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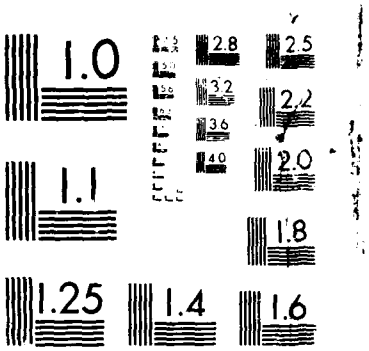

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A STUDY OF THE SYSTEM SAFETY CONCEPT AS IT RELATES TO THE NEW WALTER REED ARMY MEDICAL CENTER, WASHINGTON, D.C.

A Problem Solving Project

Submitted to the Faculty of

Baylor University

In Partial Fulfillment of the

Requirements for the Degree

of

Masters of Health Administration

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by

Captain John E. Anderson, AMSC

March 31, 1978

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The study determines the essential criteria and an expected outcome of a systems safety program at a large Army medical center. Through literature review of technical and public safety documents and through semi-structured interviews, the study established the safety level of the originally designed facility and the extent of current safety modifications. The objectives evaluated the safety components of various in-house systems and developed a qualitative hazard analysis matrix. The study concluded that a formal System Safety Program could identify many safety hazards thus leading to design improvements. The study provided several recommendations to formalize the Systems Safety Program in a health care facility. the system as referenced in this document refers to:

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Chapter I.

INTRODUCTION

A study of the processes involved in the safety components of design, construction, and proposed systems management of the new Walter Reed Army Medical Center (WRAMC), Washington, D. C., was conducted during the period of August 1977 through February 1978. This was accomplished in order to gain a complete understanding of the procedures and responsibilities involved in these processes so that problem areas could be identified and analyzed.

Development of the Problem

Conditions which Prompted the Study

The design of the new WRAMC has incorporated multiple functional and managerial subsystems, closely integrated, intended to produce an efficient and effective medical treatment facility. Through the design and construction phases, and in the formulation of operational plans, safety has been considered, and has become an integral part of each subsystem. The realization that the resultant safety of design was only a by-product of good engineering

practices, has been addressed as a significant problem by the Safety Director and Directorate of Facilities Engineer personnel. As subsystems become increasingly complex, safety problems become more acute. Accelerated technology and demands for compressed development schedules results in an evolved need to formally organize safety engineering and management throughout all phases of the system's life cycle.

Statement of the Problem

The problem was to determine the feasibility, essential criteria, and the expected outcome of a systems safety program applied to a medical treatment facility as large as the new WRAMC.

Limitations

At the time the problem solving project proposal was submitted, the scheduled completion, occupancy, and operation of the new WRAMC was anticipated to be in the December 1977 to January 1978 timeframe. Due to numerous construction delays, the transition into the new medical treatment facility is interrupted and delayed for up to an additional year. For this reason, the evaluation of the efficiency and effectiveness of systems functions, staffing, and

proposed transition training/orientation of personnel must, by necessity, be on a theoretical basis.

The system safety concept as defined and applied in the Department of Defense System Safety Program involves the establishment of requirements and criteria for all phases of the safety life cycle: concept formation, contract definition, development, production, and operational phases.[1] Due to the advanced stage of the development and production phases of the new WRAMC medical treatment facility, this research project was limited to the analysis of what safety engineering and management has taken place to this point secondary to good engineering practices, and how or if the system safety concept can now be designed and applied to the operational phase of the new WRAMC.

Review of the Literature

Medical science and technology have advanced incessantly. Advances such as organ transplants, cryogenics, computer assisted tomography, renal dialysis, and sensor devices all requires sophisticated instruments, machines, and techniques. Any medical advancement can, however, be limited or even negated by a generally human failure: the accident. The sole service of the hospital is

health care through competent diagnosis, reliable therapy, and constant safeguarding of the patient. To do this, the hospital must apply vigilance to the total safety of the patient, visitor, and employee, or it is working against its very reason for existence. Simple logic would suggest that hospitals have a special affinity for practicing safety. Evidence, however, does not bear out this idea. The safety record for health care facilities in the recent past has been inferior to that of many industries.[2] The situation clearly indicated the urgency for a program specifically designed to reduce the danger of accidents from physical safety hazards or unsafe techniques.

The resultant need for safety consciousness is much greater than purely the avoidance of a monetary loss. Carelessness may mean an irreparable setback in hard-won public goodwill and community relations. Until fairly recent years, hospitals have enjoyed a peculiar status with respect to the doctrine of charitable immunity in which churches and hospitals could not be held responsible for employee negligence leading to the injury of others. The courts and legislatures of most states have abolished this doctrine with the legal opinion that hospitals are basically business corporations and are subject to the very restrictions and penalties imposed

on businesses. Hospitals are now required to exercise reasonable care with respect to the maintenance of buildings and grounds, the selection of equipment for the purpose intended, the maintenance of this equipment to ensure proper operation, and the selection or retention of personnel.[3] These principles of responsibility were, in part, established by the landmark case of Darling vs Charleston Community Hospital in 1965.

Throughout recent history, a plethora of standards, regulations, and codes affecting safety in health care institutions have been promulgated in both the public and private sectors. These documents have all identified what should be done, but none have provided adequate guidance on how it should be done.[4] The most comprehensive standards and requirements in terms of a hospital's overall safety program are outlined by the Joint Commission on Accreditation of Hospitals (JCAH) and the Occupational Safety and Health Administration (OSHA). These nationally recognized, consensus standard-producing organizations, for the most part, reference the Life Safety Codes of the National Fire Protection Association (NFPA) as a primary basis of their own requirements.[5,6] It is a recognized fact that major revision of standards by such organizations as the NFPA will lead to revision of the JCAH and OSHA

requirements and standards.

