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Building Vulnerability Assessment and Mitigation

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PREFACE

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Commission), annually awards up to $62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

- PIER funding efforts are focused on the following six RD&D program areas:
- Buildings End-Use Energy Efficiency
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Strategic Energy Research.

What follows is the final report for the Building Vulnerability Guide, 500-01-034, conducted by the Lawrence Berkeley National Laboratory. The report is entitled Building Vulnerability Assessment and Mitigation. This project contributes to the Buildings Program.

For more information on the PIER Program, please visit the Commission's Web site at: http://www.energy.ca.gov/research/index.html or contact the Commission's Publications Unit at 916-654-5200.

ABSTRACT

Understanding the vulnerabilities of buildings to chemical, biological, and radiological attack is a key consideration in estimating the consequences of deliberate or accidental toxic agent releases and - more importantly - in determining how to mitigate or eliminate them. Some of the key vulnerability issues addressed in this project are:

- Location of outside air intakes for HVAC systems,
- Particle filter efficiency (including leakage around the filters),
- Building and zone pressures,
- Control of mechanical systems for manipulating building air supply and flows,
- Duct and damper leakage,
- Routes of internal air and contaminant transport,
- Evacuation routes and potential 'safe' zones,
- Mechanical room access
- Access to mechanical system control software
- Emergency response teams and response planning for internal and external releases.

The Building Vulnerability Assessment and Mitigation Program (BVAMP) is a field-tested, software tool designed for use by a typical building owner or operator. Although the users need to be familiar with the operation of building systems and emergency response plans for their facility, they do not need to be knowledgeable in the area of chemical or biological vulnerability. The program guides the user through a series of questions and then presents a report listing potential vulnerabilities and mitigation actions, along with cost levels, energy implications, and threat levels that would warrant implementation of the mitigation measures. The BVAMP software and supporting documentation is freely available at http:\\securebuildings.lbl.gov.

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EXECUTIVE SUMMARY

Introduction

Chemical or biological attacks on buildings are seen as an increasingly credible threat – either directly targeted at a specific building or possibly the "downwind" effect of being in the vicinity of a targeted building. However, building owners and operators who wish to assess and reduce the vulnerability of their buildings must sift through many different sources of information containing sometimes conflicting advice or analyses. The purpose of this project was to analyze and refine the best current advice and, based on this analysis, develop a user-friendly building vulnerability assessment methodology for building owners, operators, and consultants. Threat or risk assessment is a separate issue, which is not included in this program. Threat assessments are best performed in co-operation with law enforcement personnel.

Project Approach

The formulation of the Building Vulnerability Assessment and Mitigation Guide is based upon simulation and experimental work performed at Lawrence Berkeley National Laboratory (LBNL) and elsewhere for understanding airflows and contaminant transport into and within buildings. We also drew upon documents pertaining specifically to emergency response and protection in buildings. The primary goal of the Building Vulnerability Assessment and Mitigation Guide is to provide the best available advice in an easy to use application that provides consistent results, organizes these results in an easy to interpret fashion, and explicitly considers the energy implication of mitigation measures. To meet this goal, the methodology divides the assessment process into three parts, as follows:

1) A walk-through assessment that is designed to be printed out and taken with the user during a physical inspection of the building, systems and documents,

2) A software tool (the Building Vulnerability Assessment and Mitigation Program or BVAMP) which leads the user through the assessment process, and

3) A Vulnerability Assessment Report that provides individualized vulnerability and mitigation advice for the building, including information regarding relative cost, energy implications, and whether measures are warranted for all buildings or should be considered primarily by those at increased risk.

The three parts of this methodology, taken together, form the basis for the Building Vulnerability Assessment and Mitigation Guide.

These tools are intended for use in typical office buildings with low to moderately high threat levels. Although buildings with very high threat levels or highly specialized facilities may find the program is useful as a screening procedure, these facilities should consider conducting follow-up assessments which take into consideration their specialized needs.

Project Outcomes

This study had two main objectives: 1) develop and test procedures for assessing the vulnerability of buildings to chemical or biological agent attack, including the impact remedial measures would have on building energy systems and 2) produce a guidance document for vulnerability assessment and mitigation for buildings to reduce the likelihood and effectiveness of potential attacks, with consideration for impacts on the building energy systems.

Since energy impacts are included in the recommendations, use of these guidelines will help users understand the energy implications of various mitigation measures. One expected outcome of this effort would be private sector implementation of these guidelines and assessment procedures to meet the challenge of assessing and reducing building vulnerabilities across California. Implementation of the guidelines would reduce the severity of an attack and may also reduce the likelihood of attack.

The final product of this project is a computer-based assessment guide which walks the user through the assessment process and then prints a report which outlines any identified areas of vulnerability, measures to mitigate those vulnerabilities, cost range (higher or lower) and energy implications for implementation, and threat conditions (levels) that would warrant implementation. One essential feature of the Building Vulnerability Assessment and Mitigation Guide is that it was field tested in several different buildings to assure that the advice was clear, comprehensive, and robust. The initial plan was to use several high profile government buildings as part of the field-testing plans. However, security issues prevented the use of these buildings. As a consequence, field-testing was performed in lower profile buildings that have lower levels of risk.

The BVAMP software developed in this project, along with all supporting documentation, is available for free download at http://securebuildings.lbl.gov. It is platform-independent and runs on the Java virtual machine, which is available for free at http://sun.com.

Conclusions and Recommendations

This report presents the basis for the preparation of the interactive Building Vulnerability Assessment and Mitigation Guide. The Building Vulnerability Assessment and Mitigation Guide (BVAM Guide) is the first field-tested, easy-to-use protocol that building owners and operators can utilize to reduce the likelihood and severity of a chemical, biological, or radiological agent attack. The BVAM Guide consists of a building walkthrough questionnaire, an interactive software program (BVAMP), and the vulnerability assessment and mitigation report produced by the software. BVAMP and all supporting materials are freely available at http://securebuildings.lbl.gov. This guide explicitly considers the costs of mitigation measures and whether the measure is suggested for all buildings or is more appropriate for those buildings at increased risk. The report considers both favorable and unfavorable energy impacts from the implementation of mitigation measures and encourages the user to consider energy impacts when designing a mitigation plan.

The BVAM Guide was produced using the best currently available information. As new information regarding vulnerability reduction and mitigation strategies becomes available, this guide will need to be updated. The majority of the time and budget allocated to this project was invested in assuring that the Building Vulnerability Assessment and Mitigation Guide was comprehensive, easy to use, and utilized the best currently available information on threat and consequence reduction for buildings. Enhancements to the look and feel of BVAMP and the report generated by BVAMP would enhance usability. Achieving the maximum benefit from this project requires an extensive outreach program. The purpose of the outreach program is to increase awareness within the building management community of the availability and usefulness of the Building Vulnerability and Assessment Guide. Use of this guide throughout the California building stock will provide positive benefits for reducing both the likelihood and the severity of a chemical, biological, or radiological attack.

1.0 INTRODUCTION

Over the past several years, there has been increased interest in protecting buildings and building occupants from potential terrorist attacks. A portion of this attention has centered on reducing threats posed by chemical, biological, and radiological agents or materials. To this end, various governmental and private organizations have developed information and guidance designed to address some of the issues associated with terrorist attacks on buildings. Most of this information has taken the form of published web pages and/or printed guides. The purpose of this project is to analyze and refine the best current advice and, based on this analysis, develop a user-friendly building vulnerability assessment methodology for by building owners, operators, and consultants.

In the first stage of this project we identified and collected advice on assessing and mitigating building vulnerability to chemical or biological attack. This information was collected and reported in the California Energy Commission report "Existing Methodology and Protocols Summary (December 2002)" which is included in this report as Appendix C. In many cases, there are common themes among many of the information sources, for example, the obvious vulnerabilities presented by accessible and easily identifiable HVAC air inlets. In other cases, opinions and/or advice differ, such as recommendations for manipulating the HVAC system to control the spread of contaminants indoors. We have based this present work on our synthesis of the previous work and on our own studies on airflow and the transport and fate of contaminants in buildings. It is worth noting that the “science” underlying the assessment of vulnerabilities and what to do about them is not yet definitive. We, as others have done, have relied on best engineering judgment in a number of areas, recognizing that buildings and building operations differ, even among buildings of the same class. Broad advice appropriate for typical buildings of the same class may need to be tailored for individual buildings.

During the second stage of the project we developed a methodology for evaluating building vulnerability that is presented in the California Energy Commission report "Building Vulnerability Assessment Methodology (August 2003)”, which is included in this report as Appendix D. This methodology was field-tested in a variety of buildings during the third phase of the project, as part of the development of the final Building Vulnerability Assessment and Mitigation Guide. This field testing resulted in an evaluation of the effectiveness, robustness, ease of use, and applicability of the methodology. The assessment methodology was modified, based on the results of the field testing, and developed into the final Building Vulnerability Assessment and Mitigation Guide (BVAM Guide) that building owners, operators, and/or their consultants will be able to use to determine areas of vulnerability and how to reduce them. The cornerstone of this guide is the Building Vulnerability Assessment and Mitigation Program (BVAMP), as software program that leads users through a series of building vulnerability assessment questions.

1.1. Report Organization

This final report contains an overview of the development process for the Building Vulnerability Assessment and Mitigation Guide (BVAM Guide). The report is organized as follows

Section 1.0	Introduction
Section 2.0	Project Approach
Section 3.0	Project Outcomes
Section 4.0	Conclusions and Recommendations

The report includes the following appendices:

Appendix A:	Building Walk-Through Questionnaire
Appendix B:	Sample Assessment Report (includes the questions asked by the BVAMP software)
Appendix C:	Existing Methodology and Protocols Summary (December 2002)
Appendix D:	Building Vulnerability Assessment Methodology (August 2003)
Appendix E:	Building Test Report

The results of the literature review from the first phase of the project are presented in the reference section.

2.0 PROJECT APPROACH

The formulation of the Building Vulnerability Assessment and Mitigation Guide (BVAM Guide) built on simulation and experimental work performed at Lawrence Berkeley National Laboratory (LBNL) and elsewhere for understanding airflows and contaminant transport into and within buildings. We also drew upon documents pertaining specifically to emergency response and protection in buildings. A starting place for building research was an LBNL report detailing data needs and existing data relating to building characteristics such as HVAC systems, and filtration and building airflow, such as infiltration and natural ventilation (Thatcher, et al. 2001). The information contained in this report is highly relevant to the issues associated with building vulnerability reduction and was incorporated into our building assessment methodology. In addition, we drew upon information gained through previous building airflow modeling, such as COMIS or CONTAM. An overview of multizone airflow models and a detailed description of the COMIS model were presented by Feustel, 1999.

Threat reduction and assessment work done by LBNL, first responder training materials developed at LBNL, and relevant published work from other organizations has also been incorporated into the guide. Important references include The Army Corps of Engineers guide to protecting buildings (October 2001) and ASHRAE's risk management guide for extraordinary incidents (12 January 2002)”. A full list of documents used in the development of the Building Vulnerability Assessment and Mitigation Guide is presented in the reference section of this report.

The primary goal of the building vulnerability assessment methodology is to provide the best available advice in an easy to use application that provides consistent results. Several different methodologies were considered during the development process. Initially it was felt that a flipbook approach might be most appropriate. The flipbook is a format where each page represents a question. Based on the responses to questions, users are instructed to turn to a different page. In this manner the flipbook leads the user through a serious of questions to determine appropriate actions. Sometimes flipbooks are used by first responders to identify quickly appropriate actions during unusual situations. However, the length and complexity of the building vulnerability assessment caused this approach to be unwieldy.

A second approach considered was the use of flowcharts. These charts can be navigated easily to determine which actions need to be undertaken. As a part of this project, flowcharts were developed for building vulnerability assessment. However, it became evident that length and complex connections of the logic paths made the flowcharts difficult to use. In addition, based on flowchart structure, the length of the recommendations was restricted and there was no option for creating a final report. The user would need to organize and distill the recommendations into a usable format at the end of the assessment process. Although the flowcharts did not end being the final assessment format, they did form the basis for developing the logic in the final assessment tool.

We ultimately chose to develop a software based assessment tool because it provided the ultimate in ease of use, flexibility, and reporting. This assessment tool became the Building Vulnerability Assessment and Mitigation Program, or BVAMP. To provide free access to the maximum number of users, we decided to make this software available via the Internet on LBNL's Secure Buildings Website (http:\\securebuildings.lbl.gov). This website was developed to provide emergency response information to building operators and first responders for chemical and biological agent releases. Since security for the building specific information obtained in the vulnerability assessment is critical, the software tool is a downloaded application run on a local computer, as opposed to a web based application. We felt that data security issues would make a web based tool undesirable for many users. The programming language chosen for the software was Java virtual machine. This application was chosen mainly because it is compatible across a wide range of operating systems and it is freely available.

Since the software tool might prove daunting to those who were not familiar with all aspects of building operations, a walk-through questionnaire was developed to assist with gathering the information needed to complete the questions asked during the assessment process. The final methodology divides the assessment process into three parts, as follows:

1) **Walk-through assessment:** This is an information gathering step. The walk-through guides users to those features or functions for which attention is warranted and

points out what informational items need to be determined prior to filling out the questionnaire. This assessment tool is designed to be printed out and taken with the user during a physical inspection of the building, systems and documents. A copy of the walk-through sheet is provided in Appendix A.

2) **Building Vulnerability Assessment and Mitigation Program (BVAMP): The** BVAMP software tool was developed from a series of flowcharts. These flowcharts form the basis for the interactive computer-based questionnaire. The questions are ordered so that only relevant detailed questions are presented. The first tier of questions represents broad topics and is fairly short. The answers to the first tier of questions can lead to subsequent questions, depending on the user's answers. The number and type of follow-up questions depend upon the initial responses. For instance, answering "no" to the question asking if the facility has a mailroom will cause the program to skip additional questions about mailroom systems and procedures. A list of all the questions included in BVAMP is provided in Appendix B.

3) **Vulnerability Assessment Report:** An individualized assessment report, based on the answers given, is provided to the user at the completion of the questionnaire. The report presents mitigation actions that can be taken, evaluates the relative cost categories, and provides guidance on threat levels that would necessitate addressing a given vulnerability. The site visits, Project Advisory Committee input, and testing of the assessment guide have been incorporated into the final product. An example report, based on a BVAMP run in which no questions were answered, is provided in Appendix B.

The three parts of this methodology, taken together, form the basis for the Building Vulnerability Assessment and Mitigation Guide (BVAM Guide).

A secondary goal of this project was to provide advice to a small number of high-profile state buildings during the development of the vulnerability assessment guide. However, we were unable to obtain access to these buildings due to security concerns. Although building management expressed interest in conducting assessments for the buildings approached, the security obstacles inherent in having outside individuals conduct these assessments could not be overcome. Some of the security measures proposed included having only LBNL personnel with security clearances perform the assessments, having no written or electronic information with the location of the building or the names of any individuals interviewed, and having LBNL staff leave all electronic and paper copies of the assessment and mitigation reports at the test site. Although the building management determined that they could not participate in the tests, they were interested in using the software to perform their own assessments once it became available. Since it was not possible to conduct field-tests in high-profile buildings, the research team determined that assessments on lower-risk facilities should be substituted for those at high-risk facilities.

During the development process, we took care to assure that the BVAM Guide highlights potential increases in energy usage from mitigation strategies, and seeks to minimize the energy impacts of mitigation strategies where possible. Some strategies for reducing building vulnerability will also have favorable energy consequences. For instance, reducing infiltration around doors and windows, through cracks, and around utility chases and building penetrations will not only improve the effectiveness of sheltering within a building during an emergency, it can also reduce energy usage year-round. In instances where a recommendation for reducing building vulnerability would also have favorable energy impacts, the energy benefits are highlighted in the BVAMP recommendation report.

In some instances, implementing a mitigation strategy may have unfavorable energy consequences. For instance, upgrading to higher efficiency filters could increase energy consumption due to the increase in pressure drop across the filter. In other cases the energy implications are unclear. For instance, if the recommendation is to separate a single AHU zone into two completely separate zones, the energy consequences could be unfavorable if this is accomplished by simply adding a new system for one zone, or they could be favorable if an older system is replaced by two new units that are smaller and more energy efficient. The BVAMP report includes information about both potentially unfavorable and uncertain energy consequences.

The BVAM Guide was field-tested using different types of buildings. The results and comments from the test buildings were incorporated into the final product to assure that this guide was both useable and useful for the intended audience of building owners and operators. The BVAM Guide is intended for use in buildings with low to moderate threat levels. Although buildings with very high threat levels or highly specialized facilities may find the program is useful as a screening procedure, these facilities should consider conducting follow-up assessments which take into consideration their specialized needs.

3.0 PROJECT OUTCOMES

At the onset of the effort, the expected outcome of this project was a set of guidelines and assessment procedures that would aid private sector contractors and facility managers in assessing and reducing building vulnerabilities across the state of California. The mitigation methods were to be guided by the related goals of improving energy efficiency and indoor air quality, thereby reducing the energy requirements associated with reducing building vulnerability. This goal has been met by the Building Vulnerability Assessment and Mitigation Guide.

The primary way in which the goal has been met is through the development of a software tool (BVAMP) for the assessment and mitigation of building vulnerability to chemical, biological, and radiological agents and associated documentation. The use of these tools by building owners and operators will help increase the overall preparedness of buildings by providing information for improving emergency response planning, decreasing access and availability of building information in order to increasing the likelihood that an attack will be detected during the planning stages, and reducing the consequences and casualties were an attack to occur. Use of this product will help assure that available funding for mitigation is used in cost effective manner and that the energy consequences of mitigation strategies are considered in the decision making process.

3.1. Building Vulnerability Assessment Methodology

The goal of the first stage of the project was to develop, based on existing knowledge, a procedure for assessing building vulnerabilities to interior and exterior chemical or biological attack. This task consisted of two major tasks: first, to research and report on existing methodologies and protocols and second, to develop an Assessment Methodology and submit a report detailing this methodology.

The "Existing Methodology and Protocols Summary (December 2002)" provided in Appendix C documents the literature review performed to complete the first task. Since only a portion of the information on chemical, biological, and radiological vulnerability and protection for buildings is available in peer-reviewed journals, non-traditional sources, such as the Internet and trade association journals, were also searched. The results of the literature search are presented in the reference section of this report.

