60	75	85
D.C. Rating Information								
Maximum continuous amp ratings								
110VDC Resistive	9	12	16	25	30	50	60	70
240VDC Resistive	6	12	14	15	20	30	40	55
600VDC Resistive	—	—	—	—	—	—	—	—
2 contacts in series, 110VDC, inductive	9	12	16	25	30	50	60	70
3 contacts in series, 110VDC, inductive	9	12	16	25	30	50	60	70
2 contacts in series, 240VDC, inductive	6	12	14	15	20	38	47	56
3 contacts in series, 240VDC, inductive	9	12	16	25	30	50	60	70
3 contacts in series, 600VDC, inductive	—	—	—	—	—	—	—	—
Maximum H.P. ratings, 2 contacts in series								
110VDC	1	1	1.5	3	3	5	7.5	7.5
240VDC	1	2	3	3	5	10	12.5	15
600VDC	—	—	—	—	—	—	—	—
Maximum H.P. ratings, 3 contacts in series								
110VDC	1	1	1.5	3	3	5	7.5	7.5
240VDC	2	2	3	5	7.5	12.5	15	15
600VDC	—	—	—	—	—	—	—	—
Coil Operating Data								
A.C. power consumption								
Inrush 60 Hz, VA	80	80	80	100	100	200	200	200
Holding 60 Hz, VA	10	10	10	11	11	20	20	20
Holding 60 Hz, W	2.4	2.4	2.4	3.3	3.3	5.5	5.5	5.5
D.C. power consumption								
Inrush, cold, W	7	—	7	7	7	200	200	200
Holding, warm, W	7	—	7	7	7	4	4	4
A.C. operating time, ms (milliseconds)								
Closing time, ms	9 - 17	9 - 17	9 - 17	10 - 20	10 - 20	20 - 25	20 - 25	20 - 25
Opening time, ms	5 - 13	5 - 13	5 - 13	5 - 15	5 - 15	10 - 15	10 - 15	10 - 15
D.C. operating time, ms (milliseconds)								
Closing time, ms	50 - 75	—	50 - 75	50 - 75	50 - 75	40 - 49	40 - 49	40 - 49
Opening time, ms	15 - 30	—	15 - 30	15 - 30	15 - 30	16 - 20	16 - 20	16 - 20
Auxiliary Contacts								
NEMA Rating, AC	A600	A600	A600	A600	A600	A600	A600	A600
AC rated voltage, VAC	600	600	600	600	600	600	600	600
AC thermal rated current, (Amps)	10	10	10	10	10	10	10	10
AC maximum volt-ampere making, VA	7200	7200	7200	7200	7200	7200	7200	7200
AC maximum volt-ampere breaking, VA	720	720	720	720	720	720	720	720
NEMA Rating, DC	P600	P600	P600	P600	P600	P600	P600	P600
DC rated voltage, VDC	600	600	600	600	600	600	600	600
DC thermal rated current, Amps	5	5	5	5	5	5	5	5
DC Maximum make-break, Amps	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

B Contactors & Starters

Technical Data

	B9	B12	B16	B25	B30	B50	B63	B75
General Data								
Approximate weight, lbs.	0.7	0.7	0.7	1.01	1.2	2.25	2.25	2.25
Contactor	1.04	1.04	1.04	1.35	1.54	3	3	3
Starter								
Temperature limits								
Maximum at full load, thermal current	50° C	50° C	50° C	50° C	50° C	50° C	50° C	50° C
Maximum operating temperature	70° C	70° C	70° C	70° C	70° C	70° C	70° C	70° C
Minimum operating temperature	-25° C	-25° C	-25° C	-25° C	-25° C	-25° C	-25° C	-25° C
Minimum storage temperature	-40° C	-40° C	-40° C	-40° C	-40° C	-40° C	-40° C	-40° C
Contactor life								
Mechanical endurance (mil.)	10	10	10	10	10	10	10	10
Electrical endurance (mil.)	0.4	>1	>1	>1	>1	>1	>1	>1
Frequency of operations per hour								
Maximum (mechanical switching)	6000	6000	6000	3000	3000	3000	3000	3000
At full load (electrical switching)	1200	1200	1200	1200	1200	1200	1200	1200
Plugging, inching, or jogging	300	300	300	300	300	300	300	300
Wire range, AWG	14 - 10	14 - 10	14 - 10	14 - 8	14 - 8	10 - 1/0	10 - 1/0	10 - 1/0
Number of wires per phase	2	2	2	2	2	1	1	1
Maximum Short Circuit Ratings								
MCP, Amps/kA @ 480 VAC	25/18	25/18	25/18	25/18	50/18	100/18	100/18	100/18
MCCB, Amps/kA @ 480 VAC	50/35	50/35	50/35	50/35	70/35	100/35	100/35	100/35
Fuse, Amps-Type/kA, 600 VAC	35J/50	35J/50	360J/50	35J/50	100J/50	200J/50	200J/50	200J/50
Approximate Outline Dimensions								
Contactor								
Width	1.73	1.73	1.73	2.12	2.75	3.23	3.23	3.23
Height	2.72	2.72	2.72	3.19	3.54	4.33	4.33	4.33
Depth (with A.C. coil)	3.22	3.22	3.22	3.43	4.53	4.21	4.21	4.21
Depth (with D.C. coil)	4.49	4.49	4.49	4.72	5.75	4.21	4.21	4.21
Starter								
Width	1.73	1.73	1.73	2.12	2.75	3.23	3.23	3.23
Height	4.92	4.92	4.92	5.40	5.78	6.70	6.70	6.70
Depth	3.83	3.83	3.83	3.83	4.51	4.37	4.37	4.37