Problem Solving Methodology

Research for this project was primarily conducted by means of literature review of technical literature, applicable government publications, public and private sector regulations and standards, and through the use of semi-structured interviews with personnel in safety, fire control, facilities engineer, development directorate, Army Corps of Engineers, logistics, security, and hospital staff members.

Data collection was aimed at determining what was originally designed and what was the current status of systems installed to ensure safety within the new medical treatment facility. Further analysis was directed toward determining the viability and adaptability of established Department of Defense system safety concepts and criteria as they relate to the new facility. This analysis also addressed, in part, the question of whether NFPA codes, JCAH standards, and Army standards were adequate to ensure the safety of WRAMC patients, personnel, and facilities.

Objectives

The intermediate objectives of the problem solution were:

1. Determination of whether the new WRAMC can be classified as a system having characteristics appropriate for a System Safety Program.

2. Examination and evaluation of present management safety components of the emergency power subsystem, materiel transportation subsystem, and the fire protection subsystem of the new WRAMC to determine their adequacy in terms of system safety management.

3. Examination and evaluation of present engineering safety components of the emergency power subsystem, materiel transportation subsystem, and the fire protection subsystem of the new WRAMC to determine their adequacy in terms of system safety engineering.

4. Evaluation of the adequacy of NFPA, JCAH, and Army Safety Standards in meeting the new WRAMC's needs in terms of system safety.

5. Development of a hazard analysis matrix or survey sheet to assist in the documentation of system safety hazards in terms of qualitative and urgency measures.

6. Development of recommendations, based upon research findings, of safety components to be included in a new WRAMC System Safety Program.

Criteria

The criteria was derived from national and organizational published safety standards. These include:

National Standards. --

1. JCAH standards, as published in their 1976 Accreditation Manual for Hospitals, as revised, states that a hospital must be designed, constructed, equipped, and furnished in such a way as to be in compliance with all applicable building codes, fire prevention codes, state and/or federal occupational safety and health codes and standards, and the 1973 edition of the Life Safety Codes of the NFPA. When an occasion arises where there is a conflict in applicable codes or standards, the more restrictive provisions shall prevail.[7] The JCAH also states that the hospital shall have comprehensive safety systems installed, and practices, policies and procedures instituted to minimize hazards to patients, hospital staff, and visitors.[8] The standard goes on to interpret detailed requirements for various safety subsystems such as electrical safety, fire

warning and safety subsystems, compressed gas systems, engineering and maintenance systems, etc.

2. Section 101 (Life Safety Codes), Chapter 10 of the 1977 National Fire Codes, published by the NFPA, provides detailed engineering requirements for life safety from fire and like emergencies. This covers both new construction and existing facilities of health care institutions. In terms of fire protection for hospitals, this code requires the existence of an electrically supervised, manually operated fire alarm system installed to transmit an alarm automatically to the responsible fire department. It also states that any fire detection device or system shall be electrically interconnected with the fire alarm system, and that all detection and alarm systems shall be provided with an alternative power supply.[9]

3. The 1972 Safety Guide for Health Care Institutions, published by the American Hospital Association and the National Safety Council, provides broad guidance on the management and engineering of safety components. The Guide emphasizes the adherence to all safety standards and regulations, recommends a safety surveillance program concomitant with the hospitals size and complexity, and delineates the objectives to include in both the safety surveillance program and a hospital safety education program

which should be provided to all employees.[10]

Organizational Standards. ---

1. Army Regulation No. 385-16, System Safety, sets forth the objectives, concepts, policies, responsibilities, and requirements for the Army Safety Program for systems, and establishes essential life cycle system safety engineering and management tasks. As a minimum, it requires that safety criteria identifying essential characteristics and standards, below which the item will be unsatisfactory for Army use, be included in all system and military specifications and contractural documents.[11]

2. Military Standard 882, System Safety Program for System Safety Program for Systems and Associated Subsystems and Equipment, identifies DOD System Safety Program policies, objectives, and requirements in order to provide uniform requirements and general criteria for establishing and implementing a system safety program.

Footnotes

1. U.S. Department of Defense Military Standard 882, System Safety Program for Systems and Associated Subsystems and Equipment (Washington, D.C.: Government Printing Office, July 15, 1969), p. 1.

2. Accident Prevention Manual for Industrial Operations. 6th ed. (Chicago: National Safety Council, 1969), p. 5.

3. Safety Guide for Health Care Institutions. (Chicago: American Hospital Association and the National Safety Council, 1972), pp 5-6.