The "Building Vulnerability Assessment Methodology (August 2003)", provided in Appendix D, documents the methodology developed to complete the second task. This report presents the rationale behind the development of the methodology, the walk-through questionnaire used to collect information regarding the building, and all of the flowcharts that provide the logic and questions for BVAMP.

3.2. Building Vulnerability Assessment Guide

The goal of the second stage of the project was to produce a guidance document that could be used to implement the assessment procedures and suggest measures for reducing vulnerabilities identified in the assessments. During the course of the project, we determined that the most useful form for the guidance document would be as an interactive software tool. The tool that was developed was the Building Vulnerability Assessment and Mitigation Program (BVAMP). This program and the supporting documentation are freely available at http://securebuildings.lbl.gov.

The guide was to assess the efficacy of control and mitigation measures based on effectiveness for reducing potential risk, effectiveness in reducing potential exposure in the event of an attack, capability of protecting against a broad range of CB agents, practicality, difficulty of implementation, suitability to level of risk, energy consequences, and social acceptance. All of the above issues were incorporated into the development of BVAMP and the BVAMP reporting structure.

This task also required the development and submission of an Assessment and Mitigation Guide Field Test Plan. The Field Test Plan developed for this project consists of three phases: Phase 1 (Hypothetical Buildings), Phase 2 (Preliminary Test Buildings), and Phase 3 (Final Building Testing).

The purpose of Phase 1 (Hypothetical Buildings) was to evaluate the overall usability of the assessment guide and the appropriateness of the advice given. During this stage, we enter data for a variety of hypothetical buildings ranging from high to low risk buildings and from high to low levels of preparedness. Three different individuals participated in the hypothetical building tests (Tracy Thatcher, Lawrence Berkeley Laboratory Indoor Environment Department; Steve Greenberg Lawrence Berkeley National Laboratory Facilities and Applications Departments; and Mike Koontz, Geomet Incorporated). In aggregate these data represent hypothetical buildings, but the data are derived from our experience in actual buildings. The reports generated from the hypothetical building were evaluated to assess the level of detail, the ease of application, and the appropriateness of the advice provided by BVAMP. Problems in logic, software coding, readability, user interface, and reporting were identified and corrected at this stage.

The second phase, preliminary building testing, was originally to consist of two building tests, one building on the Lawrence Berkeley Lab site to be assessed by LBNL staff and the other building near the subcontractor's site (Geomet) to be assessed by Geomet staff. However, Geomet was unable to secure a building for testing during the preliminary testing phase. As a consequence testing of the Geomet building was delayed until Phase 3. Summaries of the building tests are presented in Appendix E.

The building tests were an integral part of the development process. During the building tests errors in logic, programming bugs, ambiguous questions, and unforeseen circumstances were discovered. These problems were corrected during the development and refinement of BVAMP and the BVAM Guide.

3.3. Information Dissemination

Achieving the maximum benefit from this project requires an extensive outreach program. The purpose of the outreach program is to increase awareness within the building management community of the availability and usefulness of the Building Vulnerability and Assessment Guide. The Guide is being promoted through the Lawrence Berkeley National Laboratory Secure Buildings Website, the tri-fold brochure provided to the Energy Commission as a deliverable of this project, internal and external newsletters at LBNL, an article submitted to a building management journal, a presentation at the 2004 Northern California Regional ASHRAE Conference in Sacramento, and dissemination to the PAC members. Additional methods of increasing awareness within the building management community are being explored and will continue to be pursued after the completion of the project. Improvements and updates of BVAMP will be made, as possible within the constraints of time and funding.

4.0 CONCLUSIONS AND RECOMMENDATIONS

This report presents the basis for the preparation of the interactive Building Vulnerability Assessment and Mitigation Guide. The Building Vulnerability Assessment and Mitigation Guide (BVAM Guide) is the first field-tested, easy-to-use protocol that building owners and operators can utilize to reduce the likelihood and severity of a chemical, biological, or radiological agent attack. The BVAM Guide consists of a building walkthrough questionnaire, an interactive software program (BVAMP), and the vulnerability assessment and mitigation report produced by the software. BVAMP and all supporting materials are freely available at http://securebuildings.lbl.gov. This guide explicitly considers the costs and potential favorable and unfavorable energy impacts of mitigation measures and whether the measure is suggested for all buildings or is more appropriate for those buildings at increased risk.

The BVAM Guide was produced using the best currently available information. As new information regarding vulnerability reduction and mitigation strategies becomes available, this guide will need to be updated. For example, if developments in the area of CBR sensors make them more affordable and accurate, these systems may be recommended for higher risk buildings. Another area of research that could impact this guide is chemical filtration. Current chemical filtration technologies not only require large expenditures in both capital and operating costs, but also have not been proven to work over extended periods in the building environment. Improvements in chemical filtration technology and additional research may make these filters advisable in some situations. In addition, if CBR events occurred more frequently, additional mitigation strategies would be recommended for lower risk facilities.

The majority of the time and budget allocated to this project was invested in assuring that the Building Vulnerability Assessment and Mitigation Guide was comprehensive and easy to use, with the best currently-available information on threat and consequence reduction for buildings. Enhancements to the look and feel of BVAMP and the report generated by BVAMP would enhance usability. Two of the features that we hope to add to BVAMP are navigation and progress toolbars, and color coding for the yes/no buttons to indicate the answer for previously answered questions. In addition, we plan to add the choice of creating an HTML version of the report, in addition to the plain text version. This will give users the option of having both an HTML version with enhanced formatting to improve the readability and organization of the report, and a plain-text version that can be custom-formatted or easily incorporated into another document.

Achieving the maximum benefit from this project will require an extensive outreach program. The purpose of the outreach program is to increase awareness within the building management community of the availability and usefulness of the Building Vulnerability and Assessment Guide. In addition to the public awareness efforts completed under this contract, LBNL plans to work with trade organizations such as BOMA and ASHRAE, as well as issuing a press release and LBNL publications. Additional outreach effort from the California Energy Commission would also improve public awareness of this tool. Use of this guide throughout the California building stock will provide positive benefits for reducing both the likelihood and the severity of a chemical, biological, or radiological attack. By helping building owners include energy implications into the assessment process, it can also reduce the unfavorable energy consequences that could be associated with some mitigation measures.

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APPENDIX A: BUILDING WALK-THROUGH QUESTIONAIRE

Appendix A: Building Walk-through Questionnaire

The following is the text of the Building Walk-through questionnaire that is distributed with the assessment program:

Building Vulnerability Assessment: Walk-Through

The questions in this walk-through are designed to help you gather the information needed to answer the questions in the building vulnerability assessment program, BuildingIQ, understand the assessment recommendations, and plan for improvements to your building preparedness. While it is not essential to complete the walk-through before starting the BuildingIQ program, it will make the process proceed more smoothly. Alternately, you can print out all of the Building IQ questions from the file entitled “assessment_questions.doc” and review these before starting the assessment program.

BUILDING EXTERIOR

1. Are there any gaps or openings in the building shell leading into the building, such as around pipes or other services entering the building?
2. Have blower or similar tests been done to assess building tightness? Have measures been taken to seal leaks in the building envelope?
3. Where are HVAC inlets? Are they equipped with screens and baffles at least a 45-degree angle from horizontal? What security measures are in place around them, if any? If below 12ft. off the ground can they be moved to the roof, to above 12ft. off the ground, or can a 12ft. extension be built without interrupting flows or balance (this will require an engineering assessment)?
4. Are windows operable? If so, by whom and when? Do you have plans to close them in case of a chemical or biological release? Are windows well sealed when closed? Is caulking in good repair, no gaps or flaking?

ROOF

5. Who has access to roof and how (keys, keycards, etc.)? Can access be restricted?
6. Are any HVAC systems and/or outside air inlets on the roof?
7. What security measures are in place on the roof (cameras, motion activated lights, etc.), if any?

BUILDING ENTRANCES

8. Who has access to building and how do they gain access: is it always locked, are card keys issued to building occupants, are some doors unlocked during certain hours, etc.?
9. Are there any visible gaps between doors and doorjambs? Do the doors directly connect the inside and the outside of the building or are there a series of doors passing through a vestibule?
10. What security measures are in place at entrances (guards, cameras, metal detectors, etc.)?
11. What are pressure differentials across entrances (is air blowing into or out of cracks around doors)? Is it possible to maintain a positive pressure with respect to outside at all times? Sometimes? For a few hours? Is this weather dependent? This may require an engineering assessment.

MAIN LOBBY

12. Is the general public allowed into this area?
13. Is the general public allowed unrestricted access to the rest of the building from the lobby?
14. Does the lobby use a different air-handling unit than the rest of the building? Are there any local controls to make HVAC changes? What other areas of the building, if any share this air-handling unit? Is the lobby equipped with an exhaust fan and exhaust controls?
15. Which direction is the pressure differential between the lobby and the rest of the building? If known, is it possible to maintain a negative pressure with respect to the rest of the building at all times?

MAIL ROOM

16. Do you have a mailroom in the building?
17. Are mailroom personnel trained to identify and respond to suspicious mail? How?
18. Who has access to the mailroom and how?
19. Do mailroom personnel wear gloves when handling mail?
20. Is there a fume hood or other similarly vented area in the mailroom that is used to inspect all mail or suspicious mail?
21. Is there a well sealing receptacle devoted to hazardous materials?
22. Are deliveries required to be scheduled? If so, what is the procedure for receiving an unscheduled delivery?
23. Are deliverers required to present identification?

24. Is mailroom on a separate air-handling unit from the rest of the building? What other areas of the building, if any, share this air-handling unit? Are there any local switches to make changes to HVAC?
25. Is the mailroom equipped with a local exhaust fan and exhaust fan controls?
26. Is it possible to maintain a negative pressure differential with respect to the rest of the building at all times? For a few hours? This may require an engineering assessment. Can a vestibule or airlock be installed between the mailroom and the building?

GARAGE AND LOADING DOCK

27. Does your building have a garage and/or loading dock?
28. Are either garage, loading dock, or both equipped with local exhaust fan and exhaust fan controls?
29. What kind of doors lead from garage and loading dock to rest of the building?
30. Are they on separate air handling units from the rest of the building? If not, what other areas of the building share their air-handling units? Are there any local controls to make HVAC changes?
31. Can they be maintained at negative pressurization to the rest of the building at all times? For a few hours? This may require an engineering assessment.

STAIRWELLS

32. Are there any external stairwells?
33. Is it possible to maintain stairwells at positive pressure with respect to the rest of the building? For how long?

TUNNELS OR SKYWAYS TO OTHER BUILDING

34. Are there tunnels, skyways, or passageways for your building to others?
35. Are they well sealed from all buildings? Are there doors? Are doors normally opened or closed? Is there a plan for closing doors in case of chemical or biological release?
36. Who is responsible for them?
37. Is it possible to maintain them at a negative pressure with respect to connecting buildings? This may require an engineering assessment.

STORAGE AREAS

38. Where are they located?
39. Who has access to them and how? Can access be restricted?
40. How often are they inspected for foreign objects or abnormalities?

HAZARDOUS MATERIALS STORAGE

41. What hazardous materials are in the building, in outdoor storage, in nearby buildings? Do you have Material Safety Data Sheets for each?
42. Where is your building located with respect to places where hazardous materials might be released, either accidentally or on purpose? Examples would include large industrial facilities like oil refineries, a rail yard, highways, or freight rail lines.

HVAC MAINTENANCE AN UTILITY ROOMS

43. Who has access to them and how? Can access be restricted?
44. Where are utility systems (water, electrical, gas, etc.) and controls located? How far are each (saving incidental systems) from lobby, mailroom, loading dock, garage, and other high-risk areas?
45. How often are these areas inspected for foreign objects or other abnormalities?
46. Are any utility systems able to be controlled remotely? If so, what security measures are in place to prevent unauthorized access?

ROOMS WITH HVAC CONTROLS

47. Where are they located? How far from lobby, mailroom, loading dock, garage, and other high-risk areas?
48. Who has access to them and how?
49. Are emergency procedures and phone numbers posted in each control room?
50. How is the building divided into HVAC zones? Is there a map showing which air-handling units supply air for each zone?
51. Is there any central control for all air-handling units, such as an **Energy Monitoring and Control System (EMCS)**? If so, can it be controlled via computer and is this system accessible remotely? If remotely accessible, what security measures are in place to prevent unauthorized access?
52. Is there a single switch HVAC control for sheltering in place and purging and where is this switch located?

AHU'S, HVAC FILTERS, DAMPERS, EXHAUSTS, ETC.

53. Where are Air Handling Units?
54. Where are HVAC filters?
55. Where are dampers?
56. Where are exhaust vents located?
57. Who has access to these areas and how?
58. What is the Minimum Efficiency Reporting Value (MERV) of the filters you are using? What is the maximum MERV rating each system could handle (this may require an engineering assessment)?

59. How often are filters changed? How often does the manufacturer or your HVAC professional recommend they be changed? When are the filters changed and by whom?
60. Are there any visible cracks between filter and rack or filter and supply fan?
61. Do dampers automatically close when fans are turned off? Approximately how quickly? Are they automatically closed in case of power failure?
62. Are there any visible gaps when dampers are closed?
63. How long does it take fans to wind down (stop) when turned off?
64. Is the Test, Adjust, and Balance (TAB) report current? Is the building operated at a slight overpressure?

DUCTS

65. Are ducts exposed within accessible areas of the building? If so, is it possible to "hide" these areas?
66. How leaky are ducts (your HVAC professional can perform a test)?

RETURN AIR GRILLES

67. Where are they? Are these areas accessible to the public? Are the grilles themselves accessible to the public? If so, can they be moved or extensions built to a more secure area without upsetting HVAC flows and balance?
68. Are there any obstructions to visibility (desks, plants, etc.) in front of them?
69. Are they continuously visible (by security guard, camera, etc.)?

DIVISIONS BETWEEN HVAC ZONES

70. Are there HVAC zones that are physically separated from the floor to the bottom of the floor above with walls and doors? Are these doors normally open or closed?
71. Are there some zones which are well isolated from the rest of the building and may be suitable for sheltering during an emergency?

EMERGENCY RESPONSE PLAN

72. Do you have an Emergency Response Plan that includes specific procedures for a chemical, biological, or other hazardous materials release? Does it address the differences between indoor and outdoor releases? 68. Does it address the possibility of multiple system failures (i.e.; a release accompanied by loss of power)?
73. Do you have an Emergency Response Team? List members, contact information, and duties. What type of training do team members receive? Do building occupants know who they are and how to contact them?
74. What kinds of training and safety information are building occupants given on how to respond to a chemical or biological release? How often do you run drills specifically for chemical or biological release? How about fire or earthquake?

75. How do/will you communicate with building occupants in case of an emergency (public address system, alarm, etc.)? Do you have a prewritten or recorded message for a chemical or biological release? What information does it contain?
76. Do you have an evacuation route planned for CB release? For fire? What areas of the building does it ask occupants to travel through?
77. Have you identified a shelter-in-place room? Where does it draw air from and what other areas share this HVAC zone? Is it an interior room (no external walls)? Can the HVAC be controlled from this area (shut off, for example)? Can the room be "sealed" to prevent entry of contaminants into the room? What is stocked in shelter-in-place room (emergency supplies, first aid equipment, etc.)? Is shelter-in-place room accessible to all building occupants? List other beneficial attributes of shelter-in-place room, such as whether it is big enough for all building occupants?
78. Where is Emergency Response Plan stored and who has access to it?

BUILDING PLANS, DRAWINGS, AND DOCUMENTS

79. How many copies exist?
80. Where/how are they stored? Who has access to this area?
81. What contractors have been given copies or have made their own building plans? Do contractors have security procedures with respect to building documents?

GENERAL SECURITY MEASURES

82. What security measures are taken concerning contractors and outside maintenance workers: are they escorted, is their work inspected, how do you establish trust?
83. List general security measures in place (guards, fences, cameras, motion activated lights, etc.).

APPENDIX B: SAMPLE VULNERABILITY ASSESSMENT REPORT

Appendix B: Sample Vulnerability Assessment Report

The following report was prepared using a BVAMP run in which no questions were answered. This yields an assessment report that recommends most of the possible mitigations.

BUILDING IQ: BUILDING VULNERABILITY MITIGATION REPORT

Profile Name: C:\My Documents\blank_BVA

Date: May 28, 2004

The recommendations below are based upon the answers given during the building assessment phase. A list of the questions asked and your responses follows the Recommendation section. The recommendations are divided into 6 sections: emergency response plans, shelter-in-place, HVAC systems, air exchange rate reduction, security, and special risk areas. For each section, specific recommendations for your building are separated into groups based on both the probable cost of implementation (high or low) and the type and level of risk that would warrant implementation.

Determining risk or threat for a specific building is a complex matter. The terrorist threat risk is influenced by the nature of the activities performed in the building (whether there are terrorists who would consider that facility a particularly good target), the number of occupants (increased occupancy tends to lead to increased risk), historical or other special building status (well-known or symbolic buildings may be at increased risk). Buildings with quantities of chemical, radiological and/or biological materials that pose a health hazard are at increased risk of injury or death from an accidental release. Added precautions may be necessary.

The threat level for facilities is also influenced by the buildings and activities in the surrounding area. Being near a facility at high terrorist risk or a facility with large quantities of chemical, radiological and/or biological materials, puts your building at an increased risk of having an attack or accident at these nearby facilities impact your building. Buildings near high risk facilities need to take added precautions to reduce to the impact of external contaminants.

Local law enforcement and emergency response planning agencies can assist you in determining the terrorist risk level for your facility and determining the threat posed by other local facilities.

EMERGENCY RESPONSE PLANS

Up-to-date and complete emergency response plans are a crucial component of any vulnerability reduction strategy. Pre-planning and employee awareness, coupled with a well thought out and rehearsed emergency plan can reduce confusion and save lives during an actual emergency. Many of the planning measures recommended for preparing for chemical, radiological and biological (CBR) attack are also helpful for responding to other types of emergencies, such as fires or tornadoes.

