Integrating Chemical Fume Hood Inspection and Maintenance Control into an Institutional Equipment Management Program

by

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ABSTRACT

Chemical fume hoods are standard equipment in the laboratories of medical institutions and represent significant costs related to their maintenance and energy consumption; particularly when they are improperly managed. XYZ Medical Center's methods of managing chemical fume hoods exposes the institution to potential loss related to health, property, and energy consumption. Specific issues with the system include an inadequate location tracking mechanism, and non-existent maintenance and repair records which, upon inspection, ultimately result in a high number of defective hoods year after year. Having strict control over chemical fume hoods will ensure employee safety, reduced equipment costs, and reduced energy costs. Increased control can be attained by integrating the inspection and maintenance management of chemical fume hoods into the existing Maintenance Management System at XYZ Medical Center.

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Chapter I: Introduction

Chemical fume hoods are commonplace in both clinical and research laboratories operating in medical institutions around the globe. Designed to provide primary exposure protection to laboratory personnel working with hazardous chemicals (Northwestern University, 2007) chemical fume hoods represent a significant investment to medical institutions. Aside from the initial purchase price, additional costs include the power requirements for ventilation systems to maintain continuous air flow, scheduled preventative maintenance, and general upkeep. With an estimated 750,000 chemical fume hoods in the United States they also represent a substantial portion of electricity consumed; with each hood requiring over three times the energy of an average house (Mills & Sartor, 2005). The safety of the chemical fume hood user is another primary concern because adequate protection only occurs when the unit is operated within a narrow range of average face velocity; any lower or higher and the chemical fume hood is not providing the user with an acceptable level of protection (Lawrence Berkeley National Laboratory, 2002).

With the high operating costs and safety implications of each chemical fume hood it becomes increasingly important for medical institutions with several units to effectively manage their maintenance and use in order to avoid the added cost of energy inefficiency and compromised employee wellbeing. Additionaly, periodic inspections for proper chemical fume hood function are required by various regulatory bodies that have oversight of the healthcare industry: they include the chemical hygiene plan requirements from the Occupational Safety and Health Administration (OSHA) (Occupational Safety & Health Administration, 2006); the Joint Commission's Environment of Care standards relating to clinical laboratories (Joint Commission, 2008); and the laboratory

accreditation requirements of the College of American Pathologists (CAP) for laboratory safety (College of American Pathologists, 2007).

Despite the presence of a program at XYZ Medical Center to manage chemical fume hoods there exists substantial opportunity for financial loss relating to unit inefficiency and employee hazard exposure. Currently, the system for chemical fume hood management is administered by XYZ Medical Center's Occupational Safety Department. The system consists of a Microsoft Excel (MS Excel) database that lists the chemical fume hood location, maintenance identification number, comments on any previous issues, date of the last inspection, average face velocity at inspection, and an indication of pass or fail. An "approved" sticker with the last inspection date is place on the chemical fume hoods that have passed inspection and are ok for use. In the event that a chemical fume hood fails, the inspector sends an e-mail message to the Maintenance Department where repair duties are delegated to the appropriate individuals. This system may have been effective in the past when XYZ Medical Center had fewer chemical fume hoods but continued growth over the years has significantly increased their numbers and therefore requires an improvement to their system of management.

The current system limits the degree to which chemical fume hoods can be managed as an asset, which, in turn, limits both department and institution level continuous improvement activities. Main problems with the system include: an absence of notification when the chemical fume hood is moved to a different location; no record of when identified maintenance issues are resolved, which could have regulatory implications; limited access to the database for chemical fume hood users; and a labor intensive process involving multiple departments for administering the system. XYZ Medical Center does, however, maintain an electronic Maintenance Management System (MMS) that has, historically, only been used for tracking the maintenance status of

medical equipment critical to patient care. The MMS has recently become available, based on changes to regulatory language dealing with medical equipment management, to equipment that is less critical to patient care; chemical fume hoods, for example. The electronic system keeps a continually updated list of equipment location, provides use status, lists preventive maintenance schedules and status, sends automatic alerts for inspections and maintenance, is linked to the work order generating database, and keeps a record of all activity relating to a particular piece of equipment. The availability of the MMS to a wider variety of equipment classifications provides XYZ Medical Center, and other medical institutions under similar regulatory jurisdiction and of similar size and complexity, an opportunity to more effectively manage their equipment, particularly chemical fume hoods, to reduce costs and ensure employee safety.

Statement of the Problem

The lack of a fully integrated system for inspecting chemical fume hoods at XYZ Medical Center requires a more labor-intensive process than is necessary and places the institution at risk for loss related to health, property, and energy consumption.

Purpose of the Study

The purpose of this study is to integrate the management of chemical fume hoods into the equipment management program at XYZ Medical Center to increase the efficiency of the preventive maintenance, inspection, and repair process.

Goals of the Study

The main objectives of this study are to:

1. Identify opportunities for improving the management of chemical fume hoods at XYZ Medical Center.
2. Identify changes in regulatory language that will allow for the management of chemical fume hoods within an equipment management program.

3. Summarize the phases for transitioning chemical fume hood management into the equipment management program at XYZ Medical Center.

