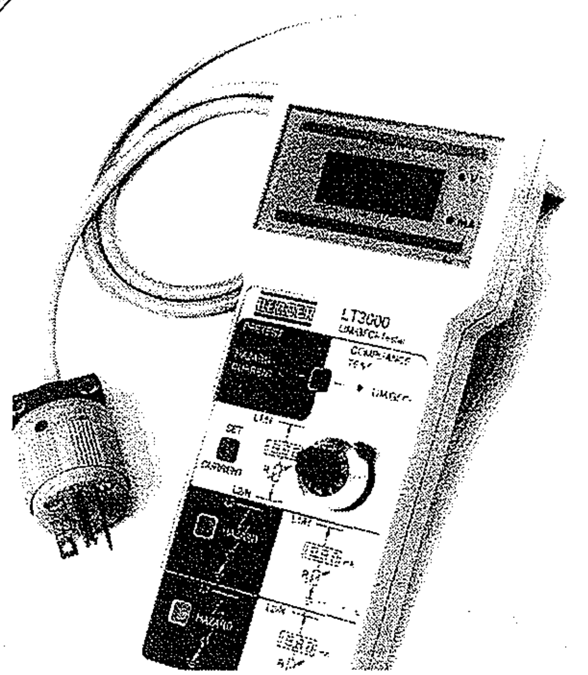
BENDER



LT3000

ISOLATED POWER

PORTABLE CHECK-OUT AND DIAGNOSTIC TEST SET
FOR
HEALTH CARE FACILITIES

USER MANUAL

50 YEARS EXPERIENCE WITH ELECTRICAL SAFETY PRODUCTS

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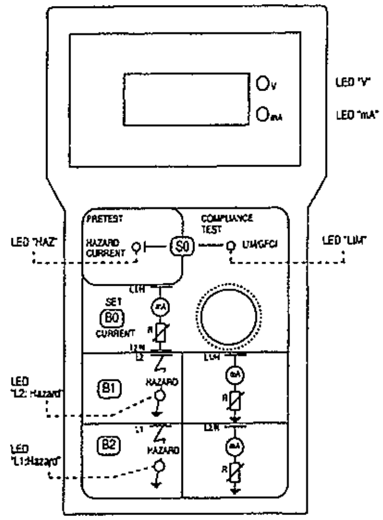
QUICK USER CHART

ISOLATED POWER

There are two modes of operation: 1. The PRETEST mode, and 2. The COMPLIANCE TEST mode. It is first necessary to run the PRETEST mode to find out if there is any single fault that exists and that might not have been detected because of a faulty LIM. A 1st fault causes an Isolated Power supply to behave like a grounded system. This fault should be cleared as soon as possible before a 2nd fault occurs. A 2nd fault creates a short-circuit in the ground loop which, depending on its magnitude, may or may not be cleared by the branch circuit protection equipment. If undetected, it is a source of hazard for personnel and property alike.



NFPA 99 requires that the LIM circuit be tested after installation on a regular basis. The LT3000, when used in the COMPLIANCE TEST mode, simplifies this procedure and is equally easy to use regardless of the magnitude of the system voltage. Plug the LT3000 into any Isolated Power receptacle. When first plugged in, the LT3000 displays the line voltage. If the LCD display is BLANK: 1. Check that the associated circuit breaker is ON and operational, 2. Check for a faulty receptacle, and 3. Check for an OPEN in one of the two Isolated Power conductors.

PRE-TEST

PRELIMINARY ⇒ PUSH SELECTOR BUTTON **S0** UNTIL **"HAZARD CURRENT"** LED ILLUMINATES

TEST SEQUENCE	ACTION	OUTCOME	LCD READ-OUT
Step #1	Press and hold **B1** Note: Disregard LIM alarm	A. "L2:HAZARD" LED is OFF B. "L2 HAZARD" LED is ON Note: Outcome B indicates system fault or excessive leakage on L2. Check LIM and system before proceeding any further	< 5 mA > 5 mA Note: Current is limited to 12 mA
Step #2	Press and hold **B2** Note: Disregard LIM alarm	A. "L1 HAZARD" LED is OFF B. "L1 HAZARD" LED is ON Note: Outcome B indicates system fault or excessive leakage on L2. Check LIM and system before proceeding any further	< 5 mA > 5 mA Note: Current is limited to 12 mA