It is critical for emergency response team members to be familiar with and drilled on the appropriate responses for both interior and exterior CBR releases. Several scenario driven emergency announcements for sheltering in place and evacuating to different areas should be developed. These written response scenarios should be accessible only to authorized personnel. A team member, or back-up, should be available to cover each emergency team position at all times.

Employees should be familiar with emergency plans and understand that evacuation routes and staging areas may differ, depending on the specific emergency. Drills should include both evacuations and sheltering in place. Videotaping drills to show new employees can be helpful. Plans should be made to assist employees with special needs during both evacuation and sheltering. You may incorporate elevator use for disabled building occupants in your CB emergency evacuation plans, when there has been no physical damage to the building and this is the fastest evacuation mode for them.

Although each incident will be different, in general one should SHELTER IN PLACE in case of an OUTDOOR release and should remain sheltered until the concentration indoors exceeds that outdoors or the concentration outdoors is deemed safe. It may not be obvious where the release is, especially if it is not in the immediate vicinity of the building. In many cases, building occupants may not know about a release unless they are notified by authorities. In some situations, there may be signs of an outdoor release, such as an out-of-place smoke or fog, people collapsing in the street, etc.

Although each incident will be different, in general one should EVACUATE in case of an INDOOR release or in any situation where the concentration indoors exceeds that outdoors. Signs of an indoor release are quick-spreading symptoms of illness in building occupants, coupled with an absence of any signs of outdoor release, i.e., people collapsing in the street, and/or strange smoke or fog. In either case, smell is probably not a reliable indicator, as many materials have no ‘significant’ smell.

-- Building Specific Lower Cost Recommendations - All Facilities:

Many aspects of emergency response planning are inexpensive to implement and provide a significant improvement in emergency readiness. The following actions are recommended for improving emergency response planning at your facility. In most facilities, these actions can be implemented at little cost and will provide benefits for both CB and other types of emergencies.

Assemble an emergency team with members (and backups) for the following positions:

- a main decision maker who is or will be well acquainted with the different ways a release may occur and the proper action for each. This person must have the authority to take these actions swiftly in an emergency.
- someone to contact the authorities, who is known to them and building occupants. This member should have the numbers for 911, local police, fire department, CDC, and the team.
- someone to read or play prewritten/prerecorded messages and extra instructions.
- a first aid coordinator who is (or can be) trained in general first aid -- this person will be in charge of separating contaminated individuals from the rest of the building population and administering simple first aid until help arrives.
- someone who is (or will be) well acquainted with the different HVAC responses to different releases and how to make these changes safely and swiftly.

Choose someone (and backup) for the emergency response team to read or play prewritten/prerecorded messages and add extra instructions from the main decision maker.

There should be a team for all duty shifts, and replacements for vacation and sick days.

Write an emergency response announcement to be read, or recorded and played, on each floor, or in each area, so that all can hear. Designate someone for each area to be contacted by a central coordinator to read the announcement, along with any additional instructions from the main decision maker.

The Emergency Response Team needs to review the emergency plan for what to do in case of CBR release and be certain that they understand all actions that they will need to coordinate. The members of the Emergency Response Team (or back-ups) should be always reachable by phone, radio, beeper, pager, etc. The building occupants should all know how to reach the Emergency Response Team. The members of the Emergency Response Team should all be drilled on all possible actions contained in the emergency response plan.

Building occupants should know to contact the Emergency Response Team in case of unusual odors, unusual sounds, smoke, unusual fog, physical symptoms (such as irritation to eyes or throat, nausea, disorientation, difficulty breathing, convulsions), or suspicious activities (such as finding an unattended package, receiving a threat, finding an unidentified device or gas cylinder, or receiving a suspicious parcel).

Your emergency response announcement should include instructions for sheltering in place, evacuation to several choices of exterior meeting location, and instructions for employees with special needs. It should also repeat continuously, if possible.

Choices of whether to shelter or evacuate and how to change HVAC operation are very dependent upon where the release is and what sort of release it is. Develop a building specific plan to detail what actions to take for both an interior and exterior chemical, radiological or biological (CBR) release. In general, facilities in moderately to highly populated areas should plan on sheltering in place for most outdoor releases (since evacuation from these areas is often difficult and slow) and evacuating for interior releases.

Plan to use stairwells that can be positively pressurized for evacuation, if possible.

Any chemicals in building should be accompanied by a Material Safety Data Sheet (MSDS).

-- Building Specific Lower Cost Recommendations - Higher Risk Facilities:

The following actions may be useful if your facility is at a higher risk of attack or uses chemicals on site of a sufficient quantity and toxicity to pose a danger to employees if accidentally released. In most facilities, these actions can be implemented at low to moderate cost.

Plan primary and secondary evacuation routes that (1) at least one does not go through the lobby, mailroom, loading dock, or garage (2) it uses elevators only for building occupants with physical need and (3) it is accessible to all building occupants

Install windsocks at each exterior meeting point or other nearby location which can be seen from the building or EHS command center, so that wind direction can be easily determined.

Designate assembly points north, south, east and west of building. The location used during an emergency should be chosen based on the wind direction.

-- Building Specific Higher Cost Recommendations - Higher Risk Facilities:

Rapid and effective communication is critical during any emergency situation, although the following recommendation may entail significant costs, it can provide a significant benefit for those at higher risk. If your facility is at increased risk of attack, is near buildings that could be considered significant terrorist targets, uses chemicals of sufficient quantity and toxicity to present a threat to building occupants, or is near a facility which poses an increased risk of chemical, radiological or biological releases, you should consider the following:

Install a public address system for emergency communications during a CB attack. This system would also be useful for communication during other types of emergency situations.

SHELTER-IN-PLACE ROOM or ZONES

During an accidental or intentional outdoor chemical release, it may not be possible to safely evacuate building occupants. In most cases, occupants will need to stay indoors until the chemical plume passes the building. While the building itself will provide some protection, reducing the air exchange rate by sealing leaks in the building shell and turning off the HVAC system will provide more protection. Buildings at high risk should consider the benefits of providing additional protection in a designated shelter-in-place room.

-- Building Specific Higher Cost Recommendations - Higher Risk Facilities:

If your facility is at increased risk of attack, is near buildings that could be considered significant terrorist targets, uses chemicals of sufficient quantity and toxicity to present a threat to building occupants, or is near a facility which poses an increased risk of chemical, radiological or biological releases, you should consider setting up a shelter-in-place room or location with the following attributes:

In shelter in place areas(s), install weather stripping and/or rubber gaskets on the doors. Typically, rooms with windows aren't ideal shelter-in-place areas, but if no other alternative exists, windows should be sealed and not permitted to openn.

[Note: any sealing measures taken in the building may have the side benefit of allowing the HVAC to draw less power.]

Shelter-in-place sites need to be able to be completely isolated from the rest of the building with all penetrations (such as electrical conduits, ceiling plenums, and around drain lines) sealed or isolated. If this is not possible, choose a different shelter in place site if there is a better one or seal as well as possible.

Ideally, the shelter-in-place site should be on its own air handling unit with independent controls. Consider high-efficiency particle filters (effective for biological agents, but not for most chemicals) and chemical filters for both the supply air and recirculated air for the shelter-in-place room. These filter systems could be set up for use only under emergency conditions, to reduce energy consumption. A building engineer should be consulted to assure that any changes do not affect normal building operation. In some cases, if the SIP response is part of a general HVAC control or shutdown, then a separate air handler may not be necessary.

[Note: Introducing new air-handling units for different areas of the building (or reassigning existing units) is a major undertaking with large power use ramifications. Certainly with new units there will be new power draws, but with a better distribution of filters and filter types the energy draw may be less than before.]

Shelter in place site(s) needs to accommodate all building occupants. Make certain site(s) will hold all occupants for several hours. If needed, identify an alternative shelter-in-place site for occupants with special physical needs, and/or plan routes and assistance for them to reach the existing site.

Stock shelter-in-place sites with tables and chairs, telephone, radio, water emergency lights, important telephone numbers, first aid supplies, and personal filters for chemical and biological protection.

Ideally, shelter-in-place site(s) should be an interior room or area with no external walls. If such locations aren't available, then sites with external walls are acceptable if the walls have (or can be made to have) low leakage to the outside.

Contact local emergency planning commission to ask if any hazardous materials are used nearby.

If there are nearby hazardous biological, radiological or particulate chemical materials or sources of particle phase chemicals (powders or dusts) in quantities or toxicity that present a hazard to your facility if released, consider greater HVAC filter efficiency.

If there are nearby facilities where hazardous chemical materials are stored in quantities or toxicity that present a hazard to your facility if released, consider getting a personal chemical filter or in-room chemical filter for the shelter-in-place area which can remove the chemicals of concern.

HVAC SYSTEM

The HVAC system and its controls are the first line of defense during a chemical, biological or radiological emergency. Properly implemented HVAC controls can be used to reduce exposure to building occupants and improve the safety of evacuation routes. Although altering HVAC controls can reduce a building's vulnerability to CBR attack, it is important to assure that any changes made to the HVAC system do not compromise its effectiveness either during normal operation or in other emergency situations (such as fires). It is best to involve the Fire/Life Safety Officer in all planning meetings that envision significant modification to the HVAC system(s) and to contact the Fire/Life Safety Officer to coordinate a Fire/Life Safety inspection once building HVAC modifications have been completed.

There are two main classes of filtration, particle filters and chemical (gas) filters. Of these, the first is far more commonly employed in buildings than the latter. Particle filters vary in both type and particle removal efficiency; in most commercial buildings, filters with moderate removal efficiency are typical. In some cases, upgrading the filtration is simply a matter of installing higher efficiency filters; a minimum efficiency rating of MERV 13 is recommended, with MERV 15 or

16 providing improved particle protection at minimal impact. Higher efficiency particle filtration can be achieved, but the additional pressure drop may require reengineering the HVAC fans. Chemical filtration is currently best done using treated activated carbon filters; typically these filtration systems impose a significant pressure drop on an HVAC system and are not widely used. They also have fairly high replacement costs and are not effective against all types of chemicals. If protection against chemicals is needed, an alternative to filtration is establishing a safe room or shelter that limits air exchange with the out-of-doors. Chemical filtration for the shelter area may be considered for higher threat facilities or when proximity to high risk operations (such as chemical manufacturing) put a facility at increased risk. You should consult with your HVAC professional to evaluate what filter efficiencies your system could handle and which of these best fits with your perceived risk and budget.

-- Building Specific Lower Cost Recommendations - All Facilities:

The following recommendations can typically be implemented at low cost and are beneficial for all facilities:

Periodically (biannually) test all the HVAC settings and control functions recommended in your emergency response plan.

Develop and maintain up-to-date HVAC diagrams and post them in control rooms or other locations accessible only to necessary personnel. These diagrams should clearly show AHU zones, locations of independent exhaust fans (like those serving restrooms),), and the locations of all controls, safe rooms, etc.

Ensure that the portion of the HVAC system between the filters and the AHU fan is tightly sealed so there is no by-pass of unfiltered air into the air supply. Seal any cracks between HVAC supply fan and filter with mastic or equivalent sealing material (NOT duct tape).

[Note: The less leaky an HVAC system is, the less power it will need to provide the same service.]

[Note: A higher filter rating will require your HVAC to work harder and use more power. But regular filter changes will cut down on this power cost, because clean filters require less air force from the HVAC.]

Use better fitting HVAC filters, adjust filter rack to prevent leaks, or seal with gaskets.

-- Building Specific Higher Cost Recommendations - All Facilities:

The following recommendations may have significant costs for implementation, however they also will provide significant risk reductions and should be considered for all facilities:

Change HVAC filters regularly as suggested by filter literature for your building size and use.

[Note: Regular filter changes may let your HVAC work more efficiently and draw less power, depending on the system type. Typically, variable-air volume systems will be more efficient, while constant-volume system efficiencies remain the same.]

-- Building Specific Lower Cost Recommendations - Higher Risk Facilities:

If your facility is at increased risk of CBR attack, the following actions are relatively inexpensive and should be implemented to reduce the likelihood that a CBR agent could be thrown into your building air intakes.

Install louvers or baffles (they need not be movable) and screens over HVAC inlets at no less than a 45 degree angle from horizontal.

-- Building Specific Higher Cost Recommendations - Higher Risk Facilities:

If your facility is at increased risk of attack, is near buildings that could be considered significant terrorist targets, uses chemicals of sufficient quantity and toxicity to present a threat to building occupants, or is near a facility which poses an increased risk of chemical, biological or radiological releases, you should consider the following improvements. Depending on your facility the costs of these changes could vary from minor to substantial:

Make sure HVAC dampers close fully when the fan system is shut down and the dampers are equipped with gaskets to ensure a tight seal.

Take into account the possibility of multiple system failures. Any equipment necessary for your CB emergency response should be on backup power including dampers and lights in escape routes and shelter rooms. Consider performing a detailed Systems Analysis of the building and its major systems for points of failure, such as power loss, ventilation system failure, or potential re-routing of large volumes of make-up or ventilation air. Examine standby and emergency generators for their time lag to engage for restoring under emergency and normal power scenarios. Ensure that this power backup latency does not exceed the needs of the emergency plan. Consider redundant power suppliers/sources when available. Evaluate and designate alternate shelters or evacuation routes in case an HVAC system fails.

Install MERV 13 filters, if your HVAC system can accommodate them. If your system cannot accommodate MERV 13 filters, upgrade filtration to the extent possible and consider upgrading your HVAC to accept higher efficiency filters. Upgrade HVAC systems to integrate filter performance monitoring into the building monitoring system. Install a building monitoring system, if one does not exist, to serve as the principal monitoring system for the building systems. This is important if the threat to your building is posed by biological agents or chemicals which form particles (as opposed to gases) in the air. Particle filters will not reduce the risk from gaseous chemicals.

Depending on your current system, improved filtration may present additional energy costs due to increased pressure drop. However, there are now many high-quality filters with relatively low pressure drops on the market. Also, if the area of the filter bank can be increased, the power required will be less.

Consider performing a detailed Systems Analysis of the building and its HVAC systems to determine infiltration rates, zone cross-over airflows and the effectiveness of existing HVAC filtration. Set criteria levels for the performance of shelter-in-place HVAC systems and establish a plan to meet those criteria levels (for instance, you may want the shelter-in-place area to have less than 20% of the air exchange rate of the rest of the building).

Seal ducts with duct sealing system or mastic.

Set up system so that dampers automatically close when fans are turned off, or when there's a power failure.

AIR EXCHANGE RATE REDUCTION

Reducing the air exchange rate, or leakiness, of a building can reduce the exposure of occupants to an accidental or intentional release of chemical, biological or radiological agents outdoors. Reducing building leakage may also improve comfort (through elimination of drafts), improve moisture control, and increase energy efficiency - depending on current building conditions. Reducing the air flow between high risk areas, such as lobbies and mailrooms, and the rest of the building will reduce the transport of indoor releases in these zones to occupants in other areas.

-- Building Specific Lower Cost Recommendations - All Facilities:

The following actions are recommended to help reduce the leakiness of your building. These items should represent a fairly low cost for implementation and may also yield benefits due to reduced energy costs and a reduction of perceived 'draftiness' by occupants

Doors between lobby, mail room, loading dock, garage and rest of building should be automatic or always closed and equipped with rubber gaskets to reduce leaks.

[Note: Automatic doors introduce a new power draw to the building, but this may very well be balanced by the added benefit of a better sealing entry that reduces entry of unconditioned air and causes the HVAC system to use less power.]

Install better sealing doors and windows, install weather stripping and rubber gaskets on windows and doors, re-caulk windows, seal cracks in walls and obvious gaps (like where pipes enter the building.

Perform blower door testing to assess and identify building leakage. Seal leakage pathways identified during testing.

SECURITY

Increased security can reduce the suitability of your building as a target and increase the likelihood of detecting a threat before an attack. By making it more difficult for potential terrorists to gain access to, and find information about your building, you increase the likelihood that they will be caught while planning the attack. Many of the actions needed to improve security represent very low costs. However, they may require a change in the way a facility shares information and therefore be difficult to implement. The recommendations in this sections deal with security as it pertains to HVAC and CB agent vulnerabilities. They do not deal with threats posed by bombs, thefts, or other issues.

-- Building Specific Lower Cost Recommendations - All Facilities:

The following actions are recommended to help reduce access to HVAC and mechanical areas and documentation for your building. These items should represent a fairly low cost for implementation:

Storage areas should be locked and access restricted.

Storage areas should be inspected regularly for unexpected objects.

Locks should be installed on all maintenance room and HVAC control doors, and access given to only those with an expressed need. The importance of keeping these areas locked (not propping or tying them open) should be stressed.

Locks should be installed on all maintenance room and HVAC control doors, and access given to only those with an expressed need. The importance of keeping these areas locked (not propping or tying them open) should be stressed.

Any work done by contractors or external maintenance workers should be inspected for abnormalities (like unusual equipment left behind) before they leave.

Contractors and external maintenance workers should be escorted when working in building unless you have established a high level of trust.

-- Building Specific Higher Cost Recommendations - Higher Risk Facilities:

Install additional security measures -- cameras, motion activated lighting, security guards -- in areas with exposed ductwork. Build encasements (chases) for exposed ductwork.

Install fences or other security measures around HVAC inlets. People should not be able to place or throw any objects inside.

SPECIAL RISK AREAS

Some areas present an increased risk, either due to the materials handled, such as packages or chemicals, or due to increased public access, such as lobbies. For these areas, it is beneficial to have specific procedures and equipment to reduce the hazards posed:

-- Building Specific Lower Cost Recommendations - All Facilities:

The following actions are recommended to help reduce vulnerabilities identified in the special risk areas of your building. These items should represent a fairly low cost for implementation.

Require all unknown mail carriers to present identification -- alert delivery companies.

If your facility is at high risk of attack, you should consider the following improvements. In most cases, these measures are not warranted at low risk facilities:

Equip mail room with a hazardous waste receptacle -- a trash can with a well fitting lid devoted to this duty (don't use it for trash).

Equip mail room with a fume hood in which to inspect mail. A fume hood will introduce a new constant power draw. If used properly (e.g., kept closed when not in use) the power draw will be fairly minimal

Mail room personnel should always wear gloves when handling mail.