Significance

The integration will streamline the inspection and maintenance of chemical fume hoods to ensure the complete control of chemical fume hoods, thus reducing operational expenses and employee exposures to hazardous chemicals. The primary goal of the integration will be to eventually transfer the administration of the chemical fume hood maintenance program to the Facilities Operations Department; this will enable personnel in the Occupational Safety Department to allocate additional time to other activities related to risk management. Also, if the system is working it is expected that the number of "defective" hoods would be reduced from one year to the next, which would be an indication of continuous improvement, and, at the same time, a demonstration of the viability of using an existing medical equipment management system for the purposes of managing less critical laboratory equipment.

Definition of Terms

Average face velocity: "Air speed necessary to overcome opposing air currents and contain a contaminant in the hood for exhaust to the outdoors", measured in feet per minute (fpm). (Brookhaven National Laboratory, 2009, p. 2).

Biosafety cabinet: "An engineering control, which provides protection for both the work product (biological specimen) and the user. A laminar flow of HEPA filtered air is passed across the work surface. The air is then re-filtered before being exhuasted, usually back into the laboratory" (Brookhaven National Laboratory, 2009, p.2).

Chemical fume hood: "An engineering control designed to contain hazardous vapors and gases and exhaust them outside the building" (Brookhaven National Laboratory, 2009, p. 3)

Local exhaust ventilation systems: An engineering control used to contain hazardous chemical vapors and gases and exhaust them outside the building; often installed at lab benchtops, sinks, or near processing equipment they include slot hoods, canopy hoods, and snorkel hoods.

Preventive maintenance: "A procedure of inspecting, testing, and reconditioning a system at regular intervals according to specific instructions, intended to prevent failures in service or to retard deterioration" (McGraw-Hill, 2009, p. 1).

Vented specimen processing equipment: An engineering control used to contain hazardous chemical vapors and gases and exhaust them outside the building; often connected to a self-contained piece of laboratory equipment designed for automated specimen processing.

Limitations

The scope of this study is strictly limited to include only the management of chemical fume hoods within XYZ Medical center. Other types of laboratory ventilation, such as local exhaust ventilation systems, biosafety cabinets, and vented specimen processing equipment are excluded: biosafety cabinets are currently managed within the MMS and are not handled by the Occupational Safety Department; the management of local exhaust ventilation systems and vented specimen processing equipment pose a similar problem to XYZ Medical Center that chemical fume hoods present and are the focus of future projects. This study does not address the development or administration of a medical equipment management program as prescribed by Joint Commission; but rather an exploitation by the Occupational Safety Department of the systems and programs

developed to support an equipment management program. Additionaly, this study does not address the specific technical evaluation of chemical fume hoods, local exhaust ventilations systems, biosafety cabinets, or vented speciment processing equipment.

Assumptions

This study is confined within the scope of a large, multi-disciplinary medical center with facilities dedicated to direct patient care, clinical and research laboratory activities, and medical education; all of which are under the jurisdiction of all applicable regulatory bodies, both federal and private. In addition to this, the institution operates a fully integrated medical equipment management program.

Chapter II: Literature Review

The purpose of this study is to integrate the preventive maintenance management of chemical fume hoods into the equipment management program at XYZ Medical Center. The benefits of performing preventive maintenance on equipment vital to business operations has been studied since the 1950's (Dekker, 1996) and the effective execution of such programs is likely to save a company both time and money (Worsham, 2008). It is for these reasons that XYZ Medical Center would likely experience a decrease in operational costs if chemical fume hoods were managed to a greater degree. The following is a review of selected topics related to the purpose of this study. The topics include: Reactive maintenance, Preventive maintenance, Chemical fume hood maintenance, Equipment management regulatory requirements in healthcare, Equipment management standards of practice, Chemical fume hood management practice in industry, and Summary.

Reactive Maintenance

Reactive maintenance essentially means to leave equipment running until it breaks down before performing any maintenance. According to the U.S. Department of Energy (2007), over 55% of maintenance activities at businesses in the United States are reactive in nature. Though reactive maintenance may cost less and have lower staffing demands in the beginning, the costs associated with unplanned equipment outages, equipment repair or replacement, and increased staffing for making repairs will easily negate any of the initial savings. Additionally, as Christer Idhammar (2004) points out, the number of injuries or incidents actually increases during reactive maintenance activities because the work is often hurried and poorly planned. He goes on to describe a company that calculated a 28% increased chance of their maintenance personnel having an incident while performing reactive maintenance on equipment in their facility.

Preventive Maintenance

An alternative to reactive maintenance is preventive maintenance. The objective with preventive maintenance is to reduce the chances for equipment failure (Weibull, 2007) by periodically cleaning, making minor adjustments, and replacing minor parts; similar to routine car maintenance (Worsham, 2008). There are multiple benefits, all relating to cost, of a preventive maintenance program: increased production, longer equipment life, efficient use of maintenance staff, reduced number of large repairs, reduced cost of repairs, improved product quality, and increased employee safety.

Chemical Fume Hood Maintenance

Up to 35% of the energy used in a typical business can be contributed to heating, ventilation, and air conditioning (HVAC) systems (NCDENR, 2003). Adding chemical fume hoods to the HVAC system increases energy consumption in laboratories to four- to five-times that of a traditional commercial building (Lawrence Berkeley National Laboratory, 2007). Routine preventive maintenance is typically performed to avoid a reduction in the efficiency and the safety of these systems (ETSU, 2008). Common preventive maintenance activities include inspections of the fan housing and ductwork for leaks, inspecting the fan motor, and making sure the electrical system is functioning. Testing the face velocity of the chemical fume hood ensures that employees are properly protected as well as being a good check to be sure that the unit is not exhausting more air than is required, which will add cost (Lawrence Berkeley National Laboratory, 2007).