LIM COMPLIANCE TEST

PRELIMINARY ⇒ PUSH SELECTOR BUTTON **S0** UNTIL **"LIM/GFCI"** LED ILLUMINATES

TEST SEQUENCE	ACTION	OUTCOME	LCD READ-OUT
Step #1	Press and hold **B0** while turning the 10-turn pot	Adjust the potentiometer until 5 mA is displayed on the LCD read-out	5 mA as per NFPA 99
Step #2	Press and hold **B1**	The LIM meter will rise somewhat above 5 mA and there shall be both a visual and audible alarms	DISREGARD the LCD display
Step #3	Press and hold B2	The LIM meter will rise somewhat above 5 mA and there shall be both a visual and audible alarms	DISREGARD the LCD display

QUICK USER CHART

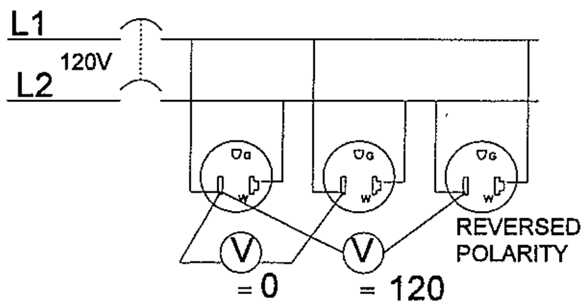
RECEPTACLE CHECK FOR REVERSED POLARITY

ISOLATED POWER

This procedure can be carried out without turning the power OFF. Three methods are presented here.

Method 1

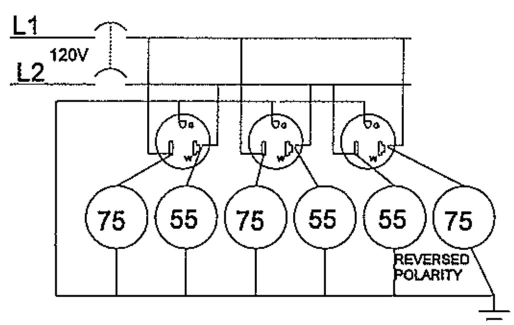
Connect a voltmeter between "like" blades on the receptacles. The wiring is consistent and proper if the voltmeter reads zero. Otherwise, there is a polarity reversal which should be corrected.



The disadvantage with this procedure is that two people are required to carry it out because of long distances between receptacles.

Method 2

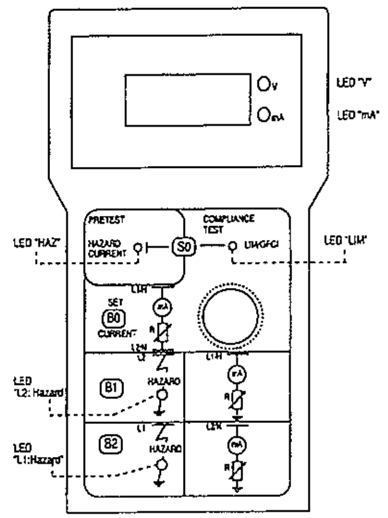
This procedure involves measuring the voltage between each isolated conductor and ground. The voltage between each "like" blade and ground should be the same unless some of the receptacles have reversed polarity.



QUICK USER CHART

GROUNDED POWER

NFPA 99 states that "If GFCIs are used, a device or component that causes 6 mA to flow to ground shall be momentarily connected between the energized conductor of the power distribution circuit being protected, and ground, to verify that the GFCI does indeed interrupt the power. If the test is performed when the system is in use on a patient, it must not endanger the patient even if the grounding circuit being tested is faulty".



NFPA 99 requires that GFCIs be tested at regular intervals. The LT3000 simplifies this procedure and is equally easy to use regardless of the magnitude of the system voltage. As a side benefit, it detects an "open" ground wire and a reversal of the "H" and "N" wires.

