wyle laboratories

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TEST REPORT

FIELD LABELING OF FIFTY (50) SECURITY FENCE CONTROL PANELS & ONE (1) ACTIVE SECURITY FENCE SYSTEM

For

SENTRY SECURITY SYSTEMS, INC.
7608 Fairfield Road
PO Box 21832
Columbia, SC 29221

STATE OF ALABAMA
COUNTY OF MADISON }

Robert D. Hardy, Department Manager, being duly sworn, deposes and says: The information contained in this report is the result of complete and carefully conducted testing and is to the best of his knowledge true and correct in all respects.

Robert D. Hardy

SUBSCRIBED and sworn to before me this 24 day of Sept 20 09

Sandra A. Daniel
Notary Public in and for the State of Alabama at Large

My Commission expires June 5, 2011

Wyle shall have no liability for damages of any kind to person or property, including special or consequential damages, resulting from Wyle's providing the services covered by this report.

PREPARED BY: Jimmy W. Smith 9-24-09
Jimmy W. Smith, Senior Engineering Specialist Date

APPROVED BY: James E. Feller 9/24/09
James E. Feller, Senior Engineer, NCE Date
iNARTE Certified EMC Engineer, No. EMC-003159-NE

WYLE Q. A.: Sandra Moore 9/24/09
FOR Raul F. Terceno, Q. A. Manager Date

ACCREDITED
CERT. # 845.01

TABLE OF CONTENTS

ATTACHMENTS

1.0 SCOPE OF EVALUATION

Wyle Laboratories conducted a Field Evaluation of fifty (50) Security Fence Control Panels and one (1) Active Security Fence System, hereinafter referred to as the Equipment Under Test (EUT), located at Old Dominion Freight Line, 9010 NE 13th Avenue, Portland, OR 97211. This inspection and evaluation was requested by Sentry Security Systems, Inc. of Columbia, SC and was conducted August 25-26, 2009.

This evaluation report is valid only for the model and identification numbers indicated on the Field Label Inspection Forms located in Attachment A of this report. Any changes, revisions or corrections to the evaluated Control Panels or active Security Fence System after this evaluation shall invalidate this certification until the panel(s) and/or system can be reevaluated and a revised report issued. See Section 9.0 of this report for additional details regarding certification and liability.

NOTE: Wyle Laboratories' certification of the Security Fence Control Panels and Active Security Fence System, identified on the Field Label Inspection Forms (see Attachment A), is valid for battery powered systems only. This certification will be deemed invalid if the Security Fence Control Panels and/or Security Fence System are connected in any manner to the AC mains. Further, the Security System Control Panels listed on the Field Inspection Form are certified for installation only in the State of Oregon and under the jurisdiction of the State of Oregon.

2.0 REFERENCED STANDARDS AND REQUIREMENTS

- OSHA 29 CFR 1910:2004, "Occupational Safety & Health Standards"
- NFPA 70, "National Electrical Code" (NEC 2008)
- UL 69:2006, "Standard for Electric-Fence Controllers, 9th Edition"
- IEC 60335-2-76:1997: Edition 2.1, 2006, "Household and Similar Electrical Appliances – Part 2-76: Particular Requirements for Electric Fence Energizers"

3.0 PRODUCT DESCRIPTION

Table 3-1 EUT Description

Items	Model Numbers	Identification Numbers	Quantity
Security Fence System Control Panels	See Field Labeling Inspection Forms – Attachment A	See Field Labeling Inspection Forms – Attachment A	Fifty (50) Control Panels & One (1) Security Fence System

The products covered by this field report are Battery Powered Security Fence Control Panels. The Control Panels consists of an electric fence charger, battery charge regulator, warning enunciator relay, telephone emergency relay, and associated components.

The complete Security Fence System further consists of a UL listed Photovoltaic Cell used for battery charging, dual external warning enunciators (horns), external grounding and UL listed fence wire (see Table 5-1 of this report).

There are no components in the Security Fence Control Panels and/or fence warning system that are intended to be connected direct to the AC mains.

3.0 PRODUCT DESCRIPTION (continued)

1. Equipment is: ☐ detachable cord connected; ☐ permanently connected: ☐ floor standing; ☒ wall mounted; ☐ desktop ☐ rack mounted ☐ bolted to floor
2. Equipment is housed in: ☒ metal; ☐ plastic; ☐ both; ☐
3. End product environment is: ☐ office; ☐ factory; ☐ home; ☐ central office ☐ computer room; ☒ outdoors; ☐ laboratory
4. Equipment has metallic tip and ring circuits: ☒ yes ☐ no
5. Duty Cycle: ☒ Continuous; ☐ Short term; ☐ Intermittent

3.1 Electrical Rating

12 VDC input – Energizer and Alarm System

3.2 Main Enclosure Dimensions (H x W x D)

18" x 24" x 8"

4.0 THEORY OF OPERATION

The Security Fence System uses a constant voltage monitoring process to determine if contact has been made with the energized portion of the external wiring. If a loss of voltage has been detected due to a path to ground being made by an external source, the charger transmits a 7,000 VDC, 50 mA pulse for a period of three thousandths of a second (0.003 sec.). The amount of available energy and the length of transmission time of the applied current are not sufficient to cause fibrillation in a human subject. (See Table 4-1)

Table 4-1 Effect of Current on Humans [(1)]

Current (1 Second Contact)	Physiological Effect	Voltage required to produce the current with assumed body resistance of 110,000 Ohms (normal human body resistance)
1 mA	Threshold of feeling, tingling sensation	100 V
5 mA	Accepted as maximum harmless current	500 V
10-20 mA	Beginning of sustained muscular contraction	1,000 V
100-300 mA	Ventricular fibrillation	10,000 V
6 A	Sustained ventricular contraction	600,000 V

Note: 1) Reference: Nave, C.R. and Nave, B.C., 1985, Physics for the Health Sciences. 3rd edition Chapter14, Table 14-1

4.0 THEORY OF OPERATION (continued)

System activation also results in an alarm signal being transmitted through a UL listed relay to the Alarm Control box. This device processes the signal, which is transmitted to a remote location and the local enunciators (horns) emit an alarm signal for ten minutes.

Warning signs are provided on the energized portion of the fence spaced fifty (50) feet around the perimeter of the protected area (see Photographs Nos. 5 and 6). The text of the signs alternates between English and Spanish and includes the ISO symbol (lightning bolt) for high voltage on each sign.

5.0 SAFETY CRITICAL COMPONENTS

Table 5-1 Safety Critical Components Relating to the Security Fence System

Component Type	Description
DC Supply Wiring	Listed, 18 AWG, Type CL2, double insulated
DC Internal Wiring	Listed, 18 AWG, Type CMR/CL3R
External Power Wiring from Charger to Fence	.030 in. thick PVC Jacketed, 14 AWG, 19 x 37 Tinned Copper. Dielectric Strength: 15 kV, Insulation Resistance: 2.5 kV, Spark Voltage: 15 kV.
Strain relief used on permanently connected equipment	Listed, metal, with screw type adjustable clamp
Fence Voltage Alarm	CE Listed Component, 12 VDC, 10 – 100 mA, IPX4
Low Voltage Voice/Data Protector	DITEK Model DTK-MRJ, UL Listed E163310
Relays	Listed, Advanced Signal Company, Model/Cat. No. ASRB-1
Power Supply	One (1) provided: Lead Acid Battery, rated 12 VDC
Charge Controller	Sun Selector Model M-4. Max input: 25 VDC, 6A. Provided with blocking diode for reverse charge protection and overcharge protection (CE recognized).
Photovoltaic Cell	Listed, Kyocera, Model KC60, rated output: 16.9 VDC, 3.55 A
Alarm Controller	Listed, Networx, Model NX-8V2
Fence Charger	Various: See Field Labeling Inspection Form – Attachment A

6.0 EVALUATION PROTOCOL

Components were examined to determine whether they were applied within their product classification. A visual inspection of the product was performed, with particular attention to the following areas:

- Suitability of use in accordance with IEC Standard 60335-2-76:1997: Edition 2.1 2006 and the National Electrical Code (NEC)
- Compatibility of the product with the installed environment
- Suitability of electrical component enclosures
- Appropriate use of NRTL "listed" or "recognized" components
- Appropriate application, mounting, damage and modification of components
- Permanent nameplate providing appropriate information
- Appropriate warning labels and other markings
- Appropriate conductor ratings, identification, methods, separation and bending space
- Appropriate guarding and/or isolation of electrical and mechanical hazards
- Appropriate grounding and bonding methods

7.0 SPECIAL CONSIDERATIONS

None

8.0 MODIFICATIONS TO ACHIEVE COMPLIANCE

None

9.0 SUMMARY

There are no current North American Safety Standards that address the use of a Battery Powered Security Fence System for human deterrent (security) purposes. Underwriters Laboratories (UL) 69:2006, "Standard for Electric-Fence Controllers, 9th Edition" addresses applications of Battery Powered Security Fence Systems for livestock containment only.

Since there are no current North American Safety Standards to consult for human deterrent (security) applications, IEC Standard 60335-2-76:1997: Edition 2.1 2006, "Safety of Household and Similar Electrical Appliances – Part 2-76: Particular Requirements for Electric Fence Energizers" was consulted for the evaluation of the Sentry Security Battery Powered Security Fence System and Controllers. In addition, NFPA 70 (NEC 2008) was consulted relating to wiring and electrical connections, battery installation and Solar Photovoltaic Systems.