Equipment Management Regulatory Requirements in Healthcare

Three primary bodies exist to regulate the organizational management of medical equipment. The following is a review of each.

Occupational Safety and Health Administration. OSHA does not have regulations specifically addressing the management of medical equipment for the sake of patient

safety. They do, however, address worker safety regarding exposures to hazardous substances in laboratories and state, in 29 CFR 1910.1450(e)(3)(iii), that chemical fume hoods are to be working correctly and that appropriate actions be taken to meet performance standards (OSHA, 2006). Appropriate actions can be interpreted in a variety of ways, from remedial to complex solutions, and OSHA always has the right to cite, under the General Duty Clause, what they deem to be a condition hazardous to the health and well-being of an employee regardless of the presence or absence of an equipment management plan.

College of American Pathologists. Taking the OSHA regulation just one step further in terms of chemical fume hood regulations, CAP (2007) requires annual inspection of the face velocity to ensure proper functioning units. Still, like OSHA, no broad equipment management program requirements exist, or are intended to exist, considering the primary concern of CAP is "...advocating excellence in the practice of pathology and laboratory medicine" (CAP, 2009, paragraph 1). In other words, CAP's primary objective is to ensure that clinical laboratory specimens are handled appropriately.

Joint Commission. The Joint Commission has the most stringent requirements regarding medical/laboratory equipment management. On July 27, 2004 the Joint Commission (formerly the Joint Commission on the Accreditation of Healthcare Organizations (JCAHO)) formed an alliance with OSHA in order "…to work together to protect health care employees' health and safety, particularly in reducing and preventing exposure to biological and airborne hazards in health care and addressing emergency preparedness, ergonomics, and workplace violence issues" (OSHA, 2009, paragraph 1). This alliance demonstrates that OSHA looks to Joint Commission as a basis of reference for standards of practice in healthcare. OSHA does not require Joint Commission

accreditation, but the benefits of accreditation for a healthcare institution are numerous and include automatic compliance with the Medicare Conditions of Participation; meaning they would not need to be surveyed by the Centers of Medicaid and Medicare Services (CMS) to qualify for Medicare and Medicaid reimbursement, (Subhan, 2007). Additionally, states, like New York, are beginning to require Joint Commission accreditation of their healthcare practitioners (NY State Department of Health, 2009); and due to the wide acceptance in healthcare of voluntary accreditation, particularly by the Joint Commission (ACCE, 2006), it is certainly in a medical institution's best interest to become accredited.

Under their Environment of Care standards, the Joint Commission requires healthcare facilities to have documented and implemented management plans for each of seven elements: safety, security, hazardous materials and waste, emergency management, fire safety, equipment, and utility systems (Joint Commission, 2008); also, under the Joint Commission standard EC.6.10, laboratories are required to manage their equipment risks. Inclusion of equipment into the management program is to be determined by using risk criteria that account for the specific function of the equipment, the physical risks of using the equipment, and any maintenance requirements of the equipment. As recommended by the Association for the Advancement of Medical Instrumentation (AAMI, 1999), such inclusion can be determined by assigning an Equipment Management number, EM, calculated using EM = Function + Risk + Required Maintenance, and deciding inclusion into an equipment management program based on the value of the outcome. Equipment included in the equipment management program must then be inspected, tested, and maintained based on intervals defined and documented by the laboratory (Joint Commission, 2008).

As described by Rice and Wang (2003), JCAHO's July, 2001 changes to the

equipment inclusion criteria enabled healthcare facilities to better manage their equipment by allowing them to customize the testing requirements for each piece of equipment included in the plan. Previous to the changes by Joint Commission, the requirements were such that some equipment with lower risk ratings, while still high enough to be included in the equipment management program, was being needlessly over-tested, thereby wasting resources.

Equipment Management Standards of Practice

The American College of Clinical Engineers (ACCE) recommends the medical equipment management program be responsible for three general organizational duties: inventories of all clinical equipment; maintenance responsibilities for all clinical equipment; and advisement on the acquisition, retirement, and replacement of all clinical equipment (ACCE, 2006). The ACCE further defines specific components of the medical equipment management program:

- Develop and implement equipment inclusion criteria.
- Conduct audits to determine effectiveness and code compliance/accreditation conformance.
- Maintain continuous improvement and performance review processes.
- Include upper management.
- Actively participate with equipment acquisition.
- Actively participate with equipment related incident investigation.
- Periodically review the program.

In addition to the AAMI's EM calculation mentioned earlier, Wang and Levenson (2000) describe two other calculations, Equipment Management Rating (EMR) and Adjusted Equipment Managing Rating (AEMR), for determining equipment risk criteria (as cited in Rice and Wang, 2003). With the intent of finding a more useful method of

determining equipment risk, Rice and Wang explain that the EMR and AEMR were developed in order to consider both patient risks and the mission of the organization, in addition to utilization, in the case of AEMR, when determining the degree of inclusion to an equipment management program (Rice and Wang, 2003). The degree of inclusion can be more appropriately described, as Rice and Wang do, as a classification. Rather than merely deciding if the equipment will be a part of the equipment management plan, the classification determines the degree to which the equipment will be managed within the plan.