It is only necessary to plug the LT3000 into the GFCI receptable or any receptacle supplied by a GFI circuit breaker. When first plugged in, the LT3000 displays the line voltage. If the LCD display is BLANK: 1. Check that the associated branch circuit breaker is ON, and 2. Check that the GFCI is RESET.

GFCI COMPLIANCE TEST

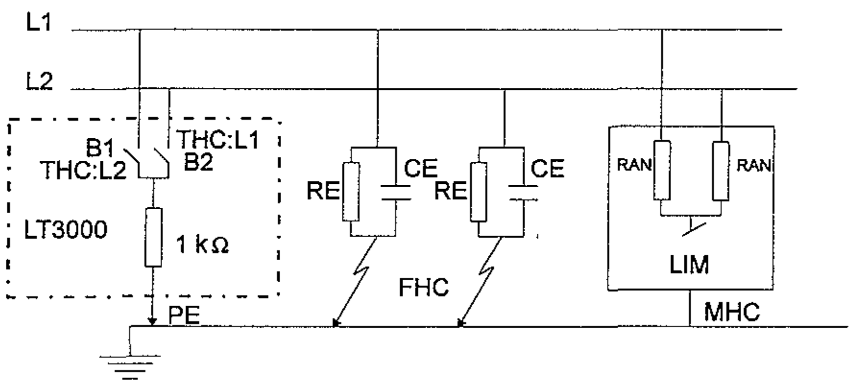
PRELIMINARY ⇒ PUSH SELECTOR BUTTON **S0** UNTIL **"LIM/GFCI"** LED ILLUMINATES

TEST SEQUENCE	ACTION	OUTCOME	LCD READ-OUT
Step #1	Press and hold **B0** while turning the 10-turn pot	Adjust the potentiometer until 6 mA is displayed on the LCD read-out	6 mA as per NFPA 99
Step #2	Press and hold **B1**	A. **The LCD read-out becomes BLANK** Depending on the design of the GFCI, as much as 7 seconds can elapse before it trips	BLANK
		B. **The LCD display reads 0 mA** This can happen if: 1. The ground wire is open, and/or 2. The "H" and "N" wires are reversed. The latter can be confirmed by pressing and holding B2 and observing the LCD display. It will be BLANK if "H" and "N" are reversed.	0 mA

LT3000
TECHNICAL INFORMATION

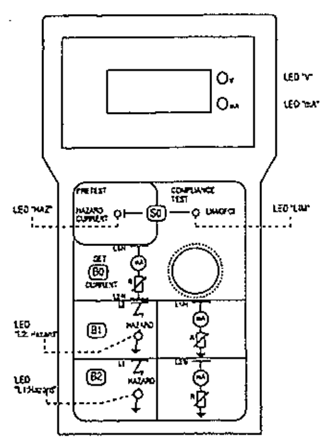
PRETEST MODE

A functional schematic is shown below,



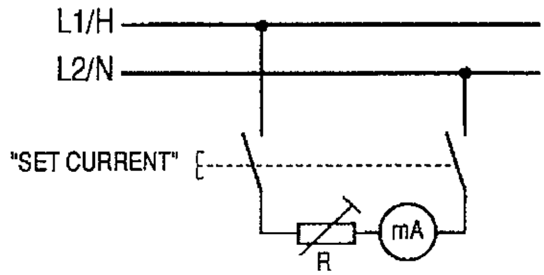
The impedance between each isolated power conductor and ground is comprised of the parallel combination of R_E and C_E. Generally the values will be different for L1 and L2.

Alternately depressing **B1** and **B2** causes the connection to be made between L1 and L2 as shown on the diagram. There is a built-in electronic element which automatically limits the current to 12 mA for a severe external fault.

