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Installation of an Ocular Fluorophotometer into the Hyperbaric Chamber

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Woodrow AD, Milligan ML. Installation of an ocular fluorophotometer into a hyperbaric chamber. J Hyperbaric Med 1991; 6(1):5–9.—Installation of the fluorophotometer in the hyperbaric chamber has expanded the capability to diagnose and evaluate central serous retinopathy and related ophthalmologic disorders. Safety and chamber adaptability were two critical elements evaluated before installation. The accurate function of this electro-optical equipment under hyperbaric conditions was the final measure of effective planning and installation.

ocular fluorophotometer, hyperbaric chamber

Introduction

Research of physiologic processes that occur or are modified in the hyperbaric environment is an essential element to the development and reinforcement of the efficacy of hyperbaric oxygen (HBO) therapy. Each new protocol using HBO often requires a piece of medical instrumentation that has not yet been approved for use under the conditions existent in a pressurized chamber. Too often, researchers presume that the performance of equipment they are familiar with in the normobaric setting will be unchanged at pressures greater than sea level. However, before any instrument is introduced for use in the hyperbaric chamber, thorough evaluations must address its safety, effectiveness, and serviceability in the high pressure environment. This paper reviews general guidelines to follow when evaluating equipment, specifically the introduction of the ocular fluorophotometer to a clinical hyperbaric chamber.

The Department of Hyperbaric Medicine at USAF Medical Center at Wright-Patterson AFB recently installed a coherent ocular fluorophotometer (Fluorotron) for use in a protocol studying the effect of HBO on retinal vascular disorders. For the purpose of this study, the instrument is operated only at sea level or at 45 fsw (2.4 atm abs). The Fluorotron, model FM-2, is a multicomponent instrument composed of the optic head, a computer (PC) with disc drive, printer, and power ribbon cables. It is an electro-optical

instrument used for objectively measuring fluorescein concentrations in the eye. The optic head is located in the lock portion of an interconnected three chamber system. During fluorescein angiography, subjects leave their breathing stations in the main chamber, enter the lock chamber for the retina scan, then return to their position in the main chamber.

The Fluorotron is designed to detect retinal vascular disorders before ophthalmoscopic signs are present, and to monitor the progress of treatment in the control of the disease. Other applications include detection and diagnosis of retinitis pigmentosa, macular edema, hypertension, pars planitis, and optic neuritis (1).

Materials and Methods

The evaluation and configuration of the system included electrical safety, integrity of pressure barrier around a modified hull penetrator, and security of the interface between the optic head and PC at sea level as well as under pressurized conditions. Because the unit is run on 110 AC power, a review of National Fire Protection Agency (NFPA) guidelines and manufacturer's operating instructions was accomplished before any modifications or installation occurred. The NFPA 99, Health Care Facilities, covers utilization of electrical equipment in the hyperbaric chamber in sections 19-2.7.2.1 and 19-2.8.3. All chamber interior 110 AC power receptacles are explosionproof as per manufacturer specifications, and their power is fed from an isolated breaker panel with a ground fault interrupter (2). The receptacle boxes and conduit are purged with an inert gas (nitrogen) at a flow rate maintained at 7 in. of water pressure above chamber pressure. As stated in the NFPA publication, when the percent by volume of oxygen in the chamber exceeds 23.5%, all equipment used in the chamber must be specifically designed for function in an environment of 100% oxygen at 3 atm abs. When the percent by volume of oxygen in the chamber is less than 23.5%, as is the case with this chamber system, the equipment must be purged with nitrogen or be categorized as intrinsically safe for that atmosphere (3). Additional references in NFPA 70, National Electrical Code, reinforce the requirements for equipment in the hyperbaric environment to be explosionproof or intrinsically safe (4).

Evaluation of the Fluorotron's optic head and pass-through power ribbon by the system manufacturer and the Naval Facilities Engineering Command (NAFEC) determined that all safety specifications were met for this unit. NAFEC is the certifying agency for all Department of Defense clinical hyperbaric chambers and reserves the approval of equipment installation and chamber modifications for case-by-case evaluation.

The first task confronted while evaluating the actual installation was providing a safe power source to the optic head and linking the PC to the scanning hardware. The optic head power is supplied from an interior electrical receptacle and has a 37-pin ribbon cable attached for communication to the com-

puter located outside the chamber. Modification of a standard brass hull penetrator allows the ribbon cable passage through the chamber wall. The penetrator was machined to accommodate an electrical insert containing 60 no. 22 AWG wires to allow interface between the optic head and the central processing unit (CPU) positioned outside the chamber pressure boundary (Fig. 1). Once the penetrator was complete and installed in the vessel wall, waterproof, explosionproof junction boxes were mounted to the penetrator, and DB36 pin connectors were mounted in the junction boxes to allow the hook-up from the computer to the optic head through the pressure vessel wall.