Chemical Fume Hood Management Practice in Industry

The publically available information regarding equipment management practices at institutions comparable in size and scope of business operations to XYZ Medical Center is limited; due, in part, to the fact that many, including XYZ Medical Center, maintain an intranet to house their policies and procedures that is accessible only to employees. With that said, the institutions that were identified all have similar processes for both chemical fume hood management and follow the Joint Commission guidelines for administering equipment management plans. The institutions are: Boston Medical Center, Duke University, Johns Hopkins, UCLA, and University of Toledo.

Their policies all infer that chemical fume hoods are managed separate from a medical equipment management program (Duke University, 2007; Johns Hopkins, 2008a; University of Toledo, 2007; Boston Medical Center, 2009; UCLA, 2008); they do not, however, provide information on a system of management for chemical fume hoods. Duke University's equipment management plan explains the equipment inclusion criteria and makes it clear that chemical fume hoods fall into the lowest category and therefore would not be included in the equipment management program (Duke University, 2007). Johns Hopkins (2008b) does not have a publically available policy that outlines

equipment inclusion criteria but does have separate policies that deal with chemical fume hood management and the equipment management plan. Boston University and UCLA both indicate that their respective Offices of Environmental Health and Safety handle the inspection and management of chemical fume hoods (Boston Medical Center, 2009; UCLA, 2008), but no information was available regarding their inclusion in an equipment management program. Each of the institutions makes reference to the Joint Commission's Environment of Care standards as the primary regulatory force behind the administration of their equipment management programs.

Summary

The Joint Commission is the primary regulating body that controls the requirements for institution wide equipment management plans. The required equipment management plans allow for inclusion criteria to be established based on the risks inherent in the operation of the equipment; the requirements also allow the degree of management to vary based on the risk level. Therefore it is reasonable to include low risk equipment, like chemical fume hoods, into an equipment management plan even if only for purposes of inventory control and yearly inspection and preventive maintenance cycles. Despite this, it appears that the institutions comparable to XYZ Medical Center continue to exclude low-risk equipment from their equipment management programs.

Chapter III: Methodology

To ensure that chemical fume hoods continue to operate safely and efficiently, staff of XYZ Medical Center's Occupational Safety Department conducts yearly evaluations of each unit. The existing system supports an increasing potential for loss due to an inefficient equipment management process for the tracking and preventive maintenance scheduling of chemical fume hoods. The purpose of this study is to integrate the preventive maintenance management of chemical fume hoods into the equipment management program at XYZ Medical Center.

Subject Selection and Description

XYZ Medical Center was selected as the subject of this study. XYZ Medical Center is a large, multi-disciplinary healthcare institution with approximately 38,000 employees, about 15 million square-feet of space, and a scope of operation encompassing clinical practice, research, and education.

The author is currently employed as a full-time Occupational Safety Associate at XYZ Medical Center and has access to policy documents, files, and personnel within the institution.

Data Required

Data required for this study included, 1) a review of current chemical fume hood management practices performed by XYZ Medical Center, 2) an evaluation of the performance of chemical fume hoods over the past five years, 3) a policy review of existing practices used by XYZ Medical Center's peer institutions, and 4) a literature review of equipment management standards of practice.

Data Collection Procedures

Current management practice. Information on the current practices for managing XYZ Medical Center's chemical fume hoods was reviewed from collected documents.

First, electronic files from the Occupational Safety Department's shared hard drive on XYZ Medical Center's server were obtained from the location known to the author: these files included the chemical fume hood evaluation procedure and data sheet document, and the MS Excel file serving as the chemical fume hood evaluation records database. Second, the institutional policy regarding the evaluation and management of chemical fume hoods was obtained from the Laboratory Policy Manual located on XYZ Medical Center's server. The specific procedures for managing chemical fume hood inspections and preventive maintenance are not documented; however, due to job responsibilities at XYZ Medical Center, the author possesses a working knowledge of the process. The procedures are outlined in Chapter IV.

Past performance. The performance of the existing chemical fume hood management practice was evaluated by calculating the rate of defect in the hoods from the evaluation records of previous years.

Using the MS Excel Hood Evaluation Records database, a review of the inspection records for the years 2008, 2007, 2006, 2005, and 2004 was conducted. Reliable records for years prior to 2004 were not available. Defective chemical fume hoods were defined as those with a measured average face velocity outside of the allowable limits, less than 80 fpm or greater than 150 fpm, or those that could not be located, and, therefore, could not be evaluated. The number of defective hoods was determined by manually reviewing the evaluation records and tallying the number of defective chemical fume hoods for each year; the total number of hoods on record was also counted. The rate of defect was calculated by dividing the sum of all defective hoods in one year, by the total number of hoods on record for that year, then multiplying the result by 100 to determine the percentage of defective chemical fume hoods for that year.

Results were compiled in Table 1 of Chapter IV and include: the total number of hoods; the number of hoods with an inadequate flow rate; the number of hoods not located; the total number of defective hoods; and the percent defect. A side-by-side comparison of each year could then be accomplished to identify any potential trends present in the rate of defect over the five years in order to quantitatively gauge the performance of the current chemical fume hood management practice. Decreasing defect rates from one year to the next indicate continuous performance improvement, while increasing or unchanging defect rates would not indicate continuous performance improvement.