Mail room personnel should know how to identify suspicious packages: those that appear to have been tampered with or opened, suspiciously shaped, or coated in powder. Suspicious packages should be moved smoothly (do not jostle) to hazardous waste receptacle, and authorities contacted as well as those who sent and were to receive package or mail.

Only essential personnel should be allowed in mail room by key card, or other authorization that keeps out anyone else.

All non-routine deliveries should be scheduled, to the extent possible.

Unscheduled deliveries should be held outside until the recipient is contacted.

Install walls between AHU zones with well sealing doors. This is most important for high risk zones, such as the lobby.

Install an emergency switch to close isolation doors during a chemical or biological emergency. Typically, this will interface with the fire alarm system.

Relocate ventilation equipment and utilities at least 50 feet away, approximately, from high-risk areas.

Install walls where necessary to close off lobby, mail room, loading dock and garage (including any air return plenums) and seal all cracks and holes in existing walls.

[Note: any sealing measures taken in the building may have the side benefit of allowing the HVAC to draw less power.]

Equip high-risk areas (such as material handling areas) with local on/off switches for their air handling units.

Install local exhaust fans with readily available closed/100% exhaust switches in high-risk areas (such as material handling areas).

[Note: Local exhaust switches in high-risk areas introduce no new continual power draw and power consumption will depend on the size, type, and usage hours.]

Any chemicals in building should be accompanied by a Material Safety Data Sheet (MSDS).

End of recommendations

The following section reports your responses to the questions in each of the modules: Risk, ERP, Building Utilities, Building Access, and Network. Please note that, based on your responses, you may not have been asked certain questions (for instance, if you do not have a mailroom, you would not be asked questions regarding your mailroom procedures). Questions which you were not asked and those which you did not answer are both listed as 'unanswered).

RISK: YOUR RESPONSES

Are there any chemicals stored inside the building? : unanswered

Are chemical storage areas inside the building equipped with separate ventilation system(s) from the rest of the building? : unanswered

Are chemicals in designated areas and accompanied by material safety data sheets? : unanswered

Do you know if hazardous materials are used nearby? : unanswered

Are there nearby hazardous materials sufficient in quantity or toxicity to present a biological, radiological, or chemical hazard to your facility if released? : unanswered

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EMERGENCY RESPONSE PLAN: YOUR RESPONSES

Do you have a written emergency response plan? : unanswered

Does your written emergency response plan include response planning for chemical and biological emergencies, including responses for indoor versus outdoor releases and chemical or radiological versus biological releases? : unanswered

Does your written emergency response plan include instructions for when and how to shelter in place? : unanswered

Does your written emergency response plan include instructions for when and how to evacuate for non-fire emergencies? : unanswered

Does your written emergency response plan include contingency plans for multiple system failures (i.e., a chem/bio release in tandem with electrical failure?? : unanswered

Have you identified a shelter-in-place location? : unanswered

Does the identified shelter-in-place site have well-sealing windows and doors? : unanswered

Is the identified shelter-in-place site well-sealed (no unsealed openings to the rest of floor/building such as open utility chases, passthroughs or plenums)? : unanswered

Does the identified shelter-in-place site have its own air-handling unit? : unanswered

Is the identified shelter-in-place site accessible to all employees including those with special physical needs? : unanswered

Is the shelter-in-place site stocked with emergency supplies of: tables and chairs, telephone, radio, water, emergency lights, important telephone numbers personal filters for chemical and biological protection first aid supplies? : unanswered

Is the identified shelter-in-place site in an interior room (no external walls)? : unanswered

Do you have a primary and secondary evacuation route planned, specific to a CB release? : unanswered

Do both routes go through the lobby, mailroom, loading dock or garage? : unanswered

Do you have a fire evacuation route planned? : unanswered

Do all building occupants know where to report suspicious activity, packages, etc.? : unanswered

Do all building occupants know how to recognize a chemical or biological hazard? : unanswered

Do all building occupants know who to call in an emergency? : unanswered

Do you have a building-wide emergency public address system in place? : unanswered

Do you have a pre-recorded or pre-scripted emergency announcement? : unanswered

Does your emergency announcement include instructions for sheltering in place and evacuation? : unanswered

Do you have a fire alarm that can be programmed to provide different signals? : unanswered

Do you have different signals in your alarm system for (1) sheltering in place; (2) evacuating the building (including communicating with deaf or hard-of-hearing employees)? : unanswered

Do you have an emergency response team? : unanswered

Does your emergency response team include a main decision maker? : unanswered

Does your emergency response team include a contact for/to authorities? : unanswered

Does your emergency response team include someone to communicate with building occupants? : unanswered

Does your emergency response team include a first aid coordinator? : unanswered

Does your emergency response team include someone in charge of HVAC manipulation? : unanswered

Does your emergency response team cover all duty shifts as well as replacements for vacation and sick days? : unanswered

Do you have the ability to quickly determine wind direction from within the building (e.g., with a windsock or a wind-gauge)? : unanswered

Do you have a primary and secondary outdoor assembly area which can be chosen based on wind direction? : unanswered

----
BUILDING UTILITIES: YOUR RESPONSES

Is there a switch that will be easily accessible in an emergency (in shelter-in-place area, fire control cabinet, or similar location) where emergency response team members can make necessary HVAC changes for sheltering in place and purging the building? : unanswered

Can all air-handling units be operated from a single location? : unanswered

Does HVAC control system initiate changes in less than 30 seconds (approximately)? : unanswered

Is your building connected to other buildings by tunnels, skyways or other passageways? : unanswered

Are all tunnels between your building and other buildings sealed with doors? : unanswered

Are the tunnels between your building and other buildings negatively pressurized with respect to both buildings? : unanswered

Are all air handling units fitted with filters rated at least MERV 13? : unanswered

Do all filters seal tightly in rack, with no visible cracks or gaps? : unanswered

Are the spaces between filters and supply fans sealed well, with no visible cracks or gaps?? : unanswered

Are filters changed regularly in accordance with manufacturer specifications? : unanswered

Are AHU zones served by well-sealing dampers? : unanswered

Are AHU zones served by well sealed ducts? : unanswered

Are AHU zones served by dampers that close automatically when fans are turned off or in electrical failure? : unanswered

Are separated AHU zones (those not sharing supply and/or return air) separated by walls and doors with no sizeable openings (no space around doors, passthroughs in walls, etc.)? : unanswered

Are isolation doors between separated AHU zones open during normal building operation? : unanswered

Have blower door or similar tests been performed to assess building tightness and identify leaks? : unanswered

Have measures been taken to seal cracks and leaks in the building envelope? : unanswered

Are utility systems and ventilation equipment located at least fifty feet away from lobby, mail room, loading dock and garage (excepting local systems? : unanswered

Is it possible to positively pressure any stairwells with respect to the rest of the building for the time it will take to evacuate? : unanswered

Are there any external stairways that are accessible to employees? : unanswered

Do you have a lobby, mail room, loading dock or garage? : unanswered

Are the lobby, mail room, loading dock and garage each in a separated AHU zone, sharing neither supply nor return air with the rest of the building? : unanswered

Are the lobby, mail room, loading dock and garage each equipped with local switches to turn off their air-handling units? : unanswered

Are the lobby, mail room, loading dock and garage each equipped with local exhaust fans and exhaust fan controls? : unanswered

Are the lobby, mail room, loading dock and garage each well sealed off from the rest of the building with automatic, well-sealing doors? : unanswered

Are the lobby, mail room, loading dock and garage each well sealed off from the rest of the building with well-sealed walls? : unanswered

Are the lobby, mail room, loading dock and garage each well sealed off from the rest of the building with negative pressurization? : unanswered

Is there an airlock or vestibule between lobby, mail room, loading dock and garage and rest of building? : unanswered

Are external windows operable? : unanswered

BUILDING ACCESS: YOUR RESPONSES

Is building accessible to non-employees without escort? : unanswered

Are maintenance rooms (especially those containing air handling units) off-limits to non-employees without escort? : unanswered

Are maintenance areas locked and is access to these areas limited to a select few individuals? : unanswered

Are maintenance areas locked and is access to these areas limited to a select few individuals? : unanswered

Does the building manager keep an up-to-date list of who has keys or access to maintenance rooms? : unanswered

Are storage areas off-limits to non-employees without escort? : unanswered

Is the roof off-limits to non-employees without escort? : unanswered

Are HVAC inlets off-limits to all employees except designated maintenance personnel with access needs? : unanswered

Are all HVAC inlets at roof level? : unanswered

Are HVAC inlets below roof level? : unanswered

Are HVAC inlets over twelve feet off the ground? : unanswered

Are HVAC inlets less than twelve feet off the ground? : unanswered

Are HVAC inlets equipped with screens and baffles? : unanswered

Is the screen over HVAC inlet at at least a 45-degree angle with respect to horizontal? : unanswered

Is there a fence in place around HVAC inlets? : unanswered

Is exposed ductwork in areas which are off-limits to all employees except designated maintenance personnel with access needs? : unanswered

Are HVAC exhausts off-limits to all employees except designated maintenance personnel with access needs? : unanswered

Are indoor air returns in areas off-limits to all employees except designated maintenance personnel with access needs? : unanswered

Are indoor air returns always visible to building occupants? : unanswered

Do you have a mail room? : unanswered

Does your mail room require identification from non-standard delivery persons? : unanswered

Does your mail room have a hazardous waste receptacle? : unanswered

Does your mail room have a fume hood? : unanswered

Does your mail room require personnel handling mail to wear rubber gloves? : unanswered

Does your mail room require authorization to enter? : unanswered

Are your mail room personnel trained to identify and deal with suspicious packages? : unanswered

Does your mail room require deliveries from non-standard carriers to be scheduled, including large freight? : unanswered

Are contractors and outside maintenance workers escorted while in the building? : unanswered

Is the work of outside contractors inspected before they leave? : unanswered

Are any building plans -- security system, ventilation system, blueprints, emergency procedures, mechanical -- available to the public? : unanswered

Are contract and non-employee maintenance workers and contractors allowed free access to any building plans (given copies, allowed to take plans off-site, etc.)? : unanswered

----

NETWORK SECURITY: YOUR RESPONSES

Are any of the following controlled by computer? utility systems - HVAC (such as an Energy Monitoring and Control System -- EMCS) power (including UPS) - elevators - security systems - site access (i.e., card readers, gates, locks) - cameras : unanswered

Are all computer(s) which run control applications accessible only from their location(s)? : unanswered

Are there any computer(s) running control applications which are accessible from different interfaces throughout the building i.e., control panels on walls)? : unanswered

Are any computers which control applications accessible on site over TCP/IP or other network protocols? : unanswered

Are any computer(s) running control applications accessible from off site, i.e., via modem or ethernet? : unanswered

Is the only way to gain access to control computers from off-site through specific (IP address identified) computers? : unanswered

Is a strong password (different for each user) required to gain access from offsite, and is periodic changing of passwords enforced? : unanswered

Is the control computer password protected, with different passwords for each user, and are these passwords changed regularly? : unanswered

Is the room containing the control computer locked and only accessible to a select few known to the building manager? : unanswered

Are control panels or other on-site interfaces secure, i.e., physically locked, password-protected (with different passwords for each user) or under security surveillance? : unanswered

Is the network designed with properly configured routers, firewalls, and subnets which reflect business functions (i.e., controls accessible only to building occupants who need such access)? : unanswered

Are off-site computers which can connect to site controls accessible only to people who truly need remote access to building controls? : unanswered

Are building controls or security outsourced? : unanswered

End of your responses

APPENDIX C: EXISTING METHODOLOGY AND PROTOCOLS SUMMARY

Existing Methodology and Protocols Summary

For the

Building Vulnerability Guide Project

On behalf of the:
California Energy Commission

Public Interest Energy Research (PIER) Program

December 2002

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Deliverable Number: Task 2.4

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3. Renewable Energy
4. Environmentally Preferred Advanced Generation
5. Energy-Related Environmental Research
6. Strategic Energy Research.

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INTRODUCTION

Over the last year, there has been increased interest in protecting buildings and building occupants from potential terrorist attacks. A portion of this attention has centered on reducing threats from chemical or biological attack. To this end, various organizations have developed information and guidance designed to address some of the issues associated with terrorist attacks on buildings. Most of this information has taken the form of published web pages and/or printed guides. This report provides a list of currently available materials and discusses the information that is most applicable to this project. We will continue to review new materials as they become available and incorporate them into our methodologies when appropriate.

A recent report from the National Academy of Sciences/National Research Council ("Making the Nation Safer: The Role of Science and Technology in Countering Terrorism") discusses some of the scientific research needs associated with protecting buildings. This report notes the need for better understanding building vulnerabilities – and in particular the role of HVAC systems in either helping disperse contaminants within buildings or in providing protection through air filtration.

SEARCH APPROACH

In this project, we are most interested in information that would help to construct a basic vulnerability assessment methodology, applicable to many types of buildings under a broad set of circumstances. The purpose of the guide is to reduce harm to building occupants in the event of a chemical or biological release either inside or outside the building.

Since most of the material on this topic has been published very recently, we began our search by looking at documents we were aware of and then by searching on-line. Using the Google search engine and searching for simple phrases such as "building biological release" and "building chemical release" garnered much information that fell into three categories: preemptive precautions, hazard identification guidelines, and emergency management plans. The preemptive precautions were, for the most part, building guidelines – how to make your HVAC system more secure, how to construct safe areas, and what sorts of personal devices (masks, clothing) one needs on site for the building occupants. These are labeled “preventive actions” in our discussion below. Much of the recent information fell into the second category – how does one determine if there is a chemical or biological hazard in the building, and what type might it be? How would your response then differ for different hazards? These we called “identification” in our discussion below.

Many groups have drafted their own plans for responding to terrorist threats. The most applicable of these have been collected in the third category, called “emergency response”. Although some of these are quite rudimentary, offering only the most basic three or four steps to safeguard oneself under these circumstances, they provide a variety of formats to explore for the products of our own project. Several agencies have prepared lengthy documents describing in detail the necessary components of an emergency plan. Those decision trees, checklists, etc. that have already been written for others to use are filed under “sample plans.” Several more of these sorts of documents were turned up by searching for such things as “evacuation decision tree” or “emergency plans.”

Searching the journals proved much less fruitful. Search titles for the same sorts of phrases turned up very little. Much that was found was quite old and outdated, or better documents had already been found on-line. There are a few of the best documents here (and some that are slightly off-task in the “miscellaneous” section). They mostly showed up in emergency management journals and those that discuss industrial and work place hazards.

SUMMARY OF MOST RELEVANT MATERIALS

The following sections discuss some of the most relevant articles, guides, web pages, and journal articles for each of the major sections from the literature search. This is not a comprehensive summary of all the information contained in the articles. It is rather a summary of the available literature and its relevance to development of a building vulnerability assessment and mitigation guide.

Preventive Actions Against Chemical or Biological Airborne Hazards

This section reports information that is aimed at planning for and/or responding to airborne release of hazardous chemical or biological materials. The four sets of guidelines that are the most complete and the most applicable to this project were published by Center for Disease Control (CD/NIOSH), the U.S. Corp of Army Engineers, American Society for Heating, Ventilation, and Air Conditioning Engineers (ASHRAE), and Lawrence Berkeley National Laboratory (LBNL). Each of these guides is somewhat different in format and content.

A fifth source of information worth noting here – while less directly relevant to large buildings – is the extensive work done for the Chemical Stockpile Emergency Preparedness Program (CSEPP). This program is mainly directed to communities in the vicinity of the chemical stockpile storage and disposal facilities and has focused most of its work on shelter-in-place and personal protection concepts for the general population. Somewhat surprisingly to us, we have not found in our literature searches to date any CSEPP information or advice for non-residential buildings – at least in the form of building protection planning beyond the shelter-in-place activities.

The CDC/NIOSH guide, "Guidance for Protecting Buildings from Airborne Chemical, Biological, and Radiological Attacks", is aimed at owners and operators of commercial buildings. This guide was developed by an interagency working group – the Building Air Protection Work Group - at the request of the federal Office of Homeland Security (now Department of Homeland Security) with CDC/NIOSH taking the lead. LBNL is a participant in this working group. It provides general information on important aspects of building operation. The guide also provides specific recommendations for (1) things not to do, (2) physical security, (3) ventilation and filtration, and (4) maintenance, administration, and training. This guide focuses on actions that can be taken prior to an incident to reduce the likelihood and severity of an attack.

The U.S. Army Corp of Engineers document, "Protecting Buildings and Their Occupants From Airborne Hazards", presents physical design and security measures to be taken, as well as addressing important issues for the development of a protective action plan. It specifically addresses the importance of determining whether a release is internal or external, and basing actions on location. It divides its recommendations into 5 categories (1) architectural and mechanical design, (2) security measures, (3) actions for perceptible hazards, (4) developing a protective-action plan, and (5) air filtration.

The ASHRAE report, "Risk Management Guidance for Health and Safety under Extraordinary Incidents", focus on the important role played by ventilation systems. They list 10 important areas for building owners and operators to consider risk and stress the importance of assuring that building systems are operating properly.

The LBNL report and website, "Protecting Buildings From a Biological or Chemical Attack: actions to take before and during a release" and http://securebuildings.lbl.gov/, are aimed at both building owners and first responders. The website contains information about simple steps that can improve preparedness, as well as measures that require modification of building systems and controls. There is a substantial section discussing how agents move within a building and steps that can be taken during an event. The report documents the rationale behind the advice provided on the website.

Identification of Specific Agents

There are a multitude of books and websites that provide information on the effects of chemical and biological agents. "Jane's Chem-Bio Handbook" by Sidell, et al. is perhaps the best known of these reference books, as it is written as a handbook for first responders and others seeking guidance for 'field' emergencies. It focuses on providing the kind of quick reference which is essential for identify agents during an event. More general discussions of agents themselves and their properties can be found in several references, including (1) "Database of physical, chemical, and toxicological properties of chemical and biological (CB) warfare agents for modeling airborne dispersion in and around buildings" by Thatcher, et al. and (2) "Chemical Warfare Agents: Toxicology and Treatment" by Marrs et al. Both provide tables of properties for the major chemical and biological agents, along with references to some of the best sources for agent data.

Emergency Actions – Guidelines for Creating an Action Plan

This section contains references for (1) guidelines for incident response, (2) information on interfacing public and private emergency planning, (3) and other preparedness issues. This information, while not specifically related to building vulnerability, provides reference information that will improve the usability and usefulness of the final guide produced by this project.