B CONTACTORS

00.00 ——— inches
00.00 ——— millimeters

Dimension:

B9, B12, B16

B25

B30

B50, B63, B75

ITEM			CONTACTOR TYPE								
AC operated	Type		B6	B9	B12	B16	B25	B30	B50	B63	B75
DC operated	Type		BC6	BC9	—	BC16	BC25	BC30	BE50	BE63	BE75
Motor output, P_n , AC2, AC3											
3-phase	220-230 V	kW	2.2	2.2	3.0	4	6.5	9	15	18.5	22
50/60 Hz	240 V	kW	2.2	2.2	3.0	4	7.5	9	15	18.5	22
	380 - 400 V	kW	4	4	5.5	7.5	11	15	22	30	37
	415 V	kW	4	4	5.5	7.5	11	15	25	37	40
	500 V	kW	3	4	5.5	7.5	11	15	30	37	45
	600 - 690 V	kW	—	4	5.5	5.5	11	15	30	37	40
	1000 V	kW	—	—	—	—	—	—	—	—	—
Rated current, max. I_n											
AC1 ambient temp. $\leq 40^\circ\text{C}$ ①	A		20	22	24	28	45	55	100	115	125
ambient temp. $\leq 55^\circ\text{C}$ ①	A		16	20	22	25	40	45	85	95	105
ambient temp. $\leq 70^\circ\text{C}$ ①	A		—	17	19	23	32	36	70	80	85
with cable area	mm ²		2.5	2.5	2.5	4	6	6	50	50	50
AC3	220 - 230 V	A	9	9	12	16	25	33	53	65	75
3 - phase	240 V	A	9	9	12	16	25	32	50	65	75
50/60 Hz	380 - 400 V	A	9	9	12	16	25	30	50	65	75
	415 V	A	8.5	9	12	16	25	30	50	65	72
	500 V	A	5.5	7	10	13	17	23	45	55	65
	660 - 690 V	A	—	6	8	8	13	18	35	43	46
	1000 V	A	—	—	—	—	—	—	—	—	—
Short circuit protection fuse											
Type GL, gL or gG	A		20	25	25	32	40	50	80	125	125
for contactor without thermal O/L relay, class 2 acc. to IEC 947-4											
Coil consumption											
AC	Closing 50 Hz	VA	3.5	60	60	60	85	85	175	175	175
	60 Hz	VA	3.5	80	80	80	100	100	200	200	200
	Holding 50 Hz	W/VA	3.5	2.2/9	2.2/9	2.2/9	3/10	3/10	5/20	5/20	5/20
	60 Hz	W/VA	3.5	2.4/10	2.4/10	2.4/10	3.3/11	3.3/11	5.5/20	5.5/20	5.5/20
DC	Closing, cold	W	3.5	7	—	7	7	7	200	200	200
	Holding, warm	W	2.9	7	—	7	7	7	4	4	4
Endurance											
Mechanical	Mil. ops.		10	10	10	10	10	10	10	10	10
Electrical											
I_n , AC3, 380 V	Mil. ops.		0.4	>1	>1	>1	>1	>1	>1	>1	>1
Thermal overload relay			Type	T25DU					T75DU		
Current range			A	0.11-10.5					18 - 80		

LEGEND			
I	Making current, A	U_r	Recovery voltage, V
I_b	Breaking current, A	$P = U_r I_n$	steady state power consumption, W
I_n	Rated current, A	$T_{0.95}$	Time (in ms) to reach 95% of the steady state current (Max 300ms)
U_c	Voltage before making, V		
U_n	Rated voltage, V

① Temperature measured up to the contactor.

IEC

International Ratings

Ratings Current

A contactor can have several different current ratings depending on application.

The rated thermal current is the current which a contactor can withstand without becoming overheated. The temperature of the contactor coil and terminals must not exceed certain limits or damage will occur.

The rated operational current is determined by the capability of the contactor to make and break current under the conditions given in the "Utilization Category" column of the A.C. and D.C. tables on page 86.

Utilization Categories

The rated operational current of a contactor is dependent upon its intended use. The contactor international standards, IEC 158-1, specifies four categories for A.C. contactors (designated AC 1 to AC 4) and five categories for D.C. contactors (designated from DC 1 to DC 5). Furthermore, a differentiation is made between normal conditions of use (on which the endurance is determined) and the abnormal conditions of use (on which the making and breaking capacities are determined).