Industry benchmark. A review of policies regarding chemical fume hood evaluation and management at five institutions of similar size and scope of business operations at XYZ Medical Center was conducted.

To identify comparable institutions, XYZ Medical Center's Marketing Department was contacted via internal electronic mail and asked to aid in the development of a list of five institutions that generally compete in a similar market as XYZ Medical Center; these institutions were defined as Tier I institutions for the purposes of this study and are listed in Appendix B. The website of each Tier I institution was located by conducting an Internet search using the Google Internet search engine. Internal policy documents were then searched for by navigating the website menus or, if available, entering "chemical fume hood" or "equipment management" as a key phrase into the website search field. An institution was not used in the comparison if internal policy documents were not available from their public website.

To supplement the Tier I institution list and ensure that five institutions were used in the comparison with XYZ Medical Center, a secondary list was generated. The medical institutions in the secondary list were not required to be direct competitors of

XYZ Medical Center; these institutions were defined as Tier II institutions for the purposes of this study and are listed in Appendix C. Tier II institutions were identified through the Internet search engine Google using the key phrase, "medical equipment management, chemical fume hood". The results were then reviewed and narrowed, beginning with those listed highest and continued for no more than three pages, to reveal only medical facilities with publically available policies relating to chemical fume hood evaluation or medical equipment management. Tier II institution websites were searched in the same manner as Tier I institution websites as described above. Ultimately, five institutions with publically available policies were identified and selected for the comparison; these institutions are listed in Appendix D.

Each policy was read to determine: 1) the mode of management for chemical fume hoods (medical equipment management plan, or other) and 2) the department responsible for administering the management of chemical fume hoods (Safety, or Facilities) at each institution. The results were compiled for comparison with XYZ Medical Center and presented in Table 2 of Chapter IV.

Equipment management standards of practice. Each medical institution uses and maintains a large amount of medical equipment and is required to manage the equipment (Joint Commission, 2008) according to a set of industry standards, particularly those of the Joint Commission. A review of the published literature containing recommendations for administering a medical equipment management program in addition to the literature defining the Joint Commission requirements of a medical equipment management program was conducted.

Reviewed published literature was obtained by searching the Google Scholar Scientific Literature search engine. Websites, articles, organizations, and any other useful information were obtained by searching the Google Internet search engine. Keyword and

search phrases that were used during the search included: "Medical Equipment Management", "Joint Commission Equipment Management Plan", "Environment of Care", and "Equipment Management Requirements". A summary of the reviewed literature is included in the Joint Commission, and Equipment Management Standards of Practice sections of Chapter II.

Data Analysis

The information that was gathered regarding current management practices, past performance, industry benchmark, and medical equipment management standards of practice was all considered and used to define the opportunity for XYZ Medical Center to improve the method of management for chemical fume hoods. The results indicating the past performance of chemical fume hoods was used to gauge the effectiveness of the current management practice. The review of equipment management standards of practice was used to identify the role of an equipment management program and any existing possibilities for utilizing a medical equipment management program for inventory control and preventive maintenance scheduling of chemical fume hoods.

Chapter IV: Results

To ensure that chemical fume hoods continue to operate safely and efficiently, staff of XYZ Medical Center's Occupational Safety Department conducts yearly evaluations of each unit. The existing system supports an increasing potential for loss due to an inefficient equipment management process for the tracking and preventive maintenance scheduling of chemical fume hoods.

The integration of preventive maintenance management of chemical fume hoods into the equipment management program at XYZ Medical Center was initiated after consideration of: 1) current management practices, 2) past equipment performance, 3) industry benchmark data, and 4) equipment management standards of practice.

Presentation of Collected Data

Current management practices. The existing procedures for managing chemical fume hoods were obtained from a the Safety Department's hard drive on XYZ Medical Center's server. The chemical fume hood management practices were compiled through a combination of procedure document review and the author's knowledge of the process; they are as follows:

1. The list of chemical fume hoods to be evaluated in the current year is populated using the MS Excel Chemical Fume Hood Evaluation Records database from the year previous. The list includes a unique identification number, building, floor, and room number for each hood.
2. The Occupational Safety staff member conducts the chemical fume hood evaluations (technical chemical fume hood evaluation procedures are beyond the scope of this study and are therefore not reviewed) and records information on the chemical fume hood evaluation data sheet; one data sheet is used per hood.

3. Completed data sheets are cross-referenced with the "to be evaluated" list and the status of each chemical fume hood is updated in the Chemical Fume Hood Evaluation Records database by (see Appendix A: Chemical Fume Hood Database):
    - Entering the average face velocity and indicating if it was "pass" or "fail".
    - Noting any broken, missing, or malfunctioning parts.
    - Entering "hood not located" if a chemical fume hood was not in the location it was listed as being in; or if the room no longer exists due to renovations.
    - Adding, or updating location information for chemical fume hoods that were found in a different location than listed, or that were not listed at all.
4. A list of the chemical fume hoods requiring maintenance or repair is forwarded via electronic mail to the Facilities Operations Manager who then assigns the repair duties accordingly.