Decision Methodologies

Decision Science is a broad and growing field. While the references listed are not meant to be an authoritative or complete review of the available literature, they provide a sampling of the types of decision analysis currently in use. The references chosen represent methods and examples for using decision science in situations similar to those considered in this project. While it is unlikely that the final Building Vulnerability Assessment and Mitigation Guide will take on the identical form of any of these examples, they will be used to guide and influence our project.

Conclusions

This report presents a summary of the most relevant articles, guides, web pages, and journal articles for preparation of the Building Vulnerability Assessment and Mitigation Guide. While many of these references provide valuable information that will be used during the development process, none of them present a comparable guide. At the completion of this project, the Building Vulnerability Assessment and Mitigation Guide will be the first field-tested, easy-to-use protocol that building owners and operators can utilize to reduce the likelihood and severity of a chemical or biological agent attack. Additionally, this guide will explicit consider reducing the energy impacts of mitigation measures and help owners assess the energy impact of various options.

APPENDIX D: BUILDING VULNERABILITY ASSESSMENT METHODOLOGY

Building Vulnerability Assessment Methodology

For the

Building Vulnerability Guide Project

On behalf of the:
California Energy Commission

Public Interest Energy Research (PIER) Program

August 2003

Tracy L. Thatcher and Richard G. Sextro

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The first task in this project was to identify and collect advice on assessing and mitigating building vulnerability to chemical or biological attack. This information was collected and reported in the CEC report "Existing Methodology and Protocols Summary (December 2002)". In many cases, there are common themes among many of the information sources – e.g., the obvious vulnerabilities presented by accessible and easily identifiable HVAC air inlets. In other cases, opinions and/or advice differ – e.g., the efficacy of manipulating the HVAC system to control the spread of contaminants indoors. We have based this present work on our synthesis of the previous work and on our own studies on airflow and the transport and fate of contaminants in buildings. . It is worth noting that the "science" underlying the assessment of vulnerabilities and what to do about them is not (yet) definitive. We, as others have done, have relied on best engineering judgment in a number of areas, recognizing that buildings and building operations differ – even among buildings of the same class – so 'broad' advice for 'average' buildings of the same class may have to be tailored for individual buildings.

The current report presents the results from the second stage of the project. In this stage we present a methodology for evaluating building vulnerability. This methodology will be field tested in a variety of buildings. This field testing will result in an evaluation of the effectiveness, robustness, ease of use, and applicability of the methodology. The assessment methodology will be modified, based on the results of the field testing, and developed into the final Assessment and Mitigation Guide that building owners, operators, and/or their consultants will be able to use to determine areas of vulnerability and how to reduce them.

ASSESSMENT METHODOLOGY APPROACH

The primary goal of the building vulnerability assessment methodology is to provide the best available advice in an easy to use application that provides consistent results. To meet this goal, the methodology divides the assessment process into three parts, as follows:

1) **Walk-through assessment:** This is an information gathering step. The walk-through guides users on those features or functions for which attention is warranted and what informational items need to be determined, prior to filling out the questionnaire. This tool is designed to be printed out and taken with the user during a physical inspection of the building, systems and documents. A copy of the draft walk-through sheet is provided in the following section.
2) **Building assessment program:** The assessment was developed as a series of flowcharts, currently being developed into an interactive computer-based questionnaire. In the present flowcharts and in the eventual interactive questionnaire, the answers to the first series or tier of questions lead to subsequent questions. The first tier of questions is broad and fairly short. The number and type of follow-up questions depend upon the initial answers. In the final product, there will be many places where the user can obtain more information to assist with the interpretation of the question and/or give details about how to find the answer. The Assessment Methodology flowcharts are provided in the section following the walk-through assessment.
3) **Vulnerability assessment report:** An individualized assessment report, based on the answers given, will be provided to the user. The report will present mitigation actions that can be taken, rank the risk due to the various vulnerabilities, and evaluate the relative cost categories. There will also be a discussion of risk levels and how to match these with the level of mitigation. The boxes with the '*' represent recommendations. The ranking of the recommendations will be based, at least in part, on the user's responses. The site visits, Project Advisory Committee input, and testing of the assessment guide will have a large influence on how the assessment report is presented in the final product.

The three parts of this methodology, taken together, will form the basis for the final Building Vulnerability Assessment and Mitigation Guide. The flowcharts are being developed into an interactive computer program which will have as its output the vulnerability assessment report. Field testing and PAC member input will be used to assure that the guide meets the project goals.

Assessment Methodology Tools

The following sections provide the text of the walkthrough questionnaire and the flowcharts for the assessment program. The flowcharts are being developed into an interactive computer program for the final Building Vulnerability Assessment and Mitigation Guide.

Walk-through Questionnaire

Building Walk-through Questionnaire

The following questionnaire is organized by functional area and is designed to be taken with you as you tour your facility. By carefully answering the questions below, you will obtain all of the information needed to complete the Building Vulnerability Assessment and Mitigation Program.

Building Entrances

1. What sort of doors lead into the building (i.e. automatic, revolving) and are there visible gaps between them and the doorjambs? Do the doors directly connect the inside and outside of the building or are there a series of doors passing through a vestibule?

2. How do people enter the building: is it always locked, are key cards issued to building occupants, are some doors unlocked during certain hours, etc.?

3. What security measures are in place at entrances (guards, cameras, etc.)?

4. What are the pressure differentials across entrances (is air blowing into or out of the cracks around the doors)? Is it possible to maintain a positive pressure with respect to outside at all times? Sometimes? For a few hours? Is this weather-dependent?

Main Lobby

5. Is the main lobby confined to a small portion of one floor or is it an atrium spanning two or more floors?

5a. Is the general public allowed into this area?

6. Is the general public allowed unrestricted access to the rest of the building from the lobby?

7. Does the lobby use a different air handling unit than the rest of the building?

8. What is the pressure differential between the lobby and the rest of the building? Is it possible to maintain a negative pressure with respect to the rest of the building at all times? For a few hours? Is this weather-dependent?

9. Are packages and mail normally delivered through the lobby?

Building Exterior

10. Are there any gaps or openings in the building shell leading into the building, such as around pipes or other services entering the building?

11. Are there any outside air inlets for the HVAC system on the side of the building below 12 ft. above ground or at (or below) ground level outside the building?

If yes to 11:

11a. Can they be moved to the roof without harming HVAC flows or balance?

11b. Can they be moved to 12ft. or higher on the side of the building without harming HVAC flows or balance?

11c. What security measures are in place around them?

11d. Are they covered by screens angled at a minimum of 45 degrees from horizontal and baffles?

11e. Can an extension be built to only allow air in at 12ft. or higher?

12. Are the windows operable? If so, by whom and when? Are windows well sealed when closed? Is caulking in good repair, no gaps or flaking?

Roof

13. Who has access to the roof and how (keys, key cards, etc.)? Can access be restricted?

14. Are any HVAC systems and/or outside air inlets on the roof?

15. What security measures are in place on the roof (cameras, motion activated lights, etc.)?

16. Is roof accessible in any way other than from inside your building (e.g. from the roof of a nearby building, stairs or ladder on the outside of the building, including fire escapes)?

Rooms with HVAC controls

17. Who has access to it/them and how (keys, etc.)?

18. Are emergency procedures and phone numbers posted in the room(s)?

19. How is the building divided into HVAC zones? Is there a map showing which air handling units supply air for each zone?

20. Is there any central control for all air handling units, such as an Energy Monitoring and Control System (EMCS)? If so, is this system accessible remotely and what security measures are in place to prevent unauthorized access?

AHUs, HVAC filters, dampers, exhausts, etc.

21. Who has access to these areas and how (keys, etc.)?

22. How often are filters changed? How often should they be changed per manufacturer's suggestion? When are the filters changed and by whom?

23. What is the MERV rating for the filters? What is the maximum MERV rating each system could handle?

24. Are there any gaps between the filters themselves and the mounting racks?

25. Do dampers automatically close when fans are turned off? Are they automatically closed in case of power failure? Are the actuators pneumatic or electric?

26. Do dampers seal well when closed?

27. How long does it take fans to wind down (stop) when turned off?

28. How long does it take for dampers to close when commanded closed?

28a. What is the last date of the building Test, Adjust and Balance (TAB) report? Are airflows close to specification? Is the building operated to be slightly overpressurized?

HVAC Maintenance and Utility Rooms

29. Who has access to them and how? Can access be restricted?

30. How far are they from lobby, mailroom, loading dock, garage, and other high risk areas?

31. How often are these areas inspected for foreign objects or other abnormalities?

32. What security measures are taken with outside maintenance workers (background check, escorted while in building, inspect work, etc.)? Are they allowed access to building plans? What about plans they generate?

Ducts

33. Are ducts exposed within accessible areas of the building?

33a. If so, is it possible to 'hide' them in these areas?

34. How leaky are ducts (your HVAC professional can perform a test)?

Return Air Grilles

35. Are they in areas accessible to the public? Are the grilles themselves accessible to the public?

35a. If so, can they be moved or extensions built to a more secure area without upsetting HVAC flows and balance?

36. Are there any obstructions to visibility? (desks, plants, etc.) in front of them?

37. Are they continuously visible (by security guard, camera, etc.)?

Storage Areas

38 Where are they located? Do HVAC or other utility services pass through these areas?

39. Who has access to them and how? Can access be restricted?

39a. How often are they inspected for foreign objects or abnormalities?

Divisions between HVAC zones

40. Are there HVAC zones which are physically separated from the floor to the bottom of the floor above with walls? Are there some zones which are well isolated from the rest of the building and may be suitable for sheltering during an emergency?

41. Are the lobby, mailroom, garage, and loading dock serviced by one or more separate air handling unit(s) – i.e., not the same HVAC units as the rest of the building?

Mailroom

42. Do mailroom personnel wear gloves when handling mail?

43. Are mailroom personnel trained to identify and respond to suspicious mail?

44. Is there a fume hood or other similarly vented area in the mailroom that is used to inspect all mail or suspicious mail?

45. Is there a well sealing receptacle devoted to hazardous materials?

46. Are deliveries required to be scheduled? If so, what is the procedure for receiving an unscheduled delivery?

47. Are deliverers required to present identification?

48. Who has access to mailroom and how? Can access be restricted?

49. Is mailroom on a separate air handling unit from the rest of the building?

50. Is it possible to maintain a negative pressure differential with respect to the rest of the building at all times?

51. What kind of door goes from the mailroom to the building?

52. Can a vestibule or airlock be installed between the mailroom and the building?

53. Is it possible to maintain the garage and loading dock at a negative pressure with respect to the rest of the building?

Tunnels or Skyways to other buildings; Stairwells

54. Who is responsible for them?

55. Are they well sealed from all buildings?

56. Is it possible to maintain them at a negative pressure with respect to connecting buildings?

57. Is it possible to maintain stairwells at a positive pressure with respect to the rest of the building(s)?

Hazardous Materials Storage

58. What hazardous materials are in the building, in outdoor storage, in nearby buildings. Do you have Material Safety Data Sheets for each?

58a. Where is your building located with respect to places where hazardous materials might be released – either accidentally or on purpose? Examples would include large industrial facilities like oil refineries, a rail yard, highways or freight rail lines.

Emergency Response Plan

59. Does it include specific procedures for a chemical, biological or hazardous materials release?

60. Do you have an Emergency Response Team? List members, contact information, and duties. What type of training do team members receive?

61. How do/will you communicate with building occupants in case of an emergency (public address system, alarm, etc.)?

62. What kinds of training and safety information are building occupants given?

63. How often do you run drills specifically for chemical or biological release? What about fire or earthquake?

64. Do you have an evacuation route planned for CB release? For fire?

65. Have you identified a shelter-in-place room? Does it meet one or more of the following criteria:

    a. Is it an interior room (no external walls)?
    b. Can the HVAC system be controlled for this area (shut-off, for example)?
    c. Can the room be 'sealed' to prevent entry of contaminants into the room?
    d. Are supplies stored in the room to support a stay of up to several hours, including emergency supplies, first aid equipment, communications equipment, etc.
    e. List other beneficial attributes of shelter-in-place room, such as whether it is big enough for all building occupants.

66. What is stocked in shelter-in-place room?

67. Is shelter-in-place room accessible to all building occupants?

68. Where is Emergency Response Plan stored and who has access to it?

Building Plans, Drawings, and Documents

69. How many copies exist?

70. Where are they stored? Who has access to this area?

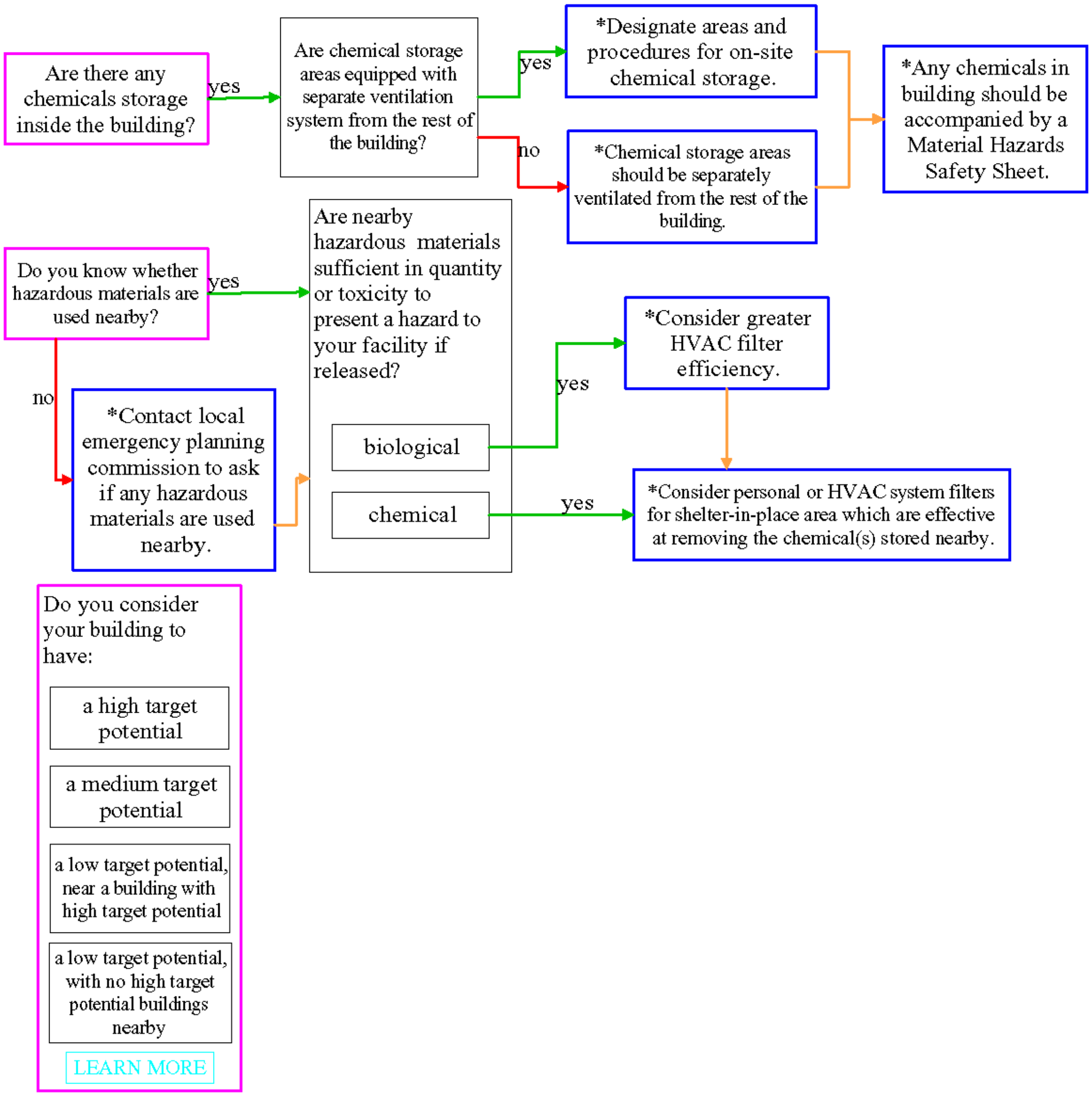
71. What contractors have been given copies or have made their own building plans? Do contractors have security procedures with respect to building documents?