Rated Voltage

The rated insulation voltage is determined by the insulating material and the clearances of the contactor. The rated insulation voltage of a contactor can

vary according to different standards depending on the different requirements regarding insulation distance.

The rated operational voltage is determined by the breaking capacity of the contactor and cannot exceed the rated insulation voltage.

Short Circuit Protection

Contactors and thermal overload relays are protected against short circuits by incorporating series-connected fuses. In the case of contactors provided with thermal overload relays, the fuse with the lowest rating is selected.

Note that the fuses listed in the tables on pages 84 & 85 are the maximum permissible. In many cases, fuses of lower rating may be more appropriate. The lower limit is determined by the amount of current a fuse must be able to withstand while a motor is starting.

ABB Line and IEC Standards

IEC 947-4-1 is the most recent international standard by which contactors and motor starters are rated. This standard specifies twelve utilization categories for A.C. contactors (designated AC-1 to AC-8b) and four utilization categories for D.C. contactors (designated DC-1, DC-3, DC-5, & DC-6). In addition, the scope of IEC 947-4-1 includes increased ratings to 1000 VAC and 1500 VDC (not previously covered by IEC 158-1). All ABB Line contactors and motor starters meet the requirements of IEC 947-4-1.

ALTERNATING CURRENT

UTILIZATION CATEGORY	TYPICAL APPLICATIONS	NORMAL CONDITIONS OF USE						ABNORMAL CONDITIONS OF USE					
		MAKING			BREAKING			MAKING			BREAKING		
		Current I_i	Voltage U/U_n	Power Factor	Current I_b	Voltage U/U_n	Power Factor	Current I_i	Voltage U/U_n	Power Factor	Current I_b	Voltage U/U_n	Power Factor
AC-1	Non-inductive or slightly inductive loads, resistance furnaces	1	1	0.95	1	1	0.95	1.5	1.1	0.95	1.5	1.1	0.95
AC-2	Slip-ring motors: Starting, plugging ①	2.5	1	0.65	2.5	1	0.65	4	1.1	0.65	4	1.1	0.65
AC-3	Cage motors: Starting, switching off motor during running I_n , A												
	≤ 17	6	1	0.65	1	0.17	0.65	10	1.1	0.65	8	1.1	0.65
	$17 \leq 100$	6	1	0.35	1	0.17	0.35	10	1.1	0.35	8	1.1	0.35
AC-4	Cage motors: Starting, plugging ①, inching ② I_n , A												
	≤ 17	6	1	0.65	6	1	0.65	12	1.1	0.65	10	1.1	0.65
	$17 \leq 100$	6	1	0.35	6	1	0.35	12	1.1	0.35	10	1.1	0.35
Control Relay, AC													
	Operating of AC electromagnets	10	1	0.7	1	1	0.4	11	1.1	0.7	11	1.1	0.7

DIRECT CURRENT

UTILIZATION CATEGORY	TYPICAL APPLICATIONS	NORMAL CONDITIONS OF USE						ABNORMAL CONDITIONS OF USE					
		MAKING			BREAKING			MAKING			BREAKING		
		Current I_i	Voltage U/U_n	L/R Ω	Current I_b	Voltage U/U_n	L/R Ω	Current I_i	Voltage U/U_n	L/R Ω	Current I_b	Voltage U/U_n	L/R Ω
DC-1	Non-inductive or slightly inductive loads, resistance furnaces	1	1	1	1	1	1	-	-	-	-	-	-
DC-2	Shunt motors: Starting, switching off motors during running	2.5	1	2	1	0.1	7.5	4	1.1	2.5	4	1.1	2.5
DC-3	Shunt motors: Starting, plugging ①, inching ②	2.5	1	2	2.5	1	2	4	1.1	2.5	4	1.1	2.5
DC-4	Series motors: Starting, switching off motors during running	2.5	1	7.5	1	0.3	10	4	1.1	15	4	1.1	15
DC-5	Series motors: Starting, plugging ①, inching ②	2.5	1	7.5	2.5	1	7.5	4	1.1	15	4	1.1	15
Control Relays, DC		$T_{0.95}$			$T_{0.95}$			$T_{0.95}$			$T_{0.95}$		
DC-11	Operating of DC electromagnets	1	1	6P	1	1	6P	1.1	1.1	6P	1.1	1.1	6P

LEGEND

I	Making current, A	U_r	Recovery voltage, V
I_b	Breaking current, A	P	$= U \cdot I$ = steady state power consumption, W
I_n	Rated current, A	$T_{0.95}$	Time (in ms) to reach 95% of the steady state current (Max 300ms)
U	Voltage before making, V		
U_n	Rated voltage, V		

- ① Plugging: Stopping or reversing the motor when running.
 ② Inching: Energizing a motor repeatedly for short periods.
 ③ L/R = Inductance / Resistance

DATE

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END