As a result of this evaluation, the subject Battery Powered Security Fence System was judged to be acceptable for application relating to human deterrent (security) purposes and was found to be in compliance with the subject IEC and the NEC standards.

Note: Acceptance and/or approval of the final installation of the Battery Powered Security Fence System(s) for use for human deterrent (security) purposes will be at the discretion and sole authority of the local Authority Having Jurisdiction (AHJ).

10.0 QUALITY ASSURANCE

All work performed on this program was in accordance with Wyle Laboratories' Quality Assurance Program and Wyle Laboratories' Quality Program Manual, which conforms to the applicable portions of International Standard Organization (ISO) Guide 17025.

The Wyle Laboratories, Huntsville Facility, Quality Management System is registered in compliance with the ISO-9001 International Quality Standard. Registration has been completed by Quality Management Institute (QMI), a Division of Canadian Standards Association (CSA).

Wyle Laboratories is accredited (Certificate No. 845.01) by the American Association for Laboratory Accreditation (A2LA), and the results documented in this test report have been determined in accordance with Wyle's scope of accreditation unless otherwise stated in the report.

ATTACHMENT A

FIELD LABEL INSPECTION FORMS

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Field Label Inspection Form

Customer: Sentry Security Systems, LLC **Wyle Job No:** T56954
Inspection Site Address: Old Dominion Freight, 9010 NE 13th Ave, Portland, OR 97211
Inspection Date: August 25-26, 2009 **Inspection Time:** 07:30 **to** 16:00
Customer Representative: Michael Pate **Phone:** 803-404-6204
Fax: 803-786-6458 **E-mail:** mpate@electricguarddog.com
Product Type Information: Security Fence Control Panels
Applicable Standard(s): NFPA 70 (NEC 2008) & IEC 60335-2-76

Power Fence Charger Model B1200				
Charger P/N	**Charger S/N**	**Alarm M/N**	**Alarm S/N**	**Panel S/N & Wyle NRTL Label #**
G332404	0849471078	ACN 005 550 845	11424	56954-001/2672
G332404	0849471077	ACN 005 550 845	11624	56954-002/2673
G332404	0532230007	ACN 005 550 845	11388	56954-003/2674
G332404	0850172002	ACN 005 550 845	11428	56954-004/2675
G332404	0539434161	ACN 005 550 845	11263	56954-005/2676
G332404	0849471079	ACN 005 550 845	11367	56954-006/2677
G332404	0820672011	ACN 005 550 845	11599	56954-007/2678
G332404	0443315015	ACN 005 550 845	11384	56954-008/2679
Power Plus Charger Model B280				
Charger P/N	**Charger S/N**	**Alarm M/N**	**Alarm S/N**	**Panel S/N & Wyle NRTL Label #**
G366504	0846572133	ACN 005 550 845	11264	56954-009/2680
G366504	0843274027	ACN 005 550 845	11392	56954-010/2682
G366504	0846572130	ACN 005 550 845	11383	56954-011/2683
G366504	0846572132	ACN 005 550 845	11391	56954-012/2684
G366504	0846572134	ACN 005 550 845	11380	56954-013/2685
G366504	0807473161	ACN 005 550 845	9010	56954-014/2686
G366504	0843274067	ACN 005 550 845	4900	56954-015/2687
G366504	0837572064	ACN 005 550 845	11600	56954-016/2688
G366504	0846572100	ACN 005 550 845	11394	56954-017/2689
G366504	0846572101	ACN 005 550 845	11390	56954-018/2690
G366504	0841374159	ACN 005 550 845	11368	56954-019/2691
G366504	0843274026	ACN 005 550 845	11426	56954-020/2692

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Field Label Inspection Form (continued)

Power Plus Charger Model B80				
Charger P/N	**Charger S/N**	**Alarm M/N**	**Alarm S/N**	**Panel S/N & Wyle NRTL Label #**
GS62504	0845274076	ACN 005 550 845	5693	56954-021/2693
GS62504	0845274078	ACN 005 550 845	11432	56954-022/2694
GS62504	0845274075	ACN 005 550 845	11007	56954-023/2695
GS62504	0845274077	ACN 005 550 845	11429	56954-024/2696
GS62504	0837171136	ACN 005 550 845	11423	56954-025/2697
GS62504	0845274070	ACN 005 550 845	11365	56954-026/2698
GS62504	0837171139	ACN 005 550 845	10831	56954-027/2699
Power Plus Charger Model B180				
Charger P/N	**Charger S/N**	**Alarm M/N**	**Alarm S/N**	**Panel S/N & Wyle NRTL Label #**
G364504	0748473116	ACN 005 550 845	11596	56954-028/2700
G364504	0804173205	ACN 005 550 845	11469	56954-029/2701
G364504	0804173203	ACN 005 550 845	11471	56954-030/2702
G364504	0804173202	ACN 005 550 845	11470	56954-031/2703
G364504	0804173201	ACN 005 550 845	11472	56954-032/2704
Power Plus Charger Model B700				
Charger P/N	**Charger S/N**	**Alarm M/N**	**Alarm S/N**	**Panel S/N & Wyle NRTL Label #**
G39500	0905372125	ACN 005 550 845	11474	56954-033/2705
G39500	0841573041	ACN 005 550 845	11477	56954-034/2706
G39500	0905372124	ACN 005 550 845	11475	56954-035/2707
G39500	0841573049	ACN 005 550 845	9326	56954-036/2708
G39500	0905372160	ACN 005 550 845	11375	56954-037/2709
G39500	0905372128	ACN 005 550 845	11478	56954-038/2710
G39500	0905372161	ACN 005 550 845	11370	56954-039/2711
G39500	0918473155	ACN 005 550 845	10050	56954-040/2712
G39500	0918473159	ACN 005 550 845	5785	56954-041/2713
G39500	0841573046	ACN 005 550 845	11366	56954-042/2714
G39500	0918473154	ACN 005 550 845	11396	56954-043/2715
G39500	0841573042	ACN 005 550 845	5024	56954-044/2716
G39500	0918473158	ACN 005 550 845	7856	56954-045/2717

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Field Label Inspection Form (continued)

Power Plus Charger Model B700 (continued)				
Charger P/N	**Charger S/N**	**Alarm M/N**	**Alarm S/N**	**Panel S/N & Wyle NRTL Label #**
G39500	0905372152	ACN 005 550 845	11379	56954-046/2718
G39500	0905372153	ACN 005 550 845	11473	56954-047/2719
G39500	0841573040	ACN 005 550 845	11595	56954-048/2720
G39500	0841573044	ACN 005 550 845	11476	56954-049/2721
G39500	0918473156	ACN 005 550 845	11397	56954-050/2722

Notes:

1. Control Panel Serial Numbers were assigned by Wyle Laboratories
2. Wyle NRTL Label # 2681 is intentionally not included in the number sequence.
3. The Security Fence Control Panels meets the requirements of the applicable sections of NFPA 70 (NEC 2008) and IEC 60335-2-76: Edition 2.1, 2006 as defined in Section 3.108 "Battery-operated Energizer."

Jimmy W. Smith 26 AUG 2009 Jimmy W. Smith

Inspector Signature Date Printed Name of Inspector

Page 3 of 3

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Field Label Inspection Form

Customer: Sentry Security Systems, LLC **Wyle Job No:** T56954

Inspection Site Address: Old Dominion Freight, 9010 NE 13th Ave., Portland, OR 97211

Inspection Date: August 25, 2009 **Inspection Time:** 07:30 **to** 16:00

Customer Representative: Michael Pate **Phone:** 803-404-6204

Fax: 803-786-6458 **E-mail:** mpate@electricguarddog.com

Product Type Information: Security Fence System

Applicable Standard(s): NFPA 70 (NEC 2008) and IEC 60335-2-76: Edition 2.1, 2006

Charger Model Number, Part Number & Serial Number	Security Fence System Serial Number (1)	Description	Conformity Mark(s)	Wyle Label
M/N: B600 P/N: G332404 S/N: 0749174059	56954-051	Security Fence System (2) consisting of charger control panel, alarm relay panel, associated wiring, solar panel, alerter horns, fence components and wiring	UL/CE	2723

Notes:

1. System Fence Serial Number was assigned by Wyle Laboratories
2. The Security Fence System meets the requirements of the applicable sections of NFPA 70 and IEC 60335-2-76: edition 2.1, 2006 as defined in Section 3.108 "Battery-operated Energizer."