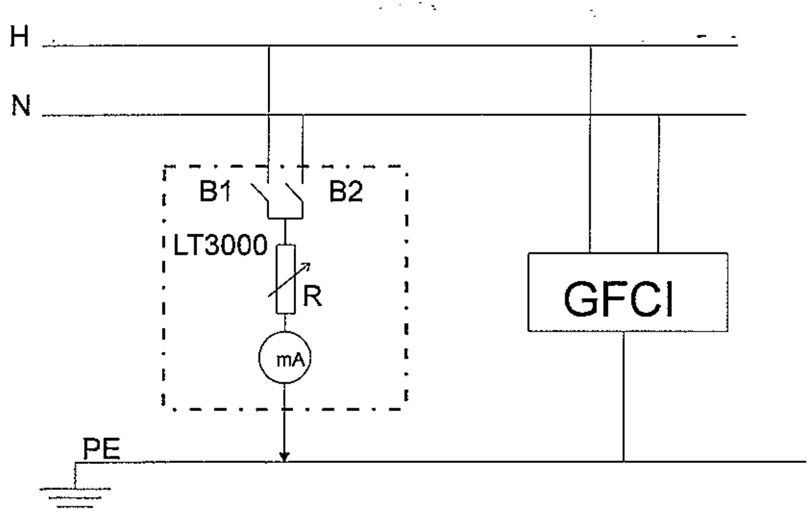


GFCI COMPLIANCE TEST MODE

The arrangement is similar to what is done in the LIM COMPLIANCE TEST MODE. It is first necessary to set the current to 6 mA as required by section 3-5.2.3.1 of NFPA 99 which states: "If GFCIs are used, a device or component that causes 6 mA to flow to ground shall be momentarily connected between the energized conductor of the power distribution circuit being protected, and ground, to verify that the GFCI does indeed interrupt the power. If the test is performed when the system is in use on a patient, it must not endanger the patient even if the grounding circuit being tested is faulty."



The test circuit is shown below. See **QUICK USER CHART** for more details on the actual procedure.



IMPORTANT LEAKAGE CURRENT DEFINITIONS

MONITOR HAZARD CURRENT

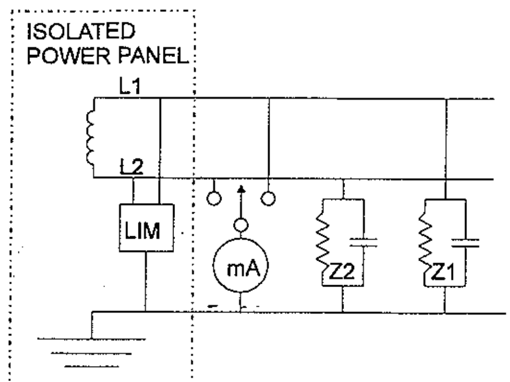
The Monitor Hazard Current (MHC) is the leakage current contributed only be the monitor (LIM) and indicators (remote and/or local). The MHC shall not exceed 1.0 mA.

FAULT HAZARD CURRENT

The Fault Hazard Current (FHC) is the leakage current contributed by the connected fault impedance only..

COMMENT: Each device that is plugged or wired into the Isolated Power supply contributes to the FHC. The current level is generally small and is normally due to capacitive coupling to ground. Nevertheless, even though it may only be in the microampere level, it is thought of as a fault that contributes to the make-up of FHC.

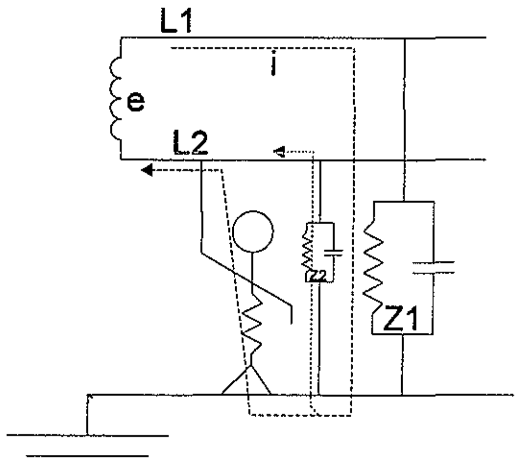
The fault load as seen by the Isolated Power supply (and the LIM) can be thought of as made up of two impedances each connected between an isolated power conductor (L1 and L2) and ground. Each impedance is made up of a resistive and capacitive component. In the real world, the impedance is mostly capacitive. The FHC component can be determined by taking a reading while alternately switching the milliammeter between L1 and L2. The LIM shall not alarm for a FHC of 3.7 mA or less.