Past performance. Chemical fume hood inspection records were reviewed for the years 2008, 2007, 2006, 2005, and 2004; results are listed below in Table 1. Flow rate data for 2004 was not available and as a result the defect rate could not be calculated. The rate of defect in 2005 was 26.9%, which decreased by approximately 4% in 2006 and then increased by over 10% from 2006 to 2007. The rate of defect for 2008 reduced negligibly, to 33%, from 2007.

Table 1

Chemical Fume Hood Defect Data for the Years 2004-2008

Year	Total Hoods	Number With Inadequate Flow	Number Not Located	Total Number Defective	% Defect
2004	356	No Data	1	1	_
2005	356	95	1	96	26.9
2006	381	61	27	88	23.1
2007	470	115	42	157	33.4
2008	496	73	91	164	33.0

Industry benchmark. Chemical fume hood management practices at institutions similar to XYZ Medical Center were reviewed from publically available policy documents (Chapter II: Literature Review). The policy document review did not identify any clear differences in the way XYZ Medical Center manages chemical fume hoods compared to peer institutions; none utilized an institutional medical equipment management plan. The department responsible for chemical fume hood management was Safety in the case of two institutions, not including XYZ Medical Center, and could not be ascertained for the others. A summary of the mode, and the department responsible for the administration of chemical fume hood management at each institution is included in Table 2 below.

Table2

Mode of Chemical Fume Hood Management and Responsible Department at Institutions Benchmarked against XYZ Medical Center

	Responsible Department		Mode of Management	
Institution	Safety	Facilities	Equipment Management Program	Other
XYZ Medical Center	x			x
Boston Medical Center	x			x
Duke	NA			x
Johns Hopkins	NA			x
UCLA	x			x
University of Toledo	NA			x

NA = Information not available

Equipment management standards of practice. Equipment management standards of practice and Joint Commission requirements were reviewed from published literature (Chapter II: Literature Review). The literature suggests the medical equipment management plan be responsible for controlling inventory and preventive maintenance to facilitate continuous improvement thereby reducing loss (to property, health, and excess energy consumption). Additionally, the program should have upper management involvement and be periodically audited to ensure compliance. Based on the requirements and guidelines, it is clear that a formal equipment management program is the ideal operating environment for managing many types of equipment. Also discerned in the literature are explanations of the Joint Commissions inclusion criteria allowing for non-medical equipment, such as chemical fume hoods, to be included in the medical

equipment management program. This leaves the institution to decide to what degree a certain piece of equipment should be managed based on the risk that it poses to the user.

Summary

The deficiencies in the existing chemical fume hood management system expose XYZ Medical Center to an increasing potential for loss related to health, property, and excess energy consumption. Based on an evaluation of current chemical fume hood management practices at XYZ Medical Center, past equipment performance, methods of management at similar institutions, and general equipment management standards of practice, a plan has been initiated for the integration of chemical fume hood management into the institutional equipment management plan. Stricter control of this equipment within an established system is likely to ensure safe and efficient operation, in addition to sustaining an environment of continuous improvement.

Chapter V: Conclusions and Recommendations

The purpose of this study was to integrate the management of chemical fume hoods into the equipment management program at XYZ Medical Center to increase the efficiency of the preventive maintenance, inspection, and repair process. The integration was initiated after consideration of: 1) current chemical fume hood management practices at XYZ Medical Center, 2) past equipment performance, 3) benchmark data from comparable institutions, and 4) equipment management standards of practice.

For the past five years (2004-2008) XYZ Medical Center has increased the number of chemical fume hoods in laboratory spaces by an average of 12 hoods per year, while the rate of defective hoods has effectively remained unchanged, or increased. With effective management, it is assumed that equipment control would tighten with each passing year and the rate of defect would decrease over time; an indication of continuous improvement and one of the primary objectives of an institutional medical equipment management plan.

Results of this study indicate that the current system at XYZ Medical Center for managing chemical fume hood inspection and preventive maintenance activities is not effective at reducing the potential for loss. The system, however, does not appear to be any different than that of peer institutions, which could indicate either a potential for improvement industry-wide, or that XYZ Medical Center has simply allowed for sub-par chemical fume hood management. It is disconcerting to observe these outcomes in an environment that both requires and supports a fully integrated and controlled medical equipment management program, and reveals a dichotomy, and inconsistency, at XYZ Medical Center in the way non-patient equipment is managed.

Apart from flat or decreasing equipment performance, the method of chemical fume hood management at XYZ Medical Center limits information availability to

equipment users who may have preventive maintenance questions related to regulatory compliance. While a user of patient care-related equipment has the ability to look-up maintenance records in the medical equipment management program's electronic interface, a user looking for information related to chemical fume hoods must contact the Safety department during business hours and receive the information verbally. Additionally, if a chemical fume hood is identified as requiring maintenance, there is no follow-up or record of when that maintenance is initiated or completed.

Deficiencies related to performance, maintenance record keeping, and information availability dictate that chemical fume hood management at XYZ Medical Center is due for an overhaul.

Conclusions

The following major points were identified through the review of information related to the integration of chemical fume hood management at XYZ Medical Center.

- Chemical fume hoods represent a significant expense to medical institutions and should be managed as such. The current system of chemical fume hood management at XYZ Medical Center is ineffective at reducing the incidence of defective hoods and does not support continuous performance improvement.
- A review of policies at institutions similar to XYZ Medical Center revealed that others within the industry also manage chemical fume hoods separate from an institutional medical equipment management plan.
- Regulatory bodies overseeing medical facilities do not limit medical equipment management plans to include only high-risk medical equipment. There exists significant opportunity for other equipment that are considered low-risk, like chemical fume hoods, to be managed to a greater degree within an institutional equipment management program.