4. Elwing, David R. Hospital Safety Compliance Guide. (Chicago: InterQual, 1977), p. 1.

5. Accreditation Manual for Hospitals. (Chicago: JCAH, 1976), p. 29.

6. Occupational Safety and Health, Vol. I, General Industry Standards and Interpretations. (OSHA, 1977), p. 8.

7. Accreditation Manual for Hospitals, p. 29.

8. Ibid., p. 35.

9. National Fire Codes, Vol. 9. (Boston: NFPA, 1977), pp. 101-110 and 111.

10. Safety Guide for Health Care Institutions, pp. 2-9 and 20.

11. Army Regulation No. 385-16, System Safety. (September 22, 1972), p. 2.

Chapter II

DISCUSSION

Walter Reed as a System

On August 26, 1972, after more than five years of planning, groundbreaking ceremonies were held for the new Walter Reed Army Medical Center (WRAMC). Today the new 1,280 bed hospital stands 125 feet tall, equal in height to a ten story building. The hospital's 5,500 rooms cover some 1.2 million square feet of floor space. The four inpatient floors each, in fact, contain more beds than eighty-seven percent of all the hospitals registered with the American Hospital Association.[1]

The new medical treatment facility is designed as a modified Gordon Friesen concept arrangement, intended to provide the most up-to-date, thorough care for the patient, as well as an efficient, comfortable working environment for the staff. Architecturally designed to provide optimal patient care through easy materiel distribution and efficient delivery of patient care services, each of the new WRAMC's seven patient care floors are sandwiched

by a six foot, nine inch interstitial service floor. It is within these service floors that the majority of the utilities, plumbing, electrical wiring, air handling and life support systems, communication lines, and automated materiel transportation systems are housed. This will allow for eighty percent of all repairs and routine installations to be performed away from the patient care areas.

Concepts in ultimate health care delivery are being built into the new facility through the use of advanced automated mechanical and communications systems, and through the use of innovative medical and administrative support concepts. Automated systems will include a modern "food factory" Food Service where meal items are mass produced from days to months in advance, then bulk or individually portioned, chilled or flash frozen, and stored in inventory until needed. Computer programs will assist in menu and ingredient preparation, inventory control of fresh and frozen food supplies, in the actual preparation process by monitoring the appliances in the production area, and in preparing specialized diets for all WRAMC inpatients. At a designated time, preportioned servings are withdrawn from storage, loaded into twenty automatic loaders and six manual loading stations, and then automatically

loaded onto patient trays as the tray travels down a conveyor. Completed trays are then loaded into automatic food carts which keep the food items refrigerated. These are transported to patient wards on automated monorails, plugged into refrigerated units and a half an hour before meal time, the cart will start heating certain items on the tray to the proper temperature through the help of an internal computer program.

Another automated system is the Telelift system, an electronic miniature railcar running on aluminum track through the service floors and along two major vertical tracks. There are 78 sidings located in nursing care units, clinics, operating room area, laboratories, pharmacy, and key administrative offices. Designed to replace the conventional pneumatic tube; records, x-ray films, laboratory specimens, and administrative materials will travel in 240 motorized cars at an average speed of one hundred feet per minute. Encoding magnets are set by the sender and the Telelift cars course is routed by electronic sensors, directing the car along the shortest pathway to the desired destination.

Computerized systems will play a major role in the

functioning of the new WRAMC. They will furnish complex communication and information systems such as the Hospital Information System and the Interim Food Service System currently being developed by the DOD Tri-Service Medical Information System Group. Computerized systems will also take care of the sterilization and distribution of supplies and linens throughout the hospital. There is also a computerized, integrated electronic surveillance system that will automatically monitor all internal transportation systems, the environmental control systems, the power distribution and emergency power systems, gas distribution and emergency protection systems.

An innovative management system found in the new WRAMC is the "Pri-Team" nursing concept. Each patient on the ward is assigned to a nursing team consisting of a registered nurse, a licensed practical nurse, and one or two other paraprofessional personnel. This team is responsible for all nursing care delivered to a small group of patients from the time they are admitted through discharge. This includes preparation of nursing care plans and communication with staff members regarding the individual patient's

requirements and progress. Continual contact with the same patients will allow the "Pri-Team" staff to better determine all of the patient's needs and thus improve the quality of care through a more informed planning process.

One of the pre-requisites of a successful "Pri-Team" nursing care system is an adequate administrative support system on the ward. As a result, the Unit Management system was developed and is currently being implemented to provide this administrative support. Each of the top four patient floors will have an Assistant Administrator who will have under his control a team of nursing unit administrators who, in turn, will control a number of communications clerks, medical record technicians, logistics technicians and housekeeping personnel. This unit administration system will free the nursing staff, who have traditionally spent up to forty percent of their time with administrative tasks, to concentrate on direct patient care.

The hospitalized patient at the new Walter Reed will probably be unaware of most of the advanced technological and

management systems which will govern nearly every aspect of his care, but much of the treatment he receives will be the outcome of highly advanced processes which must occur in a very coordinated manner behind the scenes.

The new Walter Reed clearly fits into the definition of "system" as defined by the system safety program concept, i. e., as defined in APPENDIX A, and, indeed, would fulfill the requirements of any systems definition. Only a small number of the internal "subsystems" designed and planned for the new WRAMC have been discussed in this section. It is evident that the new medical treatment facility is an accumulation of highly complex operational and support subsystems that must be accurately integrated to produce the desired outcome of a total health care system.

Management Safety Components Evaluation

There are many possible faults in any given system, including its safety components. If a subsystem does become faulty for safety or any other reason, the overall effectiveness and efficiency

of the total health care system is compromised. The importance of good system design and thorough analysis, engineering, and management of all components, including safety, becomes critical in maintaining system and subsystem integrity.

