ISOLATED POWER IS NOT THE SOLUTION TO ELECTRICAL HAZARD PROBLEM

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ABSTRACT

Although direct contact with hazardous electrical systems is designed to be improbable, certain instances exist where human beings are intentionally and purposefully bound and attached to electronic and other systems which, in turn, are intimately connected to vast, distributed electrical systems.

In modern hospitals, the frequency of such instances is increasing and the hazards are being compounded. To prevent a corresponding increase in the rate of mortality and morbidity due to this clause, we

(1) define the electrical hazard with regard to
  a - shocks
  b - burns
  c - fibrillation
  d - arrest
(2) criticize the thoughtless extension to such areas as post-operative recovery rooms and intensive care units of electrical practices intended for application in areas where explosive materials are used or stored, and
(3) recommend an economically realistic approach which provides true protection against the flow of small currents instead of only warning of a non-existent possibility of explosion.

This approach is embodied in isolating, not the electrical system from ground, but in isolating the patient from ground and the electrical system.

Electric power by its very nature is hazardous to living organisms. The hazards are well recognized and separate into roughly two categories, shock and fire. To minimize the probability of accidental contact with hazardous electrical power sources and to reduce the possibility of fire spreading from faulty electrical apparatus, electrical installations must meet the minimum requirements established by certain electrical codes. In Canada, this is the Canadian Electrical Code[1] (CE Code); in the United States, the National Electrical Code.[2]

In areas where explosive dusts, vapours or gases may be encountered special precautions must be taken and separate sections of the CE Code specify safety requirements for these areas. The requirements pertaining to explosion hazard locations in hospitals are covered by Section 24 of the CE Code and by CSA standard Z32.

Although some requirements for equipment intended to be electrically connected to the body have been written,[3] as yet no code specifies mandatory or even recommended minimum standards of practice when a human being is intentionally and purposefully bound and attached to electronic and other systems. Clearly a gap exists between safe electrical practice on the electric power distribution system together with its connected appliances and safe medical-electronic practice on the patient. In effect, the sources of all electrical hazards to a patient are the pieces of electrical and electronic equipment with which he casually or purposefully comes in contact. In modern hospitals, the frequency of such instances is increasing and the hazards are being compounded.

ELECTRICAL HAZARDS

Human beings exposed to electric power may suffer either shocks, burns, fibrillation, or arrest, or a combination of these.

i) Shocks are involuntary muscle and neural reactions stimulated by an electric current.
ii) Burns are tissue damage resulting from the heat generated by an electric current flowing through tissue.
iii) Cardiac fibrillation is a state of activity characterized by ineffective, unorganized and rapid contractions.
iv) Cardiac arrest is a state characterized by a total lack of spontaneous activity.

While shocks may be quite innocuous, the morbidity of a burn depends on the magnitude of the current and the duration of exposure, and inversely on the cross-sectional area through which the current passes. Electrically induced fibrillation and arrest, unless reversed, result in death by electrocution.

SOLUTIONS

Unlike the cure to pain induced by beating your head on a wall, the relief to electrical hazards is not to stop the use of electricity but, to isolate the patient from the power source. Since by and large the patient is never connected directly to the source, but only indirectly to it by the equipment to which he is attached, then the onus of responsibility for isolating the patient must lie mainly on the equipment to which he is directly bound and attached. This is patient isolation and it differs in purpose from power and system isolation.

THREE TYPES OF ISOLATION

Three types of isolation sketched in Fig. 1 are frequently encountered. System isolation differs from power isolation only on the secondary side of the isolation transformer. Most areas employ the grounded three wire distribution system. Special areas where flammable or explosive agents are used employ an ungrounded three wire distribution system. Usually a dynamic ground fault detector (GFD) monitors the leakage impedances between each power line and the ground system and sounds a defeatible alarm when the impedance level drops below 100 to 120 kΩ. With such isolation a fault which grounds one power line will not produce a spark of sufficient energy to ignite a flammable or explosive mixture, it is believed.

Patient isolation is usually achieved by complicated but inexpensive electronic means and effectively ensures that wires and other conductive paths connected to a patient are virtually completely unassociated or isolated from the equipment ground or its power source.