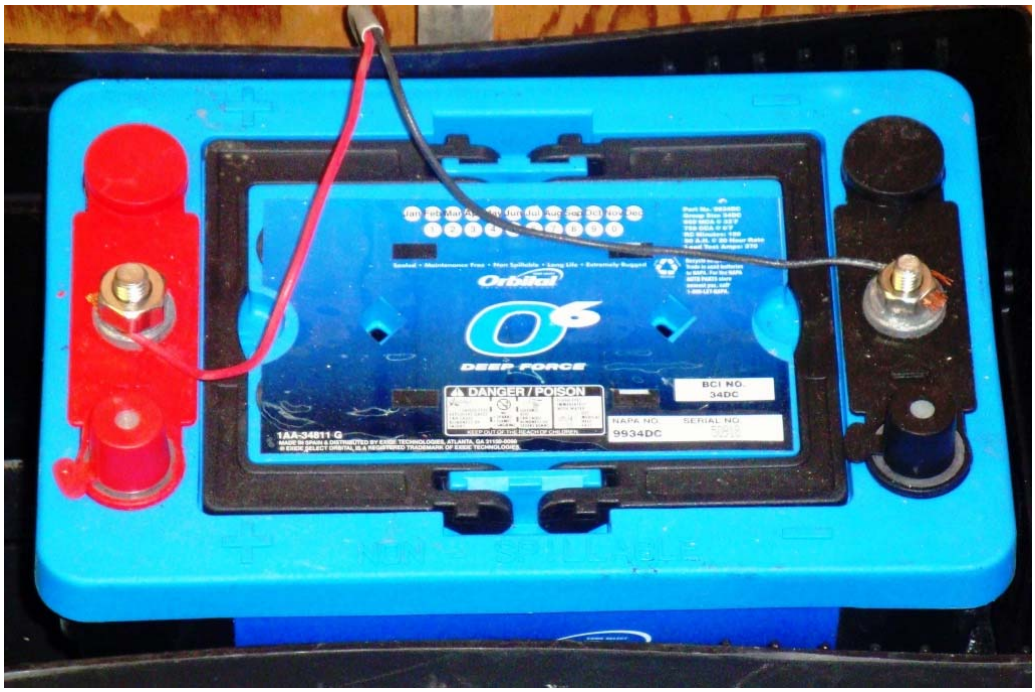
Jimmy W. Smith 25 Aug 09
Signature/Date of Inspector

Jimmy W. Smith
Printed Name of Inspector

ATTACHMENT B

PHOTOGRAPHS

Photograph No. 1 - Active Energizer and Alarm Control Components Installed at the Old Dominion Freight Company, Portland, Oregon Location

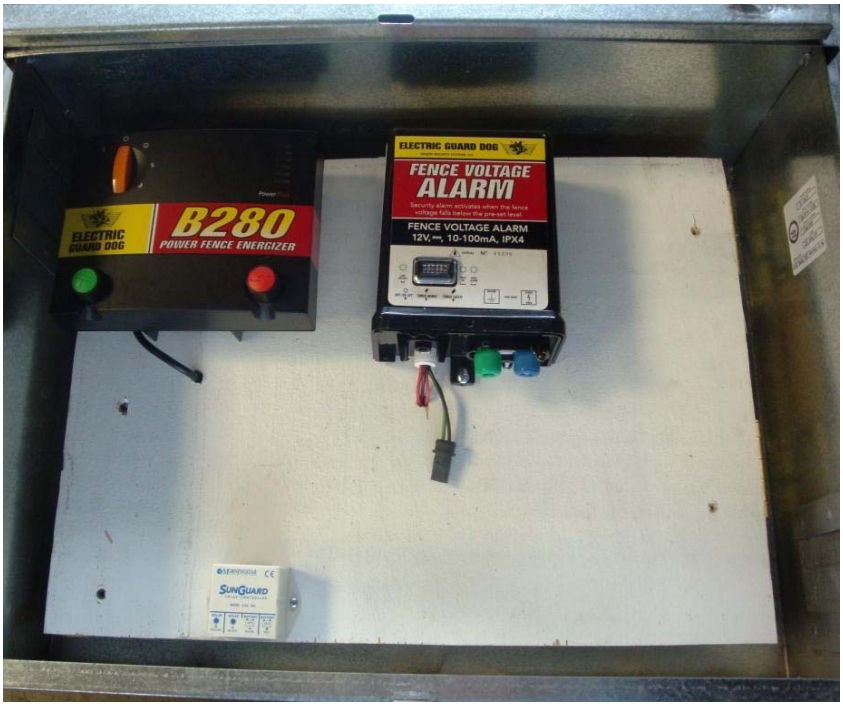


Photograph No. 2 - Marine Type 12 VDC Lead Acid Battery Installed at the Old Dominion Freight Company, Portland, Oregon Location

Photograph No. 3 - Solar Panel and Alarm Horns
Installed at the Old Dominion Freight Company, Portland, Oregon Location

Photograph No. 4 - English Warning Sign
Installed at the Old Dominion Freight Company, Portland, Oregon Location

Photograph No. 5 - Spanish Warning Sign
Installed at the Old Dominion Freight Company, Portland, Oregon Location



Photograph No. 6 – B280 Control Panel

Photograph No. 7 – B700 Control Panel

Photograph No. 8 – B1200 Control Panel

ATTACHMENT C

ENERGIZED FENCE SAFETY TEST REPORT

Sentry Security Systems, LLC position on the relationship of security fences

to codes and standards

Electric fencing is used safely throughout the world, with applications for both animal control and commercial security. In a commercial security setting, security fences deter crime and help apprehend criminals. The mere presence of a security fence discourages unlawful entry, theft and the destruction of property. Additionally, it is easier to apprehend the determined criminal because the owner and police are notified instantaneously when the criminal distorts or breaks the fence. Security fences also protect the people who work at a site, providing business owners and employees significant peace of mind.

The security fence sold by Sentry Security Systems is powered by a 12 volt DC marine (or similar) battery. The National Electric Code does not cover battery powered products such as smoke alarms. Therefore, the security fence sold by Sentry Security Systems is not covered by the NEC.

There is in fact no US standard that addresses security fences whether main or battery powered. UL 69 addresses animal control fences but not security fences. There is, however, a good international standard - IEC 60335-2-76 - that addresses security fences. This standard is attached for your information.

We respectfully request that you determine that, as a battery powered device, security fences do not fall under the National Electric Code.

1

THE UNIVERSITY of WISCONSIN MADISON

January 8, 2008

Edward T. Dickerson, PhD., P.E.

Dear Dr. Dickerson,

I have tested the Gallagher Group Ltd PowerPlus B600 and Gallagher Group Ltd PowerPlus B280 electric fence energizers. I tested them to the International Electrotechnical Commission Standard: IEC 2006 *Household and similar electrical appliances – Safety – Part 2-76: Particular requirements for electric fence energizers*, (IEC 60335-2-76, Edition 2.1). It is the most appropriate standard to use because it specifically describes "electric security fences" 40 times.

I describe the testing methods and the results in detail in the attached paper: Amit J. Nimunkar and John G. Webster, "Safety of electric fence energizers." Figure 3 in this paper shows the electric current versus time for these two electric fence energizers and compares them with three other electric fence energizers in use in the USA. Table I shows the electric fence energizer electric current I_{rms}, compares it with the IEC standard I_{rms}, and shows that all five electric fence energizers pass the IEC standard electric tests.

I conclude that the Gallagher Group Ltd PowerPlus B600 and Gallagher Group Ltd PowerPlus B280 electric fence energizers passed all IEC electric tests and thus are safe to use.

If I can provide you any further information, please let me know.

Sincerely,

John G. Webster, Professor Emeritus
Phone 608-263-1574
Webster@engr.wisc.edu

Department of Biomedical Engineering
2130 Engineering Centers Building University of Wisconsin–Madison 1550 Engineering Drive Madison, Wisconsin 53706–1609
608/263–4660 Fax: 608/265–9239 Email: bme@engr.wisc.edu http://www.bme.wisc.edu/

Safety of electric fence energizers

Amit J. Nimunkar1 and John G. Webster1

1Department of Biomedical Engineering, University of Wisconsin, 1550 Engineering Drive, Madison, WI 53706 USA.
E-mail: Webster@engr.wisc.edu (John G. Webster) Tel 608-263-1574, Fax 608-265-9239

Abstract

The strength–duration curve for tissue excitation can be modeled by a parallel resistor–capacitor circuit that has a time constant. We tested five electric fence energizers to determine their current-versus-time waveforms. We estimated their safety characteristics using the existing IEC standard and propose a new standard. The investigator would discharge the device into a passive resistor–capacitor circuit and measure the resulting maximum voltage. If the maximum voltage does not exceed a limit, the device passes the test.

Key words: strength–duration curve, cardiac stimulation, ventricular fibrillation, electric safety, electric fence energizers, standards.

1. Introduction

The vast majority of work on electric safety has been done using power line frequencies such as 60 Hz. Thus most standards for electric safety apply to continuous 60 Hz current applied hand to hand. A separate class of electric devices applies electric current as single or a train of short pulses, such as are found in electric fence energizers (EFEs). A standard that specifically applies to EFEs is IEC (2006). To estimate the ventricular fibrillation (VF) risk of EFEs, we use the excitation behavior of excitable cells. Geddes and Baker (1989) presented the cell membrane excitation model (Analytical Strength–Duration Curve model) by a lumped parallel resistance–capacitance (*RC*) circuit. This model determines the cell excitation thresholds for varying rectangular pulse durations by assigning the strength–duration rheobase currents, chronaxie, and time constants (Geddes and Baker, 1989). Though this model was originally developed based on the experimental results of rectangular pulses, the effectiveness of applying this model for other waveforms has been discussed (IEC 1987, Jones and Geddes 1977). The charge–duration curve, derived from the strength–duration curve, has been shown in sound agreement with various experimental results for irregular waveforms. This permits calculating the VF excitation threshold of EFEs with various nonrectangular waveforms. We present measurements on electric fence energizers and discuss their possibility of inducing VF.

2. Mathematical background and calculation procedures

Based on the cell membrane excitation model (Weiss–Lapique model), Geddes and Baker (1989) developed a lumped *RC* model (analytical strength–duration curve) to describe the membrane excitation behavior. This model has been widely used in various fields in electrophysiology to calculate the excitation threshold. Figure 1 shows the normalized strength–duration curve for current (*I*), charge (*Q*) and energy (*U*). The expression of charge is also known as the charge–duration curve which is important for short duration stimulations.