The Department of Defense System Safety Program, as outlined by Military Standard 882, is directed at the procurement of major military defensive and tactical systems. The principles utilized in the standard are applicable, however, to the preparation of safety requirements for contractural documents in the procurement of all types of military systems. The scope and magnitude of the system safety program must be tailored to the specific requirements and peculiarities of the system or project involved. The program places the responsibility of system safety tasks, i. e., identifying, planning, organizing, controlling, and analyzing all program elements, upon the prime contractor for the system.[2] The original plan outlining these responsibilities are prepared and inserted into the contract by the procuring activity. It is also incumbent upon the contractor to conduct system safety program reviews to assess the status of compliance with the overall safety

program objectives. Deficiencies identified shall elicit further development guidelines as required.[3] It also becomes essential in any system safety program that an analysis be performed to determine safety requirements for personnel, procedures, and equipment used in installation, maintenance, support, testing, operations, and training during all phases of intended life cycle use. Results of this analysis can stimulate design changes, special inspections and emergency procedures to minimize personnel injury, and special procedures for servicing or handling the subsystem.

The general management of system safety factors during the concept formulation, contract definition and production phases of the new WRAMC project, as compared to the formal DOD System Safety Program, has been enlightening. The prime contract for the new WRAMC awarded to Blake Construction Company in July 1972 contained sixteen divisions. The specification contract required that all codes existing at the time of bidding were the codes that would govern the entire construction project. These existing codes,

with their effective dates, were all listed in the specification contracts. The accreditation process for the new WRAMC will in fact, be based upon Joint Commission on Accreditation of Hospitals (JCAH) standards in existence prior to 1973. There are a few exceptions to this policy due to the JCAH requirement that some current standards must be met without equivalencies.[4] All changes to the construction and safety codes that have taken place since the initial construction began in 1972 have been reviewed and analyzed by a Technical Review Committee composed of the Area Engineer, Architects' Representative, and the WRAMC Development Project Officer. The resultant analysis determines if a formal contract change is essential. The Corps of Engineers have made as many changes as practicable to keep with current standards and codes. Of the 708 contract changes made since July of 1972, only eight of them have been mandatory changes due to building code requirements.[5]

The testing of various mechanical systems for building and safety code compliance has been handled in two ways, as specified in the original contract. In the majority of cases, the contractor or subcontractor is required to demonstrate the proper and safe

operation of the system before the system is accepted by the Corps of Engineers. Few exceptions to this procedure exist. Two known exceptions include the testing of all elevators by General Services Administration inspectors and for testing of the heating - ventilating - air conditioning system by a professional, independent inspecting firm.[6] The Baltimore District Office of the Corps of Engineers develops all test plans that the contractor must meet. These test criteria are based upon the standards specified in the original contract and the test plans are themselves included in these contracts. The systems test is also supervised by the Corps of Engineers. It became evident to this researcher that many of the personnel in the Directorate of Facilities Engineer who will ultimately become responsible for the management of a given system, do not feel that adequate systems tests are performed before that system is accepted by the Corps of Engineers. A primary example of this is the inability to identify <u>all</u> components that are supplied by the standby emergency power source. A major component that should be supplied by the emergency power system, as required by NFPA 76A, and is not so supplied is the hospital public address system.[7] This should be

readily available for issuing instructions to patients and staff during emergency situations.

The original systems test plan for the monorail transportation subsystem also contained inherent weaknesses in its design. The initial tests of the system were conducted with the monorail subcontractors personnel present in the interstitial space. This allowed the subcontractor personnel to assist carts that were having difficulties along the track and to manually activate directional relays that would not activate automatically. When this situation was recognized during the analysis of the original tests, further testing protocols were developed which prohibited any monorail subcontractor personnel within the interstitial space.[8]

An established management safety component is the systems training of WRAMC personnel in one of two areas: system maintenance/operator training and system user training. The complexity of the given system is generally the determinant of the extent of the training furnished. Training plans are developed by the Area Engineer, based on his analysis of need, and staffed through the systems contractor before being included in the contractural agreement. Facilities

Engineer maintenance personnel repeatedly made note of the fact that there is a perceived lack of contractor furnished training programs in the technical operation and maintenance of materiel transportation systems.[9,10] Systems training in this case has, for the most part, been by personal observation of contractor personnel who happen to be working on a given system. The fact that the ultimate user or maintainer/operator of a new system is not consulted as to the areas they feel contractor-furnished training is essential, can lead to decreased scope and effectiveness of that training. This deficiency in the scope of systems orientation is noted by Fire Department personnel in regard to the fire protection systems.[11]

The operational outcome of the Environmental Control Unit, which will be mechanically explained as an engineering safety component, is an excellent management safety component for the new WRAMC. Procedures have been established in the Environmental Control Unit to electronically monitor all systems associated with the internal transportation subsystems, the environmental control subsystems, the power distribution and emergency power subsystems, and all

emergency fire warning and protection subsystems. The ability to monitor and retrieve this data ensures compliance with all functional safety standards, for the subsystems mentioned, as required by JCAH.[12] These JCAH standards are, themselves, a compilation of the National Fire Protection Association (NFPA) Life Safety Codes.

Engineering Safety Components Evaluation

There are a multitude of primary mechanical systems designed and installed in the new WRAMC which apply advanced engineering techniques and which will require technical competence for safe operation and maintenance. These systems include, in part, all transportation components, environmental control, power distribution, gas distribution, communication, computerized information, waste disposal, fire protection, and materiel management subsystems. The functions and responsibilities of ensuring engineering safety is somewhat different between the DOD System Safety Program and the conventional methods utilized in designing and building the new WRAMC.