Recommendations

It is recommended that XYZ Medical Center continue the process of integrating the management of chemical fume hood preventive maintenance activities into the institutional medical equipment management program. Managing the administration of programs, in any realm, is challenging. It is for this reason that the full integration of chemical fume hood management into the institutional equipment management plan will occur in stages over an undefined period of time. Based on the complexity of the systems currently in place, the transition process is broken into three phases; the following is a summary of each.

Phase one. Completed, for the most part, prior to the beginning of First Quarter, 2009, each chemical fume hood has received an Equipment Maintenance Identification tag with a unique number. Through cooperation with Facilities Operations, these numbers are used to create a record in the Maintenance Management System (MMS) for each chemical fume hood and contain information on the brand, specifications, location, and preventive maintenance requirements and schedule of each hood.

Phase two. Once an MMS record has been created for each hood, the next step, having begun January 1st, 2009, is to identify each chemical fume hood and ensure their actual location matches with the location listed in the equipment database. This step is an unfortunate necessity due to the lack of a mechanism for tracking location changes, which is being addressed, simultaneously, in another project within the Safety Department. The end of phase two will be characterized by the consistent and proactive updating of chemical fume hood locations in MMS, and will be identified by periodically auditing a subset of hoods; the expectation is that 95% of the hoods are found to be in the location they are listed as being in. Also occurring in phase two is the formalization of inspection schedules to streamline inspections and ensure the efficient use of personnel.

Chemical fume hoods will be sorted by building and floor within the MMS and divided so that an equal number will be inspected each quarter.

Phase three. This last step involves the complete transfer of responsibility for administering the chemical fume hood management system from Safety to Facilities Operations. Initiating the final phase will not occur until all components of the previous phases are fully operational and adequate staffing is present in Facilities Operations to support the additional responsibilities.

Areas of Further Research

Future studies related to this topic would likely include a more thorough benchmarking analysis to identify the exact chemical fume hood management process at other institutions. Additionally, XYZ Medical Center may benefit from an analysis of local exhaust ventilation system management, as well as an analysis into energy saving opportunities involving both chemical fume hoods and local exhaust ventilation systems.

References

Association for the Advancement of Medical Instrumentation (AAMI). (1999). *Recommended practice for a medical equipment management program*. Retrieved February 19, 2009, from http://marketplace.aami.org/eseries/scriptcontent/docs/Preview%20Files/EQ56preview.pdf

American College of Clinical Engineers (ACCE). (2006). *Guidline for medical equipment managment programs*. Retrieved February 18, 2009, from http://www.accenet.org/downloads/reference/Guidelines-MedicalEquipmentManagementPlans.pdf

Boston Medical Center. (2009). *Chemical fume hoods*. Retrieved March 7, 2009, from http://www.bu.edu/research/compliance/oehs/research-safety/laboratory-safety/equipment/cfh.shtml

Brookhaven National Laboratory. (2009). *Laboratory hood face velocity testing*. Retrieved March 7, 2009, from http://www.bnl.gov/esh/shsd/sop/pdf/IH_SOPS/IH62420.pdf

College of American Pathologists. (2009). *About CAP*. Retrieved March 7, 2009, from http://www.cap.org/apps/cap.portal?_nfpb=true&_pageLabel=about_cap

College of American Pathologists. (2007). *Laboratory accreditation manual*. Retrieved February 20, 2009, from http://www.cap.org/apps/docs/laboratory_accreditation/standards/lapmanual_0707.pdf

Dekker, R. (1996). Applications of maintencance optimization models: a review and analysis. *Reliability engineering and system safety, 51*, 229-240.

Duke University. (2007). *Equipment management program*. Retrieved March 7, 2009, from http://clinicalengineering.duhs.duke.edu/wysiwyg/downloads/CE020-Equipment_Management_Program.pdf

East Tennessee State University (ETSU). (2008). *General work practices for chemical fume hoods at ETSU*. Retrieved February 28, 2009, from http://www.etsu.edu/healthsafety/Chemical_and_Lab_Safety/Chemical_Fume_Hoods.pdf

Idhammar, C. (2004). *Safety and reactive maintenance.* Retrieved March 8, 2009, from http://www.idcon.com/article-reliability-maintenance-reactive.htm

Johns Hopkins. (2008a). *Clinical equipment*. Retrieved March 7, 2009, from http://www.hopkinsmedicine.org/hse/Policies/HSE_Policies/indiv_sections/hse009.pdf

Johns Hopkins. (2008b). *Environment of care management plans*. Retrieved March 7, 2009, from http://www.hopkinsmedicine.org/hse/Policies/HSE_Policies/indiv_sections/HSE310.pdf

Joint Commission. (2008). *Management of the laboratory environment*. Retrieved February 28, 2009, from http://www.jointcommission.org/NR/rdonlyres/266E870D-BEB4-48CC-9ABC-2EC3210C8291/0/BHC2008ECChapter.pdf

Lawrence Berkeley National Laboratory. (2002). *Applications team*. Retrieved February 28, 2009, from http://ateam.lbl.gov/hightech/fumehood/brochure/FHB4RevG.htm

Lawrence Berkeley National Laboratory. (2007). *The berkeley hood.* Retrieved March 8, 2009, from http://ateam.lbl.gov/hightech/fumehood/About.html

McGraw-Hill. (2009). *Preventive maintenance.* Retrieved February 28, 2009, from http://www.answers.com/topic/preventive-maintenance

Mills, E., & Sartor, D. (2005). Energy use and savings potential for laboratory fume hoods. *Energy, 30*, 1859-1864.