2

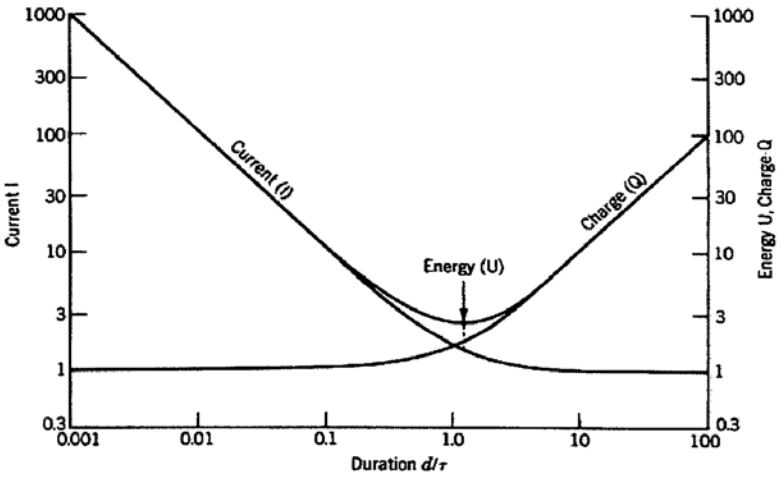


Figure 1. Normalized analytical strength–duration curve for current I, charge Q, and energy U. The x axis shows the normalized duration of d/τ. Note that for $d << \tau$, Q is constant and the most appropriate variable for estimating cell excitation. (from Geddes and Baker, 1989).

The equation for the strength–duration curve is (Geddes and Baker, 1989),

$$\Delta v = IR(1 - e^{-\frac{t}{\tau}}), \tag{1}$$

where I is a step current intensity, R is the shunt resistance, Δv is the depolarization potential threshold which is about 20 mV for myocardial cells, τ is the RC time constant, and t is the time I is applied.

If we let the stimulation duration go to infinity, the threshold current is defined as the rheobase current ($I = b$). If we substitute I in equation (1) by b and define the threshold current $I_d = \Delta v/R$ for the stimulation with duration d. Equation (1) becomes,

$$I_d = \frac{b}{1 - e^{-\frac{d}{\tau}}}. \tag{2}$$

We can calculate the threshold charge (Q_d) by integrating equation (2) and it becomes,

$$Q_d = I_d d = \frac{bd}{1 - e^{-\frac{d}{\tau}}}, \tag{3}$$

For short duration stimulation ($d << \tau$) with duration shorter than 0.1 times the *RC* time constant, equation (3) can be approximated by equation (4) and it yields equation (5),

$$1 - e^{-\frac{d}{\tau}} \approx \frac{d}{\tau}, \tag{4}$$

$$Q_d = b\tau \tag{5}$$

Equation (5) suggests that the charge excitation threshold for short duration stimulation is constant and equals the product of the *RC* time constant τ and the rheobase b. Geddes and Bourland (1985) showed that the charge–duration curve for single rectangular, trapezoidal, half sinusoid and critically damped waveforms had a good agreement for short duration stimulations. Therefore we used the same model to estimate thresholds for stimulation sources where I was not constant, under the same stimulation setting.

Cardiac cell excitation has been intensively studied at the 60 Hz power line frequency because most accidental electrocutions occur with 60 Hz current, which has a longer duration relative to the cardiac cell time constant of about 2 ms. However, EFEs operate with pulse durations much shorter than the time constant.

3. Methods

Figure 2 shows our experimental test set-up. The EFEs under test consist of Gallagher Group Ltd PowerPlus B600 (EFE1), Gallagher Group Ltd PowerPlus B280 (EFE2), Speedrite HPB (EFE3), Intellishock 20B (EFE4) and Blitzer 8902 (EFE5) EFEs. The short duration electrical pulses from these EFEs are passed though a series of eleven 47 Ω (ARCOL D4.29, HS50 47 R F) resistors which measure 518 Ω, which represents approximately the internal resistance of the human body. It is further connected to two 18 Ω (RH 10 207 DALE 10 W 3%) resistors connected in parallel which measure 9.08 Ω. This is used as the sensing resistor across which the oscilloscope measures the output voltage. For these very short pulses it is important to use noninductive resistors because the same current flowing through a resistor that has substantial inductance will measure a larger current than a resistor that is noninductive. To reduce electromagnetic interference, a faraday cage, covered with aluminum foil, was connected to ground. This diverted the electromagnetic interference to ground. The data were collected in EXCEL format from a disk in the Agilent 54621 oscilloscope. The calculations for different parameters presented in Table 1 and the Figures 3–5 were plotted using MATLAB.

4

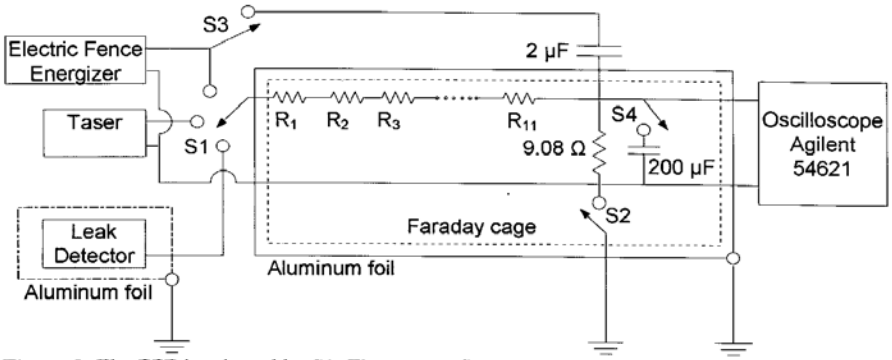


Figure 2. The EFE is selected by S1. The current flows through a string of 47 Ω resistors R_1–R_{11} (total 518 Ω) which approximates the internal body resistance of 500 Ω. The 9.08 Ω yields a low voltage that is measured by the oscilloscope.

3.1. Determination of current

EFEs are used in conjunction with fences wires to form animal control fences and security fences. We tested five EFEs (EFE1–EFE5) using the experimental set-up in Figure 2 and obtained the output currents shown in Figure 3.

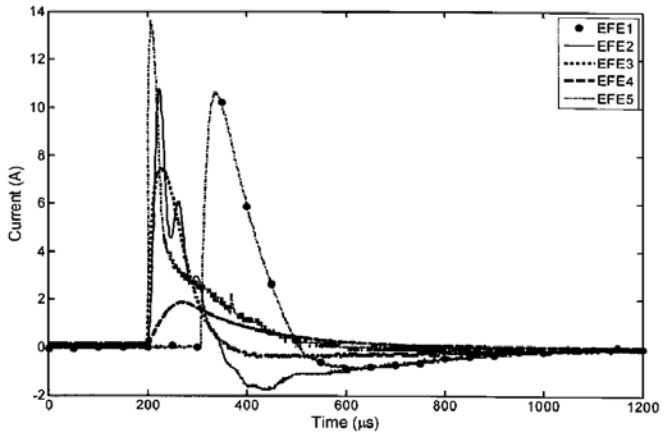


Figure 3. The output current waveform for five EFEs. EFE1 yields about 7.75 A for 151 μs = 1170 μC, EFE2 yields about 3.34 A for 345 μs = 1150 μC, EFE3 yields about 5.69 A for 91 μs =

518 μC, EFE4 yields about 1.25 A for 252 μs = 315 μC and EFE5 yields about 5.7 A for 137 μs = 781 μC.

4. Results

Table 1 shows the approximate results for the rms current, power, duration and charge for all the EFEs.

Table 1 Approximate results for all EFEs.

EFEs		EFE1	EFE2	EFE3	EFE4	ECF5
Parameters	Units					
A. (IEC)						
Total Energy	A^2ms	7.94	4.04	3.10	0.42	4.69
95% Energy Duration	μs	129	346	91	253	138
I_{rms}	A	7.65	3.33	5.69	1.25	5.69
IEC Standard I_{rms}	A	13.0	6.21	16.8	7.85	7.37
Pass IEC Standard	Yes/No	Yes	Yes	Yes	Yes	Yes
B. Proposed standard						
Voltage	V	3.88	2.91	NAv	NAv	NAv
Duration	μs	233	132			
Current	A	3.33	4.41			
Charge	μC	776	582			

NA- not applicable, NAv- not available

IEC (2006) defines in 3.116 "impulse duration: duration of that part of the impulse that contains 95% of the overall energy and is the shortest interval of integration of $I^2(t)$ that gives 95% of the integration of $I^2(t)$ over the total impulse. $I(t)$ is the impulse current as a function of time." In 3.117 it defines "output current: r.m.s. value of the output current per impulse calculated over the impulse duration." In 3.118 it defines "standard load: load consisting of a non-inductive resistor of 500 Ω ± 2.5 Ω and a variable resistor that is adjusted so as to maximize the energy per impulse or output current in the 500 Ω resistor, as applicable." In 22.108, "Energizer output characteristics shall be such that – the impulse repetition rate shall not exceed 1 Hz; – the impulse duration of the impulse in the 500 Ω component of the standard load shall not exceed 10 ms; – for energy limited energizers the energy/impulse in the 500 Ω component of the standard load shall not exceed 5 J; The energy/impulse is the energy measured in the impulse over the impulse duration. – for current limited energizers the output current in the 500 Ω component of the standard load shall not exceed for an impulse duration of greater than 0.1 ms, the value specified by the characteristic limit line detailed in Figure 102; an impulse duration of not greater than 0.1 ms, 15 700 mA. The equation of the line relating impulse duration (ms) to output current (mA) for 1 000 mA < output current < 15 700 mA, is given by impulse duration = $41.885 \times 10^3 \times (\text{output current})^{-1.34}$." We used these definitions and calculated the total energy, the shortest duration where 95% of the total energy occurs, the rms current for that duration from Figure 3 for the EFEs (EFE1–EFE5). Similarly we calculated the output current using the relationship impulse duration = $41.885 \times 10^3 \times (\text{output current})^{-1.34}$, provided by the IEC for all the EFEs (EFE1–EFE5). Table 1 lists these under the heading "A. (IEC)". Table 1 shows that all the EFEs pass the IEC standard.