TOTAL HAZARD CURRENT

The Total Hazard Current (THC) is the leakage current contributed by the monitor, remote and local indicators, field wiring, fixed and plugged-in medical apparatus. An alarm signal shall be obtained when the THC reaches a threshold value of not more than 5.0 mA. At the threshold value, the alarm condition shall be continuous.

The current that will flow through the person can be calculated from the sketch shown below,



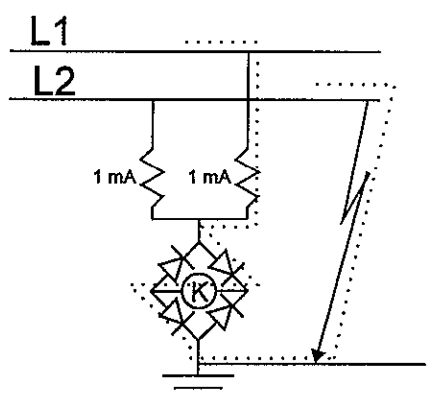
The impedance between L1 and ground will generally be capacitive even though it is shown as also having a resistive component. The maximum current in this instance is

$i_{max} = e/Z1$

From this background information, we can now proceed to explain the function of the LIM. Before we do that, it may be worthwhile to briefly review the types of LIMs that one might find if they were to look at various Isolated Power installations:

- <u>Ground Fault Detector</u>

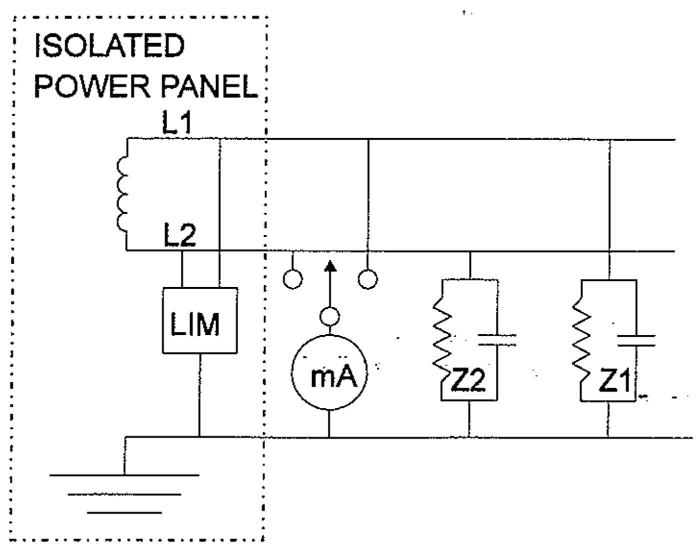
  The sketch below illustrates the concept,



Contacts associated with the relay "K" activate an alarm when the fault current exceeds a pre-determined level.

The Ground Fault Detector and Switching LIM are no longer sold although the installed base is high. The Switching LIM introduces electrical noise on the Isolated Power bus and is often a source of interference for sensitive medical devices that draw their power from the bus. For this reason, Switching LIMs are no longer allowed. The Ground Fault Detector is obsolete. Among its flaws is its inability to accurately predict the hazard current that could flow through a person who comes in contact with one of the two Isolated Power conductors. It also does not provide a continuous indication of the hazard current. In contrast, the modern LIM — as available from BENDER — is a powerful predictive device that accurately predicts the hazard current that could flow through a person. Its contribution to the Total Hazard Current is less than 35 μA. It accurately calculates the ***impedance*** between each Isolated Power conductor and displays the Total Hazard Current. There are no wire harnesses between the printed circuit boards which are designed using advanced printed circuit board technology. The result is a high performance device that is not only reliable but provides repeatability between measurements that is a must for this type of application.

Let us now see how the LIM works by examining the sketch below,



The LIM CONTINUOUSLY calculates the magnitude of the impedance between EACH isolated power conductor and ground. One of these will generally be smaller than the other. For this discussion, let us say that Z1 is the smallest of the two impedances Z1 and Z2. The current displayed on the LIM meter is e/Z1. This is a worse-case situation and represents tha MAXIMUM current that could flow through a zero ohm person that might come in contact with — in this example — the L2 isolated power conductor. The current would, of course, be less if the person made contact with the L1 conductor.