General Security Measures

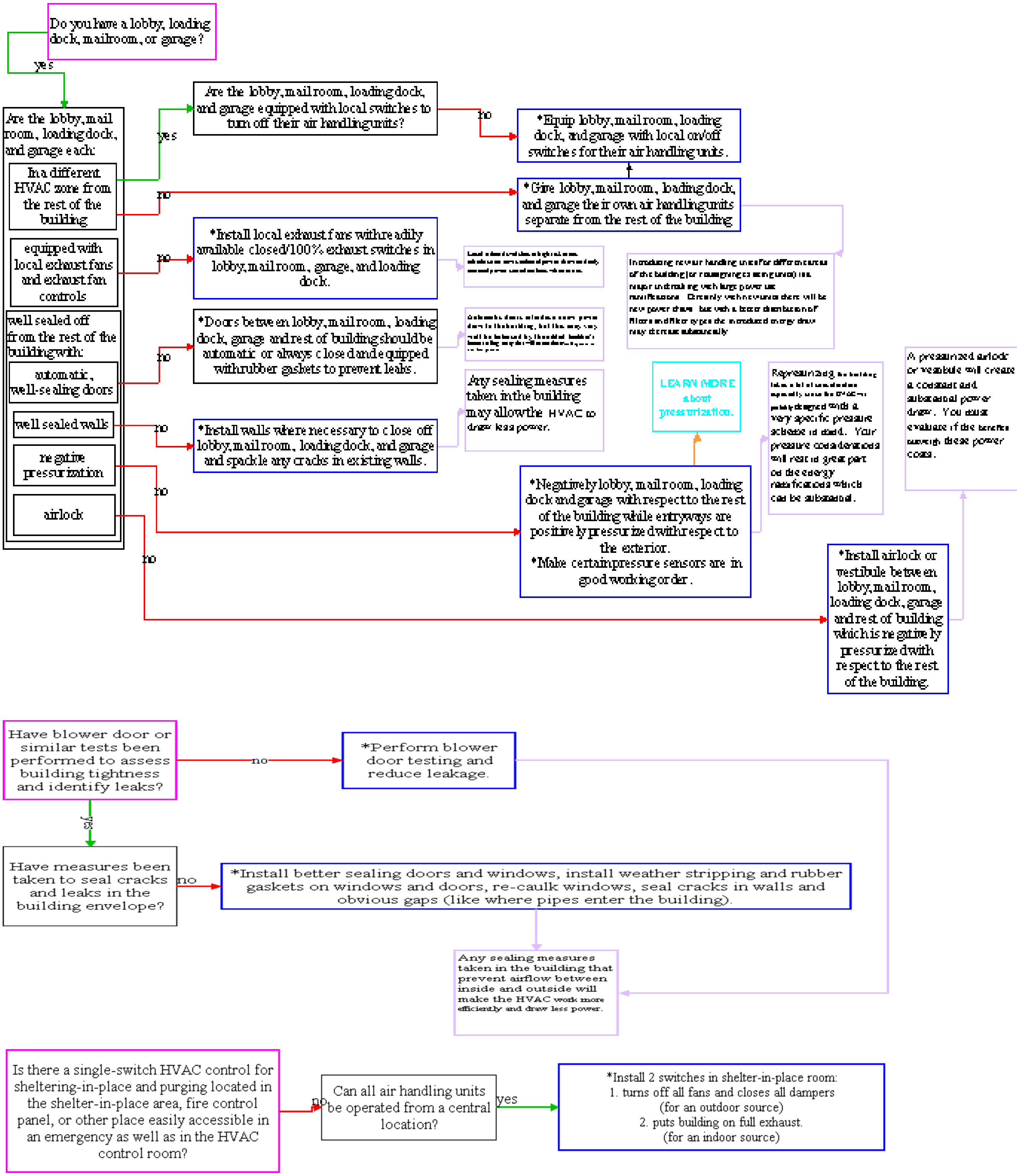
72. Note measures in place (guards, cameras, fences, lights activated by motion sensors…).

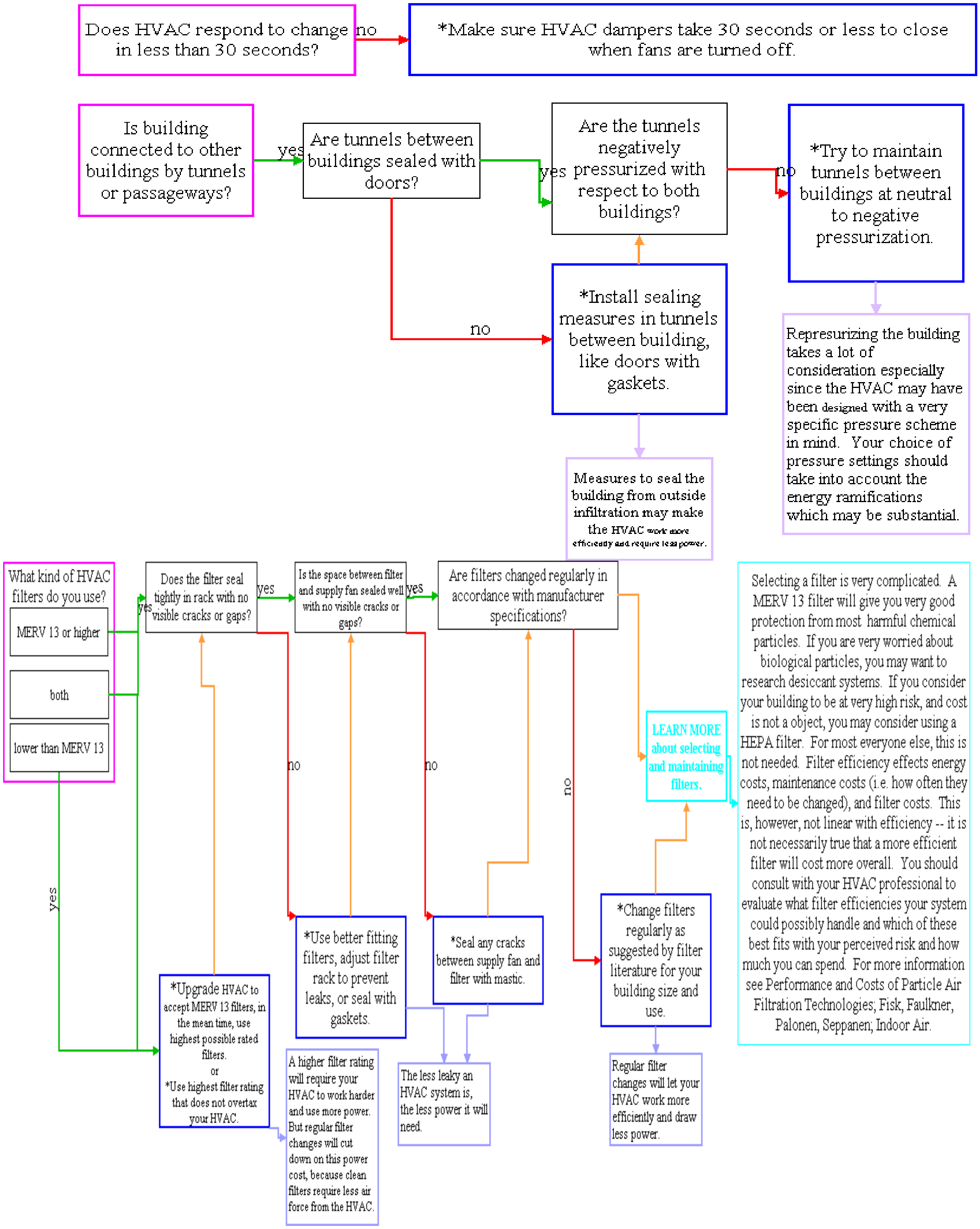
73. If HVAC controls are accessible from off-site, note computer security measures for HVAC controls.