5. Proposed new standard

IEC (2006) uses the rms current for the shortest duration where 95% of the total energy occurs as the standard to determine if the EFE is safe for use. Geddes and Baker (1989) have shown that for pulses shorter than the cardiac cell time constant of 2 ms, the electric charge is the quantity that excites the cells. We propose a simple experimental set-up shown in Figure 2 to determine the maximum amount of charge that would flow from the EFEs and cause cardiac cell excitation. The cardiac cell is modeled as an *RC* circuit in Fig. 2 with $R = 9.08\ \Omega$ and $C = 200\ \mu F$ (GECONOL 9757511FC 200 µF ±10% 250 VPK) with the *RC* time constant of 1.82 ms. For the EFEs (EFE1 and EFE2) the switches S1 and S4 are closed. This allows the 200 µF capacitor to charge rapidly (about 100 µs) and discharge fairly slowly ($\tau = RC = 1.82$ ms). Figures 4 and 5 show the voltage vs time waveforms for the different EFEs. The test was not performed for electric fence energizers EFE3–EFE5.

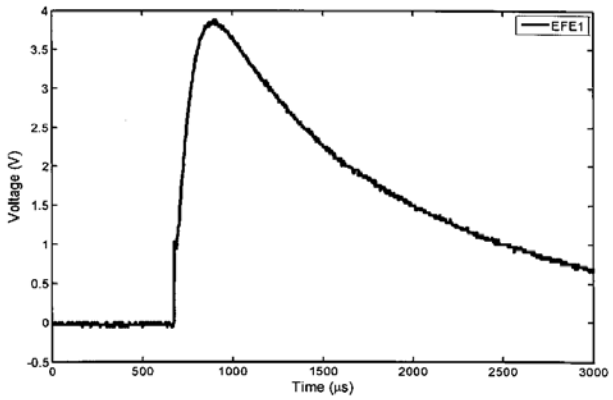


Figure 4. Output voltage waveform for EFE1. The maximal charge that flows through the cardiac cell model is given by $Q = CV = 200\ \mu F \times 3.88\ V = 775\ \mu C$, the current during which the capacitor charges to maximal value is given by $I = CV/T = (200\ \mu F \times 3.88\ V)/233\ \mu s = 3.33\ A$.

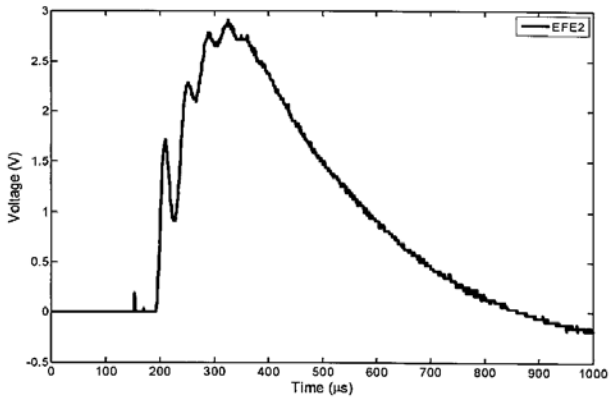


Figure 5. Output voltage waveform for the electric fence energizers EFE2. The maximal charge that flows through the cardiac cell model is given by $Q = CV = 200\ \mu F \times 2.91\ V = 582\ \mu C$, the current during which the capacitor charges to maximal value is given by $I = CV/T = (200\ \mu F \times 2.91\ V)/132\ \mu s = 4.41\ A$.

6. Discussion

Geddes and Baker (1989) have shown that for pulses shorter than the cardiac cell time constant of 2 ms, the electric charge is the quantity that excites cardiac cells. Because the first half wave is the largest, the charge integrated in the first half wave determines cardiac cell excitation. The next half wave discharges the cardiac cell capacitance and does not contribute to cardiac cell excitation. Thus we list integral $I(t)$ = charge Q in Table 1.

IEC (2006) integrates $I^2(t)$, which is roughly equal to $I(t)$. Their Figure 102 roughly follows charge.

We propose revising EFE standards for measuring current to determine a safety standard to prevent VF. The new standard would measure cardiac cell excitation. It would not require the complex calculations required to determine "The current which flows during the time period in which 95 percent of the output energy (is delivered)." It would use a simple circuit similar to that in Figure 2 composed of resistors and a capacitor. The investigator would discharge the device into the circuit and measure the maximum voltage. If the maximum voltage does not exceed 5 V (as a conservative estimate), the EFE passes the test. The 500 Ω resistor closely approximates the resistance of the body and determines the current that flows through the body.

Acknowledgements

We thank L Burke O'Neal and Silas Bernardoni for their help and suggestions.

References

8

Geddes L A, and Baker L E 1989 *Principles of applied biomedical instrumentation* (New York: John Wiley & Sons) pp 458–61

Geddes L A and Bourland J D 1985 The strength-duration curve. *IEEE. Trans. Biomed. Eng.* **32(6)** 458–9

IEC 1987 *International Electrotechnical Commission IEC Report: Effects of current passing through the human body* (IEC 60479-2) pp 47

IEC 2006 *Household and similar electrical appliances – Safety – Part 2-76: Particular requirements for electric fence energizers*, (IEC 60335-2-76, Edition 2.1)

Jones M and Geddes L A 1977 Strength duration curves for cardiac pacemaking and ventricular fibrillation *Cardiovasc. Res. Center Bull.* **15** 101–12

ATTACHMENT D

SENTRY SECURITY SYSTEMS
SAFETY DOCUMENTATION AND
INSTALLATION INFORMATION

Sentry Security Services, Inc.
7608 Fairfield Rd. ✓ PO Box 210356 ✓ Columbia, SC 29221
9803) 786-6333 ✓ fax 9803) 786-6458

Dear Sirs:

This letter is intended to furnish you with the information regarding our freestanding perimeter security system.

This system is the latest technology in outdoor security systems. While it does deliver a memorable electric shock, it is completely safe. It is primarily a psychological deterrent with an alarm for detecting voltage fluctuation (our patent No. 4220494) built into it.

The complete system is installed inside of a locked chain link fence and is only activated at night. It is a (12) twelve volt system that runs off of a car battery with a small solar panel. Hundreds of thousands of these energizers have been used worldwide without a single incident or injury.

A standard system was site surveyed by the Electronics Testing Lab, Inc. and was found to be completely safe. Two major insurance carriers, Travelers Insurance, Co. and Cigna Insurance, Co., have had the system looked at by their loss prevention safety engineers and both approve it for use by their customers.

Overworked police departments have high praise for this system. The major attributes of the system are that it is extremely effective, safe and has proven successful with minimal false alarms.

The system provides a safe work place for employees. In the type of businesses we provide service for, employees are often required to enter facilities alone or in the middle of the night and have been known to surprise intruders. One of our customers, Yellow Freight, in Detroit, MI was being broken into on a weekly basis for over eight years with three guards on duty 24 hours a day. They had also had an employee shot four times by an intruder. Since our system was installed in December, 1999, they have not had a single break-in.

Other nationally known companies that use our system in multiple locations include: Michelin North America, Old Dominion Freight Lines, FedEx, Saia Motor Freight, ADESA Auto Auctions, Yellow Freight, Overnite Transportation, Manheim's Auto Auctions, Goodwill Industries, FedEx Freight East and Roadway Express.

Several Cities have been able to amend city ordinances to accommodate the system, and still manage to impose enough restrictions to eliminate would-be problems. (i.e. Inside 6' chain link, only used during closed hours, warning signs every 50', $200,000,000 insurance policy- city provided with certificate of, etc.)

Enclosed is a certificate of our liability insurance, as well as documentation supporting the safety of our fences, information regarding our patent on the system and changes that have been made to city/county ordinances to accommodate our fencing.

We understand the initial concern by persons responsible for the safety of the community. We feel that after you review this information you will feel much more comfortable about the system. We will be glad to work with you any way we can and we'll answer any other questions you may have. We thank you for your concern, and we look forward to hearing back from you soon.

Thank You,

J.W. Mullis
President, Sentry Security Services, Inc.

INTRODUCING THE ELECTRIC GUARD DOG™

Safeguarding Your Business With The Most Effective Perimeter Security Solution On The Market.

Perimeter security is your first line of defense at keeping criminals at bay and away from your employees and business.

When it comes to keeping your facility secure, you have a range of choices – from guards and dogs to complex, custom solutions. But these options can be expensive to install and maintain, prone to false alarms and often unreliable.

Since installing our first Electric Guard Dog in 1991, we have grown to be the leading provider of electric security fencing in the U.S. Our success is the result of providing our customers an effective, economical, hassle-free and safe solution to their perimeter security needs, and the proof is in the more than 2,000 Electric Guard Dog-secured sites throughout the U.S.