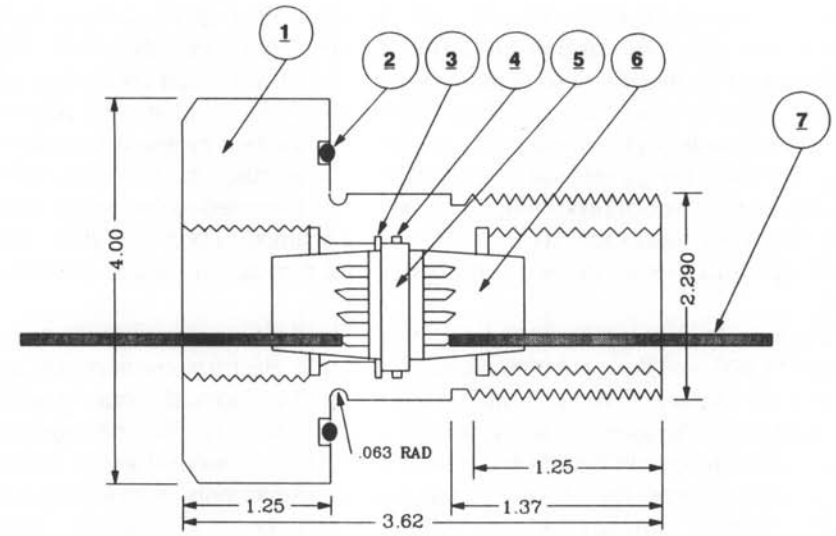
The junction box inside the chamber was also modified to accept a nitrogen purge (a 600 cm^3 flow of 100% nitrogen over the electrical connections) to reduce the danger of oxygen build-up in areas of the electrical contact points. An additional nitrogen line was routed to the optic head to allow nitrogen to flow across the circuit boards and other electrical components located under its protective cover. The nitrogen, once past the components, is ventilated out of the chamber through the chamber ventilation system to maintain a safe environment of 21% oxygen at all times.

Once completely installed, the unit was run through a battery of functional tests using the scanning procedures described in the manufacturer's operating manual (5). Each test was accomplished both at sea level pressure and again at 2.4 atm abs (45 fsw) in accordance with the protocol profile (6). Because the instrument is not intended to operate during pressure changes, evaluation was accomplished only at steady pressures. For optimum effectiveness of Fluorotron scanning, the chamber had to be completely darkened. This was accomplished by inserting foam circles, cut from 3-in.-dense foam, into each chamber viewport to block out external room lighting, and by dialing the rheostats of the interior lights down to 0%. The Fluorotron scanning program was run through various options including retina scanning, saving patient data, printing of graphs from each scan, and establishing new patient files.

Before activating the Fluorotron and associated hardware, the oxygen supply was shut off at the built-in-breathing-system selector panel to prevent any excess oxygen build-up in the chamber. Following approved protocol profiles, equipment evaluations were then completed at 2.4 atm abs (45 fsw) with no indication of component failure.

Summary

The use of the ocular fluorophotometer in ophthalmology-related protocols involving HBO therapy is an example of how standardized tests, like fluorescein angiography, can be adapted to the unique high pressure environment of a hyperbaric chamber. Through careful planning and adaptation of electronic modules, a multi-component fluorophotometer system was successfully installed and put into use for clinical investigations. It should be emphasized



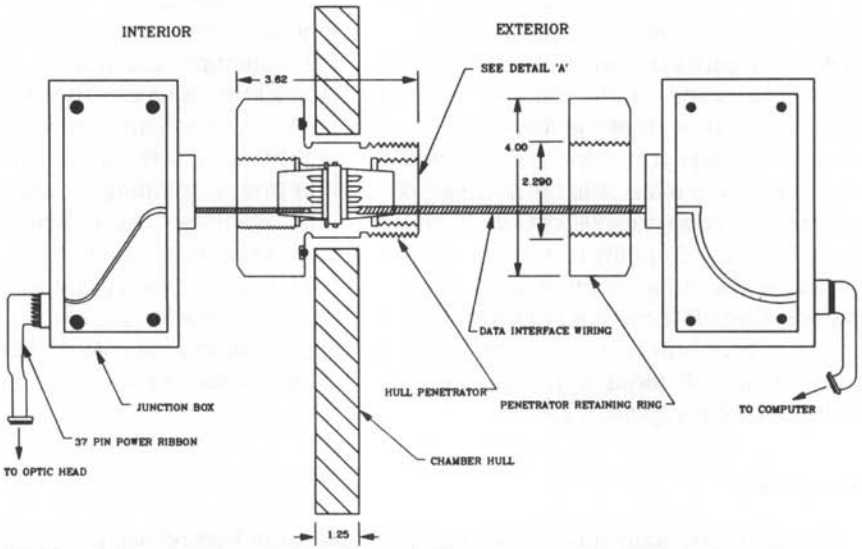


FIG. 1—Hull penetrator. Modified brass hull penetrator with insulated ceramic insert for communication between optic head inside chamber and PC outside chamber. Cross section of chamber hull with modified penetrator, interface wiring, and power junction boxes. Data from ocular head are transmitted through penetrator to a PC on the exterior of the chamber.

that introduction of any new piece of equipment to the hyperbaric environment must be thoroughly evaluated by the component manufacturer and national agencies responsible for safety certification. Progression of clinical investigations and subsequent treatment of diseases like retinal vascular disorders require that standard diagnostic technologies be adapted to the hyperbaric environment.

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