The DOD System Safety Program is aimed at providing a disciplined approach to methodically control and evaluate the safety level of a system's design and to identify hazards and prescribe corrective action in a timely, cost effective manner. This is accomplished through the application of scientific and engineering principles. The principles and methodologies of engineering safety components are closely associated with and overlap those of management safety components. The success of the program is directly dependent upon management emphasis.[13]

Safety engineering components are also a responsibility of the prime contractor from the concept formulation phase through the development and production phases, according to DOD System Safety Program requirements.[14] This requires the evaluation of safety engineering objectives against safety design criteria to provide the early identification and correction of safety hazards before the production and operational phases. The methods of ensuring safety engineering for the new WRAMC were, again, somewhat different. The basic design objectives were outlined by the Corps of Engineers and given to the potential primary contractors during the concept development phase. The resultant safety of design was,

therefore, a by-product of good engineering practices with emphasis on current safety standards and codes. The design engineer was then expected to incorporate the necessary features and operational procedures into the system to assure the overall safety of the new WRAMC.

Located on the second floor of the new WRAMC is the Environmental Control Unit, a room designated to the Facilities Engineer for the integrated electronic surveillance of all mechanical equipment in the new WRAMC. The Environmental Control Unit (ECU) will serve as the single most important component of safety management procedures to be utilized in the new medical treatment facility. The functions of the ECU center around a General Data Corporation NOVA-1200 computer. This computer has the capacity of monitoring 3,000 in-put control points. As designed, the computer will initially monitor 1200 control points on all seven floors and interstitial spaces of the new facility. It will receive in-put on the operational status of the heating - ventilating - air conditioning systems, chilled water pumps, pumps for and pressure of the domestic water supply, medical gas systems, compressed air system, vacuum system, all fire protection systems, all internal transporation systems

including the trash and linen collection systems, all emergency power systems, the pressure on the incoming steam line, and other miscellaneous pumps. The monitoring system will function by the computer continuously sending out signals to each control point and then receiving a return signal from that control point. If the computer receives a normal response from the control point, nothing happens. If the response is abnormal, a message acknowledging that fact and the control point involved will be displayed on a cathode ray tube monitor and simultaneously be printed out on teletype printer. Engineering personnel will monitor the cathode ray tube and all other ECU functions on a continuous basis. When a control point does monitor a malfunction, ECU personnel will dispatch maintenance personnel to inspect that control point and make any necessary repairs.

The ECU computer is also designed to run a printout of the building's systems status each day. This will assist in the planning of repairs and act as a data source for establishing more energy efficient operations. The engineering personnel also will have the capability of "calling up" any system or control point to double check

any abnormal data. The computer in the ECU can be programmed on eighteen separate channels. One program currently in effort will monitor the power uptake of the emergency power generators in the event of a power failure and will restart, in a sequential manner, all items of equipment that are programmed for the life safety or critical branches of the emergency power systems. Separate display panels in the ECU will also illustrate, monitor, and control the Telelift transportation system, the medical gas system, and the linen and trash chute system.

It is evident to this researcher that a significant management safety potential exists through proper utilization of the ECU. The requirements of many of the safety standards and codes are met by the outcomes produced by the electronic monitoring system of the ECU. Specifics will be addressed as each of the three selected systems are discussed in terms of safety engineering compliance.

The emergency power system was engineered based on the safety codes as of 1972. Changes in standards and codes and the

realization of basic design deficiencies has resulted in extensive re-evaluation of the emergency power components. Emergency power is generated by eight diesel engines, each having a one thousand kilowatt capacity, which individually run a generator having a six hundred kilowatt capacity. The hospital is geographically divided into quadrants with the emergency power for two quadrants supplied by one bank of four generators and the other two quadrants by the other bank of four generators. There are three life safety and critical branches of the emergency power system which can adequately be supplied by one generator from each bank of four generators. Extensive testing of the emergency power system was performed prior to its acceptance from the contractor. Each week the Facilities Engineer personnel run 30 minute tests of each emergency generator under actual or simulated loads as required by the NFPA.[15] The NFPA codes also require the automatic transfer of power to the emergency power source within ten seconds of the regular power source's failure. Test of the new WRAMC emergency generator system have shown that a bank of

generators can start from a "cold" start, come up to speed, synchronize, and pick up the entire load in no more than seven seconds.[16] Early tests of this emergency power system revealed a fault in the design of the ECU operation. During the time between the failure of regular power and the acquisition of emergency power, the data being monitored by the ECU computer was lost. A program addition to the computer system has corrected this deficiency. It is a situation such as this that a system safety program, as outlined in Military Standard 882, is designed to identify, evaluate, and correct while the system is still in the design phase.

The primary materiel transportation systems include the ACCO monorail system, designed to transport large food carts and logistics supply carts to the various floors of the new WRAMC, and the Telelift railcar system to handle small administrative and supply items. The design of these systems dealt with a description of the desired routes, station locations, and a general description of performance. As previously described, the Telelift cars are powered by electric motors and travel at a speed of one hundred feet per

minute. The ACCO monorail system is a power-free system; part of the time the carts are driven forward by a power chain system, the rest of the locomotion is a gravity fed system where the monorail tips downward and the cart moves by a combination of inertial and gravitational force. This system is designed to move the cart in the interstitial spaces at a maximum speed of forty feet per minute. The movement of these carts between floors is provided by a cart-lift, dumbwaiter type system that travels at 350 feet per minute. Basic design requirements for the ACCO monorail system were the responsibility of the contractor of the system. Design specifications for ensuring a safe design and operation are governed by the Occupational Safety and Health Administration (OSHA).[17] As required, a delay mechanism is built into the monorail system. When the start switch is activated there is a ten second operational delay during which time warming buzzers sound throughout the monorail systems conveyor area. This will allow any maintenance or contractor personnel working along the monorail pathway to get themselves out of the way before

the carts on the monorail start to move. An additional safety feature is the presence of emergency stop buttons every forty feet along the monorail pathway in the interstitial floors so that if any maintenance personnel see something wrong, they can immediately stop the system. A clutch system is also included on the portion of the monorail system that is powered so if something were to get in the pathway of a moving cart, the cart would stop with a pre-established amount of pressure and the drive clutch would slip.