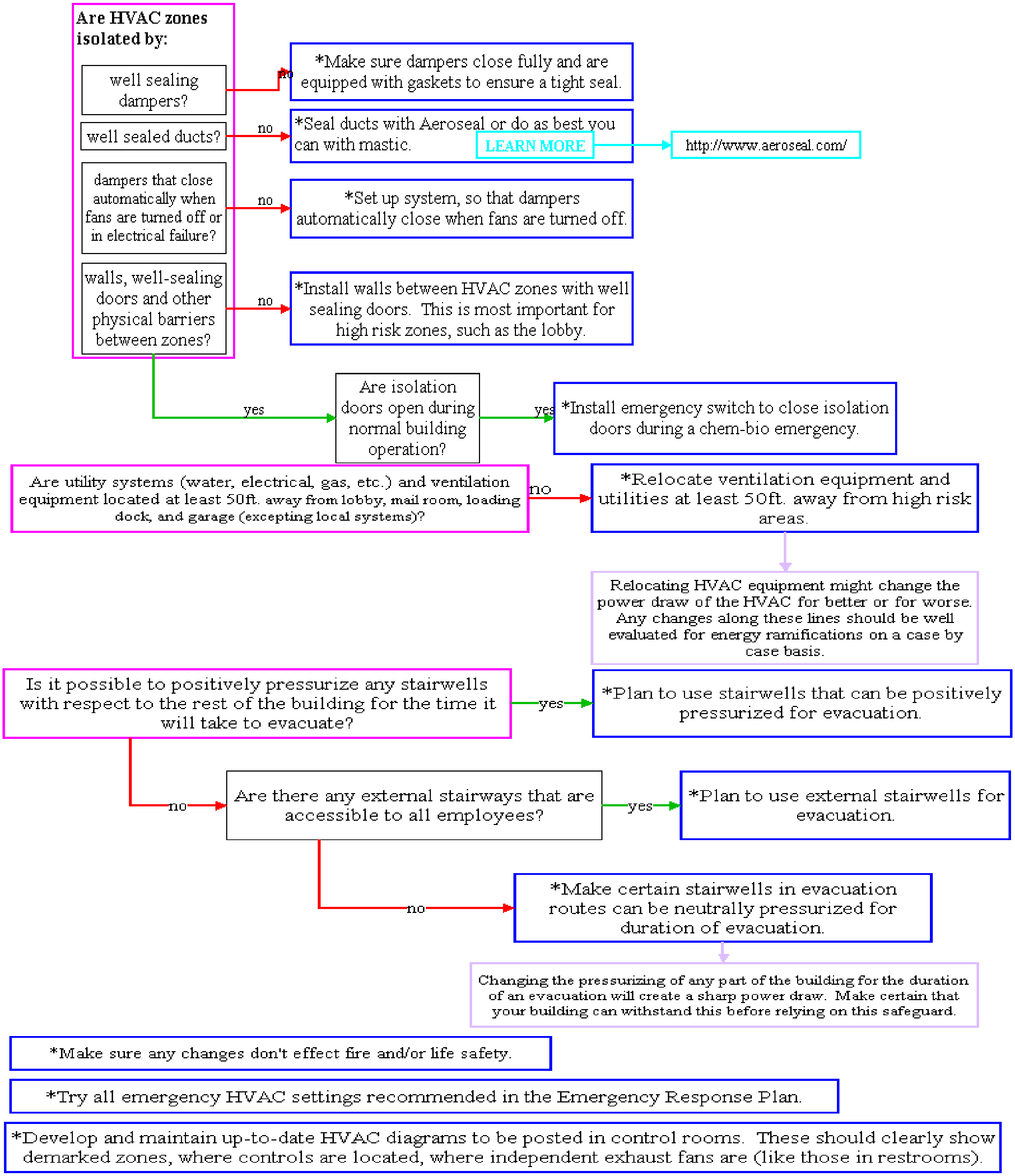
Threat Assessment Flowcharts



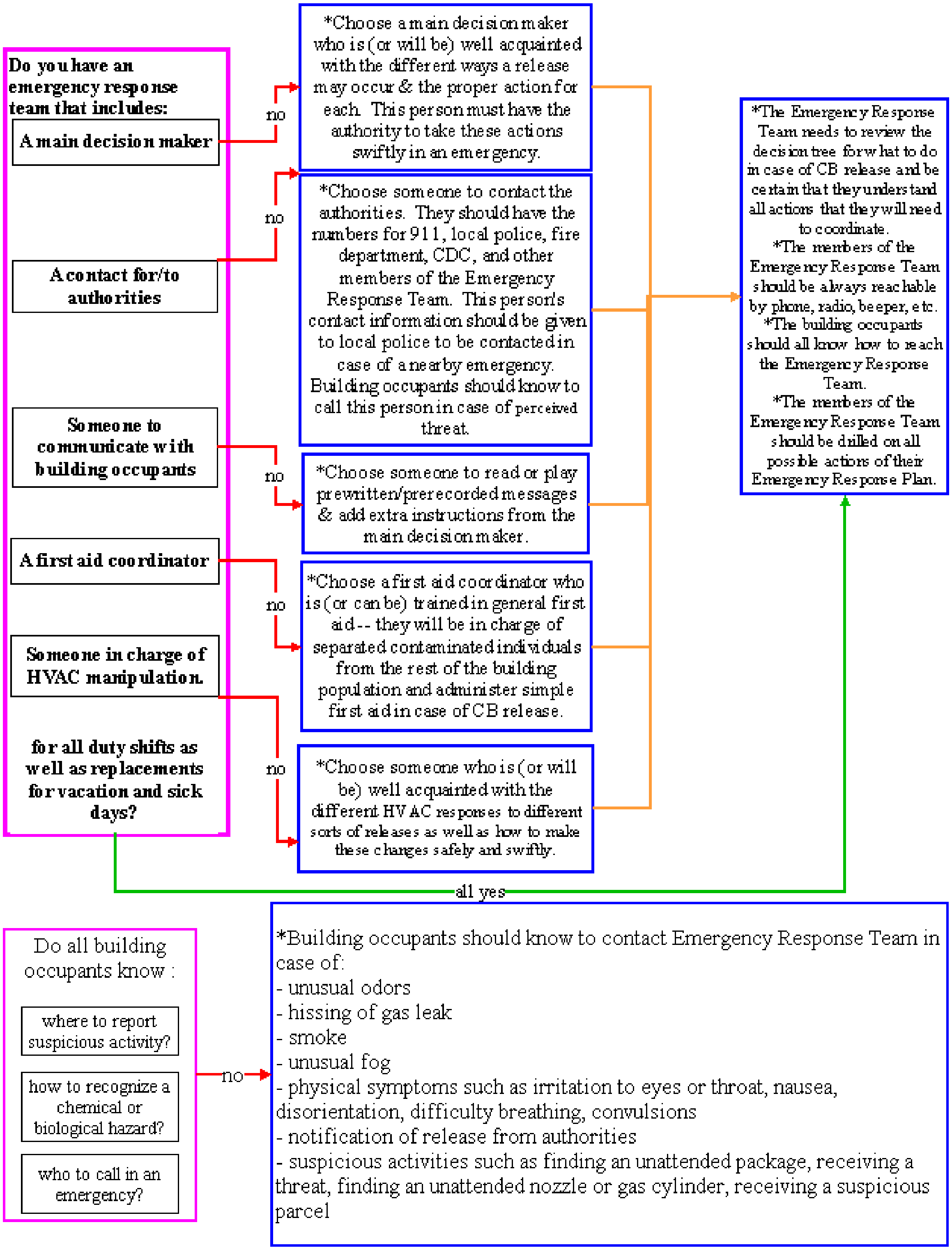
Safety Assessment Flowcharts

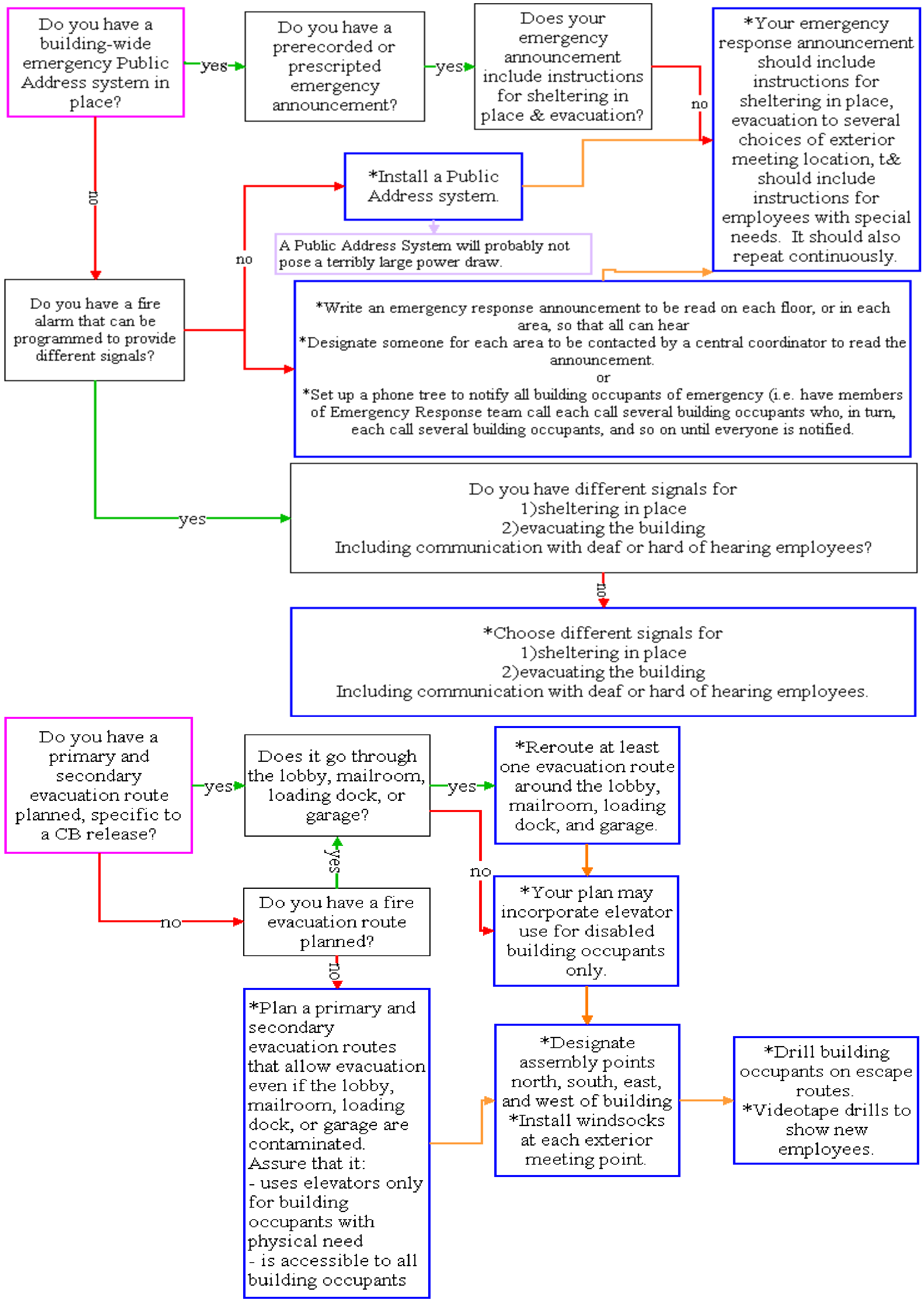


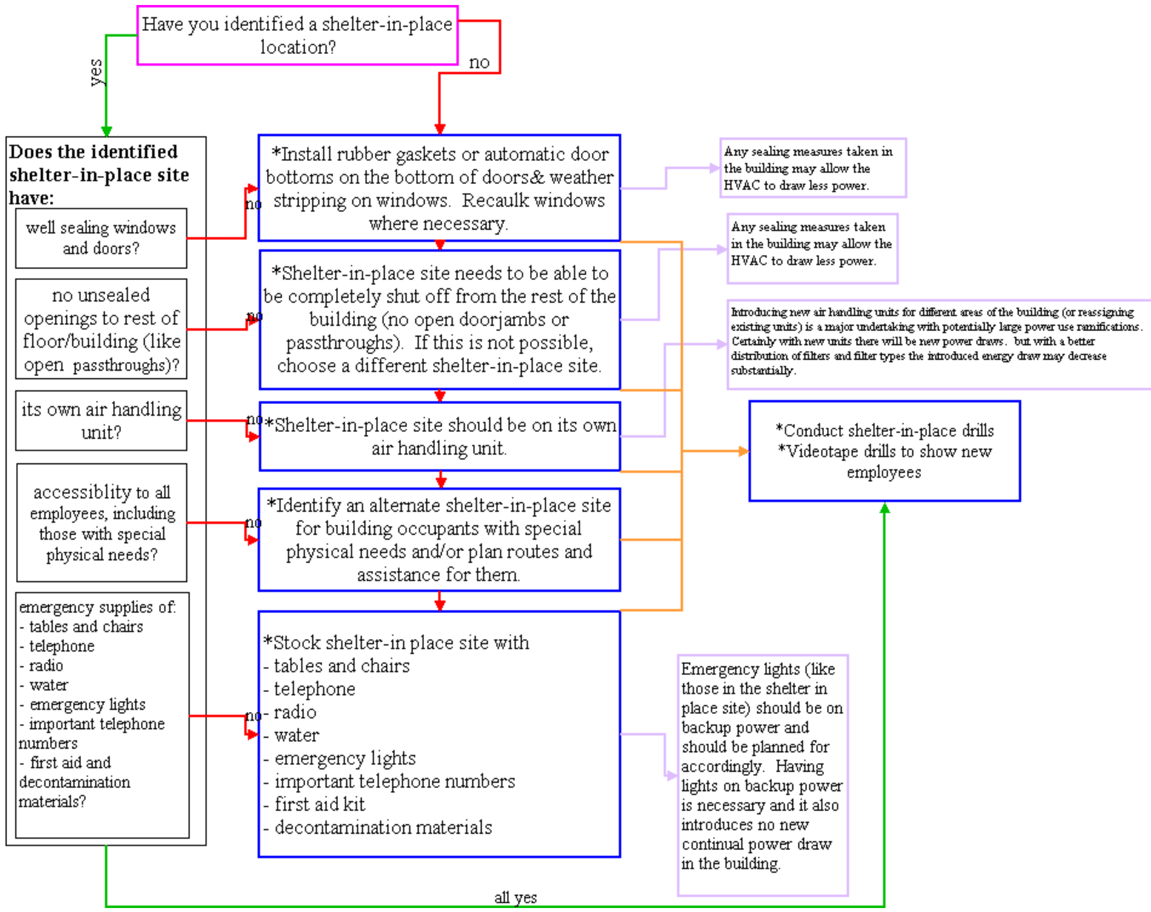

Does HVAC respond to change in less than 30 seconds?
no
*Make sure HVAC dampers take 30 seconds or less to close when fans are turned off.
Is building connected to other buildings by tunnels or passageways?
yes
Are tunnels between buildings sealed with doors?
yes
Are the tunnels negatively pressurized with respect to both buildings?
no
*Try to maintain tunnels between buildings at neutral to negative pressurization.
Represurizing the building takes a lot of consideration especially since the HVAC may have been designed with a very specific pressure scheme in mind. Your choice of pressure settings should take into account the energy ramifications which may be substantial.
no
*Install sealing measures in tunnels between building, like doors with gaskets.
Measures to seal the building from outside infiltration may make the HVAC work more efficiently and require less power.
What kind of HVAC filters do you use?
MERV 13 or higher
both
lower than MERV 13
yes
yes
Does the filter seal tightly in rack with no visible cracks or gaps?
yes
Is the space between filter and supply fan sealed well with no visible cracks or gaps?
yes
Are filters changed regularly in accordance with manufacturer specifications?
no
no
no
LEARN MORE about selecting and maintaining filters.
Selecting a filter is very complicated. A MERV 13 filter will give you very good protection from most harmful chemical particles. If you are very worried about biological particles, you may want to research desiccant systems. If you consider your building to be at very high risk, and cost is not a object, you may consider using a HEPA filter. For most everyone else, this is not needed. Filter efficiency effects energy costs, maintenance costs (i.e. how often they need to be changed), and filter costs. This is, however, not linear with efficiency -- it is not necessarily true that a more efficient filter will cost more overall. You should consult with your HVAC professional to evaluate what filter efficiencies your system could possibly handle and which of these best fits with your perceived risk and how much you can spend. For more information see Performance and Costs of Particle Air Filtration Technologies; Fisk, Faulkner, Palonen, Seppanen; Indoor Air.
*Upgrade HVAC to accept MERV 13 filters, in the mean time, use highest possible rated filters.
or
*Use highest filter rating that does not overtax your HVAC.
*Use better fitting filters, adjust filter rack to prevent leaks, or seal with gaskets.
*Seal any cracks between supply fan and filter with mastic.
*Change filters regularly as suggested by filter literature for your building size and use.
A higher filter rating will require your HVAC to work harder and use more power. But regular filter changes will cut down on this power cost, because clean filters require less air force from the HVAC.
The less leaky an HVAC system is, the less power it will need.
Regular filter changes will let your HVAC work more efficiently and draw less power.

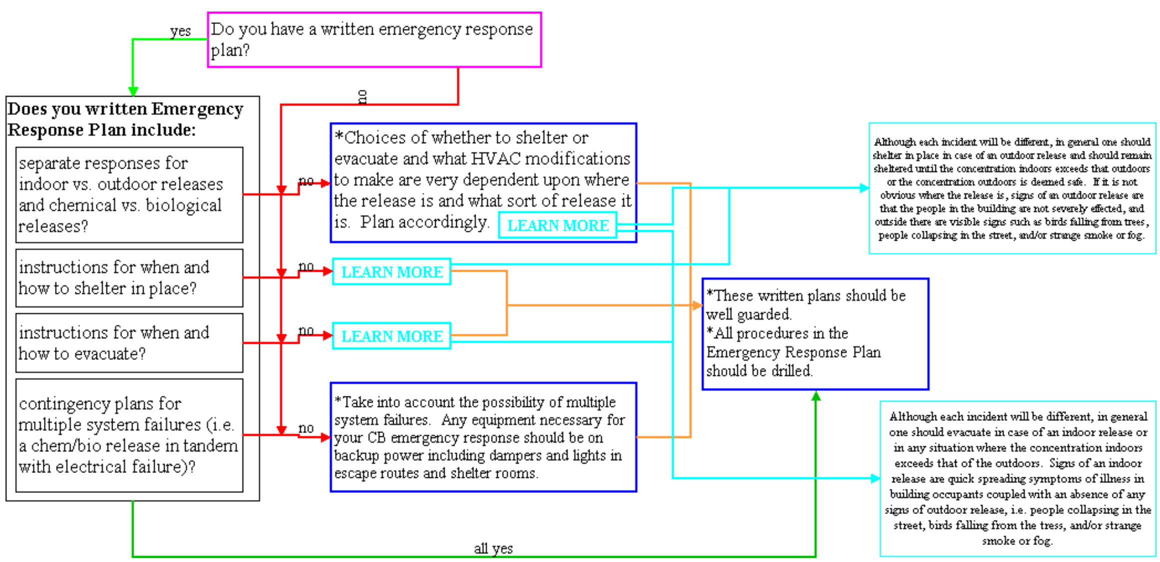

Are HVAC zones isolated by:
well sealing dampers?
no
*Make sure dampers close fully and are equipped with gaskets to ensure a tight seal.
well sealed ducts?
no
*Seal ducts with Aeroseal or do as best you can with mastic.
LEARN MORE
http://www.aeroseal.com/
dampers that close automatically when fans are turned off or in electrical failure?
no
*Set up system, so that dampers automatically close when fans are turned off.
walls, well-sealing doors and other physical barriers between zones?
no
*Install walls between HVAC zones with well sealing doors. This is most important for high risk zones, such as the lobby.
yes
Are isolation doors open during normal building operation?
yes
*Install emergency switch to close isolation doors during a chem-bio emergency.
Are utility systems (water, electrical, gas, etc.) and ventilation equipment located at least 50ft. away from lobby, mail room, loading dock, and garage (excepting local systems)?
no
*Relocate ventilation equipment and utilities at least 50ft. away from high risk areas.
Relocating HVAC equipment might change the power draw of the HVAC for better or for worse. Any changes along these lines should be well evaluated for energy ramifications on a case by case basis.
Is it possible to positively pressurize any stairwells with respect to the rest of the building for the time it will take to evacuate?
yes
*Plan to use stairwells that can be positively pressurized for evacuation.
no
Are there any external stairways that are accessible to all employees?
yes
*Plan to use external stairwells for evacuation.
no
*Make certain stairwells in evacuation routes can be neutrally pressurized for duration of evacuation.
Changing the pressurizing of any part of the building for the duration of an evacuation will create a sharp power draw. Make certain that your building can withstand this before relying on this safeguard.
*Make sure any changes don't effect fire and/or life safety.
*Try all emergency HVAC settings recommended in the Emergency Response Plan.
*Develop and maintain up-to-date HVAC diagrams to be posted in control rooms. These should clearly show demarked zones, where controls are located, where independent exhaust fans are (like those in restrooms).

Emergency Response Plan Assessment Flowcharts

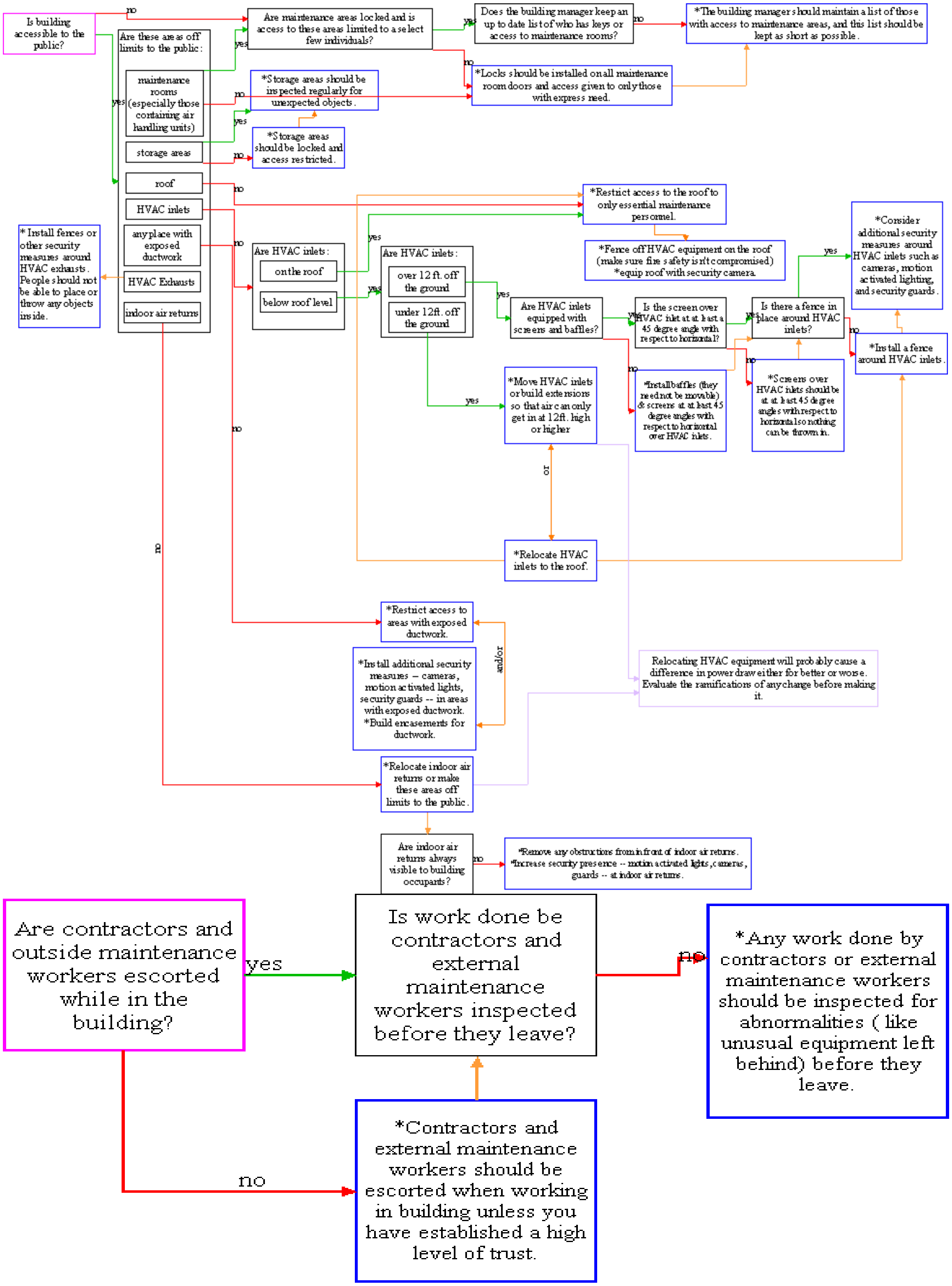


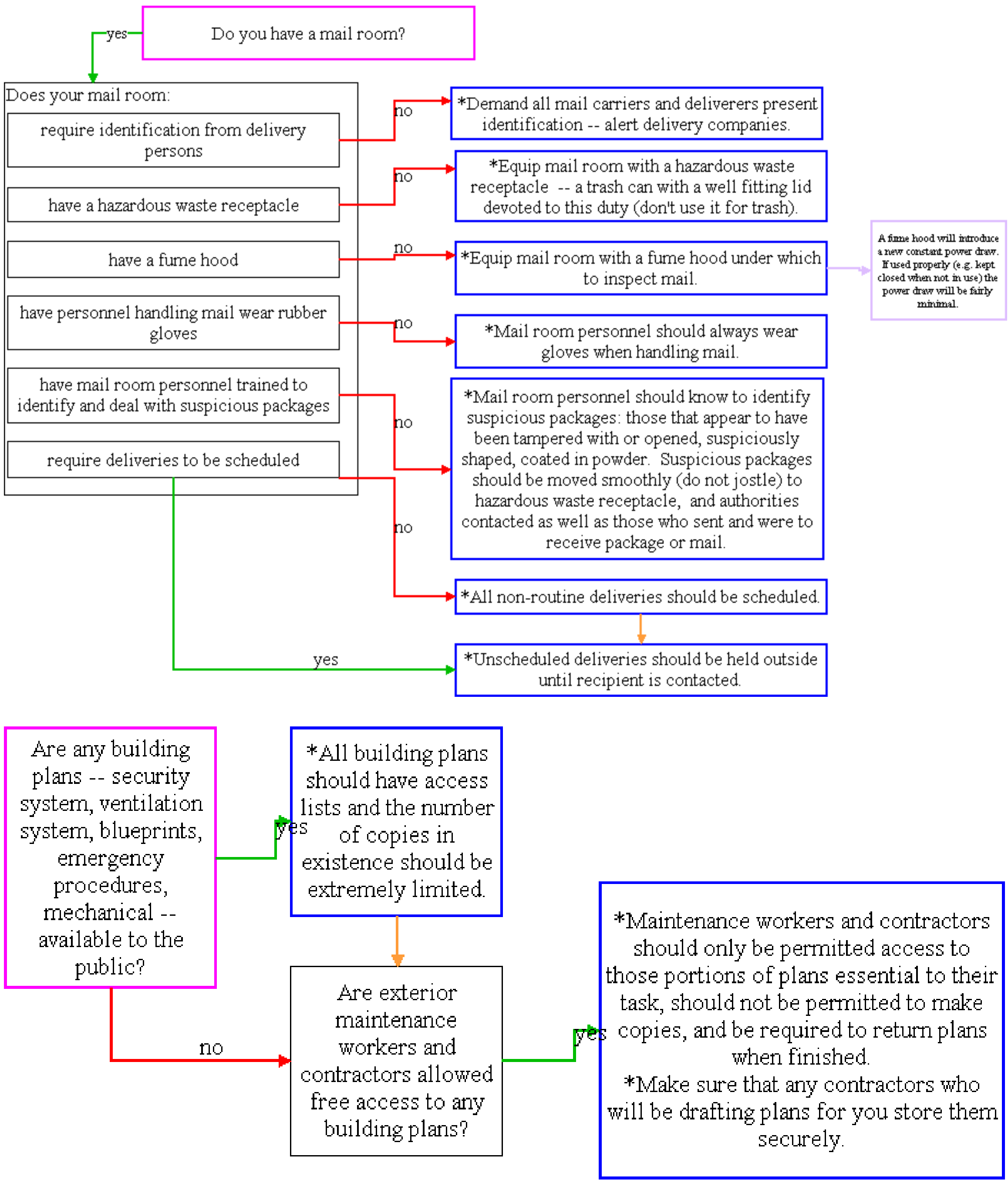

Do you have a building-wide emergency Public Address system in place?
yes
Do you have a prerecorded or prescripted emergency announcement?
yes
Does your emergency announcement include instructions for sheltering in place & evacuation?
no
*Your emergency response announcement should include instructions for sheltering in place, evacuation to several choices of exterior meeting location, t& should include instructions for employees with special needs. It should also repeat continuously.
no
*Install a Public Address system.
A Public Address System will probably not pose a terribly large power draw.
no
Do you have a fire alarm that can be programmed to provide different signals?
*Write an emergency response announcement to be read on each floor, or in each area, so that all can hear
*Designate someone for each area to be contacted by a central coordinator to read the announcement.
or
*Set up a phone tree to notify all building occupants of emergency (i.e. have members of Emergency Response team call each call several building occupants who, in turn, each call several building occupants, and so on until everyone is notified.
yes
Do you have different signals for 1)sheltering in place 2)evacuating the building Including communication with deaf or hard of hearing employees?
no
*Choose different signals for 1)sheltering in place 2)evacuating the building Including communication with deaf or hard of hearing employees.
Do you have a primary and secondary evacuation route planned, specific to a CB release?
yes
Does it go through the lobby, mailroom, loading dock, or garage?
yes
*Reroute at least one evacuation route around the lobby, mailroom, loading dock, and garage.
no
*Your plan may incorporate elevator use for disabled building occupants only.
yes
no
Do you have a fire evacuation route planned?
no
*Plan a primary and secondary evacuation routes that allow evacuation even if the lobby, mailroom, loading dock, or garage are contaminated. Assure that it: - uses elevators only for building occupants with physical need - is accessible to all building occupants
*Designate assembly points north, south, east, and west of building *Install windsocks at each exterior meeting point.
*Drill building occupants on escape routes. *Videotape drills to show new employees.