The LIM is a predictive device. In the above example with the two pieces of medical apparatus and the open ground bonding jumper, the LIM will correctly predict the current that would flow through the person making contact with the two devices **BEFORE** contact is actually made.

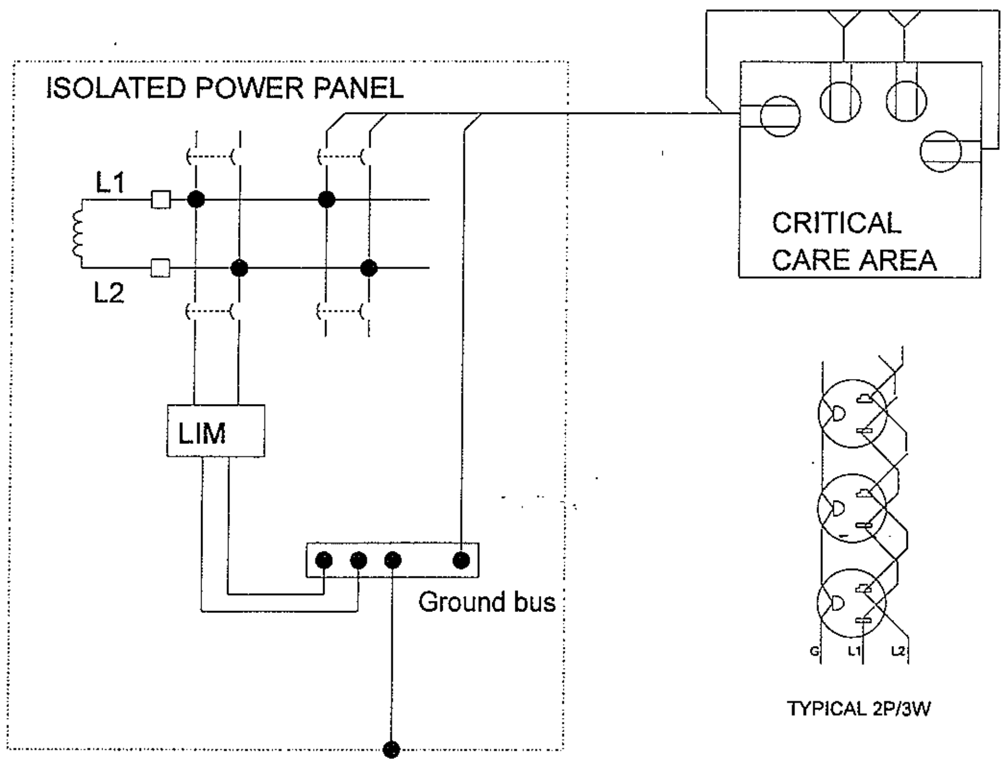
APPLICATION NOTE 2

NUISANCE ALARMS

DIAGNOSTIC PROGRAM FOR KEEPING NUISANCE ALARMS UNDER CONTROL

A typical Isolated Power distribution circuit is shown below. Branch circuits normally total between eight and sixteen. The majority of Isolated Power panels have a 5 or 7½ KVA rating. Tha sample panel shows 4 duplex receptacles connected to one of the branch circuits.

Wiring is one of the contributors to system leakage current. A medical device plugged into a receptacle also contributes to the leakage current. A heart lung machine, for



example, can contribute as much as 350-450 µA of leakage current.

A systematic approach is required to assess the significance of a nuisance alarm. The question that must be answered is: "Is it legitimate?" Was the system operating near "FULL ALLOWED LEAKAGE CURRENT LIMIT OF 5 mA" before the alarm? This could occur at a transformer current draw less than 100% of the design load.

The LT3000 is a powerful tool that can be used to understand the cause of nuisance alarms. Here is what needs to be done:

Step #4: Re-connect the LIM ground and repeat Step #3. The higher readings constitute the LIM contribution to the leakage current.