Facilities Engineer personnel will have the responsibility of maintenance and safety of the ACCO monorail and Telelift systems. The ECU will play the major role in these functions. The monorail cart-lift will be considered a dumbwaiter type system and will fall under the NFPA and American National Standards Institute codes for elevators and dumbwaiters.[18] Inspections to date exhibit compliance with standards. The General Services Administration will conduct periodic inspections of the ACCO cart-lift system as they will with all other elevator and dumbwaiter systems in the new WRAMC.

The fire protection system for the new medical treatment

facility is a compilation of subsystems which include the standpipe subsystem, automatic sprinkler subsystem, automatic smoke detection subsystem, heat detection devices, automatic carbon dioxide and halon extinguishing subsystems, fire extinguishers, and compartmentalized fire zone construction. All of these fire protection/suppressant subsystems currently meet NFPA, JCAH, and OSHA fire safety code requirements except for one notable exception.[19] The standpipe subsystem was designed as a dry system, i. e., without water maintained in the system at all times. At the time of design completion and awarding of the contract in 1972, a dry standpipe system complied with NFPA and JCAH requirements. Since that time, JCAH has increased their requirements to a wet (primed) standpipe system and have limited the equivalencies that they will accept. Walter Reed has developed change orders for the contractor to convert the present dry standpipe subsystem to a modified wet system. The present system consists of a twelve inch mainline around the basement perimeter of the building. From this line, there are six inch risers that periodically come off and travel to the seventh floor. Two and one half inch lines exit the risers at each

floor and interstitial space and travel to fire hose connections throughout the hospital. Fire department siamese connections are located externally at each corner of the building. It is to these locations that the fire trucks would go in case of fire and pump water into the standpipe system while firemen take hoses to the appropriate location and connect with the internal hose connections. As the system now stands, it is estimated that it would take something over one hour to pump enough water into the system to reach the seventh floor.[20] JCAH now requires that standpipe systems be wet, having a separate constant water supply and an internal pump which will maintain a constant water pressure. The modified wet standpipe system, having received JCAH equivalency approval, will allow WRAMC to maintain a primed standpipe system which will continue to require fire department pumpers to connect to external siamese connections to furnish a source and pressure of water supply.[21]

Other fire protection systems provide numerous sophisticated methods of detection and control. The interstitial spaces are each protected by sixty to seventy heat detectors that are activated by either a

maximum temperature of 135° F or a rate-of-rise of fifteen degrees per minute. The automatic sprinkler system is supplied with water flow sensing devices throughout. Each floor is also compartmentalized into fire retardent zones containing a two hour rated fire barrier around the perimeter with one hour rated partitions within a given zone. Corridor doors establishing part of the fire zone perimeter are two hour rated and will close automatically when any smoke or heat detector within that zone is activated. All of the fire detection and suppressant sensoring devices are simultaneously connected to the electronic monitoring devices in the ECU and to a printout device in the WRAMC fire station. All of these sensors are also supplied by emergency power sources.

Evaluation of Safety Standards

Historically, the need for and emphasis on safety from all types of hazards is well established for all industries and businesses, including hospitals. The occurrence of fires or accidents do not merely happen, they are caused. These occurrences can result in severe injuries, extensive property loss, and curtailment of services

that inevitably stirs the general public, professional groups, and governmental officials to take corrective action. This corrective action takes the form of legislation which in the area of building construction is known as building codes and standards. The minimum standards are established to protect the health and safety of the general public and generally represents a compromise between optimum safety and economic feasibility. The promulgation of modern building codes which are in use today began with the disastrous fire incidents which this country experienced at the turn of the century. As early as 1905, the National Board of Fire Underwriters published a National Building Code.[22] Since that time numerous organizations have developed codes that established requirements that differ widely from one jurisdiction to another. Recognizing problems involved with regional requirements, national organizations have been formed to promote uniformity of building codes and safety components. These are usually adopted into building specification documents and are a basis for accreditation standards in hospitals today. The Life Safety Codes portion of the National Fire Codes are a compilation of codes,

standards, recommended practices, manuals, guides, and model laws prepared by technical committees organized under the NFPA. Numerous NFPA standards are referenced by the model building codes and, thus, obtain legal status where these model codes are adopted.[23]

Throughout recent history, an enormous number of standards, regulations, and codes affecting safety in health care facilities have been promulgated. These have emphasized what should be done to comply, but have failed to adequately direct how it should be done. Practical guidance on how to comply with the intent of all established requirements has been noticably lacking. This has recently changed with the publication of the Hospital Safety Compliance Guide by David R. Elwing.[24] This source appears to this researcher to perform a vital service to health care facilities by acquainting hospital personnel with the code requirements, their intent, and practical methods of compliance. This could most beneficially be used by hospitals conventionally designed in accordance with established standards and codes.

The usefulness of safety analysis during a projects conceptual and design phases is also well established. A systematic approach to safety can materially contribute to a system's effectiveness by increasing the system's availability due to freedom from accidental loss or damage, its dependability due to safe design, and its capabilities due to safe performance. This is the primary purpose of a system safety program, established for major systems acquisition by the Army and adequately documented in many DOD documents.[25,26] When systems have been developed without adequate analysis and identification of potential hazards, and suggestion of corrective actions during the design phase do not occur, the result tends to be costly retrofit actions necessary before safe implementation of that system can be accomplished.