WHAT OUR CUSTOMERS SAY

"Without exception, we have had 100% success in every facility using The Electric Guard Dog System. This system has proven to be the most reliable, cost effective way to protect our perimeter."

THE LEADER IN PERIMETER PROTECTION

Deterrence is a key principal of our system, and we believe that the best security system is one whose alarm you never hear.

EFFECTIVE

Our experience tells us that your security problems are likely to go away upon the installation of our system because The Electric Guard Dog™ is an imposing barrier and an active deterrent to potential intruders.

If someone does attempt to gain entry, an on-premise alarm will sound and a signal is transmitted to our monitoring station that alerts you and the police to the unauthorized access.

ECONOMICAL

Unlike many of the alternatives, The Electric Guard Dog™ requires no costly upfront investment. You only pay a reasonable monthly service fee.

Your operating costs are neglible as the power source for the system is a 12-volt DC battery charged by a solar panel.

HASSLE-FREE

With The Electric Guard Dog™, we install the system and we maintain it. Our patented design minimizes nuisance alarms caused by birds, small animals and weather – all of which are characteristic of alternative perimeter security systems.

If you experience any issues, technical support is available 24 hours a day, 365 days a year. In the rare event we can't solve your problem on the telephone, our nationwide field service organization will be dispatched to your location to resolve the issue allowing you to focus on running your business.

SAFE

The Electric Guard Dog™ is a battery-powered system that delivers would-be intruders a short – yet memorable – shock. The safety of the system is a function of the pulsating nature and short duration of the charge, and our systems are proven safe by years in the field as well as customer and laboratory testing.

The energizer and other critical components conform to international safety standards and are installed in accordance with our design specifications by our trained installers and field service organization. Furthermore, because we retain ownership of the system, we stand behind its safe operation.

To learn more about Sentry Security Systems℠, The Electric Guard Dog™, or for an estimate and recommendation on how we can secure your perimeter, please contact us.

The Electric Guard Dog

Sentry Security Systems

Sentry Security Systems, LLC
P.O. Box 21832
Columbia, SC 29221

Phone: 803-786-6333
Fax: 803-786-6458
E-mail:
sentry@electricguarddog.com
www.electricguarddog.com

Frequently Asked Questions

Do you install residential systems?

No. Our systems are designed specifically for commercial and industrial locations.

What are the minimum site requirements for an Electric Guard Dog system?

Electric Guard Dog is fueled by a solar panel(s), so it can be installed virtually anywhere, and can be adapted to accommodate other security electronics that may already be on-site or may be added later.

Every Electric Guard Dog is custom-fit per topographic and other site-specific factors, and can presently be found on sites ranging in size from 400 square feet to 400 acres.

Because Electric Guard Dog is an electrified secondary fence installed along the interior of a perimeter fence, customers are responsible for ensuring the structural integrity (no gaping holes, etc.) of the outer perimeter fence. Customers are also responsible for modest grounds upkeep along the Electric Guard Dog fence. Modest grounds upkeep would include occasional mowing or trimming, and removal of foreign objects such as fallen tree limbs and piles of leaves along the fence.

Is the system safe?

Yes. In fact, among the leading options in perimeter security, Electric Guard Dog is the safest solution. Unpredictable behavior makes dogs and guards a liability risk, yet our voltage is far below international standards for safe electric fencing.

Electric Guard Dog zaps intruders with an extremely short but intolerable 7,000-volt pulse every 1.3 seconds ñ long enough to jolt a person off or away from the fence but too short to be a cardiovascular threat.

What happens if there is a problem with my system?

Sentry's technical support center can be called 24 hours a day to assist with any operational issues that arise. In the rare event we canít solve a problem over the telephone, our nationwide field service organization can be promptly dispatched to resolve issues on site.

Is the system prone to false alarms due to wild animals, bad weather, high winds, or debris?

No. Our patented design minimizes nuisance alarms caused by birds, small animals and weather ñ common pitfalls of alternative perimeter security systems. A key failsafe on our system withholds alarm signals until a voltage change continues for a preset timeframe. This eliminates nuisance alarms caused by isolated blips, and ensures that alarm signals are reserved for genuine intrusion and tampering efforts.

What are the start-up and operating costs?

Start-up costs are very low compared to other perimeter security solutions. The customer must provide a structurally sound ìouterî perimeter fence ñ something already present on most potential sites. Sentry owns and services all the essential Electric Guard Dog materials, though the additional, third-party items may be added at the customer's choice and customer's expense.

Operating costs are negligible because Electric Guard Dog is powered by a 12-volt marine (DC) battery continuously charged by a solar panel(s). Traditional power sources (the grid) may be used as a backup measure or to assist in charging the battery ñ options that would not noticeably increase energy costs.

Is the Sentry system compatible with other security systems and equipment?

Yes. Our system can be installed as a stand-alone perimeter system or integrated with other access control systems and security components such as motion detectors, lighting and cameras.

Can the system control employee access for different security zones?

Yes. The system can be configured in multiple zones, with tiered accessibility linked to employee code authorization levels ñ all typically controlled via keypads or magnetic card-readers.

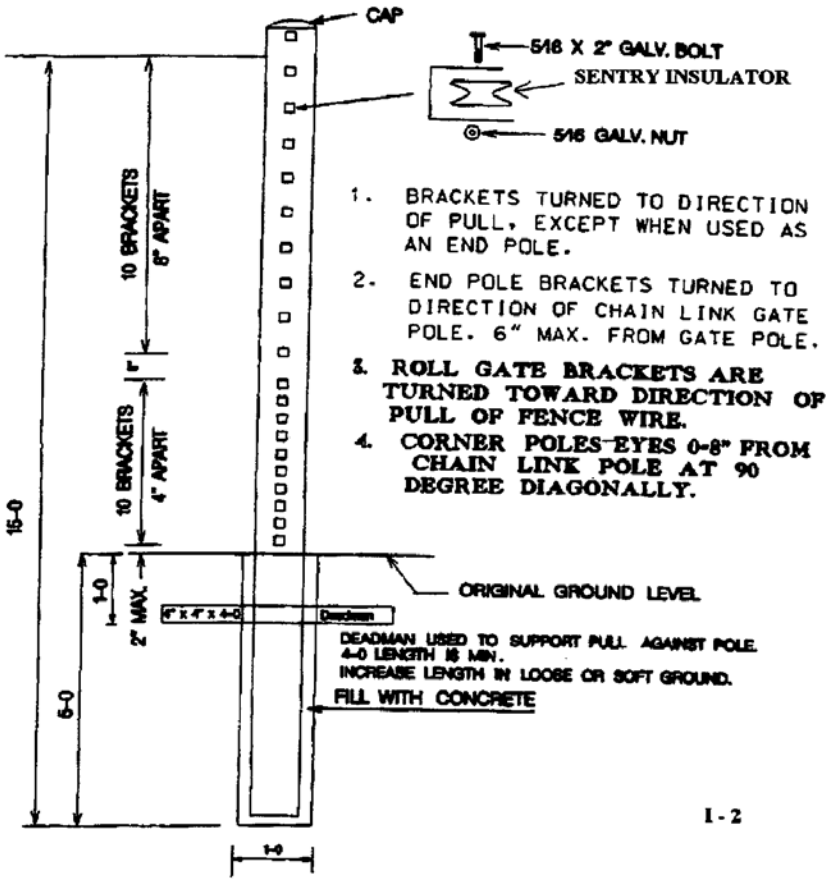
What Do I Need to Do Before My Location is Ready for The Electric Guard Dog™ System?