North Carolina Department of Environmantal and Natural Resources (NCDENR). (2003). *Energy efficiency in industrial HVAC systems.* Retrieved March 8, 2009, from http://www.p2pays.org/ref/26/25985.pdf

Northwestern University. (2007). *ORS laboratory safety*. Retrieved February 28, 2009, from http://www.research.northwestern.edu/ors/labsafe/hoods/

NY State Department of Health. (2009, January). *Office-based surgery*. Retrieved March 7, 2009, from http://www.health.state.ny.us/professionals/office-based_surgery/

Occupational Safety & Health Administration (OSHA). (2006). *Occupational exposure to hazardous chemicals in laboratories*. Retrieved February 28, 2009, from http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106

Occupational Safety & Health Administration (OSHA). (2009). *The Joint Commission and Joint Commission Resources (JCR)*. Retrieved March 7, 2009, from http://www.osha.gov/dcsp/alliances/jcaho/jcaho.html

Subhan, A. (2007). *The Joint Commission medical equipment standards*. Retrieved February 20, 2009, from http://www.24x7mag.com/issues/articles/2007-03_06.asp

U.S. Department of Energy. (2007). *Energy efficiency and renewable energy*. Retrieved March 8, 2009, from http://www1.eere.energy.gov/femp/operations_maintenance/om_reactive_main.html

University of California Los Angeles (UCLA). (2008). *Chemical safety*. Retrieved March 10, 2009, from http://map.ais.ucla.edu/portal/site/UCLA/menuitem.789d0eb6c76e7ef0d66b02ddf848344a/?vgnextoid=641614bb06af1110VgnVCM200000ddd76180RCRD

University of Toledo. (2007). *Equipment management plan: Procedure no. ME-08-000.* Retrieved March 10, 2009, from http://www.utoledo.edu/depts/safety/docs/ME-08-000.pdf

Wang, B., & Rice, W. P. (2003). JCAHO's Equipment Inclusion Criteria Revisited - Application of Statistical Sampling Technique. *Journal of Clinical Engineering* , 37-48.

Weibull. (2007). *Preventive maintenance*. Retrieved March 8, 2009, from http://www.weibull.com/SystemRelWeb/preventive_maintenance.htm

Worsham, W. C. (2008). *Is preventive maintenance necessary*. Retrieved March 8, 2009, from http://www.maintenanceworld.com/Articles/worshamw/ispreventive.html

Appendix A: Chemical Fume Hood Database Example

Location	Maint. ID #	Monitor Works 2009	Flow Rate at 12" face velocity 2009	Reduced flow switch works 2009	New Date 2009	2009 Observations
## 19-366	147331	Y	102	Y	2/12/09	
## 19-366	147328	Y	147	Y	2/12/09	
## 19-366	147336	Y	122	Y	2/12/09	
## 19-366	147334	Y	129	Y	2/12/09	
## 19-366	147332					Not in room
## 19-466	147320	Y	142	Y	2/12/09	
## 19-466	147321	N	126	Y	2/12/09	Alarms in low flow mode with sash closed
## 19-466	147322	Y	132	Y	2/12/09	
## 19-466	147323	N	123	Y	2/12/09	Alarms in low flow mode with sash closed
## 19-466	147324	N	142	Y	2/12/09	
## 19-466	147325	N	151	Y	2/12/09	Alarms in low flow mode with sash closed
## 19-466	147326	Y	140	Y	2/12/09	
## 19-466	147327	Y	174	Y	2/12/09	
## 19-466	147329	N	127	Y	2/12/09	Alarms in low flow mode with sash closed
## 19-466	147330	N	117	Y	2/12/09	Alarms in low flow mode with sash closed
## 19-151	167938	Y	131	Y	2/12/09	
## 19-151	167939	Y	112	Y	2/12/09	
## 19-151	167940	Y	123	Y	2/12/09	
## CL036	145713	Y	119	Y	2/13/09	
## CL-54	147682	Y	147	Y	2/13/09	
## CL-47	147685	Y	135	Y	2/13/09	
## 1-21A	145673	Y	135	Y	2/13/09	
## 1-21A	145674	Y	130	Y	2/13/09	Edges of glass sash doors are chipped in multiple places

Appendix B: Tier I Institutions

The following is a list of medical institutions that compete, generally, with XYZ Medical Center:

- Cleveland Clinic
- Johns Hopkins
- Mass General
- New York Presbyterian
- UCLA

Appendix C: Tier II Institutions

The following is a list of medical institutions that do not necessarily compete with XYZ Medical Center:

- Boston Medical Center
- Duke University
- University of Toledo

Appendix D: Medical Institutions Selected for Comparison

The following is the list of medical institutions selected for comparison with XYZ Medical Center:

- Boston Medical Center
- Duke University
- Johns Hopkins
- UCLA
- University of Toledo