It is incumbent on each health care facility designer and manager to systematically review and implement all applicable standards, codes, and regulations so that he can essentially eliminate all faults within that system.

Safety Analysis Methodologies

The need for a formalized safety surveillance program is well established by JCAH standards.[27] This program must include, as a minimum, a written safety policy; an organized, multidisciplinary safety committee; and a qualified safety director. Functions of these safety program components have also been established in broad terms.

With the multiplicity and complexity of the systems engineered for and installed in the new WRAMC, the need for mechanisms to assure that optimum safety has been designed into the systems and is being maintained within the systems is a dominant requirement of any safety program. Information gathered by the safety program should insure timely identification of potential hazards, adequate controls over existing hazards and a means to initiate necessary corrective actions. For the safety program to be effective it's findings must be made known to all personnel; its primary function must be to engender, stimulate, and maintain interest in safety and fire prevention among all personnel. Formal and informal lines

of communication for reporting suspected safety hazards and established mechanisms for analyzing systems for potential hazards are essential to any safety program. This researcher determined a common perception that these factors are lacking at WRAMC. As the WRAMC personnel assume control of the new facilities systems, this fact must be corrected.

Hazard analysis is a systems safety technique designed to determine the adequacy of design concepts and operational procedures to meet the essential safety characteristics of the system. Analysis at the systems level is designed to investigate possible hazards that may exist in the interface between subsystems, where the effects of malfunctions or failures in one subsystem may produce a hazardous effect in another subsystem. Once identified, actions are initiated to either eliminate or control these hazards. Hazard analysis at the operational level is performed to point out the operating functions which should be hazardous to personnel, equipment, or both. The results of this form of analysis will often be safety precautions, procedures, or warnings that need to be included in safety training programs and operational standard operating procedures.

Much of the work in hazard analysis is concerned with hazard categorization. An attempt is made to identify potentially hazardous components or events and classify them according to their criticality, i.e., negligible, marginal, critical, or catastrophic.[28] Given the level of criticality of an identifiable hazard, safety should also be viewed in terms of the urgency required for providing corrective actions based on the hazard category. The information given by safety hazard analysis may be compiled in many formats. The format used should be one which will give the desired information. An example of a hazard analysis survey sheet is illustrated in Figure 1. This worksheet will identify what operation is being performed, what is the operational function, and what is the normal effect of that function. It then allows for the identification of what hazard can result from the operation, the hazard categorization, its urgency/priority rating, and comments relative to what should be done to prevent the hazard or protect against the consequences.

The primary objective of performing a qualitative analysis on systems is to provide a technical assessment of the relative

OPERATION	FUNCTION	EFFECT		HAZARD CATEGORY	PRIORITY RATING	PROPOSED IMPROVEMENTS
		NORMAL	HAZARD			

Figure 1: Hazard Analysis Sheet

safety of a system, to assure that hazards associated with each system, subsystem, or equipment are identified and evaluated, and eliminated or controlled to an acceptable level. The hazard analysis survey sheet constitutes documented evidence of hazard evaluation and can become an important communication mechanism in the over-all system safety program.

Footnotes

1. Interview with LTC Thomas Montague, Director, Directorate of Facilities Engineer, WRAMC, February 10, 1978.

2. Military Standard 882, System Safety Program. (Department of Defense, July 15, 1969), p. 1.

3. Ibid, p. 9.

4. Interview with Charles R. Schroer, Area Engineer, Baltimore District Corps of Engineers, WRAMC, February 8, 1978.

5. Ibid.

6. Ibid.

7. David R. Elwing. Hospital Safety Compliance Guide. (Chicago: InterQual, 1977), p. 42.

8. Interview with James Masten, Chief, Transportation Branch, DFAE, WRAMC, February 9, 1978.

9. Ibid.

10. Interview with Richard Dubicki, Chief, Environmental Control Unit, DFAE, WRAMC, March 8, 1978.

11. Interview with William C. Duvall, Chief, Fire Department, DFAE, WRAMC, March 8, 1978.

12. Accreditation Manual for Hospitals. (Chicago: JCAH, 1976), pp. 35-38.

13. DARCOM Pamphlet No. 385-23, System Safety. (Headquarters, DARCOM, June 1, 1977), p. 1-2.

14. Military Standard 882, p. 6.

15. Elwing, p. 41.

16. Interview with Charles R. Schroer, February 8, 1978.

17. Ibid.

18. National Fire Codes, Vol. 9. (Boston: NFPA, 1977), p. 101-65.

19. Elwing, pp. 18-22.

20. Interview with William C. Duvall, March 8, 1978.

21. Ibid.

22. McKinnan, Gordon P. and Tower, Keith. Fire Protection Handbook. (Boston: NFPA, 1976), p. 6-111.

23. Ibid, p 6-112.

24. David R. Elwing, Hospital Safety Compliance Guide. (1977).

25. DARCOM Pamphlet No. 385-23, p. 1-2.

26. Military Standard 882, pp 1-3.

27. Elwing, p. 3.

28. DARCOM Pamphlet No. 385-23, p. 6-3.

Chapter III

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

An attempt to relate a program (System Safety) that does not adequately apply to a system (Walter Reed) that does not, as yet, adequately exist, in order to make a definitive evaluation, was met with incomplete success. Although the new Walter Reed Army Medical Center with its accumulation of technically complex operational and support systems, obviously fits in the scope of any systems' definition, the Department of Defense System Safety Program is directly applicable to only the procurement of military systems such as aeronautical, nautical, vehicular, missile, electronics, weapons and munitions. Various other differences in the methodologies of safety management between the DOD System Safety Program and the historical data of the new WRAMC project also demonstrates their incompatibility. The DOD System Safety Program is designed to start during the concept formulation phase and continue through the system's entire life cycle. The new WRAMC project is too far advanced to institute a formal System Safety