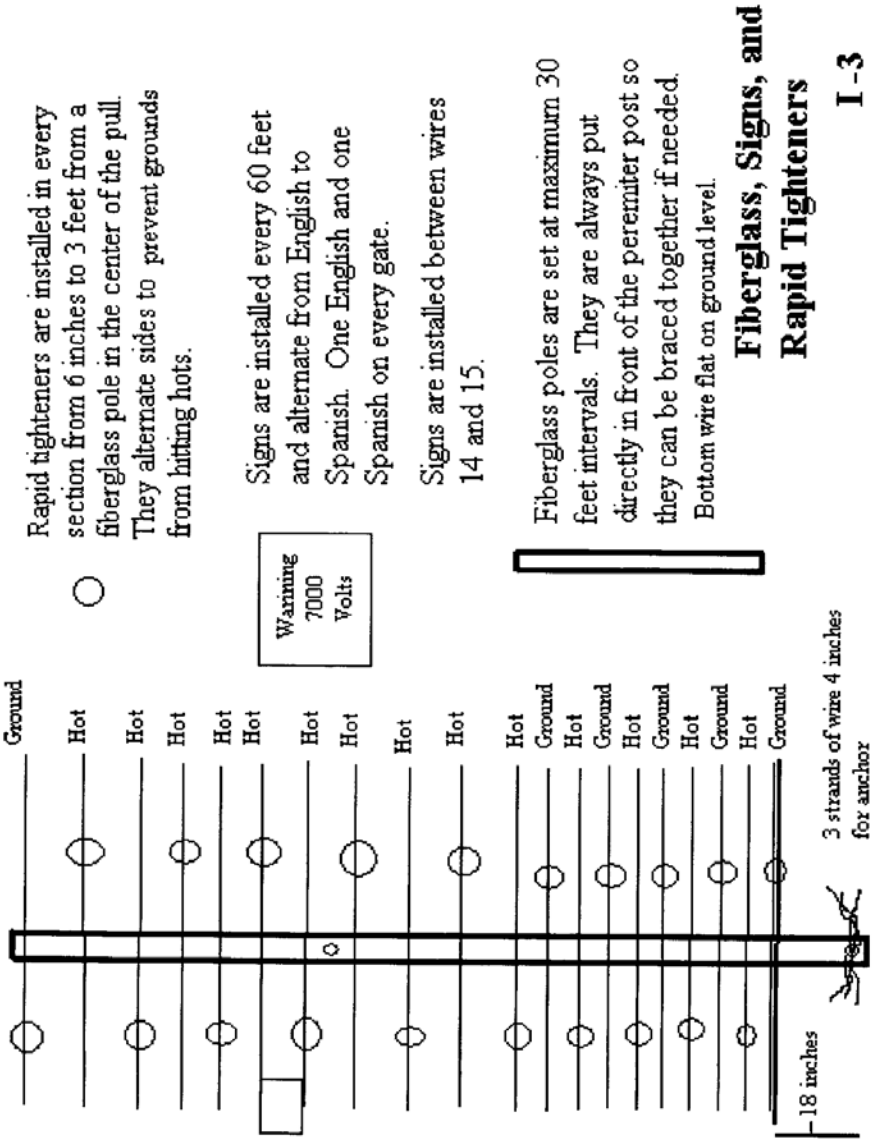
_____

_____

_____

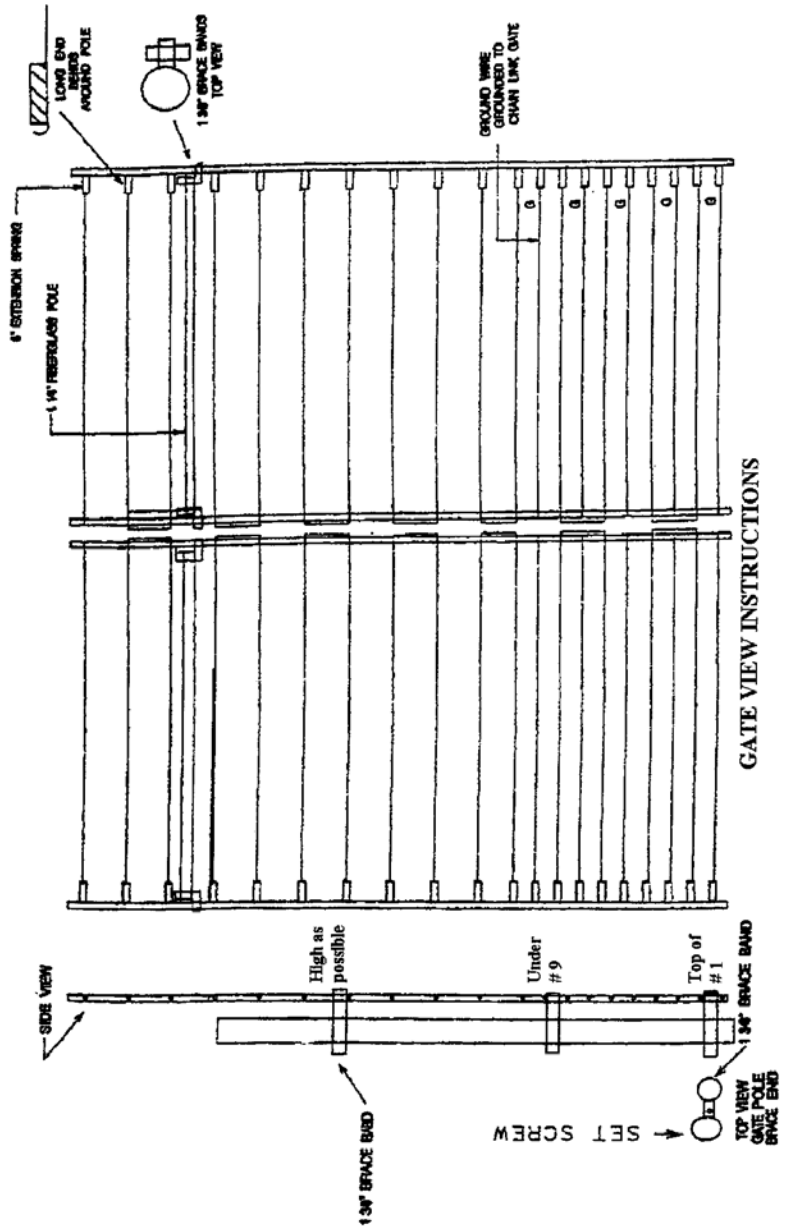
_____


CAP
5/16 X 2" GALV. BOLT
SENTRY INSULATOR
5/16 GALV. NUT
10 BRACKETS 8" APART
10 BRACKETS 4" APART
15-0
1-0
2" MAX.
6-0
1-0
ORIGINAL GROUND LEVEL
DEADMAN USED TO SUPPORT PULL AGAINST POLE. 4-0 LENGTH IS MIN. INCREASE LENGTH IN LOOSE OR SOFT GROUND.
FILL WITH CONCRETE
1. BRACKETS TURNED TO DIRECTION OF PULL, EXCEPT WHEN USED AS AN END POLE.
2. END POLE BRACKETS TURNED TO DIRECTION OF CHAIN LINK GATE POLE. 6" MAX. FROM GATE POLE.
3. ROLL GATE BRACKETS ARE TURNED TOWARD DIRECTION OF PULL OF FENCE WIRE.
4. CORNER POLES-EYES 0-8" FROM CHAIN LINK POLE AT 90 DEGREE DIAGONALLY.
I-2