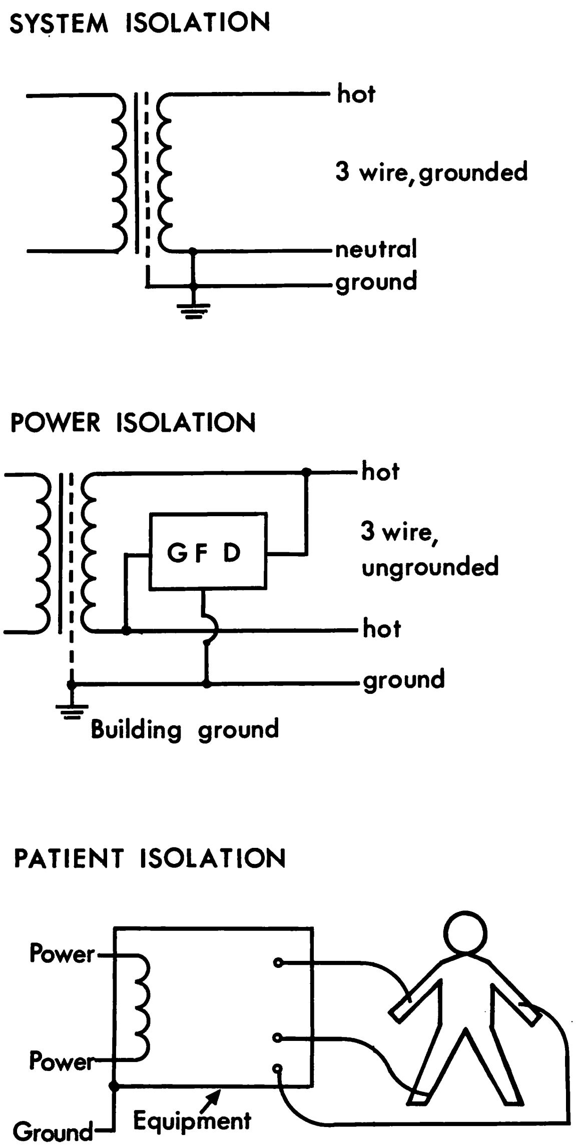

Fig 1

No connections, no hazards.

It makes no difference whether such patient-isolating equipment receives power from a three wire grounded or a three wire ungrounded system.

<u>GROUND</u>

The purpose of the third or grounding wire is to ensure that the cases, chassis and other conducting surfaces of the immediate electrical environment are all held at the same potential. To achieve this condition, we must ensure that sizeable currents do not flow through the grounding system; otherwise, the voltage drops across the non-negligible resistances of this system defeat the intention of an equipotential environment. Properly designed and operated equipment does not introduce ground currents, however, certain electrical failures within the equipment might introduce substantial ground currents which create a hazard but otherwise do not noticeably affect the operation. A ground fault interrupter (GFI) will ensure that such failures never introduce more than 1 mA, say, of ground current before the flow of power to a hazardous instrument is interrupted.

<u>CONCLUSIONS</u>

Each environment poses its own peculiar hazards. Judging the extent to which we must provide protection is difficult because ideally we should eliminate the possibility rather than reduce the probability of electrical morbidity and mortality. An economically realistic approach which provides true <u>protection</u> against the flow of small currents instead of only <u>warning</u> of a non-existent possibility of explosion is demanded. This approach is embodied in isolating, not the electrical system from ground, but in isolating the patient from ground and the electrical system and simultaneously disconnecting from the power source, equipment and instruments which become defective as a result of ground faults.

<u>REFERENCES</u>

1) CSA Standard C22.1-1969. Canadian Electrical Code Part 1 (Tenth Edition). Cdn. Stds. Ass., Ottawa (1969).
2) National Electrical Code Handbook. McGraw-Hill, New York.
3) CSA Standard C22.2 No. 125-1964. High Frequency Therapeutic and Electro-Surgical Equipment (First Edition). Cdn. Stds. Ass., Ottawa (1964).