Program, although it was evident that a systems safety analysis of the new WRAMC during its concept formulation and design phases could have identified many safety hazards, leading to design alterations and thus saving current retrofit costs. The DOD program also makes it incumbent on the primary contractor for the evaluation, planning, management, testing, and education of all safety aspects for a given system. In the WRAMC project, the Corps of Engineers is responsible for specifying and directing all safety requirements the contractor must fulfill.

The need for a systematic approach to safety is both real and demanding. Although the formal System Safety Program does not apply to the new WRAMC, its philosophies of safety management and engineering could be very beneficial to WRAMC. The most significant deficits for the ensurance of safety within the new WRAMC obviously lie in the management components of system safety. Insufficient testing procedures of various systems before turning over to the Corps of Engineers was demonstrated in regards to the emergency power, Telelift, and fire protection systems. There was also

a perceived lack of contractor furnished training by systems managers and operators, as well as insufficient consultation with them in an effort to determine their training needs.

Engineering safety components are, for the most part, sufficient to meet safety requirements of the original design. Current standards and codes have necessitated some mechanical/ engineering changes to bring the system within acceptable limits of the state of the art. An example of this is the conversion of the dry standpipe system to a modified wet standpipe system.

Standards and codes are designed for providing minimum safe levels of operation. It appears that the new WRAMC has been designed and equipped to meet all the safety engineering criteria of the established national standards criteria.

Difficulties were encountered in identifying a long range safety program for the new WRAMC, or mechanisms to systematically analyze and identify potential safety hazards. In the same light, there is a perceived lack of communication between operational personnel and safety personnel for the reporting of any potential or real hazardous situations. The degree to which safety program

objectives are met and, consequently, the degree of safety achieved in a given system is directly dependent upon management emphasis. A formalized program of system safety management needs to be developed to provide a technical assessment, in qualitative terms, of the relative safety of a system design and operation.

Recommendations

1. A formal System Safety Program should not be utilized in the new WRAMC; instead, a program utilizing conventional safety management procedures, based on current codes and standards, should be established.

2. The WRAMC Safety Directorate should establish a safety surveillance program to systematically inspect all major mechanical/electrical systems in the new WRAMC for existing or potential design or operational hazards. This analysis should be based on current safety standards and codes.

3. A functional hazard analysis survey sheet, as previously illustrated in Figure 1, should be utilized by the Safety Directorate

Staff to document and prioritize findings.

4. A review of pre-delivery tests and contractor furnished training for various mechanical/electrical systems should be performed by Corps of Engineers and Facilities Engineers to determine its appropriateness and thoroughness. Changes in the testing and training processes should occur where deemed necessary and feasible.

5. Where inadequate testing and training procedures cannot be altered prior to system acceptance and operation, supplemental testing and training should be developed and implemented as a hazard preventative safety measure.

6. A report of all periodic tests of major mechanical/electrical systems in the new WRAMC should be submitted by the Directorate of Facilities Engineers to the Center Safety Committee for their review and analysis.

7. Maximum use of existing safety analysis materials, such as the Hospital Safety Compliance Guide published by InterQual, should be utilized to evaluate compliance with current safety standards and codes.

8. Management emphasis should be placed on communications by and with the WRAMC Safety Directorate to improve awareness of all areas involved in safety hazard analysis and the mechanisms established to communicate and correct those hazards.

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APPENDIX

APPENDIX A

DEFINITIONS

Hazard Category I -- Negligible: Conditions such that personnel error, environment, design characteristics, procedural deficiencies, or subsystem or component failure or malfunction will not result in personnel injury or system damage.

Hazard Category II -- Marginal: Conditions such that personnel error, environment, design characteristics, procedural deficiencies, or subsystem or component failure or malfunction can be counteracted or controlled without injury to personnel or major system damage.

Hazard Category III -- Critical: Conditions such that personnel error, environment, design characteristics, procedural deficiencies, or subsystem or component failure or malfunction will cause personnel injury or major system damage, or will require immediate corrective action for personnel or system survival.

Hazard Category IV -- Catastrophic: Conditions such that personnel error, environment, design characteristics, procedural deficiencies, or subsystem or component failure or malfunction will cause death or severe injury to personnel, or system loss.

Safety: Freedom from those conditions that can cause injury or death to personnel, damage to, loss of, or degradation of equipment, property, or system.

System: A composite, at any level of complexity, of operational and support equipment, personnel, facilities, and software which are used together as an entity and capable of performing and/or supporting an operational role.

System Safety: The optimum degree of safety, within the constraints of operational effectiveness, time, and cost, attained through specific application of systems safety management and engineering principles throughout all phases of a systems life cycle.

System Safety Engineering: An element of systems engineering involving the application of scientific and engineering principles for the timely identification of hazards and initiation of those actions necessary to prevent or control hazards within the system.

System Safety Management: An element of program management which insures the accomplishment of the system safety tasks, including identification of the system safety requirements; planning, organizing, and controlling those efforts which are directed toward achieving the safety goals; coordinating with other system program elements; and analyzing, reviewing, and evaluating the program to insure effective and timely realization of system safety objectives.

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