Fiberglass, Signs, and Rapid Tighteners

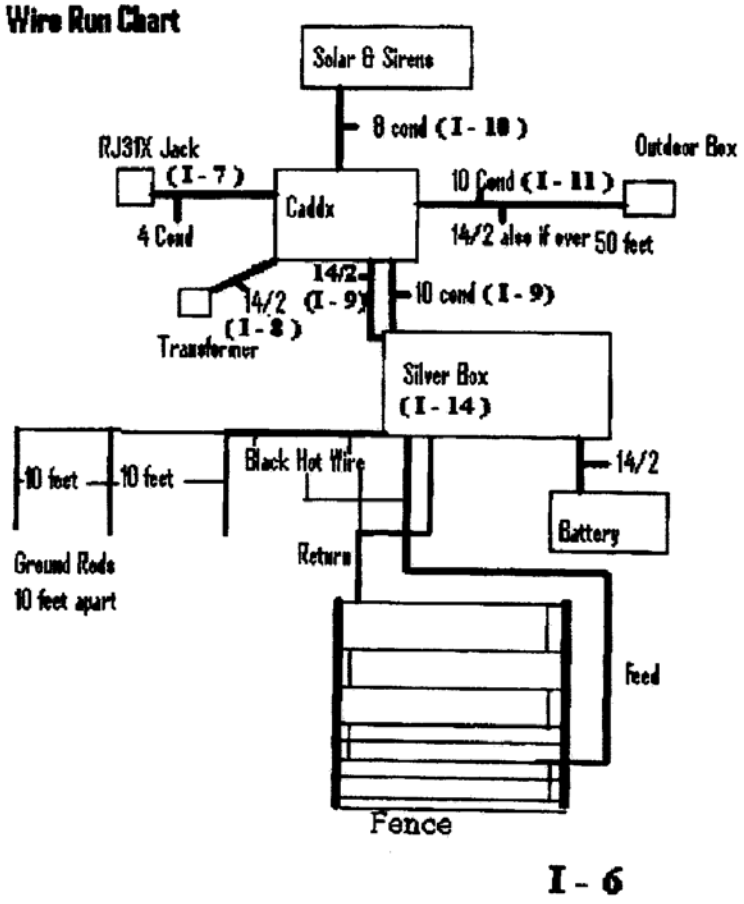
I -3

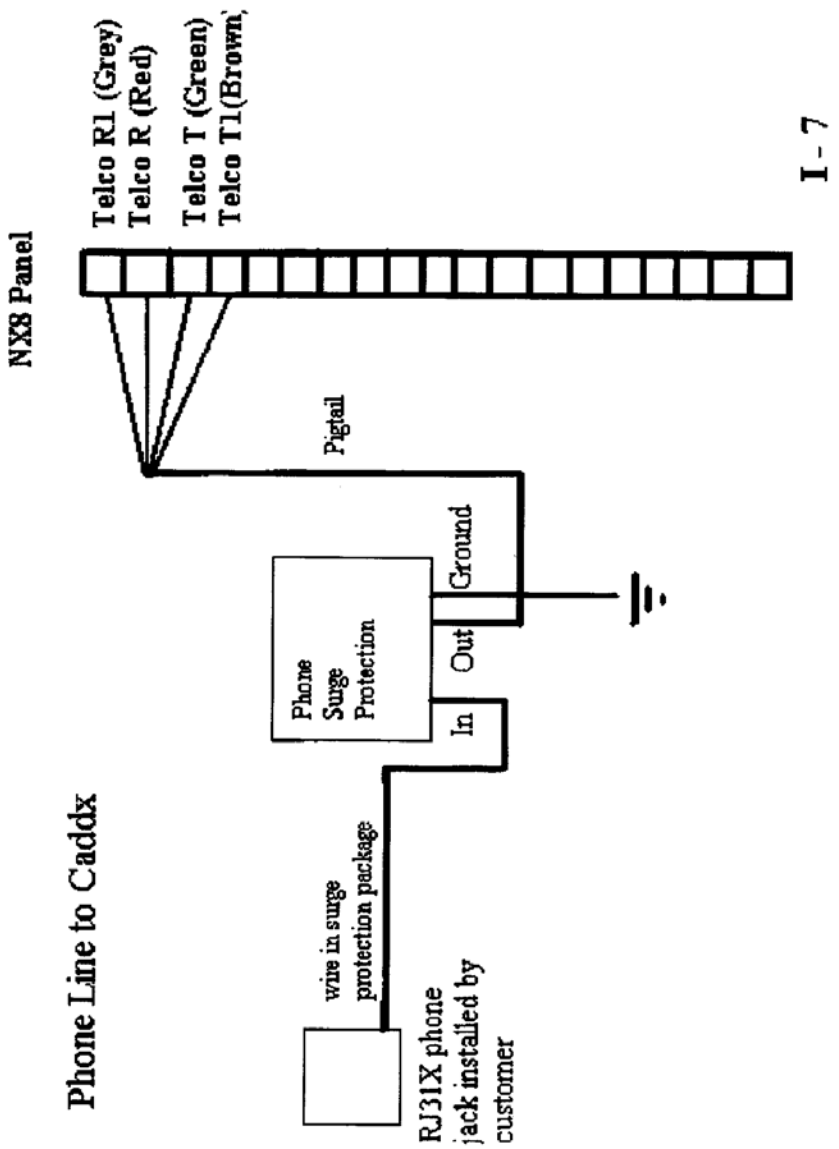


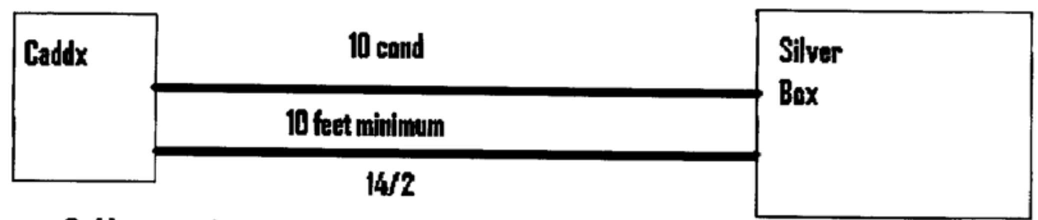
GATE VIEW INSTRUCTIONS

1. BRACE BANDS ARE LOCATED ON TOP OF #1, UNDER #9, AND AS HIGH ON THE CHAIN LINK AS POSSIBLE.
2. SPRINGS ARE LOCATED ON OPPOSITE SIDE OF LOCK.
3. ALL FIBERGLASS ON GATES ARE 1 1/4 INCH POLES.
4. ALL CONTACTS MUST INCLUDE SPRING.
5. ALL CONTACTS MUST HAVE BOLT THROUGH FIBERGLASS (NO SET SCREWS).
6. ALL BRACE BANDS HOOKED TO CHAIN LINK MUST HAVE SET SCREW.
7. EVERY GATE PANEL MUST HAVE A SIGN.
8. ALL GATE CONTACTS MUST BE MADE TO MAKE CONTACT WHEN CLOSED BY A BLIND PERSON.

I - 4


Wire Run Chart
Solar & Sirens
8 cond (I - 10)
RJ31X Jack
(I - 7)
Outdoor Box
Caddx
10 Cond (I - 11)
4 Cond
14/2 also if over 50 feet
14/2
(I - 9)
10 cond (I - 9)
14/2
(I - 8)
Transformer
Silver Box
(I - 14)
10 feet
10 feet
Black Hot Wire
14/2
Battery
Ground Rods
10 feet apart
Return
Feed
Fence
I - 6


Telco R1 (Grey)
Telco R (Red)
Telco T (Green)
Telco T1(Brown)
NX8 Panel
I - 7
Pigtail
Ground
Phone
Surge
Protection
Out
In
wire in surge
protection package
RJ31X phone
jack installed by
customer
Phone Line to Caddx



Caddx connections

Red: wire nut to end of diode with red soldered to panel
Black: wire nut to black wire soldered to panel and hook to COM
Green: Zone 3 (fence alarm)
Yellow: com through resistor (fence alarm)
White: wire nut to white from outdoor box
Brown: wire nut to brown from outdoor box
Grey: wire nut to grey from outdoor box
Purple: wire nut to purple from outdoor box
Orange: wire nut to orange from solar panel
Blue: wire nut to blue from solar panel

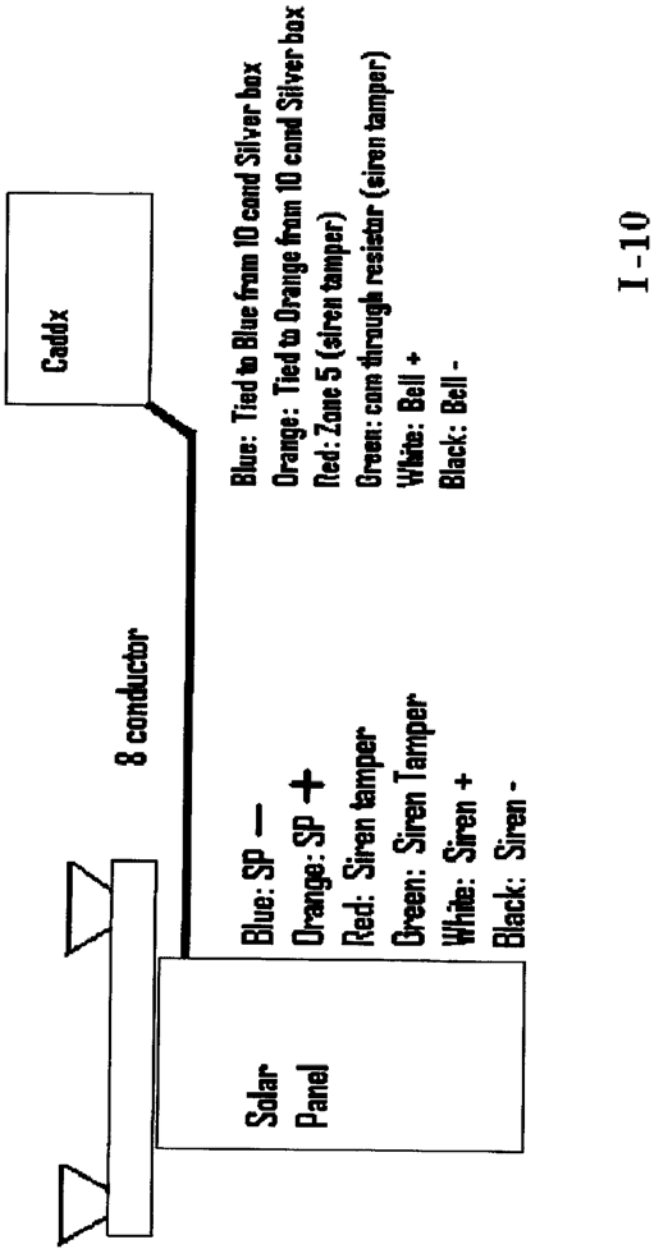
Key Switch Relay (see specialty wiring)
14/2 Red: Zone 7 (Key Switch Relay)
14/2 Black: Common Zone 7 through resistor (Key Switch Relay)

Silver box connections

Red: screw 18 (caddx +)
Black: screw 11 (caddx -)
Green: common on positive side of fence relay
Yellow: normally closed on positive side of fence relay
White: screw 4 (LED +)
Brown: screw 9 (LED -)
Grey: screw 3 (Key Switch Return)
Purple: screw 17 (Key Switch Feed)
Orange: wire nut to (solar +) for sun selector
Blue: wire nut to (solar -) for sun selector

Key Switch Relay (see specialty wiring)
14/2 Red: Normilly open on positive side of relay
14/2 Black: Comman on Positive side of relay

I - 9


Caddx
8 conductor
Blue: Tied to Blue from 10 cond Silver box
Orange: Tied to Orange from 10 cond Silver box
Red: Zone 5 (siren tamper)
Green: com through resistor (siren tamper)
White: Bell +
Black: Bell -
Solar Panel
Blue: SP —
Orange: SP +
Red: Siren tamper
Green: Siren Tamper
White: Siren +
Black: Siren -

I-10


Outdoor Box to Caddx Wiring Hook-up
outdoor box
10 conductor
run a 14/2 also if over 50 feet
Caddx
Red: Keypad +
Black: Keypad -
Green: Keypad data
Yellow: Keypad clock for 8900 panel
White: LED +
Brown: LED -
Orange: Tamper button
Blue: Tamper button
Purple: Key Switch Feed
Grey: Key Switch Return
14/2 Red: Hook with Purple Key Switch Feed
14/2 Black: Hook with Grey Key Switch Return
Red: Keypad +
Black: Keypad -
Green: Keypad Data
Yellow: Keypad Clock for 8900 panel
White: Wire nut to White to silver box
Brown: Wire nut to Brown to silver box
Orange: Zone 6 (Outdoor Box Tamper)
Blue: Zone 6 com through resistor (OD Box Tamper)
Purple: Wire nut to Purple to Silver Box
Grey: Wire nut to Grey to Silver Box
14/2 Red: Wire nut with Purple to Purple to Silver Box
14/2 Black: Wire nut with Grey to Grey to Silver Box

I - 11