Have you identified a shelter-in-place location?
yes
no
Does the identified shelter-in-place site have:
well sealing windows and doors?
no unsealed openings to rest of floor/building (like open passthroughs)?
its own air handling unit?
accessiblity to all employees, including those with special physical needs?
emergency supplies of: - tables and chairs - telephone - radio - water - emergency lights - important telephone numbers - first aid and decontamination materials?
no
*Install rubber gaskets or automatic door bottoms on the bottom of doors& weather stripping on windows. Recaulk windows where necessary.
*Shelter-in-place site needs to be able to be completely shut off from the rest of the building (no open doorjambs or passthroughs). If this is not possible, choose a different shelter-in-place site.
*Shelter-in-place site should be on its own air handling unit.
*Identify an alternate shelter-in-place site for building occupants with special physical needs and/or plan routes and assistance for them.
*Stock shelter-in place site with - tables and chairs - telephone - radio - water - emergency lights - important telephone numbers - first aid kit - decontamination materials
Any sealing measures taken in the building may allow the HVAC to draw less power.
Any sealing measures taken in the building may allow the HVAC to draw less power.
Introducing new air handling units for different areas of the building (or reassigning existing units) is a major undertaking with potentially large power use ramifications. Certainly with new units there will be new power draws. but with a better distribution of filters and filter types the introduced energy draw may decrease substantially.
*Conduct shelter-in-place drills *Videotape drills to show new employees
Emergency lights (like those in the shelter in place site) should be on backup power and should be planned for accordingly. Having lights on backup power is necessary and it also introduces no new continual power draw in the building.
all yes

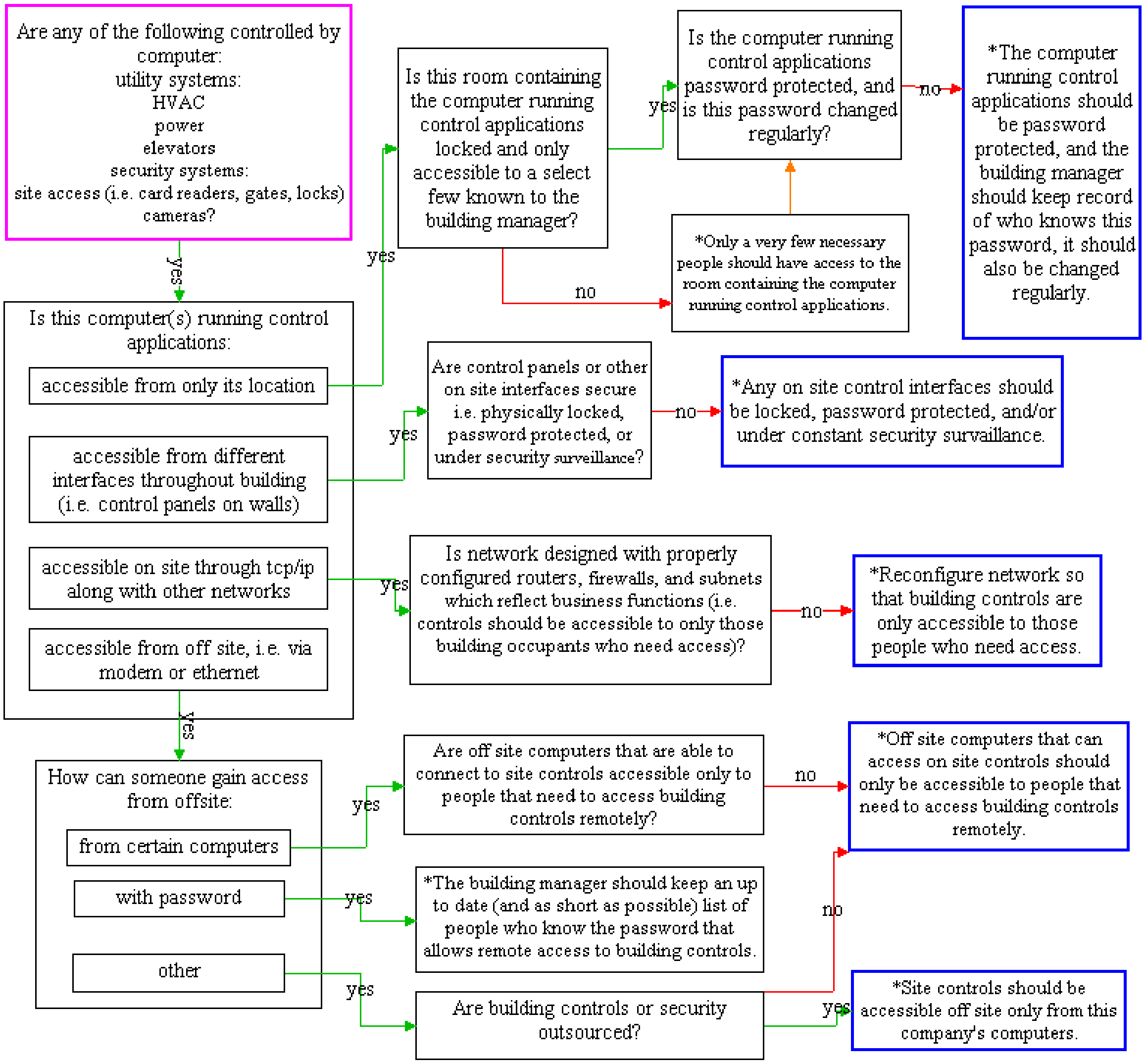

Do you have a written emergency response plan?
yes
no
Does you written Emergency Response Plan include:
separate responses for indoor vs. outdoor releases and chemical vs. biological releases?
instructions for when and how to shelter in place?
instructions for when and how to evacuate?
contingency plans for multiple system failures (i.e. a chem/bio release in tandem with electrical failure)?
no
*Choices of whether to shelter or evacuate and what HVAC modifications to make are very dependent upon where the release is and what sort of release it is. Plan accordingly.
LEARN MORE
LEARN MORE
LEARN MORE
*Take into account the possibility of multiple system failures. Any equipment necessary for your CB emergency response should be on backup power including dampers and lights in escape routes and shelter rooms.
Although each incident will be different, in general one should shelter in place in case of an outdoor release and should remain sheltered until the concentration indoors exceeds that outdoors or the concentration outdoors is deemed safe. If it is not obvious where the release is, signs of an outdoor release are that the people in the building are not severely effected, and outside there are visible signs such as birds falling from trees, people collapsing in the street, and/or strange smoke or fog.
*These written plans should be well guarded. *All procedures in the Emergency Response Plan should be drilled.
Although each incident will be different, in general one should evacuate in case of an indoor release or in any situation where the concentration indoors exceeds that of the outdoors. Signs of an indoor release are quick spreading symptoms of illness in building occupants coupled with an absence of any signs of outdoor release, i.e. people collapsing in the street, birds falling from the tress, and/or strange smoke or fog.
all yes

Security Assessment Flowcharts




Do you have a mail room?
yes
Does your mail room:
require identification from delivery persons
have a hazardous waste receptacle
have a fume hood
have personnel handling mail wear rubber gloves
have mail room personnel trained to identify and deal with suspicious packages
require deliveries to be scheduled
no
*Demand all mail carriers and deliverers present identification -- alert delivery companies.
*Equip mail room with a hazardous waste receptacle -- a trash can with a well fitting lid devoted to this duty (don't use it for trash).
*Equip mail room with a fume hood under which to inspect mail.
A fume hood will introduce a new constant power draw. If used properly (e.g. kept closed when not in use) the power draw will be fairly minimal.
*Mail room personnel should always wear gloves when handling mail.
*Mail room personnel should know to identify suspicious packages: those that appear to have been tampered with or opened, suspiciously shaped, coated in powder. Suspicious packages should be moved smoothly (do not jostle) to hazardous waste receptacle, and authorities contacted as well as those who sent and were to receive package or mail.
*All non-routine deliveries should be scheduled.
*Unscheduled deliveries should be held outside until recipient is contacted.
Are any building plans -- security system, ventilation system, blueprints, emergency procedures, mechanical -- available to the public?
*All building plans should have access lists and the number of copies in existence should be extremely limited.
Are exterior maintenance workers and contractors allowed free access to any building plans?
*Maintenance workers and contractors should only be permitted access to those portions of plans essential to their task, should not be permitted to make copies, and be required to return plans when finished.
*Make sure that any contractors who will be drafting plans for you store them securely.

HVAC Cyber-Security Assessment Flowcharts



Conclusions

This report presents, in draft form, the basis for preparation of an interactive Building Vulnerability Assessment and Mitigation Guide. At the completion of this project, the Building Vulnerability Assessment and Mitigation Guide will be the first field-tested, easy-to-use protocol that building owners and operators can utilize to reduce the likelihood and severity of a chemical or biological agent attack. Additionally, this guide will explicitly consider reducing the energy impacts of mitigation measures and help owners assess the energy impact of various options.

APPENDIX E: BUILDING TEST REPORTS

Appendix E: Building Test Reports

The first building test was performed by Steve Greenberg, of the Lawrence Berkeley Laboratory, Facilities and Applications Departments. The following assessment report covers the preliminary building test:

Assessment for Building 1

The test building is a 44 year old, 89,000 GSF, 4 floor office building with partial basement. The tester interviewed the building manager for the building (at LBNL the building manager has some safety responsibilities but is mostly the interface between building users and the facilities department; this building manager is also the safety coordinator for the Environmental Energy Technologies Division, so his knowledge of safety polices and procedures was better than most building managers). This interview lasted approximately 1-hour and would have required more time or an additional person without the manager's extra knowledge about safety). The tester also interviewed the in-house Facilities Mechanical Engineer regarding mechanical systems (approx. 15 min.), the in-house Facilities Controls Engineer regarding HVAC controls (approx. 5 min.), and the LBNL Facilities Maintenance Supervisor regarding filter specifications (approx. 10 min.). The tester also toured the building about 3 hours. Since he had access to a master key and already knew the building pretty well, he conducted the building tour alone. If the tester was an outsider or new to the building, a knowledgeable escort and more inspection time would have been required.

The tester performed the software test by looking at the building two ways: (1) as the building exists on a controlled-access campus (i.e. the greater LBNL population is all authorized personnel) and (2) as if the building were stand-alone (i.e. the greater LBNL population is "the public"). Of course the second case was not a realistic condition for the building, but it gave a good opportunity to make sure the software gave appropriate recommendations for both scenarios.

While in general the recommendations seemed appropriate for the test runs, a variety of suggestions for improving the software came from the preliminary case study. These included:

1. *Provide a printable version of the questions in BVAMP that exactly matches the software.*
2. *Improve the links between the questions and recommendations (several examples of this including deleting irrelevant recommendations on e.g. mailrooms and tunnels, conforming chemical storage recommendations with responses, etc.).*
3. *Make specific changes to recommendations (e.g. switch configuration for manual over-ride of ventilation controls).*

4. *Make it clear which recommendations were specific to the responses and which are generic.*
5. *Remove redundant recommendations.*

Overall, with implementation of the suggestions and corrections indicated, the tester found that the process and recommendations would be useful to the owners and operators of such buildings. Changes to BVAMP and the questionnaire were made to address the issues presented during this test.

In lieu of the high profile buildings specified in the experimental plan, three lower-profile buildings were used to test the BVAM Guide and BVAMP software. The original plan also called for one building to be assessed first by LBNL personnel and then by the building management. However we found that personnel in the building needed to be involved in the assessment process to such an extent that it was not possible for LBNL to perform the assessment independently. The following sections present the testing reports for the 3 test buildings in phase 3, in the order in which they were performed.

Assessment for Building 2

The assessment for Building 2 was conducted by Rich Sextro and Tracy Thatcher, Lawrence Berkeley National Laboratory's Indoor Environment Department.

Building 2 is located in Concord, California and was assessed during April 2004. The assessment was conducted in conjunction with the Facility Manager and the Environmental, Health, and Safety Manager. Several facilities personnel were also consulted during the visit. The test building is a moderate sized three story office building. One wing of the building consists primarily of individual offices, while the other wing houses a large open plan space with a two story atrium at one end. The building is served by a central air handling unit, which draws air from a roof top penthouse. The building is part of a five building complex. The building tour and completion of the Building Vulnerability Assessment and Mitigation Program took approximately 4 hours. Both the Facility Manager and Environmental Health and Safety Manager participated during the entire period. During this process, the team also took a cursory look at the other 4 buildings in the complex and discussed how they were different than the test building.

During Field Test 2, several questions were identified which needed rewording and clarification. The building being assessed was used during both the day and evening, however most of the facility staff was on shift only *during the day. Therefore questions need to be reworded to clearly apply to multiple shift facilities. Additionally, some questions regarding evacuation were unclear, due to restrictions on evacuation route off of the complex.*

In addition, the user suggested modifications to the report generated by BVAMP so that it would be more obvious which sections were general information and which were specific recommendations for the facility.

The Facility Manager found the process to be relatively straight forward and was pleased with the results. All facilities within this organization are being asked by upper management to review their risks and vulnerabilities to potential terrorist threats. The Facility Manager thought that this was a useful tool to help them with their preparedness. During the visit, there were vulnerabilities identified which the managers had not considered previously, especially in the areas of preparation for shelter-in-place scenarios, providing alternate evacuation areas, and multiple shift emergency response planning. The Facility Manager was willing to address the lower-cost mitigations, even for this relatively low risk facility.

Assessment for Building 3

The assessment for Building 3 was conducted by Rich Sextro and Tracy Thatcher, Lawrence Berkeley National Laboratory's Indoor Environment Department.

Building 3 is located in Hayward, California and was assessed during May 2004. The assessment was conducted in conjunction with the Facility Manager and the Environmental, Health, and Safety Manager. Several facilities personnel were also consulted during the visit. The test building is a 2 story, multiple use building that includes a shop area, gas cylinder storage, chemical usage, and a loading dock area. The building is served by multiple air handling and ventilation units. Air intakes are located both at ground level and at roof level. The building also has operable windows. Because the *air handling units supply only heat (not cooling), the operable windows are often left open during the spring, summer, and fall.*

The assessment took approximately 3 hours to complete the building tour and BVAMP software. The Environmental, Health, and Safety Manager participated in the entire process. The Facility Manager participated for approximately 1 hour, during the portion of the tour that included the mechanical systems. This building provided the opportunity to test the assessment process on a more complex building with multiple special use areas and unusual circumstances. The building is occupied both during the daytime and evening. The building management considers the building to be at low to moderate risk.

Much of the time spent touring the building was devoted to the kiln, chemical, and shop areas. The building is open to the public, with no controls, making it difficult to restrict access to these areas.

An area where it was difficult to interpret the BVAMP questions for this building was in the controls section. The building HVAC system controls are on a central system that can control all of the buildings in the complex. However, the air handling units can be switched to local control at the individual units and the status of this switch can not be determined remotely, making it impossible to tell whether a command has been executed. In addition, although an individual air handling unit can be shutdown rapidly, each unit must be given a separate command at the central control computer. This means that shutting down all the air handling units within a complex will take up to 30 minutes. Questions and recommendations addressing these issues were added to BVAMP.

Assessment for Building 4

The assessment for building 4 was performed by Rich Sextro, Lawrence Berkeley National Laboratory, and Mike Koontz, Geomet. This building test included training of the Geomet subcontractor in the use of the Assessment Methodology.

The fourth building that served as a test site for the vulnerability assessment tool is located in Washington, DC, a few blocks from Union Station near the center of the city. One distinguishing feature of this building, in relation to the first two buildings tested, is that it houses multiple tenants. Thus, it afforded an opportunity to assess the applicability or utility of the vulnerability assessment tool for this particular situation. The tenants include a national association and a local government agency. Although the building has multiple tenants, a facilities manager employed by the association has responsibility for the entire building.

The building has nine floors, with an area of about 5,000 ft^2 per floor, and is served by a single HVAC system (thus, a single mechanical room). This system has no vertical or horizontal zoning per se, but there is the capability to control airflows to each floor independently. The HVAC system is shut down entirely at about 6 p.m. and is started back up at 6 a.m. on weekdays; it remains shut down over the weekend. Because tenants tend to occupy entire floors and airflows can be controlled on a floor-by-floor basis, occasional needs of the occupants for space conditioning after hours or over weekends can be accommodated.

The building has an underground garage, a single-bay dock, and a central mail repository to which the U.S. Post Office delivers, with unassisted/unrestricted access, and from which individual tenants collect their mail. The garage is served by a separate ventilation system that supplies unconditioned outside air, with ground-level air intakes; air is "exhausted" from the garage via uncontrolled exfiltration.

The following are among the insights gained from this building with respect to the interactive, PC-based questionnaire:

Risk Assessment

- *What is meant by "chemicals?" Does it include, for example, industrial cleaners?*
- *The question "Do you know if any hazardous materials are stored nearby?" leads to ambiguous responses.*
- *Consider adding a question on whether there is any major thoroughfare nearby.*

Emergency Response Plan

- *How to handle multiple tenants when inquiring about emergency response plans?*

- *Too many items are listed as potential contents for the shelter-in-place area, making it difficult to respond on a yes/no basis. (There are a couple other questions that share this potential difficulty.)*

Building Utilities

- *Consider adding questions on building age and testing and balancing (TAB), to provide a better "feel" for likely building characteristics and attention to details with respect to the efficiency of the HVAC system.*

Building Security

- *The question regarding storage areas is difficult to respond to in the case of a multiple-tenant building.*

One thought about the recommendations is that they seem too "cluttered" because of the tendency to provide broad-based or generic ones in addition to those that are building-specific. Should try to provide more structure to the report and better separation for generic and building specific recommendations. Also, it would be helpful to add the ability for the user to add comments to the recommendations report, so that any specific information for the assessment could be recorded in the header (such as if there were questions unanswered, who performed the assessment, etc.)

The recommended changes for adding multi-tenant questions and changing specific questions to improve 'readability' were incorporated into BVAMP. Improvements have been made to the report structure to provide better separation between generic and specific recommendations. Additional improvements and the addition of a comments section are being planned for a future version of the software.