Step #5: Unplug all cord-connected apparatus from the receptacles that are supplied by this panel. Close all circuit breakers and repeat Step #3. Identify the one or more branch circuits that are causing, if any, a significant change in the current readings. Note the circuits.
Note: Most apparatus have a single pole switch. Therefore, it will not be possible to identify the leakage current contribution of fixed-mounted equipment unless the other conductor (normally the "neutral" wire) is temporarily disconnected.

Step #6: Make a record of the leakage current contributed by various medical apparatus that draw their power from this panel. This information will be valuable when assessing the significance of nuisance alarms, especially when the LIM reading is near the "alarm zone".

Tables 1, 2, and 3 have been prepared as possible guides for collecting leakage current data on Isolated Power panels, associated distribution circuits, and medical apparatus. Possessing this data should significantly reduce the task of assessing the significance of nuisance alarms. Partially filled-in samples are also included as an aid to the first time user.

TABLE 2
BRANCH CIRCUIT RECEPTACLE/APPARATUS SCHEDULE

BRANCH CIRCUIT	A1	A2	A3	A4	TOTAL µA
APPARATUS TYPE					
BRANCH CIRCUIT	B1	B2	B3	B4	TOTAL µA
APPARATUS TYPE					
BRANCH CIRCUIT	C1	C2	C3	C4	TOTAL µA
APPARATUS TYPE					
BRANCH CIRCUIT	D1	D2	D3	D4	TOTAL µA
APPARATUS TYPE					
BRANCH CIRCUIT	E1	E2	E3	E4	TOTAL µA
APPARATUS TYPE					
BRANCH CIRCUIT	F1	F2	F3	F4	TOTAL µA
APPARATUS TYPE					
BRANCH CIRCUIT	G1	G2	G3	G4	TOTAL µA
APPARATUS TYPE					
BRANCH CIRCUIT	H1	H2	H3	H4	TOTAL µA
APPARATUS TYPE					
BRANCH CIRCUIT	I1	I2	I3	I4	TOTAL µA
APPARATUS TYPE					
BRANCH CIRCUIT	J1	J2	J3	J4	TOTAL µA
APPARATUS TYPE					
BRANCH CIRCUIT	K1	K2	K3	K4	TOTAL µA
APPARATUS TYPE					
BRANCH CIRCUIT	L1	L2	L3	L4	TOTAL µA
APPARATUS TYPE					
BRANCH CIRCUIT	M1	M2	M3	M4	TOTAL µA
APPARATUS TYPE					

CODE:

- A, B, C… REFERS TO THE BRANCH CIRCUIT
- A1, A2, A3…B1, B2, B3…REFERS TO A PARTICULAR RECEPTACLE ON BRANCH CIRCUITS "A", "B", ETC
- "TOTAL" = TOTAL LEAKAGE CURRENT ON THAT PARTICULAR BRANCH CIRCUIT

TABLE 1
GENERAL ISOLATED POWER PANEL DATA
SAMPLE

ISOLATED POWER PANEL LOCATION	OR #5
ISOLATED POWER PANEL ELECTRICAL DATA	
• KVA	7½
• PRIMARY/SECONDARY VOLTAGE	208/120 SINGLE PHASE
• # OF BRANCH CIRCUITS	12
GENERAL LEAKAGE CURRENT DATA:	
• MONITOR HAZARD CURRENT (MHC)	35µa
• TOTAL HAZARD CURRENT (THC)	
* ALL CIRCUIT BREAKERS OFF	50 µa
* ALL CIRCUIT BREAKERS ON	2.10 mA
• LEAKAGE CURRENT CONTRIBUTION OF PANEL & TRANSFORMER[2]	15µA

2 This current should roughly equal (THC - MHC)

TABLE 3
APPARATUS LEAKAGE CURRENT DATA
SAMPLE

TYPE OF DEVICE	DESIGNATION	SERIAL #	LEAKAGE CURRENT — μA
Vacuum pump	M1	37329	110
Electro-surgery machine	M2	38732	210
Physiological monitor	M3	39435	150
Heart lung machine	M4	40675	400
Defibrillator	M5	51900	75
Respirator	M6	67432	110
Hyperthermia unit	M7	35896	162